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FINAL REPORT

ON THE IMPLEMENTATION

OF A PROTOTYPE LAND ELECTRONIC WARFARE

BATTLEFIELD SIMULATOR

Contract No. W7714-2-9657/01-QC

10 November 1994

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Final Report on the Implementation
of a Prototype Land Electronic Warfare
Battlefield Simulator

Version 01

#1600-124-017

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1 INTRODUCTION

This document is the final report for contract no. W7714-3-9753/01-SV.

1.1 References

a. Request For Proposal - Solicitation No. SV W7714-3-9753/00/A.

b. Software Kinetics Proposal for the Land EW Simulator - Software Kinetics Document No. P93142 Version 01.

c. Contract No. W7714-3-9753/01-SV.

d. "A Scoping Study For An Advanced Land Electronic Warfare Battlefield Simulator" dated 26 May 1994, Software Kinetics Document No. 1600-124-011 Version 01.

References a. and b. are, respectively, the Request For Proposal and Software Kinetics' response for the performance of a scoping study and the development of a prototype Land EW Simulator. Reference c. is the resulting contract. Reference d. documents the scope of requirements for an Advanced Land Electronic Warfare Battlefield Simulator.

1.2 Aim

This project had two related aims:

a. to define the scope of the requirements associated with the development of an Advanced Land Electronic Warfare Battlefield Simulator; and

b. to design and implement, using rapid prototyping techniques, a prototype Land Electronic Warfare Battlefield Simulator.

1.3 Background

Electronic Warfare (EW) is a land combat function. Its battlefield is the electronic spectrum. The conduct of Land Electronic Warfare is a complex process which is intended to provide the Army commander with control of the electromagnetic spectrum. Electronic Warfare Support Measures (ESM) can provide timely tactical intelligence regarding the deployment and actions of the opposing force by exploiting their electronic emissions. Electronic Countermeasures (ECM) can deny the enemy use of the spectrum. The assets available for the performance of the EW function include Direction Finding (DF) sensors (Communications and Radar), Communications Intercept sensors, Communication Jammers, the Electronic Warfare Operations Center (EWOC) and the Electronic Warfare Command Center (EWCC). An example deployment of an Army EW unit is shown in figure 1.

The EW/intelligence process starts with the Commander of the supported formation needing information about the enemy to effectively deploy his own forces. This need is translated into Primary Intelligence Requirements (PIRs) and Intelligence Requirements (IRs) by the G2 (Intelligence) staff. These requirements are passed to the Electronic Warfare Command Centre (EWCC) staff where they are interpreted to provide direction to the Electronic Warfare Operations Centre (EWOC) staff. These directions are further refined at the EWOC to provide taskings and steerage to the deployed ESM elements (search, intercept and DF) of the EW unit.

The results of these taskings (location fixes, intecepts, etc) are reported back to the EWOC where they are stored in a database. The data is analyzed to determine the Electronic Order of Battle of the opposing force, units' strengths, identities, equipment and intentions. Reports are then formulated and sent to the intelligence and/or operations staff of the supported formation through the EWCC.

As in any other combat function, the EW process needs to be exercised regularly in order that the soldiers involved in it maintain their proficiency. Most of the sensor systems fielded today are delivered with some form of computer-based training (CBT) which allows the sensor operator to train himself/herself. However, training of the entire EW process is performed by deploying the EW unit on a field exercise. This type of training is of limited value since it usually takes place against an opposing force which uses our own equipment and tactics and seldom reflects the tactics or technology of potential enemy forces. Such deployments are costly and cannot take place on a regular basis.

