Document Number
WOO3266

LORAL
Western Development Labs

COMBAT VEHICLE COMMAND & CONTROL (93) TECHNICAL REPORT (FINAL)

Training And Soldier-Machine Interface For The Combat Vehicle Command And Control System

Submitted By:
Loral Systems Company
ADST Program Office
Orlando, Fl

Prepared For:
United States Army
Simulation, Training & Instrumentation Command
Orlando, Fl

In Response To:
Contract N61339-91-D-0001
Delivery Order D006
CDRL Item A001

31 December 1993

Technical Report XXX

Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System

Nancy K. Atwood, Beverly J. Winsch, Alicia R. Sawyer, and
Laura A. Ford
BDM Federal, Inc.

Kathleen A. Quinkert
U.S. Army Research Institute

January 1994

United States Army Research Institute
for the Behavioral and Social Sciences

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System

5. FUNDING NUMBERS
N61339-91-D-0001/0025
62785A
791
2221
R01

6. AUTHOR(S)
Atwood, Nancy K.; Winsch, Beverly J.; Sawyer, Alicia R.; Ford, Laura A.; and Quinkert, Kathleen A.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
BDM Federal, Inc.
P. O. Box 967
Fort Knox, KY 40121-0967

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Institute for the Behavioral and Social Sciences
ATTN: PERI-IK
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Contracting Officer's Representative, Kathleen A. Quinkert

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release;
distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT (Maximum 200 words)
Shifts in the global balance of power, coupled with increasingly powerful technologies and systems, will bring unprecedented changes to the battlefield of the 21st century. In anticipation of these changes, the Combat Vehicle Command and Control (CVCC) program evaluated the use of automated command and control (C2) technology using a soldier-in-the-loop methodology in a distributed interactive simulation (DIS) environment. The CVCC system included a prototype C2 device with map display, navigation and digitial messaging capabilities, an automated target acquisition system, and digital workstations in a Tactical Operations Center. A total of 283 armor-qualified personnel participated in 12 weeks of data collection at the Mounted Warfare Test Bed at Fort Knox, Kentucky. Commanders and their crews were integrated with semiautomated vehicles under their control to form complete tank battalions. Each battalion completed four days of training and testing, culminating in a simulated combat test scenario. This report focuses on the training and soldier-machine interface (SMI) components of the research. The training data supported the acceptance of the training program by users and its effectiveness in preparing users to use the equipment. The SMI data supported the value of automated C2 technology in tactical environments and was viewed by users as a tool for improving their performance. Lessons learned and directions for future research on training and SMI are offered.

14. SUBJECT TERMS

CVCC	Command and control	C2 training requirements
CCD	Innovative training	Soldier-in-the-loop
Assessment	Distributed interactive simulation	Soldier-machine Interface

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

Technical Report XXX

Training and Soldier-Machine Interface for the Combat Vehicle Command and Control System

Nancy K. Atwood, Beverly J. Winsch, Alicia R. Sawyer,
and Laura A. Ford

BDM Federal, Inc.

Kathleen A. Quinkert

U.S. Army Research Institute

BDM Federal, Inc.

Field Unit at Fort Knox, Kentucky
Barbara A. Black, Chief

Training Systems Research Division
Jack H. Hiller, Director

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

January 1994

Army Project Number 2Q162785A791	Manpower, Personnel and Training

Approved for public release; distribution is unlimited.

FOREWORD

The Fort Knox Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) conducts soldier-in-the-loop simulation-based research that addresses training and soldier-machine interface (SMI) requirements for the future integrated battlefield. As part of ARI's training research program, the objective of the Future Battlefield Conditions team at Fort Knox is to enhance soldier preparedness by identifying future battlefield conditions and developing training methods that assure effective soldier performance under these conditions. Work under this program is supported by a Memoranda of Understanding (MOU) with (a) the U.S. Army Armor Center and Fort Knox, Subject: Research in Future Battlefield Conditions, 12 April 1989, and (b) the U.S. Army Tank-Automotive Command (TACOM), Subject: Combat Vehicle Command and Control (CVCC) Program, 22 March 1989.

This is the final report on training and SMI issues developed under the CVCC research program. The CVCC research program combined advanced digital and thermal technologies to enhance mounted warfighting capabilities to accomplish command and control (C2). The CVCC system includes digital map, report and overlay features, positioning and navigation functions, digital transmission capabilities, and independent thermal viewing for unit and vehicle commanders. This configuration provided a powerful medium for investigating training and SMI requirements using future automated technology for armored vehicles. The research reported here used distributed interactive simulation (DIS) to evaluate the capabilities of automated C2 technologies at the battalion level. The findings presented in this report are intended to support Army developers in determining the requirements for future training and SMI efforts.

Information resulting from this research has been briefed to the: Commanding General, U.S. Army Training and Doctrine Command; Commanding General, U.S. Army Armor Center and School; Deputy Commanding General for Combat Developments, U.S. Army Combined Arms Command; Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command; Director, Directorate of Combat Developments, U.S. Army Armor School; Chief of Staff Armor School; and Director, Mounted Warfighting Battlespace Lab.

EDGAR M. JOHNSON
Director

ACKNOWLEDGMENT

The following members of ARI's Fort Knox Field Unit provided invaluable input to this research: Dr. Barbara Black, Dr. Carl Lickteig, Mr. Gary Elliott, and MAJ James Whitehead.

In addition to the authors, the BDM Federal, Inc. research staff included Dr. Bruce Leibrecht, Mr. Glen Meade, MG (Ret.) Charles Heiden, Mr. Owen Pitney, Mr. Ryszard Lozicki. In addition, Mr. Jeffrey Schmidt, Mr. Paul Smith, Mr. Timothy Voss provided invaluable assistance in creating graphics and editing the report. Ms. Frances Ainslie provided off-site review of the report. Research Assistants supporting the project included Mr. Benjamin Boix, Mr. Silver Campbell, Ms. Ann Cash, Mr. Kenneth Fergus, Mr. Brian Gary, Mr. Lewis Graff, Mr. Gary Gulbranson, Mr. Michael Gustafson, Mr. David Johnson, Mr. Ron Jones, Mr. William Myers, Ms. Khristina Orbock, Mr. Robert Pollock, Mr. Ronald Reyna, Mr. Charles Sawyer, Mr. Daniel Schultz, Ms. Margaret Shay, Mr. Harold Wager, and Mr. Charles West.

Personnel of the on-site support contractor, Loral Training and Technical Services, supported simulation equipment and data collection/analysis. These included Mr. Jimmy Adams, Mr. Fred Brady, Mr. David Clippinger, Mr. Michael Krages, Mr. Paul Monday, Mr. Rob Smith, and Ms. Diane York.

TRAINING AND SOLDIER-MACHINE INTERFACE FOR THE COMBAT VEHICLE COMMAND AND CONTROL SYSTEM

EXECUTIVE SUMMARY

Requirement:

Unprecedented changes faced by the U.S Army as the 21st century approaches mandate the need for powerful command and control (C2) technologies and systems which will ensure optimal soldier performance on the battlefield. These emerging C2 technologies and systems will generate new training requirements and drive innovative approaches to training and system design. The U.S. Army's Combat Vehicle Command and Control (CVCC) program used a soldier-in-the-loop, distributed interactive simulation (DIS) methodology to assess the training and soldier-machine (SMI) interface requirements for future C2 systems. Previous research focused on tank crews, platoons, companies, the battalion tactical operations center, and innovative approaches to delivering training within the DIS environment. This effort completed work on the CVCC program by focusing research at the tank battalion level.

Procedure:

A total of 283 armor-qualified military personnel (94 officers and 189 enlisted men) participated in 12 weeks of data collection at the Mounted Warfare Test Bed (MWTB) at Fort Knox, Kentucky. During each training and testing period, tank crews were comprised of a vehicle commander, gunner, and driver to form eight manned simulators (with autoloaders) and integrated with semiautomated elements to form a complete tank battalion. The eight manned crews consisted of a battalion commander, battalion operations officer (S3), three company commanders, and three company executive officers. Each officer commanded a crew with two enlisted crewmembers (gunner and driver). Each participant received 3 days of training followed by one test scenario. During the test scenario, equipment usage was recorded by an automated data collection and analysis system. Following the test scenario, participants completed training evaluation and SMI questionnaires which addressed the acceptability of training and usefulness of the major components of the system.

Findings:

The training evaluation questionnaire data indicated that participants were satisfied with the training they had received. Hands-on training and tactical training exercises received the

highest degree of acceptability by users probably due to the interactive nature of the instruction. Skills test data showed that most participants acquired the skills for operating and using the equipment readily; although, many expressed the desire for additional feedback during training particularly on the most complex component of the system, the automated C2 display.

Overall, vehicle commanders found the SMI for the prototype C2 components very acceptable. Vehicle commanders tended to favor automated features such as the LOGISTICS report and the Autoadvance feature of the Position Navigation function. The Position Navigation function, which is also highly automated, was the most highly praised CVCC component. These findings replicate the results of past research. The most noteworthy drawback to the interface (also replicated in past research) was perceived report overload by participants. Questionnaire and automated data suggested that the report load was actually greater for company personnel than for battalion personnel. The issue of managing information load associated with digital messages remains unresolved and should receive additional attention in future research.

Utilization of Findings:

The findings over the course of the five-year CVCC research program have led to a number of recommendations and lessons learned for training and SMI. These recommendations focus largely on exploring the interrelationship of training and SMI issues for future development efforts.

The results of this effort provide important input in determining training and SMI requirements for future automated C2 systems in Armor combat vehicles for the 21st century. They also provide training, system, and combat developers with useful information regarding the training, use, design, and evaluation of automated C2 systems. More immediate, the CVCC research effort has yielded a model training program with strong user acceptance that can serve as a basis for training design by users of DIS facilities for a broad range of purposes.

TRAINING AND SOLDIER-MACHINE INTERFACE FOR THE COMBAT VEHICLE COMMAND AND CONTROL SYSTEM

CONTENTS

	Page
Introduction	1
Background	2
Capabilities of the CVCC Prototype Devices	2
Mounted Warfare Test Bed	12
CVCC Training	14
CVCC Soldier-Machine Interface	31
Overview of the CVCC Battalion Evaluation	48
Method	48
Participants	48
Configuration of the Test Battalion	49
Test Facilities and Materials	50
Training Materials	58
Data Collection Procedures	74
Training Results and Discussion	77
Perceived Training Effectiveness	78
Proficiency in Using the CVCC Equipment	89
Areas for Potential CVCC Individual Training Improvement	93
Summary	96
Training Conclusions	96
Lessons Learned	96
Training Issues Requiring Further Study	100
SMI Results and Discussion	102
Input Devices	103
CCD	104
Allocation of Attention	117
Navigation	119
Tactical Map	122
CITV	124
Summary	130

CONTENTS (Continued)

	Page
SMI Conclusions	131
Lessons Learned	131
SMI Issues Requiring Further Study	132
Recommendations for Future Research	133
Future Training Requirements	134
Training and Assessment Approaches for Future Research	135
References	137
APPENDIX A. CCD and CITV Training Data	A-1
B. CCD and CITV Equipment Usage Data	B-1
C. CCD and CITV SMI Questionnaire Data	C-1
D. Training and SMI Questionnaires	D-1
E. List of Acronyms and Abbreviations	E-1

LIST OF TABLES

	Page
1. Command and Control Capabilities of the Combat Vehicle Command and Control Prototype	3
2. Combat Vehicle Command and Control Training Program Changes	21
3. Combat Vehicle Command and Control Training Time Lessons Learned	25
4. Combat Vehicle Command and Control Training Media Lessons Learned Prior to the Battalion Evaluation	28
5. Combat Vehicle Command and Control Training Procedure and Training Assessment Lessons Learned	29
6. Soldier-Machine Interface Recommendations Based on the Company Evaluation (Leibrecht et al., 1992)	40

Page

7. Changes Made to the Combat Vehicle Command and Control Command and Control Display and Position Navigation System 42

8. Soldier-Machine Interface Lessons Learned for the Combat Vehicle Command and Control System 45

9. Comparison of Baseline and Combat Vehicle Command and Control M1 Simulator Capabilities 53

10. Type of Training Materials Used in the Combat Vehicle Command and Control Battalion-Level Evaluation by Day 59

11. Tactical Structure of the Battalion Test Scenario 63

12. Tactical Scenario Training Objectives (Combat Vehicle Command and Control and Baseline) 71

13. Summary of Diagnostic Measures for Issues D1 and D2 76

14. Number of Reports Received on the Command and Control Display via all Radio Nets by Stage and Echelon 106

15. Percent Duplicate Reports Received on the Command and Control Display via all Radio Nets by Stage and Echelon 108

16. Percent Reports Retrieved for Each Report Type by Stage and Echelon 114

17. Percent Reports Posted for Each Report Type by Stage and Echelon 116

18. Number of Reports Sent for Each Report Type by Stage and Echelon 118

19. Vision Block, Gunner's Primary Sight Extension, Command and Control Display, and Commander's Independent Thermal Viewer Usage by Stage and Echelon 119

20. Map Scroll Usage by Stage and Echelon 123

21. Map Scale Usage by Stage and Echelon 123

		Page
22.	Map Terrain Feature Usage by Stage and Echelon	125
23.	Commander's Independent Thermal Viewer Function Usage by Stage and Echelon	126
24.	Commander's Independent Thermal Viewer Laser Usage by Stage and Echelon	127
25.	Commander's Independent Thermal Viewer Designate Usage by Stage and Echelon	128

LIST OF FIGURES

1.	Tank commander's crewstation as seen in the Combat Vehicle Command and Control condition	2
2.	Command and Control Display interface	4
3.	The Command and Control Display in operational mode	6
4.	The Position Navigation System and Driver's Steer-to-Display	8
5.	Commander's Independent Thermal Viewer interface	9
6.	The digital link between the Command and Control Displays' and Tactical Operations Center Workstations' report functions	11
7.	Distributed Interactive Simulation architecture	13
8.	Concurrent training and Soldier-Machine Interface development	17
9.	Systems Approach to Training model	18
10.	Evolution of the Steer-to-Display	38
11.	Illustration of the battalion configuration	50
12.	Basic M1 simulator showing the turret crew compartment and driver's compartment	51

		Page
13.	Diagram of the tactical voice radio networks used in the battalion-level evaluation	54
14.	Combat Vehicle Command and Control condition evaluation weekly schedule	64
15.	Commanders' classroom instruction ratings	78
16.	Commanders' hands-on instruction ratings	79
17.	Gunners' hands-on instruction ratings	80
18.	Drivers' hands-on instruction ratings	81
19.	Commanders' crew sandbox drill ratings	82
20.	Commanders' company situational training exercise ratings	83
21.	Commanders' battalion situational training exercise ratings	83
22.	Commanders' battalion training scenario ratings	84
23.	Gunners' training scenario ratings	85
24.	Drivers training scenario ratings	85
25.	Commanders' training objectives ratings	86
26.	Commanders' feedback during training ratings	87
27.	Commanders' battalion situational training exercise debrief ratings	88
28.	Commanders' battalion training scenario debrief ratings	88
29.	Commanders' overall level of preparation ratings	89
30.	Commanders' Command and Control Display and Commander's Independent Thermal Viewer skills test ratings	90

Page

31. Command and Control Display Skills Test scores 91

32. Comomander's Independent Thermal Viewer Skills Test scores 91

33. Command and Control Display and Commander's Independent Thermal Viewer Skills Test average scores 92

34. Participants scoring less than 75% on the Command and Control Display and Commander's Independent Thermal Viewer Skills Test across the Combat Vehicle Command and Control evaluations 93

35. Combat Vehicle Command and Control commanders' refresher demonstration and refresher task ratings 95

36. Overall number of reports received by stage and echelon 105

37. Overall percent duplicate reports received by stage and echelon 107

38. Commander ratings of report load 109

39. Company and battalion echelon ratings of report load 109

40. Overall semiautomated force report ratings ... 110

41. Company and battalion ratings of semiautomated force reports 110

42. Overall percent reports retrieved by stage and echelon 113

43. Overall percent reports posted by stage and echelon 115

44. Overall number of reports sent by stage and echelon 117

45. Commander Navigation function ratings 120

46. Commander ratings of using the Position Navigation system to navigate 120

		Page
47.	Driver ratings of having no problems using Steer-to-Display	121
48.	Driver ratings of whether Steer-to-Display would improve performance	121
49.	Commander ratings of Identification Friend or Foe function	127
50.	Commander ratings of Designate function	129
51.	Gunner ratings of whether they liked the Designate function	129

TRAINING AND SOLDIER MACHINE INTERFACE FOR THE COMBAT VEHICLE COMMAND AND CONTROL SYSTEM

Introduction

The U.S. Army faces unprecedented changes as the 21st century approaches. Shifts in the global balance of power are posing new threats with anticipated capabilities for increased tempo, greater mobility and lethality, and enhanced command, control, communications and intelligence (C3I) capabilities (Department of the Army, 1993). As the Army develops and fields new mounted warfare technologies to counter these threats, anticipated training requirements for new mounted warfare technologies are expected to include proficient operation of command and control (C2) devices and effective integration of their use into tactical C2.

Such changes in training requirements can not be adequately addressed until training developers and system designers appreciate the impact of new technologies on soldier performance. For instance, current C2 capabilities permit the vehicle commander's attention to be equitably distributed between the auditory and visual modalities. This "sharing" between modalities has been found to allow for greater information processing capacity (see Wickens, 1984). However, new C2 technologies afford the opportunity for visual information displays and digitized communication. This greatly reduces the presentation of auditory information and places a heavy load on visual information processing. Such changes mandate that the human performance requirements of emerging systems be understood. It also requires that training programs be developed to support anticipated training requirements generated by new C2 technologies. Ideally, emergent systems must be designed to exploit human performance capabilities to their fullest and emphasize soldier training in the optimal use of the technology.

This report describes the last in a series of investigations of training and soldier-machine interface (SMI) issues for an automated C2 prototype developed as part of the Combat Vehicle Command and Control (CVCC) program. This effort was part of a larger battalion-level evaluation of prototype components led by the Army Research Institute (ARI) Future Battlefield Conditions (FBC) team at Ft. Knox, KY. In addition to training and SMI issues, the battalion-level evaluation examined issues related to (a) operational effectiveness (see Leibrecht, Meade, Schmidt, Doherty, & Lickteig, in preparation) and (b) tactical performance (see Meade, Lozicki, Leibrecht, Smith, & Myers, in preparation). More specifically, this report summarizes past CVCC training/SMI efforts, links current findings of the battalion effort to past findings, and suggests new approaches to investigating remaining training and SMI issues.

Background

The background areas provide the context for this research. They include: (a) capabilities of the prototype devices investigated, (b) architecture of the Mounted Warfare Test Bed (MWTB) in which the research was conducted, (c) prior training research related to the CVCC prototypes, and (d) prior SMI research related to the prototypes. The remainder of this section is organized into four parts corresponding to these areas.

Capabilities of the CVCC Prototype Devices

The research described here, conducted under the direction of the ARI-Knox FBC Team, focused on how training and SMI influence soldier use and performance with prototype components of the automated C2 system. The system was comprised of four components: (a) an automated C2 device (the Command and Control Display [CCD]), (b) a Position Navigation (POSNAV) system, and (c) a target acquisition system (the Commander's Independent Thermal Viewer [CITV]). The CCD permitted the transmission and reception of formatted combat reports and presentation of friendly vehicle locations on the tactical map. POSNAV provided the vehicle commander with information about his location and through its integration with the CCD, provides the location of other friendly units. The CITV allowed the vehicle commander to independently scan the battlefield, acquire targets, and designate targets for his gunner. Figure 1 shows the integrated system housed in the vehicle commander's workstation within a reconfigurable simulator. The CITV is in front of the commander and the CCD is on his right. Capabilities of the prototype system are summarized in Table 1. For more detailed descriptions, see Ainslie, Leibrecht, and Atwood (1991); Levine, Lickteig, and Schmidt (1993); and O'Brien, et al. (1992).

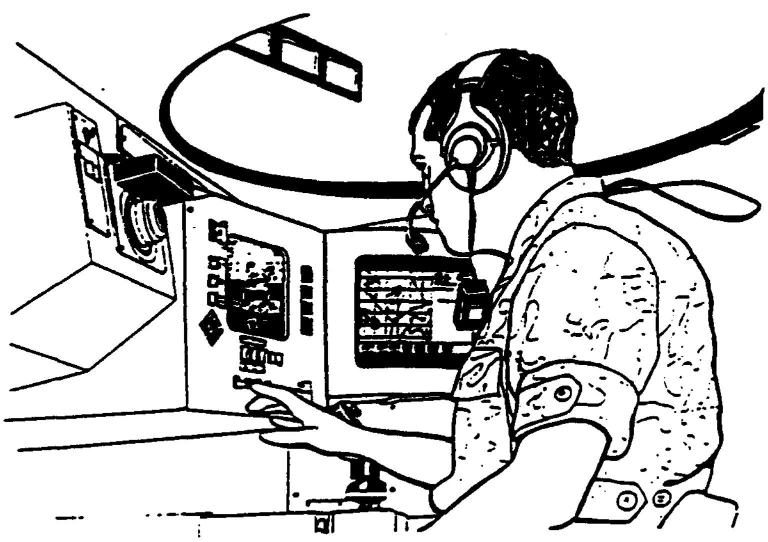


Figure 1. Tank commander's crewstation as seen in the Combat Vehicle Command and Control condition.

Table 1

Command and Control Capabilities of the Combat Vehicle Command and Control Prototype

---

Navigation

Digital tactical map with selectable grid lines, scales, and terrain features
Digital tactical overlays
Own-vehicle location (grid and icon)
Own-vehicle orientation (azimuth heading and directional icon)
Friendly vehicle location icons
Report-based icons
Graphic navigation routes with waypoints and storage/retrieval
Navigation waypoint autoadvance
Driver's display (with Steer-to-Display)

Digital Communication

Combat report preparation
Laser range finder location input to combat reports
Send/receive/relay combat reports (including report icons)
Receive/relay tactical overlays
Send/receive/relay navigation routes
Friendly vehicle locations (mutual POSNAV)
Automated logistics reports, with autorouting

CITV

Independent thermal search
- 3X and 10X magnification
- White-hot and black-hot polarity
- Gun Line of Sight lock-on
- Manual search
- Autoscan

Independent laser range finder
Identification Friend or Foe
Target Designate
Own vehicle icon (directional, all parts moving)
Laser range finder input into CCD reports

General Characteristics

Thumb (cursor) control
Touchscreen input

Command and Control Display

The CCD, shown in Figure 2, is designed to provide commanders with rapid access to battlefield information and to

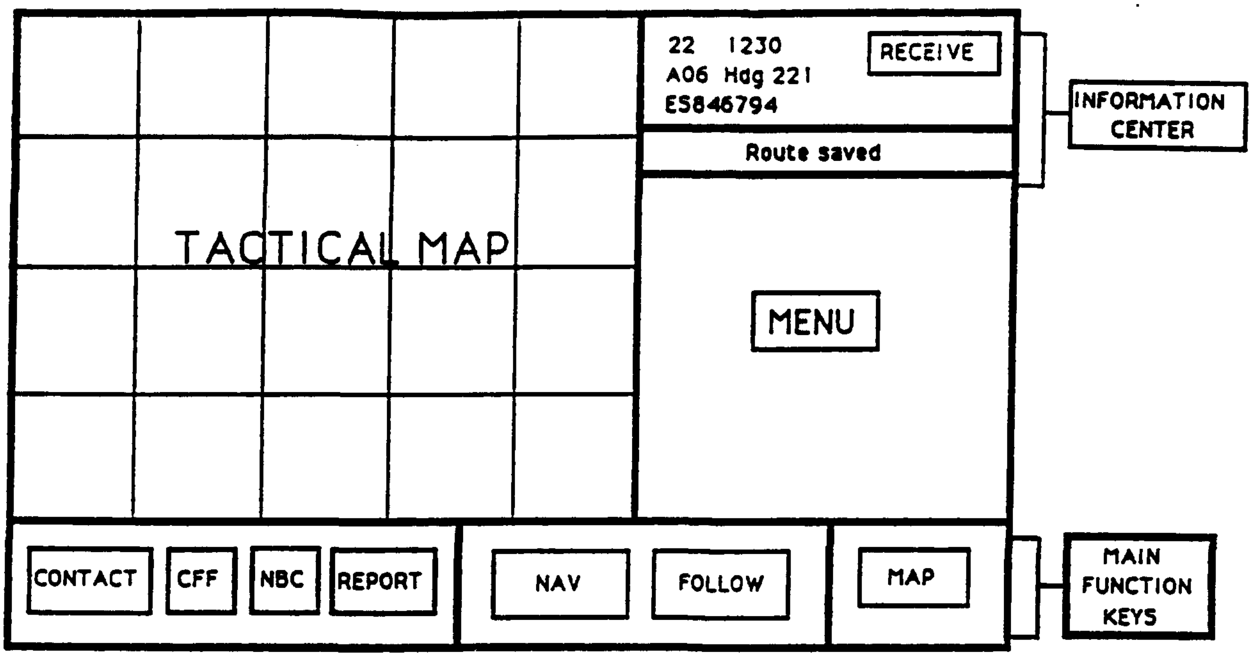


Figure 2. Command and Control Display interface.

speed the unit and vehicle commanders' decision cycles. The CCD allows the vehicle commander to send and receive digital reports and overlays. A vehicle commander can use the CCD's Navigation function to create and send route information to his driver or any other vehicle in his unit. The CCD interfaces with POSNAV to provide steering information to the driver via a Steer-to-Display. CCD capabilities also support manipulation of a tactical map which contains icons for own vehicle and friendly locations as well as North Atlantic Treaty Organization (NATO) icon symbols depicting enemy information provided by the automated reports.

The CCD's tactical map is a Universal Transverse Mercator (UTM) grid representation of the terrain. Digital data in a terrain database constitute the basis for all resident map graphics. The digital map can be tailored to show color-coded contour lines, rivers, roads, vegetation, and UTM grid lines. Map rescaling and scrolling functions for the tactical map are available.

A directional, all parts moving own vehicle icon is displayed at the correct grid location on the tactical map. The own-vehicle icon has features representing the gun tube, the CITV line-of-sight (LOS), the orientation of the vehicle, and the hull. The digital map also displays blue tank icons which represent the friendly vehicles in the battalion. These tank icons move as the actual vehicles move, providing the commander with information on friendly mission execution to aid C2. This capability is referred to as mutual POSNAV, but is most closely linked to CCD interface features. Information displayed in the Information Center (see Figure 2) augments the vehicle status information shown graphically by the POSNAV own vehicle icon. This information includes the date, time of day, vehicle call sign, own vehicle heading in degrees, and the six-digit own vehicle UTM grid location. The status information, like the POSNAV own-vehicle icon, will update as the vehicle moves along the database or at a rate of approximately every ten seconds.

The CCD supports preparation of digital reports by means of menu-driven screens. The unit or vehicle commander is able to prepare any of the eight types of formal reports available on the CCD: (a) CONTACT reports, (b) SPOT reports, (c) Situation reports (SITREP), (d) INTELLIGENCE (INTEL) reports, (e) Call For Fire (CFF) reports, (f) ADJUST FIRE reports, (g) Nuclear/Biological/Chemical (NBC) reports, and (h) SHELL reports. The commander can call up CONTACT, CFF, and NBC report formats directly from fixed function keys along the bottom of the display. When preparing the other five report types, he must select the REPORT function key first, then select a report type and "New" from the Report menu.

Each CCD report is composed of one or more pages of fields tailored to that report type. The unit or vehicle commander enters grid location information into these report fields by lasing to a vehicle or terrain point or by indicating a location on the map using the touchscreen or thumb control. He enters numbers of vehicles into report fields from a soft numeric keypad. He enters vehicle types, activities, and other report information by making selections from the available options. Blank fields are permitted. As he enters "what" and "where" information into a report, a doctrinally correct NATO symbol, called a report icon, appears on the tactical map at the location cited. The icon is blue for friendly elements, red for enemy elements, or green for obstacles (friendly or enemy). For ease in creating reports, most reports have a "walk thru" capability that highlights the next input field as the user steps through a report format. Figure 3 shows the CCD with input fields for a CONTACT report and the tactical map with a posted overlay, terrain features, and own vehicle icon. The unit or vehicle commander can begin a report and then exit before finishing to perform another CCD or POSNAV function. When the unit or vehicle commander has finished the report, he can send it digitally by pressing the SEND key.

A simulated radio interface unit (RIU) enables the unit or vehicle commander to transmit reports prepared on the CCD. A routing menu offers the option of sending the report on any of the available CCD nets. The battalion commander and operations officer (S3) have access only to the battalion command net on their CCDs. The company commanders and executive officers (XOs) can send digital reports on the company command net, the battalion command net, or both nets simultaneously. Default nets based on type and logical routing direction (upward/adjacent or downward) exist for each report created.

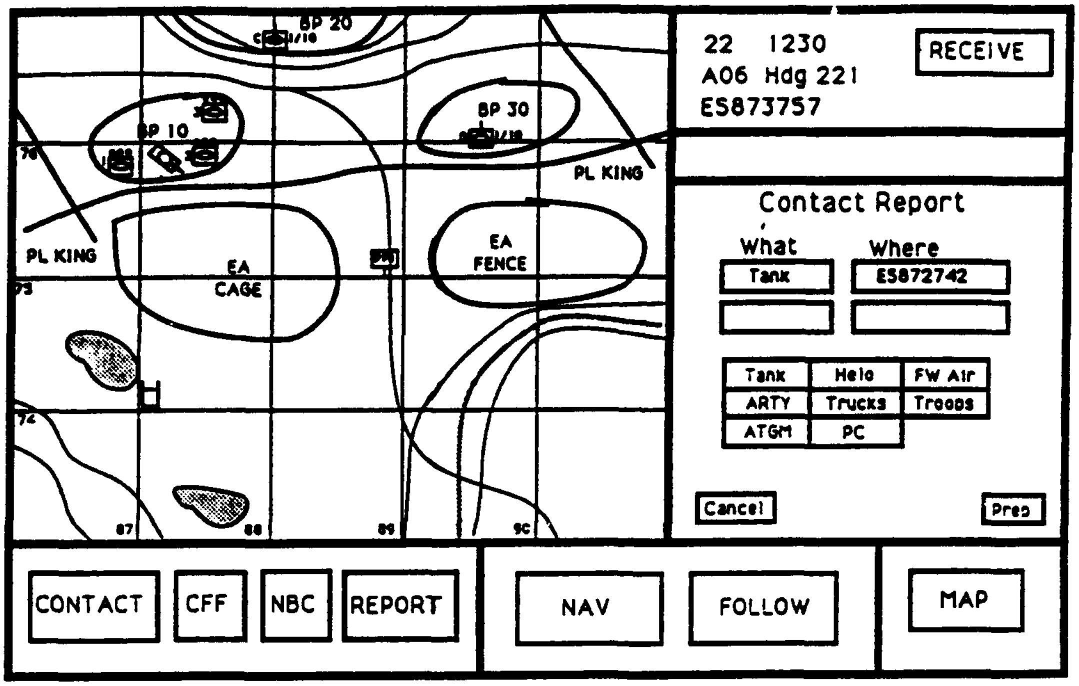


Figure 3. The Command and Control Display in operational mode.

When a unit or vehicle commander receives a transmitted report, three cues signal its arrival: the Receive key (located in the Information Center) highlights, an audible tone sounds in the commander's headset (three beeps for high priority reports, one beep for low priority), and its report icon appears on the tactical map, blinking for the first five seconds.

A new CCD function added for the battalion evaluation was the digital LOGISTICS report. The LOGISTICS report is unique in that it is automatically prepared and routes status information on ammunition, fuel, equipment, and personnel from each vehicle with a CCD within ten seconds of a change in the logistics status. Thus, the LOGISTICS report allows the commander to check his own vehicle's ammunition, equipment, personnel, and fuel status using bar charts showing Green/Amber/Red/Black (GARB) colors as well as that of other vehicles within his unit (or other units).

A particularly noteworthy CCD capability is the overlays function. The overlays function provides the capability to receive and post mission overlays transmitted from the Tactical Operations Center (TOC). These overlays are received like high priority messages in the Receive queue and may be posted to the tactical map and relayed if desired.

<u>POSNAV</u>

CCD features such as the Navigation function are enhanced by the CCD's integration with POSNAV. For instance, the CCD initially provides and then sends the routing information when the correct waypoint information supplied by POSNAV has been entered into the input field by the vehicle commander. The CCD enables the unit or vehicle commander to prepare and modify routes for navigation and to send route information to his driver as well as to other vehicles in his battalion. Using the Navigation function, routes are prepared when locations for up to six control points, called waypoints, are selected on the digital map. An icon for each waypoint appears on the tactical map. The autoadvance sends information on the next waypoint when the vehicle is within 100 m of the current waypoint.

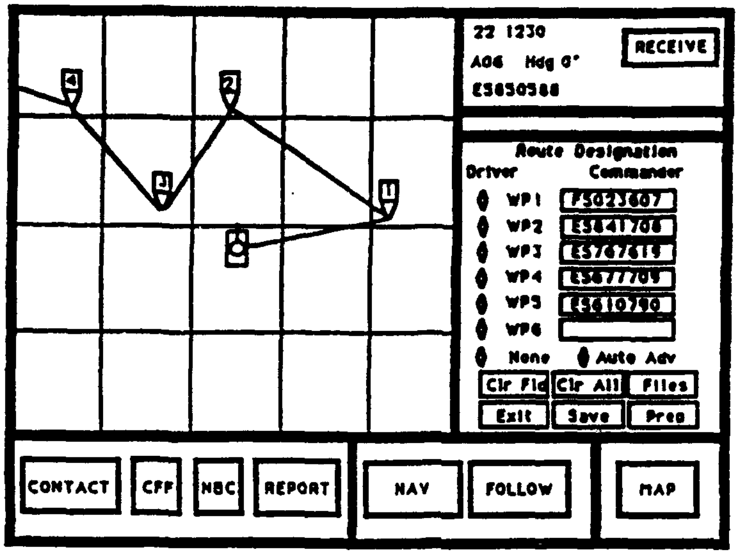
Figure 4 shows the CVCC POSNAV component linked to the Steer-to-Display in the Driver's compartment. The component provides information on own-vehicle location and heading, based on a simulated on-board inertial system. This information is updated automatically as the vehicle moves across the terrain, but not less often than approximately every ten seconds. The POSNAV information is input into the CCD for integration with tactical map, vehicle icon, navigation, Information Center, and status reporting functions as described earlier.

Commander's Independent Thermal Viewer (CITV)

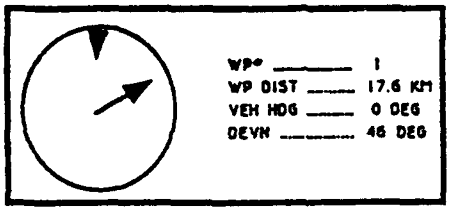
The CITV affords the unit and vehicle commander an independent thermal battlefield viewing capability and an independent laser range finder (LRF). The CITV's capabilities assist the commander in performing navigation, battlefield surveillance, target identification, and fire control tasks. Key features of the CITV are summarized below; see Smith (1990) for additional description.

Mounted directly in front of the vehicle commander, the CITV display includes control switches around three sides of a central display screen (see Figure 5). The commander controls operation of the CITV via inputs from the functional switches and from push buttons on his control handle. The control handle is also used to manually control movement of the CITV sensor. The interface components consist of: (a) rectangular (6.5 X 5.88 inches) monochrome cathode-ray tube (CRT) display screen with own vehicle icon and sighting reticle; (b) three-position toggle switch for power (OFF, STANDBY, and ON); (c) push-button selector switch for basic functions (CITV, Gunner's Primary Sight [GPS]); (d) push-button selector switches for operational functions (AUTOSCAN, MANUAL SEARCH, GLOS [Gun Line of Sight]); (e) two-position push-button switch for polarity (WHITE-HOT, BLACK-HOT); (f) Autoscan control switches for setting sector limits and adjusting scan rate; (g) control handle push buttons for switching magnification (3X, 10X), operating the laser and designating targets; and (h) control knobs for adjusting brightness and contrast.

In the GPS mode, the CITV is functionally inactivated, with the sensor stationary while the CITV picture changes as the



Vehicle Commander's
CCD



Driver's
Steer-To-Display

Figure 4. The Position Navigation system and Driver's Steer-to-display.

vehicle moves. Using the GPS mode, the commander can override the gunner in moving the turret/gun tube and firing.

The CITV permits the commander to select three types of surveillance: Gun line of sight (GLOS), Manual Search, and Autoscan. The GLOS function slaves the CITV line of sight to the main gun alignment, except when the commander depresses his palm switch to activate Manual Search. The slaved alignment provides a view overlapping the gunner's view while enabling the commander to operate his own LRF and change magnification and polarity. In Manual Search, the commander can control the CITV's line of sight by manipulating his control handle. Both direction (horizontal, vertical, and oblique) and speed of movement can be controlled simultaneously. This function allows the commander to vary his

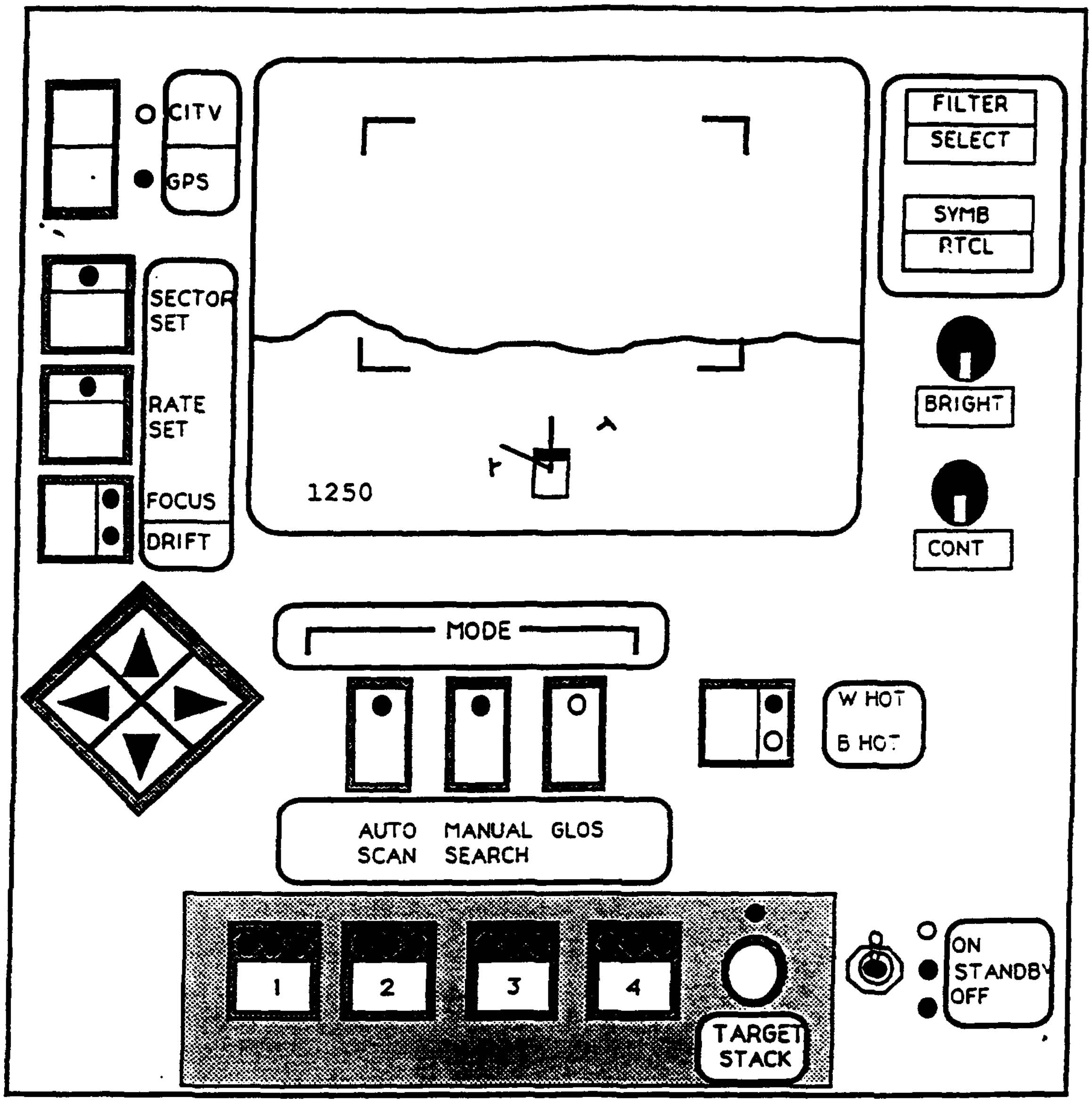


Figure 5. Commander's Independent Thermal Viewer interface. (Target stack functions, in the bottom shaded area, were inoperative.)

pace and pattern as he searches for targets. The commander cannot control or fire the main gun with his CITV activated because it is not linked to the main gun. The CITV was designed this way to promote independent battlefield scanning by the commander and gunner. Autoscan permits the commander to automatically sweep the CITV's line of sight across a specified sector at a selected rate of speed. The search pattern requires no input from the commander once initial parameters are set. Setting or resetting left and right sector limit markers defines the portion of the field of regard to be scanned. To adjust scan rate, the commander can increase or decrease the current rate, which begins at a default value upon initialization. If desired, the entire 360 degree field of regard can be selected as the scanning sector.

The own tank icon present on the display screen is fully consistent with the own tank icon appearing on the CCD tactical map. The hull portion of the icon faces the same direction as the hull of the vehicle. The main gun indicator accurately depicts the direction of the main gun/turret. The CITV indicator depicts the CITV's line of sight, and markers show the limits of the Autoscan sectors.

The CITV system includes a laser capability independent of the standard LRF. The commander can exercise this capability in GLOS, Manual Search, and Autoscan; however, lasing using Autoscan requires interruption of scanning to stabilize the sight picture. Each lase produces a range-to-target reading in meters, displayed in the lower left corner of the display screen. The CITV LRF also supports the Identification Friend or Foe (IFF) function, generating symbology (i.e., a star, two XXs, or a question mark) characterizing the target as friendly, enemy, or unknown, respectively. This symbology appears in the upper left portion of the display. The closer the target is, the more likely it is that the IFF can correctly identify it. The farther away the target is, the more likely it is that the vehicle cannot be identified. For example, within 1000 m of the target, the accuracy is 90%. The accuracy drops 15 percent for targets *within 1001-2000 m while the probability of an receiving an* IFF of "unknown" increases from 8% to 21%.

With Manual Search and Autoscan, the commander can use the Designate function to quickly hand off a target to his gunner. Having identified an enemy target for immediate engagement, the commander presses the Designate button on his control handle. This rapidly slews the main gun to the CITV's line of sight,. overriding the gunner's controls. The commander can then hand off the target to the gunner by releasing the palm switch on his control handle.

Battalion TOC Workstations

The CVCC TOC was comprised of automated workstations which support the tasks and responsibilities of the battalion commander/XO, the assistant S3, the intelligence officer (S2), and the Fire Support Officer (FSO) in a surrogate TOC. The TOC Workstations' primary purpose was to support the CVCC vehicles. The workstations exchange data on a TOC local area network, which in turn connects to the CVCC network. This digital linkage provided the means of implementing command and control procedures, coordinating, and exchanging information with the unit and vehicle commanders in the manned simulators.

The TOC workstations permitted TOC personnel to perform key command and control functions such as receiving combat information, generating combat orders and overlays, and communicating information within the TOC and throughout the battalion. Figure 6 shows a CONTACT report being created via a CCD in the simulators and then received at a TOC workstation. The TOC workstations were used to support the battalion evaluation and were not a focus of the training and SMI analyses. For more detail, see Sever, Collins, and Heiden (in preparation).

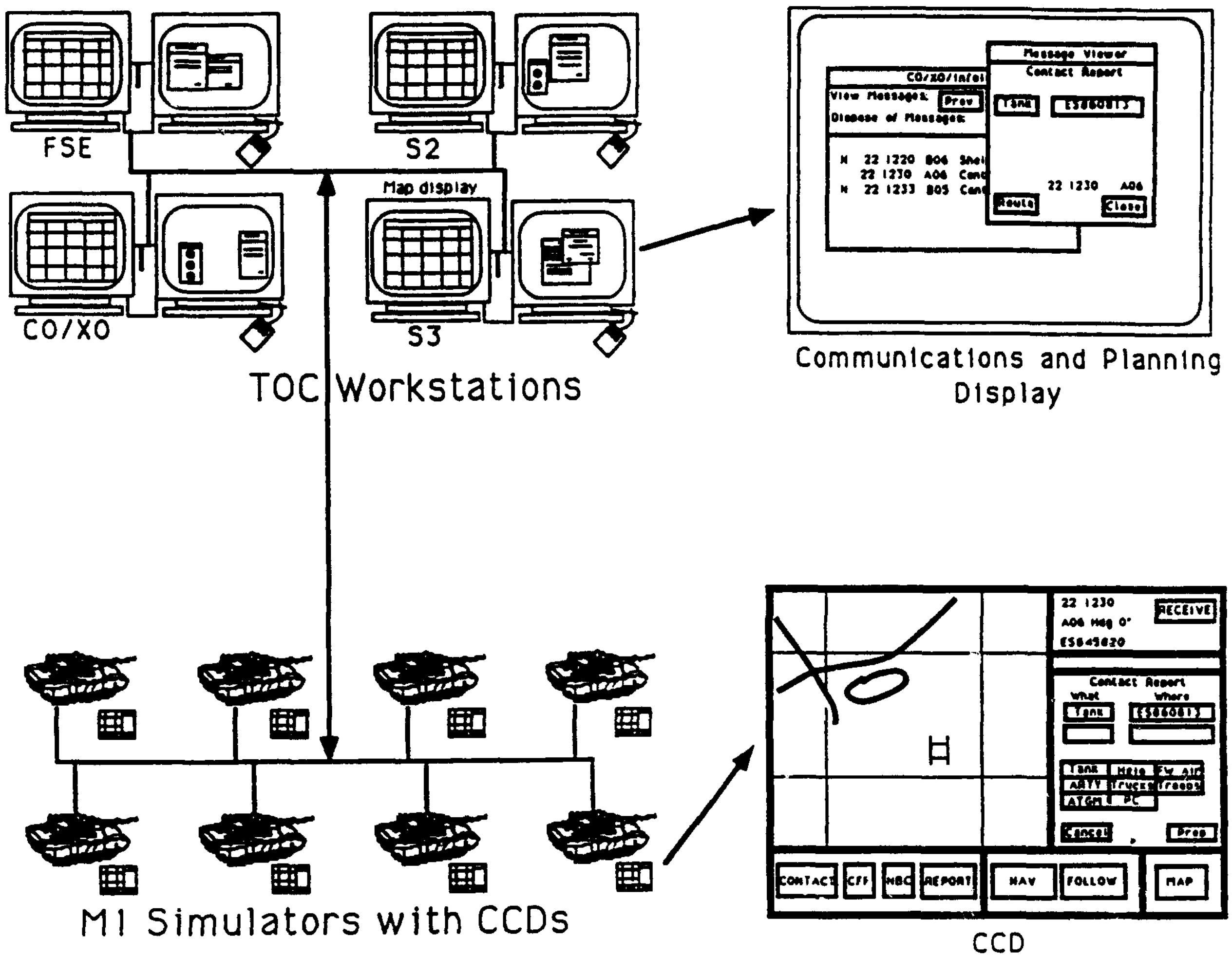


Figure 6. The digital link between the Command and Control Displays' and Tactical Operations Center Workstations' report functions.

The training approach for the prototype C2 devices described above capitalized on the Distributed Interactive Simulation (DIS) capabilities of Fort Knox's MWTB for training delivery and evaluation. Key features of the MWTB are highlighted in the next section to provide the reader the experimental context for this research.

Mounted Warfare Test Bed

The MWTB is a pioneering research and development facility which allows the Army to assess performance associated with training, soldier-machine interface, and operational effectiveness prior to final design production and field implementation of technology-based devices. The MWTB environment relies on DIS, a follow-on program to an earlier technology, simulation networking (SIMNET). Both DIS and SIMNET are characterized by extended local and long-haul networking and contain families of simulators supported by site-specific microprocessors (Miller & Chung, 1987; Du Bois & Smith, 1989).

Figure 7 shows the architecture which was developed for the CVCC program and provided the foundation for the delivery of the training program described here.

The architecture included five classes of components. The first class included the simulators themselves shown in the Simulator Bay. These M1 simulators were built to be reconfigurable so that components can be utilized as required for a particular training or testing exercise. Thus, a CVCC component such as POSNAV or the CCD can be added to simulators to support a specific requirement.

The second class of components was housed within the automated battalion (BN) TOC. Components included workstations for battalion staff to include: (a) an Intelligence Workstation, (b) Operations Workstation, (c) a Fire Support Workstation, (d) a workstation which can be used as a Battalion or an Executive Officer Workstation, (e) a Combat Service Support (S4) Workstation, and (f) a large screen Situation Display.

The third major component was the Stealth, located in the Simulator Bay (see Figure 7). The Stealth is a phantom vehicle which can be used to traverse the battlefield without detection by battlefield participants. The Stealth has been used for a wide variety of purposes including terrain analysis, reconnaissance, and after action reviews (AARs).

A fourth class of components resided in or was adjacent to the Exercise Control Room (ECR). They included: (a) a Management, Command and Control (MCC) system for controlling and monitoring manned simulators and implementing fire support; (b) a SIMNET Control Console (SCC) for initializing an exercise and setting battlefield parameters; (c) Semi-Automated Force (SAFOR) stations for creating and controlling unmanned vehicles and aircraft, both friendly (BLUFOR) and enemy (OPFOR); (d) a Plan View Display (PVD) to provide a "bird's eye view" of the battlefield which can be used to monitor exercises and flag key events; (e) a SEND utility for transmitting automated messages; (f) a LISTEN station to record digital messages; (g) a Checkpointing utility for freezing exercises; and (h) radio nets for monitoring simulated Single Channel Ground Airborne Radio

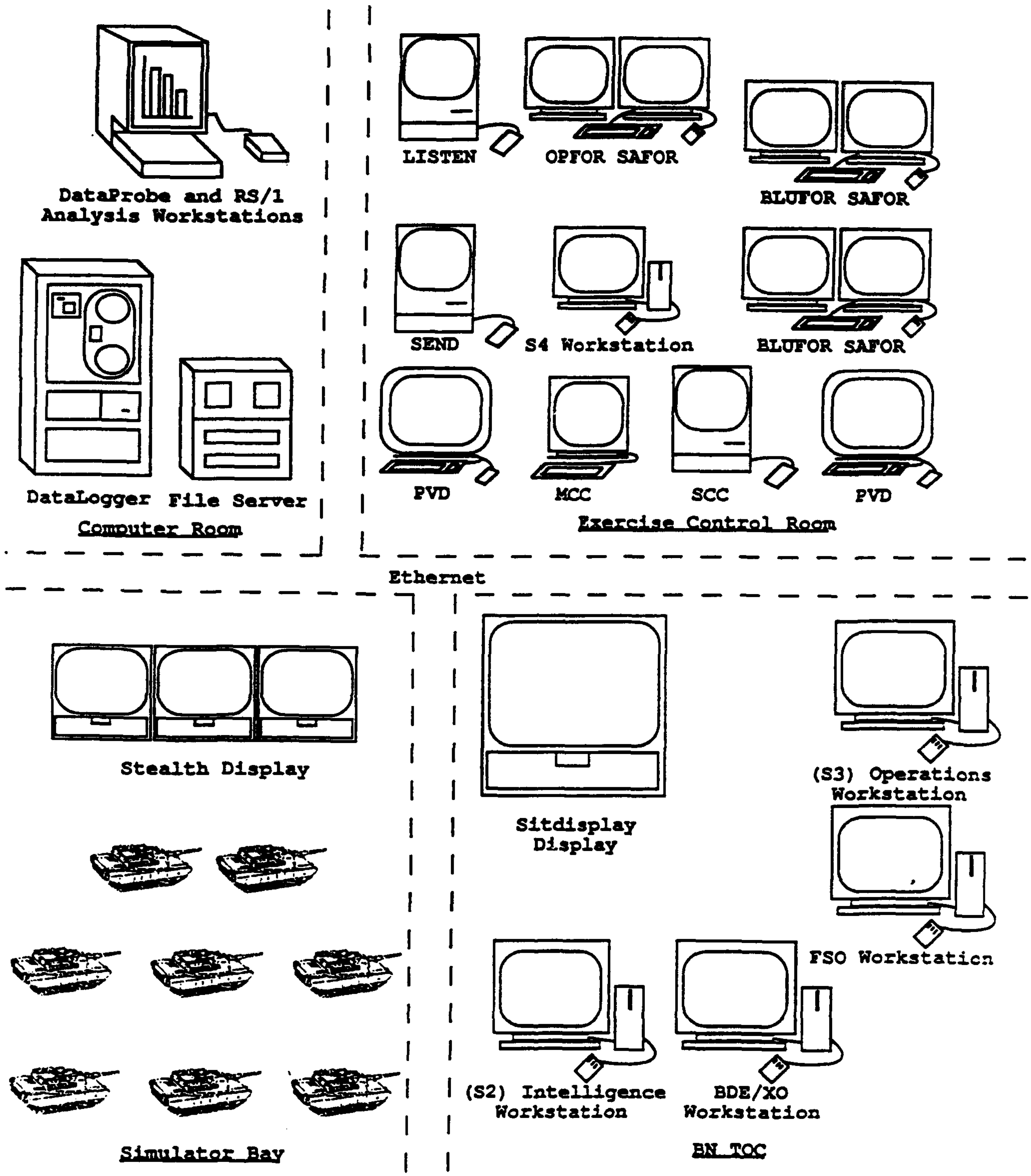


Figure 7. Distributed Interactive Simulation architecture.

System (SINCGARS) radio traffic and communicating between control stations and manned simulators.

Finally, components for use in data recording and analysis included: (a) a file server, (b) a Data Collection and Analysis System (DCA) for on-line recording of automated data and exercise playbacks (DataLogger), and (c) an off-line reduction and analysis system (DataProbe™ and RS/1™ Analysis Workstations[1]).

DataLogger received input information from instrumented features of the CVCC system (e.g., number of times microphone is keyed) via the server and the PVD. The PVD sent flags to DataLogger which marked important data milestones used later for data reduction. Two types of DCA software routines handled off-line reduction and analysis of DataLogger recordings. They included (a) extraction routines for retrieving and structuring data into intermediate files and (b) routines for analyzing data from the intermediate file by means of standard library routines as well as tailored programs.

To provide the context for addressing current CVCC training and SMI, the remainder of this section presents a review of key literature and a description of the history of CVCC training and SMI development efforts.

CVCC Training

Review of Key Literature

Armor 2000: A Balanced Force for the Army of the Future (U.S. Armor Center and Fort Knox, 1990), was designed to blueprint how Armor's roles and missions will evolve as the 21st century approaches. The evolution of these roles and missions revolves heavily around the development of new technology for C2, such as the Intervehicular Information System (IVIS). The CCD, an IVIS-like prototype, allows for more information to be received simultaneously than ever before.

Even though the design and function of these prototype systems (as they exist in the CVCC system) could be different when placed in an actual M1A2, they provide a unique opportunity to improve M1A2 tactics, techniques, and procedures (TTPs) through training and performance assessment. For instance, the CVCC training package (A. R. Sawyer, personal communication, August, 1991) can be used to support training for new C2 technologies. That is, it can be used to (a) teach the operational skills necessary, (b) effectively manage the increased information load, and (c) integrate use of the new equipment into a tactical environment.

