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IMPROVEMENT OF THE WAR-GAMING CAPABILITY,  
PHASE II (WAGCAP II)

Computer Sciences Corporation

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# IMPROVEMENT OF THE WAR-GAMING CAPABILITY PHASE II

(Short Title: WAGCAP II)

FINAL REPORT

**UNITED STATES ARMY  
COMBINED ARMS CENTER**

**COMBINED ARMS  
COMBAT DEVELOPMENTS ACTIVITY**

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KEY WORDS

LINK A

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ROLE

WT

Alternative Forces  
Combat Effectiveness  
Combat Potential  
Combat Service Support  
Combat Support  
Computer Assisted Model  
Doctrine  
Evaluation  
Firepower  
Force Design  
Intelligence  
Mobility  
Sensitivity  
War Game

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**PROJECT NUMBER 6-72**

**IMPROVEMENT OF THE WAR GAMING CAPABILITY, PHASE II,  
(WAGCAP II)**

**FINAL REPORT**

**PREPARED FOR**

**USA COMBINED ARMS COMBAT DEVELOPMENTS ACTIVITY (PROVISIONAL)  
UNDER CONTRACT DAAG 11-70-C-0875**

**IN RESPONSE TO USACDC WORK DIRECTIVE 6-72,  
IMPROVEMENT OF THE WAR GAMING CAPABILITY,  
PHASE II (WAGCAP II), 30 MAY 1972**

**JUNE 1973**

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ABSTRACT

This final report, supported by Appendices A through D, describes the work performed and the results achieved by Computer Sciences Corporation's Combat Developments Research Office (CSC-CORO) in response to USACDC Work Directive 6-72, Improvement of the War Gaming Capability, Phase II.

The Combat Developments Research Office is operated by the Field Services Division of Computer Sciences Corporation under Contract DAAG11-70-C-0875.

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IMPROVEMENT OF THE WAR GAMING CAPABILITY, PHASE II (WAGCAP II)

FINAL REPORT

CHAPTER 1

INTRODUCTION

1. PURPOSE. The WAGCAP II Final Report, supported by the appendices hereto, describes the work performed and the results achieved by the Computer Sciences Corporation Combat Developments Research Office (CSC-CDRO) in response to USACDC Work Directive 6-72, Improvement of the War Gaming Capability, Phase II (WAGCAP II). The project was executed in two 6-month phases, and the principal objectives of the project were to provide model maintenance and technical support of DIVWAG Model operations, to produce technically trained government personnel capable of operating the Division War Game (DIVWAG) Model in application to Army force and resource planning activities, and to provide a basis for acceptance of model output through sensitivity testing of the model and its principal components.

2. BACKGROUND. In order to place the WAGCAP II project in proper context with other work performed and related to the DIVWAG Model, the following chronology is presented:

a. In August 1970, under Contract DAAG11-70-C-0875, CSC-CDRO initiated Project 3-71, Improvement of the ICAS War Game Model (IMPWAG). The tasks of this project were to identify deficiencies and problem areas in the DIVTAG II (Division Through Army Group) Model through a review of documentation; to establish a priority list for correction/resolution of the deficiencies and problem areas; to correct or improve DIVTAG II within project constraints; and to document corrections, improvements, and resolutions, as well as to recommend corrective action. This project was completed in May 1971.

b. In February 1971, project tasking was issued to CSC-CDRO to design, develop, and validate the following:

(1) A computer-assisted war game model(s) which would permit determination of the impact on force effectiveness of changes in the mixes of major weapons and other systems at an appropriate level of resolution.

(2) An analytical methodology for analyzing the output of the model(s) developed and determining the effectiveness of a single force.

(3) An analytical methodology for comparing alternative forces.

The project above was identified as Project 7-71, Development of a Division War Game Model (DIVWAG), and was completed in December 1971. The war game model designed and developed under the DIVWAG project was the base from

which follow-on improvements were made under the WAGCAP project described in the following paragraph.

c. In October 1971, CSC-CDRO initiated Project 2-72, Improvement of the War Gaming Capability (WAGCAP) under tasking by USACDC to perform the following:

(1) Determine the improvements to the DIVWAG Model that could be made within the current state of the art.

(2) Establish a priority listing of candidate submodels and/or subroutines to be improved ranked in the order determined by the sensitivity of outputs, the resources available, and the fidelity and balance requirements of the model.

(3) Accomplish the model improvements in accordance with the priorities established by the Study Sponsor and/or the Study Advisory Group.

(4) Conduct tests to determine the sensitivity of model or submodel output to input data and/or model structure.

(5) Demonstrate the validity of improved submodels and/or subroutines with respect to other model output, and experimental and test data.

(6) Train government personnel in the techniques and procedures required to operate DIVWAG effectively and efficiently. The training program was required to include both the development of an appropriate data base and the conduct of a training game.

(7) Conduct a test game to demonstrate the improved model, the analysis of model output, the evaluation of game results, and the capabilities of the trained government personnel.

(8) Using the trained government personnel, conduct a war game of the WAGCAP division.

This project was completed in July 1972 and resulted in the production of documentation of the improved DIVWAG Model for operation on the Control Data Corporation 3300 computer system. Other objectives were achieved as tasked.

d. As a concurrent activity with the performance of the WAGCAP II project and impacting directly upon the latter, CSC-CDRO reprogrammed the DIVWAG Model for operation on the Control Data Corporation 6500 computer system. The CDC 6500 system became operational at Fort Leavenworth, Kansas in November 1972, and the CDC 3300 system ceased operation in mid-January 1973. Task IV, Reprogramming of the Division War Game Model (DIVWAG), of Project 1-73 was completed in April 1973.

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### 3. PROJECT TASKING:

a. The Statement of Work for Project 6-72, Improvement of the War Gaming Capability, Phase II (WAGCAP II) dated 30 May 1972, divided the year-long project into two equal phases and assigned the following tasks for performance during Phase I (1 July 1972 - 31 December 1972):

- (1) Provide required maintenance for the DIVWAG Model.
- (2) Train government personnel on all technical aspects of the DIVWAG Model.
- (3) Provide programming and other technical support to the previously trained government player and control personnel during the preparation for and conduct of DIVWAG war games.
- (4) Conduct sensitivity testing as directed by and in accordance with priorities established by the Study Sponsor.

b. On 15 November 1972, tasking for the performance of Phase II (1 January 1973 - 30 June 1973) was issued by the Contracting Officer's Representative as follows:

- (1) Provide required maintenance on the DIVWAG Model until the government assumes responsibility for required maintenance; thereafter, provide technical advice to government personnel who will maintain the model.
- (2) Complete the training of government personnel, begun in Phase I, on the technical aspects of the DIVWAG Model.
- (3) Provide technical support of testing and gaming being conducted by government personnel.

c. The USACDC tasking documents for the performance of Project 6-72 are contained in Appendix A.

### 4. PROJECT MONITORSHIP AND REPORTING:

a. Technical guidance and project monitorship on-site were provided by the Study Sponsor's Representative, Colonel Wayne D. Miller.

b. Project advice and assistance was provided by the WAGCAP II Study Advisory Group, which convened at Fort Leavenworth, Kansas on the dates indicated below:

- (1) 23 August 1972. The primary thrust of this SAG meeting was to approve the Project Work Plan and to issue instructions for the conduct of sensitivity tests during the project.

## CHAPTER 2

### WAGCAP II PROJECT RESULTS

#### Section I. INTRODUCTION

1. **PURPOSE.** The purpose of this chapter is to provide summary descriptions of the activities and the results achieved in the performance of the WAGCAP II project.

2. **ORGANIZATION.** This chapter is divided into five sections. The first section explains the purpose of the chapter and its organization, and the succeeding chapters deal, in turn, with the results of sensitivity testing (Section II), model maintenance (Section III), technical training (Section IV), and technical support (Section V).

## Section II. SENSITIVITY TESTING

3. PURPOSE OF SENSITIVITY TESTING. Sensitivity testing during the WAGCAP II project had as its purpose the establishment of the behavior pattern of the DIVWAG Model and its components in order to demonstrate that the model is a credible mathematical and logical simulation of division activity. The ultimate goal of testing was the establishment of limits of input variation for which model response was deemed realistic while the balance among submodels was maintained.

