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by

Janette D. Hooper and Derek Elsaesser

DEFENCE RESEARCH ESTABLISHMENT OTTAWA
TECHNICAL NOTE 91-11

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Janette D. Hooper and Derek Elsaesser
Communication Electronic Warfare Section
Electronic Warfare Division

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ABSTRACT

The Data Fusion and Correlation Techniques Testbed (DFACTT) is a platform on which to test new methods of data fusion and machine intelligence in the electronic warfare field. With the ability to operate multiple Smalltalk environments as well as independent tasks on a variety of VMEbus based devices, the DFACTT will provide an in-house facility at DREO to quickly prototype new ideas and technologies in the areas of sensor data fusion, parallel processing, and knowledge-based programming.

The phase I testbed developed under contract was interfaced to real EW sensors from 2 (EW) Squadron of the 1st Canadian Division Headquarters and Signals Regiment (CDHSR) for a field trial at Defence Research Establishment Ottawa (DREO), 14 Jan 1991. One station of the Communications Emitter Locating System (CELS) was connected for location inputs to the DFACTT, as were two WJ8617B receivers for radio intercept input. A scenario was developed and kept secret from those who were to act as operator and analyst on the DFACTT. Three radio networks formed the target for the DFACTT operators. The operators were to intercept and locate the emitters, track them, and determine the objective of the scenario.

Valuable information and experience was gained by using the actual field sensors as input to the system and by operating under field conditions.

RÉSUMÉ

Le Banc d'Essai pour la Fusion des Données et pour les Techniques de Corrélation (BEFDTC) a été conçu pour tester de nouvelles méthodes de fusion des données et d'intelligence artificielle dans le domaine de la guerre électronique terrestre. Le BEFDTC permettra d'utiliser simultanément plusieurs environnements Smalltalk et d'effectuer des tâches indépendantes sur différents appareils utilisant un bus VME. Le BEFDTC permettra d'évaluer rapidement, au Centre de Recherches pour la Défense, Ottawa (CRDO), des prototypes basés sur des idées et des technologies nouvelles dans le domaine de la fusion des données, du traitement parallèle de l'information et de la programmation basée sur des hypothèses.

Developpée en sous-traitance, la phase I du BEFDTC fut mise à l'essai avec des signaux provenant des capteurs de l'Escadron 2 (Guerre Electronique), Quartier général et Régiment des transmissions, 1ière Division canadienne, lors d'essais sur le terrain au CRDO le 14 janvier 1991. Deux récepteurs WJ8617B et une station du Système de Localisation d'Emetteurs de Communication (SLEC) furent branchés au BEFDTC, lui fournissant des interceptions radio et des données localisant les émetteurs. Un scénario fut établi à l'insu des opérateurs et des analystes du BEFDTC. Les opérateurs du BEFDTC avaient pour cibles trois réseaux de transmissions radio. Les opérateurs devaient intercepter, localiser et suivre les déplacements des émetteurs et, finalement, déterminer les objectifs du scénario opérationnel.

L'utilisation des véritables capteurs de l'armée comme source de signal ainsi que la participation à des opérations sur le terrain ont permis d'acquérir une expérience et des informations précieuses.

EXECUTIVE SUMMARY

The aim of the Data Fusion and Correlation Techniques Testbed (DFACTT) project is to design and implement software architectures and communications sensor information analysis and correlation algorithms suitable for a multiprocessor system. The system will act as a testbed for algorithms to be used by the land electronic warfare control and analysis system to be implemented under project L2066 and to be upgraded under project L1246.

Electronic Warfare Support Measures (ESM) analysis and control techniques are used in EW to provide enemy situation information and immediate threat warning to the commander. The information comes from assimilating sensor data from EW sensors: direction finding equipment, intercept receivers, radar intercept and location systems. Analysis techniques (multisensor fusion) will automate, to some degree, the process of information assimilation. Control techniques are also required to effectively steer the sensors to provide the answers to questions raised, or to confirm hypotheses raised during the assimilation process.

The main areas of technical difficulty are correlating the information from the different sensors to determine which sensor reports pertain to the same emitter, determining net type and unit identification from incoming sensor data, and determining the most efficient storage method for data and processor allocation for work to be done.

The phase I DFACTT has the following capabilities:

Background map grid and scanned map
Foreground overlays of symbology
Input of CELS data over radio link
Input of received radio intercept data over Ethernet link
Multiple access to a database of sensor information
Report and tasking generators

The field trial uncovered many weaknesses in the DFACTT and suggested many areas where improvements are needed. The blue team (operating the DFACTT) was unable to determine the objective of the red team (operating the radio networks); this was primarily due to the fact that the blue team members were not skilled intercept operators and were forced to use manual methods when the automated links into the DFACTT broke down.

The main area of improvement required is a graceful degradation capability so that backup methods of data entry are readily available. More attention is also to be paid to the operator control of the intercept receivers for search purposes.

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1.0 INTRODUCTION

1.1 Aim

The aim of the field trial was to use the actual Communications Emitter Locating System (CELS) data output and radio links to test software for communications EW sensor information input and analysis that is implemented in the phase I Data Fusion and Correlation Testbed Techniques (DFACTT). The objectives of the field trial were as follows:

- Test Multiple Entry Read-Out Device (MEROD) communications link from CELS master to DFACTT over RT-524 radio
- To determine if system data storage capacity is adequate under realistic input conditions
- To record a replayable, realistic scenario
- To demonstrate that the DFACTT is operable in a field environment
- To determine effort necessary to mount equipment into vehicles.

1.2 Background

ESM analysis techniques are used in electronic warfare to provide enemy situation information and immediate threat warning to the commander. The information comes from interpretation of the incoming sensor data from EW sensors such as direction finding equipment and radio intercept equipment. Assessment and interpretation of the incoming information done manually can produce information that is not always timely. Analysis techniques will automate the interpretation process to an extent to be determined. Control techniques are required to effectively steer the sensors in order to provide the information required to substantiate the interpretations of the analysts. The control techniques combined with the analysis form a feedback control system; in this system the incoming information drives the analysis, producing steerage for the sensors to provide information.

When more than one type of sensor is involved in the interpretation to produce the estimate of the enemy situation, some form of multisensor fusion is taking place. The data from different sensor types must be combined or fused in some way to support or reject the current estimate of the situation. In EW, the sensors are communications emitter location systems and intercept receivers, as well as radar identification and location equipment. The data that must be fused includes: emitter locations and location error, conversations, emitter identities, and terrain/weather information.

The DFACTT is being developed in an iterative manner to perform sensor fusion on incoming information from the EW sensors. The phase I DFACTT was assembled for a field trial on 14 January 1991.

1.3 Scope

This report outlines the functions available in the phase I DFACTT, details the field trial undertaken with the DFACTT, and describes the planned upgrades based on experience from the trial.

2.0 FUNCTIONS OF FIELDED SYSTEM

The DFACTT helps the analysts and intercept operators work together to produce situation assessments and responses to requests for intelligence. Analysts task operators of sensors and the sensor information returns to the analyst. As long as the sensor results are useful to the analyst, the task continues. The sensor operators are given a number of prioritized targets so the sensors can be used at all times. In order to operate most efficiently, both the sensor operators and the analysts must have efficient support tools. The workstation environment developed for each one attempts to maximize the output of information.

The phase I DFACTT provides software that aids the analyst and intercept operator so that the analyst has more time to analyze the data and the operator can concentrate on entering the important message information and callsigns.

The operator's main duties are to locate and monitor enemy radio transmissions. These functions are performed by scanning through the spectrum using receivers such as the WJ-8617B VHF receiver. Once a transmission has been detected the operator enters all pertinent information such as time, radio frequency, signal strength, bandwidth, modulation, and the text of the message into the operator workstation. The primary user interface on the workstation consists of a window containing an automated intercept report form which automatically updates the following fields: time up, time down, frequency, signal strength, bandwidth, and modulation type. The operator must then enter the callsigns and message text. The operator can use menus or function keys to control the VHF receivers, to switch between participants in a conversation or to save a conversation. When a conversation is saved, it is automatically sent to the DFACTT database for use by the analysts.

The operator interface in phase I is implemented on a remote PC and is tied to the DFACTT chassis via an Ethernet communication link. This link is transparent to the users. The operator also has control of one WJ-8617B intercept receiver. The control is done transparently over the Ethernet and through the General Purpose Interface Bus (GPIB) card located in the DFACTT chassis and connected to the receiver. For the field trial, another receiver was available but only under manual control.

Automatic input of the intercepted conversations into the analyst's database leaves the analyst free to analyse the data. The analysis shows up usual patterns of activity and allows the analysts to determine the battlefield situation.

The analyst workstation is equipped with a mapping user interface with overlays, an EW database (containing dynamic situation information from EW sensors), a report generator, and control interfaces to the other elements.

The DFACTT displays and allows interactive use of detailed topographic maps that have been scanned digitally and are stored in memory and on disk. The map acts as an interface to a spatial database so that any information that can be geographically referenced can be retrieved using a pointing device on the displayed map. The following features are available to the analyst using the on-screen map:

- Place and move symbols on the map (representing communications nodes and units)
- Choosing a symbol on the map returns databased information about the object
- Seamless database of maps for an area, but if maps aren't available then the background is some neutral colour and overlays still work
- Smooth pan out the sides of the on-screen map window using a pointing device
- Change of map scale (1:25 000, 1:50 000, 1:250 000 supported) but if no scanned map of appropriate scale is available, the neutral background is used

A real-time interface to the map is provided to accept radio direction finding (DF) data from the Communication Emitter Location System (CELS). Individual DF locations are displayed as dots overlaid on the topographic map. Using the interactive functions of the system, the analyst can then select multiple dots (DF location message symbols) and indicate that they are a cluster representing the same emitter.

The database for storage of the dynamic EW sensor information and developed battlefield situation data contains the following information:

DFLocationMessages (emitter locations from DF equipment)

ClusteredLocations (grouped emitter locations with average location as center)

Conversations (information from radio intercept)

Elements (pieces of formations or units that can be recognized by EW)
- CommsNodes (radio emitters)
- RadarNodes (radar emitters)

Networks (groups of communication nodes)

Units (identified entities on the battlefield)

The analysis process provides multi-sensor fusion. Multi-sensor fusion is the process of taking information about the same situation from different sensors and using the correlations between the information to confirm what the situation being observed actually is. The synergism gained by using this correlation of dissimilar incoming information allows the whole of the information gained to be more than just the sum of its parts.

Once emitters have been located, other details in the DF data can be used to determine networks. If the DF system has, over a continuous period of time on the same frequency, located several distinct emitters, they are likely communicating over the same network. The analyst can generate a Network object and assign the appropriate Conversations and ClusteredLocations (or DFLocationMessages) to it.

