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STUDY REPORT
CAA-SR-92-14

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TACTICAL COMBAT SAMPLES AND LINKAGE TO TACWAR (TAC LINK)

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**STUDY REPORT
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**TACTICAL COMBAT SAMPLES AND LINKAGE TO TACWAR
(TAC LINK)**

September 1992

Prepared by

**FORCE EVALUATION DIRECTORATE
CPT(P) Robert S. Elias, Study Director**

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REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY

US ARMY CONCEPTS ANALYSIS AGENCY
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CSCA-FEF/T (5-5d)

02 FEB 1993

MEMORANDUM FOR Deputy Chief of Staff for Operations and Plans, C3,
ATTN: CFCD, APO San Francisco 96301-0028

SUBJECT: Tactical Combat Samples and Linkage to TACWAR Study

1. Reference memorandum, CFCD, 13 January 1992, subject: Development of Combat Samples for TACWAR (TAC LINK) - Study Directive.
2. Referenced memorandum requested that the U.S. Army Concepts Analysis Agency (CAA) provide combat samples for use in TACWAR, using near term force inventories.
3. This final report documents the results of our analyses and incorporates your comments on the draft report which were received in January 1993. Included is an executive summary which provides an overview of the entire study. Questions and/or inquiries should be directed to the Assistant Director, Force Evaluation Directorate, U.S. Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814-2797, DSN 295-1677.
4. I would like to express my appreciation to all the staff elements and agencies which have contributed to the study.

E. B. Vandiver III
E. B. VANDIVER III
Director

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**TACTICAL COMBAT SAMPLES AND
LINKAGE TO TACWAR
(TAC LINK)**

**STUDY
SUMMARY
CAA-SR-92-14**

THE REASON FOR PERFORMING THE STUDY is to develop combat sample attrition data that provide some of the required inputs to the Tactical Warfare Model (TACWAR). Development of these inputs provides an audit trail on which the sponsor can rely.

THE STUDY SPONSOR is Commander, Combined Forces Command (CFC), Republic of Korea. The C-3, Combined Forces Command, established the study objective and monitored study activity.

THE STUDY OBJECTIVE is to develop combat sample attrition data to use as input for the TACWAR theater model.

THE SCOPE OF THE STUDY is the development of the operational probability of kill, operational rate of fire, and allocation of fires for each potential weapon system interaction in the Korean theater of operations. This study examines US and Republic of Korea forces deployed against a North Korean threat. Timeframe for this study is 1993.

THE MAIN ASSUMPTION of this study was that the TAC LINK output data is usable in TACWAR. This entailed the completion and testing of the COSAGE-TACWAR Interface (CTI).

THE BASIC APPROACHES used in this study were to determine attrition data by using stylized (Blue and Green on Red) forces in the Combat Sample Generator (COSAGE). The data from these simulations is analyzed and postprocessed into an acceptable TACWAR format.

THE PRINCIPAL FINDING of this study is that combat samples can be constructed to support TACWAR in the Korean theater of operations. The data provided to CFC includes the operational probability of kill, operational rate of fire, and allocation of fires for all weapon systems found in the theater of operations.

THE STUDY EFFORT was directed by CPT Robert S. Elias, Tactical Branch, Force Evaluation Directorate.

COMMENTS AND QUESTIONS may be sent to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-FEF/T, 8120 Woodmont Avenue, Bethesda, Maryland 20814-2797.

Tear-out copies of this synopsis are at back cover.

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CHAPTER 1

EXECUTIVE SUMMARY

1-1. PROBLEM. The theater model, Tactical Warfare (TACWAR), requires many specific inputs to accurately portray the desired scenario. Many of these inputs are available, easily understood, and are properly documented. A few of the necessary inputs are not readily available for TACWAR, nor are they provided in a comprehensive package, complete with documentation. The Combined Forces Command (CFC) and Eighth US Army (EUSA), requested that the US Army Concepts Analysis Agency (CAA) conduct a study to determine the operational probability of kill, operational rate of fire, allocation of fires, and provide this data, complete with proper and auditable documentation in TACWAR usable format, to CFC.

1-2. BACKGROUND. Data reliability is as important in simulations as is the analyzed output. In 1990, Central Command (CENTCOM) initiated an effort to determine accurate values for TACWAR input data that did not have an approved audit trail. CENTCOM contacted CAA during Operation DESERT SHIELD and requested CAA assistance in determining these values. CENTCOM does not have ready access to the raw data that must be determined in operational form for input values in TACWAR. There are three values that need to be determined. These input values are the operational probability of kill, operational rate of fire, and allocation of fires. This data must cover all of the various weapon types and mixes. CFC recognized their lack of an uninterrupted audit trail for these inputs and requested assistance in developing fully auditable data for their version of TACWAR. CAA's high-resolution simulation, the Combat Sample Generator (COSAGE), can provide these operational values for CFC and other TACWAR users.

1-3. SCOPE. Four steps compose the scope of this study; these are listed below.

- a. CAA developed 15 specific scenarios in accordance with CFC guidance.
- b. These scenarios are simulated using COSAGE.
- c. Analyze COSAGE output to ensure all analytical objectives are met.
- d. The analyzed results from the Combat Sample Generator simulation are then processed by the COSAGE-TACWAR Interface (CTI) into a usable form for input into TACWAR.

1-4. LIMITATIONS. The combat sample process contains two tactical limitations that must be discussed to ensure full understanding of the capabilities and limitations of COSAGE. These limitations are:

- a. Combat samples employ weapons without degradation due to fatigue, low morale, poor training, or low experience levels. The lack of use of these factors provides a highly efficient weapon/soldier throughout the simulated combat.

b. The second limitation found within this study is the lack of any type of electronic countermeasures used by either side. This means that there is no attempt to reduce or impede the use of the electronic surveillance devices, radios, or radar. The area of greatest impact is in counterbattery fires and radio transmissions. Likewise, the Red side has no means of jamming Blue counterbattery radar or radio transmissions.

1-5. TIMEFRAME. This study is a near-term study. The data represents United States, Republic of Korea (ROK), and North Korean (nK) forces during the 1993 timeframe.

1-6. KEY ASSUMPTIONS

a. Equipment substitutions for Blue, Green, and Red force inventories (Blue corresponds to US forces, Green to ROK forces, and Red to nK forces) accurately depict the capabilities of the sponsor-suggested equipment and are acceptable as replacements.

b. Attackers are fully mounted in their vehicles, and every time a unit defends, it is fully dismounted. The effect of this assumption is that there are different levels of combat strength displayed for the same forces, depending on the unit posture (attacking or defending).

c. Logistics are sufficient for the duration of the battle. That is, neither side will run out of the logistics necessary to carry on the battle.

d. Forty-eight hours of simulated combat is sufficient to develop calibration statistics for TACWAR.

1-7. APPROACH/METHODOLOGY. Ensuring the accuracy of the initial input data is the cornerstone of all studies. To guarantee meeting this requirement, the study sponsor provided all initial weapon system types, quantities, and force structures. CAA developed these into representative forces and fought them in simulated combat for 48 hours in 15 scenarios.

a. The 15 postures listed below include Blue versus Red, and Green versus Red scenarios. Of the 15 scenarios, 13 contain no tactical air (TACAIR) engagements, but do have attack helicopters in both cross-FLOT (forward line of own troops) and support engagements. The other two scenarios contain TACAIR in close support of engaged forces and in cross-FLOT operations. In each case, ground combat is being conducted by opposing forces, although it is reduced to artillery duels only in the TACAIR scenarios. All scenarios are listed below with the TACAIR scenarios in bold type.

- Red attack - Blue prepared defense
- Red attack - Blue hasty defense
- Red attack - Blue delay
- Blue attack - Red prepared defense
- Blue attack - Red hasty defense
- Defense light (Blue vs Red)
- TACAIR (Blue vs Red)**

Red attack - Green prepared defense
 Red attack - Green hasty defense
 Red attack - Green delay
 Green attack - Red prepared defense
 Green attack - Red hasty defense
 Defense light (Green vs Red)
 TACAIR (Green vs Red)

DMZ defense (Red attacking Green prepared positions on the demilitarized zone (DMZ))

b. The results of these scenarios are analyzed against the various measures of effectiveness (MOE) and essential elements of analysis (EEA) for accuracy. The study MOE and EEA are listed and explained in paragraph 1-8.

c. The final study step is to take combat sample output data and run that data through the CTI to place it in a format that is compatible for use in TACWAR.