High-technology fighting devices will only help win the war if the Army is properly trained to operate the equipment. As such, the push for new fighting technologies creates an immediate

---

[1]DataProbe and RS/1 are trademarks of Bolt, Beranek, and Newman, Inc.

requirement for the development of new and innovative approaches to training, most of which make use of new training technologies.

Edmondson (1992) identified six training technologies likely to be used to train Armor soldiers in the year 2000 and beyond:

1. Video teletraining (VTT) uses advanced telecommunication to allow an instructor to train one or more students at different locations.

2. Computer-mediated communications uses electronic mail to allow for communication between instructors and students.

3. Digital Video Interactive (DVI) technology uses a hard disk drive or a compact disk-read only memory (CD-ROM) system to access different multimedia components such as sound, full-motion video, and text simultaneously onto a computer.

4. Embedded training (ET) technology provides standardized hands-on training for the soldier in the field and on the soldier's own equipment.

5. Computer automation technology provides soldiers with a helmet-mounted display for portability. This would allow the soldier to take his simulation training programs with him to access repair manuals located on disk at a host computer, and to interact with other soldiers via voice and data radios.

6. Virtual reality allows users to interact with a computerized simulation of the real world. Virtual reality technology allows the military to enhance the training simulations currently available by increasing realism and the scope of tasks which can be trained without the danger and expense of field training.

Various forms of virtual reality technology, including DIS, are receiving a great deal of attention in the Armor community for the training of collective and C2 skills in a simulated environment. For example, Gorman (1991) discussed three types of simulation: live, constructive, and virtual. Live simulation uses simulated battle scenarios with real equipment in the field. Constructive simulation involves wargames, models, and analytical tools that may or may not involve human interaction. Virtual simulation involves manned simulators and is a component of virtual reality. DIS is a technology which permits simulators from different geographic locations to share a common synthetic battlefield environment and interact with one another. Although DIS can consist of any combination of live, constructive, or virtual simulations, it is most often associated with virtual simulation. One of the primary benefits of DIS is that it will allow soldiers to use tactical engagement simulation (TES) "in a safe, cost effective environment which can augment live field exercises" (Singley, 1993, p. 36).

SIMNET, the precursor to DIS, successfully demonstrated the potential value of networked simulation. Alluisi (1991) explained how SIMNET was intended to create cost-effective, high-technology prototype equipment quickly. The expenditure for specially-designed equipment and lengthy design and development was not justified, because in the constantly evolving world of technology, the created system would soon be superseded by another, more advanced system. Alluisi argued that one should use "iterative, rapid prototyping" and "innovative approaches" (p. 359) whenever possible.

The CVCC program, with its emphasis on iterative design and rapid prototyping, is an excellent example of how Alluisi's (1991) guidelines can be successfully used to develop high-technology prototype equipment. Further, the CVCC program has shown that these same principles of iterative design and rapid prototyping can be key ingredients in creating an effective, comprehensive, and innovative training program. The CVCC program has linked equipment design and training development, showing that concurrent equipment and training development is the most effective strategy.

As Black (1989) observed, it has often been left to training developers to overcome the limitations of inadequate equipment design in an item of fielded equipment. Soldier-in-the-loop testing allows for interface and training requirements to be identified simultaneously. Furthermore, the dual development process allows the training developer to go from task analysis to specifying training requirements to developing training materials more expeditiously than can be done when training programs and material systems are developed in isolation. Figure 8 shows the model of concurrent training and system development adapted for the CVCC program.

To further demonstrate why equipment design and training development should happen concurrently, the issue of simulator fidelity must also be considered. Fidelity, the extent to which the simulator replicates the workings of the vehicle or environment that it is designed to emulate, is a major component in the cost of simulated systems. Generally speaking, the greater the fidelity, the greater the cost. At first glance, fidelity appears to be only an equipment development issue with cost the primary determiner.

Cost is not the only factor to be considered when selecting fidelity level. Another issue is transfer of training. Transfer of training occurs whenever knowledge and skills that have been learned previously affect the acquisition of new knowledge and skills (Cormier & Hagman, 1987). Maximum transfer of training from the simulator to the battlefield can only come when critical similarities are maintained across the training and transfer tasks. Thus, the cost of greater fidelity must be weighed against the need to maximize the transfer of training knowledge (Holding, 1981).

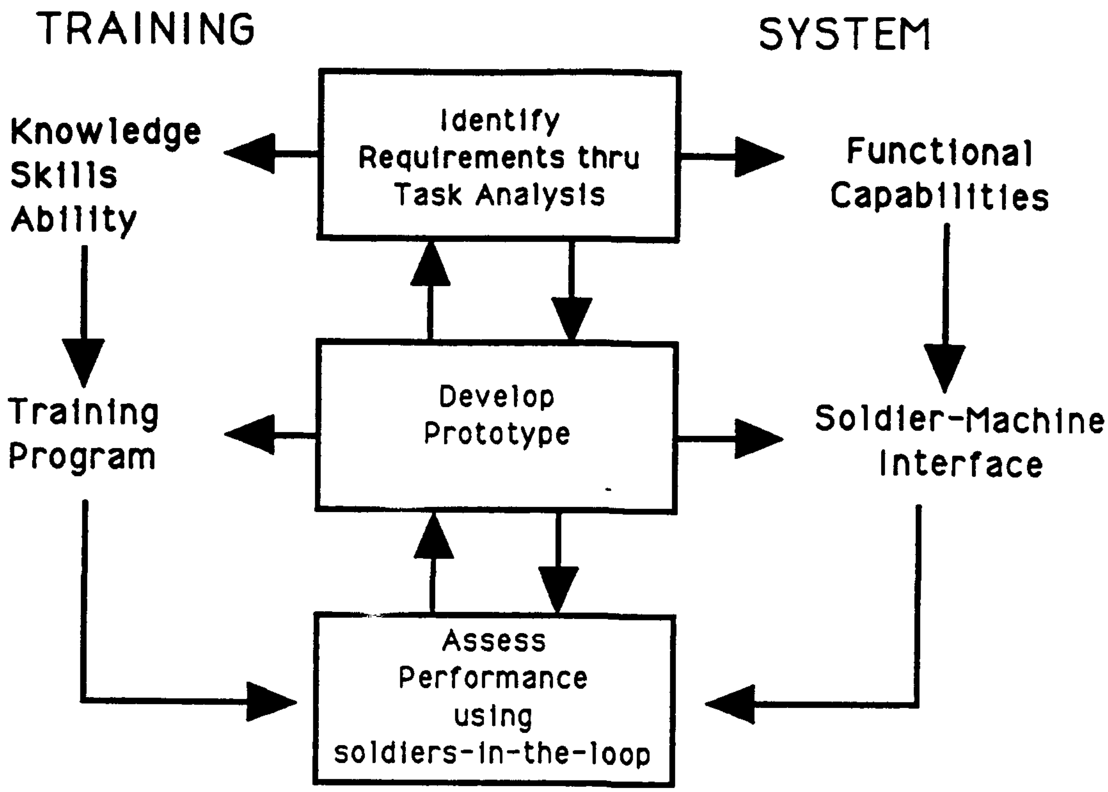


Figure 8. Concurrent Training and Soldier-Machine Interface Development.

However, it is a fallacy to believe that optimum fidelity, assuming that it is affordable, is always the best facilitator for transfer of training. For example, Schneider (1990) argued that one of the most common misconceptions on training high-performance skills is the belief that training should be conducted on the total skill with the maximum fidelity possible. There is evidence to suggest that it is preferable to train component tasks with the fidelity needed for those tasks before training the total performance with a real system (Schneider, 1990). Therefore, a decision on level of fidelity should not be made without consideration of identified training requirements.

More generally, Flexman and Stark (1987) maintain that complete physical fidelity is rarely required for effective training and transfer of skills because the function of the simulator is not to provide all possible information, but to provide critical information for training. The DIS environment of the MWTB offers selective fidelity of system features. This results in instrumentation of critical system features with remaining features represented as "mock-ups."

Evolution of CVCC Training

The CVCC training program was based on the structured approach to instructional development adapted by the Army as the Systems Approach to Training (SAT) (TRADOC, 1988). The SAT methodology requires the following steps:

1. The quality of training, testing, and materials must be continuously evaluated.

2. A front-end analysis of tasks to be trained must be conducted.

3. A training blueprint must be designed from the terminal and enabling training objectives.

4. The training program, procedures, and materials must be developed so that objectives are met.

5. The training program is implemented.

Unlike the traditional training development model where evaluation is the final step of the instructional design process, the SAT model shows continuous evaluation taking place, as depicted in Figure 9. As Atwood et al. (1991) observed, the continuous evaluation of the SAT model "allows for iterative improvements over the course of the development process along with systematic evaluation of the effectiveness of the training program as implemented" (p. 3). Thus, as the training lessons learned are documented in an SAT "audit trail" of technical and research reports, the next iteration of testing can build upon the strengths and weaknesses of the past to improve future training procedures and materials.

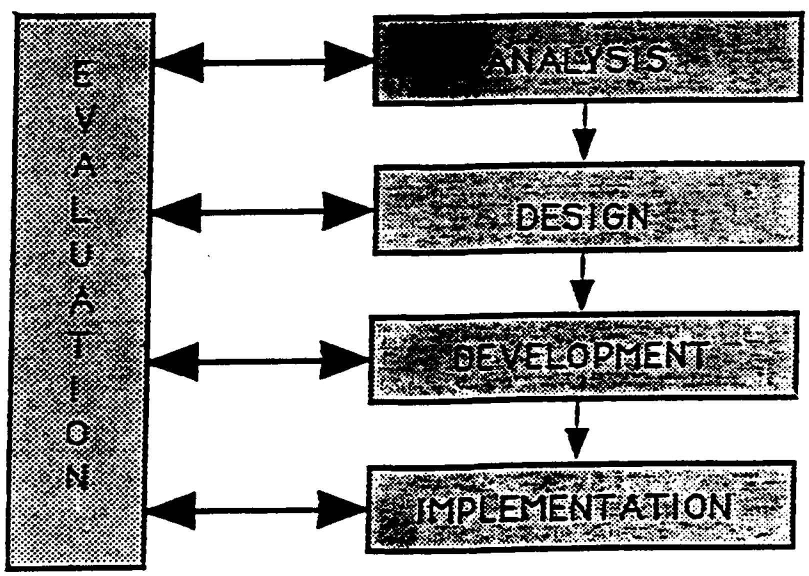


Figure 9. Systems Approach to Training model.

Key features of the SAT process are highlighted below as they evolved over the course of the CVCC program. Lessons learned derived from the process and incorporated into the battalion training package (A. R. Sawyer, personal communication, August, 1991) follow.

Battle Management System (BMS). Lickteig (1987) performed a front-end analysis of training requirements for the BMS, an early prototype resembling the IVIS. BMS was designed to partly automate C2 at the lower echelons. Lickteig based these training requirements on platoon leader tasks outlined in Training Circular 17-15-1 Tank Platoon Mission Training Plan (U.S. Army Armor Center, 1983). He was interested in determining which of the platoon leader's tasks under C2, force movement, and offensive/defensive operations might be more easily performed or perhaps eliminated by automation. Lickteig also investigated which of the platoon leader's C2 tasks could be trained by stand-alone training devices and which would require an interactive, networked system of training devices. He concluded the best way to train an automated C2 system was with computer-based instruction (CBI) and suggested embedded training would provide an effective training methodology for the BMS.

CITV. Quinkert (1987) documented the training requirements for the CITV based on a front-end analysis. She identified anticipated changes in the duties of a tank commander as the result of the addition of the CITV and how these changes could be trained. Quinkert considered three potential solutions to CITV training if it were put on the Block II tank: (a) embedded training, (b) hands-on training, and (c) training devices. Quinkert concluded that although interactive embedded training would be useful, interactive simulators were the best solution for providing the skills and necessary practice to integrate operation of the CITV with other vehicle commander duties.

In a follow-up report, Quinkert (1990) evaluated vehicle commander use of the CITV during interactive simulation exercises in the Unit-Conduct of Fire Trainer (U-COFT). Her observations raised concern that the CITV might be a difficult system for vehicle commanders to integrate into their regular routine due to "the expected additional workload, information flow, the disorientation problem associated with indirect viewing, and the changes in the current training strategy that would be necessary to integrate the CITV into the M1A1, Block II" (p. 1). Although the training was largely well-received, the participants had several suggestions for improvement. The majority of participants wanted more coordination training between gunner and vehicle commander as well as training on abbreviated fire commands. The participants also requested that more operational information be provided on how and when to use the CITV.

POSNAV. Du Bois and Smith (1989) evaluated two versions of the POSNAV component: one with a grid map display and the other with a terrain map display. Vehicle commander responses to a questionnaire item indicated that more time should be provided to allow POSNAV users to practice integrating the system with the rest of their C2 and target acquisition tasks. They also emphasized that basic land navigation skills should continue to be taught to groups with POSNAV in case of system malfunction. Finally, it was suggested that future training emphasize the increased importance of the driver's role and good vehicle commander-driver communication.

The IVIS prototype evaluation. The CCD, an IVIS-like prototype, was designed to provide improved capabilities to assess both friendly and threat battlefield situations. Du Bois and Smith (1991) examined a prototype IVIS, comparing the performance of crews and tank platoons equipped with IVIS to those using conventional C2 and conventional navigation techniques. Changes made to the prototype training program for this and subsequent evaluations are shown in Table 2. In addition to training being extended from 1 to 1/2 days, several new instruments designed to test the effectiveness of the prototype training program were developed: Vehicle commanders in both conditions completed a written SIMNET test, and vehicle commanders in the Experimental condition completed a written IVIS test. Vehicle commanders with IVIS also completed a hands-on IVIS test which required them to complete at least one task per IVIS function.

Training questionnaires completed by vehicle commanders indicated that participants wanted "slightly more time" on hands-on, crew, and platoon practice exercises but "slightly less time" in the classroom. Many unit and vehicle commanders suggested that the IVIS classroom instruction be supported by an IVIS prototype rather than viewgraphs. As in the POSNAV study (Du Bois & Smith, 1989), several vehicle commanders expressed concern that their attention became focused on the IVIS prototype at the expense of other tasks; the integration of IVIS was far more difficult than merely learning to use its functions. In response to the challenge of IVIS integration, Du Bois and Smith (1991) recommended that a group of IVIS Subject Matter Experts (SMEs) with extensive experience on integrating the system be selected and studied so that their techniques could be trained in further iterations of IVIS testing. This recommendation marked the beginning of a training issue repeatedly encountered throughout the course of evaluating the CVCC system: whether the evaluators should tell the participants how to tactically use the equipment, or whether to let each vehicle commander form his own CVCC usage and integration procedures for the test personnel to document.

Company evaluation. The company-level evaluation was the first evaluation of an integrated CVCC prototype system including CCD, CITV, and POSNAV components. Atwood et al. (1991) documented the training procedures and results, and suggested improvements to the company-level training package. Given the increased training requirements due to this integration of the

Table 2

Combat Vehicle Command and Control Training Program Changes

Company Evaluation (Atwood et al., 1991; Leibrecht et al., 1992)

- Training included CCD, POSNAV, and CITV components[c]
- Training extended from 1 1/2 days to 2 1/2 days[b, c]
- Training scenarios revised[b, c]
- Company-level training scenario added[b, c]
- Equipment-oriented checklists kept[b, c]
- Written tests replaced by hands-on tests[c]
- Training evaluations administered to all crewmembers[b, c]
- Navigation classroom training added[b]
- Written navigation assessment test dropped[b]
- Sandbox navigation exercises added[b, c]

Prototype Methods for Training C3 Evaluation (Lickteig, 1991)

- CCD demonstration added to follow CCD classroom training[c]
- Message processing vignettes added to training package[c]

Battalion TOC Evaluation (O'Brien et al., 1992)

- Time no longer a criteria in skills test scoring[b, c]
- Two battalion-level exercises added[b, c]
- Platoon-level exercise dropped[b, c]
- Battalion TOC Workstations added[c]
- Training extended from 2 1/2 to 3 days[c]
- CCD classroom training replaced by CCD demonstration[c]
- CCD Skills Test revised to make it more realistic[c]
- More CVCC information added to gunner and driver scripts[c]
- CCD refresher demonstration added[c]
- Tank Commander (TC) navigation skills drills added[b]
- Training evaluations administered after test scenario[b, c]
- Navigation refresher added[b]

Battalion Evaluation (Leibrecht, Winsch, et al., 1993)

- CCD demonstration shortened from 45 to 30 minutes[c]
- CCD demonstration script outline provided to all attendees[c]
- Refresher hands-on training session added[c]
- Participant TOC replaced by contractor-staffed TOC[b, c]
- Company training exercise revised[b, c]
- Trainer checklists include correctness as a criteria[b, c]
- CITV Skills Test revised for realism[c]
- Training objectives slides shown before training events[b, c]
- More explicit training objectives added to CCD and CITV hands-on training scripts[c]
- SAFOR briefing added[b, c]
- Pre-mission briefing using Stealth technology added[b, c]
- Officers call added[b, c]
- Condition-specific battalion SOPs used[b, c]
- Course of Action overlay added to pre-mission briefing[c]
- Controller checklists added for TC navigation skills drill[b], crew training[b, c], and navigation refresher training[b]

Note. [b] = Baseline condition; [c] = CVCC condition;

three components and the higher echelon of the test, 2 1/2 days of training were executed. Equipment-oriented checklists were provided to help prompt the trainers in providing feedback during the crew, platoon, and company-level practice exercises. Written tests were replaced by hands-on performance tests such as navigation drills and skills tests.

In their training evaluation responses, unit and vehicle commanders suggested that the redundancy be reduced between the classroom and simulator training. They indicated that hands-on training sessions should focus on practice with some time for unstructured practice rather than a repeat of the classroom lecture plus structured practice exercises. Commanders requested that time be used as a factor in scoring task performance on a skills test as a "GO" or "NO GO." (Although time was a general criteria in scoring, the allotted completion windows were generous.) Commanders also wanted more realistic, operationalized tasks to perform on skills tests. New Equipment Training Team (NETT) members participated in the company evaluation and were given a special interview to obtain their suggestions. The NETT members requested mock-ups for CCD and CITV classroom instruction and more explicit instructions on CCD, POSNAV, and CITV usage and integration.

Prototype methods for training C3 evaluation. Lickteig (1991) followed up the company evaluation with a systematic evaluation of training C2 skills using the CCD. Focusing on the issues of information relevance, workload, and CCD contributions to situational awareness, Lickteig provided an opportunity for training developers to assess the message processing portion of the CCD training package. Lickteig piloted the use of message processing vignettes which allowed participants to receive and process different message sets. Lickteig followed the CCD viewgraph slide presentation with a CCD demonstration. In the CCD demonstration, an instructor used a large screen display to show how to tailor the CCD map and how to process digital reports. Although no training evaluations were given, Lickteig's concepts of the message processing vignettes and CCD demonstration appeared to be well received by test participants and were added to the growing repertoire of CVCC training methodologies.

Battalion TOC evaluation. Building on the CVCC prototype training program begun during the company evaluation and fine-tuned during Lickteig's (1991) effort, the battalion TOC evaluation (O'Brien et al., 1991) presented new challenges to the CVCC training developers. The evaluation created new training requirements due to the addition of many new CCD features such as FREE TEXT messages, correct NATO symbology, icon aggregation, and the ability to receive multiple overlays. This effort also required that training scenarios be created to cover three echelon levels: platoon, company, and battalion. Thus, the battalion TOC evaluation had a 3-day training program, one-half day longer than that of the company evaluation. Because of the success of the CCD demonstration in Lickteig's (1991) evaluation, classroom instruction aimed at the CCD was dropped. The CCD demonstration was lengthened to include CCD navigation functions in addition to the message processing and map manipulation functions. The CCD Skills Test questions were also revised to make the questions more realistic.

A second opportunity for unit and vehicle commanders to refresh themselves on basic CCD usage skills was added in the form of a CCD refresher training demonstration. This demonstration had a script that covered functions considered more difficult by previous participants, but was tailored weekly to accommodate particular equipment usage problems noted by the trainers.

The battalion TOC evaluation also introduced workstations designed to help TOC members communicate digitally with the CVCC simulators. These TOC workstations were operated by military test personnel. The majority of the TOC staff indicated that the training they received was effective and that no part of the training could be taught in less time or omitted. They also believed that sufficient operational concepts on the TOC workstations were presented in the training. The training materials for the TOC workstations are contained in the battalion-level training package (A. R. Sawyer, personal communication, August, 1991).

Battalion evaluation. Although more CCD functions, such as the LOGISTICS module, were added for the battalion evaluation, the scheduled training time remained at three days. To decrease redundancy and create additional hands-on training time, the CCD demonstration was shortened from 45 to 30 minutes. A demonstration script was also provided to participants for note-taking. The addition of a 30-minute refresher training session filled the available time and created another opportunity for individual hands-on training. Basic simulation navigation skills and more CCD/POSNAV navigation skills were added to the gunners seat-specific orientation to accommodate a new company training exercise. In the revised company training exercise, two of the eight gunner's acted as vehicle commanders while the battalion commander and his S3 learned how the TOC staff used their workstations to interact digitally with the CCDs. In addition, the vehicle trainer checklists were revised to include correctness of usage of CVCC and basic simulator features. The CITV Skills Test was also revised to remove unused training on setting sectors using mils and to make it more realistic. There was also an increased focus on more directly stating the training objectives during the battalion evaluation. Thus, slides clearly stating training objectives were shown prior to each training event to promote more effective CCD and CITV training.

Several briefings were added to the schedule. First, a semiautomated forces (SAFOR) briefing was added to familiarize participants with the capabilities and limitations of the computerized forces. A briefing on the role of the company XO was also added following the SAFOR briefing. Also, a pre-mission briefing using a Stealth station allowed participants to view the battlefield prior to the final battalion training scenario. A pre-mission briefing using the TOC workstation's Course of Action (COA) overlay was also presented prior to the last battalion training scenario. Use of the animated COA overlay allowed the participants to rehearse the battle prior to mission execution. Finally, an "Officer's Call" was conducted to openly discuss the purpose and limitations of the evaluation, including kill suppress for manned simulators and potential reliance on SAFOR for navigation. Discussion addressed the importance of professional role-playing, despite simulation artifacts, to accurately assess performance.

During the same time frame as the battalion evaluation, a prototype innovative training exercise was conducted as a companion evaluation (see Winsch et al., in preparation). This effort involved the development of Information Management Exercises (IMEX) which piloted the use of self-paced training materials for the CCD, and focused on training for information management and situational assessment using CCD message processing vignettes similar to those created by Lickteig (1991).

Each CVCC evaluation described above produced a set of training lessons learned for use in making changes to training materials and procedures prior to the next evaluation. This process corresponded to the evaluation component of the SAT model, yielding on-going program improvements as well as documentation of lessons learned.

<u>Training Lessons Learned</u>

The following training lessons learned are presented by category rather than chronologically as many were reinforced across the CVCC evaluations.

<u>Time for training</u>. Lessons learned about CVCC training time are summarized in Table 3. Participants in the company evaluation, as documented in Atwood et al. (1991), indicated that more hands-on training time would be useful on the various CVCC functions. However, it was not until the CCD Demonstration was shortened and a hands-on refresher training module was added for the battalion evaluation that increasing hands-on training was implemented. Although the hands-on training time remained static, the battalion TOC evaluation had an even tighter training schedule as more functions and another echelon of training were introduced. Consequently, there were several time-related lessons learned during the battalion TOC evaluation that should be heeded when planning future tests.

First, more training time for battalion-level participants on the CVCC equipment would be advantageous. True to the "crawl, walk, run" approach to training, each echelon would benefit from

Table 3

Combat Vehicle Command and Control Training Time Lessons Learned

1.	Provide more opportunity for hands-on training.
2.	Training for higher echelons requires more time.
3.	Training time increases with added functionality.
4.	Complex functions take more time to train.
5.	Allow more training time for functions related to a poor soldier-machine-interface.
6.	Allow more training time when functions require workarounds and expect them to be less practiced (and used) by participants.
7.	Cross-training improves crew performance, provide ample cross-training time.
8.	Develop training to support surrogate training since participants learn from one another.
9.	Increasing Tactical Operations Center workstation (WS) training time more than three days is desirable for training TOC WS functions.
10.	Ensure that test participants have an adequate amount of experience in the duty position that they are selected to fill in their evaluation role.

having its own training scenario in addition to individual training and refresher training. This is because some participants were just starting to develop their own equipment usage patterns by the time the test scenario began. Another day of training incorporating unstructured training, information management exercises, and an additional battalion-level training scenario also would be helpful. That is, more training time should be directed at giving participants the opportunity to develop their own individual style of equipment usage, practice message processing, and gain additional experience using the equipment tactically.

Additional time-related training lessons learned center around three factors: (a) the number of functions to be trained, (b) the complexity and dissimilarity of new functions as opposed to already existing functions, and (c) the relationship between interface design and new functions. First of all, the addition of more CVCC functions generally resulted in a requirement for more training time. As noted in the previous section, despite training improvements, vehicle commanders in the battalion TOC evaluation began to suffer from information overload. Training on functions which previous participants had found relatively easy to remember, such as unposting icons, seemed to become more difficult to retain as more functions were added to the training agenda.

The interrelationship of training and SMI requirements can be demonstrated via lessons learned on different types of new CVCC functions. If the additional functions were quite different from earlier ones and reasonably complex in nature, they required a disproportionately longer amount of training time than might be initially expected. For example, the aggregation function which was added to the CCDs and implemented on the TOC workstations during the battalion TOC evaluation was very different from any functions previously trained. Aggregation was also quite complex for the following reasons: (a) there were different aggregation radii at different echelons, (b) there were default aggregation levels at varying map scales that overrode previous selections, and (c) vehicles outside the aggregation radius were treated differently by TOC workstations than by CCDs. Consequently, aggregating and deaggregating icons representing vehicles was more time-consuming and difficult to train than had been anticipated.

In cases where a function's SMI was improved, training became easier. During the battalion TOC evaluation, FREE TEXT messages were difficult to read because there was only a blank space beneath the message which was touched for scrolling. Also, once the reader had scrolled down, he could not scroll back up to re-read the first portion. Once FREE TEXT messages were revised to have scroll keys for paging up and down, reading FREE TEXT messages was an easier function to train.

Training also became easier when functions were revised so that they no longer required workarounds. Functions requiring workarounds were time-consuming to train, and participants are less likely to remember them when the training was over. For example, during the battalion TOC evaluation, icon retrieval was only possible for reports retrieved from the Receive queue. To read reports from the Old file using icon retrieval, the user had to go into the Old file and then touch each report in the queue until the correct icon highlighted. Then they manually opened the report. To compound the problem, posted icons remained on the map after a report had been deleted. As a result, participants were incorrectly instructed to go to the Old file to find messages that were no longer there. Once the function was revised so that icons retrieved reports from both the Receive queue and Old file, the training on this went more quickly, and the participants were more apt to practice retrieving reports via icons on their own.

One investment of additional training time that appeared to reap substantial benefits was increasing the CVCC training time for gunners and drivers. For the battalion TOC evaluation, the gunners and drivers received approximately a half hour of individual training time on CVCC equipment in addition to the usual half hour on using a simulator. This additional training increased gunners and drivers morale and allowed them to perform as surrogate trainers when a unit or vehicle commander was having a difficult time using the equipment.

The surrogate trainer concept represented one of the most significant training lessons learned. Substantial learning often took place during debriefings as well as within the tank as the crewmembers interacted. Although debriefings were often at the end of the day, enough time should be preserved to allow participants to share with one another the lessons that they have learned during execution of the training scenario.

Not only were lessons learned about CVCC equipment training during the TOC evaluation, but the time required to train the battalion TOC workstation functions became a major training issue. Operation of the TOC workstations took considerably longer to teach than operation of the CVCC equipment in the simulators. The TOC workstations have more functions, and several of these functions (e.g., overlay editing, linking messages to icons, and linking overlay unit symbols) were comparatively more complex than the CCD functions. Overlay creation and editing, according to O'Brien et al. (1991), were the two most difficult TOC workstation equipment functions to learn.

The last factor affecting training time for both simulator and TOC workstation test participants was the need to conduct duty position remedial training in order for some participants to effectively participate in the evaluation. Whenever this was necessary, additional training was given to the participant. Based on lessons learned from the battalion TOC evaluation, it was determined that the best solution for overcoming the limited amount of training time available to train TOC workstation operation was to place contractor personnel in the TOC positions. Still, to ensure that training is conducted on schedule, it is important to verify that participants are properly qualified to assume their test roles.

Training media. Lessons learned on training media are presented in Table 4. The training requirements documents for the CCD (Lickteig, 1987) and the CITV (Quinkert, 1987) provided recommendations for the best media to train the CVCC equipment. Lickteig (1987) advocated embedded training in addition to interactive training media or "networked" configuration (recommended for over 60% of the platoon leader tasks analyzed). Quinkert (1987) suggested interactive embedded training would be more useful. Embedded training has thus far not been implemented in the CVCC prototype training program. However, Quinkert (1987) also hypothesized that the interactive simulators themselves might provide the best opportunity for usage integration and

Table 4

Combat Vehicle Command and Control Training Media Lessons Learned Prior to the Battalion Evaluation

1. Training shortcomings should be reassessed after a training scenario has been completed.

2. Demonstration, combined with verbal explanation, is often preferred over lectures.

3. Presentation of a demonstration using a large-screen display allows for multiple viewers to see as well as hear each individual function performed.

4. Checkpointing provides additional standardization for execution of training scenarios.

5. Using SEND files in message processing vignettes allows for different trainees to receive individual message sets simultaneously.

6. Utilizing the SitDisplay during the pre-mission briefing helps participants gain large-screen view of the battle tailored to the briefers' requirements.

7. Sandbox exercises provide an excellent medium to capitalize on the capabilities of the PVD (i.e., bird's eye view, precise distance measurement, map rescaling, etc.) to assess navigational proficiency.

---

practice as well as the original acquisition of basic CVCC usage skills. Interactive simulators provide particularly effective training when participants are involved in tactical missions.

The success of the CVCC prototype training program to date has shown that interactive simulators can indeed be a powerful training medium. This is not to say that individual simulator training was not effective; however, it does underscore the importance of an incremental (crawl, walk, run) approach to training. As mentioned, participants rated the individual portions of the CVCC training highly for both the company and battalion TOC evaluations, and the one-on-one training provided necessary practice on basic skills (the first training increment). Still, during individual training vehicle commanders did not fully appreciate the benefits to target acquisition, report accuracy, and navigation provided by the CVCC system. Moreover, they did not fully comprehend the extent to which their attention would be divided between the vision blocks and the CVCC displays. Sandbox exercises conducted during crew training (the next training increment) were critical to the acquisition of navigation and crew interaction skills. Tactical usage of the CVCC equipment, accomplished during the next training increment, was necessary for participants to fully assess the advantages and challenges provided by automated C2. For example, several CCD functions such as Receive queue status symbols, unposting icons, and the posting and unposting of overlays were explained carefully during individual training. However, unit and vehicle commanders often failed to appreciate these features until they became frustrated by full Receive queues, map displays obscured by report icons, and carelessly stacked overlays during training scenarios. The CCD refresher demonstration was added following the first battalion-level training exercise to remind the commanders of available CVCC features designed to reduce the workload and help integrate CVCC into their C2 and target acquisition tasks.

Training procedures. Lessons learned on training procedures centered on length of training segments, time allotted for unstructured practice on the equipment, and emphasis on training objectives. Table 5 summarizes these lessons learned.

Table 5

Combat Vehicle Command and Control Training Procedure and Training Assessment Lessons Learned

---

TRAINING PROCEDURES

1. Participants need breaks from training approximately every 50 minutes.

2. Unstructured familiarization time should be provided.

3. Baseline participants need to better understand the importance of their contributions to the evaluation effort.

TRAINING ASSESSMENT

1. Hands-on tests are a better indicator of proficiency than written tests.

2. Providing participants with written copies of the CVCC Skills Test tasks during the test ensures greater accuracy.

The first issue related to training segment length and the acquisition of equipment usage skills. Long training sessions can become counterproductive. For example, the unpost icons and icon retrieval functions, which are toward the end of the CCD hands-on training module, frequently have to be retrained when related tasks appear in the practice exercises. CCD training is currently organized in two parts; map and navigation functions, and report functions. The report function part often lasts two or more hours. Perhaps in future training iterations, the report function should be subdivided into segments of 50 minutes with a much-needed 10-minute break between them. Although this would cost some additional time for the extra break, it would help forestall the information overload that many participants experience during the individual training.

Also, participants have repeatedly requested time for unstructured use of the equipment. Another lesson learned has been that few participants will use the CVCC equipment for more than 15 minutes after the structured portion of the individual training has been completed. The first day's training is so demanding that when the structured part is over, many unit and vehicle commanders prefer a break to independent use of the CVCC equipment. Although unstructured time should be added to the schedule if possible, it should be recognized that 15 minutes or so is probably adequate for most participants.

Training objectives are always an important part of prototype training program development and should be carefully presented in the training materials. A primary goal of the prototype CVCC training program was ensuring equivalent training for Baseline and CVCC participants. The objectives in the CVCC condition, by virtue of the automated C2 equipment, were more detailed and challenging than the objectives for the Baseline condition. Because of this, Baseline participants needed to assurance that they were making important contributions to the evaluation effort and might receive an experiential benefit from the training program. However, they also needed to realize that the purpose of the program was to conduct research. While tactical training and C2 experience were hopefully by-products of the current program, they were not the primary objective of the research or the training program itself. This was a delicate issue, because participants naturally wanted to better their tactical skills in the economical, relatively risk-free world of simulators. Even though all participants were briefed early about the importance of their contributions to the research effort, and Baseline participants were offered the opportunity to return for a CVCC demonstration, more research is needed to consider how to better explain the importance of the Baseline participants' roles in such evaluations.

Training assessment. Training assessment methods and procedures have undergone many changes over the course of the CVCC evaluations. The lessons learned that have inspired these changes are listed in Table 5. Methods of assessing training data began with a single training-related item on an equipment-oriented questionnaire. Assessment materials then grew to a combination of written and performance tests, coupled with written evaluations. Finally, assessment materials evolved to a performance-based skills tests supplemented by written training evaluations. Written skills tests were soon phased out because it was discovered that performance of CVCC equipment tasks were better indicators of training readiness than intellectual knowledge of how the systems worked. This was true with the Baseline training as well. The SIMNET Skills Test was made operational in scope, and the written Land Navigation Skills Test was replaced by the Tank Commander Navigation Sandboxes, a navigational performance test. Another improvement made to training assessment procedures was providing participants with copies of tasks to be performed. During the company evaluation, copies of tasks were not provided during testing. As noted by the trainers, many tasks were incorrectly performed because participants could not remember the exact wording of the tasks.

In conclusion, the CVCC iterative evaluation process has provided opportunities for training media, procedures, materials, and assessment methods that follow the SAT model described earlier. The lessons learned through the battalion TOC evaluation were the basis for the development of the battalion evaluation training program documented in this report. Regardless, training issues raised during the formative years for the CVCC prototype training program are offered for future research efforts. They should be regularly reviewed in light of new literature on training systems, methodologies, and procedures, as well as in support of the ongoing research efforts by the ARI-Knox FBC team.

Likewise, the evolution of new C2 technologies must be considered from the perspective of their impact on training requirements, as well as their implications for interface design. The development of the SMI "gateways" for the CVCC system has also followed an iterative design process. This process is described in the following section.

CVCC Soldier-Machine Interface

Review of Key Literature

Grandjean (1986) defines a soldier-machine system as one in which a soldier and the machine have a reciprocal or shared relationship. An important factor in this system is the interface because it affects the nature of human-machine interaction. Improvements can be made to an interface by studying the flow of information through the system. For instance, an interface such as the CCD gives information about the battlefield; the soldier absorbs this information visually, and interprets it. On the basis of his interpretation, he makes a decision (e.g., send a CFF report). His next step is to communicate this decision to the machine by interacting with the interface. A control display then tells him the result of his action (e.g., a report was sent) after the machine has carried out the process as programmed. The cycle is complete when pivotal parts of the process are displayed for the soldier to see.

Soldier performance is influenced both by human limitations and machine capabilities, and machine capabilities are influenced by available technology. These factors must be considered together in order to design an effective SMI. According to Mueller (1991), effective interfaces can make a substantial difference in (a) learning time, (b) performance speed, (c) error rates, (d) work load, (e) long-term retention of information, and (f) system satisfaction. Well-designed interfaces can be cost-effective in that they should require less technical support and system modifications following implementation. Successful design should be conducted from the user's point of view and requires repeated testing of the interface. Major factors affecting the ease of interacting with a machine is the way in which information is presented to the user and the techniques provided to interact with that information (Herot, 1982). Soldier and machine can combine to form a very productive system, as long as their respective qualities are utilized sensibly.

Interface design. Shneiderman (1992) has identified necessary steps that a "user-interface architect" should follow in order to design a valid interface. Iterative design methods that allow early testing of prototypes, revisions based on feedback from users, and incremental refinements suggested by interface designers, are necessary to arrive at a successful system. During the early design stages, performance data should be collected to provide a baseline. The model followed for the CVCC evaluations mirrors the model suggested by Shneiderman in that complete evaluations were conducted using prototype C2 components of the CVCC system (i.e., CCD, POSNAV, and CITV) during realistic battlefield situations.

Vertelney, Arent, and Leiberman (1991) identified three primary criteria interface design: usability, functionality, and visual communication. First, the ease of learning and interacting with the machine via the interface should be taken into account. The second criterion concerns functionality. Functions and controls available on the interface must allow the user to take full advantage of the machine's capabilities. The third criterion is the visual appearance and spatial location of the elements; these should optimize functionality.

In a similar vein, Shneiderman (1992) developed an outline for the iterative design, testing, and evaluation of user interfaces. He suggests that successful user interfaces are dependent on three "pillars". The first pillar is guideline documents. By following a set of predetermined guidelines in interface design, Shneiderman has found that a number of problems can be avoided in the iterative process. For example, a set of predetermined guidelines can promote consistency and completeness across many iterative cycles as well as facilitate automation of the design. Guidelines should be considered for many elements of an interface during the design process.

Another pillar in the design of interfaces is the use of rapid prototyping tools. Since usability processes should accompany the early development stages, it is vital that a working user interface (a prototype) be available for the usability test. The usability test results may cause revisions of the design specifications. Therefore, the results should be available before the design phase is completed. Later changes, (i.e., after equipment is fielded) are costly and often error-prone (Gimnich, 1991).

The third pillar of interface design suggested by Shneiderman (1992) is usability and iterative testing. An example of iterative design is seen when aircraft designers carry out wind-tunnel tests, build plywood mockups of the cabin layout, construct complete simulations of the cockpit, and thoroughly flight test the first prototype. Similarly, other interactive system designers are recognizing that many small and some large evaluations of system components are necessary before release to their customers (Shneiderman, 1992). Participants in these evaluations should be chosen to represent the intended user communities, focused on experience with the task, motivation, and education.

Usability testing encompasses all activities concerning field or laboratory experiments with end-users as test subjects (Gimnich, 1991). Hypotheses have to be developed, usability criteria and evaluation methods have to be defined, tests have to be planned and conducted, and results have to be analyzed. A further activity deals with communicating the results to the development teams. This must be done in order to interpret the findings and to find constructive solutions if usability problems are encountered. As can be seen, the usability process is both iterative and cyclical.

In all of the CVCC evaluations, the general guidelines described above were followed. Usability testing is effective because real users perform real tasks under the eye of experienced observers (Gould, 1988). Following these guidelines has yielded specific SMI issues related to the CVCC system. These issues are discussed in the next section.

<u>Optimal use of automated communication.</u> Past studies of automated communications have been reviewed by Kerns and Harwood (1991). Based on workload and preference ratings, the researchers found that the most effective procedures for message sending were those that required the least inputs for message composition and addressing messages, as well as those providing the sender complete transmission authorization.

The general findings of the literature review are relevant to soldier performance associated with CCD automated report functions in several ways. First, the results of the Kerns and Harwood (1991) literature review indicated that the combination of voice and automated communication out-performed either medium used in isolation. Second, when the two media were compared, the results generally indicated that voice communication was fast and flexible, whereas automated communication was brief and precise. Third, inherent delays with automated communication appeared to affect the synchronization of the operating behaviors of those sending and receiving messages. Fourth, although no significant global effect on workload occurred as a result of automated communications, a redistribution of workload did occur. The visual and manual workloads increased as auditory and speech workload decreased. This finding supports the suspicion that the prototype CVCC system, especially the CCD with its digital report capabilities, places a heavy visual processing load on the user. The guidelines presented below, as suggested by Kerns and Harwood, should prove useful in developing standing operating procedures (SOPs) for the CCD.

Kerns and Harwood (1991) concluded that automated communication is most effective when used as a complement to voice communication for selected applications. Sending routine messages, including tactical messages, via an automated route is acceptable. However, at least three issues should be addressed before automated communications are put into use. First, recovery procedures should be developed in case of system failure. Second, explicit control over the transmission and acknowledgement of automated communications should reside with message senders and receivers. Third, message annunciation and display sharing need to be explored. In the simulation studies reviewed, arriving messages were signalled with a tone and a visual annunciation.

The CCD report function used in the current research mirrors the capabilities of automated communication described above. Usability problems associated with automated communication in past evaluations have pointed to problems of inadequate feedback of report status (Ainslie et al., 1991). Using the iterative approach to system design, changes based on participant feedback and equipment usage have been implemented whenever possible. For example, feedback on report status was improved by adding symbols to the system to indicate whether a report has been opened, sent, or relayed. In addition, duplicate reports in the Receive queue of the CCD report function have been eliminated, thereby reducing workload.

Minimizing workload. Both the CITV and the CCD require extensive visual monitoring. The amount of visual workload is higher using the CCD versus conventional C2 methods. This is because more information is presented visually rather than auditorily. It is important to balance, as much as possible, visual and auditory workload. Deathridge (1972) suggests guidelines for the use of auditory and visual displays. Auditory displays are suggested for: (a) simple messages, (b) short messages, (c) messages dealing with events in time, (d) messages calling for immediate action, (e) visual systems with high information load, (f) poor lighting, and (g) jobs requiring continuous movement. Visual displays are suggested for: (a) long messages, (b) complex messages, (c) messages dealing with location, (d) messages calling for delayed action, (e) high noise levels, and (f) jobs requiring little movement. Although these guidelines fit the model currently employed for presenting information to CVCC participants, there may be a high load on the visual modality of CVCC users due primarily to the CCD. Training on CCD report management may reduce the load on the visual system because certain tasks may become automatic with practice. In any case, further exploration of design and training options aimed at decreasing the amount of information presented via the visual channel should be explored.

The development cycle followed for CVCC components, beginning with prototype interfaces and functionality and followed by subsequent changes and modifications, is discussed in the next section.

Evolution of CVCC Prototype Components

BMS. When improvements were being considered for the M1A1 Block II components, the U.S. Army Armor School's (USAARMS) Directorate of Combat Developments (DCD) and the ARI-Knox FBC Team developed the original automated C2 system design for the CVCC research program (Blasche & Lickteig, 1984). In 1986, Lickteig investigated the user interface requirements for the BMS, an early computer-based model of the CCD. The BMS was conceived as a tool to partially integrate C2 at lower echelons. The stand-alone prototype was used to evaluate the interface which consisted of a digitized terrain database, menu-driven functions for construction of map displays, and tactical reports for command and control.

The display (7 X 9 inches) was much smaller than a conventional Army map. Therefore, participants wanted to be able to manipulate the map features and functions when necessary, allowing them to tailor the map to their immediate needs. The following capabilities were recommended as necessary modifications to the interface: (a) add ability to select and delete man-made and natural terrain features and operational overlays, (b) add ability to resolve the map display to the user's immediate area of interest by adjusting the map scale, and (c) display redundant pictures and symbols to represent control measures and overlays.

Structured menus and preformatted entry forms were judged as an easy to use method for C2. BMS users suggested that reporting functions needed to be streamlined so that workload was kept at a manageable level. Further suggestions included the need to integrate map and report functions so that the spatial map and graphics data could be integrated with verbal reports and orders. Features that were incorporated into the BMS as a result of Lickteig's report were: (a) dedicated function keys, (b) a permanent window for incoming alerts and signals, and (c) a date and time window.

General guidelines were given for incorporating features into the BMS; i.e., interface such as brevity, consistency, flexibility, immediate feedback, and reduced operator workload. The purpose of these guidelines was to estimate the automated C2 prototype capabilities in a simulated environment. Both current and future soldier performance issues could be "systematically assessed, modified, and reassessed in a task-loaded, force-on-force combat environment such as that provided by SIMNET" (Lickteig, 1988, p. 57). This approach lead to what is currently referred to as the design-evaluate-design approach adopted for SMI development under the CVCC program. Another prototype component that has undergone the iterative design process for incorporation into the CVCC system is the CITV.

CITV. The CITV concept was initially developed under the assumption that it would be added as an M1A1 tank enhancement. The CITV was meant to give the tank crew a "Hunter-Killer" capability. That is, the vehicle commander would be able to search independently, identify and handoff targets to the gunner, and automatically slew the main gun to the target he had identified. Hence, it was predicted that less time would be necessary for the vehicle commander and gunner to detect and engage targets in their area of responsibility.

Quinkert (1988) described design and functional specifications for an early version of the CITV. Utilizing forward looking infrared (FLIR) technology, the CITV was designed to serve as the "eyes" of the CVCC system. More specifically, the CITV was meant to provide the tank commander with independent surveillance and target acquisition capability. With this equipment, it was predicted that the commander could shoot and move more efficiently and effectively, especially when smoke, darkness, or other environmental factors obscure the battlefield.

Quinkert (1990) examined the operational effectiveness of the CITV using soldier-in-the-loop information collected during interactive simulation exercises in the U-COFT. The effort provided suggestions concerning the SMI. First, it was suggested that the commander's control handle be redesigned to facilitate easy control of the CITV. A second suggestion was to incorporate a moving hull icon to the CITV interface, to represent directional movement. Similarly, a positional icon was suggested for the gunner so that he could reestablish his sense of direction after the main gun/GPS had been designated to the CITV LOS. Additional suggestions addressed the relocation of the sight magnification switch (for easier activation) and the operational mode switch (to prevent accidental activation).

The features of the company-level CITV used for the evaluation are listed in Table 1. The target stacking feature was not functional on the CITV after the company-level evaluation. This was because it was found to be too time consuming and needed to be coupled with an automatic target prioritization function (i.e., target stacking required vehicle commanders to keep track of target priority and to re-enter targets if priority changed).

The CITV interface did not change appreciably between the company-level evaluation, the battalion TOC evaluation (O'Brien et al., 1992), or the preliminary battalion-level evaluation (Leibrecht, Winsch, et al., 1993).

POSNAV. Du Bois and Smith (1989) investigated the operational effectiveness of POSNAV, a land navigation component of the CVCC. The POSNAV system was designed to give tank commanders access to automated navigational information using the following IVIS-like features: (a) analog spatial map display and own-vehicle icon, (b) own-tank location and heading window, (c) map features function, (d) map zoom function, (e) map scroll function, (f) route designation function, and (g) driver's Steer-to-Display.

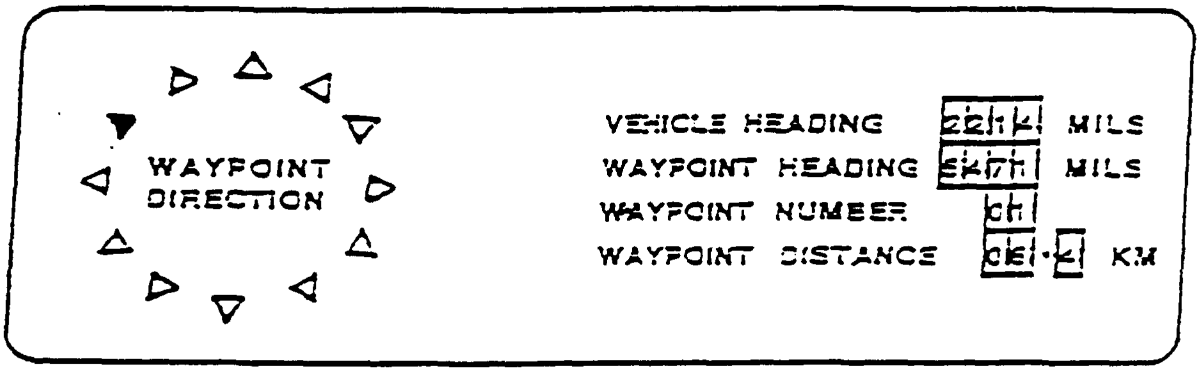
The main focus of the Du Bois and Smith (1989) evaluation was the performance of tank crews and platoons using two POSNAV prototypes compared to those using conventional navigation techniques. The prototypes evaluated were a grid map display (POSNAV-G) and a terrain map display (POSNAV-T). The POSNAV-G display showed only the UTM grid lines and no terrain or man-made features. The POSNAV-T users had the choice of displaying roads, vegetation, terrain contour lines, and UTM grid lines. Although the findings revealed little difference between POSNAV-T and POSNAV-G, performance was significantly better using the POSNAV systems compared to the performance of those using conventional navigation techniques.

Users of POSNAV generally rated both POSNAV systems positively. Crews rated the functions easy to use, the display easy to read, the position of the display in the tank acceptable, and reported no trivial information appeared on the display. Users reported that POSNAV allowed them more time to acquire targets and that all of the POSNAV features were useful in land navigation. In addition, strong emphasis was placed on the helpfulness of the navigation route designation function and the own-vehicle icon. As a result of these features, crews reported that more land navigation responsibility could be allocated to the driver.

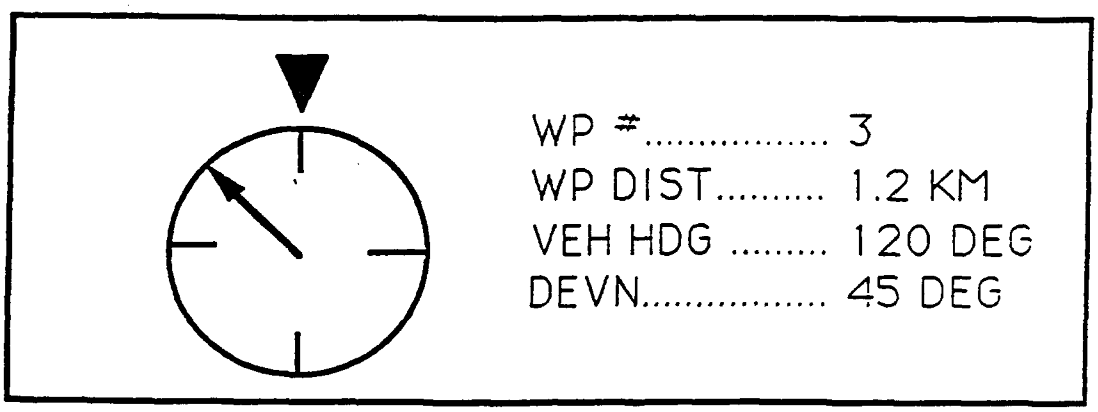
Although the system was well accepted, users offered suggestions for improving the interface. The addition of a visual or acoustic signal was suggested to indicate to the user that a route waypoint had been received by the driver or that a waypoint had been input incorrectly. Crews also recognized the necessity of having other friendly vehicle locations represented on the terrain map.

Many new features were incorporated into the POSNAV system since its inception: (a) mutual POSNAV (all friendly vehicles represented on display by icons), (b) the features of POSNAV-T, and (c) an Autoadvance feature that automatically sends information about the next waypoint to the driver's Steer-to-Display when the vehicle is 100 m away from that waypoint. A beep in the drivers' headset occurs when a waypoint has been received via the Autoadvance feature.

The Steer-to-Display is located in the driver's compartment and provides drivers with directional and distance information about the route (see Figure 10). The Steer-to-Display evaluated by Du Bois and Smith (1989) included: (a) the number of the waypoint currently displayed, (b) current own-vehicle distance from the next route waypoint (in kilometers), (c) current own-vehicle azimuth heading (in mils), (d) current own-vehicle azimuth heading required to reach the next waypoint (in mils), and (e) a steer-to indicator which shows the direction the driver should steer the vehicle to reach the next waypoint.



a. From Du Bois & Smith (1989)



b. From Ainslie et al. (1991)

Figure 10. Evolution of the Steer-to-Display.

Based on user input, design changes were made to the Steer-to-Display from the Du Bois and Smith (1989) description and implemented in the CVCC company-level evaluation (Ainslie et al., 1991). The waypoint display changed from a circular display of small, outwardly pointing triangles to a circle with tic marks at 0, 90, 180, and 270 degrees. Direction to a current waypoint is maintained by keeping the arrow at 12 o'clock. In the center is an arrow that points to the degree of deviation from the current waypoint heading. Changes to the information headings on the right side of the Steer-to-Display can also be seen in Figure 10.

IVIS prototype evaluation. Based on findings from Du Bois and Smith (1989), an integrated C2 display was designed resembling the IVIS under design for the M1A2 tank. This IVIS-like prototype included an improved POSNAV component, as well as functions for preparing, transmitting, receiving, and relaying reports. Units equipped with the IVIS-like prototype consistently out-performed units with conventional tools. Using questionnaire data, Du Bois and Smith (1991) found that vehicle commanders expressed positive reactions toward the IVIS equipment. Commanders agreed that IVIS improved their performance and should be included in future tank upgrades. The main criticisms of the system were that there were too many reports and that the size of the display was too small. Suggestions for improvement included: (a) display reports graphically (i.e., color symbols) on the tactical map, instead of storing reports in a queue; (b) implement a report filtering and prioritizing system to alleviate report overload; and (c) provide more flexibility in report functions. Each of these suggestions was incorporated into the system for the company-level evaluation.

Company evaluation. The primary objective of the company-level SMI evaluation (Ainslie et al., 1991) was to systematically evaluate soldier performance issues associated with an armor-based experimental C2 configuration which integrated the CCD, POSNAV, and the CITV. One issue dealt with the two methods of activating the CCD, the touchscreen and thumb cursor. The touchscreen was determined to be the most preferred method because some users found the thumb control hard to use. Another SMI issue with the CCD was system status. Users did not always know if the system had accepted an input. While, in general, soft switch activation resulted in highlighting, software glitches failed to highlight adequately all switch selections (e.g. POST). However, feedback on system status was gradually provided in software modifications.

CCD users also pointed out that map manipulation was difficult because, in order to modify the map, one had to exit from the report function and go into the map function. This was a time consuming process for a simple manipulation. A dedicated key was recommended for faster and easier map function access. Other recommendations were to enhance report functions by: (a) providing report status feedback, (b) filtering duplicate reports, (c) providing report aggregation, (d) providing report acknowledgement, (e) improving report icons and report formats, (f) automating vehicle status report input, and (g) providing user configuration capability. For the driver's Steer-to-Display, the recommendations included the addition of cardinal direction to the Steer-to-Display and a signal upon arrival at a waypoint. These recommendations and additional observations were categorized by B. A. Black (personal communication, October, 1990) to form the basis for providing software change recommendations. The categories and specific recommendations in Table 6 are applicable to a broad range of SMI system development efforts and are further addressed in Ainslie et al. (1991).