The other functions of the analyst are sensor steerage and report generation. For sensor steerage, the analyst has tasking browsers which he uses to inform intercept operators as to which frequencies they are to monitor. For report generation, the information gathered and generated by the analysis process can only be communicated to appropriate users by producing hard copy output of intercepted conversations.

2.1 Scenario

The scenario for the field trial is detailed in the appendix. The basic idea was that a red team was to transmit over the radios as they approached and secured their objective while a blue team operating the DFACTT was to determine their network structure and objective. The red team was composed of two squads and a command post with three radio networks interconnecting them (the two squad networks and the command network). The blue team was composed of an operator, an analyst, and a DF sensor operator and relied on the intercepted radio communications and the DF location data to determine what the red team was doing.

The DF location data was entered manually because only one of three required DF stations was available to DREO for the trial. (Only lines of bearing could be taken on active emitters). Thus, the red team did not actually go out on the scenario, but sat in one place and played through the script of the scenario as written in the appendix, over the appropriate radio. The DF sensor operator knew the script, and once the blue team had tasked the DF with the correct frequency for any of the networks, would send to the DFACTT the appropriate location data at the correct time to correspond with the transmissions that were to occur on the networks.

2.2 Events During the Trial

This section chronicals the events of the blue team inside the vehicle containing the DFACTT (called Forward EW Operations Center or FEWOC) during Field Trial Frigid Fact on 14 Jan 1991.

2.2.1 Preparation for Trial (10h00)

- Both vehicles were started so equipment could warm-up.

- The DFACTT was powered-up, four attempts were required before both analyst and operator stations were operational.

- A radio check was conducted between CELS and FEWOC for the MEROD data link and voice communications.

- The simulated CELS feed to DFACTT was tested, some problems were encountered and corrected.

- The analyst work station was set-up for start of trial, correct map was displayed with an empty database.

- The operator station was set-up and tasked to search the frequency ranges: 120 - 180 MHz and 400 - 500 MHz which contained the three communications networks (nets) used in the trial.

2.2.2 Start of Trial (11h15)

- Both analyst and operator began searching the assigned frequency ranges.

- Search was done by manually tuning through the frequencies using the two WJ-8617 receivers (only one of which was connected to the DFACTT) and listening for a "military" conversation.

- No actual use of DFACTT was made at this point.

2.2.3 Operational Problems Encountered (11h45)

- Operational difficulties became apparent. This included the cramped conditions, the awkwardness of the positioning of the receivers, and the difficulties in manually intercepting communications on unknown frequencies.

- The three networks used in the trial each represented one channel out of a possible 6000 and were active for approximately ten minutes in each hour. It took an average of five minutes to scan the frequency range listening for about five seconds to each active transmission. This resulted in a Probability Of Intercept (POI) as follows:

  Probability net is active:
  P1 = 10 minutes/1 hour = 17%

  Probability receiver tuned to net:
  P2 = 5 seconds/ 5 minutes = 2%

  Probability of intercepting a net:
  POI(net) = P1 * P2 = 0.28%

  Probability of intercepting any net during trial:
  POI(trial) = 3 nets * POI(net) = 0.84%

- The extremely low POI became evident about 30 minutes into the trial. This increased the level of frustration experienced by the team.

2.2.4 Technical Problems Encountered (12h00)

- One network was intercepted (by luck) at which time the following occurred:

  It was immediately evident that it is very difficult to type in the gist of a message which is transmitted in a cryptic fashion using only code words.

  A recording facility is required so that a message can be replayed several times to extract sufficient information to produce a useful intercept message.

The receiver parameters (frequency, bandwidth, etc) were automatically read into the intercept message browser, but when the message was saved to the DFACTT database the operator workstation crashed. The message was lost and the operator workstation had to be re-booted.

- A priority DF request was made to CELS by voice over the RT-524 VHF link. A DF location was quickly sent back over the MEROD data link and appeared in the database and on the analyst display.

  This was about the same time the intercept report was saved. Two error windows appeared on the analyst station. After the error windows were closed the analyst station appeared to be working normally; however, the intercept station could no longer save messages to the DFACTT and DF messages over the MEROD were no longer accepted.

- DF location messages on the intercepted network continued to arrive. The trial coordinator, recognizing the difficulty the team was having with search operations, also began sending DF location messages on the other two nets. This gave the team the other two frequencies of the trial.

- Now the team was faced with the problem of information overload for the following reasons:

  Since the DFACTT would no longer automatically accept DF messages they had to manually plot them on a paper map.

  An attempt was also made to enter them directly into the DFACTT database. Since there was no convenient way of doing this the attempt was unsuccessful and only aggravated the situation.

  Although all three network frequencies were known, there were only two receivers available. The team was far too busy to effectively continue intercept operations.

  The team resorted to recording all information on paper, abandoning the use of the DFACTT.

2.2.5 Termination of Trial (12h45)

- It became apparent that the team could not achieve its objective of analyzing the situation. The technical problems experienced by the DFACTT, although small, rendered the system useless.

- It was decided to terminate the trial.

3.0 RESULTS

This section discusses many of the problems encountered during the trial by the blue team and the deficiencies of the DFACTT. The operational aspect of the system, the way it is used, and technical problems encountered are examined.

3.1 Operational Considerations

Many important facts were learned during the trial. Some of these involved the methods of EW operations as well as the technical capabilities of the DFACTT. The operational considerations are of great value as they greatly affect the way the DFACTT would be used in the field. The operational understanding gained in the trial will play a significant role in the future development of DFACTT.

3.1.1 Distribution of Duties

Intercept operators generally work in one vehicle and the analysts work in another. They both possess the same skills. They may take turns performing intercept and analysis. One of the reasons they are located separately became quite evident during the trial. The functions of the intercept operator are quite different than those of the analyst. The intercept operator must be free to concentrate on listening to radio traffic and producing intercept messages. The analysts, on the other hand, must assimilate many forms of information, analyze it, and estimate the battlefield situation. When the two are performed together in the limited space of a single shelter they tend to interfere with each other. Although this may have been caused by the inexperience of the blue team it did demonstrate the need for separation of the two duties.

3.1.2 Priorities of Operations

An important concept that was clearly demonstrated during the trial was the priority in which the EW operations are carried out. At the start of the trial the only knowledge of the red team was the wide range of frequencies in which they were operating.

The first priority was to locate and identify which frequencies were being used and how many nets were involved. This made the search operation the top priority. It was the only action possible at the time since no data was available for analysis. The very low probability of intercept involved made this operation the most difficult. During the first half of the trial both blue team members conducted a manual search of the spectrum looking for a "military" conversation.

When the first conversation was intercepted two actions had to be performed immediately, recording the message and tasking the DF. Recording of the message was the responsibility of the intercept operator. The automation provided in the operator workstation required only the message context to be manually entered. DF tasking, however, required that the analyst quickly identify the frequency used and call the DF master station using the VHF voice link. A DF location message was returned over the MEROD data link. The time between detection of the transmission and the execution of the priority DF request was critical in locating the emitter while it was still active. At present there is no facility in the DFACTT to automatically task the DF.

Once intercept and DF data became available it was possible for the analyst to begin analyzing the situation. Although the DFACTT experienced technical problems at this point the trial was continued. The locations of the emitters were plotted manually on the wall map of the area and an attempt was made to analyze the actions of the red team. This also included the use of the message content of each transmission.

The operator now had two duties to perform, monitoring of the located frequency and search for other nets. While only one frequency was known the operator could leave one receiver tuned to it while manually searching with the other. A loud speaker was used on the monitor receiver while the operator used a headset for searching. This did not work well as the operator had to listen to two receivers at once while conducting search. This clearly showed the need for some form of automatic signal detection on the monitor receiver that could alert the operator.

Once all three net frequencies became known the operator was faced with a new problem, how to monitor three frequencies with only two receivers. The solution was to use one receiver to switch back and forth between two frequencies. Again, this multiplexing could be performed automatically.

After all the nets had been located the remaining priority was to analyze the actions of the red team and determine their status and plans. This is the point at which the DFACTT was to play the largest role, however the technical problems encountered prevented the intended use of the DFACTT. As a result the trial was terminated.

3.2 Technical Problems

A number of technical difficulties were encountered during the trial. Those that led to the failure of the DFACTT were caused by software problems in the interfaces with the CELS and operator workstation. Many of the other difficulties experienced during the trial occurred because the system did not provide the necessary support functions for a real situation. The following is a short description of technical problems that became apparent during the trial.

3.2.1 CELS-DFACTT Link

The CELS - DFACTT link used to automatically feed location messages from the DF master station into the DFACTT database is shown in Figure 1. The VHF radio link using the MEROD RF burst modems to send data is standard military equipment and very reliable. To use this link to automatically transmit data two interfaces had to be added. A hardware interface to connect a serial port to the MEROD so that it could be remotely controlled by a computer and the computer software interface. The hardware interface was relatively simple to design and build and worked well during the trial.

The problems encountered with the link were caused by the software interfaces at both ends. It was not possible to implement the interface to the actual CELS PC without modifying its software. As a result another PC was used to simulate the CELS output. To transmit a message using the MEROD a number of steps must be performed to control the MEROD. This was done using a software interface in both the simulated CELS PC and the DFACTT. This interface will have to be more robust and transparent if the CELS link is to be made transparent to both systems. The problem that caused the link to fail during the trial was determined to be a formatting problem in the location message generated with the CELS simulator PC. A space character in the wrong place caused an error in the message parser in the DFACTT which prevented it from accepting messages over the MEROD link. Further refinement of this software will prevent this problem.