1-8. ESSENTIAL ELEMENTS OF ANALYSIS (EEA) AND ANSWERS. Several EEAs were selected and approved for use in this study. These EEAs are listed below with their corresponding answers.

a. **EEA 1. Do the forces follow sound doctrinal principles?** Each phase of the study is doctrinally sound for:

- | | |
|------------------------------|--|
| (1) Combined arms operations | (4) Unit employment |
| (2) Unit mission | (5) Weapon employment |
| (3) Unit organization | (6) Attacking and defending force ratios |

b. **EEA 2. Do the samples make sense from a tactical point of view?** Analysis of tactical deployments and movements is based on a historical search and comparison of previously completed and approved studies. Tactical units in this study show similar initial deployment and movement to historical samples. There is a slight variation in the initial inventories for all forces; this is due to the differing study timeframes. The combat results of these scenarios are checked against the historical data also compiled from previous studies. The output data are used to calculate the system exchange ratio (SER), the fractional exchange ratio (FER), and the loss exchange ratio (LER). Comparing these values to historical data provides an excellent check for study consistency. In each case, the determined SERs, FERs, and LERs are consistent with historical trends set by previous studies.

c. **EEA 3. Are there appropriate and significant system interactions within the combat samples?**

(1) Several separate steps are taken to ensure appropriate and significant system interactions within the replicated postures. Inspection of the killer/victim matrix provides an indication of how well the weapon systems are interacting. If all systems interact with all those systems with which they were expected to interact, then the posture is acceptable in terms of appropriate interactions. If there are sparse interactions, say between two opposing tanks, then further investigation is conducted to discover the cause of the lack of interactions. Once the cause of the sparse interactions is identified and corrected, the posture is rerun and the

killer/victim matrix regenerated for inspection. This procedure is repeated until all expected interactions occur. In the final simulations, all interactions occurred as planned.

(2) Following a check for sparse interactions, a series of common sense "truth traps" are applied to the calibrated output. These "truth traps" are based on historical precedent and common sense. For example, it is expected that the M1A1 tank will have a better operational capability than the older M48A5. Each posture was reviewed for compliance with the "truth traps," and all passed the common sense portion of the test.

1-9. OTHER KEY FINDINGS. There are no additional key findings in this study.

1-10. ENVIRONMENTAL/THREAT GUIDANCE. All environmental and threat guidance is provided and checked by members of the CFC Operations Analysis Center. Such guidance is outlined in the Study Directive (Appendix B) signed by MG Silvasy, dated 14 January 1992.

1-11. CONSTRAINTS. This study includes constraints on the timeframe of the study (near-term 1993) and on the types of equipment and munitions used. All constraints are dictated by the sponsor in either the initial study directive or follow-on conversations. These constraints include such requirements as types of weapon systems used, ammunitions employed, and density of units and equipment.

CHAPTER 2

INTRODUCTION

2-1. BACKGROUND. The initial phases of this study date to Operation DESERT STORM requirements and the need to produce accurate and auditable operational probability of kill, operational rates of fire, and allocation of fires for CENTCOM's weapon systems in their campaign analysis. CENTCOM provided several personnel to do the initial research in data requirements and the feasibility of using the combat sample process as the source for that data. The CENTCOM representatives teamed up with CAA personnel to produce data and interface support for use in Operation DESERT STORM analysis. Various studies, conducted after Operation DESERT STORM, concluded that a feeder model is necessary to produce the three inputs listed above. Recognizing the need for a reliable and auditable source for these inputs, the Combined Forces Command requested that CAA conduct a study to produce the operational probability of kill, operational rate of fire, and engagement rate factors for a conflict in the Military Regional Conflict-West (MRC-W) theater.

2-2. OBJECTIVE. There are two objectives for this study. The first is to develop combat samples that provide, as a minimum, the operational probability of kill, operational rate of fire, and allocation of fires of theater weapon systems, in all desired tactical scenarios, for use in TACWAR. The second objective is to ensure that the required data audit trail is developed to support the use of this data in TACWAR.

2-3. THE COMBAT SAMPLE GENERATOR (COSAGE) AND THE TACTICAL WARFARE MODEL (TACWAR)

a. What is COSAGE? COSAGE is a two-sided, symmetrical, high-resolution, stochastic combat simulation. It models ground-to-ground, ground-to-air, and air-to-ground combat. This tool develops shooter/target interactions and final killer/victim matrices on which the Attrition Calibration (ATCAL) parameters are based.

(1) Purpose. COSAGE is used at CAA as the feeder model for all theater analysis. In this study, it is used similarly to feed the theater simulation, TACWAR, by developing the three factors necessary as operational inputs. By using COSAGE and the associated audit trail, TACWAR is able to receive auditable input factors for the operational probability of kill, operational rates of fire, and allocation of fires.

(2) Attrition Calibration Methodology. ATCAL is an iterative mathematical algorithm which develops steady state attrition statistics and ammunition expenditures for forces differing in number and composition from a calibrated base combat sample.

b. What is TACWAR? TACWAR is a deterministic, theater-level combat simulation that examines the interaction of strategic and tactical forces in a conventional, nuclear, and/or chemical environment. TACWAR is a noninteractive, two-sided model, primarily resolved to corps, although smaller units can be modeled.

(1) **Purpose.** In this study, TACWAR is used as the final modeling tool by the Combined Forces Command. TACWAR takes the operational input data derived from COSAGE and uses those inputs to drive the TACWAR scenarios.

(2) **Antipotential Potential (APP) Methodology.** The methodology used in TACWAR to determine the weapon system value is APP. A friendly weapon system's value is dependent on the rate at which that system kills enemy systems on the battlefield and on the value of those systems. To determine an opposing enemy weapon system's value, the same method must be employed. Therefore, the APP system is circular in its determination of these values, since each value is determined from the value of the systems it kills.

c. **COSAGE-TACWAR Interface.** Raw combat sample data requires some transformation for successful implementation within TACWAR. To solve this problem, CENTCOM developed the CTI. The CTI acts as a initial preprocessor of raw COSAGE output. CTI employs COSAGE output data and collects the probability of kill data, rate of fire, and weapon fire allocations and places this data into a TACWAR-readable file. These new files are then used as TACWAR input files, generating starting data for each scenario.

CHAPTER 3

EXECUTING THE STUDY

3-1. STUDY APPROACH/METHODOLOGY

a. **Introduction.** The study approach and methodology used in this study can be broken out into four distinct areas. The first area, force development, provided the development of the representative force structures and weapon mixes. Once the representative forces are developed, then these forces are arrayed in specifically designed scenarios. These scenarios are then executed using the Combat Sample Generator, and the results are analyzed and cataloged for the audit trail.

b. Force Development

(1) Unit organizations and force strengths are derived from templated organizations developed for this theater of operations and participants involved. These templates are derived from the previously Army approved Integrated Army Mobilization Study (IAMS-II) Korean theater (MRC-W) force structure.

(2) Development of the initial force structure design and organization for all participants in this study is accomplished using the IAMS-II force structure as a template. These templates provided the basic division size and structure for each force within the simulation. The initial template is corrected to reflect the specific forces and timeframe requested. The study sponsor approved all force structures used in TAC LINK. The final base case inventories (templates) are described in paragraph 3-2.

c. Scenario Formulation

(1) All sponsor-requested scenarios were developed and used except for the requested Blue attack - Red delay. This scenario was dropped from the requirement after discussions between the sponsor and CAA threat experts. These discussions determined that the threat forces do not conduct delay operations in the same sense that US forces do. Rather, they would immediately enter into a hasty defensive posture. This posture is continued until they are able to successfully disengage and move out of the engagement area.

(2) All Air Force air-to-ground engagements took place in the TACAIR scenarios. Separation of the air-to-ground postures from the ground postures allowed for the accurate accumulation of air versus ground data. Helicopters were not separated out from the ground versus ground scenarios.

(3) This study requires the use of 15 specific scenarios to properly and accurately simulate all of the scenarios requested by the study sponsor. The templated force structures are updated to represent current United States Army force structure (scheduled for deployment to the Republic of Korea), current Republic of Korea force structure, and current North Korean force structure. The force structures are then combined into specific scenarios or postures. The study sponsor requested specific organizations and unit representations within the scenarios. These specifics require the removal of TACAIR from all the posture force structures

except the specialized TACAIR-only scenario. The following scenarios (Table 3-1) are the result of the development process (where Blue represents US forces, Green represents South Korean forces, and Red represents North Korean forces):

Table 3-1. Scenario Force Ratios

Scenario description	Force ratio
Red attack - Blue prepared defense	3:1
Red attack - Blue hasty defense	3:1
Red attack - Blue delay	5:1
Blue attack - Red prepared defense	3:1
Blue attack - Red hasty defense	3:1
Defense light (Blue vs Red)	1:1
TACAIR (Blue vs Red)	1:1
Red attack - Green prepared defense	3:1
Red attack - Green hasty defense	3:1
Red attack - Green delay	5:1
Green attack - Red prepared defense	3:1
Green attack - Red hasty defense	3:1
Defense light (Green vs Red)	1:1
TACAIR (Green vs Red)	1:1
DMZ defense (Red attacking Green prepared positions on the DMZ)	5:1

(4) The scenarios are defined as:

(a) Red attack - Blue prepared defense: Red forces attacking a Blue force in a prepared defensive position with prepared alternate and secondary positions. Red forces attack with a force ratio advantage of 3:1. TACAIR was not played in this scenario.

(b) Red attack - Blue hasty defense: Red forces attacking Blue forces in hastily prepared defensive positions. Red forces attack with a force ratio of about 3:1. TACAIR was not played in this scenario.