### 4. BACKGROUND:

a. During the WAGCAP project (USACDC Work Directive 2-72) some new submodels were developed and existing submodels were improved, and all were integrated into the DIVWAG system. This integration of new and improved models occurred during the WAGCAP Test Game, which was conducted late in the predecessor project and which covered a wide spectrum of military activities. During the Test Game, some marginally acceptable system/model-dependent game output results were noted. These results, coupled with overall results of the game, indicated that in order to ensure realistic outputs when the DIVWAG Model is used in a production mode, model sensitivity, balance, and fidelity in all functional areas should be demonstrated.

b. The CSC-CDRO plan for the sensitivity testing during the WAGCAP II project was submitted as Appendix B, DIVWAG Sensitivity Test Plan, to the Project Work Plan. This appendix established general procedures for sensitivity testing and recommended 26 sensitivity tests to the Study Sponsor for accomplishment during the WAGCAP II project. The CSC-CDRO recommended tests are listed by functional area in Figure 2-1. Recognizing that accomplishment of all recommended tests was beyond the resources and time available for the project, CSC-CDRO further recommended that the sensitivity tests be accomplished in the order shown in Figure 2-2. The recommended ordering was developed on the basis of experience in model operation and knowledge of model status, and the open committee method was used to rank order the tests. Under the terms of the Statement of Work, the designation of the order of actual performance of the tests was a prerogative of the Study Sponsor and the WAGCAP II Study Advisory Group.

c. At their meeting on 23 August 1972, the WAGCAP II SAG considered the recommendations of both CSC-CDRO and the Study Sponsor's Representative for the accomplishment of the sensitivity tests and established the priority for test performance shown in Figure 2-3. Tests were to be performed in the order indicated and within resources allocated to sensitivity testing. A recapitulation by functional submodel of the tests recommended as well as those selected for performance is shown in Figure 2-4. The concentration of tests in the

| Model                    | Test Number | Test Name   |
|--------------------------|-------------|---|
| Ground Combat            | 1.1.1       | Assessments as a Function of Density of Targets by Type   |
|                          | 1.1.2       | Assessments as a Function of Target Priority and Exposed Area of Targets by Type and Posture      |
|                          | 1.1.3       | Assessments as a Function of Time Increment (Cycle Time)  |
|                          | 1.1.4       | Assessments as a Function of Kill Criteria  |
|                          | 1.1.5       | Sensitivity to Firing Rates   |
|                          | 1.1.6       | Assessments as a Function of Environment  |
|                          | 1.1.7       | Assessments as a Function of Initial Velocity of Attacking Unit(s)                                |
| Area Fire/TACFIRE        | 1.2.1       | Sensitivity Analysis of Area Fire Assessment  |
|                          | 1.2.2       | TACFIRE Assessment as a Function of Method of Attack and Target Priority                          |
| Airmobile                | 1.3.1       | Ground-to-Air Attrition as a Function of Suppression Line   |
|                          | 1.3.2       | Ground-to-Air Attrition as a Function of Aircraft Altitude  |
|                          | 1.3.3       | Ground-to-Air Attrition as a Function of Aircraft Speed   |
|                          | 1.3.4       | Ground-to-Air Attrition as a Function of Air Defense Capable Unit (ADCU) Resolution               |
|                          | 1.3.5       | Airlift Time as a Function of Aircraft Numbers  |
|                          | 1.3.6       | Assembly of Airlift Mission Units as a Function of Airbase Location and Tasking                   |
| Combat Service Support   | 1.4.1       | Supply Operations as a Function of Consumption Rates  |
|                          | 1.4.2       | Sensitivity of CSS to Internally Fixed Parameters   |
|                          | 1.4.3       | Supply Operations as a Function of Priorities   |
| Intelligence and Control | 1.5.1       | Probability of Detection as a Function of Dominant Mask for MTI, Mohawk, and Aerial Camera        |
|                          | 1.5.2       | Visual Detection as a Function of Environment   |
|                          | 1.5.3       | Intelligence as a Result of Sensor Mix  |
|                          | 1.5.4       | Processing Sensitivity to the Unit Size and Type Estimates and the Redundant Target Radii         |
|                          | 1.5.5       | Sensitivity of Fire Support Request Delay Time  |
|                          | 1.5.6       | Sensitivity of Intelligence Communication to the Information Flow Thresholds                      |
|                          | 1.5.7       | Sensitivity of the Probability of Detection, Recognition, and Identification Curves for MTI Radar |
| Engineer                 | 1.6.1       | Engineer Model Response Test  |

Figure 2-1. Recommended Sensitivity Tests

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| Recommended Priority | Test Number | Test Name   | Calendar Time (Weeks) | Man-Weeks | Relative Effort |
|----------------------|-------------|---|-----------------------|-----------|-----------------|
| 1                    | 1.1.1       | Assessments as a Function of Density of Targets by Type   | 21                    | 36        | 37              |
| 2                    | 1.1.6       | Assessments as a Function of Environment  | 14                    | 16        | 52              |
| 3                    | 1.2.2       | TACFIRE Assessments as a Function of Method of Attack and Target Priority                         | 14                    | 16        | 52              |
| 4                    | 1.5.4       | Processing Sensitivity to the Unit Size and Type Estimates and Redundant Target Radii             | 5                     | 8         | 76              |
| 5                    | 1.1.4       | Assessments as a Function of Kill Criteria  | 14                    | 12        | 57              |
| 6                    | 1.3.1       | Ground-to-Air Attrition as a Function of Suppression Times  | 8                     | 6         | 9-              |
| 7                    | 1.3.2       | Ground-to-Air Attrition as a Function of Aircraft Altitude  | 6                     | 6         | 10-             |
| 8                    | 1.3.3       | Ground-to-Air Attrition as a Function of Aircraft Speed   | 6                     | 6         | 10-             |
| 9                    | 1.3.4       | Ground-to-Air Attrition as a Function of Air Defense Capable Unit Resolution                      | 6                     | 6         | 11-             |
| 10                   | 1.5.3       | Intelligence as a Result of Sensor Mix  | 8                     | 12        | 2-              |
| 11                   | 1.2.1       | Sensitivity Analysis of Area Fire Assessments   | 4                     | 8         | 13-             |
| 12                   | 1.4.1       | Supply Operations as a Function of Consumption Rates  | 8                     | 12        | 14-             |
| 13                   | 1.5.6       | Sensitivity of Intelligence Communication to the Information Flow Thresholds                      | 5                     | 8         | 152             |
| 14                   | 1.1.7       | Assessments as a Function of Initial Velocity of Attacking Unit(s)                                | 2                     | 5         | 157             |
| 15                   | 1.1.2       | Assessments as a Function of Target Priority and Exposed Areas of Targets by Type and Posture     | 6                     | 12        | 169             |
| 16                   | 1.6.1       | Engineer Model Response Test  | 8                     | 12        | 181             |
| 17                   | 1.4.2       | Sensitivity of Combat Service Support Operations to Internally Fixed Parameters                   | 6                     | 4         | 185             |
| 18                   | 1.5.2       | Visual Detection as a Function of Environment   | 4                     | 4         | 189             |
| 19                   | 1.5.1       | Probability of Detection as a Function of Dominant Mask for HTI, MUMAMK, and Aerial Camera        | 6                     | 8         |                 |
| 20                   | 1.1.3       | Assessments as a Function of Time Increment (Cycle Time)  | 6                     | 18        |                 |
| 21                   | 1.3.5       | Airlift Times as a Function of Aircraft Numbers   | 3                     | 5         |                 |
| 22                   | 1.5.5       | Sensitivity of Fire Support Request Delay Time  | 10                    | 12        |                 |
| 23                   | 1.1.5       | Sensitivity to Firing Rates   | 2                     | 2         |                 |
| 24                   | 1.3.6       | Assembly of Airlift Mission Units as a Function of Airbase Location and Tasking                   | 4                     | 6         |                 |
| 25                   | 1.4.3       | Supply Operations as a Function of Priority   | 8                     | 10        |                 |
| 26                   | 1.5.7       | Sensitivity of the Probability of Detection, Recognition and Identification Curves for HTI Radars | 10                    | 12        |                 |

Figure 2-2. Recommended Priority for Sensitivity Tests

| Study Sponsor Priority | CSC Test Number | Test Name  |
|------------------------|-----------------|--|
| 1                      | 1.1.2           | Assessments as a Function of Target Priority and Exposed Area of Targets by Type and Posture |
| 2                      | 1.1.5           | Sensitivity to Firing Rates  |
| 3                      | 1.1.1           | Assessments as a Function of Density of Targets by Type                                      |
| 4                      | 1.1.4           | Assessments as a Function of Kill Criteria   |
| 5                      | 1.1.3           | Assessments as a Function of Time Increment (Cycle Time)                                     |
| 6                      | 1.5.3           | Intelligence as a Result of Sensor Mix   |
| 7                      | 1.5.1           | Probability of Detection as a Function of Dominant Mask for MTI, MOHAWK, and Aerial Camera   |
| 8                      | 1.2.1           | Sensitivity Analysis of Area Fire Assessment (lethal area, target density and dispersion)    |
| 9                      | 1.1.7           | Assessments as a Function of Initial Velocity of Attacking Units                             |
| 10                     | 1.3.4           | Ground-to-Air Attrition as a Function of Air Defense Capable Unit (ADCU) Resolution          |
| 11                     | 1.1.6           | Assessments as a Function of Environment   |
| 12                     | 1.3.1           | Ground-to-Air Attrition as a Function of Suppression Time (airmobile operations)             |
| 13                     | 1.2.2           | TACFIRE Assessment as a Function of Method of Attack and Target Priority                     |
| 14                     | 1.5.6           | Sensitivity of Intelligence Communication to Information Flow Thresholds                     |
| 15                     | 1.5.5           | Sensitivity of Fire Support Request Delay Time   |
| 16                     | 1.5.4           | Processing Sensitivity to the Unit Size and Type Estimates and the Redundant Target Radii    |