3.2.2 Operator Workstation

The operator workstation is connected to the DFACTT computer via an Ethernet connection. The problem that occurred during the trial preventing communications between the workstation and the DFACTT was found to be a software problem in the TCP/IP communications server in the DFACTT. This problem has since been corrected. It is not known why the pre-trial testing did not uncover this problem but does

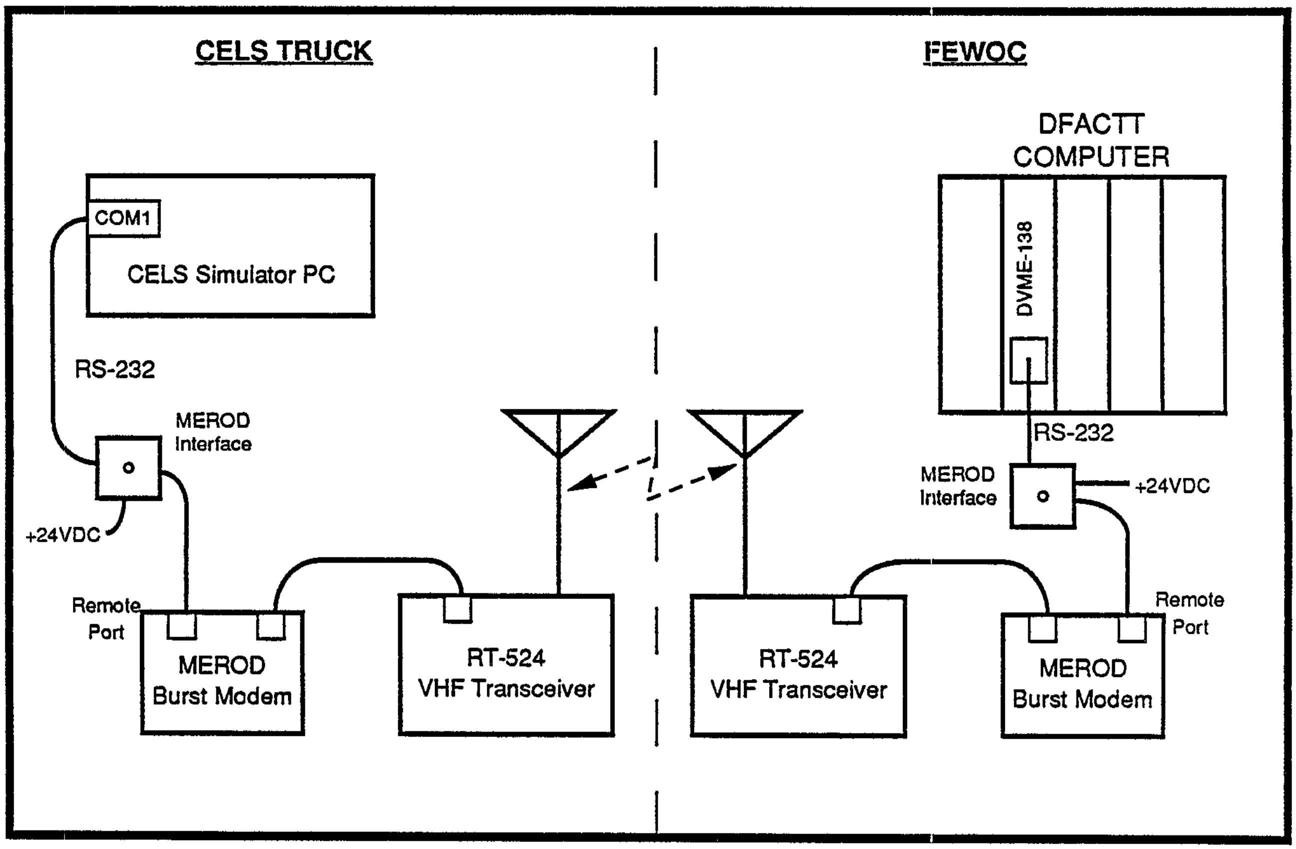

FIGURE 1: Automatic CELS-DFACTT Data Link

suggest that more extensive testing be performed on the system before another field trial is attempted.

3.2.3 Intercept/Search Operations

The intercept operator workstation has the capability to automatically read in all receiver parameters and requires only the message context to be entered. It does not, as yet, provide any tools to perform automated search operations. It was apparent during the trial that manually searching the RF spectrum for target signals is a very difficult and time consuming operation. Automating this procedure will greatly improve the Probability Of Intercept (POI) thus improving the overall effectiveness of the EW operation.

3.2.4 Fault Tolerance

The two problems that occurred during the trial could have been alleviated had the system been more fault tolerant and provided graceful degradation. Both failures occurred in the communication links. The location messages were still being successfully transmitted from the CELS to the DFACTT vehicle where they were received on the MEROD. The only problem was that the DFACTT would not automatically read in these messages. Had a method for manually entering the messages been provided on the DFACTT it would have been possible to continue the trial. The same holds true for operator link. As communications are inherently one of the most vulnerable links in any military system this is an area that will require further development.

4.0 LESSONS LEARNED

The hardware problems with the DFACTT pointed out that more attention must be paid to graceful degradation of the system so that the DFACTT can be used (if less conveniently) even if automatic links fail. Problems occurred in the DFACTT vehicle when the DFACTT stopped automatically accepting the incoming CELS data and the conversation data from the intercept operator workstation. The blue team were quickly overcome by the deluge of incoming information when they had to revert to manual methods (neither of the members of the blue team were trained, as operator nor analyst).

The problem of searching for targets of interest pointed out the need for automation of the search function on the operator workstation. It also pointed out the desirability of being able to record audio information as it is intercepted so that it can be replayed. The blue team managed to locate one of three networks of interest, but only by recognizing the voice of one of the red team members. The blue team was told that the networks of interest were located within blocks of 100 MHz. They thus had to search manually on the receivers over these 100 MHz blocks and try to determine which were of interest. There is no automation of this function in the phase I DFACTT, but this turns out to be a critical support function.

The members of the team should not feel that they cannot call off the trial at any time if something catastrophic has happened. More could have been proved about DFACTT operation if the blue team had called for a re-start so the DFACTT could have been re-booted. They felt pressure to continue to operate using manual methods so we learned a lot about the need for graceful degradation instead.

Training or at least practice is required for the blue team before a trial such as this. Operators were at a loss to interpret some of the military jargon used in the scenario because they had never been exposed to it before. It is necessary to use such jargon in order to test the system realistically, so the operators must practice. If the audio could have been recorded, blue team confirmed that they could have understood by replaying the intercept.

The scenario will be useful when entered as a file for the DFACTT simulator so that the same scenario can be played as new features are added to see how and if the features aid in the analysis. The scenario generated for the field trial is a valuable resource as it gives a continuous (120 minute) input for the DFACTT that has the conversations and locations correlated correctly. It gives a basis with which to test the automated features.

The automatic transmission of data from the CELS master vehicle worked. The DF location data was successfully transmitted over a radio link from the CELS master to the vehicle containing the DFACTT.

DFACTT system database capacity was studied and the following details were learned:

1) DF Messages

Each CELS DF Message uses approximately 300 bytes of storage. A brief traffic analysis of the CELS shows that with 60 locations per minute being generated, for total information generated of 18 Kbytes per minute, the DF master could generate 25 Mbytes per day of locations if operating continuously. In a more likely scenario, the CELS would produce the 60 locations per minute only while targets of interest were operating. If there are targets of interest operating 25% of the time, only 6.25 Mbytes will be generated per day.

In any case, it will be necessary to reduce the number of CELS DF Messages kept in memory. This can be done by storing to disk the CELS DF Messages that make up ClusteredLocations once the clusters are defined, and keeping only references to the stored messages in memory.

2) Intercept Messages

The following storage requirements for Conversations have been determined through experimentation:

Single Intercept Message, No textual data : 650 bytes
Single Intercept Message, 40 bytes Text : 700 bytes

Two Intercept Messages, No textual data : 900 bytes
Two Intercept Messages, 40 bytes text/msg :1000 bytes

Conversation Storage Size Formula

storage Size (bytes) = 400 + (250 * n) + (n * (t+10))

where: n = number of intercept messages
t = average number of bytes of intercepted text in all intercept messages contained in conversation

Using some estimated figures, the following is a brief traffic analysis for the operator-analyst link:

Each operator can produce 2 conversations per minute (peak output). If it is assumed that they average 100 bytes of text each, a worst case output over the network of 1 Mbyte/day per operator can be expected.

In order to store data on-line for 1 battlefield week (7 days at 24 hours), 7 Mbytes of memory per operator will be required. The trade-off is thus between number of days storage available on the system and number of operators producing information. With 3 Mbytes of storage and 1 operator as available on the DFACTT, data from 3 days (each at 24 hours) can be stored.

The decision must be made at some point to store some conversations to disk, with references available to retrieve them as necessary. This function shall be a parameter of the system, so the storing to disk can be done automatically.

5.0 REQUIRED ENHANCEMENTS (PHASE II)

1. Analyst Workstation

   a. MEROD RF modem interface to send and receive data

      i. CELS data
      ii. ASCII files (i.e. reports, conversations from operator)

   b. Store reports as ASCII files on floppies/send over serial port

   c. Graceful degradation

      i. Automatic CELS input (assume correct format, ending in unique character)
      ii. Automatic LOB input and display (prompt for CELS vehicle location)
      iii. Manual CELS data input browser
      iv. Manual LOB data input
      v. Automatic Ethernet connection to intercept workstation
      vi. Automatic serial message (conversations, control) input
      vii. Serial WJ control (rather than Ethernet)
      viii. Manual message input browser/prompter
      ix. Store corrupted input messages and provide browser rather than having error windows

   d. Time synchroniser procedure to synchronize operator/analyst with CELS

   e. Save database to disk
      i. entire database
      ii. DFLocationMessage objects with references in clusters
      iii. Conversations with references as necessary

   f. Automate analyst workstation start-up

   g. Report browser (TACREP format, 60 columns max)

      i. choose classification
      ii. add conversations chosen from list
      iii. add DF information related to chosen conversations
      iv. add network information related to chosen conversations
      v. include references to files containing audio info

vi. add unit info available
vii. produce on printer, in a file, send over serial, send ethernet as e_mail

h. SCSI Interface for disk drives

i. Tasking browser to task intercept

    i. containing specific target frequencies
    ii. containing target frequency ranges

j. Tasking browser for DF from analyst over MEROD link

k. Serial keyboard interface

l. Ethernet hardening

m. Correlation of messages with DF

    i. time and frequency correlation
    ii. connection of callsign to location/generation of node
    iii. annotate map with callsign of node

n. Network graphics functions

    i. generate networks based on correlations
    ii. show connections graphically between nodes
    iii. annotate map with network name
    iv. time compression function to allow analysis of locations over time
    v. show network traffic level graph versus time

o. Map declutter functions

    i. choose groups of objects to display
    ii. choice of groups based on time
    iii. choice of groups based on frequency
    iv. location history of chosen object(s)

p. Unit entry browser that allows entry of either enemy or friendly units to be displayed on the map in normal military symbology. Database should track location history

q. Graphic drawing capability on maps for arrows (axis of advance), forward edge of battle area (FEBA), lines, circles, squares, and text annotation

r. Communications hardware/software for accepting remote operator input

s. Elevation data correlation with scanned map

t. Templating interface

   i. template input via map
   ii. template overlay on screen
   iii. chosen area correlation with database data
   iv. generate tasking for DF/operators based on correlation

u. Map Gazeteer of place names (linked to map)

v. Linguist's dictionary browser/nicknames browser

   i. language dictionary
   ii. partial-word lookup
   iii. access to pronunciation through audio server

w. Map functions

   i. maps scanned at several scales of Ottawa, Kingston
   ii. multiple maps onscreen (i.e., at corner of 4 maps)
   iii. maps stored in memory (RAM disk)
   iv. maps stored on disk

2. CELS Interface

   a. Prompters for location data to be entered on PC

   b. Prompters for LOB data to be entered on PC

   c. Redirection of printed CELS data or manually entered data through PC and MEROD

   d. Accept tasking messages on PC from DFACTT through MEROD

3. Operator/Search Workstation

   a. Startup from floppy

   b. Graceful degradation
      i. output each conversation to a text file on floppy
      ii. manual generation of text reports (i.e., WP)
      iii. Serial link to DFACTT in event of Ethernet crash

iv. Totally autonomous mode using (i).

c. GPIB hardening

d. GPIB local board in PC

e. Intercept Message Browser redesign to allow:
   i. Time Up update via function key
   ii. Use of tasking information

f. Tasking browser integration

g. Frequency management tool

In order to relieve the operator of the mundane task of manually tuning the receiver through a range of frequencies to detect a transmission of interest, a computer controlled spectral search facility will be incorporated into the DFACTT. This facility will be invoked from the operator terminal. The operator can then specify the frequency range to be scanned or can task the computer to monitor a number of known frequencies for any activity. The computer will then take control of an unused receiver and perform the desired search automatically. It will record the exact center frequency, signal strength, and time of any activity it detects in its assigned range, as well as recording the audio on the digital audio server. The computer can also be instructed to avoid (only check occasionally) any of a list of frequencies. It can also be instructed to immediately notify the operator of the detection of a transmission on a priority frequency and automatically tune the operator's receiver to it if so desired.