(c) Red attack - Blue delay: Red forces attack Blue forces conducting a delaying action. Red forces attack with a force ratio of about 5:1. TACAIR was not played in this scenario.

(d) Blue Attack - Red prepared defense: Blue forces attacking a Red force in a prepared defensive position with prepared alternate and secondary positions. Blue forces attack with a doctrinal force ratio advantage of 3:1. TACAIR was not played in this scenario.

(e) Blue attack - Red hasty defense: Blue forces attacking Red forces in hastily prepared defensive positions. Blue forces attack with a force ratio of about 3:1. TACAIR was not played in this scenario.

(f) Defense Light (Blue vs Red): this scenario is fought to determine the results of conflict that is started when the opposing forces approximately equal each other in size. The battle is initiated with preplanned artillery fires and rear area helicopter missions. Force ratios in this scenario are about 1:1. TACAIR was not played in this scenario.

(g) TACAIR (Blue vs Red): this scenario is the only scenario (Blue vs Red) fought with TACAIR. The defense light scenario is used but with a large number of preplanned TACAIR support missions. The result of this scenario is that there is very little ground-on-ground combat, but mostly air-to-ground combat and some artillery fires. The data from this scenario is used in the TACWAR air module. Ground forces in this scenario remain at a force ratio of 1:1, while the air forces of both sides accurately reflect the anticipated numbers combat aircraft operating in a close air support role.

(h) Red attack - Green prepared defense: Red forces attacking a Green force in a prepared defensive position with prepared alternate and secondary positions. Red forces attack with a force ratio advantage of 3:1. TACAIR was not played in this scenario.

(i) Red attack - Green hasty defense: Red forces attacking Green forces in hastily prepared defensive positions. Red forces attack with a force ratio of about 3:1. TACAIR was not played in this scenario.

(j) Red attack - Green delay: Red forces attack Blue's forces conducting a delaying action. Red forces attack with a force ratio of about 5:1. TACAIR was not played in this scenario.

(k) Green attack - Red prepared defense: Green forces attacking a Red force in a prepared defensive position with prepared alternate and secondary positions. Green forces attack with a force ratio advantage of 3:1. TACAIR was not played in this scenario.

(l) Green attack - Red hasty defense: Green forces attacking Red forces in hastily prepared defensive positions. Green forces attack with a force ratio of about 3:1. TACAIR was not played in this scenario.

(m) Defense light (Green vs Red): this scenario is fought to determine the results of conflict that is started when the opposing forces approximately equal each other in size. The battle is initiated with preplanned artillery fires and rear area helicopter missions. Force ratios in this scenario are about 1:1. TACAIR was not played in this scenario.

(n) TACAIR (Green vs Red): this scenario is the only scenario (Green vs Red) fought with TACAIR. The defense light scenario is used but with a large number of preplanned TACAIR support missions. The result of this scenario is that there is very little ground-on-ground combat, but mostly air-to-ground combat and some artillery fires. The data from this scenario is used in the TACWAR air module. Ground forces in this scenario remain at a force ratio of 1:1, while the air forces of both sides accurately reflect the anticipated numbers combat aircraft operating in a close air support role.

(o) DMZ defense (Red attacking Green prepared positions on the DMZ): the DMZ defense scenario is a specially designed scenario that takes the DMZ defenses and other tactical considerations into account. This scenario is only run for Red attacking Green; this is based on the expectations that the Red forces will attack forward-deployed Green forces prior to attacking Blue forces. The force ratio of Red to Green forces is about 5:1. TACAIR was not played in this scenario.

d. Executing COSAGE. Each of the above-listed scenarios is replicated a minimum of 8 times to a maximum of 16 times to ensure statistical validity (see Table 3-2). The resulting data from these replications is then postprocessed into a manageable form from which the analysis then takes place. Details of the postprocessing and analysis are contained in Chapter 4 of this report.

Table 3-2. Scenario Replications

Scenario description	Replications
Red attack - Blue prepared defense	16
Red attack - Blue hasty defense	16
Red attack - Blue delay	16
Blue attack - Red prepared defense	14
Blue attack - Red hasty defense	16
Defense light (Blue vs Red)	10
TACAIR (Blue vs Red)	10
Red attack - Green prepared defense	8
Red attack - Green hasty defense	8
Red attack - Green delay	8
Green attack - Red prepared defense	8
Green attack - Red hasty defense	8
Defense light (Green vs Red)	8
TACAIR (Green vs Red)	10
DMZ defense (Red attacking Green prepared positions on the DMZ)	10

e. Data Audit Trail. Throughout the study process, one of the main objectives is to provide to CFC a data package that is completely auditable. The data provided by the combat sample process fulfills this requirement; it is completely auditable to its originating source. For example, any of the operational probabilities of kill (PK) provided as input data for TACWAR can be traced back to its original hardstand single shot probability of kill provided to CAA by AMSAA. Figure 3-1 demonstrates how the audit trail works. In this example, only one of the many inputs is considered. The starting point is the TACWAR input which is traced to the COSAGE-TACWAR interface. The input to the CTI is the output from the Combat Sample Generator. This is the stage of the process in which the static single shot probability of kill (SSPK) is converted into the operational probability of kill necessary for TACWAR. Continuing the audit trail leads to AMSAA as the provider of the SSPK; this is the result of their hardstand testing of the weapon and ammunition. All equipment data is traceable to the program managers or to the Training and Doctrine Command (TRADOC) responsible school. Doctrinal issues are traceable to specific field manuals or to doctrinal theory evolving from TRADOC.

3-2. EQUIPMENT INVENTORIES

a. Templated Divisions. As noted in paragraph 3-1(c), the unit equipment and force laydowns are developed from the templated division forces developed and approved for use in the IAMS-II Study. The actual TAC LINK base case equipment inventories are contained in Appendix E.

b. Changes to Templated Divisions

(1) Inventories of the existing theater forces were provided by the study sponsor for use in this study. The desired timeframe required changes to the original templated division inventories (derived from the IAMS-II Study). Most of the changes involved the removal of projected equipment from the template and the replacement of that equipment with an existing or currently fielded weapon system. An example of these changes is the removal of the proposed South Korean 120mm tank and its replacement with additional, currently fielded, South Korean 105mm and 90mm (M48A3 and M48A5 series) tanks. The result is an increase in the number of total South Korean tanks on the battlefield but a less capable tank force. The less potent force structure in turn affects how the unit fights in the simulation, and the results of the simulation change to reflect the new force structure. The study sponsor was briefed on these changes (see Table 3-3) and approved them as stated.