One way to potentially reduce training costs is to use an EW simulator to provide a realistic mechanism for the EW unit in which to train all facets of the EW process. Simulation, from an

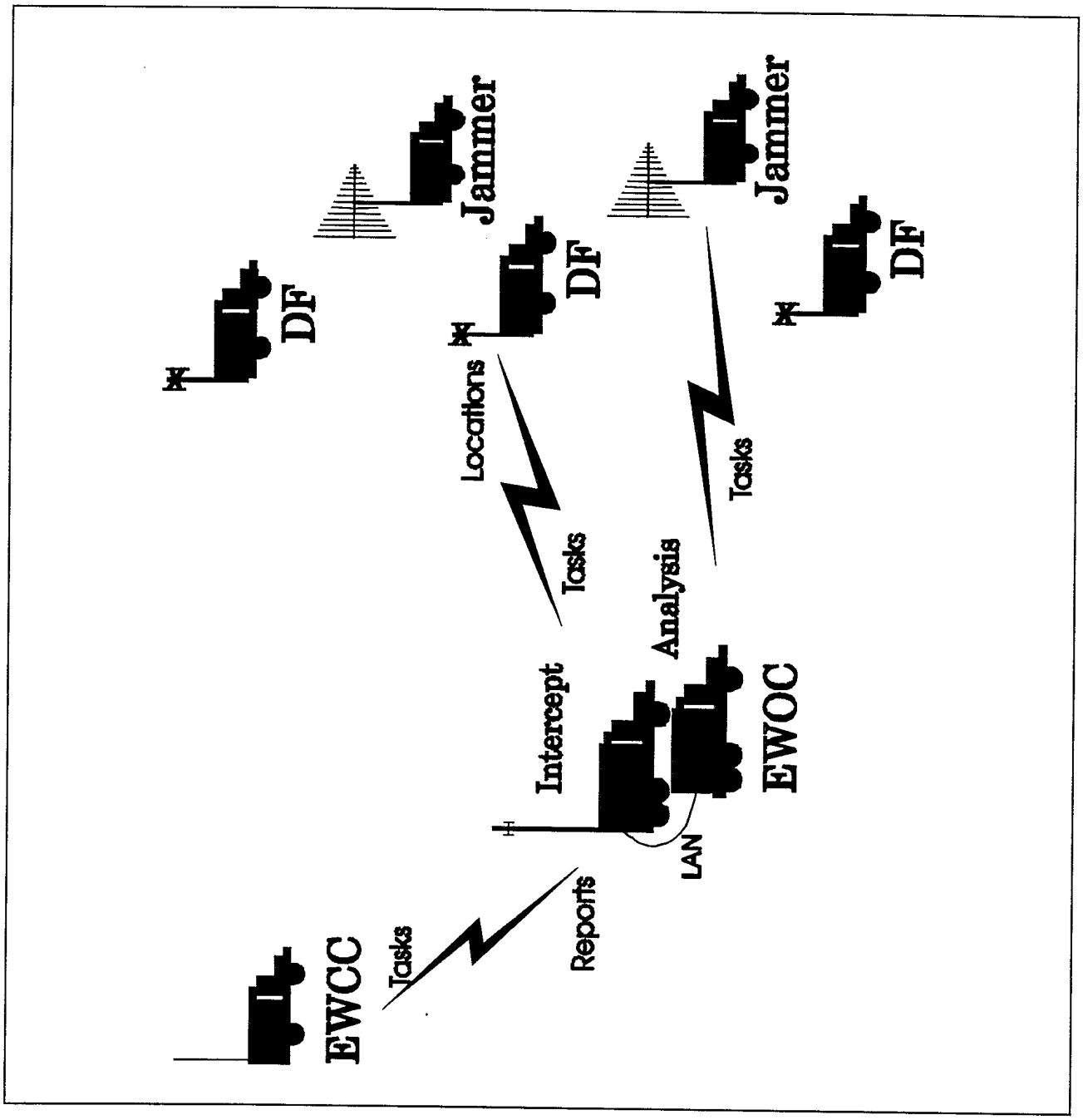

Figure 1 EW Squadron Deployment

EW perspective, includes battlefield dynamics (war gaming), emitter simulation, propagation modelling, and command and control. Achieving a high degree of competence in EW requires both the ability to read computer-based presentations of threat activity and cognitive and associative skills which the analyst must apply when time is short and the environment is one of high stress. Training EW personnel to properly interpret the electromagnetic environment and make correct decisions in this difficult environment requires a war gaming system which is highly interactive and depicts the EW environment with a high degree of realism.