Table 6

Soldier-Machine Interface Recommendations Based on the Company Evaluation (Ainslie et al., 1991)

SIMPLIFIED PROCEDURES

- Simplify/automate structure for "action" reports
- Automatically update logistic reports
- Filter identical messages
- Aggregate messages with redundant information
- Use standard information formats
- Stress graphic depiction and control

CUES, PROMPTS, AND FEEDBACK

- Provide redundant cues for critical information
- Minimize the number and type of auditory cues
- Reinforce auditory cues with redundant visual cues
- Use distinctive and easily recognized auditory cues
- Present auditory cues for limited duration
- Terminate auditory cues when users respond appropriately
- Use visual cuing to lead user through menu structure
- Provide visual prompts for data and menu entries
- Provide clear feedback on all user inputs and system delays
- Provide feedback on "message sent" or "retransmit"
- Provide clear prompts to indicate incoming messages
- Provide acknowledgements on message delivery promptly
- Provide compliance option in received message structure

DISPLAY UTILIZATION

- Provide dedicated scroll function which requires no menu
- Provide more detailed map manipulations in menu format
- Provide standardized display areas
- Remove thumb control from commander's override
- Provide an alternative input mode, redundant to touch
- Provide touch input modality
- Offset the cursor from the pointing instrument

(table continues)

Table 6 (Continued)

DECLUTTER, DELETE, AND ERROR REDUCTION

- Provide error reduction and management capabilities
- Provide direct/efficient correction for false entries
- Provide extensive declutter and delete capabilities; Activate selection with touch release, not initial touch

INITIALIZATION

- Provide originator and sender identification with each message
- Change originator identification only with change in message content
- Provide default unit SOPs for message route and creation
- Provide easy initialization for emergency situations

SUBCOMPONENT INTEGRATION (POSNAV and CCD)

- Provide routes with minimum of six waypoints
- Provide for route storage
- Provide for route transmission
- Provide the commander feedback on driver's waypoint
- Provide easy access to manual waypoint update
- Provide feedback on waypoint update with autoadvance
- Provide for easy relocation or deletion of a waypoint

SUBCOMPONENT INTEGRATION (CITV and CCD)

- Duplicate own vehicle's hull, turret, CITV orientation
- Provide map-to-sensor slew capability
- Provide for map depiction of left/right Autoscan limits
- Provide for transmission of left/right Autoscan limits

HELP SCREENS AND CHECKLISTS

- Provide "help" directive and options for difficult tasks
- Provide checklists for command and control procedures

The items listed in Table 6 served as a basis for implementing software changes that would impact the CVCC SMI. These items were prioritized, with a set of high priority items subsequently implemented. Table 7 lists all of the changes made to the CVCC SMI since the IVIS prototype evaluation.

Battalion TOC Evaluation. The battalion TOC evaluation (O'Brien et al., 1992) included an analysis of the SMI, workload, information effectiveness, and training associated with the CVCC system. The SMI component assessed the acceptability of the CVCC SMI using equipment usage data and qualitative feedback from users. The findings from the SMI evaluation of the CCD

Table 7

Changes Made to the Combat Vehicle Command and Control Command and Control Display and Position Navigation System

Company Evaluation (Ainslie et al, 1991)
- Ability to display reports graphically on the tactical map
- Report filtering and prioritization system added
- Greater flexibility for report functions added
- Redesign of Steer-to-Display

Battalion TOC Evaluation (O'Brien et al., 1992)
- Aggregation of POSNAV icons added
- Ability to receive FREE TEXT messages added
- Scroll main function key added
- Scroll functions (MAP menu) simplified
- Option to store multiple overlays added
- Friendly vehicle icons added for INTEL reports
- Status information added to report queue listings
- Capability to screen for duplicates in Receive queue added
- Touched key highlights to provide feedback to user
- Beeps added when system autoadvances to the next waypoint
- Message added to CCD tells user when system autoadvances
- Ability added to clear all waypoints simultaneously
- CCD message added telling commander when message has been sent

Battalion Evaluation (Leibrecht, Winsch, et al., 1993)
- Platform upgraded from Masscomps to SPARC™ IPXs
- Memory increased from 16-20 megabytes to 48 megabytes
- Soft numeric keypads added to INTEL, SHELL, and SPOT reports
- Text incorporated in overlays
- Obstacle icons represented by green North American Treaty Organization (NATO) symbols
- Overlays made deletable from overlay file list
- Paging added to report queues and FREE TEXT reports
- Posted icons indicated by asterisk in report queues
- Ammo status report replaced by automated LOGISTICS status reporting
- Icon retrieval added to allow viewing of reports when map icons touched
- Observer/Target (O/T) Line and Coordinate Line added to CFF
- Summary key returns user to summary page after editing a field
- Numbers added to map icons for INTEL, SHELL, and SPOT reports
- Highest echelon sender shown on report action page and within report
- Default net for relayed reports modified to select net previously unused for that report
- Duplicate copy of report gets same status symbol as copy in "Old" file
- "Section" added to aggregation level
- Forward Line of Own Troops (FLOT) icons represented by black NATO symbols
- Report icons unpost when parent reports are deleted

demonstrated that unit commanders generally found the CCD to be acceptable with POSNAV and the tactical map showed the highest degree of user acceptability. However, recommendations were made by the unit commanders to improve or modify existing components of the CCD.

One recommendation was aimed at reducing the number of report signals (visual and auditory) received by the unit commander. Several recommendations (e.g., deliver alerts after alternate reports, base alert signals on Receive queue access, reduce number of high priority report types) were made to limit the number of alert signals. Another recommendation addressed the report icons that appeared on the tactical map. The report representations needed improvement due to software limitations. That is, users could not distinguish SHELL, SITUATION, and ADJUST reports, or obstacles from INTEL reports because the icon for all of these report types was an asterisk.

Another recommendation dealt with the appearance of digital overlays. They were rated as less than acceptable, although the ability to transmit and display the overlays was rated highly. Unfortunately, inadequate contrast made the overlay graphics difficult to see. Also, low ratings were also probably attributable to hardware limitations which led to slow update rates when multiple overlays were posted to the CCD. Eventually, a hardware upgrade to a SPARC[2TM] platform alleviated this slowdown. CCD users in the battalion TOC evaluation also requested that the capability to edit overlays be added to the CCD.

As part of the battalion TOC evaluation, automated TOC workstations were also evaluated. The workstations gave the S2 and S3 automated C2 capabilities. The TOC SMI was evaluated using both questionnaires and equipment usage data. The findings led to the following recommendations for the TOC SMI: (a) provide an indication of incoming reports, (b) indicate duplicate report status, (c) improve the graphic interface, (d) present only menu options that are operational, (e) standardize naming conventions, and (f) modify training.

<u>Battalion evaluation</u>. As a result of many of the recommendations derived from the battalion TOC evaluation, software changes were made for the battalion evaluation (Leibrecht, Winsch, et al., 1993) as shown in Table 7. The SMI for the battalion evaluation was identical to the SMI for the current effort.

The design and evaluation of the CVCC components described (see Table 7) have resulted in the accumulation of lessons learned which supported the implementation of necessary design changes. These lessons learned, described in the following

---

[2]SPARC is a trademark of SPARC International, Inc.

section, will be valuable to any system designer, particularly designers of new C2 technologies.

SMI Lessons Learned

It has been a practice for the SMI design team to make changes to the CVCC system based on lessons learned. Several categories of these lessons are listed in Table 8 and are further explored below. While many of these lessons may appear straightforward, it should be noted that the real SMI challenge is the application of these lessons to the system under development. Application of SMI guidelines ideally involves providing system features which are optimally designed for the user. However, these considerations must be balanced against system functionality requirements. For example, a CVCC lesson learned is to design for simplicity. However, simplifying certain CCD features may be at the cost of reduced functionality. For a more specific list of lessons learned based on the company evaluation, see Table 6.

Use iterative design process. The iterative design process has been used from the beginning of the CVCC development cycle. The CVCC SMI has been evaluated in a number of user-based, simulated battlefield environments. During the initial design process, developers, researchers, and software/hardware engineers made a series of decisions based on required operating characteristics which influenced the design of the interface. For example, the functionality of the software must be evaluated early to ensure good design features have been incorporated into the system and to allow for adequate development of training materials. Hence, timely software development is a critical component of the iterative design cycle. However, design teams cannot predict all the uses of a system or the needs and limitations of the users before the system is fielded. Errors, misconceptions, and novel uses can only be discovered through user testing.

Provide clear and immediate feedback. During execution of the company-level evaluation, one problem that arose was the lack of feedback to the CCD user when inputs were made to the system. For example, a user would touch a function key to send a report. However, he would not receive feedback that the report had been sent or that the button press had been effective. The result was that the action often was repeated unnecessarily or randomly and caused the system to "crash." The lesson learned from this problem was that in order to avoid confusion, adequate feedback must be provided. To improve feedback, two features were added: highlighting of activated function keys and presenting messages in the information center informing the user that the report had been sent. Adequate feedback with the CCD interface was also an issue during the company-level evaluation. That is, users did not receive visual feedback as to whether they had read, opened, or sent a particular report. For instance, users had no way of knowing whether a report in their queue was a duplicate of one

Table 8

Soldier-Machine Interface Lessons Learned for the Combat Vehicle Command and Control System

USE ITERATIVE DESIGN PROCESS
1. Software delivery must be timely
2. Testing should be user-based, interactive, and performance-based
PROVIDE CLEAR AND IMMEDIATE FEEDBACK
1. Required for all user inputs and system delays
CONSIDER HUMAN LIMITATIONS
1. Make alert signals redundant across modalities (both visual and auditory)
2. Use auditory signals to capture users' attention.
3. Reduce unnecessary information.
4. Make symbology meaningful
USERS NEED ALTERNATIVES
1. "Flexible" interface parameters such as reconfigurable menu buttons are desirable to provide a best fit for different roles and preferences
2. Choice of input devices is desirable to accommodate user preferences and device failure
3. Provide multiple deletion options
4. Provide multiple map scrolling or movement options
ALLEVIATE OR REDUCE TIME-CONSUMING ACTIVITIES
1. Design for maximum simplicity wherever feasible
2. Provide dedicated menu button for "Jump" map scroll feature and icon retrieval

they had already read or relayed. They would have to open and read the report to ascertain the fact that they had already read the report. To remedy this problem, a set of symbols was added to appear on the reports in the Receive queue to inform the user the status of the report (i.e., "X" represents a new message that has not been read, "->" represents a message that has been opened and relayed, and "O" represents a message previously opened).

Consider human limitations. Another important fact that an interface designer must consider when designing any interface is that the human user has limitations (e.g., memory, cognitive processing, time-sharing, perceptual, etc.). If these limitations are not taken into account in the interface design, the system may be ineffective. For instance, due to software limitations, generic icons were used to represent some reports on the tactical map. This was eventually modified to support easier discrimination between report types. As a result of this consideration, however, one very important lesson was learned. That is, the perceptual modality by which the user processes information in his environment changed with the CVCC system, resulting in an increased load on the visual modality. In the existing fielded Abrams system, vehicle commanders obtain visual information through vision blocks and an open hatch. At the same time, they process radio report information via the auditory modality. In the CVCC system, however, the information that the vehicle commander must process is presented mainly to the visual modality. He must scan the terrain visually and also process the reports on the CCD visually. To control for the shift, design changes had to be made to reduce the visual load (e.g., distinct report icons on the tactical map), as described below.

First, auditory signals were added so that when a report arrives in the Receive queue a beep is heard in the user's headset. In this way, the user can concentrate on some other visual task without constantly monitoring the CCD for incoming reports. A similar change was made to the driver's Steer-to-Display to help alleviate missed waypoints. Because drivers were generally looking out of their vision blocks as they were navigating, they did not always notice when they had reached a waypoint. Hence, drivers continued driving in one direction after a new waypoint had been designated on their Steer-to-Display (Ainslie et al., 1991). Accordingly, an auditory signal was added to alert the drivers when they were approaching a waypoint. Drivers now hear a beep when they are 100 m from waypoint and do not have to visually monitor the Steer-to-Display as often.

To reduce information load, an interface change was made to reduce the number of duplicate reports. In an early version of the CCD, duplicate reports would appear in the Receive queue if the previous version of the report had transferred to the Old file and a duplicate report was sent to the user. Consequently, users had to open reports they had already seen, thus spending more time monitoring the CCD and less time on other tasks. To alleviate the occurrence of duplicate reports and, in turn, reduce load on the visual modality, software changes were implemented so that reports would not be accepted in the Receive queue if they were present in the Old file.

Another example related to reducing the visual processing load was the representation of reports on the tactical map. SHELL, ADJUST FIRE, and INTEL reports were all depicted on the tactical map by asterisks during the company evaluation. The user had to find the accompanying report in the Receive queue or in the Old file to determine what a particular asterisk represented (e.g., CONTACT, SHELL, SPOT report). In doing so, the user spent more time visually searching for information on the CCD. The addition of color-coded NATO symbology to the tactical map to represent specific types of reports and obstacles reduced confusion. It also lead to reduced visual demand by giving the user more information in less time. Numbers were also added to SPOT, SHELL, and INTEL report icons so users could assess at a glance whether the icon represented one vehicle or 20.

Users need alternatives. Lessons learned concerning the addition of alternative methods are important for users operating the CVCC system. For instance, flexible interface parameters might allow company and battalion commanders to configure their dedicated CCD function keys differently, driven by differences in the types of reports most frequently sent. Increased flexibility might also allow for multiple deletion, multiple map scrolling, and movement options as well. Another area where CVCC users need alternatives is related to the two methods presently available for inputting information into the CCD--the touchscreen and the thumb cursor. Although the majority of users preferred the touchscreen, some used the thumb cursor almost exclusively. User preference may affect how much and how efficiently the system is utilized. It is also important to provide alternative methods of input in case one input method fails to work. This will be especially essential when the system is fielded because the real battlefield is much more "punishing" to equipment than the simulated environment. CVCC system users also must be prepared in the case of total system failure. Paper maps and radio C2 would be the natural alternatives in this case.

Alleviate or change time-consuming activities. As with user preference, or lack thereof, system features that are too time-consuming are unlikely to be used extensively. This was the lesson learned for the target stacking capability of the CITV and the ammunition, fuel, personnel, and equipment reports on the CCD. Target stacking was a target management feature that was designed to cue the gunner about available targets. In the company-level evaluation it was used infrequently because it was difficult to use and was determined to require a target prioritization capability. As a result, target stacking was dropped as a CVCC feature during the battalion-level evaluations. Other time-saving examples include providing dedicated function keys for the "Jump" map scroll feature and icon retrieval.

A feature that was added to reduce a time-consuming activity on the CCD was the LOGISTICS report option. The LOGISTICS report provides users with automated ammunition, fuel, personnel, and equipment information. Each user's CCD was constantly updated of their own and their units' logistics. Not only was the LOGISTICS report option a substantial time-saving improvement, it demonstrated the value of user input to the design process prior to fielding the equipment. During battles, information regarding ammo, fuel, personnel, and equipment status may be critical. However, if the vehicle commander is too busy fighting the battle, tracking and sending status information to the TOC may not occur in a timely fashion or be accurate when it does arrive.

Due to the iterative, soldier-in-the-loop design process employed by the CVCC program, design changes with potential Army payoffs have been made early in the acquisition cycle. The current effort described in this report represents the final iteration of CVCC research using soldier-in-the-loop testing to provide critical information on soldier performance as related to advanced mounted warfare technologies. Lessons learned in training and SMI provided a conceptual basis for developing the CVCC Battalion Evaluation described next.

Overview of the CVCC Battalion Evaluation

The overall purpose of the CVCC Battalion Evaluation was to derive information concerning the impact of future C2 technologies on key issues associated with operational effectiveness, training requirements, and soldier-machine interface design. The evaluation consisted of two conditions: (a) a Baseline condition using conventional M1 tank simulators supported by a contractor-staffed conventional battalion TOC, and (b) a CVCC condition consisting of tank simulators with enhanced prototype C2 components supported by a contractor-staffed automated battalion TOC. The evaluation schedule required a total of twelve test weeks, with six test weeks committed to both the Baseline and CVCC conditions.

Method

This section describes the participants, facilities, materials, and procedures supporting the battalion-level evaluation with particular emphasis on the procedures and materials used for conducting and evaluating the training program as well as the SMI. For a more complete description of the methodology used for the battalion-level evaluation, see Leibrecht, Meade, et al. (in preparation). For greater detail on biographical data and test scenario materials, see Meade et. al. (in preparation). For copies of training materials, see the battalion-level training package (A. R. Sawyer, personal communication, August, 1991).

Participants

A total of 282 U.S. Army personnel and one U.S. Marine participated in this battalion-evaluation. The participants included 94 officers and 189 enlisted men. All participants were stationed at Fort Knox, Kentucky and ranged in age from 18 to 43 years. All participants, including the Marine, held armor Specialty Skill Identifiers (SSIs) or were currently qualified in an armor Military Occupational Specialty (MOS).

Participants were provided by support units for twelve test weeks (six Baseline and six CVCC conditions). With three exceptions, participants in each test week included 8 officers and 16 enlisted men. The eight officers each week were assigned positions as follows: One served as the battalion commander, another as the battalion S3, three as company commanders, and three as company XOs. Each officer commanded a crew with two enlisted crewmembers serving as gunner and driver. (A loader was not required because simulators were equipped with an autoloader.) The roles of the officers were assigned based on rank, experience by duty position, and battalion commander input. The battalion commander assigned the roles of gunner and driver, most of whom had never worked together.

There were three exceptions to the above configuration of participants. In contrast to all other participants who engaged in only one test week, one individual participated as a driver for two Baseline weeks. The remaining two exceptions concerned crew configuration. In week 7 (CVCC condition), no S3 was available, resulting in one less crew (i.e., seven rather than eight three-man crews). In week 12 (Baseline condition), one gunner position was unfilled, resulting in a S3 crew with no gunner.

Configuration of the Test Battalion

The test battalion modeled for this evaluation was a tank-pure battalion composed of four tank companies, a six-vehicle scout platoon, and a command group. Participants manned the battalion commander and battalion S3 vehicles (simulators) in the command group, as well as the company commander and company XO vehicles (simulators) in A, B, and C companies. The final company (D company), all tank platoons, and the scout platoon were represented by friendly SAFOR elements called BLUFOR. Figure 11 illustrates the battalion configuration (minus the scout platoon and the battalion TOC), and differentiates between the manned simulators and BLUFOR. The BLUFOR elements were controlled by unit commanders and operated by role-playing test personnel. These BLUFOR tanks and the manned simulators made up the friendly forces and were able to communicate by voice or digital communication (CVCC condition only). The Opposing Force (OPFOR) consisted of SAFOR only.

Four contractor Subject Matter Experts (SMEs) in the areas of C2, operations, intelligence, and fire support staffed the battalion TOC. These SMEs role-played the positions of battalion XO, assistant S3, S2, and fire support officer (FSO). The TOC staff provided C2 support for combat operations in a standardized and doctrinally-based manner. In the Baseline condition, these staff members performed their tasks manually using paper maps, acetate overlays, and markers. They communicated with the simulators solely by voice radio. In the CVCC condition, these individuals performed their tasks using the TOC workstations augmented by voice radio. See Meade et al. (in preparation) for a description of the tactical aspects related to the test

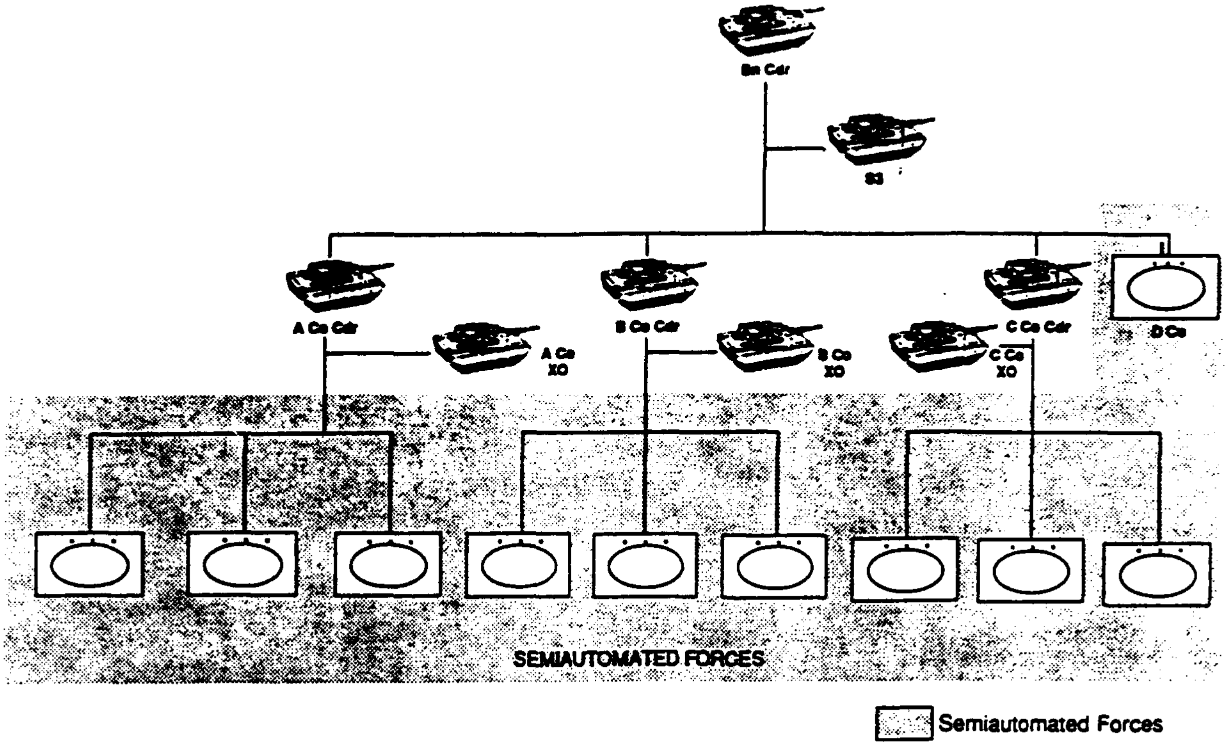


Figure 11. Illustration of the battalion configuration (minus the Tactical Operations Center and scout platoon).

methodology and a description of the battalion TOC staff's responsibilities.

Test Facilities and Materials

Simulation facilities in the MWTB supported execution of the training program and generated the SMI. In addition to a conventional classroom, these facilities included: (a) eight M1 vehicle simulators, (b) the TOC, and (c) several categories of exercise control equipment.

M1 Simulators

The battalion evaluation utilized eight M1 tank simulators. As depicted in Figure 12, the M1 simulator consists of two major sections: a driver's compartment and a turret crew compartment. The turret crew compartment has stations for the tank commander, gunner, and loader (although the latter position was performed with an autoloader in this evaluation). Detailed descriptions of the components and operation of the Baseline simulator can be found in the M1 SIMNET Operator's Guide (U.S. Army Armor School, 1987) and in the SIMNET Users' Guide (U.S. Army Armor School, 1989). Descriptions of the CVCC system can be found in the SIMNET Combat Vehicle Command and Control (CVC2) System User's Guide (Smith, 1990).

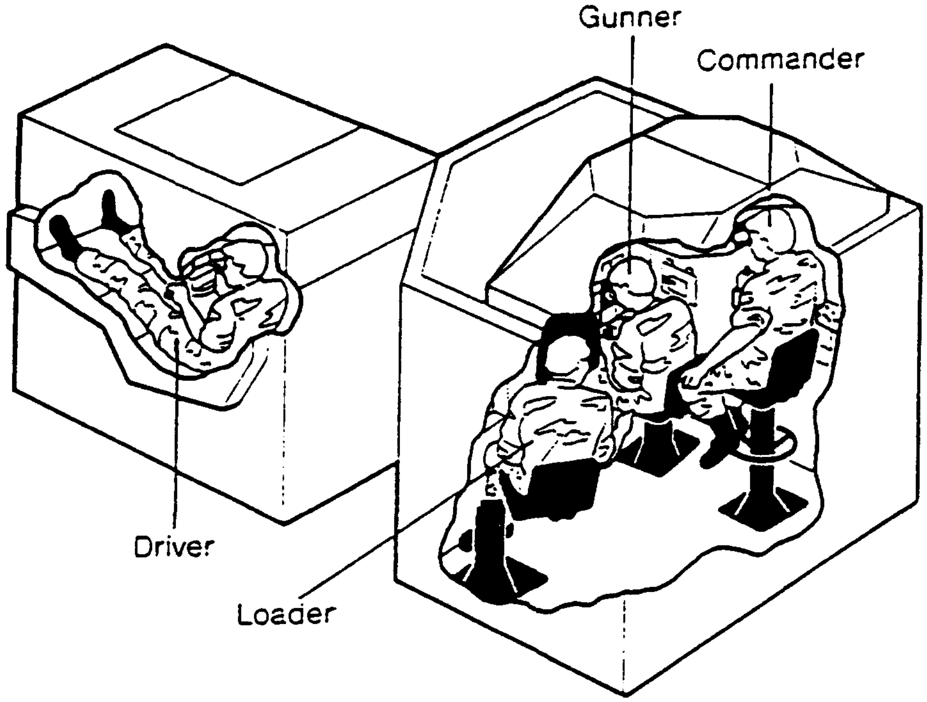


Figure 12. Basic M1 simulator, showing the turret crew compartment and driver's compartment (autoloaders replaced loaders in this evaluation).

The M1 simulators in the MWTB did not include all functions and controls found in an actual M1 tank, but only those necessary to fight. Each simulator was equipped with a 105mm main gun capable of firing high explosive anti-tank (HEAT) and SABOT rounds, three out-the-window views in the driver's and tank commander's stations, a GPS, a Gunner's Primary Sight Extension (GPSE) at the commander's station, and a single rotatable view in the loader's station. The commander's station also included a rotatable cupola that allowed him to manipulate his three out-the-window views. A headset with boom microphone was used for radio and intercom communication. The M1 simulators did not have the machine guns, Muzzle Reference System (MRS), Gunner's Auxiliary Sight (GAS), nor open-hatch views available on the fielded M1. Also, the visual system was limited to views out to 3500 m.

The sound system re-created realistic battlefield sounds from simulated vehicle operation, weapons fire, and round impacts. Vehicle sounds included engine whine, track movement, turret/main gun movement, and the opening or closing of the ammo doors. Weapons fire sounds included direct fire, indirect fire, aerial fire, and own-vehicle fire. Impact sounds included rounds hitting the vehicle.

Simulators used in both the Baseline and CVCC conditions contained several modifications not found in other MWTB M1 simulator configurations. The gunner's primary sight was equipped with a Thermal Imaging System (TIS) that could be toggled for the normal daylight view. As noted earlier, the simulator also included a simulated autoloader. The full cycle time to reload a round after firing was approximately eight seconds. During the first three and one-half seconds, the system waited for the gunner to select the desired ammunition type. In the remaining four and one-half seconds, the system opened the breech and the ammo doors, loaded a round of the selected type, and closed the breech and ammo doors. The autoloader was also capable of unloading a round when the gunner changed the ammo select switch before firing.

Each simulator was also equipped with two simulated SINCGARS radios. These radios replaced the citizens' band (CB) radios found in other MWTB simulators. The radios converted voice transmissions into digital signals, which were broadcast over the simulation Ethernet. This capability also made it possible to capture voice transmissions along with simulation data broadcast over the Ethernet.

The simulators used in the CVCC condition also included several additional features. Table 9 summarizes the key differences between the M1 simulators used in the Baseline and CVCC conditions. The major components which distinguish the CVCC M1 from the Baseline M1 are the CCD, POSNAV, and CITV.

Battalion TOC

A battalion TOC supported tactical operations in both the Baseline and CVCC conditions. The battalion TOC was located in a Standard Integrated Command Post System (SICPS) tent like the one used for a field-deployed TOC.

In the Baseline battalion TOC, battle reports, unit locations and status, and other pertinent information were maintained on wall charts and maps. The TOC staff updated staff journals manually. The radio configuration in the battalion TOC permitted voice communications using the brigade command net, brigade operations and intelligence (O&I) net, the battalion command net, and the battalion O&I net.

In the CVCC battalion TOC, an automated TOC was comprised of four automated workstations and a large-screen SitDisplay. These workstations were linked with CVCC technologies in the simulators and provided an automated tool for battalion staff. For a more complete description of the CVCC battalion TOC, see Sever et al. (1992).

Exercise Control Equipment

The stations that controlled the training events, the training exercises, and the training and test scenarios were located in the ECR. These stations consisted of: (a) two PVDs, (b) a radio network of six SINCGARS simulators (stand-alone) and

Table 9

Comparison of Baseline and Combat Vehicle Command and Control M1 Simulator Capabilities

M1 Simulator Capabilities	Baseline	CVCC
Navigation		
Out-the-window views (vision blocks)	X	X
Paper map with overlays	X	X
Odometer	X	X
Grid azimuth indicator	X	X
Turret-to-hull reference display	X	X
Main gun laser range finder (LRF)	X	X
CCD tank icon and status information		X
Digital terrain map and tactical overlays		X
Digital navigation routes		X
Driver's navigation display		X
Target acquisition and engagement		
Out-the-window views (vision blocks)	X	X
GPS/GPSE	X	X
Turret-to-hull reference display	X	X
CITV		X
Communications		
Radio intercom (communication with crew)	X	X
SINCGARS radios (voice communication)	X	X
SINCGARS radio interface unit		X
Digital combat report communication		X
Digital tactical overlay communication		X
Digital navigation route communication		X

a CB radio, (c) an MCC and SCC terminal, (d) three SAFOR workstations, (e) a CSS battalion workstation, and (f) two workstations for SEND/LISTEN CVCC utilities. The following sections further describe each station and additional test support capabilities contained outside of the ECR.

PVD. Two PVDs provided the primary monitoring capabilities during the execution of the training and test scenarios. The PVD screen provided the control staff with a real-time, "God's eye" view of the battlefield. All vehicles, aircraft, gunnery targets, impacting artillery, and mortar fires were displayed. In addition, graphic control measures, grid lines and coordinates, lasing, and direct fire engagements were available for viewing. Through a series of keyboard commands, the PVD operator could insert a "flag" or time marker into the data stream to denote a significant or critical event useful for later analysis. PVD capabilities included map manipulation, vehicle identification, intervisibility plotting, and a number of other functions.

Radio network. The simulated SINCGARS radio system serviced seven voice radio nets--brigade command, battalion command, battalion O&I, and four company command nets. Figure 13 shows the voice radio networks and configuration used in the Baseline and CVCC conditions. All nets except the battalion O&I net were available for digital burst transmission of reports and overlays.

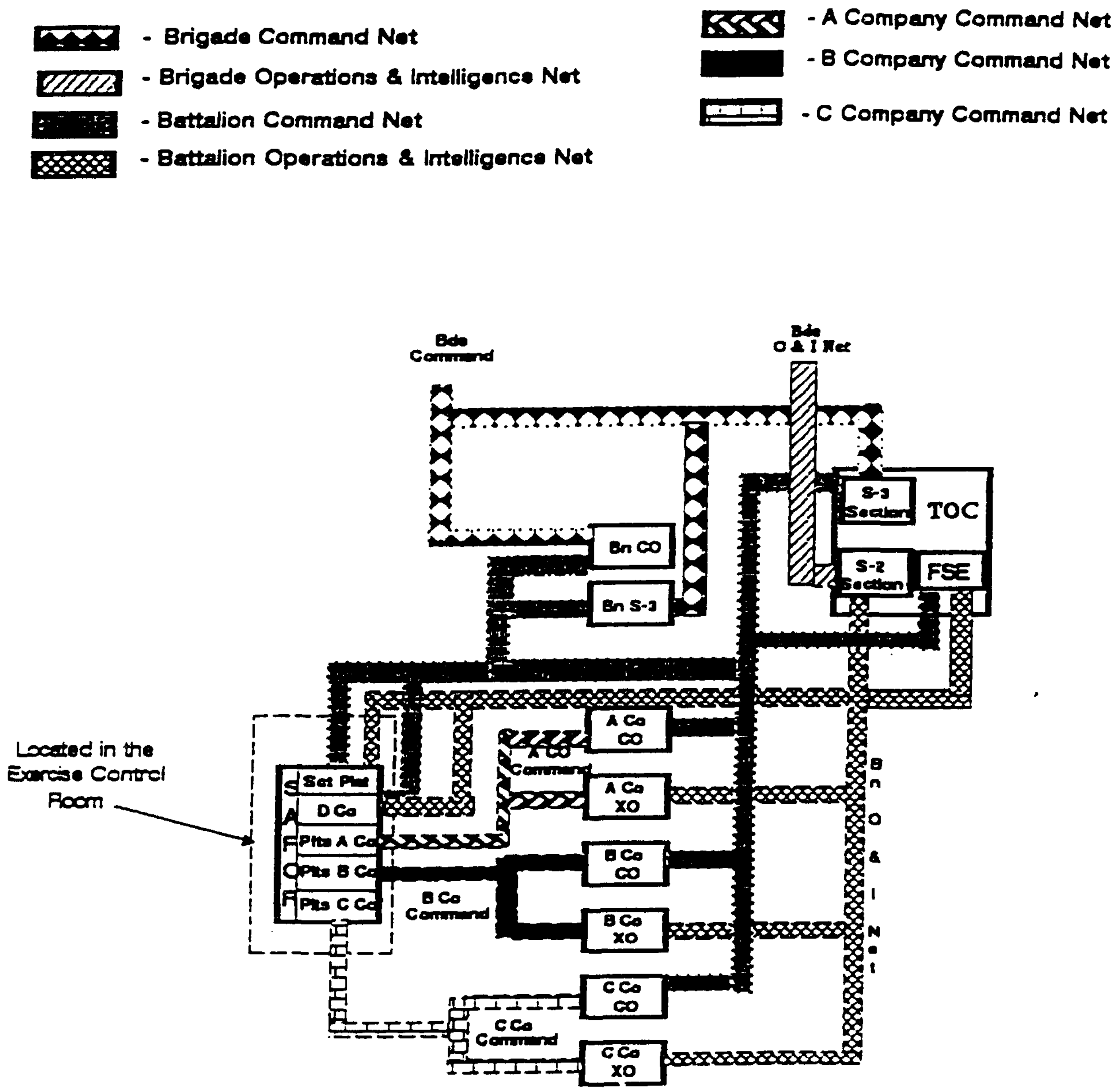


Figure 13. Diagram of the tactical voice radio networks used in the battalion-level evaluation.

The company XOs, like the company commanders, had the battalion command net and the company command net routing options on their CCDs.

Seven send/receive stand-alone radios were used to monitor operational radio nets in the ECR. Six of these were stand-alone SINCGARS simulators. The brigade command net, located at the brigade PVD station, was used by the Battle Master (military SME who oversees scenario execution) to represent adjacent battalions. During training and the test scenarios, the battalion command net, located next to the battalion PVD, monitored voice messages (e.g., crossing phase lines [PLs], reporting when SET in battle positions [BPs]).

SAFOR operators monitored the nets appropriate to their roles. During training and the test scenarios, five nets were monitored: three company nets, the battalion command net, and the battalion O&I net. An additional CB radio (brigade O&I net) permitted private radio communication between the battalion TOC and the ECR.

SAFOR software routines automatically generated and sent event-driven digital reports to the manned-simulator CCDs in the CVCC condition. During both conditions, RadioTelephone Operators (RTOs) role-played subordinate platoon leaders and the D company commander and XO. During Baseline, they relayed the automated SAFOR reports and coordination items via voice radio. This automated information included CONTACT reports, SPOT reports, and SITREPs. During the CVCC condition, the CCD-type reports were sent digitally, but coordination items not supported by the CCD (e.g., SET on battle position 41) were still sent by voice.

Stealth vehicle. The Stealth vehicle is a simulator that can move about without detection by manned simulators. It was used for reconnaissance of the battlefield during battalion training scenario pre-brief and the mission planning period of the battalion test scenario. The Stealth station consisted of three 25-inch monitors, a PVD, and a SpaceBall control integrated into a single simulated vehicle. The SpaceBall provided control input to move the vehicle around on the battlefield. The PVD was used to determine the observer location on the simulated battlefield or to attach the Stealth to other combat vehicles in the simulation. Once attached, the Stealth moved around the battlefield with the vehicle to which it was linked.

Management, Command, and Control system (MCC). The MCC system initialized and managed the simulation. Initialization selections defined the terrain database, the exercise identifier, simulator parameters, and unit organizations. These initialization selections permitted the control staff to repeatedly call up and execute scenarios in a standardized manner. Once initialized, the MCC provided easy access to status information about all operational manned simulators.

The SIMNET Control Console (SCC) is a component of the MCC system used to initiate the MCC's involvement in an exercise and to access most of the functions simulated by the MCC system. The SCC allowed the control staff to place simulators and gunnery targets in specific locations on the terrain database. Standard files for each scenario and exercise permitted all vehicles and targets to be placed on the terrain database with only a few key strokes on the computer keyboard. Thus, initialization and setup were both rapid and standardized. The SCC also provided the control staff with the ability to "reconstitute" or restore any elements that may have malfunctioned or "dropped off" the simulation network during the course of a scenario.

SAFOR workstations. The SAFOR workstations were used by the role-playing operators to monitor and control the automated BLUFOR and OPFOR units. BLUFOR operators responded to and implemented the commands of unit and vehicle commanders located in the M1 simulators. Two SAFOR operators were responsible for directing the activities of the subordinate automated forces in accordance with the directives of the participant commanders. A single OPFOR workstation operator was responsible for directing the activities of the simulated threat forces in accordance with the training and test scenarios. With SOPs, events lists, and scripted OPFOR engagement timelines and axes of advance, the set-up and execution were standardized for both comparison conditions and all rotations.

Each SAFOR workstation provided a top-down color map display capable of depicting the current state of the battlefield. In the battalion evaluation, however, this view was limited to the information reported by forces on the battlefield to include vehicle location updates. The operator could zoom in or pan to any point on the map display. Features such as contour lines, UTM grids, roads, water, trees, bridges, railroad tracks, control measures, and buildings could all be displayed. Engagement and speed parameters for all SAFOR vehicles were entered using the workstation keyboard (e.g., engagement distance rules and cross-country rate of movement). Initialization files for each scenario and exercise permitted both BLUFOR and OPFOR units to be called up in their correct starting locations using a few keyboard commands.

CSS workstation. The CSS workstation was used by the test support staff to monitor message traffic received on the battalion command net from the simulators and other TOC workstations. It also was used to transmit scripted SEND messages and to create and retrieve checkpoint files as discussed below.

CVCC utilities. Several CVCC utilities were available to the ECR staff. These included the SEND and LISTEN programs, and a special workstation coordinator option (usually running on the CSS workstation). The coordinator option permitted the CSS workstation controller to checkpoint or "snapshot" the current state of all TOC workstations and CCDs. All overlays, messages, folders, and other information on each workstation and CCD were stored to files when the checkpoint was initiated. The coordinator workstation also restored these checkpoint files. The use of checkpoint files initiated the start of each scenario stage. This capability permitted a complex series of overlays and initial message traffic to be quickly and accurately called up for each stage.

The SEND utility permitted the Battle Master to send digital combat messages to the battalion TOC workstations and CCDs. The SEND utility could send digital reports over any communication network, with any valid unit designation. In addition, messages could be saved in files on the coordinator workstation. Saving these files permitted the Battle Master to send preformatted messages quickly and accurately to participants in the exercises.

The LISTEN utility provided real-time display of all digital messages transmitted over any communication network, unlike a CCD or workstation which is limited to one or two networks. The LISTEN utility provided a printed copy of all digital messages transmitted during an exercise.

Remote communication devices. Maxon 49-HX walkie-talkies were worn by some support personnel during training and testing. These walkie-talkies operated as single-channel two-way communication devices, permitting each trainer to communicate with the Floor Monitor. The Floor Monitor passed administrative information, such as the status of an equipment breakdown, to the trainers using the walkie-talkies to minimize disruptions and sustain operations.

Video recording capabilities. Audiovisual recordings provided a supplemental mechanism for examining the performance of selected unit and vehicle commanders as well as the TOC staff. Miniature cameras, approximately three inches in length, were installed in unobtrusive locations in the simulators and in the battalion TOC. All the audiovisual recordings were time-stamped with current clock time. Verbal communications in the TOC were recorded via a microphone.

Automated data collection and analysis (DCA) system. The DCA system provided automated data recording, reduction, management, and analysis capabilities. O'Brien et al. (1992) provide a detailed description of the data collection, reduction, and analysis procedures developed for the battalion evaluation. DataLogger, one element of the DCA system, recorded all simulation network data traffic transmitted over the Ethernet in the form of data packets. A variety of data packets were generated by operator-initiated events (e.g., a CCD soft-switch press) or by timed cycles (e.g., periodic vehicle appearance packets conveying location and orientation). DataLogger permitted real-time digital data recording by storing on magnetic tape all data packets broadcast by every simulation element.

These recordings were then available for later reduction and analysis. The two PVD stations in the control room were used to embed event flags in the DataLogger recordings. These flags indicated key events such as the start of an exercise, a radio transmission, or crossing of a phase line. The CCD report contents, as well as voice radio transmissions broadcast over the simulation network, were available for subsequent analysis.

Two DCA subsystems processed off-line reduction and analysis of DataLogger recordings. DataProbe™, a data management and analysis software package, extracted data elements from the DataLogger recordings and structured them into intermediate files. DataProbe™ included a SIMNET Data Dictionary to define and label the various data packets, enabling the accurate isolation of data elements of interest. RS/1™, an interactive, programmable advanced statistics software package, was used to analyze data from these intermediate files using software routines developed specifically for CVCC databases.

Training Materials

The training materials for the battalion-level evaluation included (a) detailed lecture materials for classroom training and demonstrations, (b) scripts and performance-based skills tests for hands-on training, (c) vehicle trainer checklists, (d) a unit SOP, and (e) operational exercise-control specifications for unit exercises. Many of these materials were used for instructing the trainers as well as the participants. The training package for the battalion evaluation contains the actual materials (e.g., lecture outlines, briefing charts, evaluation instruments) used in the course of the evaluation for both the CVCC and Baseline conditions. Copies of the data collection instruments used to collect training and SMI data can be found in Appendix D. Table 10 gives a summary of the training materials used in the battalion evaluation and shows that Baseline and CVCC participants received comparable training. The following paragraphs summarize the content of these training materials.

Classroom briefings. Briefing materials, including viewgraphs and scripts, were developed to support the various classroom briefings presented in the battalion evaluation. Viewgraphs and scripts, available in the training package, were used to present the following classroom sessions: (a) a general introduction to the evaluation (b) an orientation comparing the M1 simulator to an actual M1 tank, (c) a SIMNET navigation briefing (Baseline only), (d) a CITV orientation (CVCC only), (e) a SAFOR orientation, and (f) an orientation on the role of the company XO.

Seat-specific orientation outlines. Seat-specific orientations were presented to vehicle commanders, gunners, and drivers. These orientations were used to train them on specific crewstations and on equipment being used by other crewmembers. The M1 simulator features that were different from the real M1

Table 10

Type of Training Materials Used in the Combat Vehicle Command and Control Battalion-Level Evaluation by Day

Day/Type of Training Materials	Baseline	CVCC
<u>Monday</u>		
Introductory briefing script and slides	X	X
Vehicle commander seat-specific outlines	X	X
Navigation training script and slides	X	
SIMNET versus actual M1 script and slides	X	X
CCD demonstration script and outline		X
CCD hands-on training outline		X
CCD Skills Test		X
CITV classroom slides		X
CITV hands-on training outline		X
SIMNET Skills Test	X	
Tank Commander navigation skills drill materials	X	
Training objectives slides	X	X
<u>Tuesday</u>		
CITV Skills Test		X
Gunner and driver orientation outlines	X	X
SAFOR briefing script and slides	X	X
Role of the company XO script and slides	X	X
Battalion SOP	X	X
Training objectives slides	X	X
Crew sandbox materials	X	X
Research Assistant (RA) crew training checklist	X	X
Company Situational Training Exercise (STX)/Battalion Situational Training	X	X
Company STX OPORDS and other materials	X	X
Company STX debriefing slides	X	X
RA unit training checklist	X	X
<u>Wednesday</u>		
Training objectives slides	X	X
Battalion STX OPORDS and other materials	X	X
Battalion STX debriefing slides	X	X
RA unit training checklist	X	X
CCD refresher training demonstration outline		X
CCD refresher training tasks		X
Officer's call	X	X
Battalion training scenario OPORDs and other materials	X	X
Battalion training scenario debriefing slides	X	X

tank were highlighted during these sessions. There were two versions of the seat-specific orientations, one for Baseline and one for CVCC. The basic simulator information was the same for both versions. The CVCC version also had information on the CCD, CITV, and POSNAV components. There also were tasks and practice exercises which required the participants to use the equipment at their crewstations.

CCD demonstration (CVCC condition only). The CCD demonstration utilized the large-screen monitor (which was later used as the Situation Display [Sit Display] for the TOC) and a TOC workstation brought up as a stand-alone CCD. The instructor's demonstration outline, contained in the training package, provided a general orientation and described critical features and functions of the CCD. An abbreviated demonstration outline was provided to viewers for taking notes and following the presentation. Specific contents of the CCD demonstration included (a) the CCD's information center, (b) manipulating the CCD map display, (c) creating and sending routes, (d) storing and posting digital overlays, and (e) creating, routing, receiving, and relaying reports.

Hands-on training outlines (CVCC condition only). Detailed outlines were developed to standardize the explanation and demonstration of the CCD, POSNAV, and CITV components for participants. These outlines provided a systematic, step-by-step walk-through of all features and functions. They also provided usage tips and warnings where appropriate of especially useful or potentially confusing features of the equipment being trained. For example, a usage hint was provided to unpost all old overlays before posting new overlays. This allowed the new overlays to be viewed in isolation. One of the warnings provided was that if the CITV sight was inadvertently allowed to scan the sky while the Auto Scan sectors were being set, the system would include the sky in its scan when the palm switch was released. In addition to presenting functionality descriptions, usage tips, and warnings, the hands-on training outlines also provided structured tasks and practice exercises to maximize the participants' hands-on exposure to the systems being tested.

CCD and CITV Skills Tests (CVCC condition only). These tests (Appendix D) helped determine if a unit or vehicle commander had mastered the CVCC equipment. The CCD and CITV skills tests covered the major functional features of the CCD, POSNAV, and CITV components. Each test consisted of a series of tasks with instructions to be read by the trainer. A copy of the questions was provided to each participant. Each item was designed for pass-fail (GO/NO GO) scoring by the trainer.

SIMNET Skills Test (Baseline only). This test (Appendix D) was designed to determine whether a Baseline vehicle commander understood the basic features of an M1 simulator. Simulator features highlighted included the grid azimuth indicator, odometer, and turret reference display. Like the CCD and CITV

Skills Tests, the participant either passed or failed each question. Those tasks which were failed were retrained at the conclusion of the test.

CCD refresher training (CVCC only). CCD refresher training was provided to participants after they had received an opportunity to use the CCD in a tactical setting. There were two sets of materials that went with the CVCC refresher training: a basic outline for the CCD refresher demonstration, and a set that accompanied the refresher training hands-on tasks. Before beginning the hands-on portion, the participants were provided with a copy of the tasks to be completed. At the conclusion of the approximately half hour session, the trainers gave the participants a second version with the correct answers. This allowed the vehicle commanders to work through the tasks at their own pace and check their own answers.

Unit SOP. The battalion SOP was provided in paper form to both Baseline and CVCC condition unit and vehicle commanders on the second day of training. It detailed the rules applying to maneuver, engagement, communication and reporting, combat support, combat service support, and C2 for each condition. Actually an SOP "extract," the content and format followed current doctrine and guidelines. The SOP for both conditions presented the structures to be used for radio reports as well.

Unit training checklists. During crew, company, and battalion training, a checklist served to remind the vehicle trainer of the simulator, CITV, CCD, and POSNAV functions the crewmembers were expected to exercise. The checklists also required the trainers to make judgments on whether the equipment was being used correctly and provided them with opportunities to practice report tallying. For the Baseline condition, the checklist emphasized (a) radio reporting, (b) crew interaction, and (c) the use of the grid azimuth indicator, turret reference display, and other available simulator tools for navigation. For the CVCC condition, the checklist included additional items on CCD, POSNAV, and CITV usage. At the end of the training exercises, the vehicle trainer reminded the crewmembers of any equipment functions and features not used and offered suggestions on how to improve utilization of the available equipment during the next training scenario.

Navigation aids. Both Baseline and CVCC condition unit and vehicle commanders were provided a standard set of materials to help them navigate during tactical exercises. These included: (a) SIMNET terrain maps encased in clear plastic map covers, (b) operational overlays drawn on clear acetate sheets, (c) erasable markers for drawing on overlays and maps, (d) duct tape for securing overlays to the map cases, and (e) map protractors for plotting azimuths.

Tactical Training Exercises

The tactical training exercises provided the participants with opportunities to practice using the equipment to accomplish critical C2 tasks during a tactical mission. Four training exercises were used in the battalion-level evaluation: (a) tank crew training, (b) the company STX (concurrent with battalion staff situational training exercise), (c) the battalion staff STX, and (d) the battalion training scenario. All of these exercises are described in detail in the battalion evaluation training package. Two of the exercises (company STX and battalion training scenario) were adapted from materials developed by Williams and Smart (in preparation).

Detailed descriptions were developed for each training exercise. They described the tasks to be trained as well as the conditions, standards, instructions, and all supporting materials used to conduct the exercise. The company STX, battalion STX, and battalion training scenarios were based on current doctrine and combined typical elements of realistic offensive and defensive combat operations staged on the terrain surrounding Fort Knox, Kentucky. For these exercises, detailed overlays, OPORDs, scenario event lists, SAFOR exercise files, and checkpoint files (CVCC only) were prepared. These materials helped the test personnel initialize and execute the exercises in a standardized manner.

Test Materials

Copies of all the test materials can be found in the battalion evaluation training package. Also, the tactical scenarios for both training and testing are discussed in the companion report by Meade et al. (in preparation).

Battalion test scenario. There was one test scenario which was developed with the assistance and approval of the DCD, USAARMS, Fort Knox, Kentucky. This scenario was based largely on an earlier version developed by Williams and Smart (in preparation). Executed in three stages, the test scenario involved a delay, counterattack, and delay mission. The test scenario began with a brigade OPORD briefing followed by the battalion OPORD. During the mission planning period, a leaders' reconnaissance was presented for the battalion commander, the S3, and the three company commanders assigned to the manned simulators. The leaders' reconnaissance was conducted over a pre-determined route using the Stealth vehicle to mimic a SAFOR tank. Table 11 presents an overview of the tactical structure of this scenario.

Training Procedures

Participant training for both Baseline and CVCC conditions followed the "crawl-walk-run" approach by beginning with individual training and progressing in difficulty through crew, company, and battalion exercises. Figure 14 shows the CVCC training and testing schedule that was designed to ensure training comparability between Baseline and CVCC groups. The following section explains the major components of both the Baseline and CVCC training programs. This section's headers contain letters and numbers which correspond to the events on the CVCC version of the schedule. However, unless otherwise indicated, events were common across test conditions.

Table 11

Tactical Structure of the Battalion Test Scenario

Stage	Major Activities
Initial Planning	Mission briefing, planning, leader's reconnaissance
1. Delay to Phase II Battle Positions	
A. Pre-engagement	Set up defense
B. Enemy engagement	Fight two motorized rifle battalions (+)
C. Displacement	Move to Phase II battle positions
2. Counterattack to Objective	
A. Pre-engagement	Receive fragmentary order (FRAGO), plan, move to objective
B. Enemy Engagement	Fight motorized rifle battalion (+)
C. Prepare FRAGO 2	Receive FRAGO, plan
3. Delay to Phase Line	
A. Pre-engagement	Receive FRAGO, plan, move to battle positions
B. Enemy Engagement	Fight two motorized rifle battalions (+)
C. Chemical Attack	Delay to subsequent battle positions

Day 1 Events

1a: General introduction. Day one of the participant training for both conditions was primarily for the unit and vehicle commanders. However, gunners and drivers also participated in the opening briefing for both conditions. The opening briefing included an orientation to the battalion evaluation and the CVCC program via lecture and viewgraphs. This orientation was very similar across the two test conditions. The

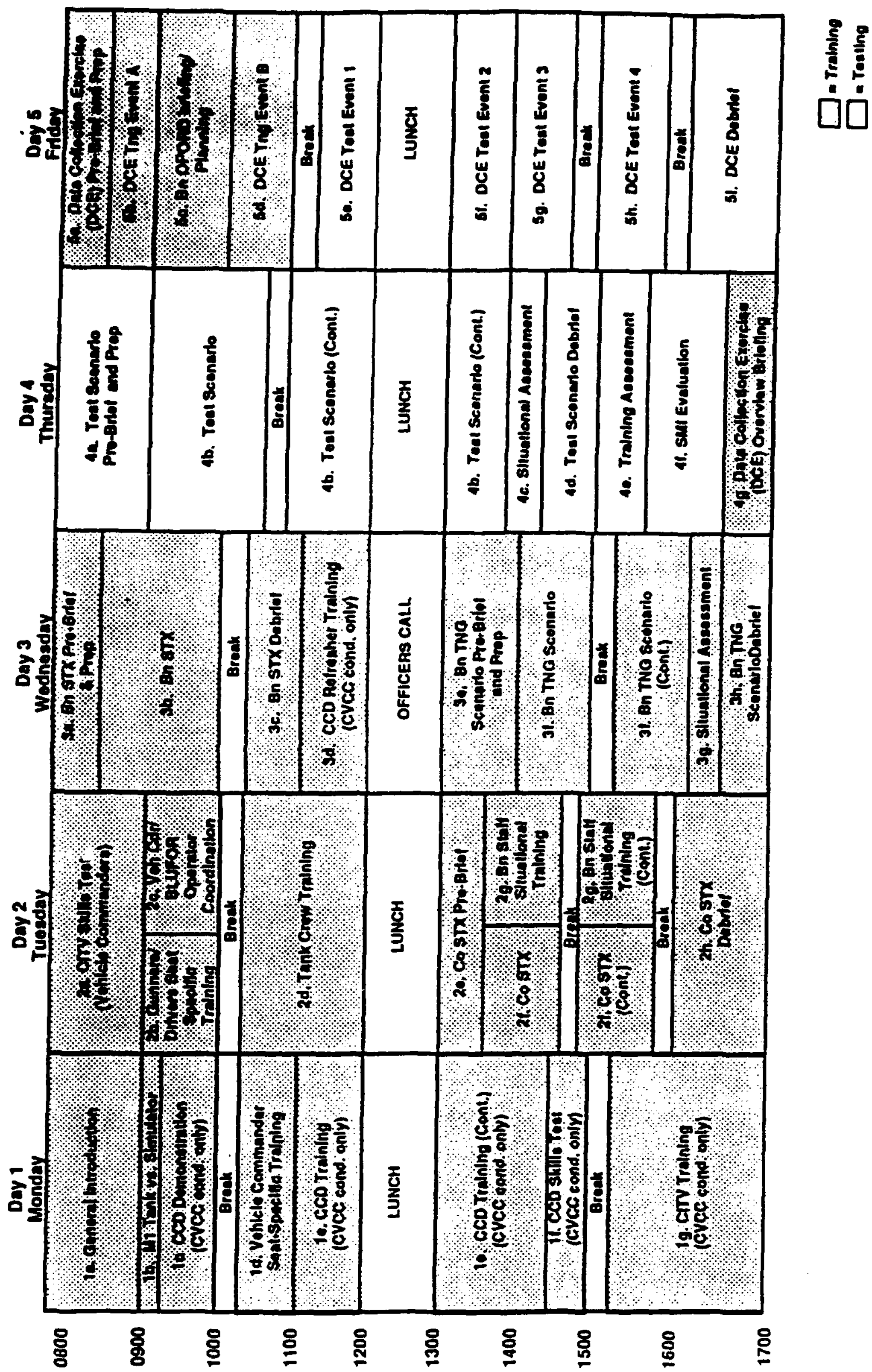


Figure 14. Combat Vehicle Command and Control condition evaluation weekly schedule.

only notable difference was that the CVCC version of the introduction included viewgraphs showing the CCD and CITV displays, and the Baseline version did not.