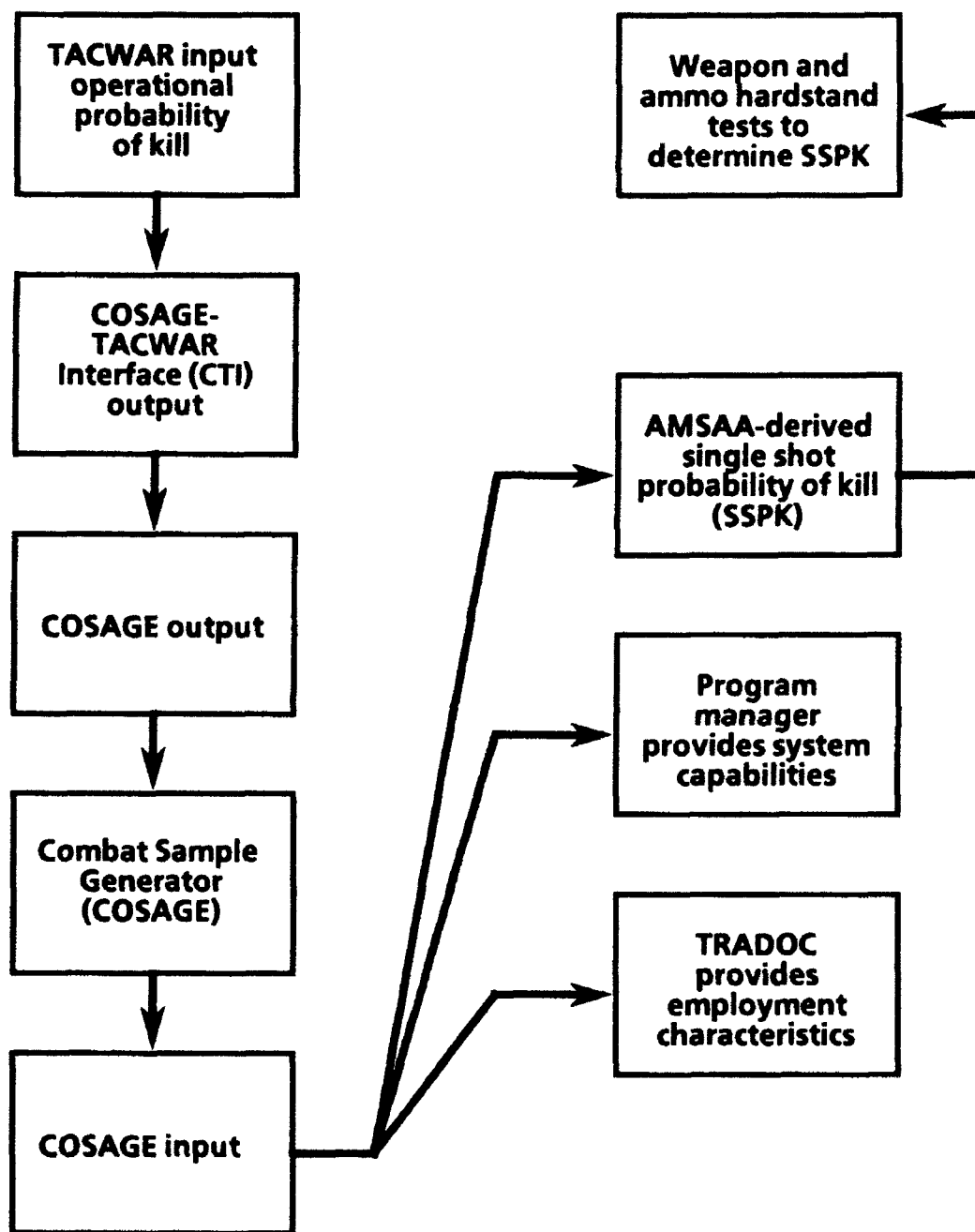


Figure 3-1. Audit Trail

(2) A second type of change involves systems on which current probability of kill data is unavailable. These systems are replaced with systems that closely replicate the characteristics and capabilities of the former system. In each case, the changes are verified and approved by the study sponsor. Table 3-3 shows the weapon system and its replacement system. Both of these replacements are due to a lack of accurate and effective probabilities of kills against all potential opponent weapon systems. The final product of these changes is contained in Appendix E of this study. The inventories in Appendix E represent the base case from which the scenario-specific force ratios are developed.

Table 3-3. Weapon Systems Replacements

System	Replacement system
ROK 57mm recoilless rifle	ROK 90mm recoilless rifle
nK T63 light tank	nK PT76 reconnaissance vehicle

c. **Inventories.** Every effort is made to ensure the accuracy of the equipment inventories. The study sponsor provided an initial aggregate inventory of weapon systems located in the theater of operations. Using this list and the approved weapon substitutions, an operational base case of weapon systems and munition types was developed. Actual sponsor-provided inventories were used whenever possible; there were occasions when changes to the inventory were made to ensure that a statistically valid number of direct fire ground weapons existed for each system category. Two methods are used to adjust the number of systems to a statistically correct amount. These are: increasing the number of weapons in a particular category by increasing the number of units in which that weapon can be found (increasing the number of weapons by increasing the number of units allows for the continued accurate employment of the system), or by combining (or rolling up) the statistically insignificant weapon into another system of similar characteristics and manner of employment. Before either method was selected, the study sponsor provided input as to the best choice and approved the final selection. Table 3-4 contains the systems that were rolled up or increased in number. Helicopters, tactical air (TACAIR), and indirect fire systems are not subject to the same statistical requirements. These systems can be played in any number.

Table 3-4. Inventory Adjustments

Force	Weapon type	Action taken
Blue	M1	Initial inventories did not contain any M1 tanks--the study sponsor requested that the M1 be represented on a par with the M1A1. The number of M1s was increased to 64
Green	175mm SP artillery	Rolled into the 203mm SP inventory
	M47/M47A2/M48A3	Rolled into the M48A5 inventory
	57MM Recoilless rifle (RR)	Rolled into the 90mm RR inventory
Red	T63 Light tank	Replaced by the PT76 reconnaissance vehicle
	152mm SP gun	Rolled into the 152mm SP howitzer

3-3. COSAGE-TACWAR INTERFACE

a. The CTI is designed to place raw COSAGE output into a format that is TACWAR-usable and man-readable. CENTCOM development of this postprocessor occurred during Operations DESERT SHIELD/STORM. The intent is to assist CENTCOM in using combat sample data in their version of TACWAR. This particular program is currently undergoing an experimental analysis to determine the accuracy of its transformation. CENTCOM and CAA have signed a Memorandum of Agreement to explore the capabilities of the CTI and then compare the resulting information against other alternatives. Other alternatives include using TACWAR with ATCAL instead of the APP methodology, or using the original TACWAR methodology. This study is currently ongoing, and its completion is not expected until after this study is published. CENTCOM is the study executor and the point of contact for future inquiries.

b. Output from the TAC LINK simulation was run through the original CENTCOM CTI prior to delivery to CFC. The resulting data provided a few operational probabilities of kill and rates of fire that seem to be significantly smaller than that normally used in TACWAR. This raises the possibility that TACWAR may not be able to effectively use some of the new inputs due to their small size. This phenomenon requires further study by both CAA and CFC.

c. The CTI output is organized into two separate matrices, as designated by CFC, for input into TACWAR. These matrices group the various weapon systems into specific categories of similar weapon systems and provide the necessary format that allows TACWAR to read the operational probability of kill figures for each potential posture. These matrices are shown in Tables 3-5 and 3-6.

Table 3-5. TACWAR Weapon Matrix (11 x 10)

Number	Blue/Green type number	Number	Red type
1	Tank	1	Tank
2	APC	2	APC
3	Small arms	3	Small arms
4	AT-1 (LAW, MAW)	4	AT-1
5	AT-2 (HAW, TOW)	5	AT-2
6	Mortars	6	Mortars
7	Artillery	7	Med cal ARTY
8	Helicopter	8	Hvy cal ARTY
9	AAA	9	AAA
10	SAM	10	SAM
11	MLRS		

Table 3-6. TACWAR Weapon Matrix (23 x 12)

Number	Blue/Green type number	Number	Red type
1	APC	1	APC
2	IFV	2	BMP
3	Tank	3	Tank
4	AT-1	4	AT-1
5	AT-2	5	AT-2
6	Mortars	6	Mortars
7	Artillery	7	Artillery
8	Small arms	8	Small arms
9	Helicopters	9	Helicopters
10	MLRS	10	MRL
11	AAA	11	AAA
12	SAM	12	SAM
13	ROK APC		
14	ROK IFV		
15	ROK tank		
16	ROK AT		
17	ROK mortars		
18	ROK artillery		
19	ROK small arms		
20	ROK helicopters		
21	ROK MLRS		
22	ROK AAA		
23	ROK SAM		

CHAPTER 4

ANALYSIS

4-1. INTRODUCTION

a. All postcombat sample process analyses are used to meet internal CAA quality requirements for each scenario. These scenarios are postprocessed using a wide assortment of analysis tools and techniques. The results are compared against the measures of effectiveness and essential elements of analysis listed below. These checks satisfy both tactical and operational considerations. Analysis of how the COSAGE-TACWAR Interface output interacts within TACWAR was not conducted during the course of this study. Therefore, one is unable to predict the acceptability of TACWAR output when using combat sample process operational probability of kill, operational rates of fire, and weapon system allocation of fires as TACWAR inputs.

b. Analysis of the COSAGE output is conducted against a series of approved essential elements of analysis and measures of effectiveness. Analysis guidelines are developed by CAA with input from the sponsor. They are approved for use by the sponsor prior to the beginning of the study. TAC LINK uses three essential elements of analysis to evaluate the combat sample process output.

4-2. ESSENTIAL ELEMENTS OF ANALYSIS (EEA)

- a. EEA 1. Do the forces follow sound doctrinal principles?
- b. EEA 2. Do the samples make sense from a tactical point of view?
- c. EEA 3. Are there appropriate and significant system interactions within the combat samples?

4-3. MEASURES OF EFFECTIVENESS (MOE)

- a. EEA 1. Do the forces follow sound doctrinal principles?

(1) MOE for EEA 1

- (a) Tactical force movement.
- (b) Attacking and defending force ratios.
- (c) Conduct combined arms operations.
- (d) Force numbers and missions.

- b. EEA 2. Do the samples make sense from a tactical point of view?

(1) MOE for EEA 2

- (a) Determine and analyze the system exchange ratio, fractional exchange ratio, and loss exchange ratio for all combatants in each posture.

(b) Test for consistent and reasonable results by comparing results to past MRC-W studies.

c. EEA 3. Are there appropriate and significant system interactions within the combat samples?

(1) MOE for EEA 3

(a) Killer/victim matrix sparse interactions.

(b) Standard "truth traps."

All major systems interact with each other.

No killing system invulnerable.

Artillery expenditures > 20 and < 200 rounds/tube/day.

Tank expenditures > 3 and < 15 rounds/tank/day.

Tank antitank rounds/kill > 2 and < 15 .

Fraction lost of major systems roughly equal on both sides.

Fraction lost of major system < 40 percent in 24 hours.

Exchange ratios of like systems in logical order.

TACAIR attrition < 10 percent per sortie.

Exchange ratio for attack helicopters is > 3 and < 20 .

Smart munition rounds/kill < 4 .

Median range of engagement for tanks and AFVs < 2000 meters.