Figure 2.3. Study Sponsor Priority for Sensitivity Testing (continued next page)

| Study Sponsor<br>Priority | CSC Test<br>Number | Test Name   |
|---------------------------|--------------------|---|
| 17                        | 1.5.2              | Visual Detection as a Function of Environment   |
| 18                        | 1.5.7              | Sensitivity of the Probability of Detection, Recognition, and Identification Curves for MTI Radar |
| 19                        | 1.6.1              | Engineer Model Response Test (suppression and movement)   |
| 20                        | 1.3.5              | Airlift Time as a Function of Aircraft Numbers  |
| 21                        | 1.3.2              | Ground-to-Air Attrition as a Function of Aircraft Altitude (air-ground engagement)                |
| 22                        | 1.3.3              | Ground-to-Air Attrition as a Function of Aircraft Speed (air-ground engagement)                   |
| 23                        | 1.2.1              | Sensitivity Analysis of Area Fire Assessment (target area)  |
| 24                        | 1.6.1              | Engineer Model Response Test (breach or force)  |
| 25                        | 1.3.2              | Ground-to-Air Attrition as a Function of Aircraft Altitude (airmobile)                            |
| 26                        | 1.6.1              | Engineer Model Response Test (priorities)   |
| 27                        | 1.3.3              | Ground-to-Air Attrition as a Function of Aircraft Speed (airmobile)                               |
| 28                        | 1.2.1              | Sensitivity Analysis of Area Fire Assessment (rounds per volley)                                  |
| 29                        | 1.3.1              | Ground-to-Air Attrition as a Function of Suppression Time (suppression, air-ground)               |
| 30                        | 1.3.6              | Assembly of Airlift Mission Units as a Function of Airbase Location and Tasking                   |
| 31                        | 1.6.1              | Engineer Model Response Test (division mission)   |
| 32                        | 1.6.1              | Engineer Model Response Test (engineer battalion strength)  |

Figure 2.3. Study Sponsor Priority for Sensitivity Testing (concluded)

| Tests       | Ground Combat | Area Fire/<br>TACFIRE | Intelligence<br>and<br>Control | Engineer | Airmobile | Combat<br>Service<br>Support | Total<br>Tests |
|-------------|---------------|-----------------------|--------------------------------|----------|-----------|------------------------------|----------------|
| Recommended | 7             | 2                     | 7                              | 1        | 6         | 3                            | 26             |
| Selected    | 7             | 2                     | 6                              | 0        | 2         | 0                            | 17             |

Figure 2-4. Sensitivity Test Recapitulation

Ground Combat Model and Intelligence and Control Model areas should be noted.

d. On 15 November 1972, the Study Sponsor's Representative formally notified CSC-CDRO that the contractor would not be tasked to conduct sensitivity analyses during Phase II of the WAGCAP II project. The Study Sponsor's Representative further indicated that utilization of the CDC 3300 computer system for sensitivity testing by CSC-CDRO would not extend beyond 31 December 1972. The CDC 3300 system was planned for removal in January 1973 and was actually closed down on 16 January 1973.

e. All sensitivity testing of the DIVWAG Model and its components was conducted using the version of the model that was operational on the CDC 3300 computer system.

f. By mutual agreement between the Study Sponsor's Representative and the WAGCAP II Project Manager, all documentation of results of sensitivity tests was to be delivered in draft final report form by 1 March 1973. Individual test results were delivered to the Study Sponsor's Representative as they were completed, and the complete draft final Appendix B, Sensitivity Test Descriptions, was delivered on 1 March 1973.

g. On 14 March 1973, the Study Sponsor's Representative indicated formal acceptance of Appendix B with minor corrections to be incorporated in the WAGCAP II Final Report.

#### 5. SENSITIVITY TEST PROCEDURES:

a. The sensitivity tests were generally conducted using response surface techniques. A response surface can be described as a relationship between a quantitative or numerical response and quantitative factors affecting the response. The relationship may be deterministic or it may involve random variables. The functional form of the relationship may be known explicitly (e.g.,  $y = f(x_1, \dots, x_n)$ ), it may be known except for the values of several unknown parameters, or very little may be known about the response surface. The aim of response surface testing (investigation) might be either to explore and describe the response surface over some region of interest in factor space, or to optimize the response over some operability region in factor space. In any case, the basic feature of response surface methods is the experimental investigation of a response surface using observations of the response at various factor levels of data. Response surface testing was accomplished generally by varying selected subsystem input values for key model parameters, running a game period of acceptable length whenever the subsystem had new input values, extracting and arraying game period output data, and subjecting the output data to analysis.

b. For each candidate test, a concept outline was prepared as part of the sensitivity test plan. A "talking paper" was then prepared for each test selected for accomplishment. The talking paper consisted of the detailed test experimental design and included discussions of the general scenario and data

for the test and the comparisons expected to be provided by the test. (Concept outlines and talking papers are included with the documentation for the tests, Annexes I through XVII to Appendix B).

c. Upon receipt of Study Sponsor approval of a talking paper, CSC-CDRO began execution of the test according to test design, followed by analysis and evaluation of results. Study Sponsor personnel assigned proponency for each test were kept closely informed of test progress. For several tests effort was redirected, or additional guidance was received, on the basis of preliminary results. These cases are recorded with the documentation of individual tests.

d. Upon completion of each test, documentation was prepared to include a general description of the test, the constant and variable data used, a narrative description of test performance, display and analysis of results, and observations developed on the basis of test findings. This documentation comprises Annexes I through XVII to Appendix B.

6. TEST RESULTS. Sensitivity tests results are summarized in Appendix B, Sensitivity Test Descriptions, and the details of test performance are included in the annexes of Appendix B. Based upon the results of the sensitivity tests conducted, the following general conclusions and recommendations are submitted.

a. Conclusions. From the results of the sensitivity tests of the four submodels of the DIVWAG system addressed by the WAGCAP II testing program, it is concluded that:

(1) The submodels tested produce realistic results consistent with input data used for the tests.

(2) Some input data strongly influence model output; therefore, these data should be carefully examined and validated before game results are used in actual force planning studies.

(3) Continuing sensitivity tests are necessary in order to fine tune the DIVWAG Model.

b. Recommendations. From the results of the sensitivity tests conducted, it is recommended that:

(1) The DIVWAG Model be employed in a production mode.

(2) Test data acquired be used to inform gaming personnel of the most effective application of the DIVWAG Model in war gaming operations.

(3) A program be established to examine carefully and to validate data to be used in the DIVWAG Model when applied in the production mode. Where necessary, requirements for field tests to provide valid data should be initiated.

(4) Sensitivity testing of the DIVWAG Model continue with the overall objective of improving the simulation of combat operations at the division level.

(5) Data extracted from future applications of the DIVWAG Model be selectively extracted, arrayed, and compared with existing data in order to completely document the behavior of the DIVWAG Model under varying gaming objectives and scenarios.

(6) Modifications and improvements suggested by the detailed conclusions in Appendix B be given early consideration for inclusion in the Division War Game Model.

### Section III. MODEL MAINTENANCE

7. PURPOSE OF MODEL MAINTENANCE. The purpose of required maintenance of the DIVWAG Model was to maintain the model in an operational status, first, on the Control Data Corporation 3300 computer system and, later, on the Control Data Corporation 6500 computer system. The terms "model maintenance" and "required maintenance" are used interchangeably in this report.