This facility will allow each operator to monitor a larger frequency range or a greater number of emitters and to capture a larger portion of the transmitted message. It will also allow one operator to act as a search operator, and to hand off frequencies of interest to other intercept operators by using the available tasking browsers. The following facilities must be incorporated into the DFACTT:

i. search through range of frequencies and record activity
ii. search through specified frequencies and record activity

iii. allow designation of non-interesting frequencies to ignore (check every 10 minutes so can be sure)
iv. any mix of (i) and (ii)
v. control spectrum analyser to do new energy alarm
vi. show spectrogram of frequencies

4. Digital Audio Server

a. Design system to allow digital recording of audio information

b. Design and build audio cross-switch to connect operators/analysts to any of the receivers or channels of the audio server

c. Allow remote access of the digital audio server by operators and/or analysts for both storage and retrieval

6.0 CONCLUSION

The field trial showed several areas where DFACTT phase I required improvement and was thus a valuable exercise.

The MEROD communications link from CELS master to DFACTT over the RT-524 radio worked well and allows transmission of digital data from a PC with appropriate serial interface over the link.

The system capacity is adequate under realistic input conditions, provided that raw data is regularly stored to disk.

A replayable, realistic scenario was recorded for future use.

The DFACTT is operable in a field environment, but testing with a field power supply such as is used in the CELS vehicle is mandatory before being sure.

The effort necessary to mount equipment into trucks is manageable.

7.0 REFERENCES

[1] Hooper, J., Elsaesser, D., 'Data Fusion and Correlation Techniques Testbed (DFACTT): System Functional and Technical Description', DREO Technical Note 24-90, Dec 1990, UNCLASSIFIED

[2] Graham, I., 'Data Fusion and Correlation Techniques Testbed Development Map Study', Software Kinetics Limited Document No. 1600-73-019 Version 01, Contract W7714-9-9367/01-QD, January 1991, UNCLASSIFIED

8.0 ACKNOWLEDGEMENTS

Thanks are due to the personnel of Software Kinetics Limited, John Perrin, Ian Graham, and Patrick Lapensee, who prepared DFACTT for the field trial and made sure it was well installed in the vehicles. Thanks also to 2 (EW) Squadron personnel who provided useful comments on the phase I system, and provided the vehicles for the field trial.

APPENDIX

A1.0 Equipment Configuration

The field trial used two vehicles supplied by 2 (EW) squadron 1st Canadian Division Headquarters and Signals Regiment (CDHSR). The first vehicle is designated as the Forward EW Operation Centre (FEWOC) and was used to house the DFACTT and the blue (EW) team for the trial. The other vehicle involved was a Communication Emitter Location System (CELS) vehicle which was used to transmit simulated emitter locations to the FEWOC. The trial was conducted from the CELS by the red team leader who was also the trial coordinator. The two vehicles were located about 50 meters apart and communicated only by VHF radio. This is shown in Figure A1.

A1.1 Forward EW Operation Centre (FEWOC)

The FEWOC was used to house the DFACTT with one EW analyst station, and one intercept operator station. One of the aims of the trial was to evaluate the DFACTT under "field conditions". It was important to mount the equipment in a vehicle to determine the logistics for doing so and the effects the space constraints had on operation. This section describes installation of the DFACTT into the FEWOC.

A1.1.1 Shelter Layout and Equipment

The layout of the FEWOC shelter is shown in Figure A2. It included the following equipment:

- one (1) RT-524 VHF transceiver
- 24 VDC supply for RT-524 transceiver
- one 19" shock mounted equipment rack equipped with:
  - one (1) HF intercept receiver (not used)
  - one (1) WJ-8617A intercept receiver (No GPIB)
- heater, mapboard, interior lighting, and antenna mountings

The FEWOC shelter did not have an internal 110VAC. This required that AC power be fed to the vehicle from a nearby building. The only major modification made to the shelter was to rotate the 19 inch rack 90 degrees to face the door. This was easily achieved by removing 3 bolts. However, it was not possible to securely fasten the rack in the new position, thus it would not be safe for transport in this configuration.

Two antennas were borrowed from the CELS vehicle. A 2 meter ground-plane antenna was used for the RT-524, and 3