4-4. ANALYSIS OF EEA AND MOE

a. This paragraph discusses the analysis conducted on each EEA and their subsequent MOEs. Some of the EEA and MOE are easily addressable using numerical analysis. These include such MOE as force ratios, system exchange ratios, and some of the truth traps. Other MOEs are not so easily addressed and in fact require a degree of subjective military analysis rather than pure numerical analysis. Such MOE include the demonstration of tactical force movement and analysis of combined arms operations. Below are the specific EEA and MOE followed by a discussion of the steps taken to analyze each of them.

b. EEA 1. Do the forces follow sound doctrinal principles? Doctrinal principles for US forces are drawn from standard field manuals such as FM 100-5, Operations, dated May 198C. These manuals accurately describe the proper functioning of specific units and organizations when engaged in combat on the modern battlefield. Other manuals used are shown in Appendix C.

(1) MOEs for EEA 1

(a) **Tactical Force Movement.** Tactical force movement at unit level is determined by specific orders issued to each individual unit. These orders are devised to ensure that each unit moves in the manner that is appropriate to the mission and terrain. The movement of each unit is orchestrated to ensure command cohesion, at every level of command. This MOE ensures that the tactical movement of each unit meets doctrinal tenets as outlined in the appropriate field manuals (see Appendix C). Successively higher level units, such as division, brigade, or battalion, are designed to support and coordinate the operations of the smaller units (for example, company and platoon). The Blue and Green forces operate at platoon level in the scenario, while the Red forces operate at company level. The Blue and Green platoons and Red

companies are assigned orders with tactical objectives and detailed movement orders. Tactical movement of each unit is checked against the order sets developed for the unit and adjusted as necessary to ensure the units operate in a synchronized manner with the divisional objectives as the end result. All units found in each of the scenarios demonstrate the desired tactical movement.

(b) Attacking and Defending Force Ratios. Attacking and defending force ratios (Table 3-1, Chapter 3) are significant in the determination of which side has the ability to attack and at what level the opponent will resist. These ratios are determined prior to the actual running of the simulation. In each case, the force ratio of each scenario is determined during the development of the force laydown phase and provides the starting force ratios for each scenario. These ratios concentrate on, but are not limited to, the primary combat systems.

(c) Conduct Combined Arms Operations

1. Combined arms operations, for each of the different scenarios, are analyzed against existing documentation that outlines how units fight when fighting as a combined arms force. The two primary sources of documentation are Field Manuals 100-5, Operations, and 100-15, Corps Operations. These two manuals offer a good starting point for understanding and implementing the conceptual aspect of combined arms operations. Supplementing these manuals is the 71 series of field manuals which provides important employment techniques and operational data for combined arms teams and task forces. A full listing of referenced manuals is provided in Appendix C.

2. Analysis of combined arms operations concentrates on how specific units operate both individually and as part of a larger unit. Examples of combined arms operations include the use of company teams and battalion task forces using mixes of tanks and infantry fighting vehicles, cross-FLOT operations using attack helicopters, preplanned battlefield air interdiction (BAI), and the use of artillery preparatory fires in support of ground operations and SEAD (suppression of enemy air defense) operations. These operations are planned to occur independently, but support the larger divisional plan. In every case, simulated combat units performed in accordance with the tenets of AirLand battle--agility, initiative, depth, and synchronization.

(d) Force Numbers and Missions. This portion of the analysis concentrates on the specific units analyzed during the analysis of combined arms operations. In this phase of analysis, each unit is displayed at various times of the simulation. Visual displays of each unit provide an easy method of checking to ensure that each unit is performing in a manner consistent with their orders and missions. Again, the simulated units performed as expected.

c. EEA 2. Do the samples make sense from a tactical point of view? This EEA requires the analysis of exchange ratios of specific weapon systems. Another portion of the analysis for this EEA is checking for consistent and reasonable study results when compared to past studies of the same theater during the same timeframe.

(1) MOE for EEA 2

(a) For each posture, determine and analyze the SER, the FER, and the LER. Analysis of tactical deployments and movements is based on a comparison of historical data of previous studies. Combat sample output data is used to calculate the SER, the FER, and the LER for each scenario. (Exchange ratio formulas, explanations, and sample calculations (by scenario) are located in Appendix F.) The SER, FER, and LER for each major system parallel values determined in ROKMOD and IAMS-II. For example, Table 4-1 shows a comparison of ROKMOD, IAMS-II, and TAC LINK SER, LER, and FER. All formulas use selected major ground and air systems in their computations. These major ground and air system categories are listed in Table 4-2, all other systems are considered (for this analytical tool) to be nonmajor systems. Comparing these values to historical data provides an excellent check for study consistency. In each case, the determined SERs, FERs, and LERs are consistent with historical trends set by previous studies. The scenarios represented in Appendix F are the Red attack/Blue prepared defense and Red attack/Green prepared defense. Differences in SER/FER/LER computations are expected due to differing equipment densities, weapon systems, and their interactions.

**Table 4-1. SER/FER/LER Comparison
(Red attack - Blue prepared defense posture)**

Ratio	Equip	TAC LINK	ROKMOD	IAMS-II
SER				
	Tank	3.76	3.33	3.43
	Antitank	2.28	1.81	1.78
	Artillery	4.29	4.86	3.09
FER		1.58	1.87	1.51
LER		4.75	5.00	4.53

Table 4-2. Ground and Air Systems

Major ground systems	Major air systems
Armor	TACAIR
Antitank	
Artillery	
Helicopter	

(b) **Test for Consistent and Reasonable Results.** Compare results to past MRC-W studies. This MOE requires the effective combining of several other MOEs to ensure the overall success of the study when compared to previously approved studies. Areas that are compared include the following:

1. Initial starting inventories and force laydown for each scenario.
2. Final SER, LER, and FER figures for each scenario.
3. Operational probability of kill figures by vehicle and weapon system.
4. Operational rate of fire of each weapon system.

In the case of this study, TAC LINK, comparisons against IAMS-II and ROKMOD showed the TAC LINK results to be consistent with past study results. Table 4-3 shows the starting (base case) inventories of the major ground systems (identified in Table 4-2) for TAC LINK, ROKMOD, and IAMS-II. Variations within the starting inventories can be attributed to the study timeframes. ROKMOD and IAMS-II are both outyear studies (2000 and 1999, respectively) while TAC LINK is a current year (1993) study. The forces for ROKMOD and IAMS-II are, at best, estimations of what the force will look like, whereas the TAC LINK inventory is drawn from existing inventory data, supplied by the study sponsor. Table 4-4 shows a comparison of operational probability of kill and operational rates of fire for selected weapon systems. The data displayed in this table is drawn from the Red attack - Blue prepared defense scenario but is indicative of all the scenarios. Complete operational PKs and rates of engagement are available in Appendix D.

Table 4-3. Major System Base Case Inventories

System	TAC LINK	ROKMOD	IAMS-II
Tank	142	168	168
Antitank	228	228	228
Artillery	139	182	182
Helicopter	72	173	132

**Table 4-4. Selected Operational PKs and Rates of Fire/12 Hours
(Red attack - Blue prepared defense)**

Shooter	Target	Operational PK			Operational rate of fire/ 12 hours		
		TAC LINK	ROKMOD	IAMS-II	TAC LINK	ROKMOD	IAMS-II
M1A1 (US)	T62 (nK)	.191	.228	.190	40.83	37.53	38.55
M1 (US)	T62 (nK)	.178	.186	.200	33.48	25.81	29.73
IFV (US)	T62 (nK)	.412	.400	.408	10.58	11.04	7.29
ITV (US)	T62 (nK)	.475	.419	.552	15.48	16.37	17.47
T62 (nK)	M1A1 (US)	.061	.080	.084	15.48	16.37	17.47
T62 (nK)	M1 (US)	.069	.060	.045	--	--	--
T62 (nK)	IFV (US)	.052	.059	.044	--	--	--

d. EEA 3. Are there appropriate and significant system interactions within the combat samples? This EEA requires the use of another combat sample postprocess, the killer/victim matrix, and the application of a series of significant historical data points, called "truth traps." These MOE are applied to each scenario favorable results.

(1) MOE for EEA 3

(a) Killer/Victim Matrix for Sparse Interactions. Interactions within the combat sample process are checked by using a postprocessed killer/victim matrix. This matrix shows all of the engagements that occurred within the simulation. These engagements are shown as kills against a specific victim. The objective of the matrix is to ensure that there are appropriate and significant interactions between weapon systems that are expected to engage each other. For example, US M1 tanks are expected to engage North Korean T62 tanks. To ensure that there are appropriate and significant interactions between these two weapons systems, one has only to look at the killer/victim matrix to see that these interactions took place and in what quantity. The matrix shows the number of M1s (victim) killed by T62s (killer) and the number of T62s (victim) killed by M1s (killer). An example of two weapon systems that are not expected to engaged on the battlefield are the US STINGER anti-aircraft missile and the North Korean 152mm towed artillery piece. In the case of these two systems, a sparse killer/victim matrix is expected. All scenarios show appropriate and significant interactions within the combat sample process.