#### 8. BACKGROUND:

a. The Division War Game Model is a complex and sophisticated computer-assisted simulation for use in war gaming military force interactions at division level. One of the principal means of enhancing the operational capabilities of the DIVWAG Model is through continuing application to division-level war games. Such application permits ready identification of data and logic anomalies of the system that are not necessarily detectable in subsystem or system tests. For different war games, too, varying submodels of the system are exercised more frequently than others and in different simulations of military activity. During each application of the model, therefore, constant attention to model outputs as well as to the system and subsystem operation is necessary to ensure that military activities are simulated as designed and that output data generated are in keeping with the data input and with efficient model operation.

b. The WAGCAP II Statement of Work for Phase I and, as amended, for Phase II tasked CSC-CDRO to "provide required maintenance on the DIVWAG Model until the government assumes responsibility for required maintenance; thereafter provide technical advice to government personnel who will maintain the model." Required maintenance was defined by the Study Sponsor as maintaining the model in an operational status on the CDC 3300 and CDC 6500 computer systems as required. Corrections to the model as a result of continued model application, system testing, and debugging were considered within this definition.

c. During Phase I of WAGCAP II, three major applications of the DIVWAG Model provided vehicles for a close examination of the operability of the model and for modifications and debugging where required. The result of these applications was a thorough operational shakedown of the DIVWAG Model.

(1) CSC-CDRO conducted a series of 17 sensitivity tests and in so doing exercised a large number of the submodels and routines. Given early use and close scrutiny was the Ground Combat Model, which required a number of corrections before the tests were completed. Other models were similarly fine-tuned during the course of sensitivity testing.

(2) In order to reprogram the DIVWAG Model for operation on the Control Data Corporation 6500 computer system, it was necessary for the government to produce benchmark runs and for CSC-CDRO to ensure that the model was fully operational during the production of these runs. Four benchmark runs were produced, which exercised all major programs and routines of the

DIVWAG Model. In the process of making these benchmark runs, model maintenance was continued, and additional model corrections and changes were incorporated into operational files, routines, programs, and submodels in accordance with guidance and approval of the Study Sponsor's Representative.

(3) Responding to tasking from Department of the Army, USACDC Combat Systems Group conducted a limited war game using the DIVWAG Model to produce data for analysis by the Middle Model Review (MMR) Group. The overall purpose of MMR Group activities was to review operational division-level models, war games, and simulations. Each of the models under consideration was required to simulate the same combat situation, and the results were to be used to develop insights into the kinds of analytical problems each model could handle most effectively as well as to identify strengths and weaknesses of each model for the scenario gamed. The conduct of this gaming effort provided an excellent opportunity to ensure that the DIVWAG Model operated in accordance with design specifications.

d. In the performance of model maintenance, it was anticipated that maintenance of the CDC 3300 DIVWAG system and the CDC 6500 DIVWAG system would not be required concurrently. At the time that an operational capability with the CDC 6500 system was achieved, model modifications to the CDC 3300 system would stop, model modifications and changes made to that point in time would be documented, and the documentation would be forwarded to the Study Sponsor's Representative. All subsequent model modifications would be addressed to the CDC 6500 system.

#### 9. MODEL MAINTENANCE ACTIVITIES:

a. General. Based on the continuing review and analysis of the DIVWAG Model, areas in the model were identified as candidates for modification in order to enhance the credibility and acceptability of the DIVWAG Model as a division war gaming tool. Each of the areas identified as a candidate for modification was thoroughly analyzed and system tested prior to incorporation into the DIVWAG Model being used by the government personnel for the conduct of war games. The refinements, adaptations, or modifications to the DIVWAG Model were coordinated with the Study Sponsor's Representative prior to integration in the DIVWAG Model.

(1) Model modifications took the form of corrections rather than improvements. Corrections were defined as those actions undertaken to ensure that the model operated according to design specifications. Improvements, on the other hand, embraced the development of new design or the modification to the present design in order to cause the model to operate in a manner different from the WAGCAP version of the DIVWAG Model. Modifications to the model based upon continued testing and debugging were integrated into the DIVWAG Model using the WAGEDIT routine. No model corrections or changes were incorporated into operational files, routines, programs, or models without prior Study Sponsor's Representative approval.

(2) System testing and debugging of the DIVWAG Model and the data continued throughout the period of the WAGCAP II project (i.e., July 1972 through June 1973). Model modifications were made principally to elements of the Constant Data Input Processor, the Period Processor, and the Period Output Processor.

(a) The Engineer and Nuclear Assessment Models, although extant in the DIVWAG Model at the beginning of the WAGCAP II project, required extensive system testing and debugging. The results of these system tests were carefully analyzed, and the necessary corrections to the models were edited onto the operational DIVWAG Model.

(b) The Ground-to-Air Attrition (GTAA) routine of the Airmobile Model, designed and coded during the WAGCAP project, was tested and integrated into the DIVWAG Model during WAGCAP II. The GTAA routine replaced the inflight attrition routine of the Air Ground Engagement Model, which simulated assessments of inflight aircraft during airmobile operations and reconnaissance flights.

(c) The Ground Combat Model underwent exhaustive sensitivity testing during the period 15 July to 1 October 1972. As a result of this sensitivity testing, a recommendation was made to the Study Sponsor to incorporate CSC-CDRO's suggested corrections into the model. With Study Sponsor approval, corrections to the Ground Combat Model were incorporated.

b. Phase I (1 July - 31 December 1972). During Phase I of WAGCAP II, model maintenance activities were addressed specifically to the CDC 3300 DIVWAG system. Reasons for each modification or change, together with a description of the modification or change, are set forth in Section II of Appendix C to this report. Annexes to Appendix C contain change pages to the DIVWAG Model documentation for the CDC 3300 system as follows:

- Annex I - Volume III, DIVWAG Technical Manual
- Annex II - Volume IV, DIVWAG Users Manual
- Annex III - Volume V, DIVWAG Programmers Manual
- Annex IV - Volume VI, DIVWAG Data Requirements  
Definition

c. Phase II (1 January - 30 June 1973):

(1) Model maintenance activities during Phase II were predicated upon the availability of a version of the DIVWAG system operational on the CDC 6500 computer system. This version became available in the latter part of January 1973; however, the reprogrammed version of the model was not to be accepted by the Study Sponsor until all benchmark runs had been validated by the DIVWAG Reprogramming project. In the interim period, a test version of the reprogrammed model was created and used to identify how modifications and changes would be made once the reprogrammed model was accepted.

(2) Modifications and changes made to the CDC 3300 DIVWAG system prior to 1 October 1972 were accepted by the DIVWAG Reprogramming project for inclusion into the CDC 6500 DIVWAG system. After that cutoff date, however, only a limited number of modifications to the CDC 3300 system were incorporated in the CDC 6500 system, the number depending on the extent of reprogramming of the pertinent components of the model. In the early portion of Phase II, CSC-CDRO identified modifications and changes to the CDC 6500 DIVWAG system that needed to be made once the reprogrammed system was accepted and that had not been included. These modifications stemmed from sensitivity testing of components of the DIVWAG Model, the application of the model in support of the MMR Group, the preparation by CSC-CDRO of an overlay structure for loading of constant data, and the continued analysis of model structure and operation by CSC-CDRO.

(3) On 27 March 1973, the Study Sponsor established technical guidelines for modification to the DIVWAG Model once the government assumed responsibility of model maintenance of the DIVWAG system. The guidance recognized the existence of two versions of the DIVWAG Model; an operational version (Version A) and a test version (Version B). Version B was designated the vehicle for testing in the ongoing DIVWAG Model maintenance, development, and improvements program. The general plan would be for CSC-CDRO and the government to establish the validity and operability of candidate modifications to the DIVWAG system using Version B prior to changing the operational Version A. In order to ensure the full capability of the trained government personnel to operate and maintain the model, only government personnel would make modifications to Version A.

(4) On 12 April 1973, the Study Sponsor accepted the reprogrammed DIVWAG system including the responsibility for model maintenance. The Study Sponsor cancelled the requirement for preparing a draft report of changes to the CDC 6500 DIVWAG system, agreeing instead to the inclusion by CSC-CDRO in the final documentation of the project those changes actually incorporated in the system. Those changes actually made are described in Section III of Appendix C to this report and are presented in Annex V to Appendix C.

#### Section IV. TECHNICAL TRAINING:

10. PURPOSE OF TECHNICAL TRAINING. The purpose of training of government personnel in the technical aspects of the DIVWAG Model was to permit the government to achieve a full capability to apply and maintain the model.