First, the Test Director explained the goal of the CVCC program and identified the major developments involved such as the POSNAV system, CITV, the CCD, and SINCGARS. Next, he explained the scope and importance of the CVCC evaluation to the Army's plans for improving battlefield performance. He alsoaddressed training and research issues involved in the current evaluation such as the need for a stable participant group to give the results greater validity. At this time he inquired whether being present all week was a problem for any of the participants. If dedicated attendance was a problem that could not be easily worked around by a minor modification to the schedule, that participant was immediately replaced.

The Test Director then presented the weekly schedule and discussed the MWTB rules and procedures as well as the layout of the building itself. Next, the Test Director had the participants read and sign Privacy Act statements. He explained that the identity of the individual test participants would remain private and that the results of the testing would be used for research purposes only. He also informed participants that it was important that they do their best during all training and testing events so that the data collected would be valid. The participants then completed biographical questionnaires designed to collect information on demographics, military experience, education, and computer experience.

Finally, the MWTB facility rules and map were presented as well as a brief explanation of the roles of the trainers in the execution of the training and testing. This concluded the Test Director's portion of the classroom presentation, and gunners and drivers were dismissed until the following morning.

1b. M1 tank versus simulator. For both conditions, an Armor C2 SME presented a brief viewgraph lecture on the similarities and differences between the SIMNET M1 tank simulator and a real M1. Following this briefing, unit and vehicle commanders in the CVCC condition went right to the CCD demonstration described in the next paragraph. The Baseline unit and vehicle commanders, however, were given a class by the Armor C2 SME on navigation in SIMNET. This training is described with other Baseline navigation training at the end of the day one events.

1c: CCD demonstration (CVCC condition only). The CCD demonstration was a thirty-minute presentation showing important features and functions of the CCD. The demonstration was run using a TOC workstation configured as a stand-alone CCD. Through an electronic interface, the large-screen monitor mimicked the display of the stand-alone workstation, allowing the unit and vehicle commanders to watch the CCD manipulation from their seats. An instructor's assistant manipulated the CCD workstation using a mouse-controlled cursor in accordance with the instructor's cues. Digital overlays and messages were sent using the SEND utility and another TOC workstation to simulate communication between two manned vehicles with CCDs. Participants followed along using an outline of the CCD demonstration script that was provided before the presentation began.

The CCD demonstration was not designed to teach participants how to use the system in detail (i.e., what key to press when); that level of detail was presented later in the CCD hands-on training. Rather, the CCD demonstration introduced unit and vehicle commanders to the overall capabilities of the CVCC system to (a) aid navigation, (b) to create, relay, and retrieve digital reports, (c) to receive mission overlays, and to (d) tailor the CCD tactical map to suit the position and preferences of the user. The demonstration was meant to develop a mental model of the CCD that the hands-on training could build upon. Presenting the CCD demonstration prior to hands-on training was part of a whole-part-whole training scheme: a model discussed by Swanson and Law (1993). This model is exemplified by the CCD training in the following ways. First, the demonstration provided an overview of the equipment, the initial "whole" training component, and then the hands-on training provided the details or "parts." The final whole training component came during the crew training when participants were required to work all component elements of the CCD in tandem to complete the required exercise. Whole-part-whole training was provided for the CITV as well, except that the demonstration was replaced by a lecture and slide presentation prior to hands-on training.

1d. Vehicle commander seat-specific training. The classroom portion of the training was followed by hands-on training in the simulators. This training segment and all hands-on training in the simulators was conducted by the trainers. In the Baseline condition, one trainer instructed two commanders on the SIMNET M1 simulator. In the CVCC condition, vehicle commander training was one-on-one. Seat-specific training for the commanders for both conditions presented information on the tank commander's basic equipment in the M1 simulator and compared it to that in a real M1. Because many of the participants had prior experience in the training simulators in the Combined Arms Tactical Training Center (CATTC), the seat-specific training also covered a few items of gunner equipment which were either unique to SIMNET or not present in the training simulators in the CATTC. Besides explanations of the basic simulator equipment, there also were tasks which the commander was required to perform such as using the grid azimuth indicator and turret reference display to orient the tank in the correct direction. Practice exercises were conducted at the end of this session. In the CVCC condition, unit and vehicle commanders learned about the Driver's Steer-To Display. More detailed demonstrations and explanations of the test-specific equipment were presented in later sessions.

1e: CCD training (CVCC condition only). CCD training was divided into two parts. Part one concentrated on the map and navigation functions of the CCD. Part two presented the various CCD digital report functions. As in the initial seat-specific simulator training, the CCD hands-on training followed a format of explain, demonstrate, and practice. The trainers explained and demonstrated each CCD feature, and then the commander was required to practice the feature. After all of the functions had been presented and used, there were several practice exercises which required the vehicle commanders to (a) manipulate and post overlays to their maps, (b) create, send, relay, and process digital reports, and (c) prepare routes for navigation. The CCD hands-on training lasted approximately 2 1/2 hours.

1f: CCD Skills Test (CVCC condition only). The Skills Tests identified specific areas of strength and weakness in the commanders' basic simulator or CVCC equipment skills at the conclusion of the hands-on training sessions. The retraining session which followed test administration also allowed for more instruction on problematic training tasks and feedback to the unit and vehicle commanders on their equipment usage proficiency. A *post hoc* advantage to the skills tests was that scores on each item were later tallied and used to identify specific problematic training areas where the methods or materials could be modified to improve future training efforts.

For the SIMNET, CITV and CCD Skills Tests, the procedures were the same. Prior to the administration of the Skills Tests, the trainers switched to different participants so that they tested a different commander than they had trained. Then each vehicle trainer read instructions to the participant and handed him a copy of the tasks to be completed for the test. As each trainer read a task, the commander had to complete it. The trainer monitored the performance of the task to determine whether it matched the correct steps written on the reference copy. There was no time limit for completion of the task. A commander who did the task correctly the first time or immediately corrected a mistake before doing the task correctly, received a GO for that question. Any commander who could not complete the task or who did the task incorrectly was given a No GO for that question. The unit or vehicle commander received immediate feedback on whether the completion of the task had been performed correctly or incorrectly. He received retraining on all the items performed incorrectly at the end of the test unless immediate retraining was necessary to complete the testing.

The CCD Skills Test evaluated unit and vehicle commander proficiency on CCD operation. The test focused on CCD operation; the script set up tactical situations which required completion of the appropriate CCD tasks. For ease of scoring and *post hoc* analysis of the results, most questions focused on one CCD function at a time (e.g., digital report creation). The CCD Skills Test can be found in Appendix D.

1g: CITV training (CVCC condition only). The CITV training began in the classroom with a lecture on the CITV presented by an armor C2 SME. The lecture began with a brief introduction to the CITV which described its placement on a real tank and its hunter-killer capabilities. This was followed by a briefing of each CITV function, with slides presented showing each feature and its placement on the CITV display. Then the armor C2 SME suggested tips on tactical usage of the CITV, such as setting scanning sectors for optimal command and control of a company and how to use the Designate function to demonstrate scanning sector limits to the gunner.

Immediately following the CITV classroom training, the trainers met the commanders in the simulators and proceeded with the CITV hands-on instruction. Each vehicle trainer instructed the same unit or vehicle commander he or she had instructed on simulator basics and the CCD. The hands-on training followed the "explain, demonstrate, and practice" method used for earlier blocks of instruction. Following a brief explanation of the major benefit of the CITV (i.e., independent thermal view), the vehicle trainer then explained and demonstrated each CITV function. Training began with the CITV own-tank icon and continued to cover the differences between GPS mode and CITV mode, polarity, and the scanning functions of the CITV. An explanation of the Designate function and IFF concluded the training. Following the presentation of each function, a task was provided for the commander to complete so that he got practice using the CITV himself. Practice exercises completed the CITV training.

SIMNET navigation training (Baseline only). SIMNET navigation training had three components: classroom training, hands-on execution of a navigation exercise, and a SIMNET Skills Test. The SIMNET navigation classroom training included a refresher on different navigational techniques such as resection, dead reckoning, terrain association, and polar plotting. It emphasized use of the SIMNET M1 navigational components such as grid azimuth indicator, turret reference display, and odometer to navigate in the closed-hatch environment of SIMNET. Commanders were presented with SIMNET paper maps and protractors to use to complete map reading exercises. Following the classroom training, the Baseline participants practiced their navigation skills in a training exercise.

In the SIMNET navigation training exercise, Baseline commanders paired up so that one served as a driver and the other as the tank commander. Using navigation skills reviewed during classroom and seat-specific training, they negotiated a cross-country route from one checkpoint to the next. At irregular intervals, the vehicle commanders were stopped by the trainers and asked to report their six digit location to the exercise control staff. They also were asked to identify targets and terrain features at specified azimuths and distances from their current location. The exercise control staff gave them immediate feedback on whether their responses were correct. After the first round of commanders had navigated to two checkpoints, the vehicle commanders rotated with the drivers so that each had an opportunity to drive and an opportunity to command.

Baseline commander navigation training concluded with the SIMNET Skills Test. It contained tasks specifically dealing with using the grid azimuth indicator, turret reference display, and odometer to navigate the vehicle. Protractors, pencils, and paper were provided for calculations. The SIMNET Skills Test was the final activity in the half-day training for the Baseline unit and vehicle commanders.

Day 2 Events

2a: CITV Skills Test (CVCC condition only). The CITV Skills Test evaluated unit and vehicle commanders' proficiency with the CITV functions. As with the CCD Skills Test, the vehicle trainer read the instructions and then provided the participant with a paper copy of the tasks. After the participant had completed all the tasks, the vehicle trainer conducted any remedial training necessary until the unit or vehicle commanders could successfully execute each CITV tasks.

2b: Gunners/drivers seat-specific training. Gunners and drivers rejoined the unit and vehicle commanders on the morning of Day 2. Initially, crew assignments were finalized. These crews completed all the training and testing exercises, and participants remained in the same crew positions. Once they knew which position their vehicle commander had in the battalion and the names of the other crewmembers, the gunners and drivers were escorted to the simulators and trained on the basic simulator features in the gunner's and driver's SIMNET seat-specific training.

Like the seat-specific training for the unit and vehicle commanders, the Baseline and CVCC versions of the gunner's and driver's training concentrated on the differences in equipment between the MWTB M1 tank simulator and the actual M1 and training simulators at the CATTC. The training included explanation, demonstration, hands-on practice, and practice exercises at the end. For the CVCC condition, seat-specific training for gunners and drivers included all the information on the basic simulators plus training on the CCD navigation and digital message functions and the CITV target designation functions. The CCD navigation function was given particular emphasis because the battalion commander and S3's gunners were required to navigate the vehicle for the first stage of the company situational training exercise.

2c: Vehicle commander/BLUFOR operator coordination. This module consisted of a classroom briefing and orientation for unit and vehicle commanders on BLUFOR operation. The lecture explained the capabilities and operating procedures of the BLUFOR vehicles (i.e., formations, speed [rate of movement and response time], coordination of fires, engagement criteria, and message generation). It also addressed BLUFOR limitations such as the lack of platoon fire commands and inability to split sections. The need for close coordination between the commanders and BLUFOR operators through immediate intervention or FRAGOs was emphasized so that the BLUFOR operators could fulfill the directives of the commanders.

Company XO role briefing. This briefing was designed to explain how the current doctrinal role of the fighting company was to be executed in the tactical scenarios. The C2 SME used viewgraphs to show graphic depictions of the available radio nets and, in the case of the CVCC condition, the available CCD report nets. The C2 SME discussed the XO's role in monitoring the company command net and receiving, consolidating, and forwarding routine reports such as SITREPs and SHELL reports. The C2 SME also addressed the use of the battalion O&I voice net for routine voice reports as well as the transmission of intelligence traffic. The limitation of the company XO not being able to monitor the battalion command voice radio net was addressed, and a few suggestions for coordinating on the company command net were provided.

2d: Tank crew training. When the individual training was completed (the "crawl" phase of the "crawl, walk, run" approach to training), the crewmembers began collective training exercises, the "walk" portion of training. These were the same across Baseline and CVCC conditions. Descriptions of these collective training exercises can be found in Meade et al. (in preparation). Actual materials used to support these collective training exercises can be found in the battalion evaluation training package. Training objectives for the tactical training missions can be found in Table 12.

During crew, company, and battalion-level training, the vehicle trainers used checklists to help them provide feedback to the commanders, gunners, and drivers on the correct usage of the simulator equipment. In the CVCC condition, usage (i.e., did he use it?) and correctness of usage (i.e., did he use it correctly?) of the CVCC equipment were also monitored by the trainers.

The first collective training exercise was tank crew training. The focus of tank crew training was on crew coordination, navigation, and terrain negotiation. Opportunities for target acquisition and engagement were also provided.

2e: Company Situational Training Exercise (STX) pre-brief. The company STX pre-brief included briefings by the Test Director, Battle Master, and the Battalion XO on the SOPs, schedule, TOC capabilities and procedures, and on the mission itself.

Table 12

Tactical Scenario Training Objectives (Combat Vehicle Command and Control and Baseline)

2d: Crew Training

1. Reinforce individual training at all crewstations.
2. Develop crew coordination skills.
3. Practice target acquisition and engagement.
4. Report enemy contact and engagement, ammo and fuel status, enemy shelling.
5. Practice navigation with condition-specific equipment.

2f: Company STX

1. Develop tactical movement experience on SIMNET terrain.
2. Develop skills in coordinating movement of SAFOR platoons.
3. Develop working SOPs between company commanders and their XOs for reporting and navigation.
4. Develop target engagement skills by direct and indirect fire using available condition-specific equipment.
5. Learn to work with available TOC fire support.

2g: Battalion Staff Situational Training

1. Develop teamwork skills working with TOC staff.
2. Develop understanding of TOC capabilities and limitations.
3. Monitor battle in TOC and simulators.
4. Apply reporting skills in simulation setting.

3b: Battalion STX

1. Develop teamwork skills within entire battalion.
2. Apply command and control skills in a simulated battalion-level exercise.
3. Develop teamwork skills within crews.
4. Refine tactical movement skills.

3f: Battalion Traihing Scenario

1. Resolve remaining training-related problems before testing begins.
2. Reinforce C2 skills in mission type similar to test scenario.
3. Refine report processing skills and integrate additional BLUFOR Radiotelephone Operators (RTOs).
4. Integrate Stealth-based leader's reconnaissance into pre-mission planning.

2f: Company STX. The company STX was the first training scenario in which the participants interacted with other crews and units. The two-stage training scenario was designed to provide Baseline and CVCC company commanders and XOs practice in working together, in interacting with SAFOR platoons, and in using the radio net structures they would be using the rest of the week. There were also some equipment-related training objectives. For the CVCC group, the company STX also gave them their first opportunity to receive and relay digital reports andoverlays in an interactive, operational setting while the Baseline group focused on completing equivalent tasks (e.g., receiving voice reports) without the CVCC enhancements.

2g: Battalion staff situational training. Concurrent with the company STX, the battalion staff situation training provided an opportunity for the command group (i.e., battalion commander and S3) and the TOC staff (i.e., battalion XO, S2, Assistant S3, and FSO) to practice working together independent of all other participants. Practice for both conditions was primarily aimed at developing teamwork skills between the command group and the TOC staff and providing a clear picture of TOC capabilities and limitations.

2h: Company STX debrief: The company STX debrief emphasized equipment usage, adherence to the battalion SOP, and constructive suggestions on how to improve mission performance.

Day 3 events

3a: Battalion STX pre-brief and preparation. Pre-mission activities for the battalion STX followed the same general structure as for other training and test scenarios. The content included OPORDS and an intelligence briefing which highlighted possible enemy avenues of approach. Battalion STX training objectives and an exercise schedule with target completion times were presented using viewgraph slides. Next, the brigade OPORD was briefed by the Battle Master. Then, the battalion XO briefed the battalion OPORD, and participants conducted mission planning and preparation. The TOC staff was available and participated in coordination and preparation. As part of the mission preparation for the Baseline and CVCC conditions, an execution matrix was provided to the battalion commander and the S3. This matrix depicted the phases of the operation and indicated sequence of activities for each subordinate unit. For the CVCC condition, the COA overlay was activated on the large-screen SitDisplay in the TOC. The COA overlay allowed the battalion XO to use animated unit symbols to show the movement patterns (e.g., the axis of advance and subsequent objectives) that the battalion elements would take in their execution of the various phases of the mission.

3b: Battalion STX. The battalion STX provided the first opportunity for all the battalion elements to work together on a mission. It also was the first time that the battalion commander and S3 actually interacted with other battalion elements. Consequently, the report traffic was more extensive than previously encountered for both Baseline and CVCC groups.

3c: Battalion STX debrief. The battalion STX debrief, like the company STX debrief, stressed equipment usage and adherence to the battalion SOP. In the CVCC condition, any particularly difficult CCD training issues raised were addressed in the CCD refresher demonstration that followed. Baseline participants received refresher training on navigation skills by conducting sandbox exercises (see item 3d).

3d: CCD refresher training (CVCC condition only). To reinforce CCD operating procedures, a refresher training session (for unit and vehicle commanders only) followed the battalion STX debriefing. This session began with an abbreviated CCD demonstration to remind the commanders of those CVCC features which were designed to reduce the workload (e.g., icon retrieval) and to help them integrate CVCC into their C2 and target acquisition tasks. The second part of refresher training was a hands-on exercise involving map manipulation, route creation, and message and overlay processing.

3d: Navigation refresher training (Baseline only). Baseline participants also received refresher training. Crews executed navigation sandboxes, such as those completed during crew training, but they went from the last checkpoint in the sandbox to the first checkpoint. Since no gunnery targets were used, this provided test participants with an opportunity to refocus their attentions on using correct navigation techniques without the competing elements of target acquisition or engagement.

Officers call. A mid-week officers call was held on Wednesday during lunch for all unit and vehicle commanders. A representative from the ARI-Knox Field Unit addressed the following key issues: (a) the use of kill suppress (the software feature that protects manned simulators from being killed); (b) the possibility of unrealistically aggressive behavior (dubbed "Rambo" behavior); and (c) the potential for crews to follow SAFOR instead of navigating on their own. The lecturer explained the potential impact of these issues on the evaluation's findings if full participant cooperation was not given. Finally, guidelines for role-playing behavior were provided. This session was conducted in an informal manner, with the research staff exercising an "honest-broker" role.

3e: Battalion training scenario pre-brief and preparation. Prior to the battalion training scenario, a leader's reconnaissance was conducted for the battalion commander, the S3, and the three company commanders. In this activity, the battalion XO attached the Stealth sensor to a vehicle simulator. As the vehicle maneuvered on the battlefield, the Stealth followed, and the view out the vision blocks of the vehicle was mirrored on the Stealth station. The Stealth technology permitted the battalion XO to lead the commanders and staff on a standardized reconnaissance mission over the simulated terrain, highlighting friendly positions, engagement areas, enemy avenues of approach (no OPFOR vehicles were visible), and areas of terrain masking. The S2 was available at the Stealth to respond to queries about the enemy or terrain.

3f: Battalion training scenario. The battalion training scenario provided participants with the final opportunity to practice their tactical skills before testing began. It was a dress rehearsal for the test scenario and marked the "run" portion of training.

3g: Situational Assessment (SA) questionnaire. At the end of the battalion training scenario, the unit and vehicle commanders received a short orientation to the SA questionnaire. The commanders completed a practice SA questionnaire to familiarize them with the administration procedures and types of questions that would be on the test version of the SA questionnaire. More information regarding situational assessment data for the battalion-level evaluation may be found in Leibrecht, Meade et al. (in preparation).

3h: Battalion training scenario debrief. The battalion training scenario debrief was conducted in the same manner as the company STX and battalion STX debriefs. However, special emphasis was placed on answering any remaining participant questions on the test equipment or usage procedures before the test scenario began the next day. Once the test scenario began, no help was provided on either Baseline or CVCC equipment usage.

Data Collection Procedures

This section presents the issues, measures, and data collection methods used to gather data on training and SMI issues for this evaluation. The current set of performance measures was derived from the battalion TOC evaluation (O'Brien et al., 1992) which were based on measures from earlier CVCC efforts (e.g., Du Bois & Smith, 1989; Du Bois & Smith, 1991; Leibrecht et al., 1992; Quinkert, 1990). Thus, this current set of performance measures are the result of data analysis and lessons learned from previous CVCC efforts. Parts of this section are based on Leibrecht and Winsch et al. (in preparation.)

Training

The two major purposes for the information gained from the assessment materials were to provide insight as to the overall effectiveness of the training program and to identify requirements for training programs aimed at teaching the skills necessary to support automated C2 systems. Training data were used to identify required modifications to training exercises, materials, and schedules, thus ensuring adequate preparation of all participants. Because interest was primarily in participant reactions to the effectiveness of the training program, the issues formulated were largely descriptive:

1. Issue T1: What were the strengths and weaknesses of the Baseline and CVCC training?

2. Issue T2: How effective was Baseline and CVCC training in producing skilled performance?

Data were collected to address these training issues using two types of instruments: training evaluations and the skills tests. At the conclusion of the test scenario, all participants rated the training they received during the first three days of the evaluation. Using a 7-point Likert scale, participants rated training elements such as clarity of training objectives and feedback on mission performance. Each event in the training program was evaluated, and recommendations for improving each of the training modules were solicited with open-ended questions. Baseline and CVCC versions of the training evaluations for the vehicle commanders, gunners, and drivers are presented in Appendix D.

Skills tests helped determine if a unit or vehicle commander had mastered the equipment in his test condition. They also provided valuable feedback on what portions of the training program still needed improvement. The SIMNET Skills Test for Baseline participants tested vehicle commanders on M1 simulator usage skills. The CCD and CITV Skills Tests covered the major functional features of the CCD, POSNAV, and CITV components. All three skills tests are presented in Appendix D.

SMI

SMI information augmented the training data by assessing how the nature of the interface may have improved training effectiveness and performance. Diagnostic issues for the SMI addressed various aspects of CVCC equipment utilization. Separate measures were developed to identify the frequency with which different features of the CCD and the CITV were utilized. The equipment utilization measures provide valuable information to future CVCC designers and training developers. Equipment usage rates can suggest different task requirements or preferences of participants. For instance, if company commanders and XOs received more reports than their battalion counterparts, this may have translated to differences in usage rates or degree of satisfaction associated with a wide range of CCD report functions. Because of a heavier report load, individual commanders may have desired more extensive report filter mechanisms, and preferences for these filters may have varied between commanders, depending on their C2 style. The SMI data are important to understanding CVCC training. This is because systems which are optimally designed should better support training and acquisition of the necessary skills for successful

Table 13

Summary of Diagnostic Measures for Issues D1 and D2

Number	Diagnostic Measure
D1: What was the interrelationship of training and SMI for the CCD?	
D1.1	Percentage of time each map scale in effect
D1.2	Percentage of time each map feature in effect
D1.3	Percentage of time each map scroll function in effect
D1.4	Percentage of control inputs by Touch Screen
D1.5	Percentage of grid inputs to reports by laser device
D1.6	Number of reports received, by report type
D1.7	Percentage of reports received which were duplicates
D1.8	Percentage of reports retrieved from Receive queue
D1.9	Percentage of reports retrieved
D1.10	Average number of upward relays per report
D1.11	Percentage of reports relayed upward--unique relays
D1.12	Average number of downward relays per report
D1.13	Percentage of reports relayed downward--unique relays
D1.14	Percentage of reports posted to tactical map
D1.15	Mean time to retrieve reports
D1.16	Mean time to relay reports upward
D1.17	Mean time to relay reports downward
D1.18	Number of digital reports sent (originated)
D1.19	Percentage of time battalion commander and S3 used their: (a) Tactical Map (CCD) and (b) paper lap map
D1.20	Percentage of time battalion commander and S3 used their: (a) vision blocks, (b) GPSE, (c) CITV, and (d) CCD
D2: What was the interrelationship of training and SMI for the CITV?	
D2.1	Percentage of time in each CITV mode: (a) Manual, (b) Autoscan, (c) GLOS, and (d) GPS
D2.2	Number of times CITV laser used
D2.3	Number of times CITV Designate used

performance. Hence, two critical issues were identified and addressed by the equipment usage and questionnaire data:

1. Issue D1: What was the interrelationship of training and SMI for the CCD?

2. Issue D2: What was the interrelationship of training and SMI for the CITV?

Automated and manual data were used to address the SMI issues. The automated data were the product of the DCA system. As shown in Table 13, the DCA system yielded measures D1.1 through D1.18 on CCD usage and measures D2.1 and D2.2 on CITV usage. The two types of manual data collection instruments were the Research Assistant (RA) Logs and SMI questionnaires.

RAs in the battalion commander, S3, B Company commander, and B Company XO vehicles manually recorded data that the DCA system could not collect (e.g., information on vision block versus GPSE usage). Two CCD SMI measures collected in this manner were (a) percentage of time battalion commander and S3 used their Tactical Map (CCD) and paper lap map (D1.19) and (b) percentage of time battalion commander and S3 used vision blocks, GPSE, CITV, and CCD (D1.20). A CITV measure, number of times Designate was used (D2.3), was also recorded in RA Logs. For a more complete discussion of the RA Logs used in the battalion evaluation, see Leibrecht, Meade, et al. (in preparation).

Two SMI questionnaires were administered by a member of the research staff to all CVCC commanders after the test scenario debrief. Instructions for completing the self-paced questionnaire were read aloud and provided in writing. The first questionnaire covered the CCD and POSNAV, while the second covered the CITV. The commanders were asked to rate CCD and CITV capabilities using a 7-point Likert scale. They also were asked to answer open-ended questions and offer suggestions for improvement. (A copy of each questionnaire is presented in Appendix D.) A member of the research staff administered the SMI questionnaires. The questionnaires were self-paced.

Data derived from automated measures and questionnaires described above were used to analyze the quality of the training program and the relationship between training and SMI. Key results of these analyses are presented in the following sections.

Training Results and Discussion

The analysis of training data focused on three major issues. First, the perceived effectiveness of the various components of the training program was examined. Second, the level of skill proficiency attained by participants was investigated. Third, potential areas of improvement for the training program were assessed. Discussion of the data is organized in terms of the major issues with primary findings summarized at the conclusion of this section.

Training data were derived from the training evaluations and skills tests presented in Appendix D. Item level summaries of the questionnaire data can be found in Appendix A.

Perceived Training Effectiveness

Participants in the Baseline and CVCC training programs were asked to rate the quantity and clarity of different components of the training program and to provide their views on the strengths, shortcomings, and potential improvements for the program. Results are organized around four training areas: (a) individual training; (b) tactical training exercises; (c) training objectives and feedback; and (d) overall level of preparation.

Individual Training

Individual training marked the beginning of the "crawl" phase of the training program. Both Baseline and CVCC vehicle commanders began their individual training with classroom instruction. As shown in Figure 15, the majority of commanders rated classroom instruction positively. Fifty-four percent of the Baseline commanders rated the navigation classroom as "Above Average" or better in preparing them to operate the simulator, with another 38% rating it "Average." Seventy-five percent of CVCC commanders rated the CCD demonstration as "Above Average" or better, and 62% rated the CITV classroom as "Above Average" or better in preparing them to operate the CVCC equipment. "Above Average" was the modal response for the CCD Demonstration. The modal response for the CITV classroom was "Average."

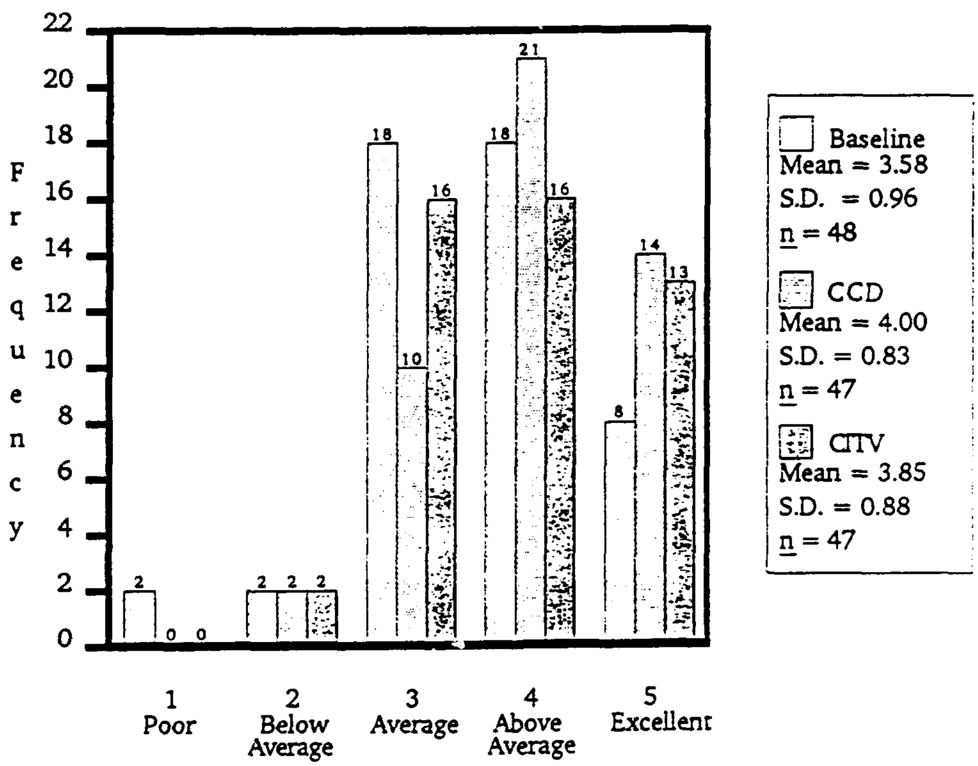


Figure 15. Commanders' classroom instruction ratings.

Some CVCC commanders wrote comments on their training evaluations indicating that they preferred demonstration to lecture presentation. These comments, combined with the positive rating of the demonstration methodology, reinforced the effectiveness of demonstration as an instructional medium for the CCD. However, this generalization does not necessarily hold for the CITV. Instruction on using the CCD screen display is well suited to a large screen demonstration. That is, interactions with the interface and their effects on the display are easily seen by training participants. However, the CITV is less well suited to a large screen demonstration because instruction requires greater focus on manipulating the device itself and less on monitoring the field of view. In this case, explanation of the CITV is better suited to classroom discussion and hands-on manipulation of a device mock-up.

Participant responses may reflect a "halo" effect due to their keen interest in the CCD and CITV and a desire for maximum hands-on opportunities regardless of what may actually be the most effective instructional medium.

Classroom instruction was followed by hands-on instruction in the M1 simulators. As shown in Figure 16, vehicle commanders' ratings of hands-on instruction were generally positive. Eighty-one percent of the Baseline commanders rated the hands-on training as "Above Average" or "Excellent." The percent of

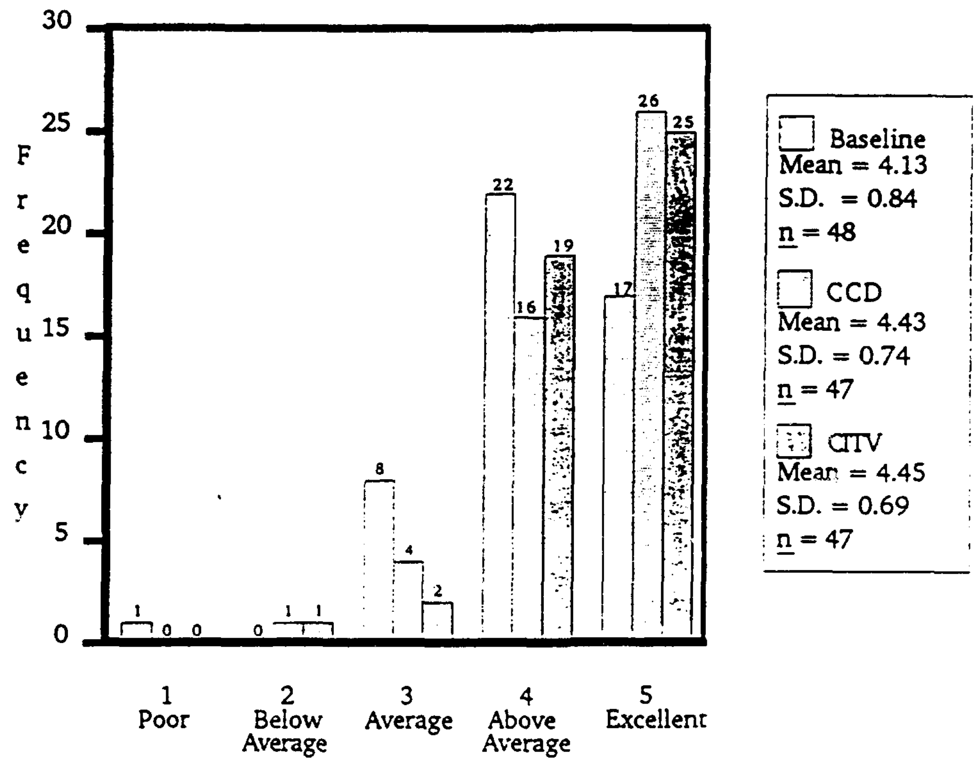


Figure 16. Commanders' hands-on instruction ratings.

commanders rating the CCD and CITV hands-on training as "Above Average" or better were 89% and 94%, respectively. Interestingly, a larger percentage of CVCC vehicle commanders rated the CCD and CITV hands-on training sessions as "Excellent" than any other training program component; possibly another indicator of participants' desire for hands-on training experience. However, these ratings can most likely be attributed to the maturity of the hands-on training program, with its iterative improvements based on past lessons learned.

Baseline gunners and drivers were, for the most part, also satisfied with their hands-on training sessions as shown in Figures 17 and 18, respectively. Sixty percent of the Baseline gunners and 62% of the Baseline drivers rated the seat-specific training as "Above Average" or better. Sixty-nine percent of CVCC gunners also rated the training as "Above Average" or better. Of all gunners and drivers, the CVCC drivers rated their individual training programs most favorably; i.e., 83% rated their seat-specific training as "Above Average" or better.

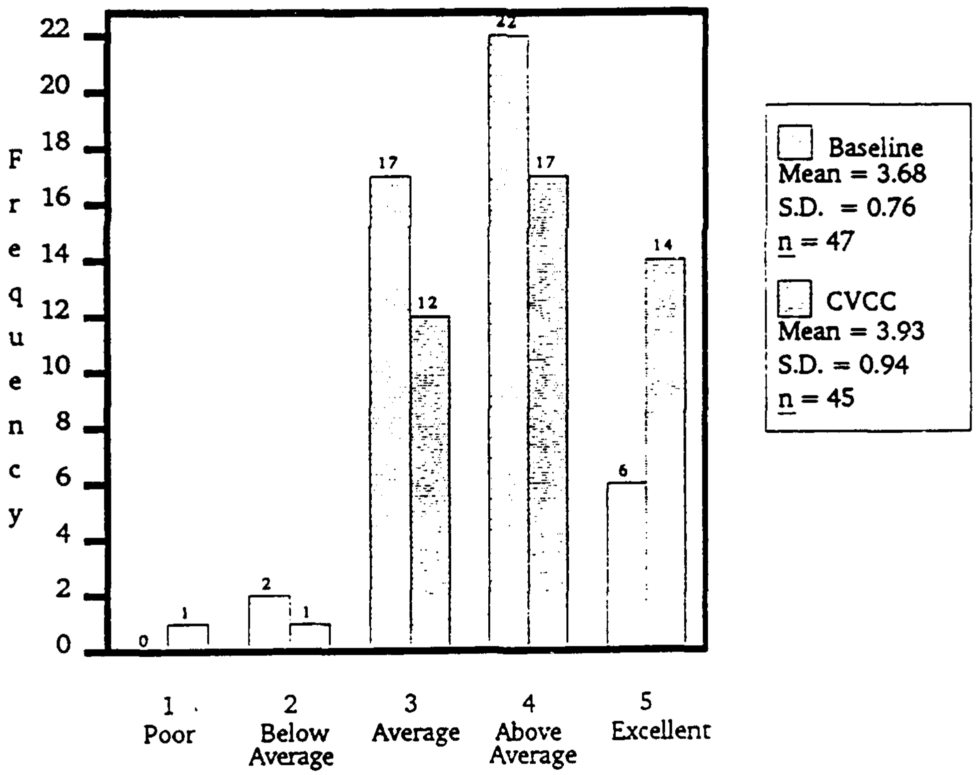


Figure 17. Gunners' hands-on instruction ratings.

Looking at individual training as a whole, vehicle commanders gave the hands-on training higher ratings than the classroom training. However, participants perceived both components as important. One commander wrote, "There seems to be a good balance in 'talk time' classes and hands-on." Although not willing to forgo the classroom instruction, CVCC commanders

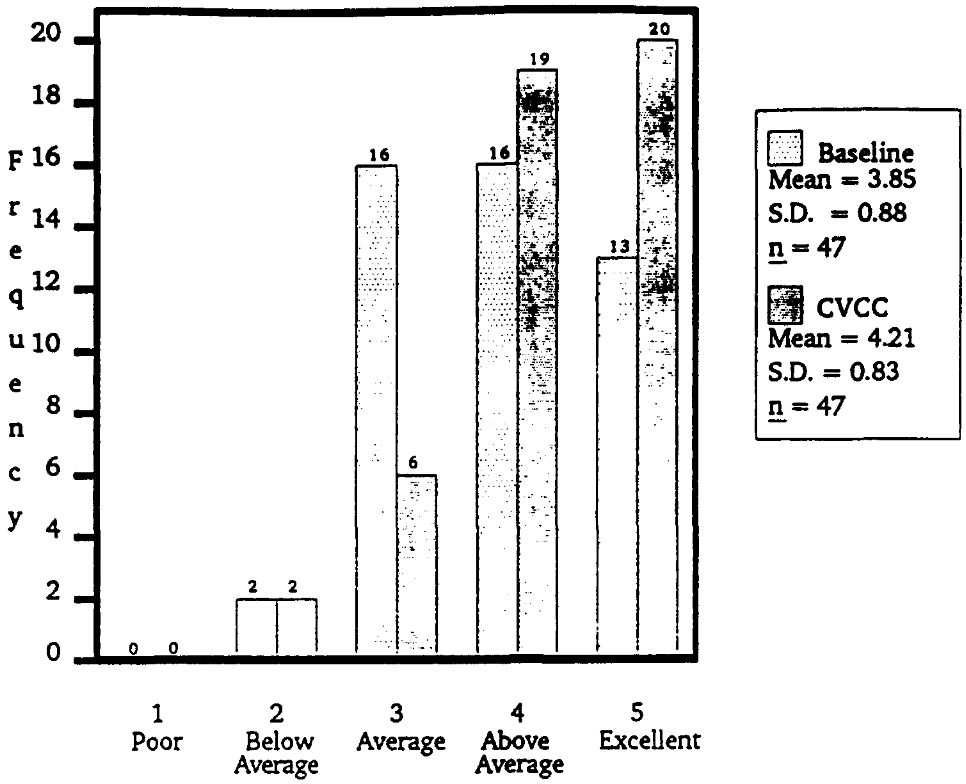


Figure 18. Drivers' hands-on instruction ratings.

stressed the need for more hands-on time. Participants suggested that the training be presented in shorter blocks, observing that there was "Too much info [information] to understand and quickly attempt to utilize."

Tactical Training Exercises

The tactical training exercises included the "walk" and "run" phases of training, beginning with a crew training exercise and progressing to a company STX and the two battalion-level exercises. Overall, CVCC commanders rated their CCD and CITV preparation levels positively, with later training exercises having a modal response of "Excellent" for both CVCC components. Although these responses by CVCC commanders were a bit higher than those given by Baseline commanders, the percentage of commanders rating the tactical training exercises as "Above Average" or better often varied by no more than a few percentage points between the two conditions.

Crew "Sandbox" Drills. Crew sandbox drills provided crews their first opportunity to practice crew coordination and navigation, and began the "walk" phase of training. These drills were unique, because they allowed multiple crews to gain crew coordination and terrain navigation experience on the simulated terrain data base without being visible to each other. As shown in Figure 19, approximately 65% of the Baseline vehicle

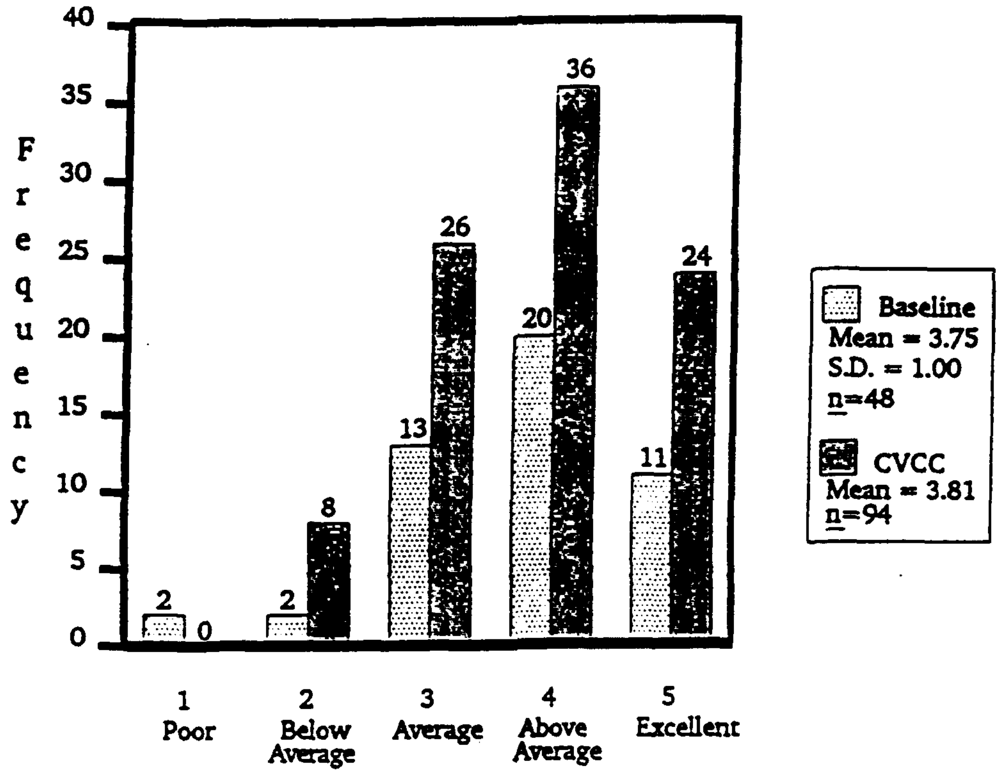


Figure 19. Commanders' crew sandbox drill ratings.

commanders rated the level of preparation provided by the crew sandbox drills as "Above Average" or better. CVCC vehicle commanders rated the same tactical training exercise for CCD and CITV preparation. For CCD preparation, 66% of the commanders rated the crew sandbox drill as "Above Average" or better. For CITV preparation, 62% of the commanders rated the crew sandbox drills as "Above Average" or better.

<u>Company STX.</u> Figure 20 shows that roughly equivalent levels of preparation were provided to both groups by the company STX. Eighty-three percent of Baseline commanders rated the company STX as "Above Average" or better in preparing them to execute a tactical scenario. Seventy-eight percent of CVCC commanders rated the company STX "Above Average" or better for CCD preparation. Seventy-four percent of CVCC commanders rated the company STX "Above Average" or better for CITV preparation.

<u>Battalion STX.</u> Eighty-three percent of Baseline vehicle commanders rated the battalion STX (see Figure 21) as providing "Above Average" or better levels of preparation. Eighty-five percent of the CVCC commanders rated the exercise as "Above Average" or better for CCD preparation. For CITV preparation, 75% rated the exercise as "Above Average" or better. "Excellent" was the rating most commonly given by the commanders for battalion STX preparation in both the CCD and CITV conditions.

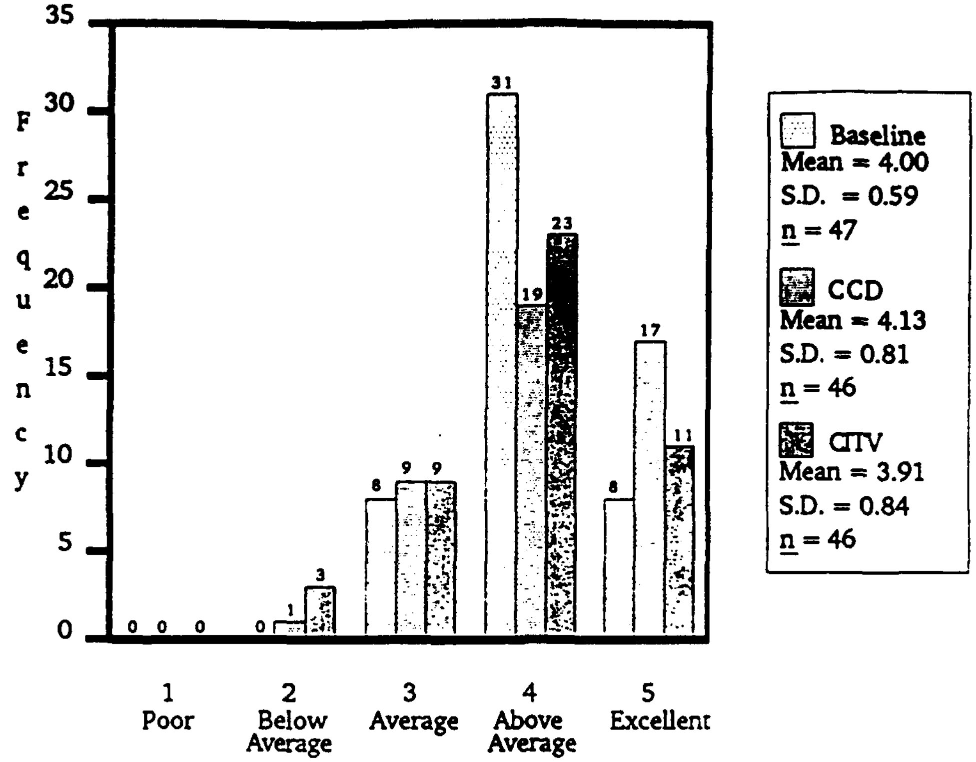


Figure 20. Commanders' company situational training exercise ratings.

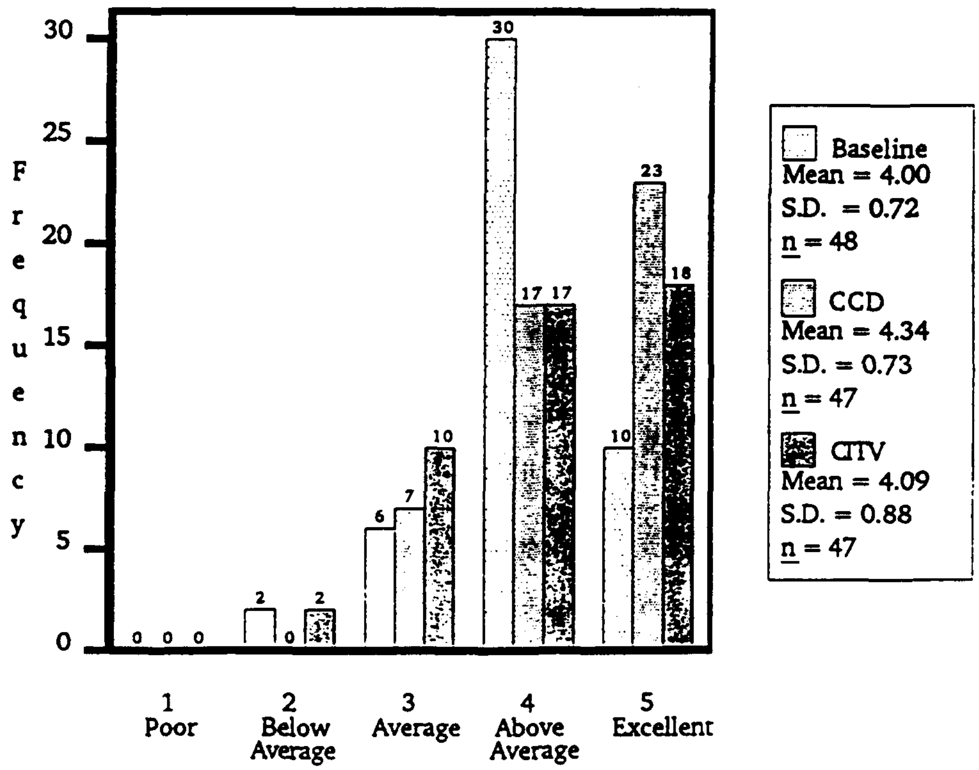


Figure 21. Commanders' battalion situational training exercise ratings.

Battalion training scenario. The "run" phase of training consisted of the battalion training scenario In parallel to the battalion STX, the same percent (83%) of Baseline vehicle commanders rated the final battalion exercise "Above Average" or better (see Figure 22). A slightly higher percent (87%) of CVCC vehicle commanders gave those ratings for CCD preparation. Eighty-one percent of CVCC commanders rated the CITV preparation as "Above Average" or better.

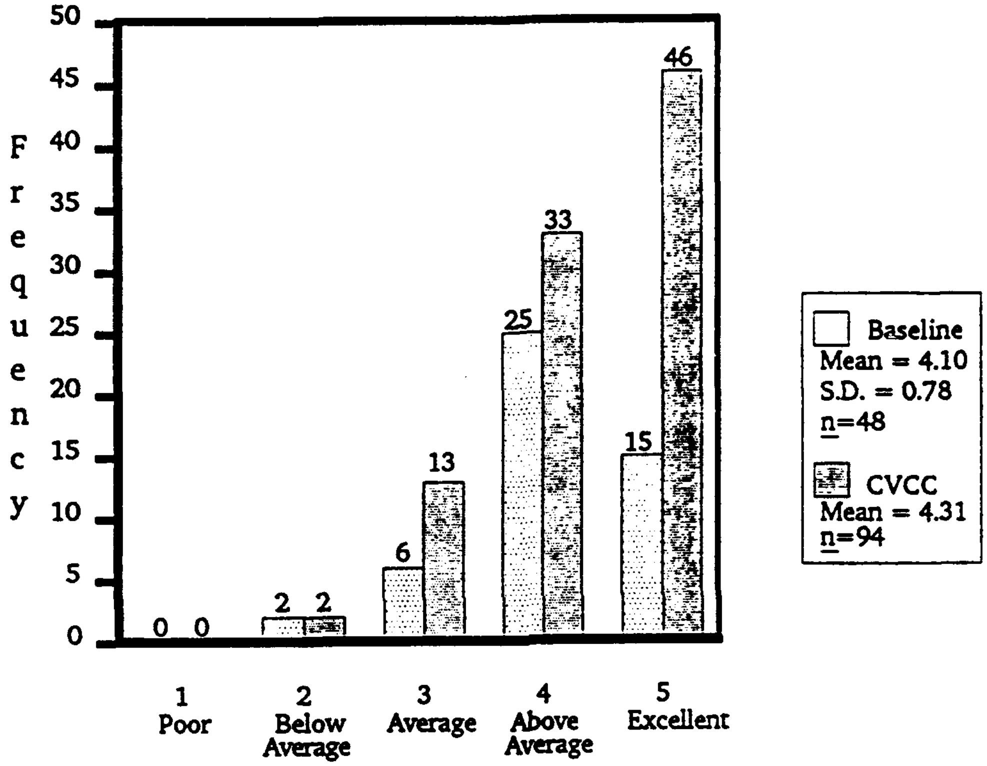


Figure 22. Commanders' battalion training scenario ratings.

Gunners and drivers ratings. Gunners (see Figure 23) and drivers (see Figure 24) rated the level of preparation provided by the tactical scenarios as a whole. The largest percent of Baseline (60%) and CVCC gunners (65%) indicated the tactical scenarios provided "Above Average" training. Fifty-eight percent of Baseline drivers rated the training scenarios as "Above Average" or better. CVCC drivers were again the most favorable of all gunners and drivers, with 68% rating the tactical training exercises "Above Average" or better.

Looking at the ratings for the tactical training exercises overall, it is clear that the majority of Baseline and CVCC commanders considered the tactical training exercises to provide "Above Average" or better levels of preparation. The modal response for Baseline commanders was consistently "Above Average," while the modal response for CVCC commanders increased from "Above Average" to "Excellent" over the course of the training exercises. Many comments readily acknowledged the usefulness of the crew sandbox drills; however, one commander

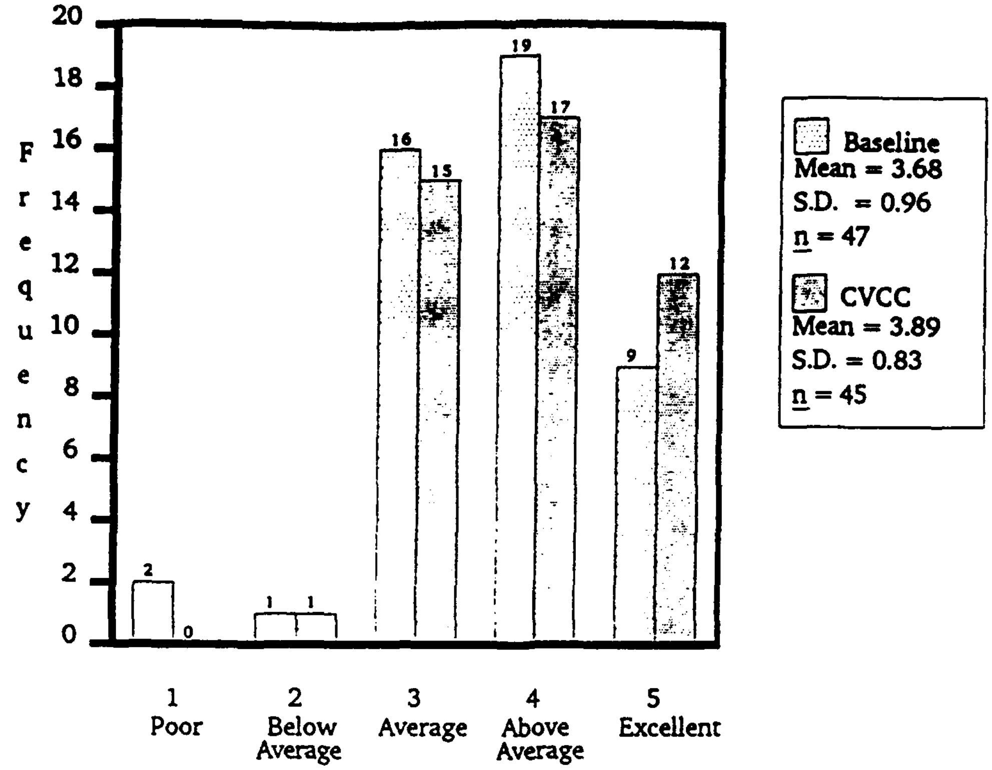


Figure 23. Gunners' training scenario ratings.