(b) Standard "Truth Traps." These truth traps (Table 4-5) are the result of many years of producing combat samples and tracking the results of these samples. These are standards that provide guidance to ensure the combat sample process does not have any incorrect inputs or invulnerable systems. Each of these truth traps is compared against each scenario's postprocessed output. Results from each scenario successfully meet each of these checks. The only area that poses some concern is the

exchange ratio of attack helicopters. The US attack helicopter exchange ratios are slightly higher than the 20:1 (helicopter kills to helicopters killed) ratio used as a guideline. Further investigation revealed the cause of this is the lack of a sophisticated anti-aircraft missile system within the North Korean inventory. The North Korean anti-aircraft inventory is made up of anti-aircraft guns and cannons. They do not have any short-range, hand-held, ground-to-air missiles for use against US helicopters. The result of this is a slightly higher US helicopter exchange ratio of about 24:1.

Table 4-5. COSAGE Truth Traps

"TRUTH TRAPS"

All major systems interact with each other.
 No killing system invulnerable.
 Artillery expenditures > 20 and < 200 rounds/tube/day.
 Tank expenditures > 3 and < 15 rounds/tank/day.
 Tank anti-tank rounds/kill > 2 and < 15.
 Fraction lost of major systems roughly equal on both sides.
 Fraction lost of major system < 40% in 24 hours.
 Exchange ratios of like systems in logical order.
 TACAIR attrition < 10% per sortie.
 Exchange ratio of attack helicopters is > 3 and < 20.
 Smart munition rounds/kill < 4.
 Median range of engagement for tanks and AFVs < 2,000 meters.

4-5. ANALYSIS OF THE COSAGE-TACWAR INTERFACE OUTPUT.

Analysis of this data is extremely difficult due to the limited historical data available for comparison. The data is checked to ensure that the CTI program produced the required TACWAR inputs in a format that is acceptable. Functional testing of the final TACWAR input data should be accomplished by the study sponsor or as a follow-on study.

CHAPTER 5

SUMMARY AND OBSERVATIONS

5-1. OBSERVATIONS. The process of producing the operational probability of kill, the operational rate of fire, and the allocation of fires for each weapon system is straightforward. The degree of success achieved by this data when used as inputs for TACWAR remains to be seen. Past experience with combat samples developed for CENTCOM indicate that TACWAR will continue to function properly while using the combat samples as input. However, there may be some output which requires further investigation. The effect of combat samples in TACWAR is the topic of another study.

5-2. FOLLOW-ON STUDIES

a. A follow-on study to TAC LINK may be required to establish the sensitivity levels of TACWAR to the combat sample input data. It is important to ensure this study does not duplicate the ongoing CENTCOM-CAA TACWAR Study, but rather fills in any gaps remaining from that study. The CENTCOM-CAA study, as previously noted, is analyzing various versions of TACWAR while using different methodologies and data sources. Three TACWAR model-data cases are to be evaluated. These are:

- (1) TACWAR/APP using the existing CENTCOM data as inputs.
- (2) TACWAR/APP using combat sample data as inputs.
- (3) TACWAR/ATCAL using combat samples as inputs.

b. Additional follow-on studies to provide combat sample data for other TACWAR studies is expected. These studies will continue to build on the fundamental structure laid down by TAC LINK and the Operations DESERT SHIELD/STORM studies.

APPENDIX A

STUDY CONTRIBUTORS

1. STUDY TEAM

a. Study Director

CPT(P) Robert S. Elias, Force Evaluation Directorate

b. Team Members

Mr. Neal Siegel

c. Other Contributors

Mr. Ron Bonniwell
Mr. Richard Cobb
Mr. Hugh Jones
Mr. John Tucker
LTC Claude Woolard

2. PRODUCT REVIEW BOARD

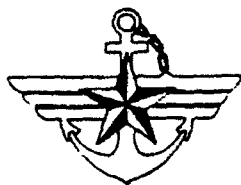
Mr. Ronald Iekel, Chairman
LTC Marshall D. Martin
Mr. Matthew D. Ogorzalek

3. EXTERNAL CONTRIBUTORS

Mr. Michael Alexander, Combined Forces Command, J-3, Analysis Group

APPENDIX B

STUDY DIRECTIVE



HEADQUARTERS
ROK-US COMBINED FORCES COMMAND
한 미 연 합 군 사 령 부
APO SAN FRANCISCO 96301-0028



CFCD

13 January 1992

Van
MEMORANDUM FOR DIRECTOR, U.S. ARMY CONCEPTS ANALYSIS AGENCY,
8120 WOODMONT AVENUE, BETHESDA, MARYLAND 20814

SUBJECT: Development of Combat Samples for TACWAR (TAC LINK)

1. REFERENCES:

a. SSO Message, CFCC, DTG 310500Z Oct 91, subject: Concepts Analysis Agency Analytic Support

b. Message, CSCA-ZA, DTG 051941Z Nov 91, subject: Concepts Analysis Agency Analytic Support

2. PURPOSE. This memorandum establishes objectives and provides guidance for the conduct of the study approved by the references and to be referred to as the TAC LINK study.

3. BACKGROUND. The C-3, SAG, Operations Analysis Center, Combined Forces Command, Korea, has undertaken the task of updating their Tactical Warfare (TACWAR) database for their Northeast Asia scenario. CINCCFC has requested through the Deputy Under Secretary of the Army for Operations Research (DUSA-OR) that CAA provide necessary combat samples to calibrate their TACWAR model.

4. STUDY SPONSOR. Operations Analysis Center, CFC, Korea, through the DUSA-OR. Their points of contact are LTC Monty Anderson and Mr. Michael Alexander, CFCD-ED-SAG-OAC.

5. STUDY AGENCY. U.S. Army Concepts Analysis Agency

6. TERMS OF REFERENCE.

a. Objective. The objective of this study is to produce combat samples to calibrate TACWAR for CFC, Korea.

b. Scope. Develop multiple combat samples for the Korean Theater.

c. Miscellaneous. N A

7. RESPONSIBILITIES.

a. CAA-Force Evaluation Directorate (FE).

CFCB

13 January 1992

SUBJECT: Development of Combat Samples for TACWAR (TAC LINK)

(1) Develop ground-to-ground combat samples to calibrate TACWAR. These combat samples will assist by providing CFC Korea with a data audit trail. The following samples by posture are needed:

Blue Attack Red Hasty Defense
Blue Attack Red Prepared Defense
Red Attack Blue Hasty Defense
Red Attack Blue Prepared Defense
Blue Attack Red Delay
Red Attack Blue Delay
DMZ, Barrier
Static
Generic (no posture)

(2) Develop combat samples on air-to-ground and air-to-air, e.g., CAS attack against blue and red TACWAR weapon systems in both a Hasty Defense posture and a Static Defense posture.

(3) Provide study proponent with progress reports and emerging results.

(4) Provide a final report (SECRET-RELROK), separate appendix (SECRET-NOFORN) with AMSAA/BRL/TRADOC source data, and analysis of items found in paragraph above (TERMS OF REFERENCE).

b. Research and Analysis Directorate (RS). Provide UNISYS time as required to load, exercise, and run COSAGE.

c. Operations Analysis Center, CFC, Korea. Provide all data file support to develop requested combat samples.

8. ADMINISTRATION.

Milestones.

Study Guidance and Study Plan	13 Jan 1992
Initial Analysis Review Board	21 Jan 1992
Data Collection and Research Completed	31 Jan 1992
Initiation of Execution/Analysis	1 Feb 1992
IPR	24 Feb 1992
Final Analysis Review Board	31 Mar 1992
External Review and Report Preparation	30 Apr 1992

Appreciate your help!!

Steve
Stephen Silvasy, Jr.
Major General, US Army
Assistant Chief of Staff C3
140702 Jan 92

APPENDIX C

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FM 71-2, Tank and Mechanized Infantry Battalion Task Force

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COSAGE-TACWAR Interface (CTI), Installation, User, and Program Description Manual, November 1990

Integrated Army Mobilization Study 1999 (IAMS-II), CAA-MR-92-5, April 1992

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APPENDIX D
PROBABILITY OF KILL DATA

Probability of kill data is to be published separately.