#### 11. BACKGROUND:

a. The US Army Combat Developments Command for a number of years utilized the war game models and facility at Fort Leavenworth in the support of analytical efforts. These analytical efforts were performed by personnel under contract to the government. The contractor personnel assumed the roles of military participants during the play of the game. Government personnel, therefore, were denied the advantage of an education in war gaming extended over a considerable period of time as well as the opportunity to develop a base of understanding in details of the war game operation. Similarly, the government had not taken full advantage of the skills and experience of military personnel well qualified to contribute to the development of doctrine or to the conduct of force planning by having these personnel participate in war gaming.

b. Under the WAGCAP project (USACDC Work Directive 2-72), CSC-CDRO presented a training program designed to train government personnel in the techniques and procedures required to operate the DIVWAG Model effectively and efficiently. The program presented was divided into two parts embracing formal classroom training. The first part consisted of training government personnel in the development of a data base and included 202 hours of instruction, both conference and practical exercise, as well as laboratory practice during which the trainee personnel developed the constant data base for the WAGCAP Test Game. The second part of the program addressed war game training and included 197 hours of formal instruction enabling government personnel to act as control team members and as Red and Blue players.

c. The formal classroom training and practical exercises in war game model application conducted under the WAGCAP project did not address the technical aspects of the DIVWAG Model; therefore, in order for the government to achieve a full capability to apply and maintain the model, it was necessary to train government personnel in the design logic of the DIVWAG system and in the programming logic and coding for all the DIVWAG Model components. The completion of this phase of training would permit the government to achieve the full capability of applying, operating, and maintaining the Division War Game Model.

#### 12. TECHNICAL TRAINING CONCEPT:

a. The concept of technical training for WAGCAP II originally visualized independent reading assignments by individual trainees followed by on-the-job training designed to acquaint the individual government trainee with execution. It became obvious, however, that a more disciplined approach to technical training would be necessary in order to achieve the results desired; therefore,

semiformal seminars were scheduled and presented. This change in approach, coupled with the diverse professional qualifications and interests of trainees assigned, caused the technical training to proceed more slowly and in greater detail than originally envisioned. Coordination between the Study Sponsor's Representative and CSC-CDRO resulted in training during Phase I being limited to training on the Period Processor and training during Phase II addressing all other parts of the DIVWAG Model.

b. It was anticipated that government personnel to be assigned for training would possess a variety of education, training, and experience; therefore, in lieu of formal classroom training, a more flexible training program stressing informal seminar sessions was designed to acquaint the individual government programmer or analyst with model operations at his level of interest. On-the-job training was to follow the informal seminar sessions and would include a period of on-the-job application during Phase II under the tutelage of CSC-CDRO personnel prior to project completion.

c. Technical training during Phase I was based on the DIVWAG Model designed and programmed for the CDC 3300 computer system while Phase II technical training concentrated on the DIVWAG Model as programmed for the CDC 6500 computer system.

d. The WAGCAP II technical training program was designed as a study program supplemented by informal seminar sessions. A series of reading assignments was prepared to direct the technical personnel in the study of the DIVWAG system and program logic. These reading assignments were principally from Volume III, DIVWAG Technical Manual, and Volume V, DIVWAG Programmers Manual, with selections from Volume IV, DIVWAG Users Manual, also being suggested. It was expected that the technical personnel would concentrate their efforts on those aspects, either design or programming logic, most closely allied with their field of specialization. Informal seminar sessions, designed to complement and reinforce assigned readings in the DIVWAG documentation, were scheduled at the convenience of both the instructor and the trainees. At the conclusion of the study program and seminar sessions, government personnel would begin on-the-job training, the nature of which would be dependent both on their specific assignment and on the activities ongoing as a result of WAGCAP II tasking and any games being conducted using the DIVWAG Model.

### 13. TECHNICAL TRAINING PRESENTED:

a. Phase I. The Phase I technical training was oriented to the Period Processor of the DIVWAG Model and was conducted during the period 2 August - 29 December 1972. In order to place the technical training of government personnel on a firm basis, CSC-CDRO first presented an introduction to the DIVWAG Model, and this was followed by technical training by functional area of the DIVWAG Model's Period Processor. The government personnel undergoing training were divided into three functional groups by the Study Sponsor, and each group devoted its principal effort to learning the models that fell within its respective functional group. The three groups designated by the Study

Sponsor and the models of the Period Processor associated with each functional group are shown below:

| <u>Firepower Group</u> | <u>Mobility Group</u>  | <u>Intelligence Group</u> |
|------------------------|------------------------|---------------------------|
| Ground Combat          | Combat Service Support | Intelligence and Control  |
| Area Fire/TACFIRE      | Engineer               | Reconnaissance            |
| Air-Ground Engagement  | Airmobile              | System Operating Routines |
| Nuclear Assessment     | Movement               | and Basic System Models   |

Under the Phase I training, 71 seminars were presented, embracing 197.25 classroom hours. Trainees frequently attended classes other than those related to their functional group as a means of increasing their knowledge and understanding of the DIVWAG system as a whole.

b. Phase II. The Phase II technical training covered the remaining four processors of the DIVWAG system not covered in Phase I (i.e., Constant Data Input, Orders Input, Period Output, and Analysis Output Processors) as well as utility programs associated with model operation. Phase II training was conducted during the period 2 January - 23 February 1973, and included 30 seminars embracing 73.50 classroom hours. Training during this phase was oriented to model maintenance personnel although other attendees were frequently present to broaden their knowledge of the DIVWAG Model.

14. RESULTS OF TECHNICAL TRAINING. The technical training presented during the WAGCAP II project, coupled with the operational training in the use of the DIVWAG Model presented during the predecessor WAGCAP project, has permitted government personnel to achieve a fundamental knowledge and understanding of the operational and technical aspects of the model. The overall state of training existing at the completion of the technical training can best be advanced by on-the-job training in model operation and application.

15. RECOMMENDATIONS AS A RESULT OF TRAINING. It is recommended that:

a. A program of on-the-job and self training be instituted that will produce a small nucleus of government staff members well trained and knowledgeable in all operational aspects of the DIVWAG Model.

b. A program of model maintenance and improvement of the DIVWAG Model, consistent with the knowledge and state of training of government personnel, be instituted and pursued at the earliest practicable time.

## Section V. TECHNICAL SUPPORT

16. PURPOSE OF TECHNICAL SUPPORT. The purpose of technical support of the USACDC/USATRADOCC war gaming effort was to provide operations research, computer systems analysis, and computer programming necessary to support testing and war gaming operations of the government.

### 17. BACKGROUND:

a. At the initiation of the WAGCAP II project, the government had made the decision to attain an in-house (government) capability not only to conduct actual war games but also to provide the full spectrum of technical support necessary to sustain war gaming operations. This capability was to be directed initially to the application of the DIVWAG Model; however, as more models became available the objective was to be capable of operating and supporting a family of war game models.

b. Under the predecessor WAGCAP project, government gaming personnel were instructed in the development of a data base to support computer-assisted war gaming and in the use of the Division War Game Model for the conduct of actual war games. The formal classroom training and practical exercises in model application did not address the technical aspects of the DIVWAG Model; therefore, at the start of the project the government possessed a cadre and a capability to apply the model but lacked personnel in sufficient numbers and with the requisite training and experience to support the gaming operations. Contractual support became necessary until qualified government technical personnel were assigned and trained to provide technical support.

c. During Phase I (1 July - 31 December 1972), CSC-CDRO was tasked to provide programming and other technical support to the previously trained government player and control personnel during the preparation for and conduct of DIVWAG war games. In the Project Work Plan and for the purposes of WAGCAP II, the term game support was used to describe the CSC-CDRO effort and was defined as that technical advice, programming, and other technical support required to maintain an efficient approach to, and execution of, the war gaming efforts. As indicated by the tasking, game support was required in preparation for and during the conduct of war games. The basic approach, then, in the execution of this task was to provide technical support on an ad hoc basis; however, at other times, available project support would be devoted to model maintenance and training.

d. During Phase II (1 January - 30 June 1973), CSC-CDRO was tasked to provide technical support of testing and gaming being conducted by government personnel, such technical support being interpreted to include:

(1) Support of on-the-job training of government personnel on technical aspects of DIVWAG.

(2) Provision of advice and assistance to gamer and model maintenance personnel on problems encountered with data base or gaming operations.

(3) Provision of assistance to government personnel test and debug of specific submodels.

(4) Provisions of assistance in the execution of edits to the DIVWAG Model based upon the identification and solution of problems encountered.

(5) Provision of documentation support in writing required errata and addenda to the CDC 6500 documentation of the DIVWAG Model.

The approach to technical support during Phase II involved recognition of completion of the technical training of government personnel on 23 February 1973 and the assumption of responsibility by the government for maintenance of the DIVWAG Model, which actually took place on 12 April 1973. With these two milestones being completed, CSC-CDRO would then turn its total contractual resources to technical support with the objective of providing that support necessary to ensure that government personnel were fully capable of maintaining the model in an operational status, that on-the-job technical training was supplied where needed, and that expert technical advice and assistance was provided to support sensitivity and operational tests of the DIVWAG system and subsystems.