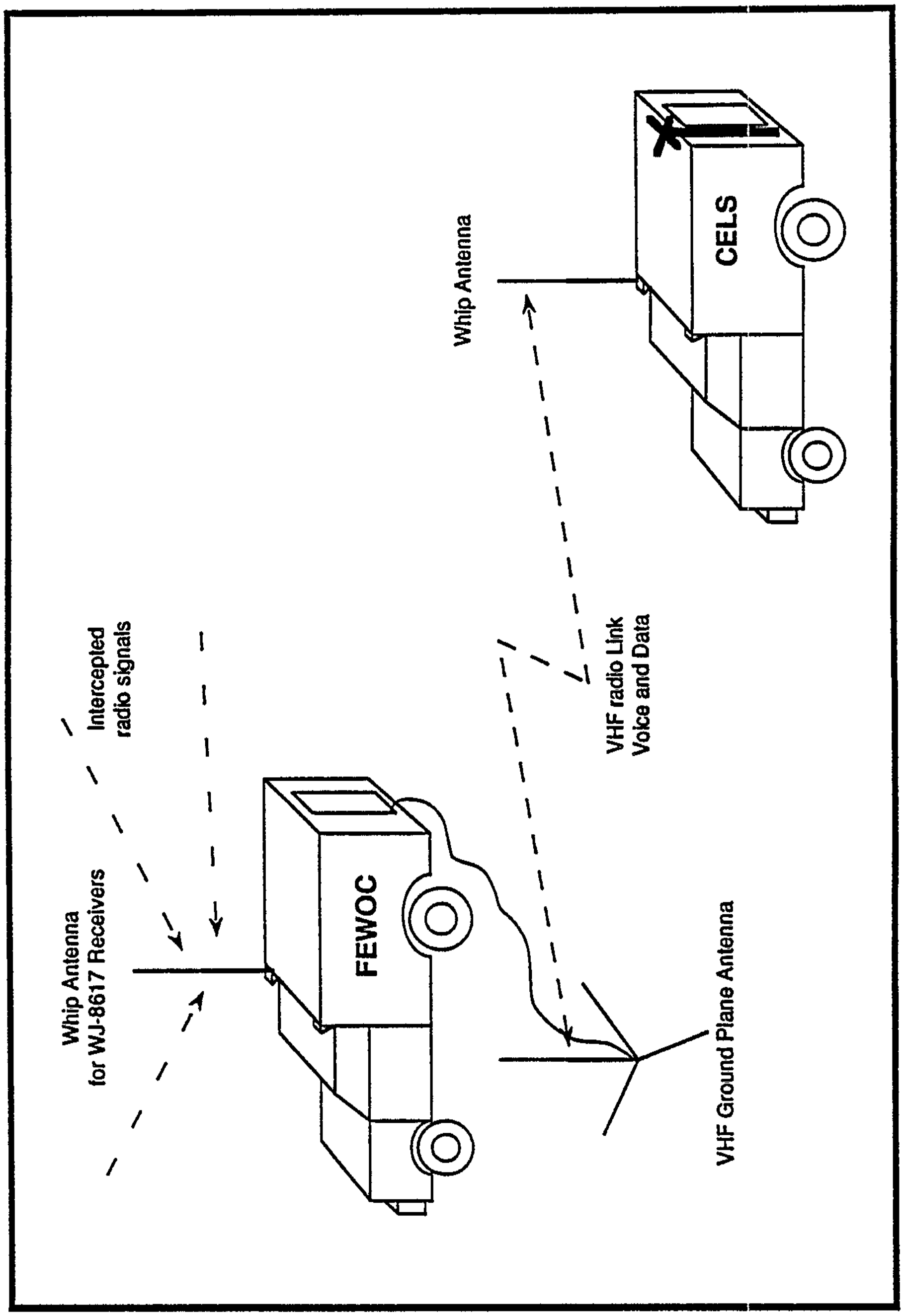

FIGURE A1: Vehicle Configuration

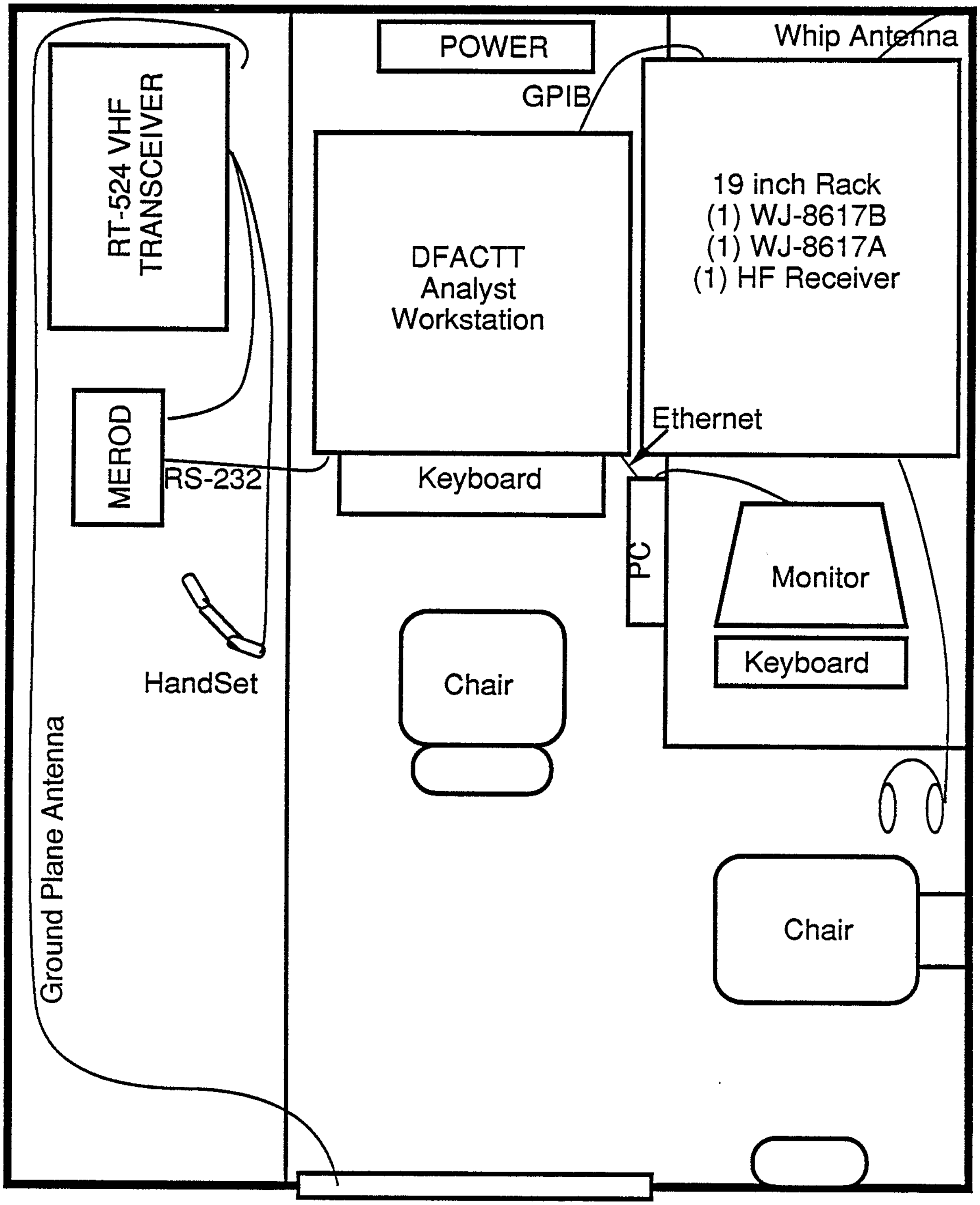

FIGURE A2: DFACTT Layout Inside Vehicle

meter whip in the roof mounting for the WJ-8617 intercept receivers .

A1.1.2 Installation of Intercept Station

The intercept station consisted of a personal computer with a standard monitor, keyboard, and mouse, and a WJ-8617 receiver equipped with GPIB (IEEE488) interface. The receiver was mounted in the repositioned 19 inch rack and connected to the 3 meter whip via the coax feed from the roof mounting. The receiver was connected to the DFACTT computer via a GPIB cable. The PC was connected to the DFACTT via a thin Ethernet cable. All AC power was distributed from the power bar on the 19 inch rack which was fed by a cable to external power.

A1.1.3 Installation of Analyst Station

The analyst station and DFACTT computer were mounted in an environmental container system (ECS) with a ruggedized 19-inch rack. The modularity of the system allowed the analyst station to be quickly and easily set-up in the FEWOC. The ECS was simply rolled down the aisle of the shelter to the back. This set-up allowed the analyst and operator to work side by side and allowed easy observation of the operation from the door of the shelter.

The DFACTT was connected to the following external equipment: WJ-8617B receiver via IEEE488 cable, Intercept operator PC via thin Ethernet, and MEROD data link to CELS. The CELS link is shown earlier in Figure 1. It consisted of an RS-232 link to a MEROD burst RF modem connected to the RT-524 transceiver. The CELS vehicle was similarly equipped with a MEROD to send data over its RT-524.

A1.1.4 System Test

The system was tested by booting-up both the operator and analyst stations using the same procedure as in the lab. The operator then attempted to read and set the WJ-8617B from the terminal and store a test intercept report into the DFACTT database.

The analyst station test consisted on accessing the database and the automatic input of emitter location from CELS. This communication link to CELS required extensive debugging during installation. It was tested until ten consecutive simulated DF reports were automatically read from the MEROD, placed in the database, and shown on the map.

It was felt that the system was working with the same dependability as it had in the lab, although it would have been desirable if more time had been available for practicing on the system. This may have exposed a number of problems that were later encountered.

A1.2 Communication Emitter Location System (CELS) Shelter

The CELS, a radio direction-finding (DF) system is to be a main sensor input to the DFACTT. An analyst using the DFACTT will be able to task the CELS system to DF on a frequency. CELS will quickly return a fix on the emitter location. This location message is to be automatically transmitted from the remote CELS master station to the DFACTT. It is then automatically entered into the database, correlated with intercept messages, and displayed for the analyst.

A1.2.1 Shelter Layout and Equipment

The layout of the CELS shelter is shown in Figure A3. The only modification to the shelter was the installation of a portable PC. The communication link from the CELS master to the DFACTT used the MEROD RF modems and the RT-524 VHF transceivers. The original aim was to redirect the output from the CELS computer from the printer to the portable computer. This portable PC would then control the MEROD and transmit the location message to the DFACTT. It was not possible to redirect the CELS output to the portable PC in the time available. The portable PC was used instead to produce simulated DF location messages and transmit them over the MEROD to the FEWOC/DFACTT.

A1.2.2 System Test

A CELS simulation program implemented in Smalltalk on the portable PC was used to transmit location messages to the DFACTT. Some communications trouble was encountered while testing the PC - MEROD link inside the CELS shelter. This was corrected during testing by setting the squelch properly. The final test of the simulated CELS - DFACTT link involved transmitting location messages to the DFACTT and verifying that they appeared in the DFACTT database. It was noted during testing that the DFACTT end of the link would fail if the location message was transmitted in an incorrect format. The addition of a space in the location message would cause the DFACTT CELS server to hang-up. There was no quick fix for this problem and it was decided that the link could be used if the correct message format was strictly adhered to. The link tested OK using the correct message format.

A2.0 Hardware Set-Up

The phase I DFACTT supports one analyst workstation and two operator workstations. The DFACTT is fed automatically with location information from the CELS master station and intercepted conversations from the operator workstations.

A2.1 Phase I Operator Workstation

The operator workstation consists of a personal computer (PC-AT) with 4 Megabytes of RAM, serial port, keyboard, Ethernet communications port, and a 14 inch color graphics display. The PC also has a 3-1/2 inch floppy drive and hard disk equipped with DOS Version 4.01. It is connected to the DFACTT chassis via an Ethernet link. The workstation controls up to two WJ-8617B VHF/UHF receivers. The receivers are controlled through the Ethernet by sending commands to a General Purpose Interface Bus (GPIB, IEEE-488) controller resident in the DFACTT chassis. The GPIB controller is connected to the control port on the receivers.

A2.2 Phase I Analyst Workstation

The analyst workstation consists of a high resolution (1280 x 1024 pixel) RGB 19-inch monitor, keyboard, and trackball. The CPU(s) and graphics controller for the workstation are embedded in the DFACTT chassis.

A2.3 Phase I DFACTT Chassis

The DFACTT chassis contains a parallel processing embedded system based on the VMEbus. The components of this system and their functions are as follows:

1. DVME-138 68030 Single Board Computer (SBC) with 4 Megabytes RAM.
   VMEbus controller and data input interfaces.

2. DVME-138 68030 SBC
   A second SBC is required to host the analyst user interface and object-oriented database, both implemented in Smalltalk running under the Harmony Operating system. The DVME 138 is equipped with hardware to utilize the VME Subsystem Bus (VSB) to access the SVME-780 graphics controller.

3. MVME-300 GPIB Controller
   This controller provides the interface between the VMEbus and the GPIB over which the WJ-8617B UHF/VHF receiver is controlled.

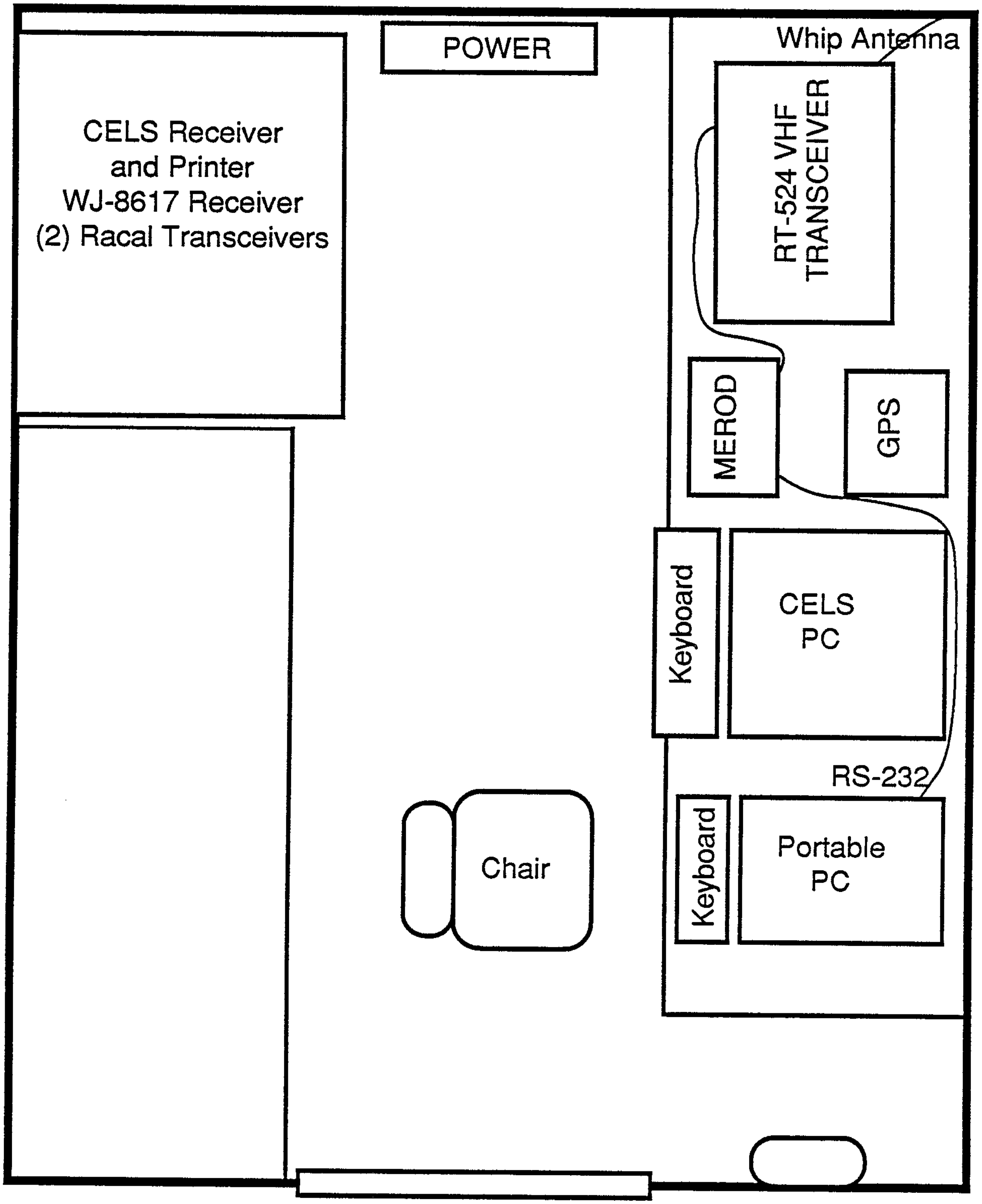

FIGURE A3: Layout of CELS Vehicle

4. DVME-714 Intelligent Serial Communications Controller.
   The DVME-714 controller provides the hardware for an RS-232 network that interfaces with the Communications Emitter Locating System (CELS) master station, and a serial printer. It has a 68010 CPU, 4 serial ports and supports DMA across the VMEbus.