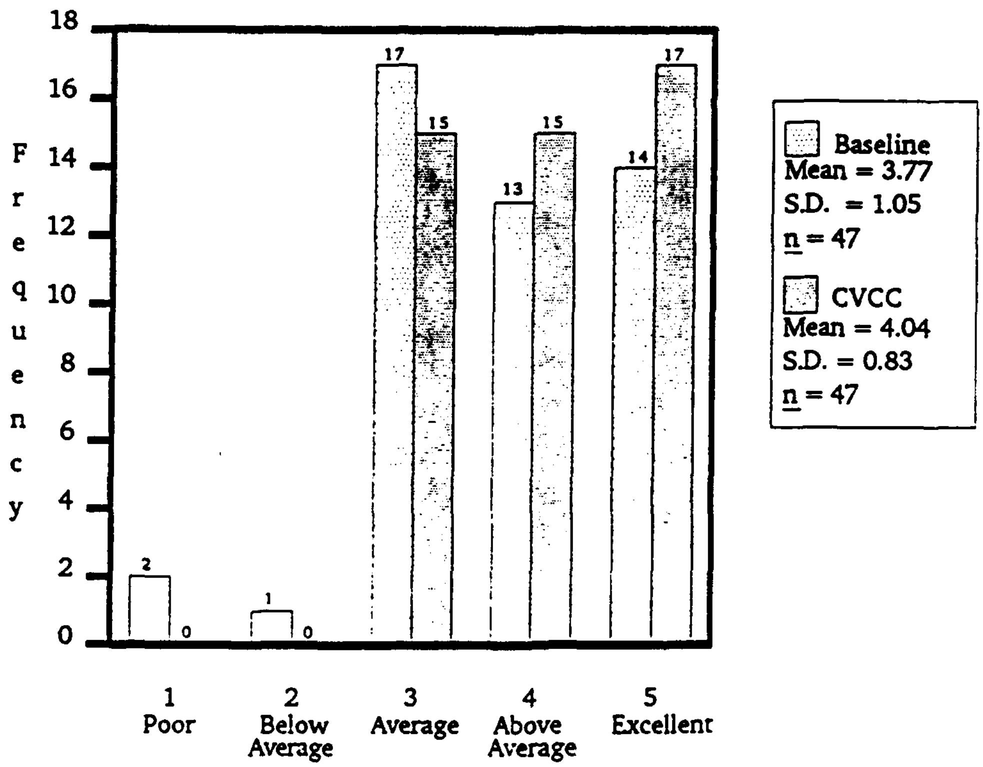


Figure 24. Drivers' training scenario ratings.

wrote that "Sandbox drills were good, but we needed more time than we received to become more proficient."

Training Objectives and Feedback

Training objectives provided the standards for assessing performance of participants. The clarity of the objectives, from the perspective of the participants, provides insight into the extent that they understood what was expected of them. Generally, commander ratings on the clarity of the training objectives were fairly high. As shown in Figure 25, 81% of Baseline commanders rated their training objectives as "Somewhat Clear" or "Very Clear." For CVCC commanders, the CCD training objectives were rated as "Somewhat Clear" or "Very Clear" by 94% of commanders. The CITV training objectives were rated similarly by 89% of the CVCC commanders.

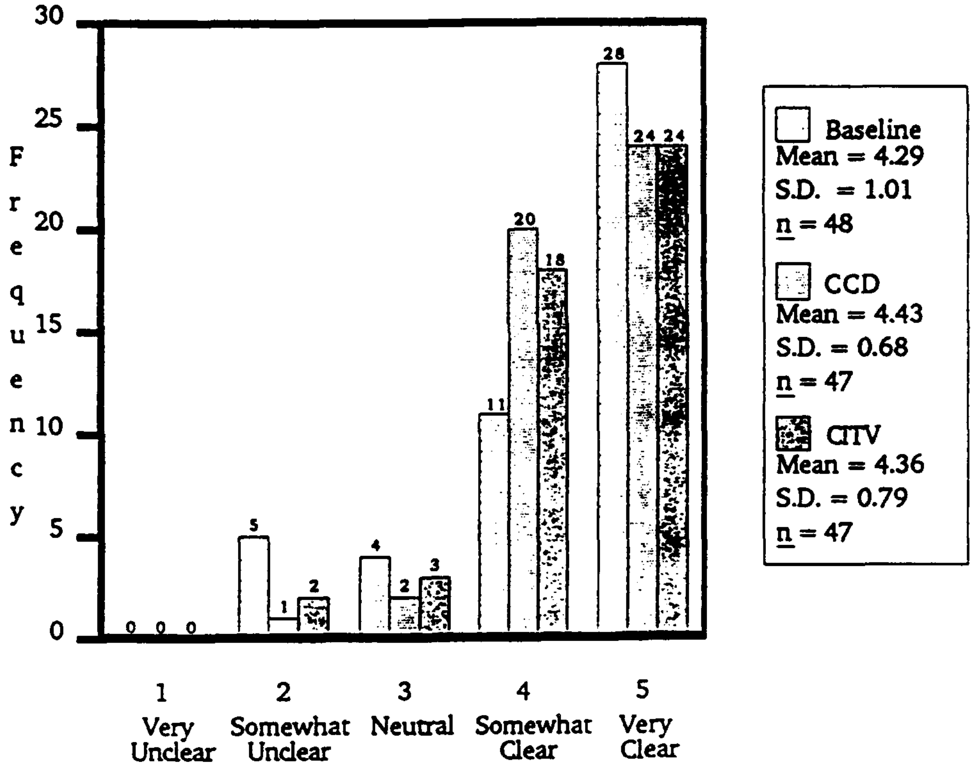


Figure 25. Commanders' training objectives ratings.

Feedback was provided to participants during training scenarios and debriefs. During training scenarios, feedback on equipment usage only was provided by trainers on an "as needed" basis. During debriefs, trainers provided tactical as well as equipment usage feedback. As shown in Figure 26, ratings for feedback provided during training scenarios were somewhat less favorable than in other areas. Sixty-five percent of Baseline commanders rated the feedback during training as either "Somewhat Clear" or "Very Clear." Slightly less than half of CVCC

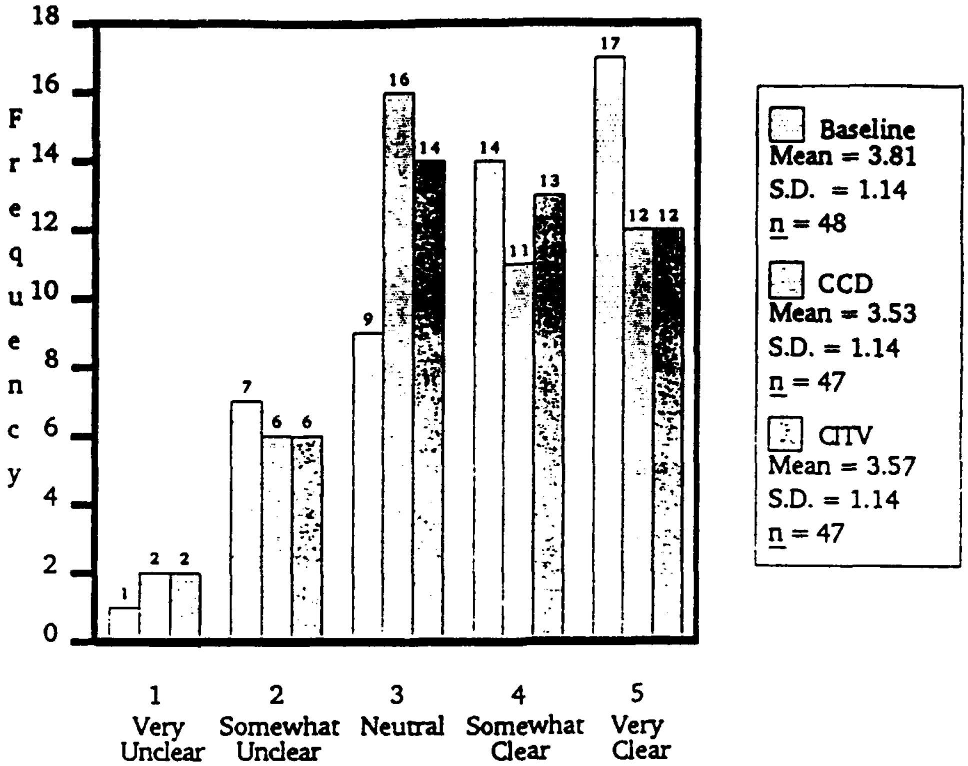


Figure 26. Commanders' feedback during training ratings.

commanders (49%) found the CCD feedback provided during training to be "Somewhat Clear" or "Very Clear," while 53% used these descriptors to rate the CITV feedback.

For CVCC commanders, the ratings on feedback provided during training were more moderate than those for most other portions of the training program. One explanation is that the aggressive CVCC training schedule left no time between the end of mission execution and the beginning of the debrief for trainers to provide individual feedback based on their observations of crew performance. One CVCC participant recommended that time be provided for "an AAR with the RA." Another wrote that "the feedback was there, but could have been more extensive, both positive and negative."

Baseline and CVCC participants primarily received tactical feedback during the debriefs. Debrief quality ratings are shown in Figure 27. For the battalion STX debrief, 71% of Baseline commanders rated the debrief as "Above Average" or better. Sixty-six percent of the CVCC commanders did likewise. As shown in Figure 28, similar ratings were given to the battalion training scenario debrief. There was only a three percent difference between Baseline and CVCC vehicle commander ratings for this final debrief. Seventy-three percent of Baseline commanders rated it "Above Average" or better compared to 70% of the CVCC commanders.

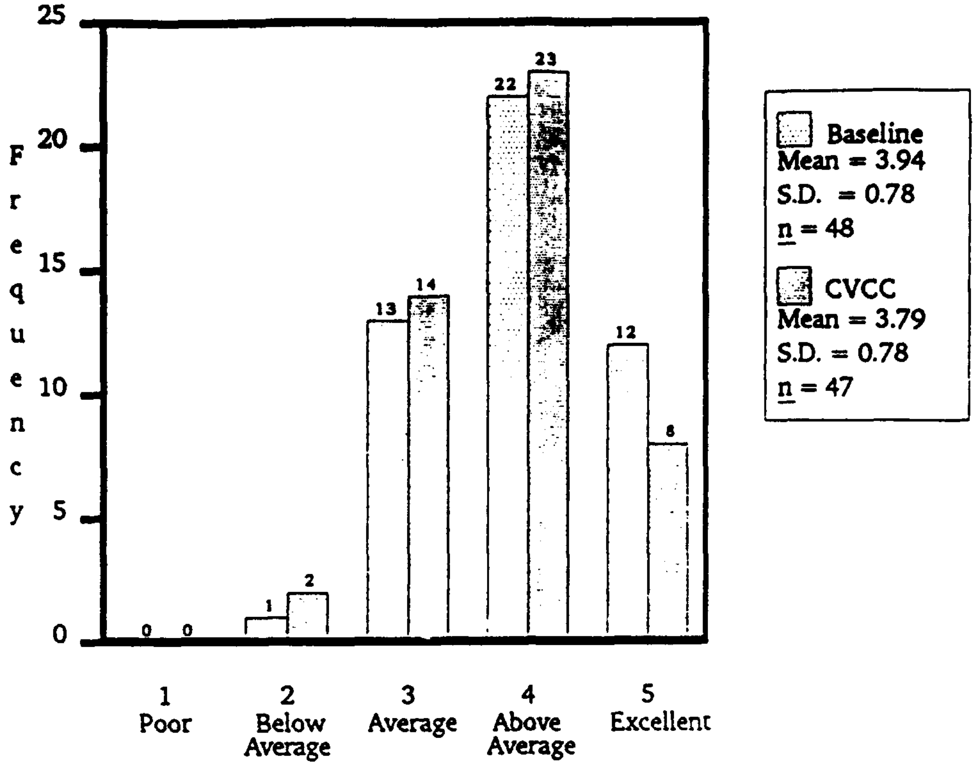


Figure 27. Commanders' battalion situational training exercise debrief ratings.

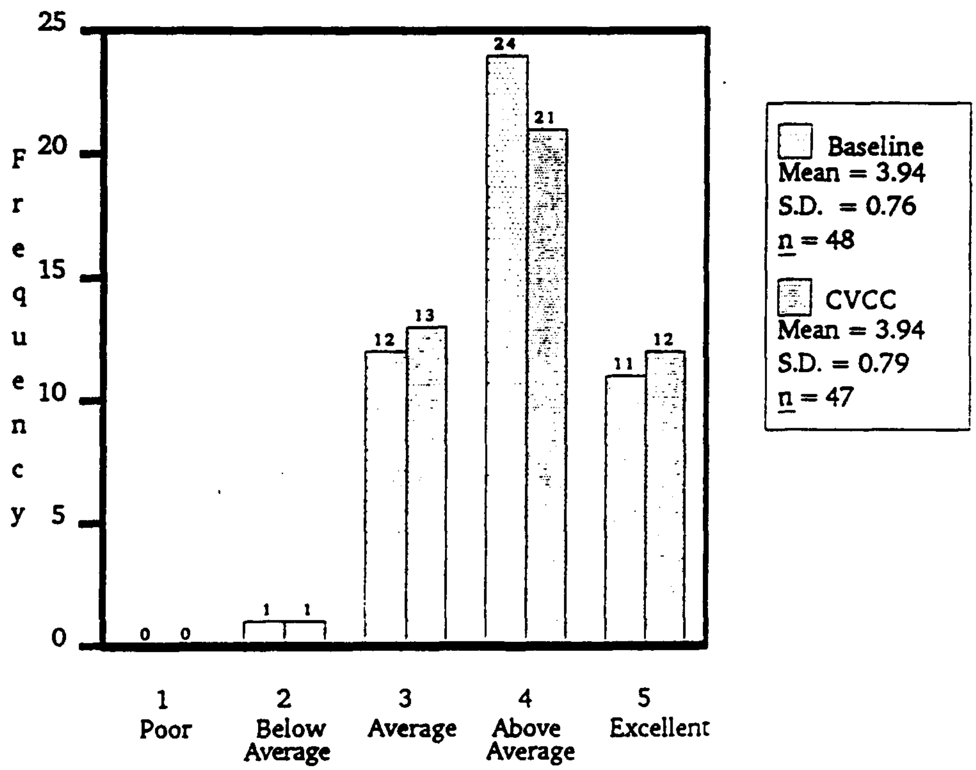


Figure 28. Commanders' battalion training scenario debrief ratings.

Overall Level of Preparation

A comprehensive training evaluation item required both Baseline and CVCC commanders to rate their level of preparation for the battalion training scenario, the culminating exercise in the training program. As shown in Figure 29, Baseline and CVCC vehicle commanders rated their preparation level as "Above Average" or better (77% for Baseline, 83% for CVCC). In sum, Baseline and CVCC participants indicated that they were well-trained and prepared to execute the tactical scenarios.

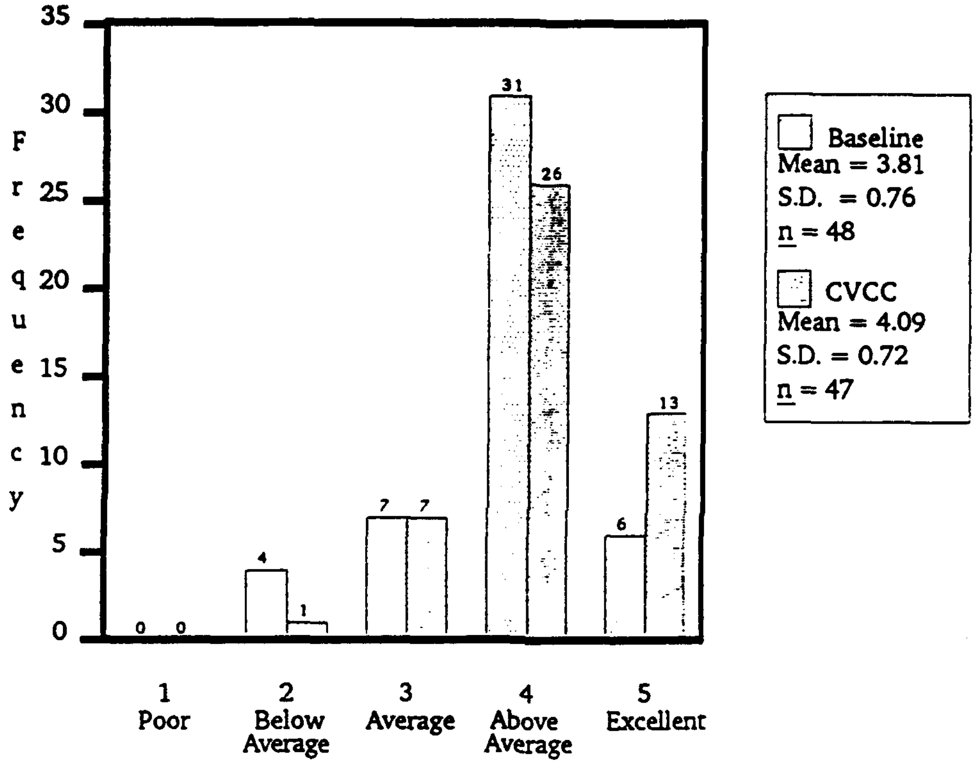


Figure 29. Commanders' overall level of preparation ratings.

Proficiency in Using the CVCC Equipment

Analysis of proficiency in using the CVCC equipment focused on two issues: (a) the level of proficiency reached by commanders using the CCD and CITV at the end of the individual training; and (b) trends related to the acquisition of C2 skills that have emerged over the course of the CVCC program.

Data from the CVCC Skills Tests provided measures of how easily CVCC usage skills were acquired. The CVCC Skills Tests were rated positively by the vehicle commanders. As Figure 30 shows, 70% of vehicle commanders rated the CCD and CITV Skills Tests "Above Average" or better on the training evaluation.

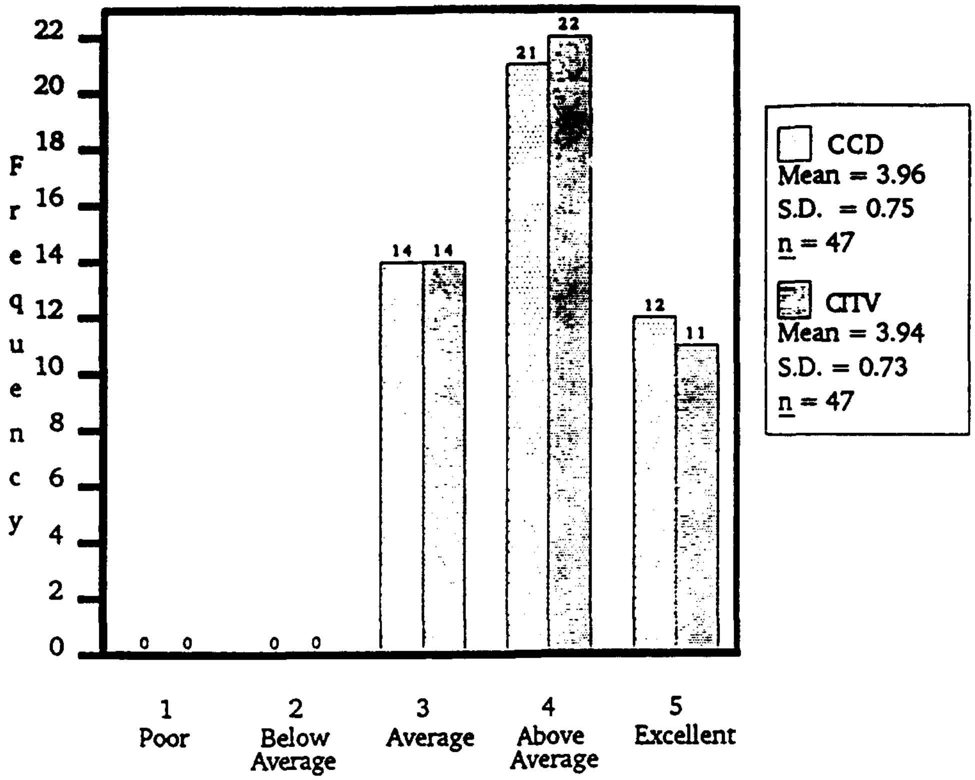


Figure 30. Commanders' Command and Control Display and Commander's Independent Thermal Viewer skills test ratings.

CVCC Proficiency by the End of Individual Training

Figures 31 and 32 show the overall percentage of commanders who earned particular skills test scores for the CCD and CITV, respectively. In terms of how well the participants met the mastery standard of 100%, 32% of the commanders performed all tasks correctly for the CCD Skills Test. For the CITV Skills Test, 68% of the participants performed all tasks correctly. Average scores were high for both CVCC components, with CCD scores averaging 89% and CITV scores averaging 94%. Although many commanders received some retraining at the conclusion of individual training, their test scores show that the average participant was relatively close to meeting the master standard of 100%.

CVCC Skills Test Trends

This analysis focused on trends in proficiency of equipment usage from the previous two evaluations to the present evaluation. During this time, the design and functionality of the CITV remained largely the same. The CCD, however, has steadily gained more functions and efforts have been made to improve the interface. Since time available for individual training of the CCD and CITV has remained the same, the issue centers on the impact of CCD redesign on proficiency

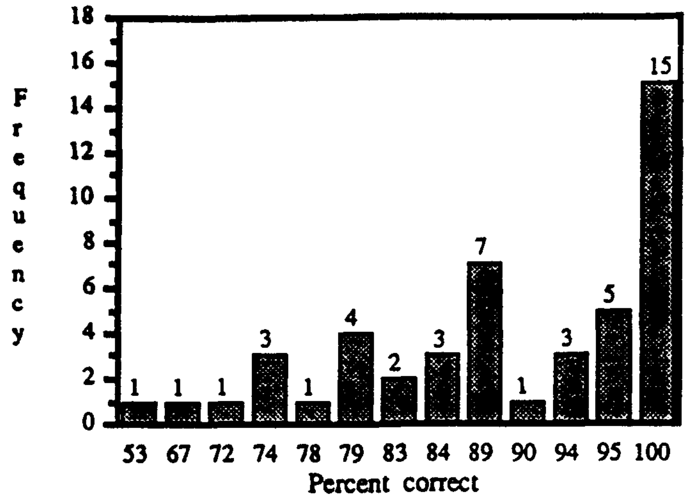


Figure 31. Command and Control Display Skills Test scores.

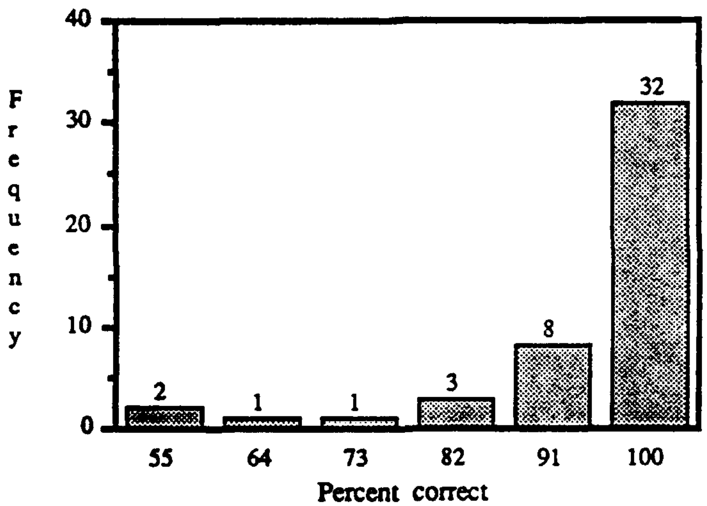


Figure 32. Commander's Independent Thermal Viewer Skills Test scores.

given a stable amount of time for skill acquisition. Because different numbers of commanders were involved in the three evaluations (35 in the company evaluation, 24 in the battalion TOC evaluation, and 47 in the present evaluation), percentages were computed to allow for comparisons between evaluations.

Figure 33 presents the mean percentage of tasks completed correctly. The mean percentage increased between the company and battalion TOC evaluations and then remained largely the same for both the CITV and CCD Skills Tests. For the three evaluations, the mean percent for the CCD Skills Test were 86%, 94%, and 90%, respectively. For the CITV Skills Test, the mean percent for the three evaluations were 78%, 95%, and 93%. The patterns of skill improvement are particularly noteworthy for the CCD given the increasing functionality of the device. They provide evidence

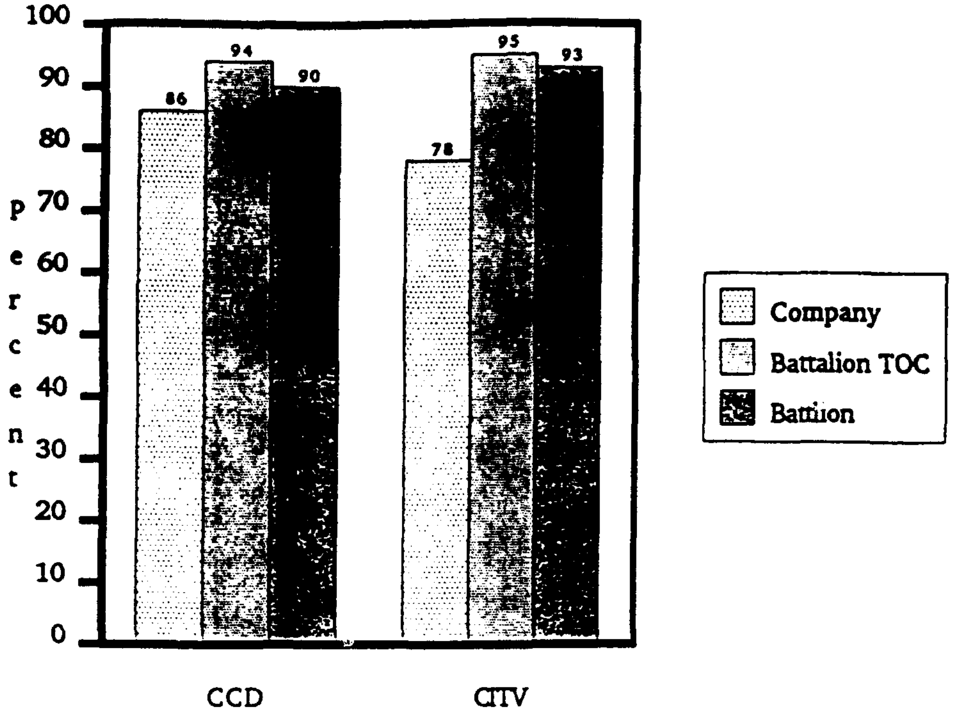


Figure 33. Command and Control Display and Commander's Independent Thermal Viewer Skills Test average scores.

for the counterbalancing effects of simplifying the interface in managing the overall complexity of the CCD as well as the functioning of the training program for both the CCD and CITV over time.

On a less optimistic note, there is some evidence of an increasing sub-population of participants who find it difficult to acquire CCD usage skills by the end of individual training. As shown in Figure 34, the percentage of participants scoring less than 75% on the CCD Skills Test has increased since the battalion TOC evaluation. Only 3% of the company evaluation participants scored less than 75% on the CCD Skills Test, while none of the battalion TOC participants and 13% of the battalion evaluation commanders had not reached a 75% proficiency level. This pattern did not occur for the CITV. In fact, the percent of commanders not achieving this proficiency level decreased from a high of 20% in the company evaluation to 4% and 9% in subsequent evaluations.

Low scoring participants are always a concern because they bring a need for retraining which requires additional time and resources. Perhaps a better understanding of the characteristics of lower scoring individuals would provide insight into adjustments to their training that would facilitate their skill acquisition.

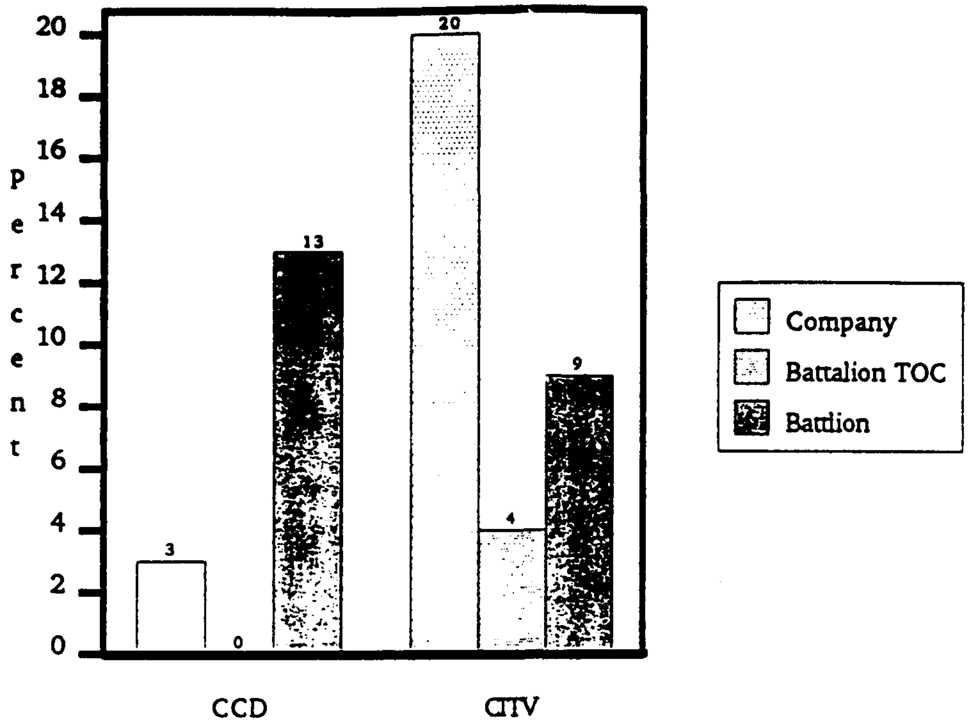


Figure 34. Participants scoring less than 75% on the Command and Control Display and Commander's Independent Thermal Viewer Skills Test across the Combat Vehicle Command and Control evaluations.

Areas for Potential CVCC Individual Training Improvement

The results of the CVCC Skills Test results and training evaluations were examined to identify areas of potential improvement for the CVCC individual training program. The results of this analysis are described in the following paragraphs.

CCD Skills Test

Of the 19 items on the CCD Skills Test, six items were missed by 15% or more of the participants. Frequent mistakes were made on placing a Forward Line of Own Troops (FLOT) icon so that it faced the wrong direction. The difficulty of this task centers on the fact that the direction the FLOT icon faces depends on whether the left or right endpoint is entered first. To correctly specify direction, the left endpoint should be entered first. A second frequent error was neglecting to open the Receive queue to access reports via icon retrieval. These two types of errors can be resolved easily by (a) providing the participants with more practice during individual training, and (b) placing more emphasis on the correct procedures during training of the trainers and the CCD demonstration.

CITV Skills Test

Of the 11 CITV tasks, two specific tasks were performed incorrectly by 13% of the commanders. The first task required use of the Designate function to show the gunner a scanning sector. The error participants often made was to release the palm switch prior to lining the CITV up with the desired area. This error suggests a need for more practice using the Designate function so as to increase the automaticity of the palm/finger activation. The second task required the commander to use the IFF to identify an enemy vehicle, determine the distance to it, and engage it. Implicit in this task is the requirement to designate to slew the gun tube to the CITV. Participants who failed this task either (a) forgot to switch from CITV mode to GPS mode to engage the vehicle, or (b) tried to use the CITV sight to engage the target. Another difficulty noted with the performance of this task was the requirement to integrate the use of the GPSE into the newly-acquired CITV SOPs. Commanders with CITVs tended to forget the system's current simulation limitations (i.e., can not fire in CITV mode, CITV not boresighted to main gun). Early in their training, commanders tried to use the CITV for all their target acquisition and engagement to the exclusion of using their GPSE. Additional practice is required for effective synthesis of both sights.

Most of the problems observed on the CITV Skills Test could be resolved if additional training time were available for commanders to practice. Not surprisingly, most suggestions made by the commanders for training program improvements related to increasing the training time. Although they liked the training program, many described it as "rushed." The comment most frequently made was that more training time was needed if commanders were to go from familiarity to mastery: "Putting it all together as a sequence just is not an instant response yet." These responses reflect the desirability of providing additional training time to allow for effective assimilation of information provided by the CVCC components.

Commander Training Evaluations

CVCC commanders identified some CVCC functions that they seemed less prepared to use during the battalion training scenario. These items included: (a) interpreting the LOGISTICS status in the battalion command vehicles for information on company vehicles; (b) retrieving text from a FRAGO overlay; and (c) removing old overlays. Although each item was introduced in the initial CCD hands-on training, these functions were not required as part of a commander's routine mission execution responsibilities until he was in a battalion-level tactical exercise. CCD refresher training was created to help cover the day-and-a-half lapse between the initial individual CCD training and the first battalion-level training exercise.

Refresher Training

Refresher training consisted of two components: a refresher demonstration and hands-on training on individual refresher tasks. The three major purposes of the refresher training was to (a) allow commanders to ask any new questions they might have on CVCC equipment usage; (b) remind them of some CCD usage "shortcuts", such as using icons to retrieve reports that they may have forgotten since the individual training; and (c) provide feedback on some equipment usage shortcomings noted by the trainers.

Data comparing the two methods of refresher training are presented in Figure 35. Overall, commanders preferred the hands-on refresher task training to the refresher demonstration. Forty-seven percent rated the refresher demonstration as "Above Average" or "Excellent" compared with 64% percent for the refresher tasks. Many participants commented that the refresher demonstration was not needed; it merely repeated tasks from the hands-on training. Nevertheless, there were still CVCC functions that commanders seemed unprepared to use effectively for the battalion training scenario. Intuitively, some form of refresher training seems necessary when tasks taught on one day are not used until two days later. The hands-on refresher training seems to have been more satisfactory to the CVCC commanders for this purpose.

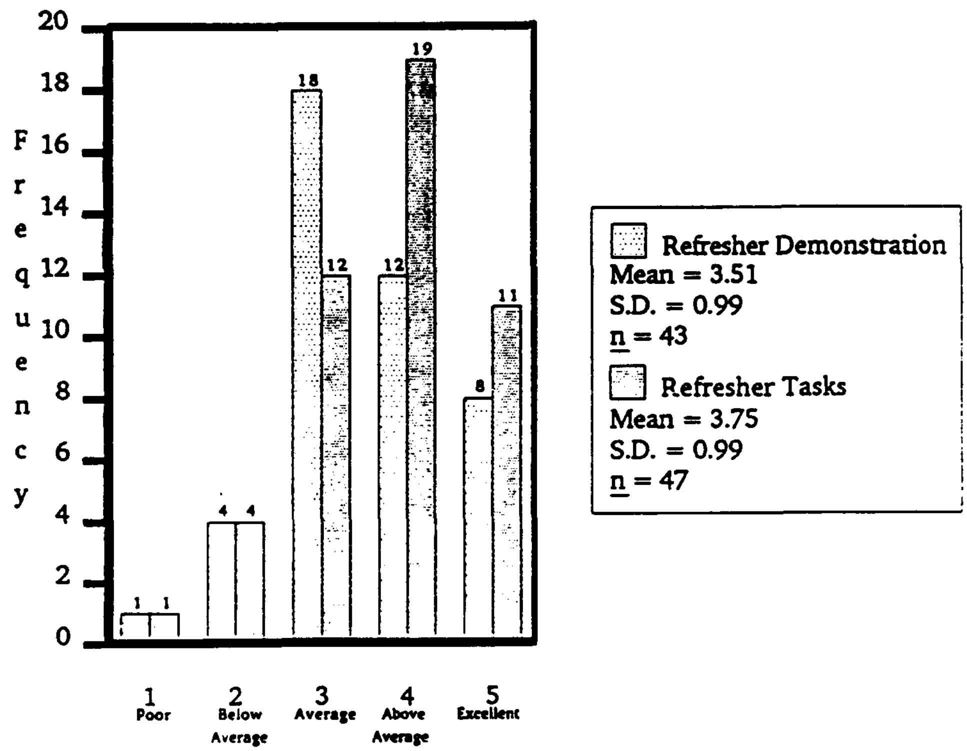


Figure 35. Combat Vehicle Command and Control commanders' refresher demonstration and refresher task ratings.

Summary

Overall, all participants were equally satisfied with and well-prepared by their respective training programs. Similar satisfaction was accorded the individual and collective components of the training programs. CVCC commanders gave more positive ratings to the hands-on training than to other elements of the training program, with the majority rating the hands-on training as "Excellent." These high ratings for the hands-on training are consistent with the training evaluation results from the battalion TOC evaluation (see O'Brien et al., 1992). High ratings also were given to the tactical training exercises for the battalion evaluation, with a modal response of "Excellent." The increasingly high ratings given by the participants are consistent with training evaluation findings from the battalion TOC evaluation (O'Brien et al., 1992). On the other hand, feedback provided during execution of the battalion-level tactical training exercises was seen as "Neutral" by many CVCC commanders. They expressed impatience with a training schedule that limited their opportunities for more extensive feedback.

An analysis of previous CCD Skills Test scores showed that average scores have remained fairly stable since the company evaluation. However, the percentage of participants scoring less than 75% since the battalion TOC evaluation has increased by 13 percent. Many of the equipment usage problems identified by the skills test can be mitigated by providing more individual training time. The request for more training time was common among commanders on their training evaluations. In this regard, further study of CVCC training evaluation data revealed that a likely candidate for elimination from the training program was the CCD refresher demonstration.

Training Conclusions

The success of the individual training portion of the CVCC program was apparent from the skills test averages of 90% and above for battalion evaluation participants. The ratings given by vehicle commanders, gunners, and drivers in the training evaluation were quite positive for the quality of the overall training program. Especially successful were the hands-on training modules and the battalion-level tactical training exercises. Many commanders expressed confidence in their ability to use the CVCC systems at the completion of training. One commander wrote, "The training is excellent. I fully understand now how to manipulate all the devices and use them to my advantage."

Lessons Learned

The legacy of the CVCC program with its carefully documented lessons learned extends beyond how well it fulfilled the training requirements of the CVCC equipment tested. It also has yielded lessons for creating or modifying training for similar systems. In the following section, lessons learned are organized into five areas for discussion: (a) overall training design, (b) hands-on training, (c) tactical training exercises, (d) feedback to participants, and (e) training data collection.

Overall Training Design

1. Use the crawl, walk, run approach for training design. The CVCC program has evidence to show that the crawl, walk, run approach to training new devices is well-accepted by participants and yields proficient performance. Commanders in the battalion-level evaluation commanders indicated that each successive component helped prepare them for the next, more complex task.

2. Present demonstrations instead of lectures where appropriate. Some CVCC commanders preferred the demonstration methodology to lecture presentation. Demonstrations should be seen as giving the participants an overview of equipment capabilities rather than as comprehensive presentations of individual equipment functions. This approach would conserve training time that can be more effectively spent by participants in hands-on learning. It also would provide a needed link in a whole-part-whole learning strategy. Training benefits also should be derived from demonstrating the best tactical use of CVCC features.

3. Include hands-on refresher training. Particularly complex functions trained but not used for a few days in a training program should be included in a refresher training program. As the battalion evaluation ratings on the refresher tasks have shown, participants prefer hands-on training. Once participants have hands-on knowledge of the equipment, they do not want to go back to being passive learners while someone else provides instructions. A trainer should be available, however, to answer individual questions and to provide the clear training feedback CVCC commanders desired. These trainers should not be there to "score" the participants; participants should be given the tools to score themselves. Finally, hands-on refresher tasks must be interactive and realistic to facilitate the transfer of skills to the tactical environment.

4. Explain any necessary artificialities early in the program. CVCC participants in the battalion-level evaluation were told about the kill suppress function on Wednesday after the battalion STX. Training personnel observations suggest that it might be preferable to tell participants about kill suppress earlier in the program so that they do not get a falsely inflated sense of their own invincibility on the battlefield. Other alternatives for obviating "Rambo" behavior include posting scorecards when unnecessary risk-taking behavior is observed or providing participants with immediate in-simulator feedback. Similarly, commanders should be told early about other necessary artificialities that accompany data collection such as canned FRAGOs and overlays.

Hands-On Training

1. Maximize hands-on time. Overall, participants prefer hands-on training to classroom training. The training methodology supported by CVCC evaluations as early as the POSNAV evaluation was based on the principle of repetition; i.e., present each function in a classroom forum and then again during hands-on training. Several battalion evaluation commanders left the CCD demonstration feeling that they had a basic understanding of the system and were prepared to practice the CCD functions. However, the participants noted that their trainers unnecessarily delayed their hands-on time by following the time-consuming methodology of "explain and demonstrate," even for those functions just covered in the CCD demonstration. These comments most likely reflect a superficial understanding of the CCD and a strong desire of soldiers to get their hands on the equipment. However, the extent to which decreasing the redundancy between the demonstration and hands-on presentations would increase overall training satisfaction without sacrificing training effectiveness should be investigated further.

2. Provide more structured practice on integrating systems in the individual training. Individual training modules used to train the CCD and CITV were followed by the sandbox exercises. While this approach follows a crawl-walk-run strategy, earlier practice on using the CCD and CITV together is needed. For example, a practice session might include exercises to verify an IFF by switching to GPS mode on the CITV and having the gunner lase to the target and verify where the threat icon appears on the CCD. Information gained from the CVCC program should be helpful in developing SOPs for equipment usage and integration.

3. Limit blocks of training on new equipment to one-hour blocks with regular breaks. Participants learning a new system, particularly with multiple functions, should be trained in short intervals with frequent breaks to avoid information "overload." In the battalion-level evaluation, commanders trained on the CCD for blocks of 1 1/2 hours at a time. Trainers noted that participants often forgot items taught at the beginning of these sessions and had to be prompted through several practice exercises. Time permitting, a better scheme might be to present training in one-hour blocks with ten minute breaks between blocks.

4. Plan for increased initial training time to introduce more complex and comprehensive digital systems. As the CCD software was modified to perform more functions and to provide better feedback to the soldier, it sometimes became more time-consuming to train, especially in the beginning. For example, the LOGISTICS module replaced the AMMO report. The AMMO report only included the ammunition status of one's own vehicle in GARB code. The LOGISTICS module, however, provided many more features than the old digital AMMO report (i.e., automaticity; inclusion of ammunition, personnel, and equipment as well as fuel; unit

logistics status as well as own vehicle status, etc). Yet, these additional features of the LOGISTICS module, beneficial as they were, required more initial training time than the simpler AMMO report. The addition of forty-five minutes of individual training time to the current training schedule, in conjunction with the above suggestion for smaller training blocks, would provide more flexibility in the event that newer features require additional training.

5. Consider making time a criterion when evaluating equipment proficiency. One element dropped from the CVCC skills tests was the criterion of using speed of task completion as a factor in scoring a "GO" or "NO GO." Trainers found it difficult to simultaneously work a stopwatch and watch a participant complete the function. However, company evaluation participants noted that time should be a criteria for scoring such tests (Atwood et al., 1991). Some battalion evaluation participants agreed. An alternative would be to use time as a criterion on scoring the refresher training. The advantage here would be that participants on the skills tests would not have the pressure of performing to a time standard early in the basic skills training, but that trying to "beat the clock" would be an additional challenge for completion of refresher training later in the week.

Tactical Training Exercises

1. Keep pace as well as demands low in the "crawl" stage. Crew training falls in the "crawl" stage of the crawl, walk, run training strategy. Participants often indicated that the crew training was rushed. In the crawl phase, participants need additional time and a slower pace to use their newly acquired skills to meet the demands of their first collective training exercise.

2. Use multi-media training aids in the pre-brief to help participants assess the battlefield situation. The COA overlay and the Stealth station were used effectively to provide an animated depiction of battlefield movement and terrain reconnaissance not possible with traditional briefing materials.

Participant Feedback

1. Structure opportunities for frequent feedback. CVCC commanders noted that the feedback opportunities during training needed to be increased. During training scenarios, trainers kept checklists on CVCC equipment usage. Trainers needed at least 5 minutes at the end of each stage of a tactical scenario (prior to the participants exiting the simulators) to provide this equipment-based feedback to the crewmembers. This feedback time should be written into the training schedule and sustained. Participants also should be informed of any restrictions on the type of feedback the trainers are allowed to give. For example, the CVCC trainers were not allowed to give tactical feedback unless it was related to equipment usage.

2. Involve training staff in the debriefs. Debriefs are an excellent resource for identifying training problems and concerns. Notes can be recorded and equipment-related questions that arise can be answered by knowledgeable training personnel. To maximize the training lessons learned from the debriefs, training issues that surface during the debriefing should be presented to the training staff before the execution of the next training scenario. This strategy would allow the entire training staff to evaluate their own crewmembers on the identified problematic functions and procedures.

Training Data Collection

1. Choose anchor points carefully. Make sure that scale anchor points can be clearly differentiated. For example, points 2 and 4 on the training evaluation scale for clarity read "Somewhat Unclear" and "Somewhat Clear." It may be difficult for some participants to distinguish between the two.

2. Make reference points as concrete as possible. When evaluating an item and later interpreting that rating, it is important that the reference point for an item be as tangible as possible. For example, if the item requires that comparisons be made to a tactical training exercise in general, less concrete information will be obtained than if the comparison is to a specific training exercise at the NTC. Participants should be reminded that the purpose of the training program was to improve their equipment usage, not to improve their tactical expertise. Battalion evaluation participants occasionally rated items on how much a training exercise helped them on improving their tactics in general. While it is beneficial for test participants to improve their general tactical execution skills, the emphasis of this research and development training evaluation was on the acquisition of equipment usage skills.

Training Issues Requiring Further Study

The CVCC program revealed several training issues which justify closer examination. These issues, listed below, merit further training research.

Increasing Integrated Equipment Training

Because the CVCC system components were prototypes with no established SOPs, participants frequently expressed how difficult it was to integrate the CVCC equipment effectively. They often explained that CITV functions such as Designate were less frequently used during scenarios because the CCD was so consuming. A related observation by trainers was the tendency of commanders to become focused on the CITV sight to the exclusion of the GPSE and vision blocks. Guidelines for effective integration need to be established and data from the CVCC program should contribute significantly to this effort. Once established, an expert could present a demonstration or be the subject of a videotape which provides concrete examples of integrating the CVCC components.

Training Information Systems Management

Participants sometimes complained about the difficulty of handling the load of incoming digital messages. Methods for training information processing and management need to be explored further.

Increasing Participants Hands-on Time

Innovative training techniques for multi-functional devices such as the CCD are needed to increase participant hands-on time without making the training schedule too lengthy. One method in training CCD usage skills which included a larger proportion of hands-on time would be a self-paced training program.

Establishing Digital Versus Voice Reporting SOPs

As was true for equipment integration SOPs, no data communication SOPs existed for the CCD when the CVCC program began. Therefore, many participants created their own SOPs on digital versus voice reporting. For example, one group decided to send voice CONTACT reports before digital ones. Another group established that they would send CONTACT reports verbally instead of via the CCD and then send digital SPOT reports. Like CONTACT reports, NBC reports have an element of urgency to them that often leads participants to choose the voice option first. Research has been conducted on voice versus digital reports for aircraft (see Kerns & Harwood, 1991). Much useful information on this issue has been collected during the CVCC program. This information can provide a basis for further research directed at establishing guidelines for voice and digital reporting by ground forces.

Providing Timely Feedback to Participants

Debriefs provide important training feedback. However, timely feedback on participant training scenario performance (i.e., friendly and enemy hits and kills) is currently not available in DIS facilities such as the MWTB. Such feedback could be used to give participants specific details on their performance during debriefs, as well as provide them with the correct answers. Perhaps some form of the Unit Performance Assessment System (UPAS) (Meliza, Bessemer, Burnside, & Schlecter, 1992) could be used to provide more timely feedback.

In addition to finding new ways to provide specific tactical feedback, the research community should explore more ways to use existing DIS technologies to present the debrief. For example, the large screen display could be combined with playback capabilities to review the mission. A related option might be the use of the Stealth station, PVD, and a large screen display.

Establishing a Standard for CVCC Proficiency Prior to Testing

CVCC participants were evaluated for equipment usage proficiency at the completion of individual training. It can be safely assumed that a different standard of CVCC proficiency had been gained as participants continued to practice and polish their skills prior to testing. It is also likely that participants found some innovative ways of using the equipment to perform their routine C2 tasks. An evaluation without the time constraints intrinsic to the CVCC evaluations would yield different standards of equipment proficiency than the ones noted here. Thus the required length of training to meet that standard must be provided. Once new standards are established, the time to train to those standards could be investigated.

SMI Results and Discussion

From the earliest stages of the CVCC program, the relationship between training and SMI was apparent. The following section explores that relationship, including potential SMI changes that could further facilitate training.

Analysis of the relationship between training and the SMI of the prototype CVCC system was focused on identifying areas where training "savings" lead to better performance and increased acceptability of the CVCC system. Such savings can be realized by making interface modifications or simplifying procedures. Ultimately, changes that improve equipment usability should reduce information load and allow for more effective training. The perception of being faced with information overload has been consistently reported by participants using prototype M1A2 C2 capabilities (Ainslie et al., 1991; O'Brien et al., 1992). Efforts to reduce the information load attributed to the CCD have involved software modifications for reducing duplicate reports (O'Brien et al., 1992). Other efforts have resulted in the development of information management training programs for the CCD (Lickteig, 1991; Winsch et al., in preparation), with promising results when used in an isolated setting.

In examining SMI issues, equipment usage data were grouped by stage of the scenario and echelon. This approach was based on prior CVCC efforts which demonstrated significant differences due to these variables (see Leibrecht et al., 1992; O'Brien et al., 1992). Effects attributed to stage were expected because (a) the three stages differed tactically, with stages one and three being defensive in nature, and stage two being an offensive mission; and (b) the three stages differed in maximum allotted execution time. Because most of the data for the SMI were derived from frequency rates (e.g., number of reports received), it was expected that the data would vary significantly between stage; i.e., the maximum duration of stage one (59 minutes) was greater than stages two (46 minutes) or three (42 minutes). Thus, opportunities to use the equipment varied significantly due to differences in tactics and allotted execution time for each stage.

Echelon was defined as battalion and company. Battalion-level included the battalion commander and S3 usage data while company-level included company commander and XO usage data. Significant effects for stage are noted, but the primary focus of interpretation is on the effect of echelon on equipment usage.

All inferential statistics for those measures showing significant effects are located in Appendix B. Most equipment usage data were subjected to multivariate analysis of variance (MANOVA) using the SPSS/PC+™ MANOVA procedure. When overall effects were found with the MANOVA procedure (alpha was set at .05), the analysis of variance (ANOVA procedure was run. Unless otherwise noted, discussion of significant effects and interactions are based on the ANOVAs.

For the SMI questionnaires, ratings were summarized using descriptive statistics (frequencies, means). SMI questionnaires are located in Appendix D. The complete set of SMI CCD and CITV questionnaire data are located in Appendix C.

Input Devices

CVCC users had a choice of input devices, depending on the task. The input devices for the CCD included: touchscreen, thumb cursor, CITV LRF, and the main gun LRF. Grid locations for reports could be obtained using any one of the input devices. When exact enemy location was critical, the laser input capabilities of the CITV and main gun should have been the preferred input devices. The touchscreen and thumb cursor were used primarily to manipulate the CCD and were only available to the vehicle commander.

The data showed no statistical differences for touchscreen input. Overall, 93% of the inputs to the CCD were accomplished via the touchscreen. These data are supported by SMI ratings for the touchscreen where 81% of the participants rated the touchscreen as "Somewhat Acceptable" or higher. Ratings for the thumb cursor were less favorable with 47% of the respondents rating the thumb cursor device as "Somewhat Unacceptable" or worse. Participants frequently commented that the thumb cursor was difficult to use and too sensitive. They also commented that the touchscreen was acceptable in a stationary tank but expressed concern over the ability to manipulate the CCD with the touchscreen in a moving tank. Participants suggested alternative input devices such as light pens or trackballs. These data are relevant to training because individuals tend to have distinct preferences for input control devices such as keyboards, joysticks, etc. As was found in the company-level evaluation

(Ainslie et al., 1991), most users did not consider the thumb cursor to be an acceptable alternative to the touchscreen. Thus, other input devices should be investigated to facilitate the performance of users who desire an acceptable alternative to the touchscreen. That is, providing users input devices which are easier to use should provide training "savings."

No statistical differences occurred for input to reports by laser. Thirty-six percent of the participants chose to use the laser for grid location input to reports. This usage rate appears low when compared to the SMI questionnaire data which showed that the ability to provide input to the CCD via the CITV laser was one of the highest ratings assigned to a CCD feature; i.e., 89% the of participants rated this capability as either "Very Acceptable" or "Totally Acceptable." Comments revealed that while vehicle commanders appreciated the ability to use the CITV laser to input grid locations to the CCD, it was perceived as being slower than using the touchscreen.

CCD

Of particular relevance to the interrelationship between training and SMI is the issue of information load. For the CCD, information load is directly related to the number of digital reports that a vehicle commander has to act upon either by receiving, reading, and posting reports or by creating and relaying reports of his own. SHELL, SPOT, CONTACT, CFF, ADJUST FIRE, NBC, SITREP, and INTEL reports can be sent to the vehicle commander via the CCD. In addition to these reports, the vehicle commander can also receive FREE TEXT reports and FRAGOs (in the form of overlays) from the battalion TOC.

On the SMI questionnaire, vehicle commanders tended to rate the CCD favorably. When asked to rate the contribution of the CCD to performance, 79% of participants rated the CCD as "Very Acceptable" or "Totally Acceptable." The Report function of the CCD was considered at least "Somewhat Acceptable" by 83% of the participants. Of concern is the finding that only 40% of the commanders considered the report load associated with the CCD to be "Somewhat Acceptable" or higher.

This pattern replicates past findings (Ainslie et al., 1991; O'Brien et al., 1992) where participants expressed concern over receiving too many reports. As noted earlier, this concern is troubling because software changes made for the battalion TOC evaluation (O'Brien et al., 1992) were aimed at reducing the number of duplicate reports received.

Report Handling

Reports received. The measure of the total number of reports received (unique and duplicate) on the CCD via all radio nets showed a significant difference between echelons for the following reports: FREE TEXT, CONTACT, SHELL, and SITREP. A companion measure, the number of unique reports received, also showed a significant difference between echelons for SHELL and SITREP reports. Finally, the percent of reports which were duplicates showed a main effect of echelon for FREE TEXT reports, CONTACT reports, and OVERALL reports. INTEL and NBC reports were not included in this analysis, due to their infrequent occurrence for this measure. The analysis resulted in a significant difference between stages for each of these measures (see Appendix B). Figure 36 shows the overall number of reports received by stage and echelon.

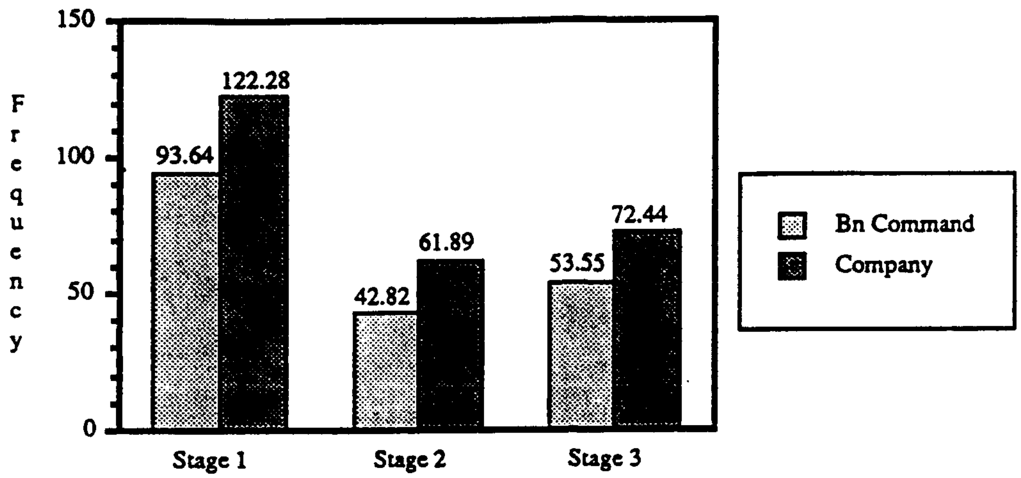


Figure 36. Overall number of reports received by stage and echelon.

As shown in Table 14, company personnel received the greatest number of FREE TEXT, CONTACT, SHELL, and SITREP reports. When only unique reports were included in the total report count, company commanders continued to receive significantly more SHELL and SITREP reports than their battalion counterparts. Conversely, when only percent duplicate reports were included in the analysis, company commanders were found to have received significantly more FREE TEXT and CONTACT reports (see Figure 37 and Table 15).