#### 18. TECHNICAL SUPPORT ACTIVITIES:

a. General. The concept for technical support of government war gaming operations was essentially one of providing that support of gaming operations not available from government resources. This concept was extended for Phase II to include similar support for system, operational, and sensitivity testing of the DIVWAG Model by government personnel. As indicated in the following subparagraphs the tasking of technical support was rather broadly interpreted, particularly in Phase II; however, the emphasis in such support was always to the objective of providing support that was not available to the government from its own technical resources. Throughout the project, the government developed an ever-increasing capability to provide its own technical support, and as this occurred CSC-CDRO's technical support was redirected to those additional technical tasks that were essential to gaming and testing operations and that government personnel and resources successively moved to cover. By this evolutionary technique, the government acquired the experience and knowledge of the complete spectrum of technical support of war gaming operations in its most comprehensive application.

b. Phase I. The project resources during Phase I were principally applied to model maintenance, sensitivity testing, and training since relatively little gaming activity occurred during the phase. Two significant gaming exercises were conducted during Phase I, however, and were supported by CSC-CDRO.

(1) Concurrently with the execution of the WAGCAP II project and under separate project tasking, CSC-CDRO reprogrammed the DIVWAG Model to operate on a CDC 6500 computer system. In order to provide a basis for later validation of the reprogrammed model, the government conducted a limited war game using the version of the model programmed for operation on the CDC 3300 computer system. The war game exercised all major components of the model, and game input and output were carefully controlled and documented. Four benchmark periods of varying length and activity were produced, and the results were used to confirm the proper operability of the reprogrammed model. During the conduct of the game, CSC-CDRO provided direct support in checking and correcting game input in the form of data and gamer orders; in programming changes and modifications to produce the results desired; in job-ordering computer runs to the supporting data processing facility; and in analyzing computer runs and game output.

(2) Responding to tasking from Department of the Army, USACDC Combat Systems Group conducted a limited war game using the DIVWAG Model in order to produce data for analysis by the Middle Model Review (MMR) Group. The overall purpose of MMR Group activities was to review operational division-level models, war games, and simulations. Technical support by CSC-CDRO was required to ensure that the DIVWAG Model produced data consistent with the fixed scenario (combat situation) involved in order that a valid comparison of the DIVWAG Model with similar models could be completed. Programming support and technical advice and assistance were provided to the government in the conduct of the war game.

c. Phase II. As indicated in paragraph 17d above, technical support of testing and gaming being conducted by government personnel during Phase II embraced a diversity of tasks.

(1) On-the-job training of government personnel on technical aspects of the DIVWAG Model was conducted from the completion of semiformal training on 23 February 1973 until the completion of the project on 30 June 1973. On-the-job training was necessary in order to provide government personnel with hands-on experience in operation of the model on the new computer system, in the diagnosis and trouble shooting of model operations based upon observed hardware and software system abnormalities, in the analysis and interpretation of computer output from model runs, and in the application of programming techniques to ensure uninterrupted operation of the DIVWAG Model.

(2) Advice and assistance to government gamer and model maintenance personnel on problems encountered with data base and gaming operations were provided by CSC-CDRO throughout Phase II. Much of the technical support in this area was provided in an informal atmosphere and generally in response to direct questioning by the government personnel. A major effort by CSC-CDRO was completed unilaterally, however, and resulted in the development of an overlay (DIVPREP) to load all constant data for the DIVWAG Model. This addition to the DIVWAG Model resulted in increased efficiency in overall model operation and running time. The modification to the documentation to accommodate DIVPREP is included in Appendix C to this report.

(3) Following the turnover to the government of the CDC 6500 version of the DIVWAG Model, modifications and changes to the model were necessary. The modifications were those identified after benchmark runs were made and which could not be made until the reprogrammed version of the model was operational, tested, and delivered. For the purpose of controlling changes made to the model, the Study Sponsor's Representative identified model modifications by source and placed them into seven groups, six of which involved CSC-CDRO support under WAGCAP II.

- (a) Group A. Programming corrections made by CSC-CDRO's reprogramming group.
- (b) Group B. Middle Model Review modifications.
- (c) Group C. DIVPREP overlay structure and associated modifications.
- (d) Group D. Changes identified but not made by CSC-CDRO's reprogramming group.
- (e) Group E. Nuclear Assessment Model changes.
- (f) Group F. Modifications suggested by sensitivity testing.
- (g) Group G. All other changes which CSC-CDRO, in its support of DIVWAG, identified.

In executing its WAGCAP II tasks, CSC-CDRO specifically addressed Groups B-G.

Procedurally, CSC-CDRO developed the detailed modifications based upon a general identification of the requirement for such modifications. Once the logic and coding modifications were structured, they were edited into the test version of the DIVWAG Model. With each change or group of changes it was then necessary to conduct component, subsystem, and/or system tests and, where necessary, to debug the modified programs and systems. CSC-CDRO either provided expert advice and assistance to government personnel conducting test and debug operations or, where government skill and experience was not available, actually conducted test and debug operations. Finally, fully tested and documented modifications were passed to government personnel who effected the modifications in the operational version of the model.

(4) As the DIVWAG Model was exercised in an operational mode, abnormalities of the model were observed and their causes were identified through diagnostic messages or through analysis of output. Once the causes of the abnormalities were identified and either the model logic or operational procedures were modified, it was necessary to edit corresponding changes into the model. Edit procedures, principally through the use of the WAGEDIT routine, were then followed in order to attain and maintain an operational capability with the model. CSC-CDRO initially made all WAGEDIT changes as approved by the Study Sponsor's Representative; however, as government personnel became

increasingly familiar and proficient with the DIVWAG Model, CSC-CDRO played an ever decreasing role in assisting in the execution of edits to the model. As the close of the project, government personnel were fully capable of effecting model changes and edits.

(5) With the assumption of responsibility by the government for maintenance of the DIVWAG Model, the government thereby also assumed responsibility for the documentation of any model changes incident to the model maintenance task. In the course of effecting model modifications under the technical guidance of the Study Sponsor's Representative, CSC-CDRO provided documentation support in writing errata and addenda to the CDC 6500 documentation of the DIVWAG Model. Documentation support was extended to modifications and changes made by CSC-CDRO only; however, by mutual agreement with the Study Sponsor's Representative, CSC-CDRO accepted model modifications and accompanying documentation prepared by the government. The objective of this agreement was to provide an integrated set of documented modifications to the DIVWAG Model. Model modifications and changes made to the CDC 6500 version of the DIVWAG Model are included in Annex V of Appendix C. In addition to errata and addenda CSC-CDRO also provided change decks and coding sheets keyed appropriately to the DIVWAG System.

(6) Concurrent with the development of the overlay to load all constant data for the DIVWAG Model (see paragraph 18c(2) above), CSC-CDRO tested the overlay and coded and tested associated changes to other processors. In addition, CSC-CDRO:

- (a) Provided an UPDATE library for the overlay.
- (b) Provided a binary library.
- (c) Verified that the entire overlay had been tested by loading a complete data base.
- (d) Submitted written specification for changes required to other processors.
- (e) Provided change decks and coding sheets for changes to the other processors.
- (f) Explained the testing methodology to the government coordinator.

## CHAPTER 3

### DIVWAG MODEL DEVELOPMENT

1. **PURPOSE.** The purpose of this chapter is to recapitulate the overall development of the Division War Game Model under Department of the Army contract number DAAG11-70-C-0875 in order to gain insights into the resources and time required to develop a sophisticated and complex simulation such as the Division War Game Model.

2. **MODEL DEVELOPMENT ANALYSIS:**

a. With the completion of the WAGCAP II project Computer Sciences Corporation, through its Combat Developments Research Office, has over a span of 3 years successfully executed a succession of projects that have produced a fully operational division war game model. Additionally, execution of the projects has produced a complement of government personnel, which has been trained and which is professionally capable of operating and maintaining the Division War Game (DIVWAG) Model. In order that this experience on the part of both contractor and government personnel be available for future planning of similar activities, the following descriptive chronology is presented and is keyed to Figure 3-1.

(1) As the initial step, CSC-CDRO conducted a critical analysis of an existing division war game model (DIVTAG II) with the objective of identifying deficiencies and problem areas which, if corrected, would result in a credible and acceptable war game model. This research and analytical effort (IMPWAG Project) provided much of the insight and basis for the model development efforts that followed.

(2) Concurrently with the conduct of the IMPWAG Project, CSC-CDRO was tasked to develop a methodology for the evaluation of alternative forces (CONAF ALTFOR) as part of a larger effort embracing the conceptual design of the army in the field. Early efforts in execution of this tasking were not fruitful; therefore, CSC-CDRO was redirected to design, develop, and validate a computer-assisted division-level war game model as well as a methodology for comparing alternative forces. This development effort (DIVWAG Project) was intended to produce a middle model, which would be dependent upon input from high resolution models; however, available high resolution models could not produce credible and acceptable data for a division-level model, and it became necessary to develop a model that would simulate dynamically at division level all the functions of land combat. Once the basic design of the original model was completed, the system was programmed and tested. While these latter activities were in progress, it became obvious that improvements should be made to the basic design. Furthermore, the expanded developmental efforts precluded extensive validation and sensitivity testing that would obviously be necessary if the model were to achieve acceptability as a military planning tool. Execution of this project resulted in complete documentation of the analytical methodologies required as well as draft final documentation of the DIVWAG Model.