5. SVME-780 Graphics Controller
   The SVME-780 is a high resolution graphics controller for a 1280x1024 pixel RGB monitor. It can use the VME Subsystem Bus (VSB) for communications between the driving processor and the graphics controller so video transfers can be kept off the main VMEbus.

6. DVME-750 Intelligent IEEE 802.3 LAN Controller.
   The DVME-750 is an ETHERNET controller that is designed to operate under the Harmony operating system over the VMEbus. It will be used to allow the analyst to communicate over an external Local Area Network with the operators.

7. Bit3 PC-VMEbus Interface Card
   The file system for the DFACTT Phase I chassis is located on a PC computer and is accessed through this interface.

8. 20 Slot VME Chassis
   All VME computer and peripherial boards are mounted in this chassis. Communication between them takes place over the VMEbus backplane.

9. DVME-134 68020 SBC with 1 Mbyte of RAM
   VMEbus master and host computer for the Internet Protocol Suite Server Software.

A2.4 Bootstrap Procedure

The system start-up procedure is as follows:

1) System Power On:	Turn on Intercept Receiver(s) Turn on Analyst VME Card Cage Turn on File Server PC Turn on Analyst Monitor Turn on Operator PC Workstation and Monitor

2) Analyst Workstation Initialization

i) Start Smalltalk on the File Server PC in the **c:\integrator** directory by invoking **v.bat.**

ii) Highlight the following code in the System Startup window on the File Server PC, press the right mouse button and select **do it:**

```
System executeCommands:
(Array with: 'cd \public\actra\vvme' with:
'actra clear 780 download').
```

iii) Note the response on the P4 terminal. If it indicates the SVME-780 server initialization failed, repeat step 1. A successful download will be indicated by the DFACTv1 banner appearing on the terminal.

iv) Highlight the following code in the System Startup window on the File Server PC, press the right mouse button and select **do it:**

```
(Vfs new in: 'c:\public\actra\vvme_int';
yourself) connect.
```

v) The P4 monitor terminal will show **[P4] accepted**, indicating a file server connection is in place. The P4 and P8 images will be downloaded in approximately 30 seconds.

vi) Highlight all code in the Keyboard Feedthrough window on the File Server PC by selecting the window, and pressing Control-A. Then, press the right mouse button and select **do it.** An hourglass will appear, and all keyboard input will be fed to the P8 processor.

vii) A window will appear on the Analyst Workstation monitor prompting the user to enter the password for Integrator. Press return (i.e. there is no password).

3) DFACTT Analyst Workstation Startup

i) Highlight **Actra start** in the DFACTT Startup window, press the right mouse button and select **do it.**

ii) Highlight **Task createGlobalTasksFor: nil** in the DFACTT Startup window, press the right mouse button and select **do it.**

iii) Select **Start DFACTT** from the main system menu. Status messages will appear in the VVME Transcript as the GPIB interface and Intercept Receivers are initialized. The Analyst Workstation is now operational.

4) DFACTT Operator Workstation Startup

i) Start Smalltalk on the Operator Workstation in directory **c:\integrator\v** by invoking **v.bat.**

ii) Highlight **Actra start** in the Operator Startup window, press the right mouse button and select **do it.**

iii) Highlight **Task createGlobalTasksFor: nil** in the Operator Startup window, press the right mouse button and select **do it.**

iv) Select Start DFACTT Operator from the main menu. A **Connection established** message will appear in the V/286 Transcript. The user will then be prompted for an Opsign. Enter an appropriate opsign and press return. The Intercept Message Browser will appear on the screen. The Operator Workstation is now operational.

A2.5 VME Address Maps

The system address map (A24 space) is shown in Figure A4.

A2.6 Map Scanning

A map of the area of the field trial was scanned at 100 dots per inch (dpi) using a digital flatbed scanner and stored on disk in a known format. It is stored as a bitmapped image in memory. A black and white (two colour) image was used.