1.4 Scope

This report discusses the development of a prototype Land Electronic Warfare Battlefield Simulator for DREO. The simulator was developed to operate with DREO's Data Fusion and Correlation Techniques Testbed (DFACTT) and the Canadian Army's Electronic Warfare Operations Center. Drawing on technology developed under the DFACTT at the Defence Research Establishment Ottawa (DREO), the system will serve as the testbed for developing new simulation models and target environment for DFACTT. The EW simulator is also needed to reduce the cost and improve the effectiveness of training of army EW personnel.

2 FUNCTIONAL REQUIREMENTS

Reference d. discusses the ideal functional requirements for an advanced land electronic warfare battlefield simulator. These are briefly reviewed here in order to frame the discussion of what was accomplished with the prototype.

The objectives of EW simulation are to:

a. test the capabilities of the participants and their equipment;

b. train the participants; and

c. assess the EW process to determine where improvements may be made.

To attain these objectives, it is necessary to define and understand the system to be simulated and the environment in which the system is to operate. A system is a collection of mutually interacting objects that are affected by outside forces. Objects that are outside the boundaries of the system, but can influence it, constitute the environment of the system. Figure 2 shows a system and its environment.

The first step in defining the Land EW system was to determine its boundaries and contents. In doing so, the inclusion of the various sensor and processes had to be determined. Those elements not included in the EW system had to be assessed to determine if they then had to be part of the EW system's environment.

As shown in Figure 2, to meet the needs of Land Electronic Warfare, there are three major functional segments of the environment which must be simulated. These are briefly described in the following paragraphs. Interested readers should review reference d.

2.1 War Gaming

War gaming is a common training tool for the evaluation of military doctrine, techniques, and capabilities. It consists of the creation and play of simulated battlefield scenarios against a unit whose aim is to prosecute the scenario as if it were real.

War gaming has several inter-related components. To ensure that the training will be useful, the simulation system must be capable of realistically presenting to the participants the situation as