APPENDIX E

BASE CASE INVENTORIES

Starting base case inventories for each of the opponents are shown below. This data is derived from the theater inventories supplied by the study sponsor. The theater inventories are used to develop a stylized force. The stylized force represents the assets of the theater in a density that can easily fight the simulated combat necessary to achieve interactions between systems. The inventories shown below include some modifications to ensure a large enough sample for each type of weapon system and the tactical integrity of each unit. These base case inventories represent the defense light scenario. Other scenarios require differing force ratios, and, as a result, the inventories in those scenarios are larger multiples of the defense light base case. For example, the scenario for Red attack versus Blue prepared defense pits three Red base case units against one Blue base case unit. This procedure is repeated for all scenarios and helps to ensure that the proper force ratio is achieved during each scenario.

a. US Force Inventory

Blue equipment	Inventory
M1A1	78
M1	64
IFV	232
CFV	40
ITV	46
HMMWV (TOW)	50
OH-58D	12
OH-58C	36
AH-1	30
AH-1	6
AH-64	30
AH-64	6
A-10	15
F-15	20
F-16	20
F-4D	4
A11	5
STINGER (hand-held)	58
PPS 15	5
VULCAN (SP)	28
M113A1	132
HMMWV	89
M-60 MG	378
Inf troops	1206
SAW	612
M203	685
AT4	507
DRAGON	192
60mm Mortar	18
81mm Mortar	21
107mm Mortar	40
155mm How (T)	32

155mm How (SP)	80
MLRS	27
M577CP	117
FISTV	22
GLLVD	9
FDC vehicle	70
TPQ 37	3
TPQ 36	3
Truck	50

b. South Korean Inventory

Green equipment	Inventory
KM105T	64
KM48	78
KM48A5	52
KIFV with .50 cal. MG	46
Jeep TOW	82
KIFV	158
Jeep with 106RR	50
KH500 helicopter	30
KH500 TOW helicopter	45
KAH1 helicopter	366
REDEYE (hand-held)	58
VULCAN	56
KM113A1	79
90mm RR	50
M60 MG	424
.50 Cal. MG	36
Infantry troops	1206
M203	685
LAW	795
Ground-mounted TOW	46
60mm Mortars	63
81mm Mortars	91
107mm Mortars	30
105mm How	18
155mm SP How	80
155mm Towed How	32
203mm SP How	32
MRL	24
KM577	117
KFDC	70
Mortar troops	624
FA troops	2,141
FA forward observers	114
KTPQ37	3
KTPQ36	3
A10	15
F-5	20
F-16	10
F-4D	15
Trucks	170

c. North Korean Inventory

Red equipment	Inventory
T62	135
PT76	24
BMP1	390
B10	63
ZPU 4A	60
ADA 37mm	18
ADA 57mm	12
APV MG	210
HIP w/ AT3	36
SU24	5
SU25	15
MIG27	5
7.62mm MG	276
Inf troops	2,665
RPG	366
AT3	141
Fwd observer	194
FA troops	2,316
Mortar troops	360
120mm Mortar	45
122mm How	54
122mm How	40
130mm Gun	16
152mm How	48
152mm How	72
203mm Gun	8
107mm MLR	32
122mm MLR	18
Sentry radar	17
SMALL FRED	17
SMALL YAWN	4
BIG FRED	4
Trucks	1,011
Sound detection	2
FDC vehicle	112

APPENDIX F

FORMULAS AND SAMPLE DATA

F-1. FORMULAS. Listed below are the formulas used while conducting the analysis portion of the study.

a. System Exchange Ratio (SER). The system exchange ratio helps to measure the effectiveness of each of the individual weapons systems used in the simulation. The system exchange ratio demonstrates each weapon system compared to other systems that it killed or by which it was killed. SER is calculated both with and without kills of the Blue system by Red air systems when those systems are included in the denominator. The formula is shown below.

$$SER = \frac{\text{Kills of all Red major ground systems by a single Blue system type}}{\text{Kills of that Blue system by all Red systems}}$$

b. Loss Exchange Ratio (LER). The LER provides a measure of how the total force structure of each side performed when compared to its opponent. The LER is calculated both with and without kills of major ground systems by air systems of the opposing side. The formula is shown below.

$$LER = \frac{\text{Kills of all Red major ground systems by all Blue system types}}{\text{Kills of all Blue major ground systems by all Red system types}}$$

c. Fractional Exchange Ratio (FER). The FER measures the relationship between the initial force ratio and the loss exchange ratio. The FER is calculated both with and without kills of major ground systems by enemy air systems. The formula is shown below.

$$FER = \frac{LER}{\text{Initial major ground force ratio}}$$

where the initial major ground force ratio is equal to:

$$\frac{\text{Density of Red major ground systems}}{\text{Density of Blue major ground systems}}$$

F-2. SAMPLE DATA

a. Table F-1 shows sample SER, LER, and FER data derived from a US-nK scenario. This scenario is the Red attack/Blue prepared defense with the North Korean forces attacking a US force in a prepared defense at a force ratio of about 3:1.

Table F-1. Sample Data - US-nK Scenario
(page 1 of 2 pages)

RED SHOOTERS VS BLUE TARGETS

Shooter	Shooter Type	Density	Total Losses	Weapon Type	Average Range (m)	Rnds at all Blue	Rnds at Blue List	Kills of Blue List	SER	Firing Rate /Sys/12 Hrs
T62	TANK	405	253.7	1-115mm 2-MG7.6	1593 500	1522.7 401.7	795.7	38.3	0.15	0.94 0.25
BMP1	ANTTK	1170	580.3	1-73mm 2-MG7.6	938 491	2709.3 882.7	1755.1	55.0	0.09	0.58 0.19
P176	ANTTK	72	33.5	1-76mm	886	56.6	42.5	0.9	0.03	0.20
SU85	ANTTK	126	54.3	1-85mm	636	68.8	16.6	0.5	0.01	0.14
HIPE	HELO	108	48.3	1-AT3 2-12.5mm	3459 2544	227.7 179.1	220.9 15.7	14.1 0.1	0.29	0.53 0.41
122mmSP	ARTY	282	25.7		7612	23347.1	10033.4	19.5	0.76	20.70
152mmSP	ARTY	360	93.7		9706	41927.4	20877.6	55.6	0.59	29.12
130mmSP	ARTY	48	15.7		17342	12808.5	10832.6	4.9	0.31	66.71
107MRL	ARTY	150	12.8		16537	15132.8	13422.9	4.0	0.31	25.22
203mmSP	ARTY	24	6.1		15798	4593.9	3466.2	12.3	2.03	47.85

Table F-1. Sample Data - US-nK Scenario
(page 2 of 2 pages)

BLUE SHOOTERS VS RED TARGETS

Shooter	Shooter Type	Density	Total Losses	Weapon Type	Average Range (m)	Rnds at all Blue	Rnds at Blue List	Kills of Blue List	SER	Firing Rate /Sys/12 Hrs
M1A1	TANK	78	44.4	1-120mm 2-.50 cal	1813 1152	862.8 1691.9	758.6	166.3	3.74	2.77 5.42
M1	TANK	64	30.4	1-105mm 2-.50 cal	1839 1081	631.7 799.1	525.3	94.7	3.12	2.47 3.12
IFV	ANTITK	132	62.8	1-TW2B 2-25mm	1932 1744	422.3 3579.3	354.1 1.5	156.5	2.50	0.80 6.78
ITV	ANTITK	46	29.6	1-TW2B 2-MG7.6	2028 686	177.7 223.7	148.4	79.4	2.68	0.97 1.22
HMVT2	ANTITK	50	36.3	1-TW2B	1887	147.3	125.7	60.1	1.66	0.74
AH64	HELO	36	7.1	1-HELPH 2-30mm	4537 3414	382.7 833.7	329.4 89.6	146.9 7.1	21.79	2.66 5.79
AH1	HELO	21	4.1	1-TW2B 2-20mm	3223 3386	179.3 378.9	162.2 69.2	29.1 6.5	8.75	2.13 4.51
155mmSP	ARTY	80	19.9		12605	14403.7	6574.9	77.0	5.90	45.01
155mmT	ARTY	32	14.0		15333	9150.5	6176.9	55.9	3.99	71.49
MLRS	ARTY	27	3.9		18894	1611.0	1295.4	45.9	11.66	14.92

b. Table F-2 shows sample SER, LER, and FER data derived from a ROK-nK scenario. This scenario is the Red attack/Green prepared defense with the North Korean forces attacking a ROK force in a prepared defense at a force ratio of about 3:1.

Table F-2. Sample Data - ROK-nK Scenario

BLUE SHOOTERS VS RED TARGETS

Shooter	Shooter Type	Density	Total Losses	Weapon Type	Average Range (m)	Rnds at all Blue	Rnds at Blue List	Kills of Blue List	SER	Firing Rate /Sys/12 Hrs
105KIT	TANK	64	36.5	1-105mm 2-.50 cal	1995 1160	996.3 1419.5	859.3	141.1	3.87	3.90 5.54
KM48	TANK	78	61.9	1-90mm 2-.50 cal	1592 973	505.0 1249.9	447.9	41.9	0.68	1.62 4.01
KM48A5	TANK	52	45.0	1-105mm 2-.50 cal	2010 1002	523.8 693.0	461.8	53.4	1.19	2.52 3.33
KIFV50	ANTITK	46	25.8	1- 2-.50 cal	858	359.1	7.5	0.1	0.01	1.95
KAH1	HELO	81	58.6	1-TW2A 2-20mm	3003 3443	943.5 5154.63	938.3 572.1	107.3 34.3	2.42	2.91 15.91
K203mmSP	ARTY	56	13.1		17792	14228.2	11556.6	94.9	7.23	63.52
K155mmSP	ARTY	112	23.4		14075	28374.4	17140.5	150.8	8.91	63.75
K105mmT	ARTY	18	1.3		9272	8106.2	2704.7	15.5	12.40	112.59