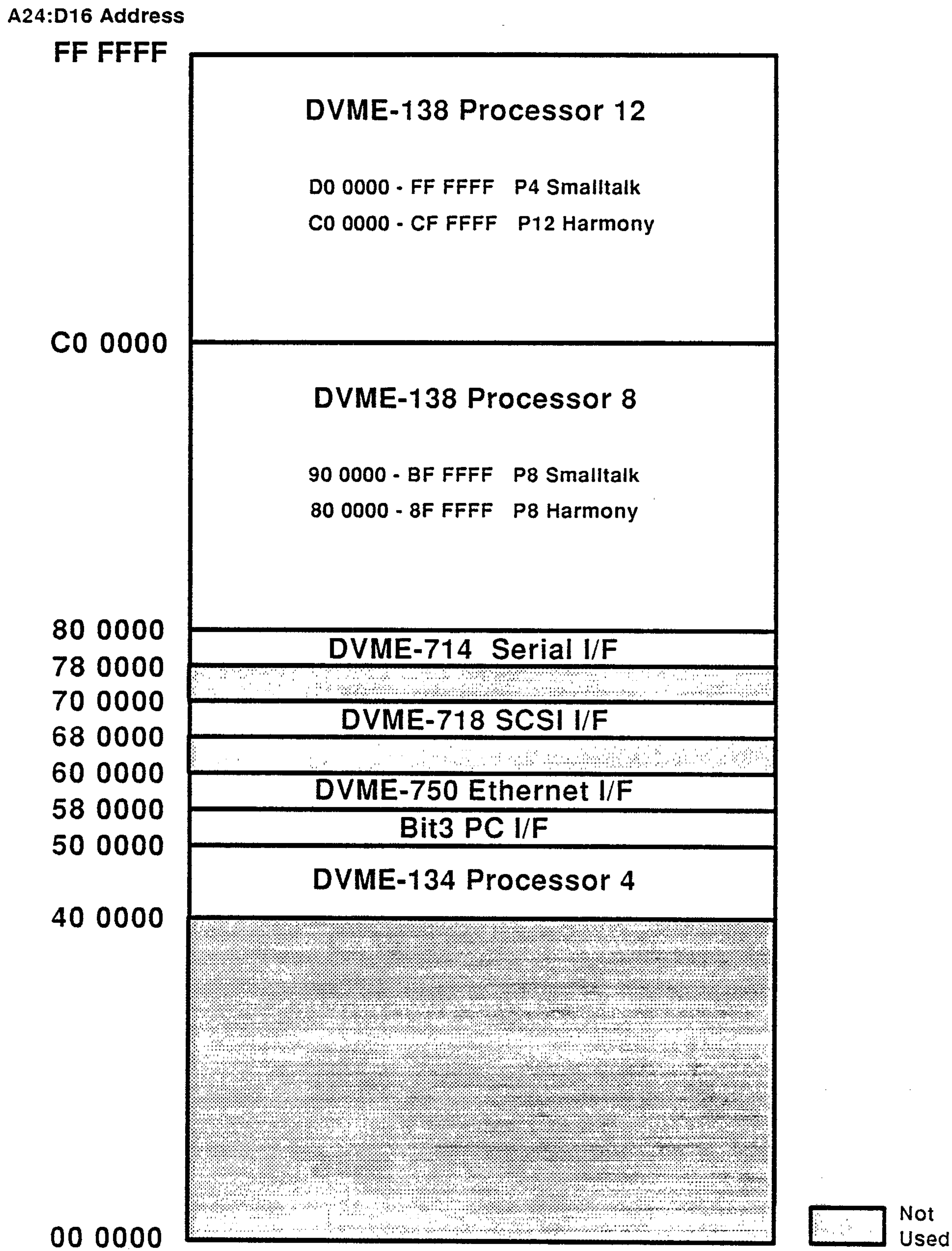

FIGURE A4: VME A24 Address Map

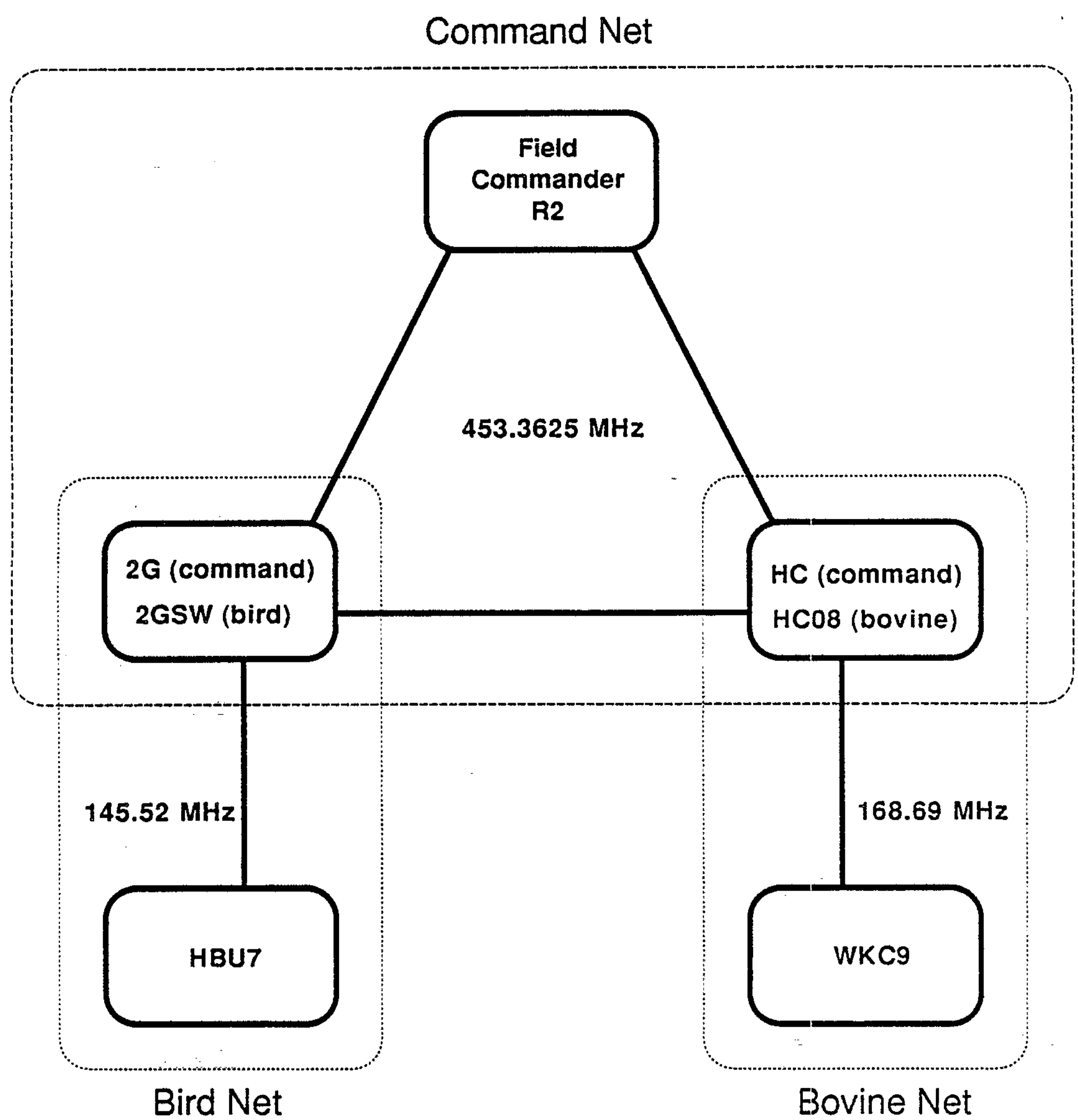

FIGURE A5: Network Topology Diagram

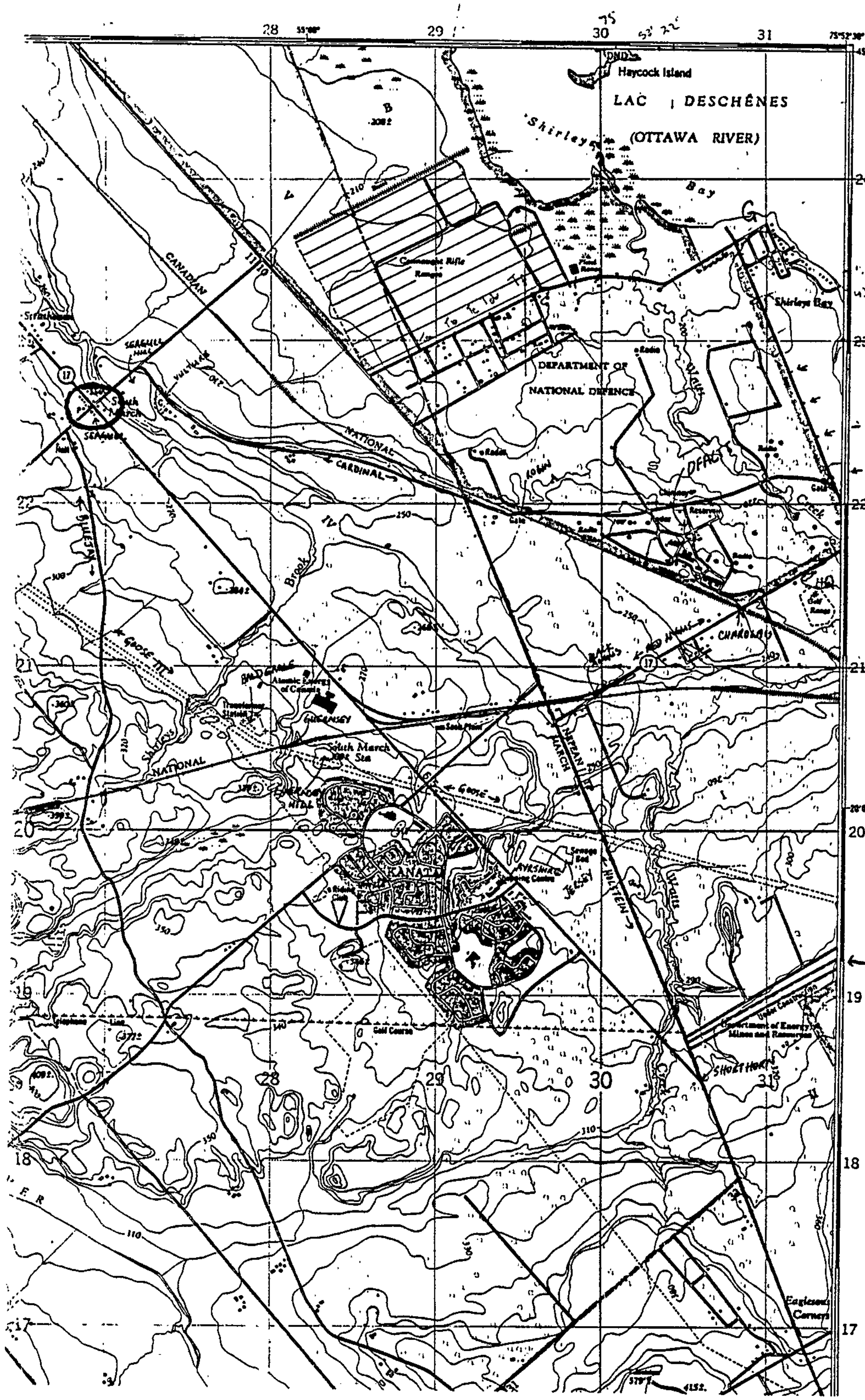

FIGURE A6: Map Of Scenario with Codewords

B1.0 Scenario Details (Field Trial Frigid Fact)

The scenario involved three radio networks, a command net and two squad networks. The frequency layout is shown in Figure A5. The following sub-sections detail the traffic that was sent over the networks. Figure A6 indicates the physical layout and codenames for the different physical locations and routes.

B1.1 Command Net

Time: 00:00

R2 to 2G	are you in position, over	VF31285 21392
2G to R2	we are approaching robin, had a problem with locked gate, ETA 2 minutes, over	VF29712 21882
R2 to 2G	roger, out	VF31285 21392
R2 to HC	are you in position? over	VF31285 21392
HC to R2	affirmitive, we are at charolais and ready to proceed, over	VF30838 21257
R2 to HC	there will be a delay while we wait for bird team. proceed on my signal, over	VF31285 21392
HC to R2	roger, out	VF30838 21257

Time: 00:05

R2 to 2G	are you ready, over	VF31285 21392
2G to R2	affirmitive, at robin, over	VF29631 21902
R2 to 2G	proceed, over	VF31285 21392
2G to R2	roger, out	VF29631 21902
R2 to HC	proceed over	VF31285 21392
HC to R2	roger, out	VF30838 21257

Time: 00:10

HC to R2	we have reached black angus, over	VF29961 20753
R2 to HC	roger, carry on , out	VF31285 21392

Time: 00:12

2G to R2	we've had a breakdown. are attempting repair, over	VF27978 22312
R2 to 2G	will this delay mission? get estimated time for arrival at seagull, over	VF31285 2139
2G to R2	will confirm, over	VF27978 22312
R2 to 2G	roger, out	VF31285 21392

Time: 00:14

2G to R2	no delay expected, will be on the way again in 10 minutes, over	VF27978 22312
R2 to 2G	roger, out	VF31285 21392

Time: 00:24

HC to R2	change in plans. jersey is too wet to go overland, we'll take holstein and double back to get to ayrshire, over	VF30253 19618
R2 to HC	any time changes? over	VF31285 21392
HC to R2	negative, we'll take it out of lunch break, over	VF30253 19618

Time: 00:25

2G to R2	we are proceeding along cardinal, over	VF27978 22312
R2 to 2G	roger, out	VF31285 21392

Time: 00:31

2G to R2	checking in , we are both past vulture and approaching seagull hill, over	VF27195 22789
R2 to 2G	roger, all is on schedule, out	VF31285 21392

Time: 00:37

2G to R2	overlooking seagull from hill. limited defences. will proceed and rendezvous in 15 minutes at bluejay intersection, over	VF27042 22762
R2 to 2G	Roger, out	VF31285 21392

Time: 00:53

HC to R2	we've reached ayrshire and will have lunch in the parking lot, then head our for goose in 10 minutes, over	VF29383 19645
R2 to HC	roger, out	VF31285 21392

Time: 00:55

2G to R2	seagull secured and guarded, proceeding to bluejay intersection, over	VF26815 22574
R2 to 2G	roger, out	VF31285 21392

Time: 01:00

R2 to 2G	radio check, over	VF31285 21392
2G to R2	roger, fine, out	VF26734 22440
R2 to HC	radio check, over	VF31285 21392
HC to R2	roger, fine, out	VF29383 19645

Time: 01:05

2G to R2	proceeding along bluejay, over	VF26734 22440
R2 to 2G	roger, out	VF31285 21392

Time: 01:12

HC to R2	we're turning onto goose, will be able to spot for bird, over	VF28973 20196
R2 to HC	roger, out	VF31285 21392

Time: 01:21

2G to R2	we are proceeding along goose. it will be rough going. luckily the ground is frozen, over	VF27012 21170
R2 to 2G	roger, out	VF31285 21392

Time: 01:32

HC to R2	guernsey is secured, and birds are in sight from guernsey hill, over	VF28293 20417
R2 to HC	roger, how does bald eagle look? over	VF31285 21392
HC to R2	looks deserted, poor perimeter defence, easily taken, over	VF28293 20417
R2 to HC	roger, out	VF31285 21392

Time: 01:40

HC to R2	someone walked in to check bald eagle, carrying some equipment, but measured then left, over	VF28293 20417
R2 to HC	roger, out	VF31285 21392

Time: 01:46

2G to R2	we are in position, over	VF27634 20740
R2 to 2G	HC reports easy to take as expected, so proceed, over	VF31285 21392
2G to R2	roger, out	VF27634 20740

Time: 01:48

HC to R2	they are moving on bald eagle, a precision move, over	VF28293 20417
R2 to HC	roger, out	VF31285 21392

Time: 01:51

2G to R2	objective secured, over	VF27634 20740
R2 to 2G	roger, well done, out	VF31285 21392
R2 to HC	well done, over	VF31285 21392
HC to R2	roger, out	VF28293 20417