One plausible explanation addressing why company-level participants received up to 50% duplicate FREE TEXT reports and up to 45% duplicate CONTACT reports is that vehicle commanders did not completely understand the communication net structure. This lack of knowledge led company commanders to relay reports that they had received on the battalion net to other company commanders who had already received the report. For instance, a company commander may have received a CONTACT report on his company net and relayed it to battalion, thereby, sending the report to adjacent company commanders. The company commander receiving the relayed report may have become confused over where the report originated (i.e., company or battalion) despite "originator tags" for each report. Since CONTACT reports contain critical information, it is likely that this company commander

Table 14

Number of Reports Received on the Command and Control Display via all Radio Nets by Stage and Echelon

Measures (# Reports)	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
OVERALL	93.64 (17.17) n=11	122.28 (21.94) n=36	42.82 (10.97) n=11	61.89 (17.04) n=36	53.55 (8.95) n=11	72.44 (11.49) n=36
ADJUST FIRE	10.73 (7.18) n=11	10.22 (6.94) n=36	3.36 (2.62) n=11	2.92 (2.29) n=36	5.00 (4.00) n=11	3.89 (3.40) n=36
NBC	0.00 - n=11	0.00 - n=36	0.00 - n=11	0.00 - n=36	2.91 (0.94) n=11	2.81 (1.19) n=36
FREE TEXT	13.36 (1.75) n=11	15.19 (2.92) n=36	5.55 (0.52) n=11	6.75 (1.99) n=36	6.18 (0.60) n=11	6.94 (1.22) n=36
CFF	12.00 (5.20) n=11	11.86 (5.52) n=36	4.55 (3.64) n=11	4.31 (3.30) n=36	7.91 (5.38) n=11	6.78 (4.45) n=36
CONTACT	11.73 (4.56) n=11	15.25 (6.29) n=36	8.00 (2.00) n=11	8.42 (2.62) n=36	6.64 (2.69) n=11	7.72 (2.79) n=36
SHELL	6.64 (3.56) n=11	12.72 (5.12) n=36	3.91 (3.81) n=11	7.17 (5.50) n=36	10.64 (6.52) n=11	17.00 (5.87) n=36
SITREP	16.09 (5.39) n=11	31.25 (7.67) n=36	6.27 (2.69) n=11	18.78 (5.69) n=36	8.18 (3.57) n=11	21.39 (7.07) n=36
SPOT	19.64 (4.63) n=11	21.94 (5.68) n=36	9.00 (3.79) n=11	11.17 (5.11) n=36	5.09 (2.95) n=11	4.89 (3.13) n=36
INTEL	2.64 (1.03) n=11	3.00 (1.26) n=36	0.09 (0.30) n=11	0.22 (0.54) n=36	0.00 - n=11	0.00 - n=36
FRAGO	0.82 (0.40) n=11	0.83 (0.38) n=36	2.09 (0.54) n=11	2.17 (0.38) n=36	1.00 (0.00) n=11	1.03 (0.17) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

would relay the report on the battalion net, resulting in reception of duplicate reports for the rest of the company commanders and their XOs. The explanation is similar for FREE TEXT reports except that they originated on the battalion net.

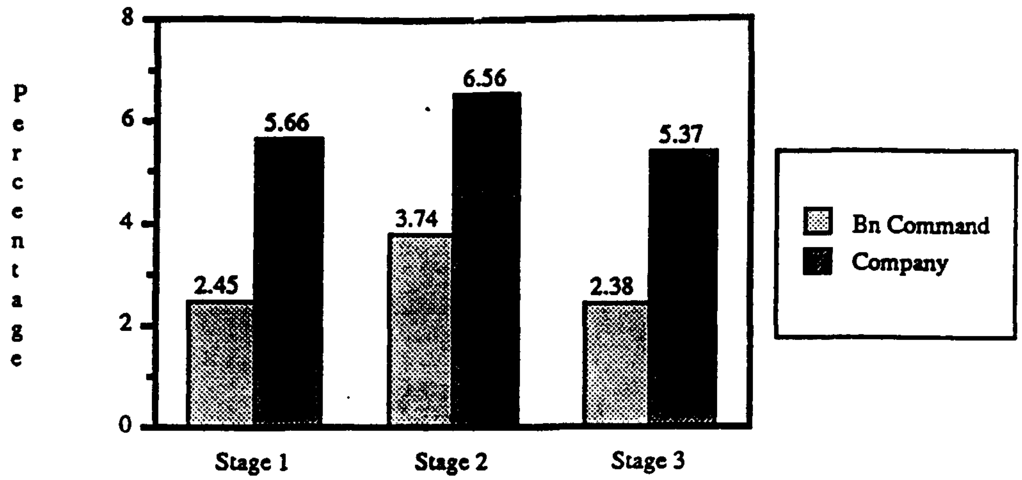


Figure 37. Overall percent duplicate reports received by stage and echelon.

What most likely happened is that once a company commander received a FREE TEXT report, he relayed it on the company net. This, in turn, resulted in the XO receiving a duplicate of the FREE TEXT report he had received on the battalion net.

Overall, these results indicated that duplicate CONTACT and FREE TEXT reports were the biggest problem for company commanders and their XOs. The software modification for duplicate reports only works as a filter for reports which are still in the Receive queue (e.g., reports which have not yet been relayed). This is because if a report is still resident in the Receive queue and a duplicate is sent, the duplicate will simply replace the report in the Receive queue. However, once a report has been relayed or opened it is removed from the Receive queue, allowing a duplicate to enter the Receive queue when relayed from another CCD. This may result in the same report being opened twice or at the very least, the commander spending time determining whether the report is a duplicate.

These findings are of particular importance because the SMI questionnaire data indicated an unsatisfactory information load associated with CCD report handling (see Figure 38). Overall, participants rated "the number of reports received" fairly negatively with 60% of the participants considering the number of reports received to be "Borderline" or worse. As shown in Figure 39, company and battalion vehicle commanders differed in their ratings of report load in the direction expected. Sixty-four percent of company commanders rated the number of reports received as "Borderline" or worse compared to 46% of "Borderline" ratings by battalion commanders.

The data for number of duplicate reports received indicated that at least some of the report overload problem can be attributed to the reception of duplicate reports. Several participants suggested that a significant improvement would be to

Table 15

Percent Duplicate Reports Received on the Command and Control Display via all Radio Nets by Stage and Echelon

Measures (%Duplicate Reports)	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
OVERALL	2.45 (1.60) n=11	5.66 (4.21) n=36	3.74 (2.73) n=11	6.56 (6.22) n=36	2.38 (1.79) n=11	5.37 (3.91) n=36
ADJUST FIRE	0.00 - n=11	0.66 (2.43) n=36	0.00 - n=9	0.00 - n=28	0.00 - n=9	0.00 - n=29
NBC	0.00 - n=11	0.00 - n=36	0.00 - n=11	0.00 - n=36	7.88 (13.93) n=11	11.06 (15.63) n=36
FREE TEXT	3.43 (4.04) n=11	12.34 (10.86) n=36	0.00 - n=11	11.45 (16.90) n=36	1.30 (4.31) n=11	11.46 (12.43) n=36
CFF	0.40 (1.31) n=11	1.11 (3.09) n=36	4.55 (10.11) n=11	5.56 (10.92) n=34	0.00 - n=11	2.36 (9.17) n=35
CONTACT	1.57 (3.51) n=11	5.08 (8.36) n=36	8.03 (6.44) n=11	14.90 (14.85) n=36	2.44 (5.43) n=11	6.57 (8.12) n=36
SHELL	6.06 (13.48) n=11	2.16 (5.22) n=36	1.71 (5.13) n=9	1.72 (4.51) n=32	1.05 (3.48) n=11	4.87 (6.92) n=36
SITREP	0.38 (1.26) n=11	1.32 (2.44) n=36	0.00 - n=11	1.10 (2.73) n=36	3.54 (4.98) n=11	2.41 (4.50) n=36
SPOT	4.16 (6.41) n=11	10.09 (10.77) n=36	3.56 (6.28) n=11	5.67 (10.32) n=36	4.55 (10.11) n=11	6.29 (10.50) n=36
INTEL	11.36 (17.19) n=11	17.98 (21.57) n=36	0.00 - n=1	16.67 (25.82) n=6	0.00 - n=11	0.00 - n=36
FRAGO	0.00 - n=9	0.00 - n=30	0.00 - n=11	0.00 - n=36	0.00 - n=11	0.00 - n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (_n_).

give the vehicle commander the capability to tailor report filtering and CCD report buttons to suit his specific information needs. That is, what may be an appropriate filter for the company commander may not be desirable for a battalion commander.

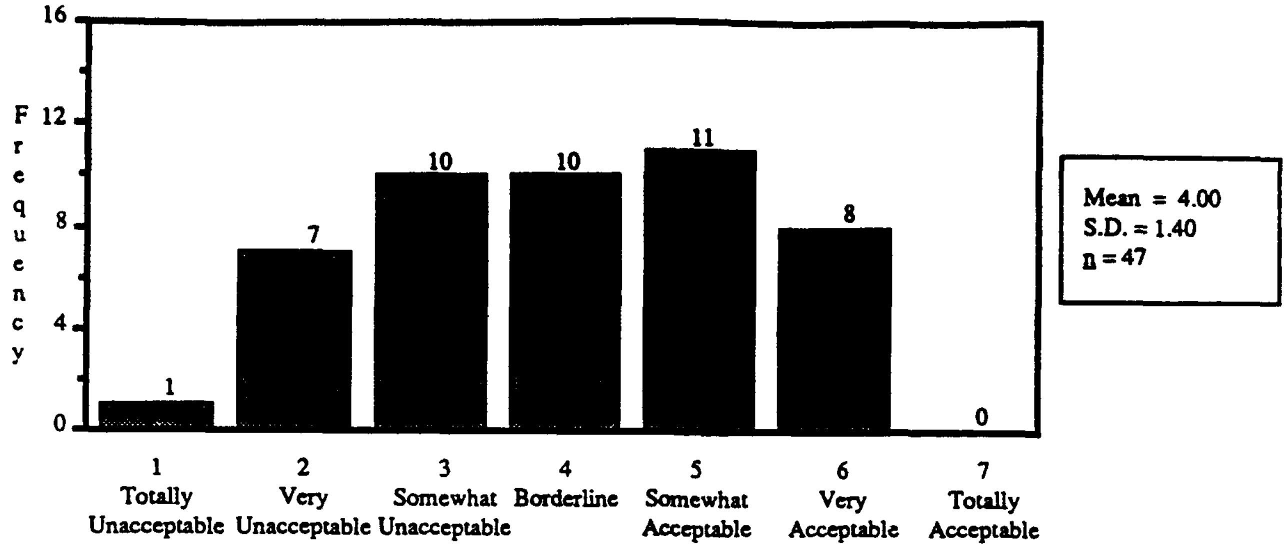


Figure 38. Commander ratings of report load.

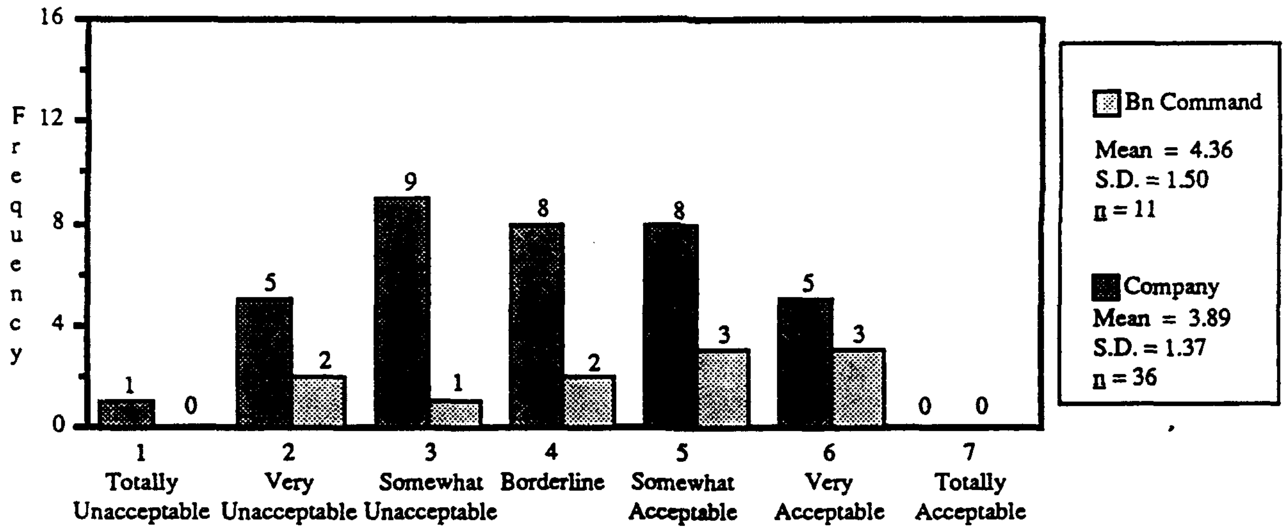


Figure 39. Company and battalion echelon ratings of report load.

Several commanders stated that they would like to be able to filter reports from certain adjacent units. Other suggestions for improving message load included combining SPOT and CONTACT reports, making SPOT reports a higher priority than CONTACT reports, and assigning CFFs low priority. The message load problem was probably best described by one participant who characterized the report receiving nature of the CCD as a "partyline."

Other SMI questionnaire items related to report reception dealt with reports received from SAFOR and the reception of overlays. As shown in Figure 40, 30% of the participants rated the reports sent from SAFOR as "Somewhat Unacceptable" or

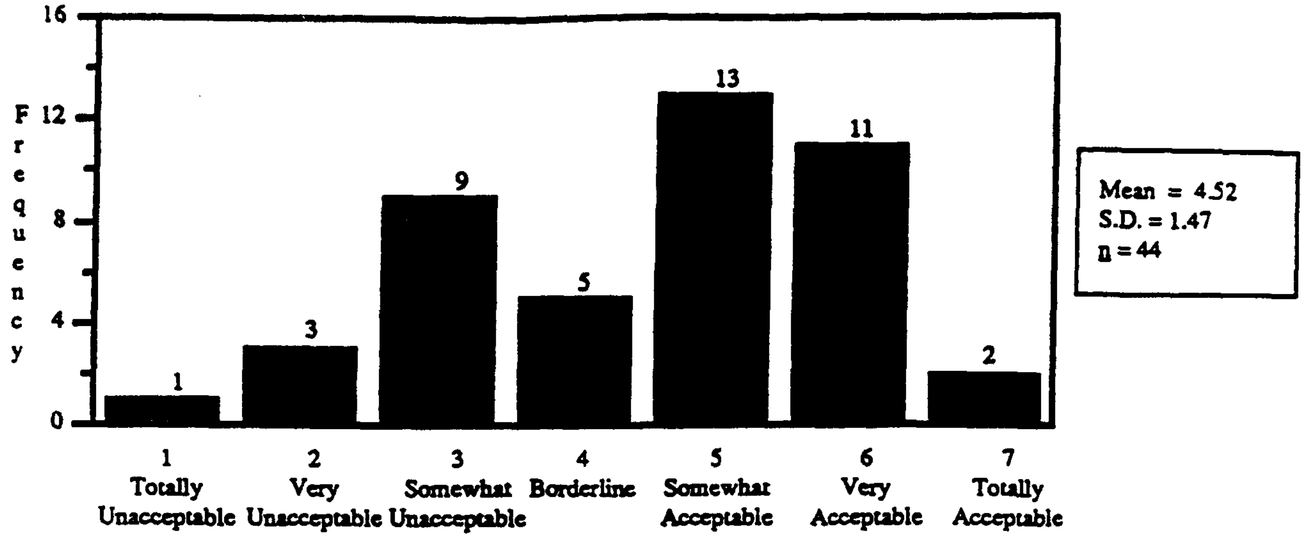


Figure 40. Overall semiautomated force report ratings.

less. Interestingly, Figure 41 shows that 36% of company-level commanders rated SAFOR reports to be "Somewhat Unacceptable" or worse while no battalion-level commander rated this item lower than "Borderline."

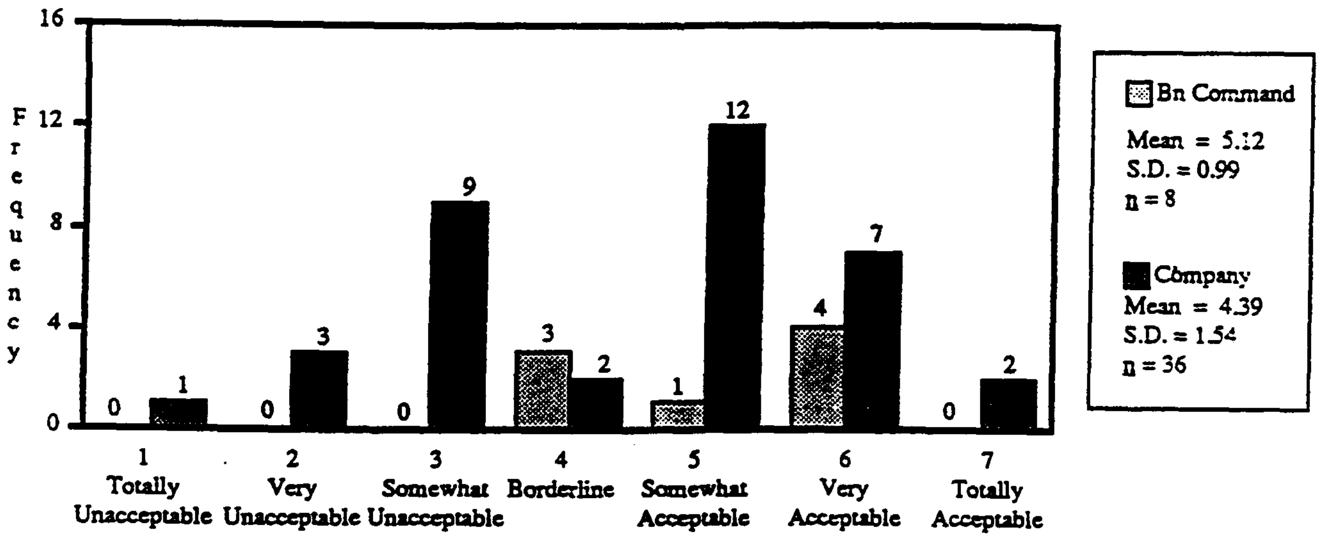


Figure 41. Company and battalion ratings of semiautomated force reports.

The capability to receive and transmit overlays was rated as "Very Acceptable" or better by 77% of the respondents. The appearance of overlays also was rated favorably with 50% of the respondents rating this item "Totally Acceptable." However, when asked how they would change the Overlay component, participants requested the ability to create and edit overlays. Participants also wanted overlays to appear more distinct from each other both on the map and in the Old file. This item important training implications in that unit commanders are trained to unpost overlays from their tactical map before posting new overlays. However, a common complaint is that commanders end up with indistinguishable layers of overlays on their tactical maps. Training "savings" would be realized if a prompt emerged asking the commander whether he wished to unpost any old overlays whenever he attempted to post a new overlay. Another option would be to allow users to "Preview" overlays temporarily by removing other overlays and placing the new overlay over the correct map location. In addition, overlays in the Old file should provide the commander with additional information to allow for better discrimination between the overlays. Implementation of these options should lessen the commander's information load and make it easier for him to avoid unnecessary multiple overlay postings on the tactical map.

CCD features which should help commanders manage information more effectively include CCD report icons, report signals, and, the LOGISTICS report. CCD report icons were rated very favorably with 93% of the participants rating this feature as "Somewhat Acceptable" or better. Common suggestions for improvements included adding the number of destroyed vehicles to SPOT report icons and creating distinct icons for dead and live BLUFOR vehicles.

CCD report signals are visual and auditory. Visual signals consist of a highlighted RECEIVE button on the CCD. Auditory signals consist of beeps to the commander's headset with one beep denoting a low priority report and three beeps denoting high priority reports. Visual report signals were rated positively with 57% of participants rating them "Very Acceptable or Totally Acceptable." Auditory signals were rated similarly with 61% of the participants rating them as "Very Acceptable or Totally Acceptable." Participant comments on report signals focused on the auditory signals. Several participants stated that they had difficulty hearing the beep(s) and believed those difficulties would be more pronounced in a real tank. Suggestions included limiting beeps to high priority reports and changing report prioritization.

The LOGISTICS report provides each vehicle commander with current ammunition, equipment, fuel, and personnel status by showing the status (individual or unit) in a green, amber, red, or black (GARB) bar chart. Nearly all participants who responded to the SMI questionnaire agreed that the LOGISTICS report was very useful. Many participants wanted the unit status information to be consolidated and the report to be more accessible. Suggestions regarding accessibility included assigning the LOGISTICS report a dedicated function key or providing a continuous display of the report in a small window. Several participants commented that the use of bar charts and color for displaying information was confusing.

Reports retrieved. Another set of measures that provide insight into the information load associated with the CCD included percent reports retrieved, percent reports retrieved from the Receive queue, and mean time to retrieve reports from the Receive queue. Percent reports retrieved was defined as the proportion of the total number of unique reports received on the CCD which were subsequently retrieved from the Receive queue or the Old files. This did not include reports retrieved via icons. Percent reports retrieved from the Receive queue was defined as the proportion of the total number of unique report retrievals on the CCD which were selected from the Receive queue as opposed to the Old files and does not include icon retrievals. (NBC, INTEL, ADJUST FIRE, SHELL, SITREP, and FRAGO reports were not included in the analysis for this measure since their frequency of retrieval from the Receive queue resulted in too few cases to support the MANOVA procedure.) The measure, mean time to retrieve reports from the Receive queue showed only significant differences for stage (see Appendix B).

A significant difference between stages for percent reports retrieved for SHELL and SITREP reports also was found (see Appendix B). In addition, the data show a main significant difference between echelons for the following report types: FREE TEXT , CFF , CONTACT, SHELL, SITREP, SPOT, FRAGO, and Overall. (NBC and INTEL reports were dropped from the analysis for this measure due to lack of occurrence.) The data for percent reports retrieved from the Receive queue showed no significant differences.

As shown in Figure 42 and Table 16, battalion commanders and S3s retrieved more reports than company commanders and XOs. This finding is interesting given that, overall, company commanders and XOs received the most reports. Battalion-level personnel are responsible for the elements in the battalion, including D company and the scouts. Hence, it is a reasonable expectation that battalion personnel would open more reports. Since company-level personnel received the same reports as battalion personnel, as well as additional reports from their SAFOR company elements, they may have been compelled to conduct a more deliberate decision-making process (i.e., examining the report type, originator, and report creation time) in determining whether to open a report. Selectivity would be increased further if company-level commanders perceived that they were receiving outdated or redundant reports from SAFOR. This self-imposed report filter may have resulted in increased workload for company personnel.

Reports relayed. Once a report has been received and opened, a commander must decide whether to relay the information. Several measures were developed to assess the total number and percent unique reports received on the CCD which were subsequently relayed. Several related measures assessed the amount of time required to relay unique reports. The only relay option for battalion commanders and S3s was to relay a report

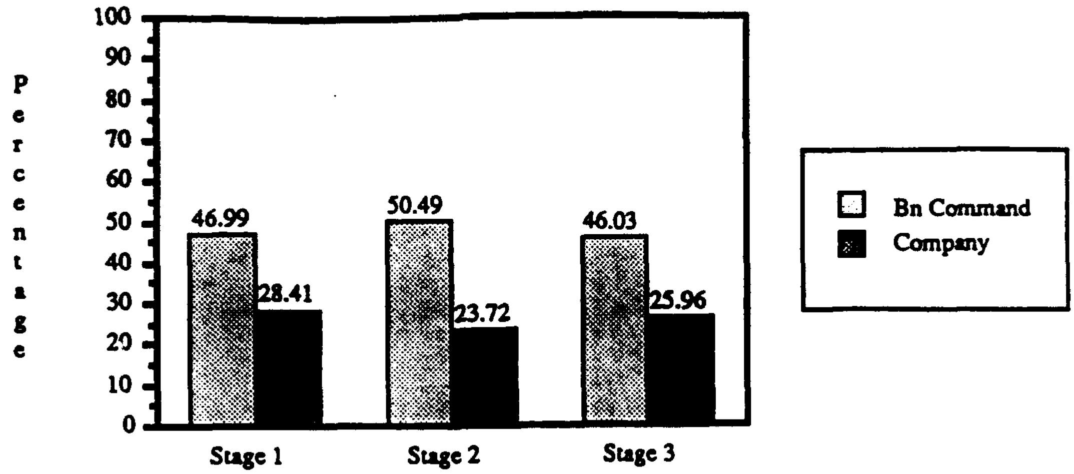


Figure 42. Overall percent reports retrieved by stage and echelon.

lower while company commanders and XOs could relay a report higher or lower. (Due to infrequent occurrence, valid comparisons between echelon could not be made for the number of reports relayed upward.) While both battalion and company personnel could relay reports downward, the small amount of data collected for number, percentage, and time to relay measures did not support analyses. Most likely, the absence of data is directly related to the specification that only *unique* reports which were subsequently relayed were to be counted as a relay. The lack of data for these measures supports the earlier assertion that part of the information load associated with the CCD may be attributable to relays of duplicate (nonunique) reports. Another plausible explanation concerns company commanders and XO's knowledge that their downward relays were going to unmanned units (SAFOR). These commanders may have been less likely to relay downward despite instructions to role-play their parts in the scenario as realistically as possible.

Reports posted. Once a report has been received and opened, the vehicle commander must decide whether posting the report icon to his tactical map is warranted. Posting important events to the tactical map should help the vehicle commander keep a more accurate view of the battlefield; however, it is sometimes difficult to ascertain what should and should not be posted to support visualization of the battlefield. Too little information may leave gaps in the commander's battlefield awareness, while too much information may clutter his tactical map, making it an unnecessary source of information load. The measure, percent reports posted to the tactical map, was defined as the proportion of the total number of unique reports received on the CCD whose icons were subsequently posted (first postings only) to the tactical map. Because of lack of postings, INTEL, NBC, and FREE TEXT reports (which cannot be posted to the tactical map) were not included in the analysis for this measure. FRAGOs (overlays) were also dropped from the analysis since the DCA system could not track these postings.

Table 16

Percent Reports Retrieved for Each Report Type by Stage and Echelon

Measures (% Reports Retrieved)	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
OVERALL	46.99 (24.52) n=7	28.41 (16.50) n=31	50.49 (20.67) n=8	23.72 (17.25) n=32	46.03 (21.90) n=11	25.96 (17.20) n=33
ADJUST FIRE	14.57 (24.31) n=7	4.18 (10.28) n=31	2.38 (5.83) n=6	4.76 (16.76) n=24	4.17 (8.84) n=9	4.66 (19.39) n=27
NBC	0.00 - n=11	0.00 - n=36	0.00 - n=11	0.00 - n=36	61.36 (38.42) n=11	32.07 (38.98) n=33
FREE TEXT	75.46 (28.20) n=7	67.18 (26.75) n=31	73.75 (19.39) n=8	60.10 (30.05) n=32	79.65 (20.38) n=11	64.14 (27.32) n=33
CFF	13.93 (12.73) n=7	8.82 (12.37) n=31	15.56 (28.53) n=8	9.24 (23.34) n=30	22.65 (33.33) n=11	10.11 (20.30) n=32
CONTACT	53.99 (30.35) n=7	33.48 (24.77) n=31	77.23 (37.31) n=8	34.04 (23.06) n=32	68.82 (34.31) n=11	25.62 (26.15) n=33
SHELL	23.02 (20.47) n=7	13.29 (16.18) n=31	7.14 (18.90) n=7	6.80 (20.38) n=30	25.33 (34.26) n=11	17.75 (17.26) n=33
SITREP	52.05 (28.08) n=7	24.51 (21.11) n=31	31.39 (33.37) n=8	14.89 (22.34) n=32	54.32 (29.98) n=11	28.71 (26.19) n=36
SPOT	63.14 (38.17) n=7	34.07 (20.21) n=31	50.89 (36.34) n=8	18.16 (21.86) n=32	58.26 (42.10) n=11	26.49 (33.57) n=33
INTEL	90.48 (16.27) n=7	67.74 (39.89) n=31	0.00 - n=11	100.00 (0.00) n=5	0.00 - n=11	0.00 - n=36
FRAGO	100.00 (0.00) n=6	56.00 (50.66) n=25	93.75 (17.68) n=8	64.58 (35.36) n=32	100.00 (0.00) n=11	87.88 (33.14) n=33

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

The data indicated a significant difference between stages for SITREP and SPOT reports and OVERALL report types (see Appendix B). A significant difference between echelons for CONTACT, SITREP, SPOT, and OVERALL reports was also found.

Figure 43 and Table 17 show that overall, battalion personnel posted more information to their tactical maps than company personnel. One explanation for the echelon difference may be that company personnel were too busy trying to keep up with their message traffic to take the time to post reports to their map. Also, battalion personnel may have been more compelled to post reports in order to maintain the "big picture" of the battlefield (Interested readers should refer to Leibrecht, Meade et al., [in preparation] for a discussion of situational awareness and its relationship to the CVCC capabilities).

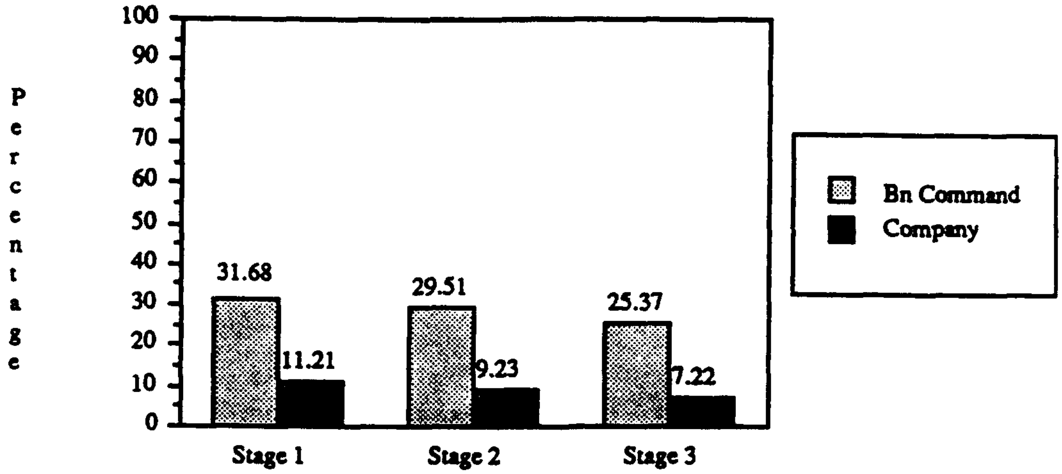


Figure 43. Overall percent reports posted by stage and echelon.

Reports sent. The number of digital reports sent was defined as the number of CCD transmissions of reports by each vehicle commander per stage and excluded duplicate reports and relays. The data (see Figure 44 and Table 18) showed that the number of reports sent differed significantly for battalion and company vehicle commanders with more reports being originated from company vehicle commanders for the following report types: ADJUST FIRE, NBC, CFF, CONTACT, SHELL, SITREP, SPOT, and OVERALL. (Since original FRAGO and FREE TEXT reports can not be generated by vehicle commanders and INTEL reports were generated very infrequently, these report types were not included in the analysis.)

SMI questionnaire data related to sending reports showed that participants rated the task of creating reports favorably with 49% of the participants rating this item "Very Acceptable" or better. Participants also liked the automatic advance of input fields. Report formats were rated somewhat lower with 40% of participants rating formats "Very Acceptable" or better. Comments relating to report formats mostly called for simplification wherever possible (i.e., reduce the number of report pages, autoadvance to next page, automatically provide input to reports where possible, and replace "DEST" field on the SPOT report with "KILLED"). Other suggestions included replacing the dedicated function key for CONTACT reports with a SPOT report

Table 17

Percent Reports Posted for each Report Type by Stage and Echelon

Measures (% Reports Posted to the Tactical Map)	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
OVERALL	31.68 (18.56) n=11	11.21 (8.23) n=36	29.51 (17.76) n=11	9.23 (7.10) n=36	25.37 (14.92) n=11	7.22 (6.62) n=36
ADJUST FIRE	3.48 (10.01) n=11	8.35 (17.81) n=36	0.00 - n=9	5.99 (19.92) n=28	2.78 (8.33) n=9	9.39 (38.00) n=29
NBC	0.00 - n=11	0.00 - n=36	0.00 - n=11	0.00 - n=36	56.82 (42.63) n=11	32.18 (38.94) n=36
FREE TEXT	NA - -	NA - -	NA - -	NA - -	NA - -	NA - -
CFF	19.19 (17.13) n=11	21.20 (66.56) n=36	8.18 (18.34) n=11	9.24 (21.88) n=34	21.35 (33.35) n=11	6.47 (11.35) n=35
CONTACT	53.05 (32.17) n=11	22.17 (27.51) n=36	65.61 (36.38) n=11	31.35 (32.57) n=36	63.22 (41.79) n=11	17.91 (25.23) n=36
SHELL	14.65 (30.76) n=11	5.89 (10.32) n=36	1.85 (5.56) n=9	6.17 (12.55) n=32	14.90 (19.09) n=11	6.96 (11.26) n=36
SITREP	22.98 (24.59) n=11	4.61 (6.26) n=36	21.21 (33.15) n=11	2.99 (7.54) n=36	21.32 (27.44) n=11	2.10 (5.10) n=36
SPOT	69.37 (37.70) n=11	26.88 (20.61) n=36	56.67 (39.02) n=11	15.64 (17.46) n=36	52.07 (39.62) n=11	19.85 (28.21) n=36
INTEL	72.73 (38.92) n=11	39.81 (43.33) n=36	100.00 - n=1	83.33 (40.82) n=6	0.00 - n=11	0.00 - n=36
FRAGO	NA - -	NA - -	NA - -	NA - -	NA - -	NA - -

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

key and integrating or automatically linking CONTACT and SPOT reports.

Additional suggestions for improvements related to sending reports included receiving an acknowledgement when a report is read by a recipient, removing the "Prep" button, and providing vehicle commanders with the capability to create overlays and FREE TEXT messages. Many participants reported that it took too

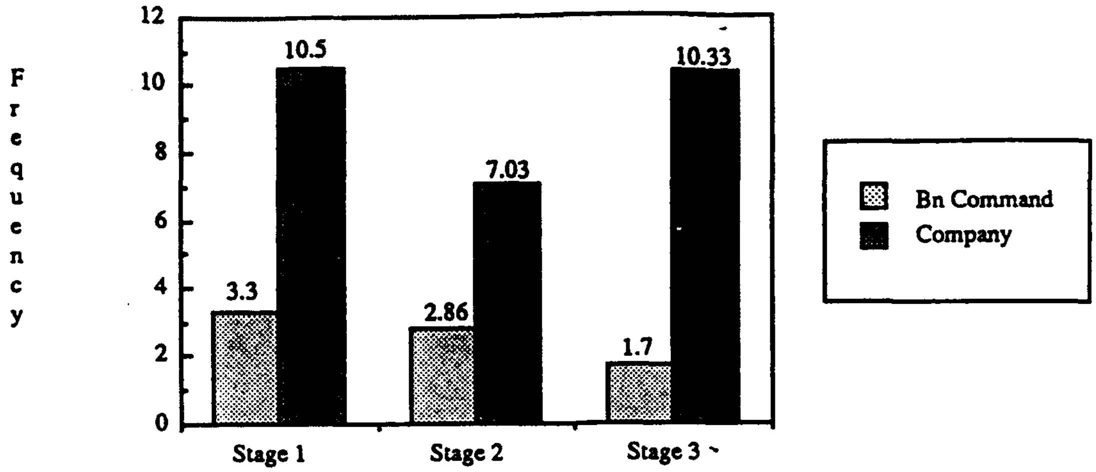


Figure 44. Overall number of reports sent by stage and echelon.

long to send CONTACT reports and suggested streamlining the CONTACT/SPOT report creation process.

Allocation of Attention

While much of the previous discussion focused on the information load strictly associated with the CCD, the way that vehicle commanders divide their attention between potential sources of information also has important training implications. This issue was addressed using two sets of estimates made by RAs: (a) the percent time vehicle commanders attended to their CCD tactical map versus the traditional lap map and (b) the percent of time vehicle commanders divided their attention between vision blocks, the GPSE, the CITV, and the CCD. No significant effects were found for tactical map versus lap map usage.

For vision block usage, the data in Table 19 showed significant differences for condition and echelon. Baseline commanders used their vision blocks significantly more than CVCC commanders (82% compared to 5%) while battalion personnel used their vision blocks significantly less than company personnel (41% compared to 44%). The GPSE data showed a significant effect for condition with Baseline commanders using their GPSE more than their CVCC counterparts (15% compared to 3%). The data also indicated that battalion personnel used their GPSE significantly more frequently than company personnel (11% compared to 6%). The data for CCD and CITV usage estimates showed no differences for echelon or stage. It was estimated that vehicle commanders devoted 34% of their time attending to the CCD and 14% of their time attending to the CITV, resulting in nearly 50% of their time being divided between attending to either the CCD or CITV. When asked to rate the acceptability of the integration of the CCD with the CITV for tasks such as lasing to an object to input grids to a report, 91% of the CVCC commanders responded "Very Acceptable" or "Totally Acceptable." This response pattern indicated that participants

Table 18

Number of Reports Sent for each Report Type by Stage and Echelon

Measures (# Reports Sent)	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
OVERALL	3.33 (2.60) n=9	10.50 (6.10) n=36	2.86 (2.73) n=7	7.03 (4.38) n=36	1.70 (1.25) n=10	10.33 (7.76) n=36
ADJUST FIRE	0.67 (0.71) n=9	2.03 (2.68) n=36	0.00 - n=7	0.86 (1.31) n=36	0.00 - n=10	1.03 (1.90) n=36
NBC	0.00 - n=9	0.00 - n=36	0.00 - n=7	0.00 - n=36	0.00 - n=10	0.47 (0.56) n=36
FREE TEXT	NA - -	NA - -	NA - -	NA - -	NA - -	NA - -
CFF	1.00 (1.50) n=9	2.14 (2.58) n=36	0.43 (0.79) n=7	1.08 (1.59) n=36	0.30 (0.48) n=10	1.67 (2.33) n=36
CONTACT	0.56 (0.73) n=9	1.72 (1.45) n=36	0.29 (0.49) n=7	1.64 (1.46) n=36	0.40 (0.52) n=10	2.17 (2.34) n=36
SHELL	0.11 (0.33) n=9	0.97 (1.06) n=36	0.43 (0.79) n=7	0.64 (0.80) n=36	0.50 (0.71) n=10	1.64 (1.68) n=36
SITREP	0.11 (0.33) n=9	1.58 (1.89) n=36	0.14 (0.38) n=7	0.89 (1.01) n=36	0.10 (0.32) n=10	1.14 (1.51) n=36
SPOT	0.89 (1.54) n=9	2.00 (1.39) n=36	1.43 (1.51) n=7	1.89 (1.69) n=36	0.40 (0.70) n=10	2.17 (2.31) n=36
INTEL	0.00 - n=9	0.06 (0.23) n=36	0.00 - n=7	0.03 (0.17) n=36	0.00 - n=10	0.03 (0.17) n=36
FRAGO	NA - -	NA - -	NA - -	NA - -	NA - -	NA - -

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

favored capabilities which lessen the commander's workload by better supporting parallel processing of information.

Table 19

Vision Block, Gunner's Primary Sight Extension, Command and Control Display, and Commander's Independent Thermal Viewer Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
% Time						
VISION BLOCKS (CVCC)	3.55 (3.80) n=11	4.83 (5.20) n=12	1.27 (1.19) n=11	7.25 (10.56) n=12	2.82 (2.89) n=11	7.33 (9.93) n=12
VISION BLOCKS (BASELINE)	74.50 (24.81) n=12	88.18 (10.15) n=11	79.58 (23.50) n=12	88.73 (10.69) n=11	79.00 (28.66) n=10	82.56 (31.30) n=9
GPSE (CVCC)	4.09 (3.96) n=11	3.08 (3.00) n=12	2.36 (3.01) n=11	2.17 (3.71) n=11	3.00 (3.79) n=11	2.00 (3.16) n=12
GPSE (BASELINE)	25.50 (24.81) n=12	11.82 (10.15) n=11	20.42 (23.50) n=12	11.27 (10.69) n=11	11.00 (8.10) n=10	6.67 (5.55) n=9
CCD	67.55 (23.67) n=11	59.92 (18.02) n=12	73.09 (21.45) n=11	58.08 (20.05) n=12	71.45 (26.03) n=11	62.92 (19.24) n=12
CITV	24.82 (18.96) n=11	32.17 (14.68) n=12	23.27 (20.83) n=11	32.50 (17.10) n=12	22.73 (23.41) n=11	27.33 (15.80) n=12

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (n).

Navigation

The Navigation function provided vehicle commanders the capability to create navigation routes of up to six waypoints by selecting locations on the tactical map with an input device. Each waypoint could be sent individually to the driver's Steer-to-Display or they could be sent automatically using the Autoadvance feature. SMI questionnaire data and debriefing comments were used to evaluate the usability of this function.

Several items on the SMI questionnaire addressed the Navigation function. Figure 45 shows that when asked to give an overall rating to the Navigation function, 81% of the vehicle commanders rated it "Totally Acceptable." When asked how they would change the Navigation function, the overwhelming response was to change nothing. As one participant wrote, "Good as is. Don't change anything." The only other consistent suggestion provided by vehicle commanders was to add the ability to input more waypoints.

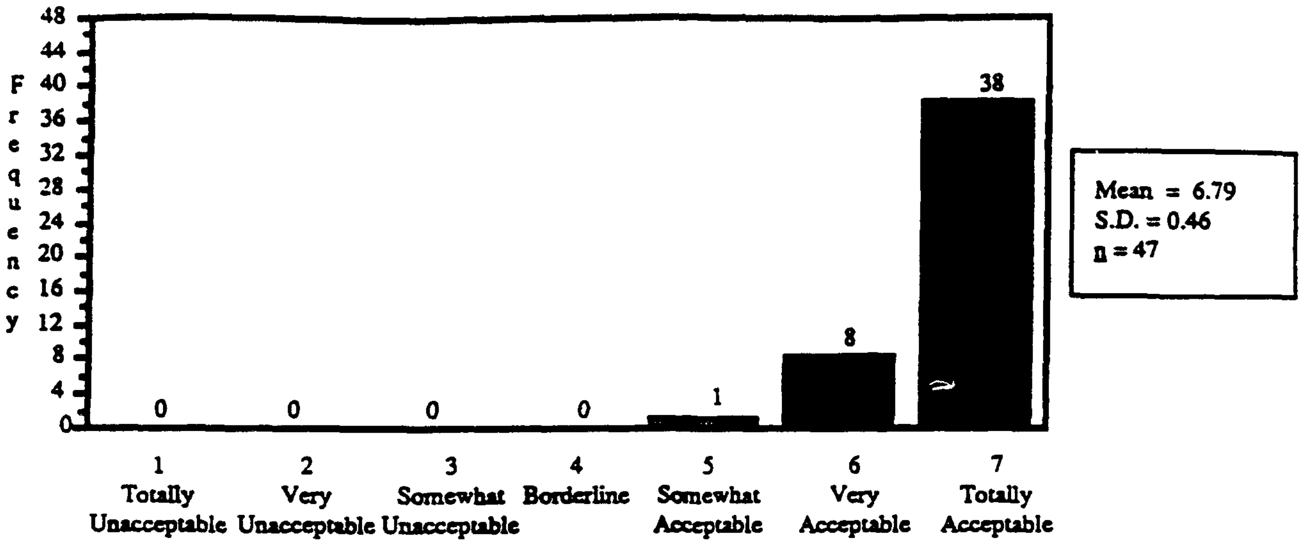


Figure 45. Commander Navigation function ratings.

Figure 46 shows that 83% of unit commanders rated the ability to navigate using POSNAV as "Totally Acceptable". Other questionnaire items dealt with creating routes, changing waypoints in a route and sending waypoints to the driver. The modal response for all three of these questionnaire items was "Totally Acceptable."

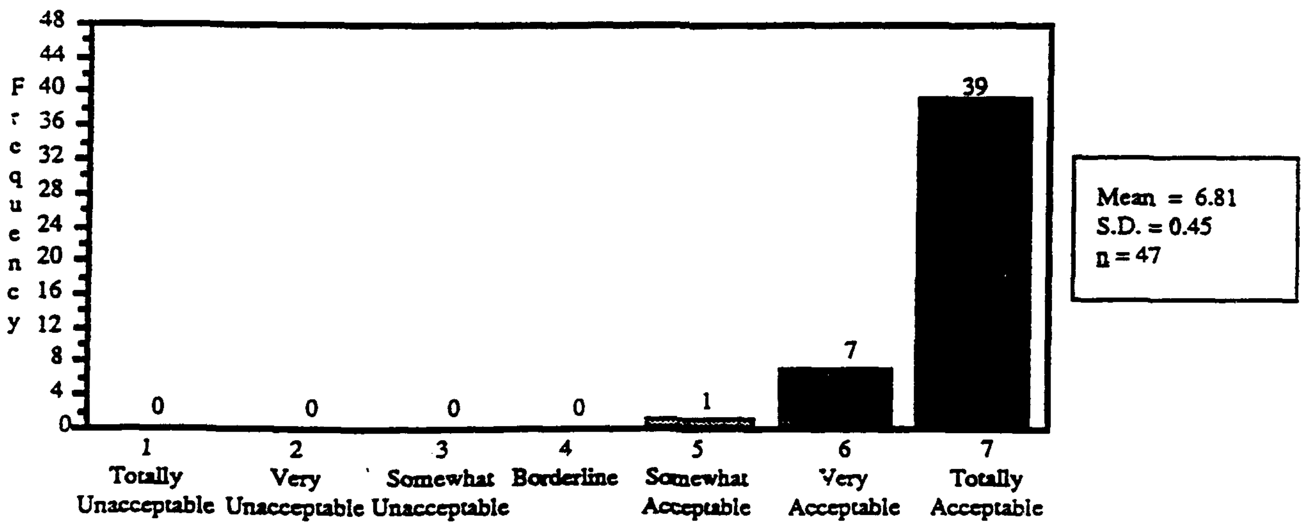


Figure 46. Commander ratings of using the Position Navigation system to navigate.

While drivers did not complete the SMI questionnaire, a few items on their training evaluation questionnaire asked them to assess the Navigation function from a driver's perspective. Figures 47 and 48 show that 94% of the drivers responded "Agree or Strongly Agree" that they had no problem using the Steer-to-Display. Seventy-six percent responded "Agree or Strongly Agree"

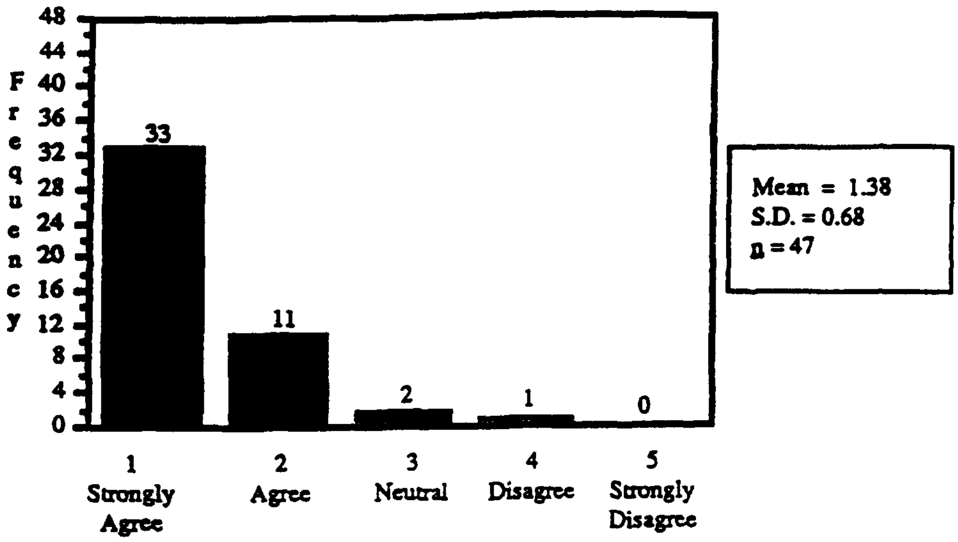


Figure 47. Driver ratings of having no problems using Steer-to-Display.

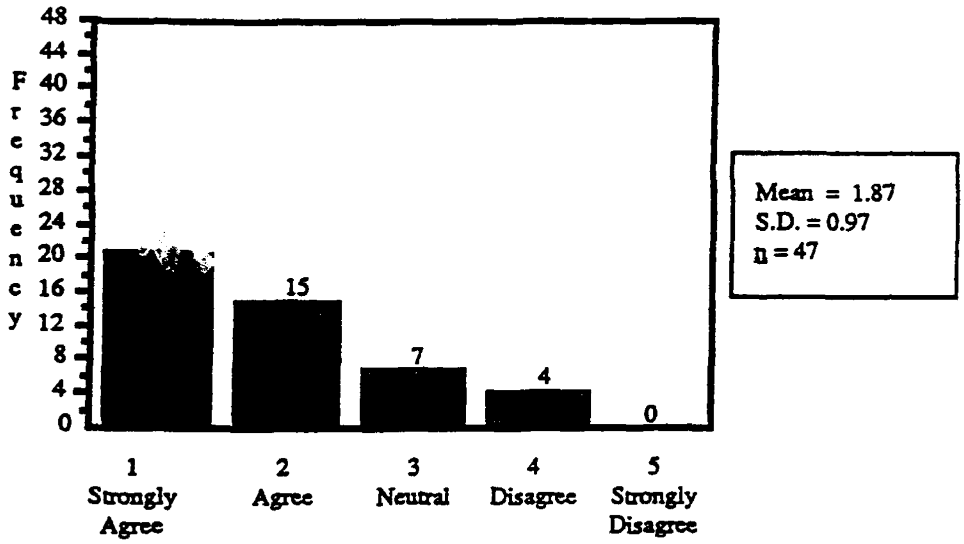


Figure 48. Driver ratings of whether Steer-to-Display would improve performance.

when asked whether the Steer-to-Display would improve their performance in a real tank.

The results for the Navigation function substantiate the trends reported by Ainslie, et al. (1991) which suggest that vehicle commanders and drivers consider the Navigation function a very useful and well designed component of the CCD. There were no comments from participants related to making the Navigation function simpler or needing additional training to use it successfully. Clearly, the Navigation function is a case where optimal design allowed for effective training and helped participants appreciate the potential performance payoffs.

Tactical Map

The tactical map is a critical source of information for vehicle commanders. When asked to provide an overall rating of the tactical map on the SMI questionnaire, 87% of respondents rated it as "Very Acceptable or Totally Acceptable." Several features have been developed to assist the vehicle commander in managing the information on his tactical map; their usability is examined below.

Map Scroll

The usage measure for the map scroll functions was the percent time each map scroll was in effect. This measure was defined as the proportion of time during mission execution each map scroll function (JUMP, FOLLOW, MOVE) was in effect on the tactical map. The JUMP and FOLLOW options are activated using a dedicated function key. If JUMP is activated, eight boxes appear around the perimeter of the map at 45 degree increments. When a box is activated (by touchscreen or thumb cursor), the map scrolls one-half the distance of its width/length in the desired direction. The MOVE function allows the user to place his own vehicle icon anywhere on the display, relative to his location. The FOLLOW mode allows the map to scroll beneath the vehicle icon wherever it was last placed on the map using the MOVE function. Significant differences were found for stage (see Appendix B). A significant difference between scroll types showed that FOLLOW was the map scroll type in effect for the greatest amount of time, followed by JUMP and MOVE. The rather marked difference between the duration of MOVE (less than 2%) usage and the other map scroll types is probably due to the fact that MOVE is accomplished much more quickly since the user does not stay in MOVE (i.e., users access FOLLOW once they finished repositioning their vehicle) and not a reflection of the frequency of use the MOVE function relative to the other scroll functions. These data are shown in Table 20.

On the SMI questionnaire, several commanders commented that compared to FOLLOW, JUMP was too slow. Overall, participants seemed satisfied with the scroll function, with 77% rating it as "Very Acceptable" or higher.

Map Scale

Four map scales were available to all commanders, each providing a different amount of terrain (and level of detail) for monitoring the battlefield. The four map scales were: 1:25,000, 1:50,000, 1:125,000, and 1:250,000. Results indicated a significant difference between stages for the 1:50,000, 1:125,000, and 1:250,000 scales (see Appendix B), and a significant difference between echelons for the 1:50,000 and 1:125,000 scales. As shown in Table 21, battalion personnel spent the majority of their time with their tactical map scales set at 1:125,000 (40%), although they used the 1:50,000 scale 31%

Table 20

Map Scroll Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
% Time each Map Scroll Function in Effect						
Follow	44.66 (36.83) n=11	55.32 (35.05) n=36	48.61 (43.58) n=11	35.70 (32.96) n=36	21.09 (27.84) n=11	32.08 (35.90) n=36
Jump	50.35 (35.82) n=11	39.62 (35.81) n=36	15.80 (12.55) n=11	27.44 (30.14) n=36	40.37 (42.80) n=11	25.30 (33.44) n=36
Move	1.44 (2.63) n=11	1.41 (2.73) n=36	2.65 (3.82) n=11	0.81 (1.79) n=36	1.13 (1.65) n=11	1.34 (2.99) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

Table 21

Map Scale Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
% Time each Map Scale in Effect						
25K	2.89 (5.41) n=11	9.27 (22.68) n=36	5.80 (14.50) n=11	10.71 (18.38) n=36	1.39 (2.62) n=11	8.96 (15.35) n=36
50K	38.89 (36.34) n=11	82.74 (24.15) n=36	28.63 (28.69) n=11	49.42 (34.64) n=36	26.73 (28.57) n=11	48.30 (37.97) n=36
125K	52.02 (38.62) n=11	4.04 (7.17) n=36	32.45 (39.97) n=11	3.43 (5.94) n=36	34.13 (37.40) n=11	1.46 (2.53) n=36
250K	2.65 (7.41) n=11	0.30 (0.78) n=36	0.19 (0.32) n=11	0.39 (1.50) n=36	0.34 (0.66) n=11	0.00 - n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

of the time. Company personnel set their map scale at 1:50,000 for the majority of their time (60%). These results are similar to the trends reported by O'Brien et al. (1992) and appear reasonable since battalion personnel would be expected to view larger segments of the battlefield in order to see all of their forces while commanders at the company-level are focused on company elements.

When asked how they would change the tactical map, most comments on the SMI questionnaire related to increasing the size of the display and replacing the 1:125,000 scale with a 1:100,000 scale. As one commander stated "Need to go to 1:100,000 vs 1:125,000. That's the scale we actually use and train with. Would make comparison from screen to map a much easier transition." The 1:125,000 scale was originally selected because of software implementation considerations (i.e., it was faster to base the map scales on the map scaling already available with the PVD and time was of the essence). This issue represents a good demonstration of the practical difficulties sometimes incurred in implementing what appears to be common sense recommendations. That is, development time and programming resources are sometimes critical factors that overwhelmingly shape system design.

Map Terrain Features

Another measure analyzed was the percent time each map feature was in effect. The map features included contour lines, grid lines, rivers, roads, and vegetation. Results indicated a significant difference between each map terrain feature type (see Appendix B), and a significant difference between echelons for vegetation. As shown in Table 22, battalion personnel overall used the map terrain features less than company personnel (32% compared to 57%), and the vegetation feature significantly less This finding supports the assertion that battalion personnel were more interested than company commanders in viewing larger segments of the battlefield with minimal "clutter" to their tactical map. Currently, there is no way to ascertain whether usage of terrain features varied by different phases of the scenarios. Future efforts should consider addressing this issue.