RED SHOOTERS VS BLUE TARGETS

Shooter	Shooter Type	Density	Total Losses	Weapon Type	Average Range (m)	Rnds at all Blue	Rnds at Blue List	Kills of Blue List	SER	Firing Rate /Sys/12 Hrs
T62	TANK	405	202.0	1-115mm 2-MG7.6	1965 493	2762.9 724.0	1533.6	85.9	0.43	1.71 0.45
BMP1	ANTITK	1170	384.5	1-73mm 2-MG7.6	926 494	3605.0 1600.4	1174.1	57.4	0.15	0.77 0.34
PT76	ANTITK	72	23.3	1-76mm	840	158.0	51.9	0.6	0.03	0.55
SU85	ANTITK	126	42.3	1-85mm	1029	15.5	4.5	0.1	0.01	0.03
HIPE	HELO	108	49.9	1-AT3	3522	301.1	286.6	18.5	0.37	0.70
122mmSP	ARTY	282	42.6		7508	23877.2	7125.8	8.1	0.19	21.17
152mmSP	ARTY	360	111.0		9762	36420.3	15872.5	26.3	0.25	25.29
130mmSP	ARTY	48	23.0		17345	12050.4	10375.3	3.8	0.16	62.76
107MRL	ARTY	150	6.0		16728	16341.2	14414.3	4.5	0.75	27.24
203mmSP	ARTY	24	9.6		16269	4325.5	3299.1	12.0	1.25	45.06

APPENDIX G

SPONSOR'S COMMENTS



CFC

HEADQUARTERS
ROK-US COMBINED FORCES COMMAND
한 미 연 합 군 사 령 부
UNIT #15255
APO AP 96205-0028



MEMORANDUM FOR ~~Director~~, U.S. Army Concepts Analysis Agency,
8120 Woodmont Avenue, Bethesda, Maryland 20814

SUBJECT: Tactical Combat Samples and Linkage to TACWAR Study for
Sponsor Review

1. References:

- a. Memorandum, CSCA-FEF/T, 20 November 1992, SAB.
- b. Study Report, CAA-SR-92-14, September 1992, subject:
Tactical Combat Samples and Linkage to TACWAR (TACLINK).
2. A written evaluation in compliance with AR 5-5, para 3-5 is
included as enclosure 1.
3. Suggested additions to the distribution list are included as
enclosure 2.
4. The Concepts Analysis Agency is commended for an excellent
study that is comprehensive, conclusive, ~~and~~ most importantly can
be put to immediate use as base data in the CFC Tactical Warfare
Model (TACWAR).

Thanks!

Encl
as

~~STEPHEN SILVASY, JR.~~
Major General, US Army
Assistant Chief of Staff, C3

311400 10092

TACLINK STUDY EVALUATION

1. **BACKGROUND:** Prior to the TACLINK Study, Combined Forces Command TACWAR analysts used the best available weapons attrition data, plus some analytical judgement, to input weapon systems probability of kill data into the TACWAR model. The CFC, C3 Plans, Operations Analysis Branch, as well the majority of the CINC analytical organizations (i.e. USCENTCOM-CCCA, USEUCOM-ECCS-AS), utilize a ten by ten blue versus red weapon system matrix in the TACWAR ground warfare database. These matrices represent generic weapon system categories (i.e., tank, APC, artillery, antitank/TOW, etc.). In the past, TACWAR analysts have chosen a specific weapon system to represent a generic weapon system category (i.e., tank=M60 tank, artillery=155mm howitzer). The analysts would then extract specific weapon system PKs from the Joint Munitions Effectiveness Manual (JMEM). These specific weapon system PKs were AMSAA-derived single shot probability of kill (SSPKs) under test/hardstand conditions. These PKs were then directly input into the TACWAR ground database PK tables/matrices. This method of representing generic weapon system PKs is a recognized shortfall of the TACWAR model. In September 1991, during the 6th ROK/US Defense Analysis Seminar, the Director of the US Army Concepts Analysis Agency noted during a TACWAR model discussion that this shortfall could be overcome by a CAA study effort to provide verifiable operational PKs specific to the CFC TACWAR model. This suggested study effort was welcomed by the CFC Staff and the TACLINK study was officially initiated in January 1992.

2. **THE STUDY OBJECTIVE:** The TACLINK Study's primary objective was to develop combat sample attrition data to use as input for the CFC TACWAR theater model. A secondary objective was to develop and provide an audit trail to support the use of this data in TACWAR. Both of these objectives were clearly accomplished by the Concepts Analysis Agency. TACLINK provided a much needed aggregation of Theater specific weapon system operational probability of kill, operational rate of fire, and allocation of fires data that can be directly input into the Combined Forces Command TACWAR model. It has also provided CFC with a verifiable ground weapon systems attrition database for the TACWAR model.

3. **IMPLEMENTATION:** The TACLINK Study combat sample attrition data will be used by the CFC C3 Plans, Operations Analysis Branch, in the CFC TACWAR model. Specifically, during the 2nd Quarter of FY 93, OAB analysts will conduct sensitivity analyses on TACWAR model runs of an OPLAN 5027-92 Base Case with existing attrition data, compared to model runs using the TACLINK-provided attrition data. These analyses will allow OAB to fully integrate the TACLINK data into the CFC TACWAR database by the 3rd Quarter FY 93, with full utilization of this improved TACWAR model database during the annual Ulchi Focus Lens 93 Exercise.

Enclosure 1

APPENDIX H
DISTRIBUTION

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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

AAA	antiaircraft artillery
AMSAA	US Army Materiel Systems Analysis Activity
APP	Antipotential Potential
APC	armored personnel carrier
arty	artillery
AT	antitank
ATCAL	Attrition Calibration
BAI	battlefield air interdiction
CAA	US Army Concepts Analysis Agency
CENTCOM	Central Command
CFC	Combined Forces Command
COSAGE	Combat Sample Generator (model)
CTI	COSAGE-TACWAR Interface
DMZ	demilitarized zone
EEA	essential element(s) of analysis
EUSA	Eighth US Army
FER	force exchange ratio
FLOT	forward line of own troops
FM	field manual
HAW	heavy antitank weapon
how	howitzer
HMMWV	high mobility multipurpose wheeled vehicle
IAMS-II	Integrated Army Mobilization Study
IFV	infantry fighting vehicle
ITV	Improved TOW vehicle

LAW	light antitank weapon
LER	loss exchange ratio
MAW	medium antitank weapon
MG	machinegun
MLRS	multiple launch rocket system
MOE	measure(s) of effectiveness
MRC-W	Major Regional Conflict-West
MRL	multiple rocket launcher
nK	North Korea
PK	probability of kill
ROK	Republic of Korea
ROKMOD	Republic of Korea Modernization Study
SAM	surface-to-air missile
SAW	squad automatic weapon
SEAD	suppression of enemy air defense
SER	system exchange ratio
SP	self-propelled
SSPK	single shot probability of kill
TAC LINK	Tactical Combat Samples and Linkage to TACWAR (study)
TACAIR	tactical air
TACWAR	Tactical Warfare Model
TOW	tube-launched, optically tracked, wire-guided (weapon)
TRADOC	US Army Training and Doctrine Command



**TACTICAL COMBAT SAMPLES AND
LINKAGE TO TACWAR
(TAC LINK)**

**STUDY
SUMMARY
CAA-SR-92-14**

THE REASON FOR PERFORMING THE STUDY is to develop combat sample attrition data that provide some of the required inputs to the Tactical Warfare Model (TACWAR). Development of these inputs provides an audit trail on which the sponsor can rely.

THE STUDY SPONSOR is Commander, Combined Forces Command (CFC), Republic of Korea. The C-3, Combined Forces Command, established the study objective and monitored study activity.

THE STUDY OBJECTIVE is to develop combat sample attrition data to use as input for the TACWAR theater model.

THE SCOPE OF THE STUDY is the development of the operational probability of kill, operational rate of fire, and allocation of fires for each potential weapon system interaction in the Korean theater of operations. This study examines US and Republic of Korea forces deployed against a North Korean threat. Timeframe for this study is 1993.

THE MAIN ASSUMPTION of this study was that the TAC LINK output data is usable in TACWAR. This entailed the completion and testing of the COSAGE-TACWAR Interface (CTI).

THE BASIC APPROACHES used in this study were to determine attrition data by using stylized (Blue and Green on Red) forces in the Combat Sample Generator (COSAGE). The data from these simulations is analyzed and postprocessed into an acceptable TACWAR format.

THE PRINCIPAL FINDING of this study is that combat samples can be constructed to support TACWAR in the Korean theater of operations. The data provided to CFC includes the operational probability of kill, operational rate of fire, and allocation of fires for all weapon systems found in the theater of operations.

THE STUDY EFFORT was directed by CPT Robert S. Elias, Tactical Branch, Force Evaluation Directorate.

COMMENTS AND QUESTIONS may be sent to the Director, US Army Concepts Analysis Agency, ATTN: CSCA-FEF/T, 8120 Woodmont Avenue, Bethesda, Maryland 20814-2797.



**TACTICAL COMBAT SAMPLES AND
LINKAGE TO TACWAR
(TAC LINK)**

**STUDY
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CAA-SR-92-14**

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