END OF FIELD TRIAL

B1.2 Bird Net

Time: 00:04

2GSW to HBU7	are we ready, over	VF29631 21902
HBU7 to 2GSW	affirmative, out	VF29631 21902

Time: 00:06

2GSW to HBU7	proceed down cardinal as planned, over	VF29631 21902
HBU7 to 2GSW	roger, out	VF29631 21902

Time: 00:10

HBU7 to 2GSW	the truck has stalled on cardinal. we're near a clump of houses, over	VF28117 22292
2GSW to HBU7	get out sight of the houses and get that truck going. we'll wait, over	VF27978 22312
HBU7 to 2GSW	roger, out	VF28117 22292

Time: 00:13

2GSW to HBU7	how goes repair? over	VF27978 22312
HBU7 to 2GSW	we have found the problem, should be ready to proceed in about 10 minutes, over	VF28117 22292
2GSW to HBU7	roger, out	VF27978 22312

Time: 00:25

HBU7 to 2GSW	we are ready to proceed, over	VF28117 22292
2GSW to HBU7	roger, proceed, out	VF27978 22312

Time: 00:30

2GSW to HBU7	we just passed vulture, are you with us? over	VF27378 22621
HBU7 to 2GSW	roger, just coming up on vulture, out	VF27539 22467

Time: 00:35

2GSW to HBU7	we are on seagull hill, in sight of seagull. seems poorly defended. approaching on road seems most efficient, over	VF27042 22762
HBU7 to 2GSW	we are also on seagull hill. roger the plan. will proceed on your signal, out	VF27166 22682

Time: 00:36

2GSW to HBU7	we will observe for 5 minutes then proceed. your main target is the post office, we'll go for the telephone exchange. rendezvous 15 minutes afterwards at bluejay intersection, over	VF27042 22762
HBU7 to 2GSW	roger, out	VF27166 22682

Time: 00:40

2GSW to HBU7	lets move, over	VF27042 22762
HBU7 to 2GSW	roger, out	VF27166 22682

Time: 00:50

HBU7 to 2GSW secured post office, no resistance, over VF26881 22460
2GSW to HBU7 roger, we secured phones also. carry out house to house

search of immediate area to be sure, out VF26815 22574

Time: 00:55

HBU7 to 2GSW	area is fully secured. we will leave one guard as planned, over	VF26881 22460
2GSW to HBU7	roger, out	VF26815 22574

Time: 01:01

2GSW to HBU7	radio check, over	VF26774 22440
HBU7 to 2GSW	roger fine, out	VF26734 22440

Time: 01:02

2GSW to HBU7	are you ready to proceed along bluejay? over	VF26734 22440
HBU7 to 2GSW	affirmative, over	VF26734 22440
2GSW to HBU7	lets move, out	VF26734 22440

Time: 01:15

2GSW to HBU7	approaching goose crossing bluejay, will wait for you here, over	VF27012 21170
HBU7 to 2GSW	roger, out	VF27034 21304

Time: 01:20

HBU7 to 2GSW	ready at goose, over	VF27012 21170
2GSW to HBU7	proceed carefully along goose, out	VF27012 21170

Time: 01:25

HBU7 to 2GSW	this ground is really hard to drive over. I think we have a flat, over	VF27172 21042
2GSW to HBU7	stop and check, report back with details, out	VF27056 21136

Time: 01:27

HBU7 to 2GSW	it was a flat, its almost fixed, we should be moving in a couple of minutes, over	VF27173 21042
2GSW to HBU7	okay we will carry on. stop when bald eagle is in sight. we are hidden from view, over	VF27056 21136
HBU7 to 2GSW	roger, out	VF27173 21042

Time: 01:45

2GSW to HBU7	objective bald eagle is in sight, over	VF27634 20740
HBU7 to 2GSW	from here also, out	VF27561 20713

Time: 01:47

2GSW to HBU7	proceed to take bald eagle but don't damage anything. we want it intact, over	VF27634 20740
HBU7 to 2GSW	roger, out	VF27561 20713

Time: 01:50

HBU7 to 2GSW	all secured, over	VF27854 20599
2GSW to HBU7	roger, out	VF27634 20740

Time: 01:52

2GSW to HBU7	well done from R2, over	VF27634 20740
HBU7 to 2GSW	roger, out	VF27854 20599

END OF FIELD TRIAL

B1.3 Bovine Net

Time: 00:06

HC08 to WKC9	proceed down red angus as planned, over	VF30838 21257
WKC9 to HC08	roger, out	VF30838 21257

Time: 00:09

WKC9 to HC08	we're at a fork. do we go left or right to get to black angus? over	VF29961 20827
HC08 to WKC9	left, can't you see it? over	VF29961 20753
WKC9 to HC08	oh yeah, there it is	VF29961 20827

Time: 00:11

HC08 to WKC9	okay, cross black angus and head for holstein, remember to turn left when we get there, over	VF29961 20753
WKC9 to HC08	roger, out	VF29961 20753

Time: 00:15

HC08 to WKC9	we have jersey in sight and are just crossing goose. jersey looks a bit messy. crossing may be difficult also sounds like bird is having vehicle trouble but no	

	change in plans yet, over	VF30290 19839
WKC9 to HC08	roger, we see jersey too. going down goose would have been a better idea, out	VF30275 19886

Time: 00:20

HC08 to WKC9	I'm heading off road, follow my tracks, over	VF30275 19624
WKC9 to HC08	roger, out	VF30312 19631

Time: 00:23

HC08 to WKC9	I'm really getting bogged down, jersey is too wet, we'll have to take road. carry on down holstein until the first possible right turn. we'll call it shorthorn, over	VF30253 19618
WKC9 to HC08	roger, see you at shorthorn, out	VF30304 19597

Time: 00:45

HC08 to WKC9	have you found shorthorn? over	VF30465 19033
WKC9 to HC08	affirmative, we're waiting just past phone line, over	VF30458 18946
HC08 to WKC9	carry on toward ayrshire, out	VF30465 19033

Time: 00:52

HC08 to WKC9	I've reached ayrshire, we can rendezvous in the parking lot. the area seems quiet, over	VF29383 19645
WKC9 to HC08	roger, can we have lunch? over	VF29456 19645
HC08 to WKC9	affirmative, but we roll in 10 minutes, out	VF29383 19645

Time: 01:01

HC08 to WKC9	radio check, over	VF29383 19645
WKC0 to HC08	roger fine, out	VF29456 19645

Time: 01:05

HC08 to WKC9	proceed toward goose, over	VF29383 19645
WKC9 to HC08	roger, out	VF29456 19645

Time: 01:10

HC08 to WKC9	I'm turning onto goose. I think it will be slow going, over	VF28973 20196
WKC9 to HC08	roger, we're right behind you, out	VF28973 20196

Time: 01:15

HC08 to WKC9	taking guernsey on black angus in this muck is going to be difficult. can you see guernsey hill yet? over	VF28790 20249
WKC9 to HC08	affirmative, we're approaching the base of the hill, out	VF28563 20343

Time: 01:22

HC08 to WKC9	we're on guernsey hill and I can see both guernsey and bald eagle, over	VF28293 20417
WKC9 to HC08	roger, we'll surround guernsey now, over	VF28102 20451
HC08 to WKC9	roger that, all is clear and we see birds coming along goose, outVF28293 20417	

Time: 01:30

WKC9 to HC08	all is secure along guernsey, hope your train schedule was right, over	VF28102 20451

Time: 01:31

HC08 to WKC9	roger, out	VF28293 20417

Time: 01:52

HC08 to WKC9	well done, from R2, over	VF28293 20417
WKC9 to HC08	roger, out	VF28102 20451

END OF FIELD TRIAL

C1.0 System Packaging Procedures

1) Analyst Workstation Files

All files in the following directories must be copied from the Novell Network (Drive N) to the File Server PC (Drive C):

```
n:\public\manager             to    c:\public\manager
n:\public\manager\release8    to    c:\public\manager\release8
n:\public\actra\vvme          to    c:\public\actra\vvme
n:\public\actra\vvme_int      to    c:\public\actra\vvme_int
```

If any development is to be done on the target system (modification of the Harmony configuration or any user primitives), the following directories must also be copied from Drive N to Drive C:

```
n:\public\harmony             to    c:\public\harmony
n:\public\mcc68k              to    c:\public\mcc68k
n:\public\actra\userprim      to    c:\public\actra\userprim
n:\public\actra\build         to    c:\public\actra\build
n:\public\actra\main          to    c:\public\actra\main
```

2) File Server

The file server must also be reconfigured to operate without the Novell Network. The files in the following directory must be copied from Drive N to Drive C:

```
n:\home\integrator\v          to    c:\integrator\v
```

All occurences of "n:" in the integrator "go" file (c:\integrator\v\go) must be changed to reference "C:". These will be found in the loadprimitives commands and the reference to the manager database file (manager.dat).

The reference to Drive n: in the integrator image on the File Server PC (used in the System Startup Window to create the Virtual File System) must be changed from

(Vfs new in:'n:\public\actra\vvme_int';yourself) connect.

to

(Vfs new in:'c:\public\actra\vvme_int';yourself) connect.

3) Operator Workstation

All files in the following directories must be copied from the Novell Network (Drive N) to the Operator Workstation PC (Drive C):

n:\public\manager	to	c:\public\manager
n:\public\manager\release8	to	c:\public\manager\release8
n:\home\operator\v	to	c:\operator\v

All occurences of "N:" in the operator "go" file (c:\operator\v\go) must be changed to reference "C:". These will be found in the loadprimitives commands and the reference to the manager database file (manager.dat).

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(U) The Data Fusion and Correlation Techniques Testbed (DFACTT) is a platform on which to test new methods of data fusion and machine intelligence in the electronic warfare field. With the ability to operate multiple Smalltalk environments as well as independent tasks on a variety of VMEbus based devices, the DFACTT will provide an in-house facility at DREO to quickly prototype new ideas and technologies in the areas of sensor data fusion, parallel processing, and knowledge-based programming.

(U) The phase I testbed developed under contract was interfaced to real EW sensors from 2 (EW) Squadron of the 1st Canadian Division Headquarters and Signals Regiment (CDHSR) for a field trial at Defence Research Establishment Ottawa (DREO), 14 Jan 1991. One station of the Communications Emitter Locating System (CELS) was connected for location inputs to the DFACTT, as were two WJ8617B receivers for radio intercept input. A scenario was developed and kept secret from those who were to act as operator and analyst on the DFACTT. Three radio networks formed the target for the DFACTT operators. The operators were to intercept and locate the emitters, track them, and determine the objective of the scenario.

(U) Valuable information and experience was gained by using the actual field sensors as input to the system and by operating under field conditions.

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