Because of pending improvements, the Study Sponsor made the decision to defer production of the final formal model documentation until the improvements were incorporated. By the close of this project, government gaming personnel had joined USACDC Combat Systems Group; however, no formal training of any government personnel had taken place.

(3) In order to conserve time and to obtain maximum value from available contractor and government resources, a follow-on project (WAGCAP) was initiated prior to the completion of the preceding project. Contractor personnel were committed to model improvement activities while programming and testing of the basic model was still in progress. Once the basic model had been tested, a firm basis would then exist for editing in changes to improve the model. During this project, the Ground Combat Model (GCM) of the DIVWAG system was subjected to extensive validation comparison with CARMONETTE III and IUA models, both of which are high resolution simulations of ground combat. Differences in output between GCM and the latter two models were traced to, and explained by, logic and data differences among the models. Limited sensitivity testing within available resources was conducted and reported by CSC-CDRO. Lastly, government gaming and control personnel were presented formal instruction in the development of a data base and in the effective and efficient application of the model to appropriate gaming operations, including the conduct of a test game. A set of formal documentation of the DIVWAG Model was produced and delivered.

(4) With an operational model in hand, CSC-CDRO was next tasked (WAGCAP II) to conduct a series of sensitivity tests of the DIVWAG Model, to present technical training on the model to government personnel, to maintain the model in an operational status, and to provide technical support to government personnel in the conduct of testing and gaming operations. The activities performed under this project tasking are presented elsewhere in this report and will not be discussed further at this point.

(5) During the execution of the WAGCAP II project, the government replaced its Control Data Corporation 3300 computer system with the Control Data Corporation 6500 computer system. Replacement necessitated the reprogramming of the DIVWAG Model to operate on the latter system. This activity was not connected directly with the DIVWAG Model development activities; nonetheless, in the course of performing the reprogramming, additional model efficiencies were realized. The reprogramming project did, however, add information to the overall inventory of knowledge about the model and about the effort required to reprogram the model to a new computer system. Each reprogramming effort is unique to the new computer system for which the model is reprogrammed, but any effort expended in the future to reprogram the model for a different system should not exceed time and resources devoted to conversion of the model to operate on the CDC 6500 computer system. This statement is justified because of universal features (e.g., ANSI Standard FORTRAN) that were included in the reprogrammed model. Major time and resource effort in the reprogramming was demanded in order to accomplish the following:

(a) Convert programs and routines from FORTRAN IV to ANSI Standard FORTRAN.

(b) Execute in 124,000 (octal) words of core in lieu of 170,000 (octal) words previously used with the CDC 3300 computer system.

(c) Execute with one chapter of common instead of two.

(d) Reprogram operations involving character type variables to use character utility routines.

(e) Revise variable names containing more than six characters to shorter names.

(f) Redesign and rewrite the DIVWAG Scenario Language compiler.

(g) Eliminate mixed mode arithmetic operations.

(h) Eliminate assembly language routines or replace them with ANSI Standard FORTRAN routines.

(i) Eliminate non-standard print formats.

b. In guiding future efforts in model development, the following observations were made or lessons were learned.

(1) The development of a complex, computer-assisted war game model is a research and development project and as such cannot be as severely disciplined as the mechanical production of a piece of military hardware. It is an endeavor that must be thoroughly researched and executed in an evolutionary fashion; therefore, expectations of a prescribed product within a specified period of time are rarely achieved.

(2) A model development effort comparable to that for the DIVWAG Model should be carefully and thoroughly researched. Sufficient facts pertaining to the activity to be simulated, acceptable mathematical and logical techniques and procedures to be applied in the simulation, and the availability of data to support application of the simulation are required before actual model development takes place. Once a modeling effort has been initiated, redirection of the effort is extremely wasteful of time and technical personnel resources.

(3) A proper blend of operations research/systems analysis personnel and computer software and hardware personnel is essential to the orderly development of a simulation as sophisticated and complex as the DIVWAG Model. Operations research/systems analysis personnel conduct the necessary research of activities and events to be simulated as well as design the simulation, while the computer personnel program the simulation and operate the system. Obviously, an improper blend is inefficient, but the lesson learned is to avoid improper prejudging of the blend of personnel and to achieve the proper balance in an evolutionary manner. A minimum initial number of each of the disciplines is mandatory, however.

(4) Some of the activities in the development effort can be compressed in time by the addition of personnel resources; however, there is an upper limit to the number of professional personnel who can participate in such an effort and have the project proceed in an efficient and orderly manner. In addition, since much of the effort is sequential, peaks and valleys of productive effort can be smoothed out if both sequential and concurrent activities can be scheduled over a reasonable amount of time.

(5) Competition for computer time can strongly influence the span of time required to execute a comparable developmental effort, particularly when the computer system being used executes in a multiprogram mode. A dedicated computer system or a computer usage priority system will assist in compressing developmental time; however, only the former alternative will ensure minimum developmental time.

(6) A comprehensive program of testing must be conducted in order to ensure credibility and acceptability of model operations and output.

(a) Tests to ensure efficient and acceptable operation of components of the model both as to the degree to which the components simulate real activities and as to the capability of the component to execute without programming fault (system tests).

(b) Tests to compare the output of the model to the output of other models which simulate similar activities (validity tests).

(c) Tests to produce data of model operation over a real life range of input parametric values (operational tests).

(d) Tests to analyze the behavior of the model and its components over a complete range of values for model parameters, whether the parameters are hardwired into the model logic or are dependent upon constant data inputs (sensitivity tests).

(7) Data play an important role in model development. Early identification of required data for the successful operation of the model as designed is mandatory, and a data collection effort paralleling in time the model development effort is essential to a timely and efficient application of the model. Real or realistic data are essential to all phases and types of model testing. Not only is the initial preparation of an acceptable data base important, but of equal importance is the establishment and efficient operation of a system to update the data base on a periodic basis.

(8) Thorough documentation of the model or simulation is essential to its successful future application, and detailed guidance for the preparation of such documentation should be known early in the project. Preparation of the documentation should be strictly disciplined and should be executed as the project progresses. Only in this manner can all facts pertinent to the development effort be preserved for future use.

(9) The management of a major model development effort requires careful and constant attention. Thorough planning, diligent supervision, thoughtful analysis of results, and detailed reporting and documentation are essential to a useful product.

3. RECOMMENDATIONS. Having completed contractual efforts in the development of the DIVWAG Model, CSC recommends that:

a. The DIVWAG Model be applied as early as practicable in support of Army force planning.

b. A complete data base, properly documented as to source of data, be developed and maintained for use with the DIVWAG Model.

c. Sensitivity and operational testing of the DIVWAG Model be pursued with the objective of continuing improvement of the capability to analyze the model and its output.

d. A stable gaming and model maintenance team be developed and maintained in order to apply the DIVWAG Model and other models in active war gaming operations.

**APPENDIX A**

**STATEMENT OF WORK**

**This appendix presents the USACDC Work Directive and Statement of Work for WAGCAP II issued to CSC-CDRO on 30 May 1972 (Annex I). The appendix also contains the project tasking for Phase II of WAGCAP II (Annex II) issued by the Contracting Officer's Representative on 15 November 1972.**

ANNEX I

WAGCAP II WORK DIRECTIVE AND STATEMENT OF WORK

TO

APPENDIX A

A-I-J

DEPARTMENT OF THE ARMY  
HEADQUARTERS  
UNITED STATES ARMY COMBAT DEVELOPMENTS COMMAND  
FORT BELVOIR, VIRGINIA 22060

CDCCM-C

30 May 1972

Director  
Combat Developments Research Office  
Computer Sciences Corporation  
6565 Arlington Boulevard  
Falls Church, Virginia 22046

SUBJECT: Work Directive 6-72, Improvement of the War Gaming Capability,  
Phase II (WAGCAP II).

Dear Sir:

Request that you provide the U.S. Army Combat Developments Command services described in the attached Statement of Work. These services will be furnished in accordance with the provisions of Contract No. DAAG11-70-C-0875. Services will be performed at Fort Leavenworth, Kansas in Government furnished facilities under CDRO overhead and G&A rates prescribed in the aforementioned contract.

The COR will be furnished within fifteen working days the following information:

- a. Written acceptance of the Statement of Work.
- b. Name of the supervisor responsible for the contractual effort.
- c. Estimated man-months of professional effort to complete the work and total estimated cost to include identification of all direct, indirect costs and fee. Travel costs will be identified separately without burden and fee charges in accordance with paragraph 11, Modification P00011 of the contract.