CITV

Overall, the CITV was well-received with 92% of the participants rating it "Totally Acceptable" or "Very Acceptable" on the SMI questionnaire. When asked how they would change the CITV, the most common response was to enable the vehicle commander to engage targets with the reticle on the CITV. Another common response was to add a daylight mode to improve depth perception.

CITV Functions

The usage measures assessed the percent time vehicle commanders stayed in the CITV functions (Manual Search, Autoscan, or GLOS) versus the GPS function. In the GPS function, the CITV is not functional. With the Manual Search function, the commander controls the movement of the CITV with the control

Table 22

Map Terrain Feature Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
% Time each Map Feature in Effect						
Contour	60.83 (48.45) n=11	82.38 (33.89) n=36	43.53 (45.57) n=11	47.72 (39.35) n=36	41.19 (47.05) n=11	43.82 (42.67) n=36
Grid	96.45 (5.29) n=11	96.35 (4.70) n=36	67.06 (36.80) n=11	63.93 (35.38) n=36	62.60 (42.58) n=11	58.68 (41.00) n=36
River	87.38 (29.44) n=11	93.34 (16.58) n=36	64.33 (40.73) n=11	60.36 (37.48) n=36	53.52 (44.44) n=11	55.47 (42.14) n=36
Road	87.38 (29.44) n=11	96.34 (4.70) n=36	64.33 (40.73) n=11	63.93 (35.38) n=36	53.52 (44.44) n=11	58.61 (40.93) n=36
Vegetation	34.90 (48.54) n=11	76.26 (37.19) n=36	37.12 (47.10) n=11	48.58 (38.60) n=36	23.02 (38.74) n=11	45.15 (41.48) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (*n*).

handle. If the handle is not moved, then the view through the CITV does not change. With the Autoscan function, the commander sets a scanning sector and the CITV continuously scans that sector. The GLOS function allows the CITV LOS to move to the main gun's location. As shown in Table 23, there was a significant difference between functions. The Autoscan function used most frequently for company and battalion personnel (47%), followed by the GLOS function (26%), the Manual Search function (24%), and the GPS function (3%). It should be noted that in addition to the CITV, the vehicle commander also can scan the battlefield using his vision blocks or GPSE. However, the rare use of the GPS function may be an indication that the CVCC vehicle commander relied heavily on the CITV to scan the battlefield.

Preference for the Autoscan and GLOS functions was articulated by one participant's comment on the SMI questionnaire: "I preferred autoscan, it freed me up to be able to not only scan with the CITV but also to watch the CCD, read reports, send reports, and navigate all while continuing to scan for other targets. GLOS was also very useful because it could put me on target with my gunner in a blink of an eye and I could determine friend or foe quickly." While the same results can be accomplished using the GPSE, participants apparently found it

Table 23

Commander's Independent Thermal Viewer Function Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
% time in each CITV mode						
Manual Search	29.55 (35.45) n=11	24.11 (25.25) n=36	24.26 (28.23) n=11	24.12 (26.38) n=36	20.91 (21.68) n=11	22.02 (23.89) n=36
Autoscan	40.00 (39.35) n=11	47.21 (24.16) n=36	31.13 (37.92) n=11	46.32 (28.40) n=36	50.71 (34.92) n=11	53.48 (27.11) n=36
GLOS	28.96 (30.70) n=11	22.76 (18.71) n=36	39.55 (37.43) n=11	27.45 (27.56) n=36	28.15 (33.89) n=11	22.09 (19.87) n=36
GPS	1.49 (3.96) n=11	5.93 (11.66) n=36	5.06 (16.13) n=11	2.11 (5.94) n=36	0.23 (0.46) n=11	2.41 (5.56) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (n).

more convenient to switch functions on the CITV rather than turn their visual attention to the GPSE. Overall, the questionnaire data support the notion that vehicle commanders were satisfied with the CITV functions (83% of them rated the CITV functions as "Very Acceptable" or "Totally Acceptable"). The primary benefit of the CITV functions is that they allow the commander and gunner to scan the battlefield independently. This capability was rated highly with 85% of vehicle commanders agreeing that independent scanning was "Totally Acceptable." The only indication of dissatisfaction was reflected in ratings for setting sectors for the CITV's Autoscan function (19% of the participants rated this item as "Borderline" or less). Comments related to setting sectors dealt with trying to set a slow scanning rate resulted in being too slow and experiencing what appeared to users as a CITV "lock-up." In reality, the CITV did not lock up; however, it moved too slowly for users to detect movement.

CITV Laser

Data for this measure, the number of times CITV laser was used, showed a significant difference between echelons. As shown in Table 24, battalion personnel used the CITV laser significantly less than company personnel (13% compared to 22%). As explained earlier, this is probably attributable to the fact that battalion personnel were less likely to acquire or engage targets. In fact, Leibrecht, Meade, et al. (in preparation)

Table 24

Commander's Independent Thermal Viewer Laser Usage by Stage and Echelon

	Stage 1		Stage 2		Stage 3	
Measures	Battalion	Company	Battalion	Company	Battalion	Company
# of times CITV laser was used	17.73 (24.32) n=11	24.03 (20.24) n=36	7.40 (9.75) n=10	16.61 (12.58) n=36	13.18 (15.85) n=11	24.36 (26.12) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (n).

reported that company vehicles fired significantly more rounds ofammunition than their battalion counterparts for this evaluation.

Lasing supports the IFF function. Once a commander spots a potential enemy target he lases to it. This lase generates symbology in the upper left portion of the display which characterizes the target as friendly, enemy, or unknown. The IFF models an accuracy rate which ranges from 40 to 90%, depending on range to target. All vehicle commanders are instructed to verify IFF readings in their GPSE or vision blocks. Figure 49 shows that when asked to rate the acceptability of the IFF function, 62% of the participants rated it "Somewhat Acceptable" or better. The accuracy rate of the IFF function was the chief

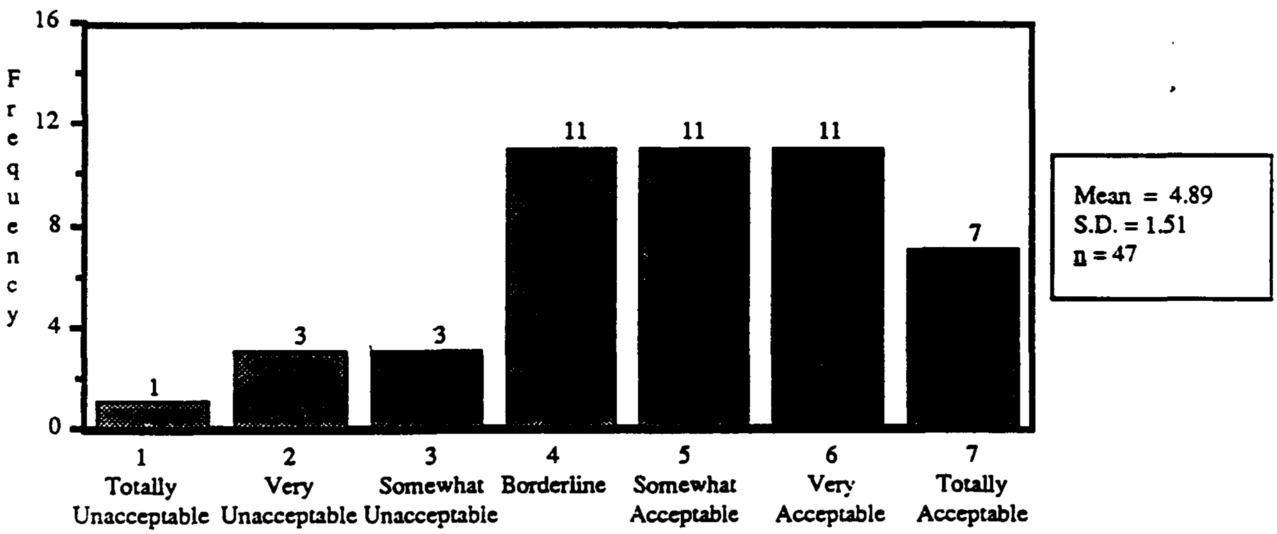


Figure 49. Commander ratings of Identification Friend or Foe function.

concern voiced among participants who considered it to be unacceptable. In addition to concerns over the IFF function, many vehicle commanders requested the ability to engage targets using the CITV laser. They commented that the requirement to switch modes prior to target acquisition was an unnecessary hindrance. It seems participants do not fully understand that keeping the vehicle commander from engaging targets with the CITV laser was an intentional design feature. The intent was to promote a hunter-killer capability requiring maximum target acquisition coordination between the vehicle commander and gunner.

Designate

In Manual Search or Autoscan, the vehicle commander can quickly designate a target to his gunner. The commander, having identified an enemy target for immediate engagement, presses the Designate button on his control handle. This causes the main gun to slew to the CITV's line of sight, overriding the gunner's controls. The analysis showed significant differences between echelons for the number of times the Designate function was used, with company vehicle commanders using it more frequently than battalion commanders or S3s. These outcomes are expected because most of the target engagement activity occurs at the company level.

As shown in Table 25, the number of times the Designate function was used for both company and battalion personnel was relatively low (1.09 occurrences for battalion and 1.84 occurrences for company). This seems incongruous with the SMI questionnaire ratings which were relatively high. As shown in Figure 50, 66% of vehicle commanders rated the Designate function as "Totally Acceptable" and no vehicle commander rated it less than "Somewhat Acceptable." The Designate function also was well

Table 25

Commander's Independent Thermal Viewer Designate Usage by Stage and Echelon

Measures	Stage 1 Battalion	Stage 1 Company	Stage 2 Battalion	Stage 2 Company	Stage 3 Battalion	Stage 3 Company
# of times Designate was used	1.55 (2.02) n=11	2.36 (2.10) n=36	0.45 (0.82) n=11	1.58 (1.57) n=36	1.27 (1.19) n=11	1.58 (1.93) n=36

Note. Each data cell includes the mean, standard deviation (in parenthesis), and number of vehicles (n).

accepted by gunners who were asked on their training evaluation questionnaire whether they liked the Designate function. As shown in Figure 51, 71% of the gunners responded "Agree" or "Strongly Agree." It appears that the infrequent use of the

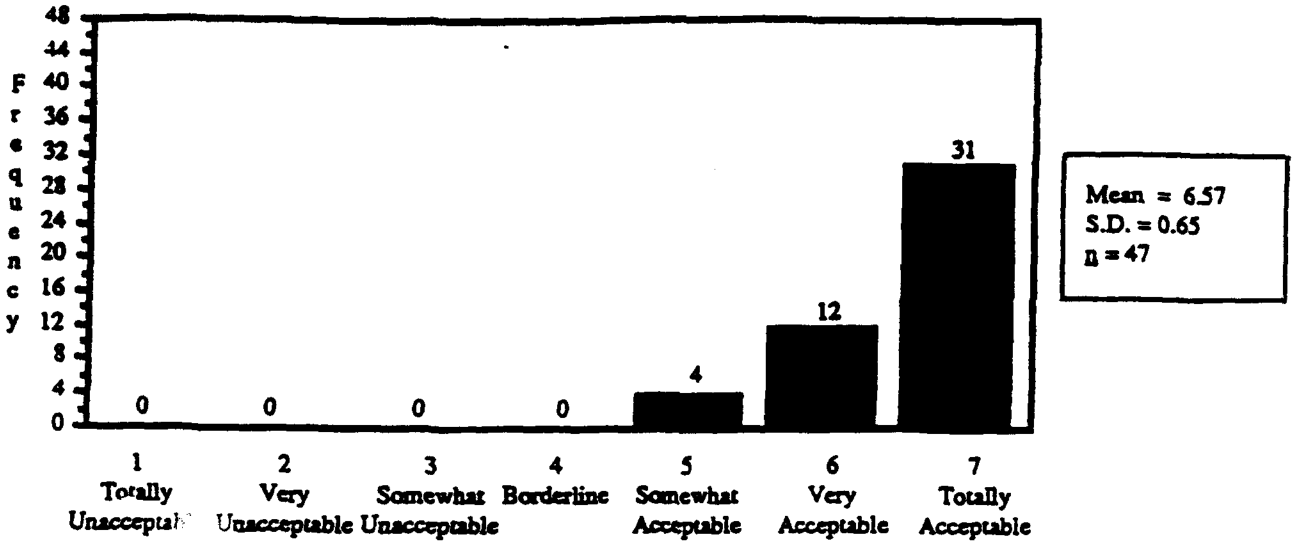


Figure 50. Commander ratings of Designate function.

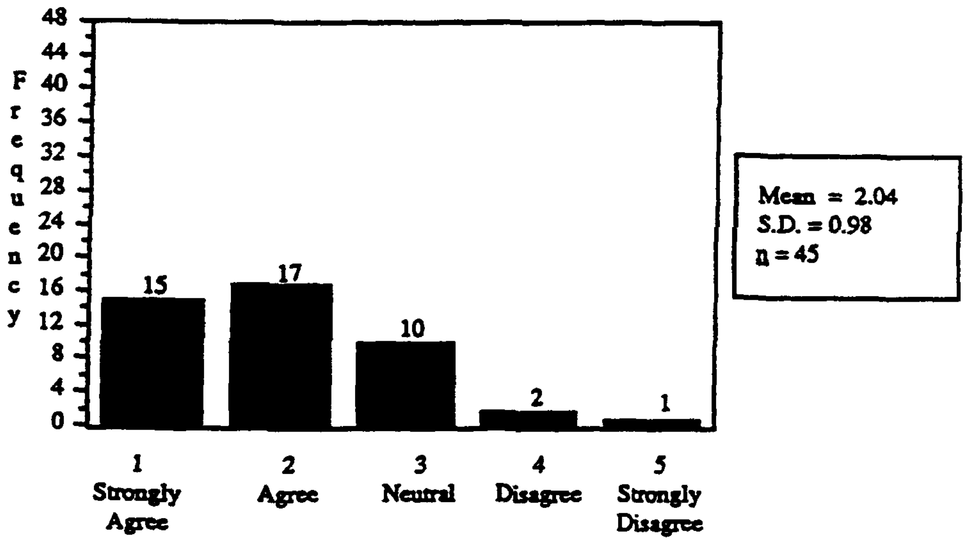


Figure 51. Gunner ratings of whether they liked the Designate function.

Designate function was due to reasons other than design problems with the function itself. One explanation is that gunners acquired targets more frequently than vehicle commanders, especially under close range conditions which would decrease the number of opportunities to use the Designate function. This is supported by RA estimates that vehicle commanders acquired and engaged the enemy less than 1% of the time.

Summary

Input Devices

As with past CVCC evaluations (Ainslie et al., 1991; O'Brien et al., 1992), participants showed a strong preference for the touchscreen over the thumb cursor both in terms of usage data and questionnaire responses. These results indicated a requirement to replace the thumb cursor with a more acceptable input device.

CCD

Overall, the equipment usage data and SMI questionnaire ratings indicated that the CCD was well-accepted by its users. Soldiers tended to favor features of the CCD which were heavily automated such as the autoadvance feature of the Navigation function and the LOGISTICS report. Related to this preference for automated features was POSNAV which was the most highly praised CVCC component. POSNAV was also very highly rated in the company and battalion TOC evaluations (Ainslie et al., 1991; O'Brien et al., 1992). Other important results of past efforts, which were replicated with the current effort's data, concern the impact of information load (primarily visual) on the vehicle commander's ability to optimally command and control his unit(s) (Ainslie et al., 1991; O'Brien et al., 1992). The question of how best to manage the information load associated with the CCD requires further study. Despite attempts to lessen the vehicle commanders' information load through software changes, a problem still exists. Information load and processing style appeared to differ by echelon with company personnel receiving and sending the most reports but retrieving and posting the fewest.

CITV

The CITV was considered by vehicle commanders to offer important advantages. Vehicle commanders and gunners appreciated the capability afforded by the CITV to search separate areas of the battlefield simultaneously. The Designate function was rated highly (albeit, seldom used) by vehicle commanders. This also replicated previous findings (Ainslie et al., 1991; O'Brien et al., 1992). Low usage rates were explained in terms of the vehicle commander's tendency to allow the gunner to acquire and engage most of the enemy targets. This tendency did not appear to be due to any problems with the Designate function itself. The primary concern expressed by participants regarding the CITV dealt with the IFF feature. Participants appeared cognizant of the fact that an IFF feature is needed for fielded tanks; however, many expressed dissatisfaction over the 40-90% reliability rate of the IFF feature used in this evaluation. Again, this result replicated findings from each of the previous CVCC evaluations. System designers need to determine an acceptable reliability rate, given current technology. However, it is clear that participants did not "trust" the current IFF feature which may have proved to be a hindrance rather than a benefit to performance.

SMI Conclusions

The SMI for the CVCC program has been developed using an iterative design process which assesses the lessons learned from each evaluation, and incorporates desirable design changes whenever feasible. The success of the CVCC program has demonstrated that the iterative design process is effective. The CVCC system, training procedures, and test materials have matured considerably since the beginning of the CVCC program. Past CVCC research has provided system developers with important data regarding the design of complex systems for soldier use: employing a soldier-in-the-loop methodology mandates careful consideration of the user. As an extension of past research, the current effort focused primarily on assessing the interrelationship of SMI and training. One way to achieve this close and mutually reinforcing interrelationship is to pay close attention to the current set of lessons learned. Thus, the conclusions for this effort are cast in the form of key lessons learned. This discussion is followed by recommendations for future research.

Lessons Learned

This research has yielded important data regarding the relationship of the CVCC SMI to training and operational effectiveness. Because most results are consistent with past CVCC findings, these data are considered reliable and are offered as lessons learned to training and system developers who want to further explore the relationship between training, system design, and operational effectiveness. There is one lesson learned that supersedes all others: *The iterative design process is effective*. Without question, CVCC training, SMI, and testing have improved considerably since the beginning of the program. The remaining lessons learned represent critical design issues, many of which have seen important progress over the course of the program. Many of the lessons learned described below complement the SMI recommendations described earlier from B. A. Black (personal communication, October, 1990).

SMI Lessons Learned

1. Provide users a choice for devices or features which will be used often. CVCC users need a new alternative input device for the CCD. Vehicle commanders did not consider the thumb cursor to be an acceptable device for inputting information to the CCD. Commanders also requested the ability to set their own report filters and report function keys.

2. Design for optimal information flow. Information load is a problem for CVCC users. Battalion and company vehicle commanders differed significantly in most of their report

handling tasks, with company commanders experiencing the greatest information load associated with the CCD. Of particular interest is the extent to which the report load provided by SAFOR report procedures is realistic.

3. Automate functions wherever feasible and desirable. For example, the automated capabilities associated with the LOGISTICS report and Navigation function were considered very useful by participants. The information provided by the LOGISTICS report is important to every commander, but the process of tracking the information manually could be overwhelming. Automating this function enhances the commander's awareness of the battlefield. While the LOGISTICS report has been well-received by participants, it is a relatively new function and demonstrates the need for iterative development. Future research should investigate alternative display parameters for the logistics information; participants commonly reported that the graphics were too complex to comprehend. The Navigation function is a good example of an automated function which has successfully undergone the iterative design process. This function serves to enhance the commander's ability to command and attend to the battlefield by saving him from doing what were previously manual tasks.

4. Design for reliability. The reliability of the IFF function was considered highly unacceptable by participants. The IFF function should be considered an automated feature; however, its lack of reliability certainly diminished the desired "payoff" and may have resulted in placing another unnecessary information burden on the participants. Additional research is needed to determine the level of accuracy that can be supported by current technology and the feasibility of its implementation.

SMI Issues Requiring Further Study

The CVCC program has provided the Armor community with a substantial base of research findings over the history of its program. The current effort, combined with its companion reports on operational effectiveness (Leibrecht, Meade, et al., in preparation) and tactical operations (Meade et al., in preparation) will provide training and system developers clear guidance for future efforts. However, the following SMI issues remain and should be addressed in future training and development efforts.

Determining the Type of Input Device Most Suitable for a CCD

Future efforts should investigate the usability of different input devices such as the trackball, light pen, and voice recognition systems for the CCD and their suitability for a fielded tank.

Striking the Optimal Balance Between Training Information Management Skills and Making System Design Fixes to Facilitate Information Management

There is a limit as to how much information can be automatically filtered for the vehicle commander. Even with additional report filters, commanders still will require training on how to allocate their attention effectively. Future efforts should investigate this important research question, beginning with a thorough analysis of CVCC lessons learned from a training and SMI perspective.

Identifying Additional CVCC Features/Functions that can be Automated

The tendency among participants was to request increased automation wherever possible. Certainly, the data indicate that there are areas where increased automation should facilitate training and improve performance. However, more research is needed to determine the feasibility or desirability of automating functions which may remove soldiers from the decision-making loop.

Determining the Requirements for an IFF System that will be Well Accepted by Users

The capability to discriminate between friend and foe on the battlefield is critical. More research is needed to determine design standards for IFF capabilities and how adequately current technologies can support those requirements. To the extent that no IFF function will be capable of perfect identifications, training approaches that will further reduce the probability of fratricide should be investigated.

Recommendations for Future Research

The CVCC research program has produced a wealth of lessons learned on training and on the influence of the SMI on training using automated C2 devices and target acquisition systems. As the program draws to a close, it is useful to reflect on (a) the training requirements, which are likely to emerge and become important as C2 technologies advance further and (b) possible approaches for delivering training and assessing soldier and unit performance, which may warrant inquiry and future research. An excellent resource is the battalion-level training package (Sawyer et al., in preparation) which represents a user-accepted training approach for delivering individual and collective training aimed at the acquisition of C2 skills for new mounted warfare technologies. This training package contains hands-on training materials which were developed to support equivalent training experiences for Baseline and CVCC groups, but the materials have been adapted to successfully support training for other programs. Examples include the Battlefield Synchronization

Demonstration, the Vehicle Integrated Defense System evaluation, and the Skalnotty evaluation.

Future Training Requirements

As the 21st century approaches, there is no question that major changes are taking place in military forces brought about by geopolitical and economic change (Black, 1993). Downsizing of military forces due to declining resources is occurring at the same time that the threat is shifting from a Soviet-dominated power bloc to a multipolar world order with regional centers of power. These new threats are projected to move more rapidly, target our friendly forces more accurately, and possess more enhanced levels of C3 than ever before anticipated (Department of the Army, 1993).

This emerging, more capable threat means that forces must be technologically prepared to counter enemy capabilities in a versatile manner. Units must be able to perform their missions under a variety of conditions and circumstances and operate in conjunction with coalition forces. They also must be able to act with speed, precision and the most complete picture of the battlefield possible. The commander's visualization of the battlefield, supported by the most timely information possible, will increasingly become a key to battlefield success. The anticipated rapid pace of battle combined with the large volume of information expected to be available to commanders have the potential to overwhelm the commander's ability to integrate information, disseminate changes in the mission, and fight effectively (Black & Quinkert, 1991).

It is imperative that the training requirements imposed by these new technologies be identified so that they can be incorporated into training programs (Quinkert & Atwood, 1993). Many of these emerging requirements have been identified over the course of the CVCC research program and warrant further inquiry. Particularly salient training requirements requiring further research center on integrated usage of C2 devices. There are at least three levels of required integration that must be addressed: (a) integration of voice and digital communication; (b) integration of multiple devices within a weapons system (such as a command and control display and an automated target acquisition device in a future tank); and (c) integration of device usage into performance in a tactical situations.

An important related set of training requirements on the horizon focuses on the "information age." These issues also are central to the SMI design, because the nature of the interface has a heavy influence on workload. Requirements meriting further study include: (a) effective allocation of workload across sensory modalities (e.g., visual, auditory); (b) strategies for accounting for individual differences in preferences and capabilities to use various sensory modalities; and (c) information management strategies for controlling workload.

Emerging training requirements, particularly those triggered by the introduction of new C2 technologies and their associated SMI issues, deserve further research and the formulation of innovative training approaches. As Quinkert and Atwood (1993) point out, simulation-based technologies such as DIS provide a useful tool for understanding these emerging training requirements by providing a task-loaded, realistic battlefield environment in which new technologies can be inserted, and the requirements levied on soldiers and units can be studied.

Training and Assessment Approaches for Future Research

The Army's move from a technology-supported to a technology-based training strategy is evident on a number of fronts. The emerging strategy can be clearly seen in the Combined Arms Training Strategy (CATS) for armor (Department of the Army, 1991). Thus, as approaches for delivering training are considered as part of research programs to address emerging training requirements, technology-based approaches warrant particular emphasis. These environments, when properly structured, offer the opportunity for the intensive, hands-on instruction found effective in the CVCC research program. A recent report (Atwood et al., in preparation) catalogues tools available in the DIS environment which can be used to structure training exercises. These tools, configured in new and creative ways, may offer innovative approaches for delivering training to address emerging training requirements.

Other training approaches worthy of inclusion in future training research programs include embedded training and performance support systems (Druffner & Lewis, 1993). Embedded training systems are built as an integral component of automated systems. They offer the advantage of being continually available to coach, correct, and support the soldier as he learns to operate the system. If such an automated system were incorporated within a DIS environment, the embedded training system would also be included and available for training. In addition, this approach offers the additional advantage of continued availability as the soldier transitions out of the training environment and into an operational environment. Such an approach might offer one solution to the problem of increasing training time demands imposed by increasingly complex systems and interfaces as observed in the CVCC training research program.

Performance support systems are also embedded; however, they offer the potential advantage of providing on-the-spot corrections and mentoring as mistakes occur. For example, the system may interrupt a user having trouble with a particular function by sending a message acknowledging his plight. A subsequent message might ask the user what he is trying to do and if help is desired. A subsequent message might even offer to do the task for the user. Research on such systems would offer a technology-based extension of hard copy job aids which have been used with success in conjunction with the CVCC TOC workstations as described earlier in this report.

Finally, future training research may wish to consider innovative approaches to training assessment. In gathering automated data from the simulation stream, the CVCC program was faced with slow turnarounds which interfered with desirable rapid feedback. More recent approaches such as the UPAS (Meliza et al., 1992) have implemented systems with the capability for quicker turnaround of feedback data in the form of summary tables and graphics. It also may be useful to consider the introduction of automated support tools into future training environments to aid human observers in the collection of training data. For example, Atwood and Rigg (1993) designed a system intended to support observers in the collection of quantitative and qualitative data which takes advantage of emerging, lightweight, portable computers.

REFERENCES

Ainslie, F. M., Leibrecht, B. C., & Atwood, N. K. (1991). Combat vehicle command and control systems: III. Simulation-based company evaluation of the soldier-machine interface (SMI) (ARI Technical Report 944). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A246 237)

Alluisi, E. A. (1991). The development of a technology for collective training: SIMNET, a case history. The Human Factors Bulletin, 33(3), 343-362.

Atwood, N. K., Quinkert, K. A., Campbell, M. R., Lameier, K. F., Leibrecht, B. C., & Doherty, W. J. (1991). Combat vehicle command and control systems: Training implications based on company-level simulations (ARI Technical Report 943). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A246 460)

Atwood, N. K. & Rigg, K. E. (1993). Performance automated measurement system: Final report. Albuquerque, NM: BDM Federal, Inc.

Atwood, N. K., Winsch, B. J., Quinkert, K. A., & Heiden, C. K. (in preparation). Catalog of training tools for use in Distributed Interactive Simulation (DIS) environments (ARI Research Product). Alexandria, VA: U.S. Army Research Institute for the Behaviorial and Social Sciences.

Black, B. A. (1989). Using simulation to determine future training requirements. Paper presented at the First Symposium on Interactive Network Simulation for Training, Orlando, FL.

Black, B. A. (1993). Role of networked simulation in meeting NATO's future training needs. Paper presented to NATO Panel 8 on the Defense Applications of Human and Bio-Medical Sciences, Brussels.

Black, B. A. & Quinkert, K. A. (1991). Networked simulation in support of NATO's future training requirements. Paper submitted to NATO Industrial Advisory Group 37, Brussels.

Blasche, T. R., & Lickteig, C. W. (1984). Utilization of a vehicle integrated intelligence (V(INT)2) system for armor units (ARI Research Report 1374). Alexandria, VA: U.S. Army Research Institute for the Behaviorial and Social Sciences. (AD A168 828)

Cormier, S. M., & Hagman, J. D. (Eds.). (1987). Transfer of learning: Contemporary research and applications. San Diego, CA: Academic Press.

Deathridge, B. H. (1972). Auditory and other sensory forms of information processing. In Van Cott, H. P., & Kinkade, R. G. (Eds.) Human engineering guide to equipment design. Washington, DC: American Institutes for Research, p. 124.

Department of the Army. (1991). The battle-focused combined arms training strategy (CATS); armor (TC 17-12-7, coordinating draft). Washington, DC: Author.

Department of the Army. (1993). The United States Army modernization plan for command, control, and communications (C3). Washington, DC: Author.

Druffner, R. A. & Lewis, R. J. (1993, March). Embedded training offers savings, improved learning. Signal, pp. 50-51.

Du Bois, R. S., & Smith, P. G. (1989). A simulation-based evaluation of a position navigation system for Armor: Soldier performance, training, and functional requirements (ARI Technical Report 834). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A210 696)

Du Bois, R. S., & Smith, P. G. (1991). Simulation-based assessment of automated command and control capabilities for armor crews and platoons: The Intervehicular Information System (IVIS) (ARI Technical Report 918). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A233 509)

Edmondson, L. (1992, March-April). Training with technology. Armor, pp. 15-19.

Flexman, R. E., & Stark, E. A. (1987). Training Simulators. In G. Salvendy (Ed.), Handbook of Human Factors (pp. 1012-1038). New York: John Wiley & Sons.

Gimnich, R. (1991). Usability engineering and user interface management. In Duce, D. A., Hopgood, F. R. A., Gomes, M.R., & Lee, J. R. (Eds.), User interface management (pp. 133-138). Berlin: Springer-Verlag.

Gorman, P. F. (1991). The future of tactical engagement simulation. Proceedings of the 1991 Summer Computer Simulation Conference, (pp. 1181-1186). San Diego, CA: Society for Computer Simulation.

Gould, J. (1988). How to design usable systems. In M. Helander (Ed.), Handbook of human-computer interaction (pp. 757-789). Amsterdam: North-Holland.

Grandjean, E. (1986). Fitting the task to the man: An ergonomic approach. London: Taylor & Francis.

Herot, C. F. (1982). Graphical user interfaces. In Y. Vassiliou (Ed.), Human factors and interactive computer systems (pp. 83-103). Norwood, NJ: Ablex Publishing Corporation.

Holding, D. (Ed.) (1981). Human skills. New York: John Wiley & Sons.

Kerns, K. & Harwood, K. (1991). Blending voice and data link for improved air traffic control communications: Implications of simulation research. The Human Factors Society Bulletin, 34 (9), pp. 1-4.

LaVine, N. D., Lickteig, C. W., & Schmidt, J. H. (1993). Description of a tank-based automated command and control system as simulated for the Combat Vehicle Command and Control program (ARI Research Product 93-02). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A258 241)

Leibrecht, B. C., Kerins, J. W., Ainslie, F. M., Sawyer, A. R., Childs, J. M., & Doherty, W. J. (1992). Combat vehicle command and control systems: I. Simulation-based company-level evaluation (ARI Technical Report 950). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A251 917)

Leibrecht, B. C., Meade, G. A., Schmidt, J. H., Doherty, W. J., & Lickteig, C. W. (in preparation). Evaluation of the combat vehicle command and control system: operational effectiveness of an armor battalion (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Leibrecht, B. C., Winsch, B. J., Ford, L. A., Sawyer, A. R., Meade, G. A., Ainslie, F. M., Smith, P. G., Sever, R. S. & Doherty, W. J. (1993). Battalion evaluation of the combat vehicle command and control system in Distributed Interactive Simulation: Preliminary findings. (ARI Technical Report 992). Alexandria, VA: U.S. Army Research Institute for the Behaviorial and Social Sciences.

Lickteig, C. W. (1986). User interface requirements for the battlefield management system (BMS) (ARI Research Product 86-25). Alexandria, VA: U.S. Army Research Institute for the Behaviorial and Social Sciences. (AD A174 811)

Lickteig, C. W. (1987). Training requirements for the battlefield management system (BMS): A preliminary analysis (ARI Research Product 87-18). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A165 648)

Lickteig, C. W. (1988). Design guidelines and functional specifications for simulation of the battlefield management system's (BMS) user interface (ARI Research Product 88-19). Alexandria, VA: U.S. Army Research Institute for the Behaviorial and Social Sciences. (AD A201 189)

Lickteig, C. W. (1991). Prototype methods for training and assessing future tactical command and control skills (ARI Research Product 92-01). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A244 328)

Meade, G. A., Lozicki, R. J., Leibrecht, B. C., Smith, P. G., & Meyers, W. E. (in preparation). The combat vehicle command & control system: Combat performance of armor battalions using distributed interactive simulation (ARI Research Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Meliza, L. L., Bessemer, D. W., Burnside, B. L., & Shlecter, T. M. (1992). Platoon-level after action review aids in the SIMNET Unit Performance Assessment System (ARI Technical Report 956). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A254 909)

Miller, D. C., & Chung, J. W. (1987). SIMNET-D capabilities and overview. (BBN Report). Cambridge, MA: Bolt, Baranek, Newman, Inc.

Mueller, N. S. (1991, July). Face to interface. CBT Directions, pp. 31-33.

O'Brien, L. H., Morey, J. C., & Levine, N. (1991). Training requirements analysis for the combat vehicle command and control (CVCC) system tactical operations center (TOC) (ARI Research Report 1624). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A254 541)

O'Brien, L. H., Wigginton, D., Morey, J. C., Leibrecht, B. C., Ainslie, F. M., & Sawyer, A. R. (1992). Combat vehicle command and control battalion-level preliminary evaluation (ARI Research Report 1627). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A257 467)

Quinkert, K. A. (1987). Preliminary training requirements analysis for the Commander's Independent Thermal Viewer (CITV) (ARI Research Product 87-19). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A185 467)

Quinkert, K. A. (1988). Design and functional specifications for the simulation of the commander's independent thermal viewer (CITV) (ARI Research Product 88-17). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A201 419)

Quinkert, K. A. (1990). Crew Performance associated with the simulation of the Commander's Independent Thermal Viewer (CITV) (ARI Technical Report 900). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A226 890)

Quinkert, K. A., & Atwood, N. K. (1993). Using distributed simulation to determine training requirements for future systems. Paper presented to NATO Panel 8 on the Defense Applications of Human and Bio-Medical Sciences, Brussels.

Schneider, W. (1990). Training high-performance skills: fallacies and guidelines. In M. Venturino (Ed.), Selected Readings in Human Factors (pp. 297-311). Santa Monica, CA: Human Factors Society.

Sever, R., Collins, J., and Heiden, C. (in preparation). Battalion Tactical Operations Center (TOC) job aid (ARI Research Product). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Schneider, W. (1990). Training high-performance skills: fallacies and guidelines. In M. Venturino (Ed.), Selected Readings in Human Factors (pp. 297-311). Santa Monica, CA: Human Factors Society.

Shneiderman, B. (1992). Designing the user interface: Strategies for the effective human-computer interaction (2nd ed.). Reading, MA: Addison-Wesley Publishing Company, Inc.

Singley, G. T. (1993, March-April). Distributed interactive simulation - a preview. Army Research Development and Acquisition Bulletin. pp. 35-39.

Smith, P. G. (1990). SIMNET combat vehicle command and control (CVC2) system user's guide (BBN Technical Report 7323). Cambridge, MA: Bolt Beranek and Newman, Inc.

Swanson, R. A., & Law, B. D. (1993). Whole-part-whole learning model. Performance Improvements Quarterly, 6(1), 43-53.

U.S. Army Armor Center and Fort Knox (1990, July). Armor 2000: A Balanced Force for the Army of the Future (White Paper). Fort Knox, KY: Author.

U.S. Army Armor Center (1983, June). Tank platoon mission training plan (Training Circular 17-15-1). Fort Knox, KY: Author.

U.S. Army Armor School (1987). M1 SIMNET Operator's Guide. Fort Knox, KY: Headquarters, U.S. Army Armor School.

U.S. Army Armor School (1989). SIMNET User's Guide. Fort Knox, KY: Headquarters, U.S. Army Armor School.

U.S. Army Training and Doctrine Command (TRADOC) (1988). Systems Approach to Training (SAT) (TRADOC Regulation 350-7). Fort Monroe, VA:

Vaden, D. W. (1993, May-June). Vision for the next decade. Army Research Development and Acquisition Bulletin. pp. 1-3.

Vertelney, L., Arent, M., & Lieberman, H. (1991). Designing the whole-product user interface. In B. Laurel (Ed.), The art of human-computer interface design (pp. 45-55). Reading, MA: Addison-Wesley Publishing Company, Inc.

Wickens, C. D. (1984). Engineering Psychology and Human Performance. Glenview, IL: Scott, Foreman, and Company.

Winsch, B. J., Atwood, N. K., Sawyer, A. R., Quinkert, K. A., Heiden, C. K., Smith, P. G., & Schwartz, B. (in preparation). Innovative training concepts for use in distributed interactive simulation (DIS) environments (ARI Research Product). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Appendix A

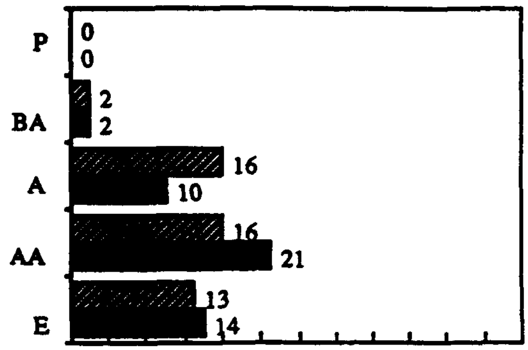
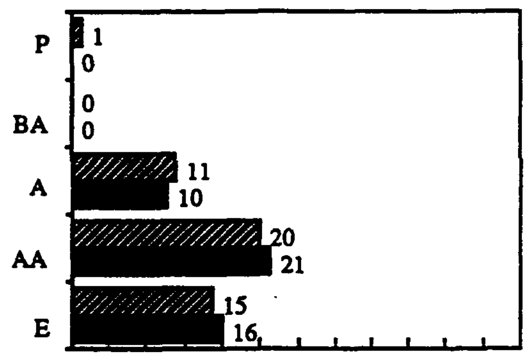
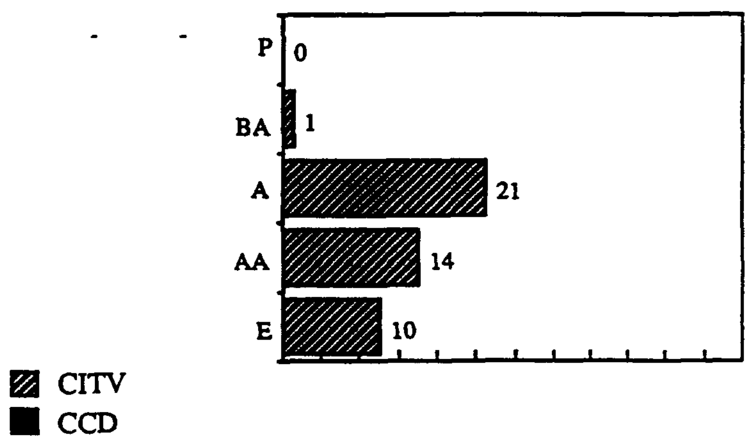
CCD and CITV Training Data

The following data are included in Appendix A:

Pages	Data
A-2 through A-16	CVCC Vehicle Commander, Gunner, and Driver Training Evaluation Ratings
A-17 through A-19	Overall CCD and CITV Skills Test Performance, and Comparisons of CCD and CITV Skills Test Performance
A-20 through A-26	CCD Skills Test Items
A-27 through A-30	CITV Skills Test Items

Figure A-1

Vehicle Commander Training Evaluation Items

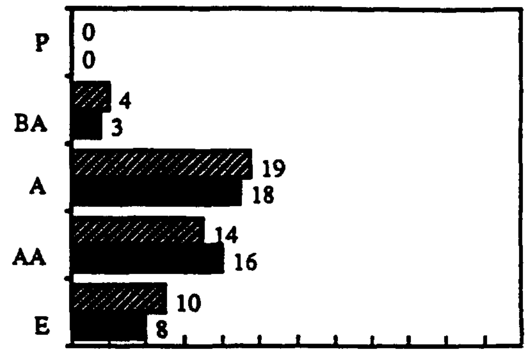
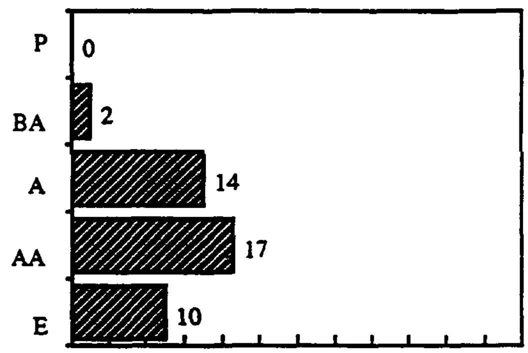
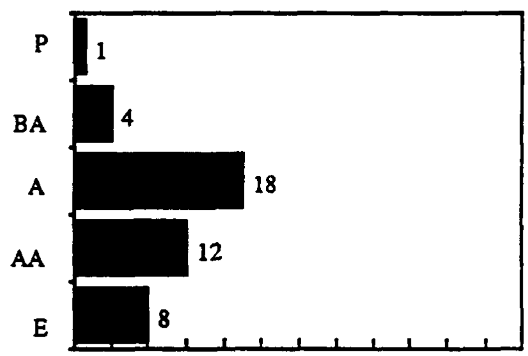
Evaluation Item	CITV M	CITV S.D.	CCD M	CCD S.D.	Response Distribution
Classroom Instuction	3.85	.88	4.00	.83	
Instructor's Presentation	4.02	.87	4.12	.74	
CITV Viewgraphs	3.68	.86	-	-	

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-1

Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	CITV		CCD		Response Distribution
	M	S.D.	M	S.D.	
Handouts	3.63	.92	3.64	.86	
			n=45		
Examples of Tactical Equipment Use	3.81	.85	-	-	
	n=43				
CCD Large Screen Refesher Training	-	-	3.51	.99	
			n=43		

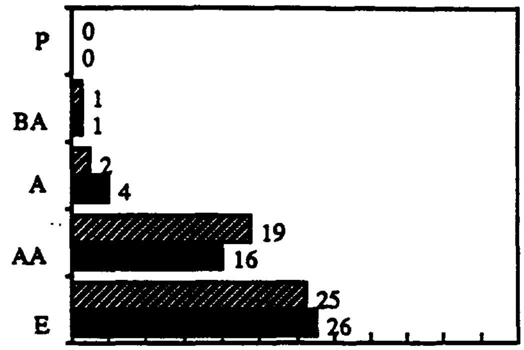
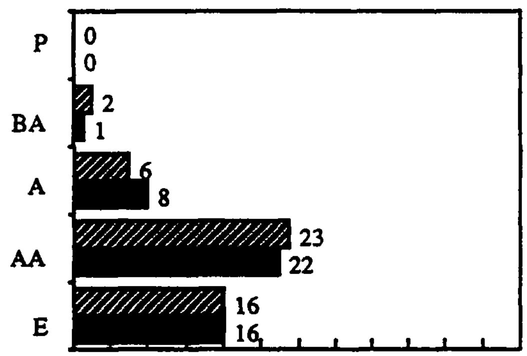
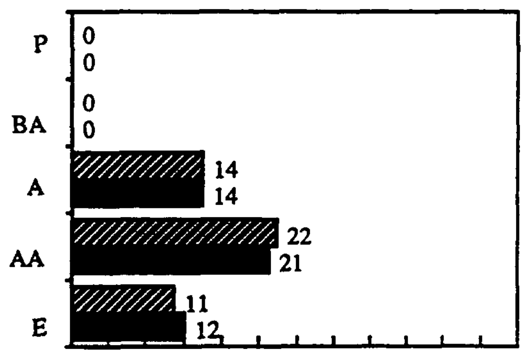
CITV
CCD

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-1

Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	CITV M	CITV S.D.	CCD M	CCD S.D.	Response Distribution
Hands On Training	4.48	.69	4.43	.74	
RA Explanations	4.13	.80	4.13	.77	
Skills Test	3.94	.73	3.96	.75	

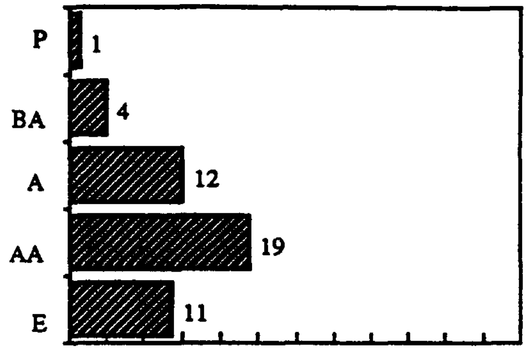
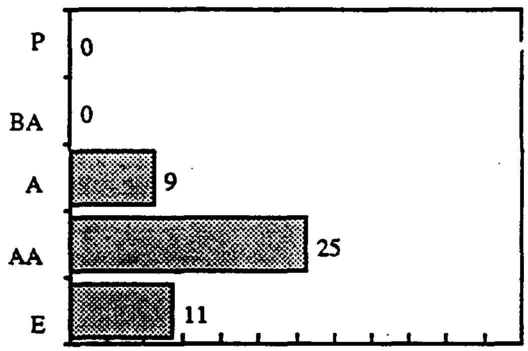
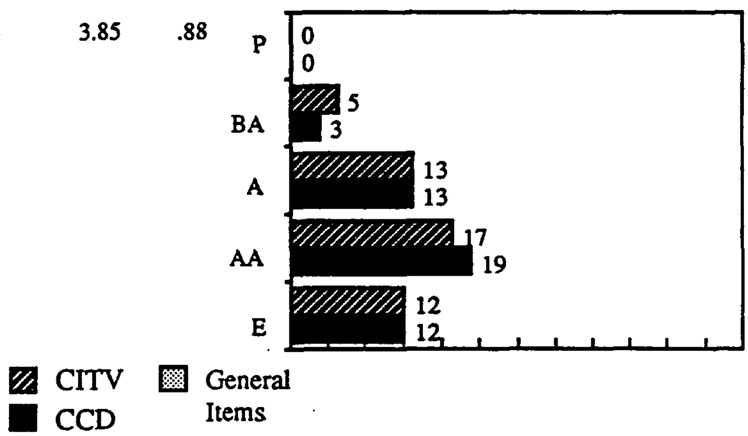
▨ CITV
■ CCD

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-1

Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	General Items M	General Items S.D.	CITV M	CITV S.D.	CCD M	CCD S.D.	Response Distribution
Refresher Tasks			-	-	3.75	.99	
Adequacy of basic simulator information	4.04	.67					
	n=45						
Sandboxes			3.77	.96	3.85	.88	

(Figure continues)

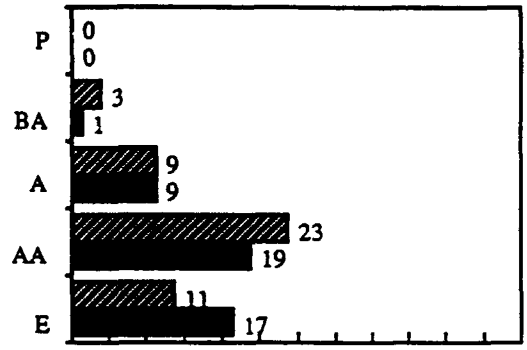
Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

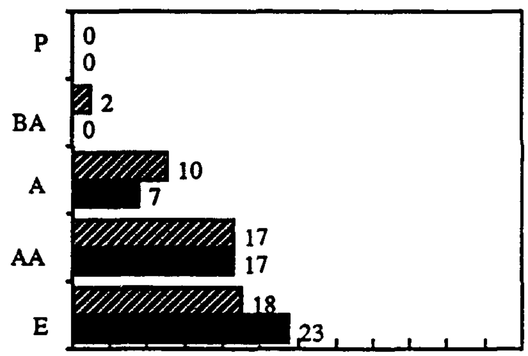
Figure A-1

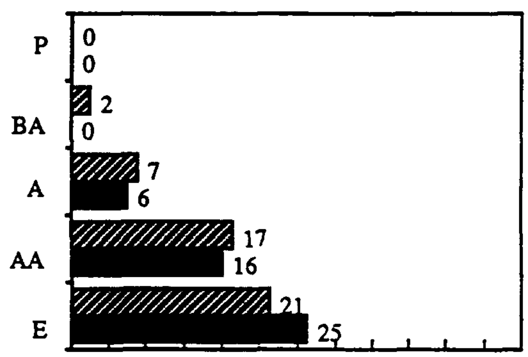
Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	CITV M	CITV S.D.	CCD M	CCD S.D.
Company Traning Exercise (CoSTX)	3.91 n=46	.84	4.13 n=46	.73
First Battalion Traning Exercise	4.09	.88	4.34	.73
Final Battalion Training Exercise	4.21	.86	4.40	.71

Response Distribution







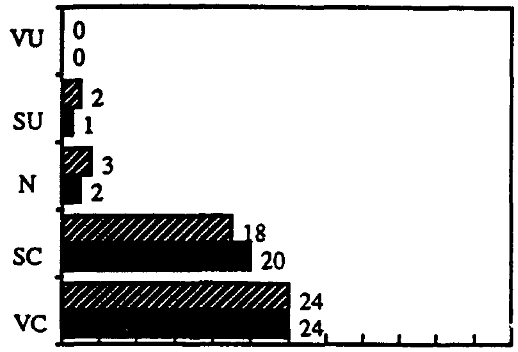
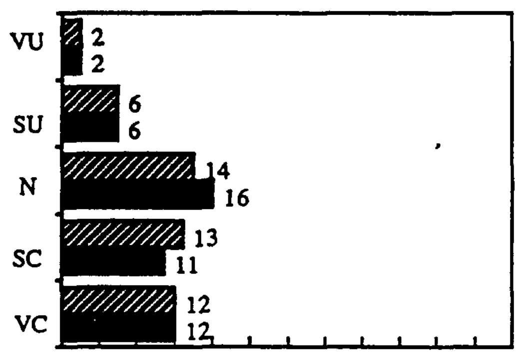
CITV
CCD

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-1

Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	CITV M	CITV S.D.	CCD M	CCD S.D.	Response Distribution
Were the training objectives clear	4.36	.79	4.43	.68	
Feedback during training	3.57	1.14	3.53	1.14	

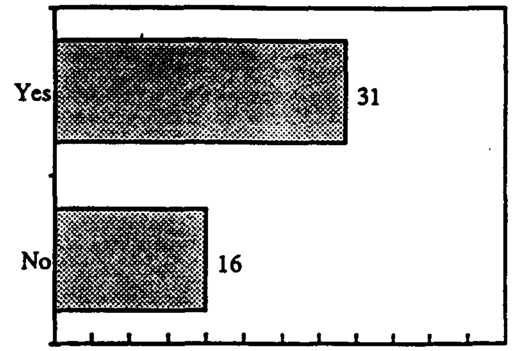
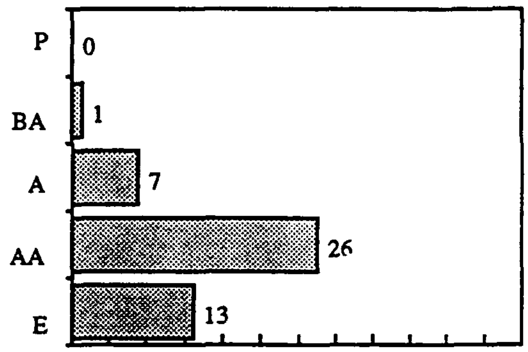
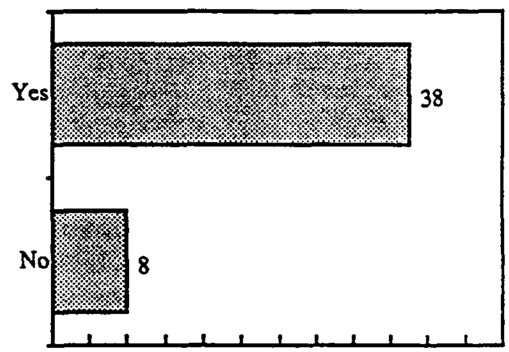
CITV
CCD

(Figure continues)

Note. VU=Very Unclear (1); SU=Somewhat Unclear (2); N=Neutral (3); SC=Somewhat Clear (4); VC=Very Clear (5). Unless indicated, n=47.

Figure A-1

Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	M	S.D.	Response Distribution
Were there any CITV or CCD functions that you didn't use?	1.34	.48	
Level of preparation for final training exercise	4.09	.72	
Were you provided with enough information about operational concepts?	1.17	.38	

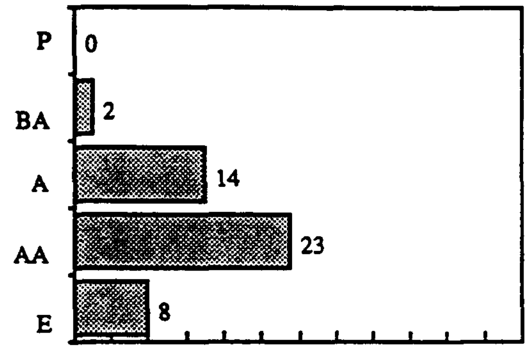
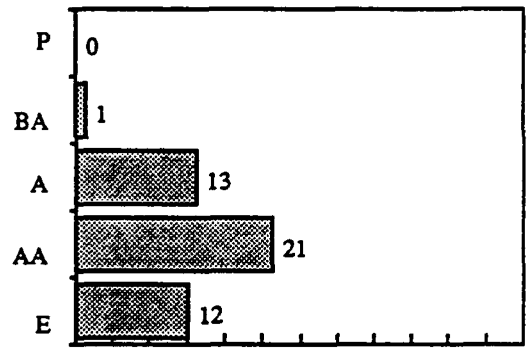
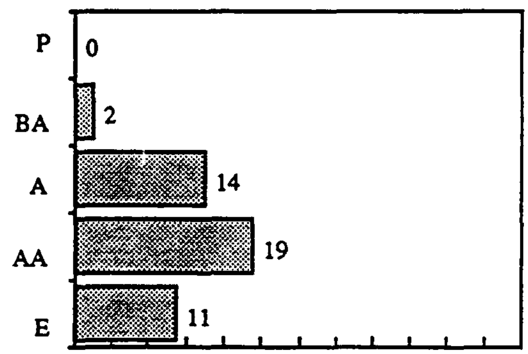
n=46

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-1

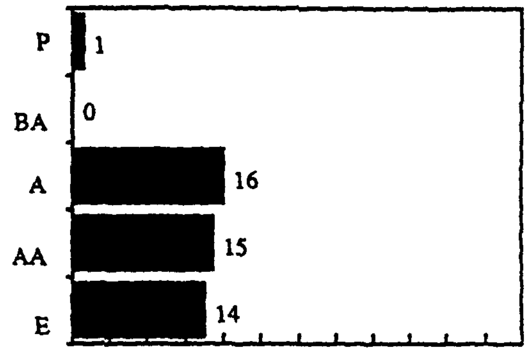
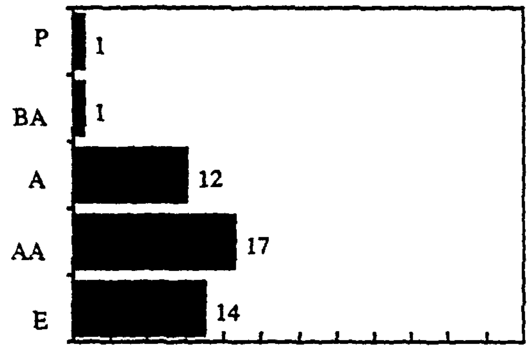
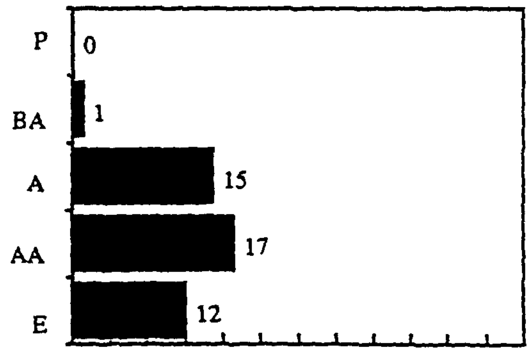
Vehicle Commander Training Evaluation Items (Cont'd)

Evaluation Item	M	S.D.	Response Distribution
Quality of debriefing for the first Battalion Exercise	3.79	.78	
Quality of debriefing for the final Battalion exercise	3.94	.79	
SAFOR as a training tool	3.85	.84	
	n=46		

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-2

Gunner Training Evaluation Items

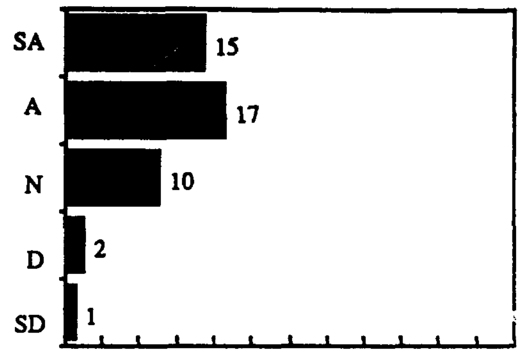
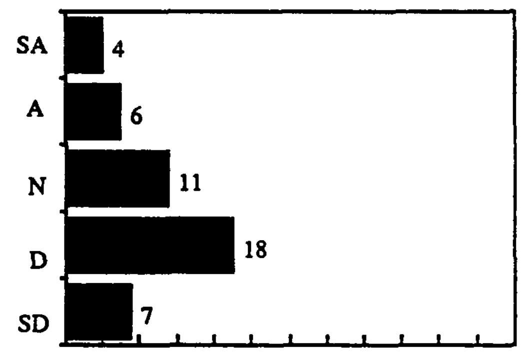
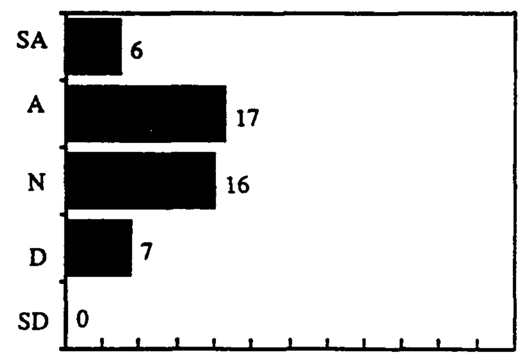
Evaluation Item	M	S.D.	Response Distribution
Classroom Instruction	3.89	.92	
Hands-on instruction	3.93 n=45	.94	
Training exercises	3.89 n=45	.83	

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, *n*=46.