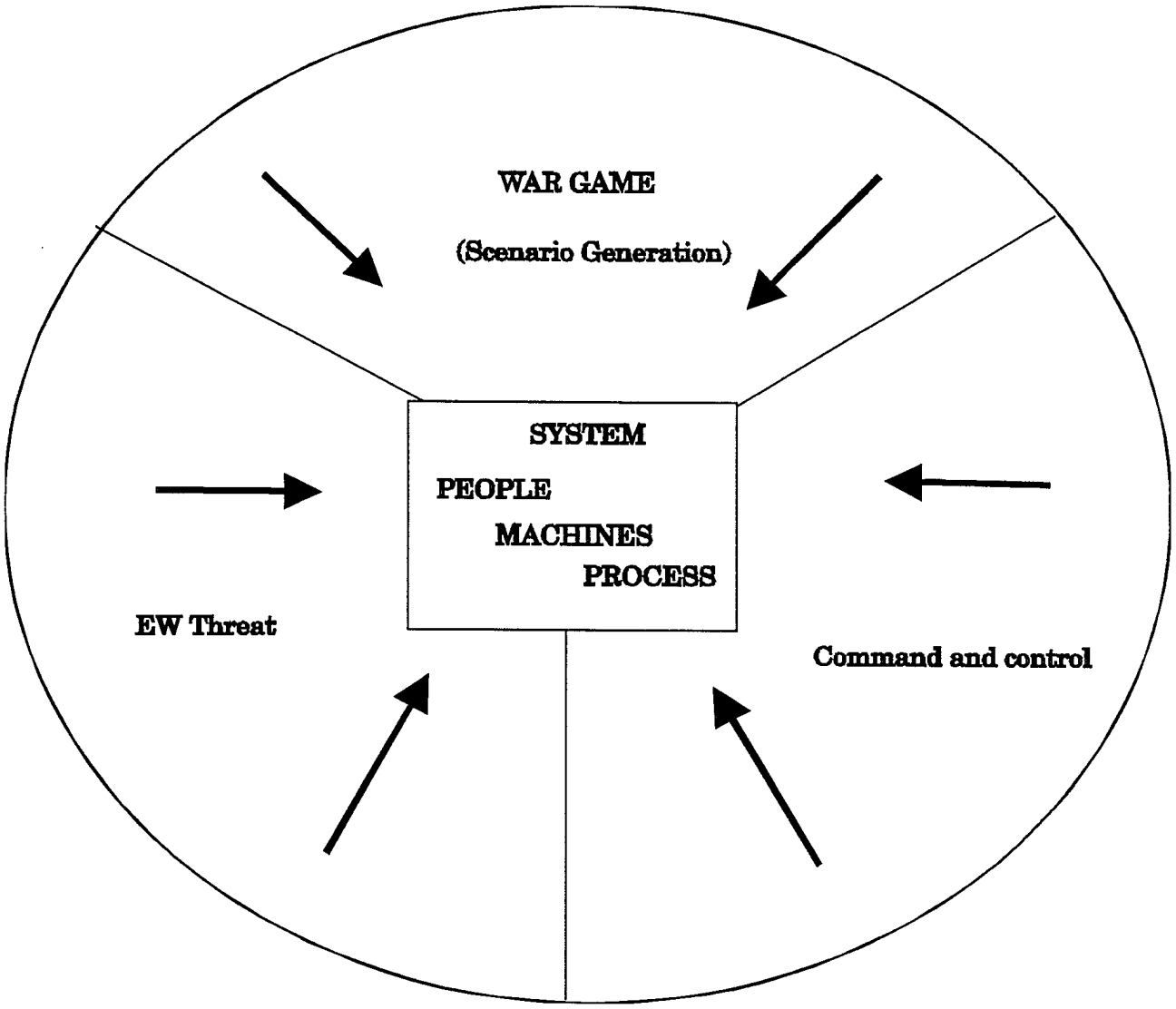

Figure 2 Electronic Warfare System and Environment

it would occur on the battlefield for a given type of conflict. For Electronic Warfare this means accounting for such factors as:

a. level of conflict (high intensity European model, medium intensity, and low intensity including guerrilla actions and civil unrest); and

b. the opposing force's:

(1) Order of Battle (ORBAT);

(2) radio and radar equipment;

(3) skill level; and

(4) doctrine.

To achieve this, the simulator must provide:

a. a high degree of signal, emitter and environment fidelity;

b. realistic opposing force doctrine and behaviour;

c. databases of known technologies and doctrines;

d. scenario generation and manipulation tools; and

e. facilities for the play and scoring of the exercise.

2.2 Command and Control

In computerized war gaming, the participants must be provided with a realistic command and control process. The command and control mechanism provides:

a. participants with information about the scenario and the means by which they react to events;

b. simulation of all missing elements in the normal command structure; and

c. facilities for monitoring, recording, scoring, and reacting to the actions of the participants.

The command and control function must also concern itself with the nature of the data to be passed between the entities listed above and the protocols (communications and message) for

passing the data.

2.3 EW Threat Modelling

Since the battlefield of an EW unit is the electromagnetic spectrum, the simulation system must present realistic signals (Communication and Radar) to the participants in accordance with the scenario. This presentation may be in the form of real, low-power signals delivered directly to the sensors or in the form of computer generated messages simulating the output of the sensors.

3 EW SIMULATOR PROTOTYPE

3.1 Design

The aim of the Land EW Simulator prototype was to simulate the environment around the EWOC. The EWOC is the main component of the EW unit and is responsible for processing the ESM data to produce an intelligence estimate of the battlefield situation. For the prototype, the three major functional capabilities (War gaming, Command and Control and EW Threat Modelling) were re-factored into the five functional areas below.