Sincerely yours,

(SIGNED)

1 Incl  
as

CHARLES D. CRAWFORD  
Contracting Officer's Representative

CF: CC, COMSGp, ATTN: Colonel W. C. Dysinger  
Ft. Leavenworth, Kansas

Mr. Charles F. Carter, Box 269  
Ft. Leavenworth, Kansas

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R 10 May 72

STATEMENT OF WORK

1. Project Study Title: Improvement of the War Gaming Capability, Phase II (WAGCAP II) ACN 20530.
2. Scope of Contractor Effort: The contractor will accomplish the following:
  - a. Phase I (1 Jul 72 - 31 Dec 72).
    - (1) Provide required maintenance for the DIVWAG model.
    - (2) Train government personnel on all technical aspects of the DIVWAG model. This training will include, as a minimum, detailed instructions in the following:
      - (a) The design logic for the DIVWAG system, major processors, subsystems, subroutines, and data files.
      - (b) The programming logic and coding for all DIVWAG components.
    - (3) Provide programming and other technical support to the previously trained government player and control personnel during the preparation for and conduct of DIVWAG war games.
    - (4) Conduct sensitivity testing as directed by and in accordance with priorities established by the study sponsor.
  - b. Phase II (1 Jan 73 - 30 Jun 73): Continuation of the above tasks as directed by the study sponsor.
3. Assumptions:
  - a. USACDC and the U.S. Army will continue to have a requirement for evaluating the impact on unit effectiveness of changes in mixes of major weapons and other systems in a constrained resource environment.
  - b. The DIVWAG model provides a realistic tool to accomplish required analyses at the division level.
  - c. Computer-assisted war games at the division level are required to gain insights to the mix of combat units and the appropriate combat support and combat service support in support of CONFAD, CONAF and other force design studies.
4. Results (End Produces) Required:
  - a. A project work plan, responsive to this Statement of Work, that describes appropriate tasks and subtasks with time phasing, allocation of

R 10 May 72

resources, estimated computer time requirements, dates for report submission, and other management items deemed necessary.

- b. Periodic study sponsor status reports and WAGCAP II SAG meetings as required.
- c. The training program provided the government personnel.
- d. A report containing the results of the sensitivity testing conducted.
- e. A final report containing the complete documentation of the training provided and any model modifications or programming changes resulting from conduct of the project.

5. Information to be Provided by the Government/COMSG:

- a. The study sponsor will provide appropriate information, such as force designs, doctrine, scenarios, and geographical areas, required by this contract.
- b. Classified documents not available from the Defense Documentation Center.
- c. Specific guidance as to tasks to be executed during Phase II NLT 15 November 1972.

6. Period of Performance:

- a. Estimated Starting Date: 1 July 1972.
- b. Estimated Completion Date: 30 June 1973.

7. Reporting Requirements: (All reports will be in a form mutually agreeable to the contractor and the study sponsor's representative. Proprietary rights of all materials produced by the contractor revert to the United States Government.)

- a. The project work plan required by paragraph 4a will be provided NLT 30 days after receipt of an approved Statement of Work.
- b. Reports required by paragraph 4b-4e will be submitted in draft for approval, NLT the due dates established jointly by the study sponsor and the contractor. The final report will be submitted on camera-ready copy within 15 days of SAG approval of the draft final report.

8. Administrative Information:

- a. Study Sponsor's Representative: COL W. C. Dysinger, Chief, USACDC Combat Systems Group, War Games Facility, Fort Leavenworth, Kansas 66027. Telephone: 913-684-4008. (AUTOVON: 552-3253).

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b. COMSG will monitor and assist the contractor in accordance with the terms of the contract. Computer time, if required, can be provided at the USACDC ADP Facility at Fort Leavenworth at no cost to the contractor.

c. A SECRET security clearance will be required for the contractor.

9. Computer Software Development:

a. USACDC computer facilities will be used to the maximum extent possible.

b. Any computer software developed on a type of computer not available within USACDC will be capable of being processed on a computer available within USACDC.

c. No programming techniques which rely for proper operation upon the number of bits (or characters or bytes) per computer word will be used.

d. No local FORTRAN IV programming language features which do not conform to ANSI Standards (ANS X3.9-1966) for FORTRAN IV will be used except by prior explicit approval of the sponsor.

e. No computer system specific subprograms (including machine or assembly language) will be used except by prior explicit approval of the sponsor.

f. All input/output using magnetic tapes will be performed in 7-channel BCD mode.

g. All printed output lines (or lines ultimately targeted for a line printer) will contain no more than 120 characters.

h. No individual program, subprogram, data storage area, task or overlay will require more computer memory than the largest module size available to a USACDC computer.

ANNEX II

WORK DIRECTIVE FOR PHASE II OF WAGCAP II

TO

APPENDIX A

A-II-1

DEPARTMENT OF THE ARMY  
HEADQUARTERS  
UNITED STATES ARMY COMBAT DEVELOPMENTS COMMAND  
FORT BELVOIR, VIRGINIA 22060

CDCCM-C

15 November 1972

Director  
Combat Developments Research Office  
Computer Sciences Corporation  
Box 223  
Fort Belvoir, Virginia 22060

Subject: Work Directive 6-72, Improvement of the War Gaming Capability Phase II (WAGCAP)

Dear Sir:

1. References.

- a. Statement of Work, WAGCAP II.
- b. Project Work Plan, WAGCAP II.

2. Pursuant to direction and approval of the SAG on 26 October 1972 the following guidance as to the tasks to be executed during Phase II (1 January 1973 - 30 June 1973) of the WAGCAP II project, ACN 20530, is provided below as required by paragraph 5c, reference 1a.

3. Task 1. Provide required maintenance on the DIVWAG Model until the government assumes responsibility for required maintenance; thereafter provide technical advice to government personnel who will maintain the model.

Required Maintenance for Phase II is defined as maintaining the model in an operational status on the CDC 3300 and CDC 6500 computer system as required. Corrections to the model as a result of continued model application, system testing and debugging will be considered within this definition.

4. Task 2. Complete the training of government personnel, begun in Phase I, on all technical aspects of the DIVWAG Model. This training will include, as a minimum, detailed instruction on the following:

- a. Procedures for setting up jobs and the necessary control cards utilized by the CDC 6500 computer.

- b. Differences in programming techniques of the CDC 6500 vs CDC 3300 computers, with emphasis on those used in the period processor, as required.

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CDCCM-C

SUBJECT: Work Directive 6-72, Improvement of the War Gaming Capability  
Phase II (WAGCAP)

c. The design logic for the DIVWAG system, major processors, sub-systems, routines, and data files. Assuming completion of all required training on the Period Processor during Phase I, this training should deal mainly with the four input/output processors, as designed and as operating on the reprogrammed (CDC 6500) version of the DIVWAG Model.

d. The programming logic and coding for all DIVWAG components not already provided under Phase I.

5. Task 3. Provide technical support of testing and gaming being conducted by government personnel. Technical support is interpreted to include:

a. Support of OJT of government personnel on technical aspects of DIVWAG.

b. Provision of advice and assistance to gamer and model maintenance personnel on problems encountered with data base or gaming operations.

c. Provision of assistance to government personnel test and debug of specific submodels.

d. Provisions of assistance in the execution of edits to the DIVWAG Model based upon the identification and solution of problems encountered.

e. Provision of documentation support in writing required errata and addenda to the CDC 6500 documentation of the DIVWAG Model.

## 6. Milestones

a. Task 2.

(1) 1 March 1973 - Completion of technical training.

b. Task 3.

(1) 1 June 1973 - Draft Final Report, Phase II.

(2) 30 June 1973 - Final Report covering the entire WAGCAP II effort or 15 days after SAG approval whichever is later.

7. In accordance with the scope and spirit of paragraphs 3 and 4 of contract DAAG 11-70-C-0875, it is anticipated that the personnel assigned to the above tasks will have detailed technical expertise on the DIVWAG Model.

CDCCM-C

SUBJECT: Work Directive 6-72, Improvement of the War Gaming Capability  
Phase II (WAGCAP)

8. Request that you provide your plans for accomplishment of each of the above tasks NLT 8 December 1972. This plan should include:

- a. Descriptions of appropriate tasks and subtasks with time phasing.
- b. Estimated resource allocations.
- c. Other management items deemed necessary.

/Signed/

DELVIN D. DOHSE

Alternate Contracting Officer's Representative

CF:

CGUSACDCCOMSG

ATTN: COL W. D. Miller

Mr Charles F. Carter, Box  
269, Leavenworth, Kans.