3.1.1 Scenario Generation

The EW simulation prototype system had to present credible scenarios to ensure that the training was realistic. To facilitate scenario generation the simulator had to provide, through a graphical user interface based on a map display, tools to allow the user to develop and record scenarios depicting the movement of any given opposing force and its associated electromagnetic emissions. Once the development of a scenario was completed, the user had to be able to save it as a template that could be recalled and modified as needed in the future.

3.1.2 RF Signal Generation

The battleground for an EW unit is the electromagnetic spectrum. EW sensors use electromagnetic energy to determine, exploit and/or reduce the enemy's use of the electromagnetic spectrum. It was, therefore, important that the prototype have the capability to generate, or simulate the generation of, RF signals in order to provide a complete picture to the system(s) being tested. For the prototype, these emissions are limited to conventional radio communications (clear voice and prerecorded signals). These simulated communications signals were produced using low power signal generators to provide a realistic signal environment for the intercept and monitoring components of the EW system.

3.1.3 Command and Control

During operation, all the elements of an EW unit are deployed over a large area on the battlefield. Command and control is carried out over the unit command net and tasking of the various sensors is done through the unit tasking net. These nets can use digital transmission equipment to provide a direct computer to computer data link. The command and control structure of the unit reflects the feedback-control-system nature of the EW process described earlier. The prototype simulator had to simulate the data link from the DF sensors and the command net between the EWOC and EWCC.

3.1.4 Exercise Scoring

The prototype simulator had to allow operators and analysts in the EWOC to perform their duties as if they were deployed on a real mission. To assess the performance of the EWOC personnel, the simulator had to provide a scoring mechanism based on a comparison between the situation estimate provided by the EW Squadron personnel and the actual ground truth from the scenario.

Because the scenario may include a high intensity of conflict with the resultant high level of activity on the part of the personnel under training, scoring had to be done automatically where feasible for each report/tasking sent which leads toward the final estimate of the enemy situation. Since human operators might do unexpected things, the system also had to provide the exercise supervisor with the ability to award/deduct points manually as appropriate.

The simulator had to include the ability to replay any exercise through use of an activity log keyed to the scenario in order to conduct post-exercise debriefing, student critique and instruction.

3.1.5 Realism and Reactivity

If the simulator were to play out the scenario without reference to the activities of the participants, the exercise would not be very realistic. At a minimum, the system had to react to the activities of the EWOC such as the placement and tasking of sensors.

3.2 Development

The EW Simulator was developed on a rack-mounted 80486 DX/2 PC running OS/2 and using GPIB controlled HP 8647A Signal Generators. It is connected to the EWOC through radio remotes and field wire and to the Intercept Receivers through a shielded RF antenna cable. A Computerized Audio Record and Playback (CARP) system, developed under DFACTT is employed to provide a mechanism for recording and playback of the audio portion of a scenario. The system employs a map-based user interface. Other functions include:

a. access to the database of existing scenarios;

b. lists of unit icons of the type familiar to EW operators with which to populate the scenario (and the map);

c. audio control features permitting recordings to be associated with emissions at set times and locations in the scenario;

d. controls for reviewing, editing and playing the scenario;

e. controls for scoring the exercise; and

f. controls for displaying the exercise for purposes of debriefing the trainees.

3.2.1 Scenario Generation

To develop a scenario, the user populates the map with units and assigns one or more emitters to each unit. The emitters are assigned initial frequencies, power levels and antennae orientations. The scenario is then built up by selecting a time and assigning activities to the emitters. The activities can include movements, emissions, and changes to any of the initial parameters. Emission events are tied to audio recordings which may be generated before the scenario is developed or during the development.

3.2.2 Command and Control and Data Links

The simulator provides the complete environment and effectively surrounds the EWOC. Thus all interactions which the EWOC may expect to have with its surroundings must be emulated. This includes both the sensors as described above and the EWCC. Thus, requests for information and other normal EWCC directives are generated by the simulator and the simulator is the natural recipient of reports and returns from the EWOC.

Algorithms which would allow the scenario to respond to active measures such as jamming or the actions of other friendly forces have not been implemented.

3.2.3 Scenario Playback and Control

Initialization of playback commences with the assignment of sensor elements to the EWOC. The EWOC personnel then issue movement and tasking orders to the sensors in accordance with their own directives, orders and doctrine. For purposes of appropriate generation of RF power levels, the EWOC must also report its own location. When an emission is scheduled in accordance with the scenario, a propagation path algorithm is used to calculate, using Digital Terrain Elevation Data (DTED), the appropriate RF power level which should have been present at the antennae of a sensor. This information is passed to the simulated DF sensor and to a process responsible for generating an RF emission. If the sensor has been tasked by the EWOC to listen to the emission frequency and, if the power level is sufficient for the sensors to have detected the emission, then an emitter location message will be sent to the EWOC.

For the intercept receivers, the simulator does not 'know' what frequency the intercept operators have been tasked to listen to. The simulator selects an RF generator to generate an RF emission with the appropriate frequency at the time specified by the scenario. The power level is calculated so that it is correct for the relative positions of the simulated emitter and the receiver with respect to the intervening terrain. The message to be transmitted is provided by using the appropriate audio recording to modulate the generated RF signal.

3.2.4 Exercise Scoring

Both internally generated and external message events are logged by the scenario for two purposes. The first purpose is to determine the score which the EWOC personnel will receive for their efforts. The second purpose is so that the simulator operator can playback the completed exercise as a means of debriefing the participants.

4 DEVELOPMENT METHODOLOGY

4.1 Development Environment

The development environment used for this project was Object Technology International (OTI) multi-user ENVY[1] Manager and ENVY Developer which supports rapid prototyping and team development of Smalltalk code.

4.2 Development Methods

In consonance with Smalltalk traditions and practice, the Simulator was developed using rapid prototyping techniques and employed extensive re-use of existing code.

The ENVY environment extends the traditional Smalltalk Class and Method hierarchy to include Applications and Sub-applications where an Application has much the same meaning as in traditional third generation languages and a Sub-application could be considered to be analogous to a software module. An Application may make use of other Applications and Sub-applications to provide additional or pre-requisite functionality.

A sensible measure of the degree of code reuse in a Smalltalk application, is to determine the functionality delivered by the reused code in proportion to the total functionality provided by the application. Using the Table of Contents from the EW Simulator user guide, 133 discrete user functions are provided. Of these, 32 were provided through re-use of existing capabilities without modification. A further 12 functions were provided through the use of modified versions of existing functions. In addition, 11 existing applications were used to provide underlying functionality including:

a. Audio Control;

b. GPIB Interface;

c. DTED Tools;

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[1] ENVY is a registered trademark of Object Technology International Inc.

d. Electronic Warfare Graphics;

e. Electronic Warfare Messaging; and

f. Communications and Networking.

The ENVY development environment was a substantial contributor to the rapidity with which the controlled development could take place. Approximately 270 person-days of effort were expended in the development of the final working prototype.

5 FIELD TRIAL

A joint field trial of the Prototype Land EW Simulator and upgraded DFACTT software and hardware was conducted during the period 17 - 28 October, 1994 with 2 EW Squadron and Reserve EW Squadron in Kingston. The first four days were spent transporting equipment, replacing existing equipment with the upgraded DFACTT equipment, configuring the systems and performing initial operability tests. The next three days were spent teaching personnel from both Squadrons how to use the equipment employing a short (2 hour) scenario.

An exercise was conducted on each of Wednesday and Thursday of the second week employing a scenario that ran for approximately 6 hours. On Friday, October 28, 1994, the squadron was debriefed by the DREO representative. The success of the exercise may be characterised by the informal request made by both squadrons to have the Simulator fielded as soon as possible.

6 CONCLUSION

The prototype is limited to simulating the environment around the Electronic Warfare Operations Center. It can currently be used to evaluate the effectiveness of the EWOC personnel and equipment. It also provides a platform to expand the concept to include other elements of the modern battlefield. The field trial validated the concept of a Land Electronic Warfare Battlefield Simulator and provided directions for future research.

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