Figure A-2

Gunner Training Evaluation Items (Cont'd)

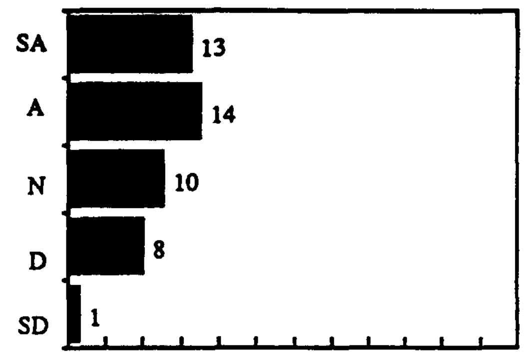
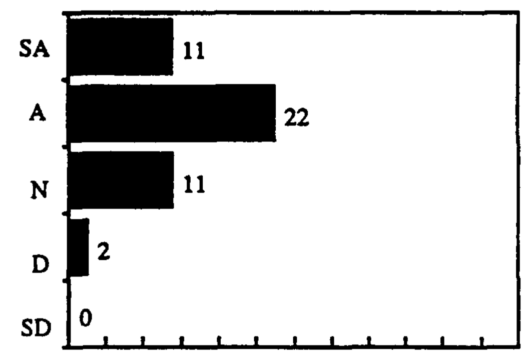
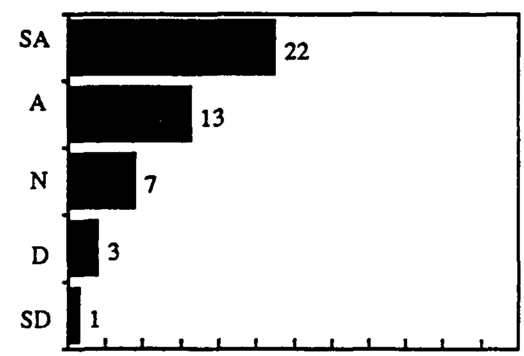
Evaluation Item	M	S.D.	Response Distribution
Liked being designated to new targets n=45	2.04	.98	
Found it easy to become disoriented when designate to a target	3.39	1.16	
As the number of targets increased,the usefulness of the CITV increased	2.52	.91	

(Figure continues)

Note. SA=Strongly Agree (1); A=Agree (2); N=Neutral (3); D=Disagree (4); SD=Strongly Disagree (5). Unless indicated, n=46.

Figure A-2

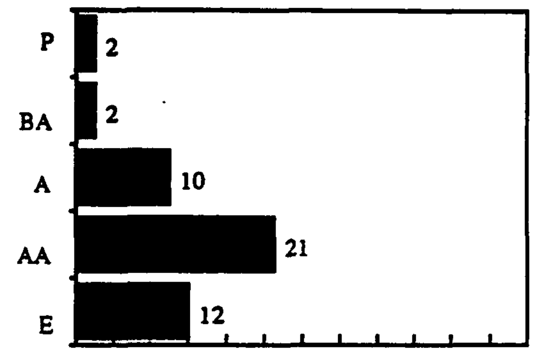
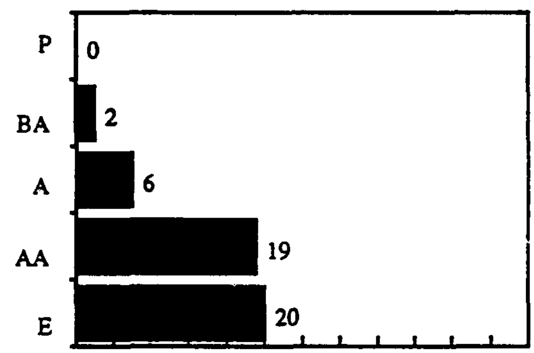
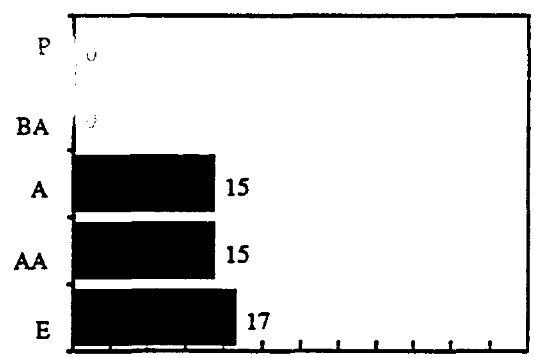
Gunner Training Evaluation Items (Cont'd)

Evaluation Item	M	S.D.	Response Distribution
Less communication with the TC was needed	2.35	1.14	
Target hand-offs were smooth and allowed me to acquire targets faster	2.09	.81	
In a real tank, I feel that designate would enable me to destroy more targets	1.87	1.05	

Note. SA=Strongly Agree (1); A=Agree (2); N=Neutral (3); D=Disagree (4); SD=Strongly Disagree (5). Unless indicated, n=46.

Figure A-3

Driver Training Evaluation Items

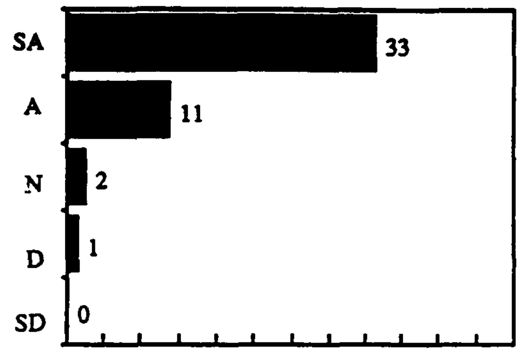
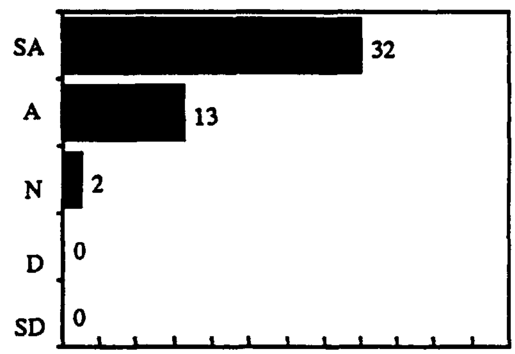
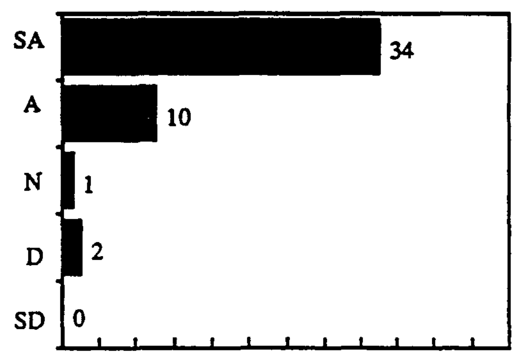
Evaluation Item	M	S.D.	Response Distribution
Classroom Instruction	3.83	1.01	
Hands-on instruction	4.21	.83	
Training Exercises	4.04	.83	

(Figure continues)

Note. P=Poor (1); BA=Below Average (2); A=Average (3); AA=Above Average (4); E=Excellent (5). Unless indicated, n=47.

Figure A-3

Driver Training Evaluation Items (Cont'd)

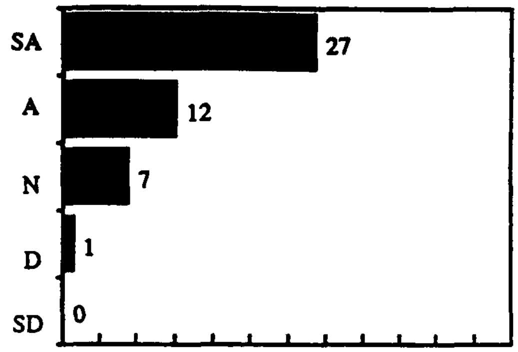
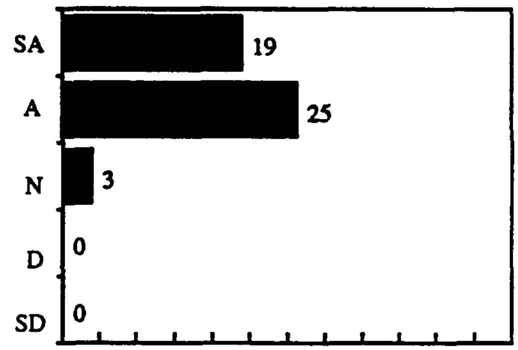
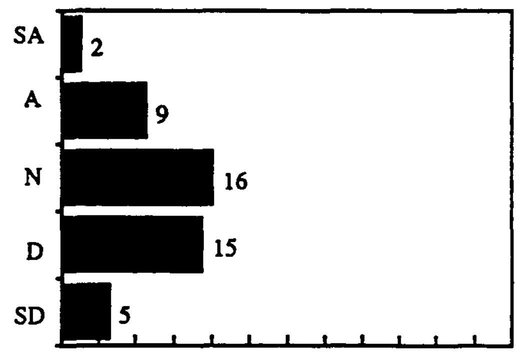
Evaluation Item	M	S.D.	Response Distribution
Didn't have difficulty in using the Driver's Drisplay	1.38	.68	
Didn't have trouble receiving waypoints	1.36	.57	
Less communication was needed with the TC	1.38	.74	

(Figure continues)

Note. SA=Strongly Agree (1); A=Agree (2); N=Neutral (3); D=Disagree (4); SD=Strongly Disagree (5). Unless indicated, n=47.

Figure A-3

Driver Training Evaluation Items (Cont'd)

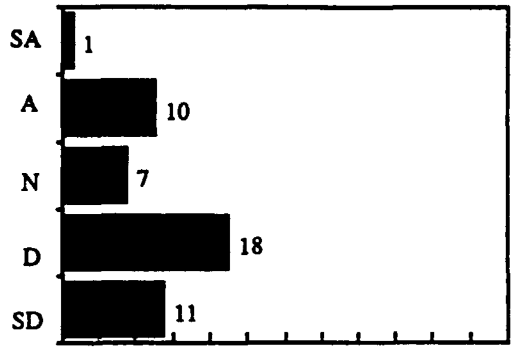
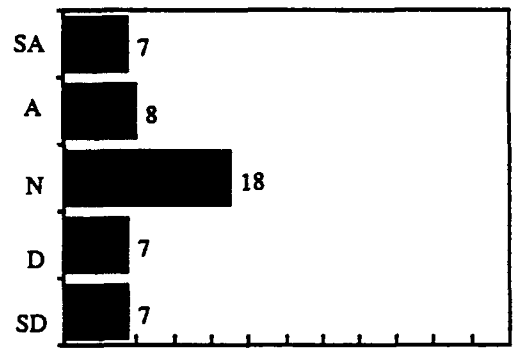
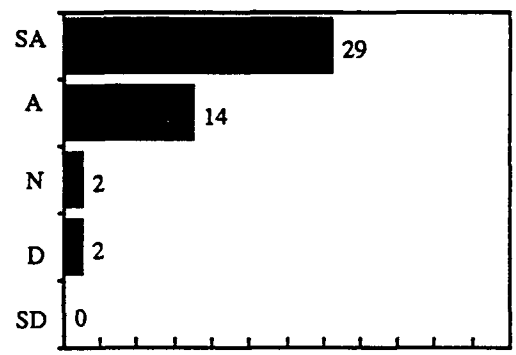
Evaluation Item	M	S.D.	Response Distribution
I could maneuver better in a real tank with the Steer-To-Indicator	1.62	.82	
The Steer-To-Indicator's response time is acceptable.	1.66	.60	
Drivers would become too dependant on the Driver's Display in a real tank	3.26	1.03	

(Figure continues)

Note. SA=Strongly Agree (1); A=Agree (2); N=Neutral (3); D=Disagree (4); SD=Strongly Disagree (5). Unless indicated, n=47.

Figure A-3

Driver Training Evaluation Items (Cont'd)

Evaluation Item	M	S.D.	Response Distribution
My TC would sometimes forget to send me new waypoints	3.60	1.14	
I would perfer to see all the waypoints at once	2.98	1.24	
The Driver's Display gave me more confidence in moving point to point	1.51	.78	

(Figure continues)

Note. SA=Strongly Agree (1); A=Agree (2); N=Neutral (3); D=Disagree (4); SD=Strongly Disagree (5). Unless indicated, n=47.

Figure A-4

CCD skills test scores overall and by echelon

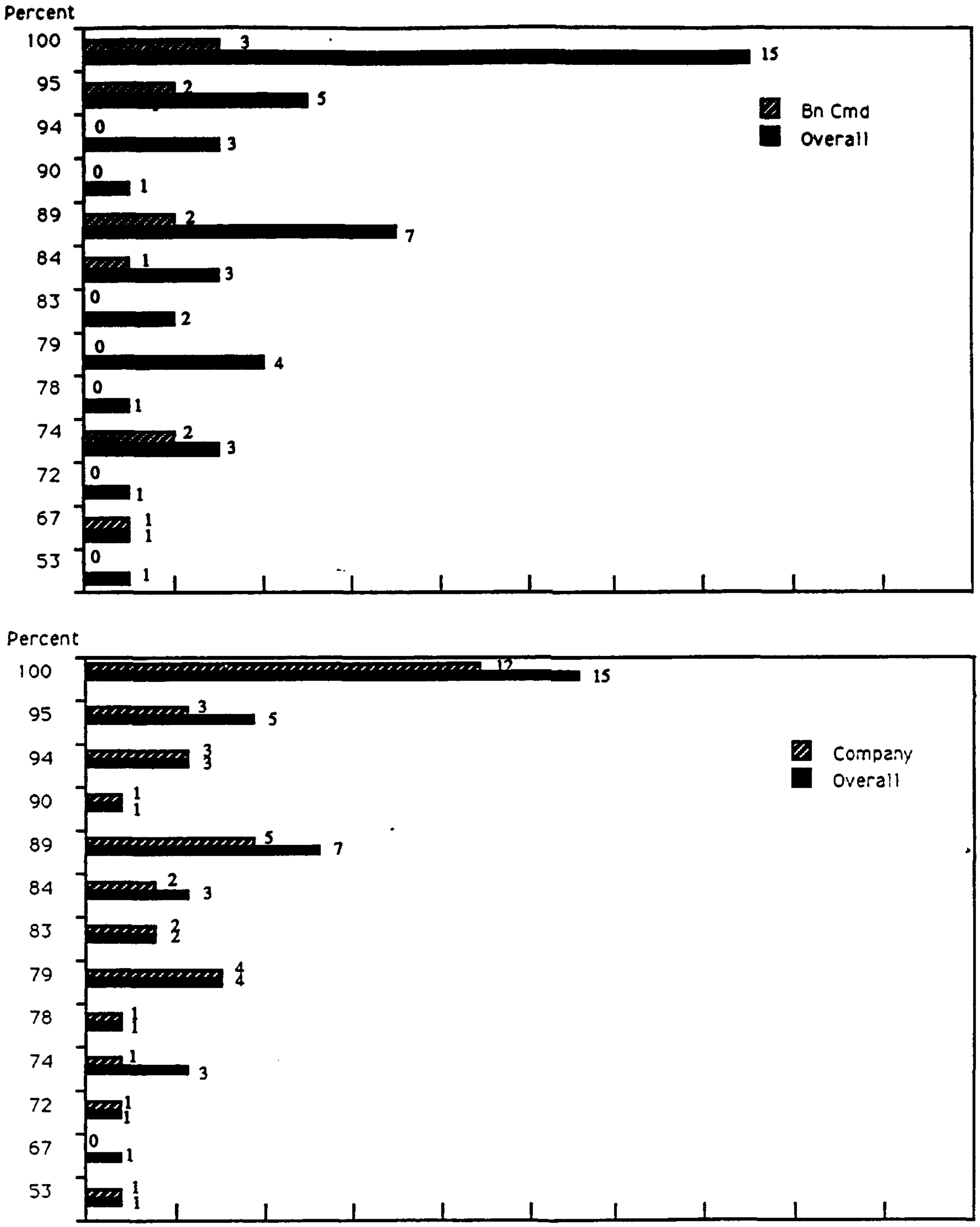


Figure A-5

CITV skills test scores overall and by echelon

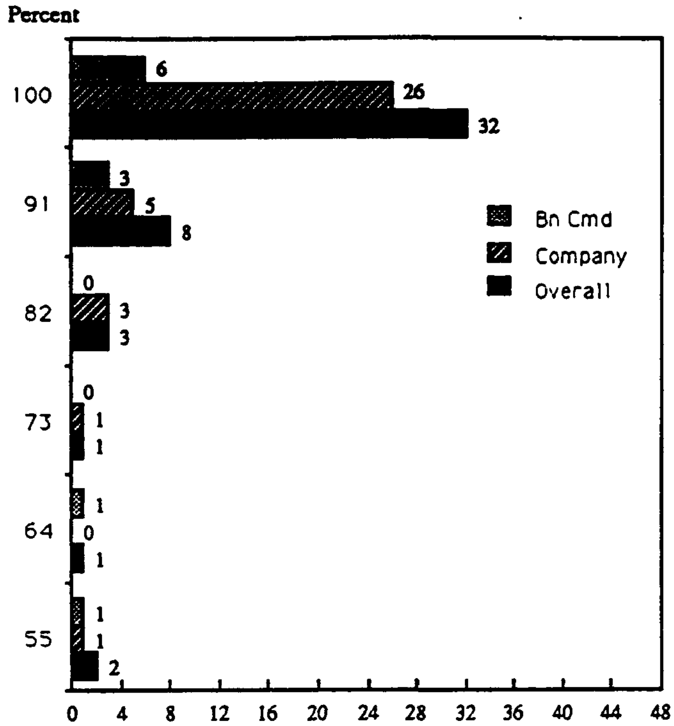
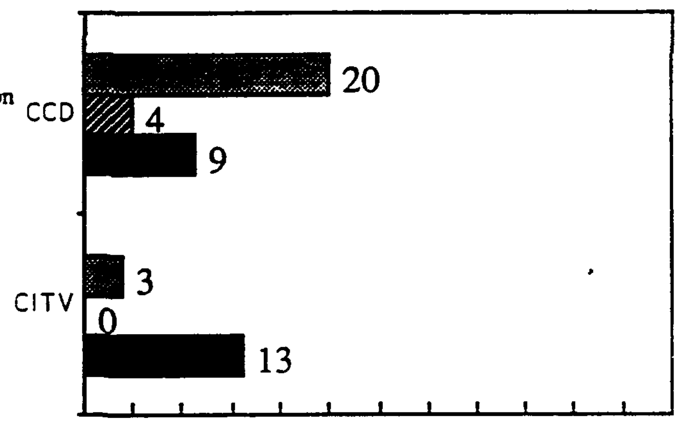


Figure A-6

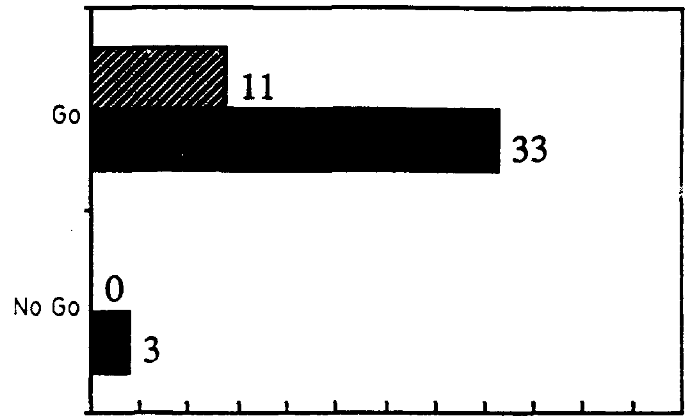
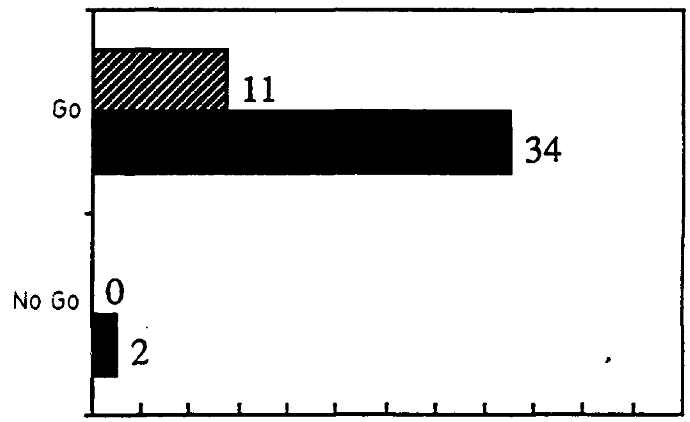
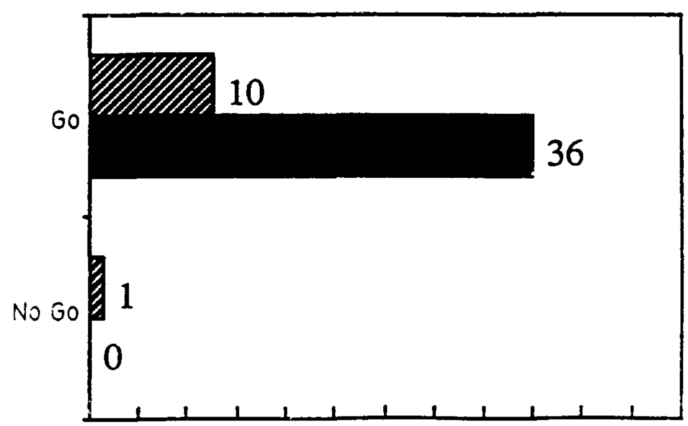
Comparisons of Skill test scores across CVCC evaluations

Item	Response Distribution
CCD and CITV skills test average scores across the company, battalion TOC, and battalion evaluations	
Percentage of participants scoring less than 75% on the CCD and CITV skills tests across the company, battalion TOC, and battalion evaluations	

Company
Battalion TOC
Battalion

Figure A-7

Data for CCD Skills Test Items

Skills Test Item	Response Distribution
1. Locating and explaining the Information Center	
2. Create a CONTACT Report	
3. Viewing a recently-received report and posting the icon without forwarding the report	

Bn Cmd
Company

Note: Unless indicated, n=47

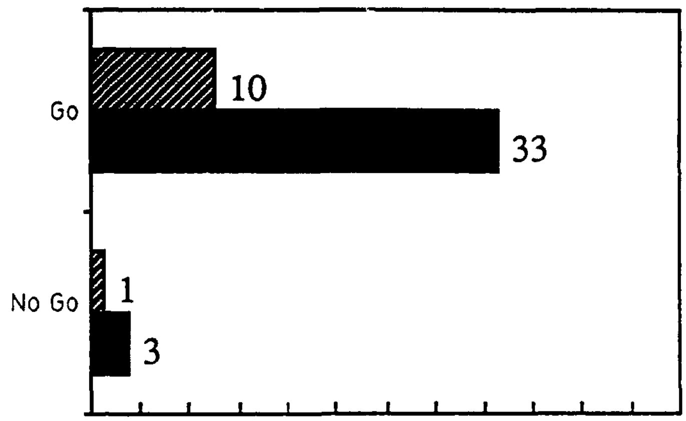
(Figure continues)

Figure A-7

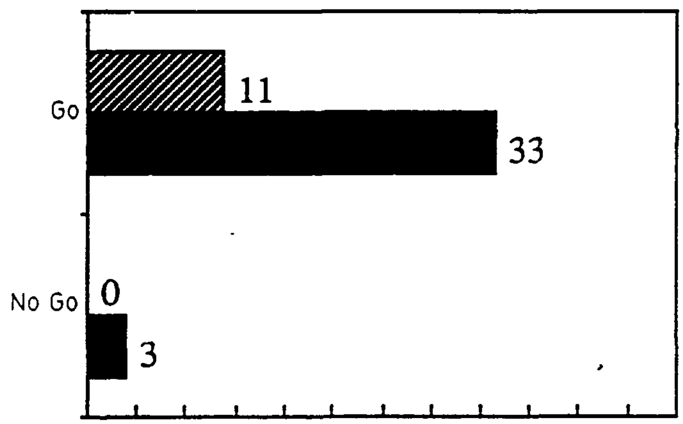
Data for CCD Skills Test Items (Cont'd)

Skills Test Item	Response Distribution

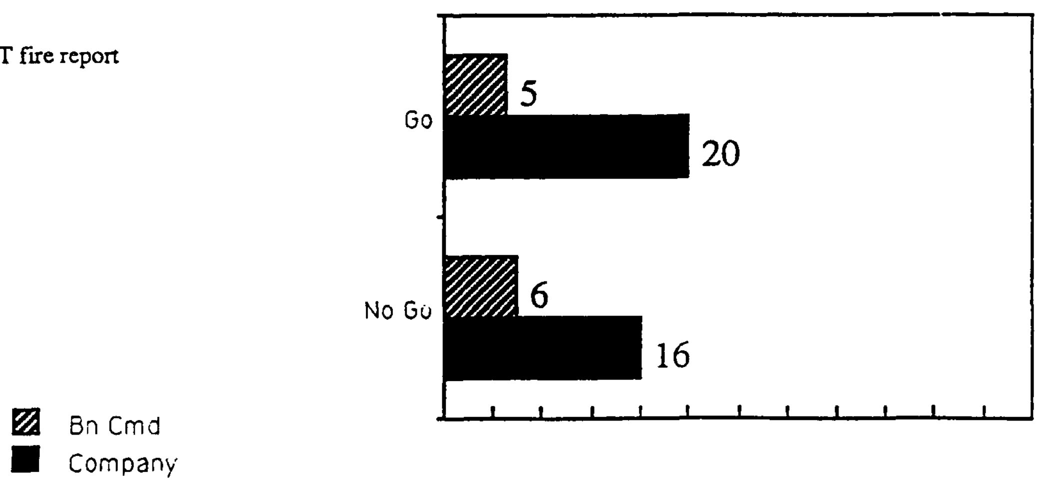
4. Create a CFF report



5. Use the receive queue to view the most recently received high priority report and tell the status, creator, and when the report was created



6. Create a ADJUST fire report



Note: Unless indicated, n=47

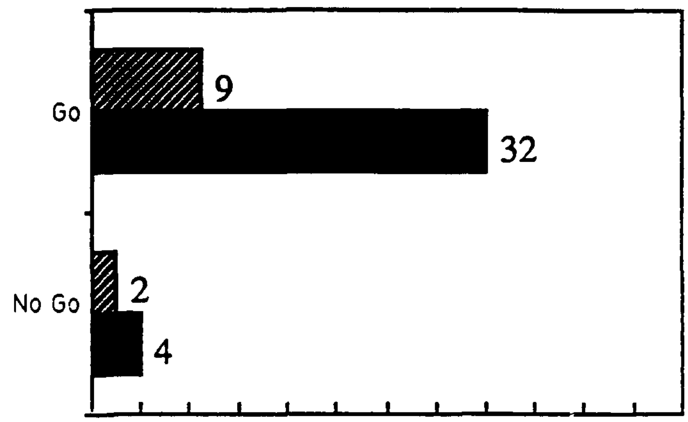
(Figure continues)

Figure A-7

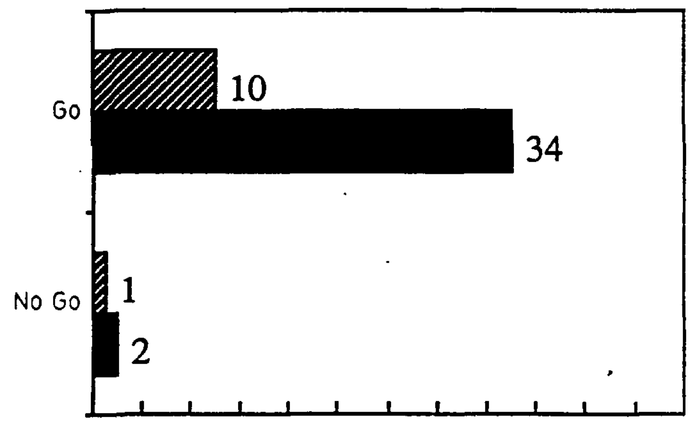
Data for CCD Skills Test Items (Cont'd)

Skills Test Item	Response Distribution

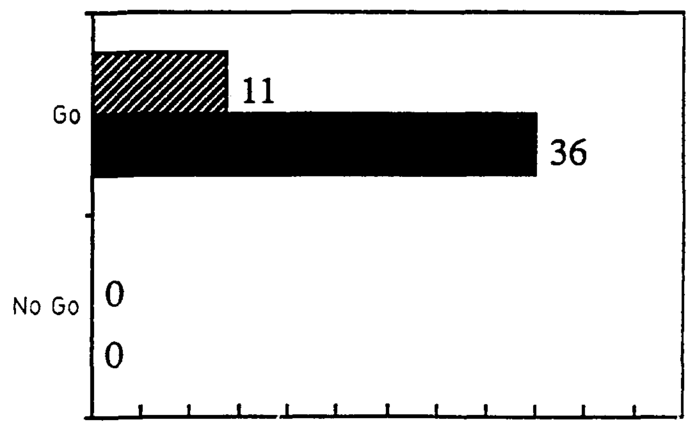
7. Create a SPOT Report



8. Adjust the map scale to show the smallest area in the most detail with all map features showing



9. Create a SHELL Report



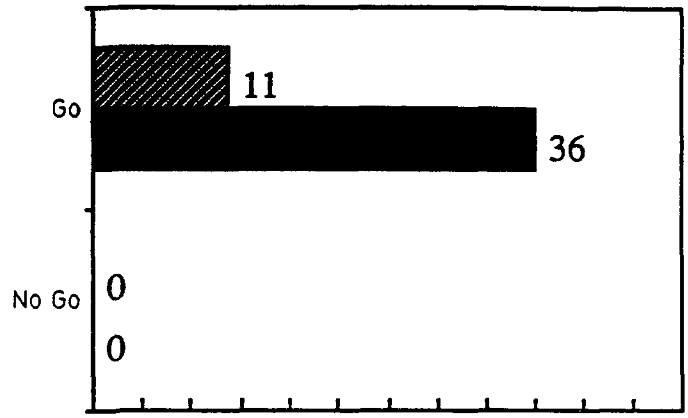
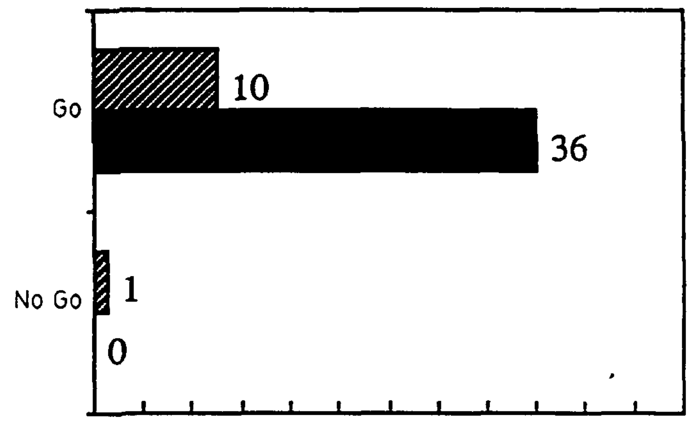
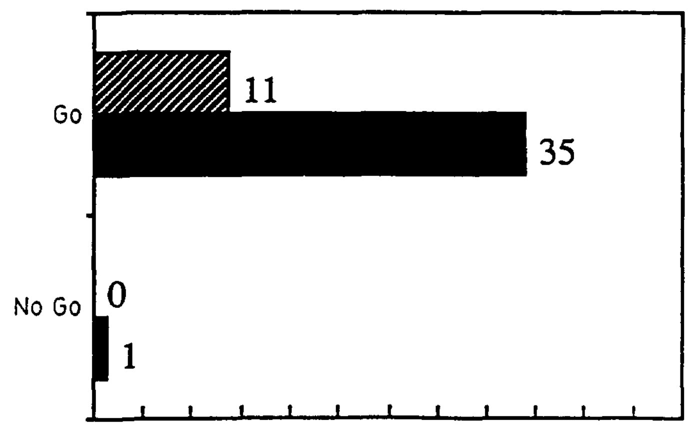
Bn Cmd
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-7

Data for CCD Skills Test Items

Skills Test Item	Response Distribution
10. Create a three waypoint navigation route	
11. Place waypoint four of your route off of your map	
12. Send waypoint 1 to your driver, save the route, and send the route	

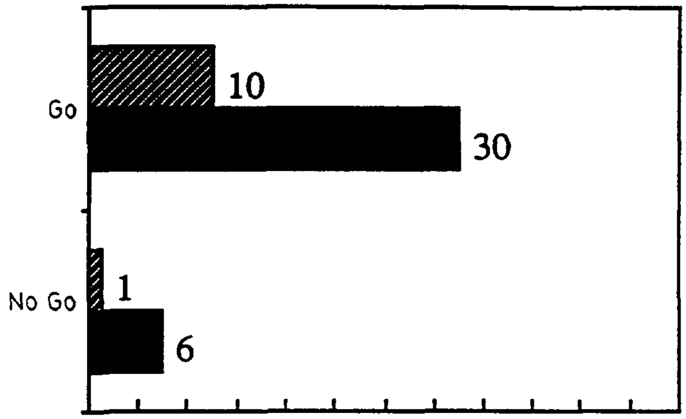
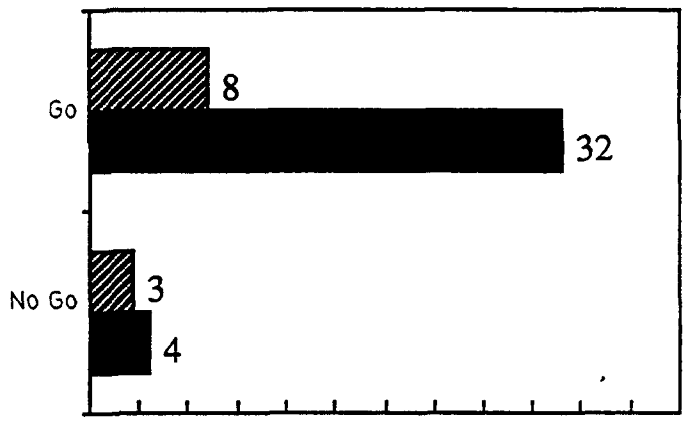
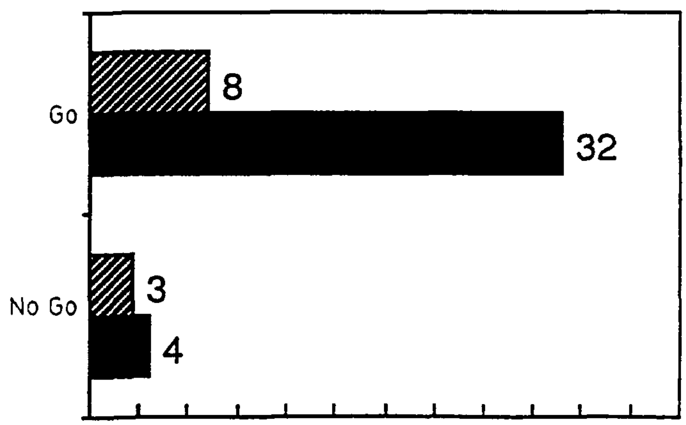
Bn Cmd
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-7

Data for CCD Skills Test Items (Cont'd)

Skills Test Item	Response Distribution
13. Make active a route from your route files then delete the previously active route	
14. Create a SITREP Report	
15. From the Old CONTACT Report files, select a unrelayed report, read it, and relay it	

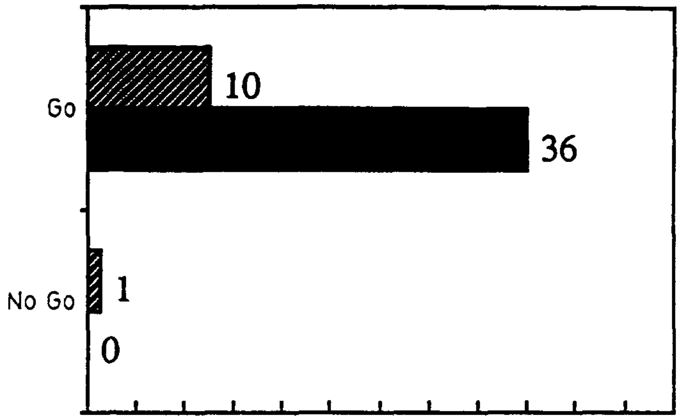
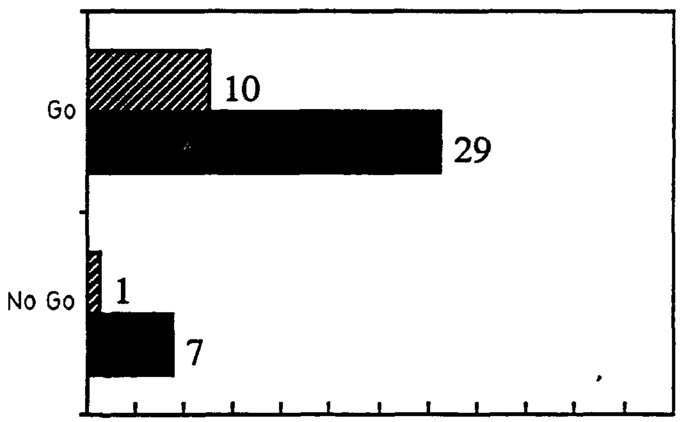
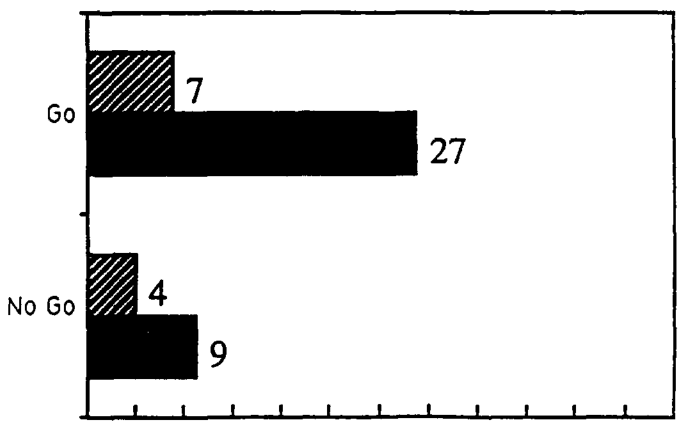
Bn Cmd
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-7

Data for CCD Skills Test Items (Cont'd)

Skills Test Item	Response Distribution
16. Unpost the current overlay and post a old overlay	
17. Delete a tank icon by pointing	
18. Viewing a CONTACT Report from the old files useing the hot icon and identifying the creator, the time it was sent, who sent the report and what net it was sent on	

Bn Cmd

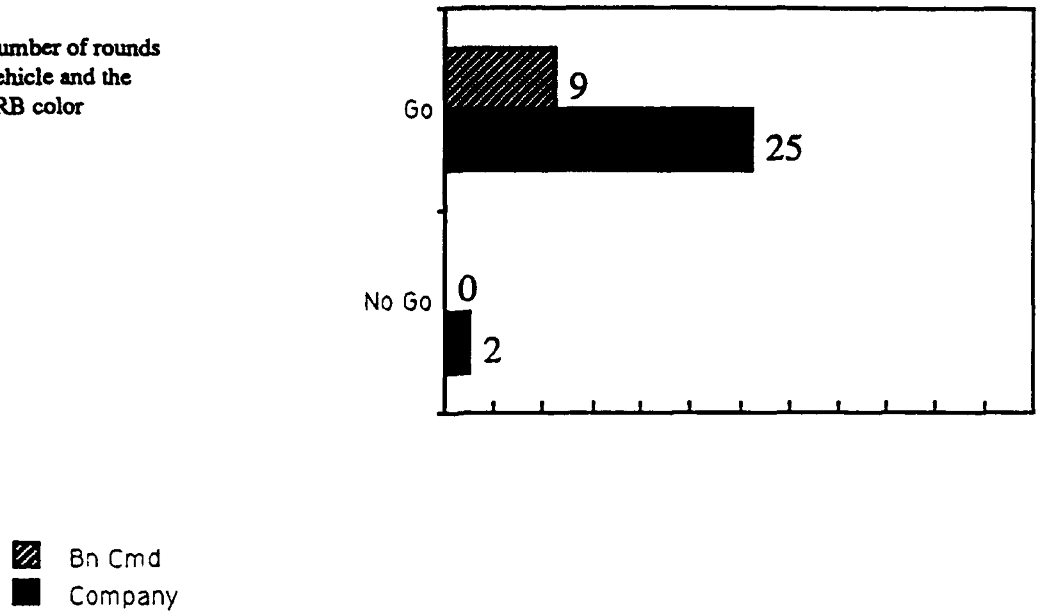
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-7

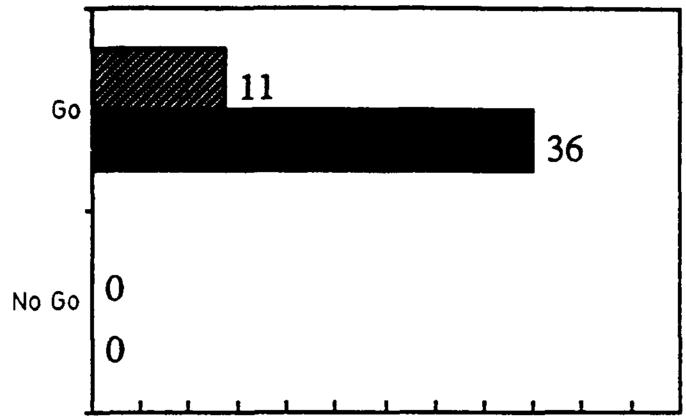
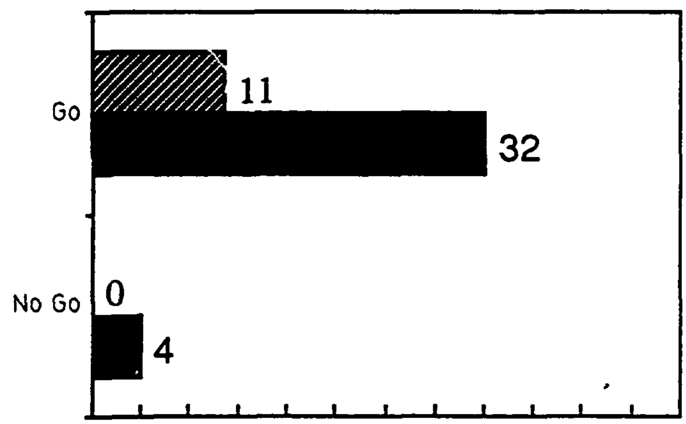
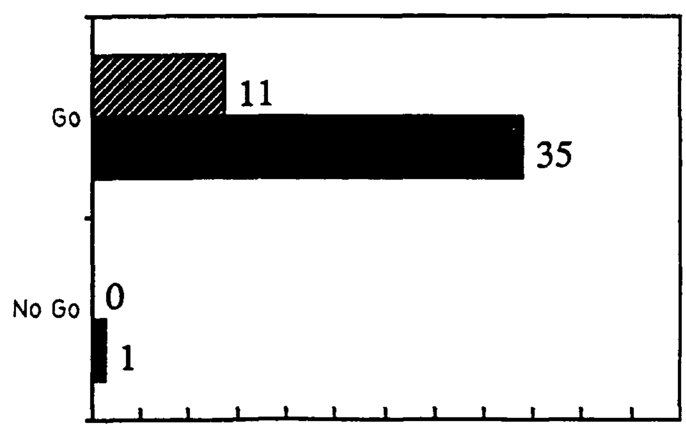
Data for CCD Skills Test Items (Cont'd)

Skills Test Item	Response Distribution
19. Find the total number of rounds available in your vehicle and the corresponding GARB color	

Note: For this item only, n=36

Figure A-8

Data for CITV Skills Test Items

Skills Test Item	Response Distribution
1. Identifying the features of the CITV tank icon	
2. Identify which display indicates heading	
3. Conduct a manual search	

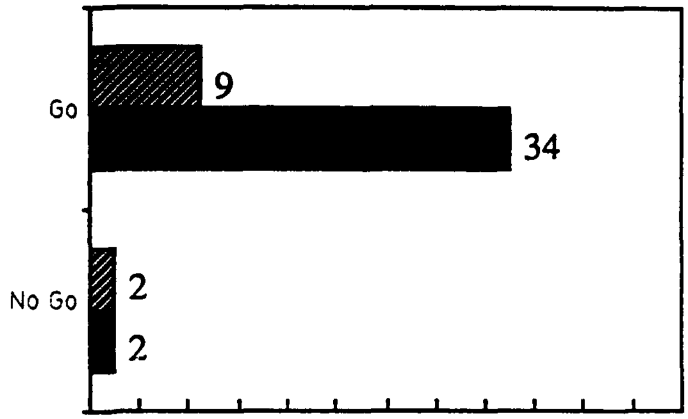
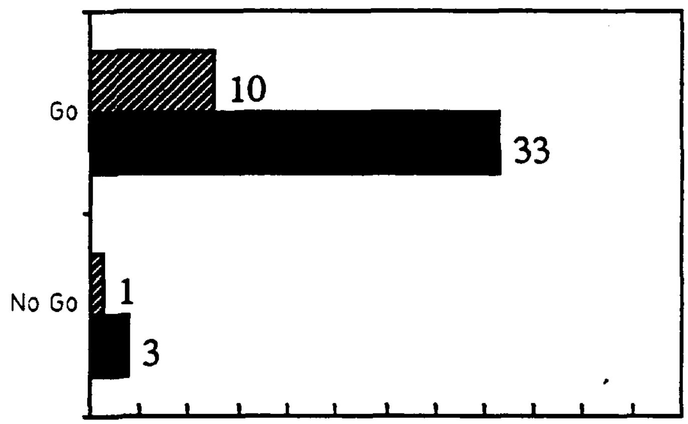
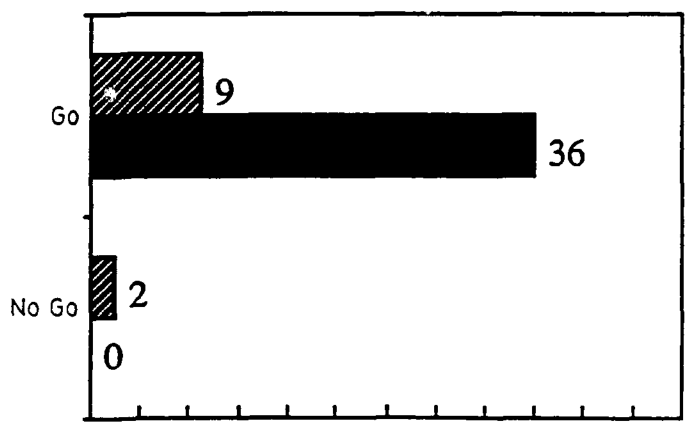
Bn Cmd
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-8

Data for CITV Skills Test Items (Cont'd)

Skills Test Item	Response Distribution
4. Demonstrate the GLOS function	
5. Set AUTO SCAN sectors using the CITV icon	
6. Set AUTO SCAN sectors over the rear of the tank	

Bn Cmd
Company

Note: Unless indicated, n=47

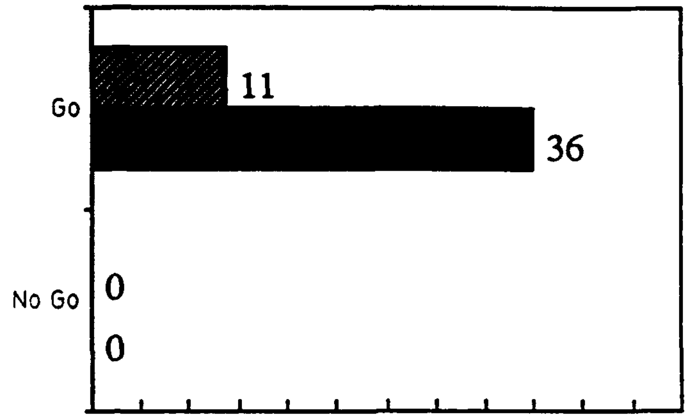
(Figure continues)

Figure A-8

Data for CITV Skills Test Items (Cont'd)

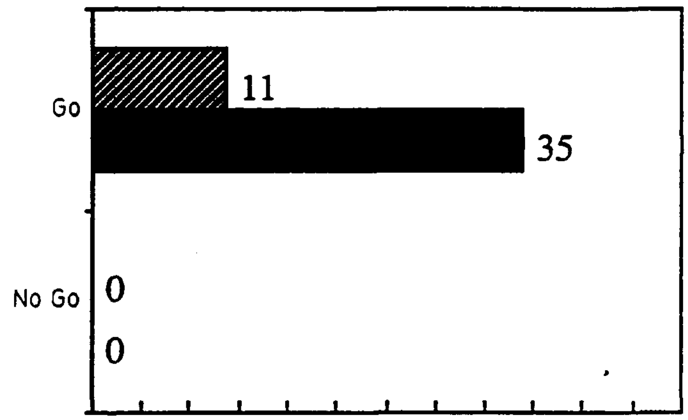
Skills Test Item	Response Distribution

7. Slow down the scan of the AUTO SCAN, ensure that you are in 3X and White Hot

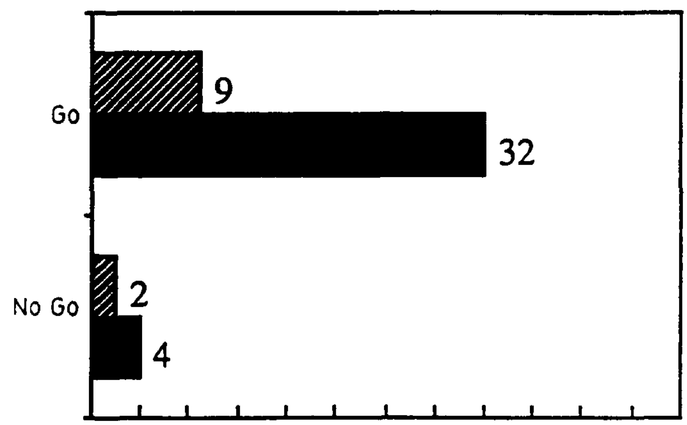


8. Use your normal TC override

n=46



9. Goto Manual Search Mode and use DESIGNATE to show the gunner his scanning sector



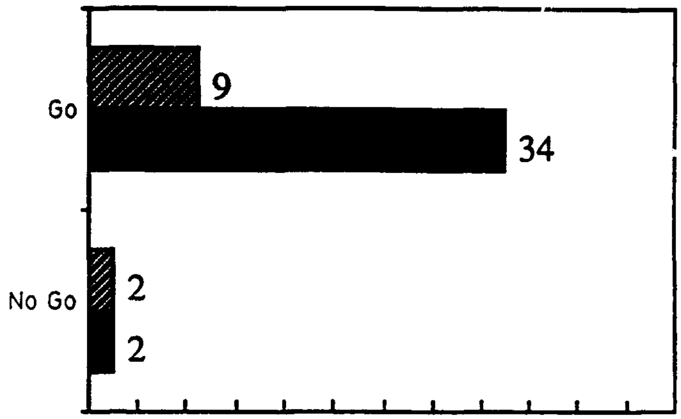
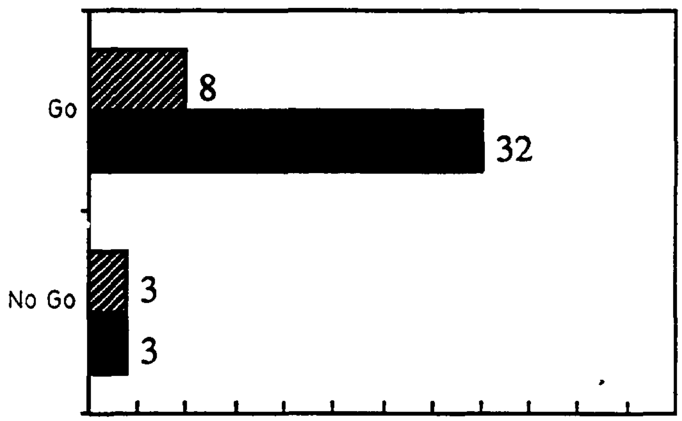
Bn Cmd
Company

Note: Unless indicated, n=47

(Figure continues)

Figure A-8

Data for CITV Skills Test Items (Cont'd)

Skills Test Item	Response Distribution
10. IFF an enemy vehicle using the CITV, DESIGNATE the gunner on the target, and give up control of the gun so he may fire	
11. IFF a enemy vehicle, tell the distance to the vehicle, and engage it from your position n=46	

Bn Cmd
Company

Note: Unless indicated, n=47

Appendix B

CCD and CITV SMI Equipment Usage Data

This appendix presents ANOVA and MANOVA data highlighted in the Results and Discussion section. The SPSS output is organized by measure, following the order of presentation in the text. The terms abbreviated in the SPSS output are listed below:

- DF	Degrees of Freedom
- Hypoth	Hypothesized
- MS	Mean Square
- Sig	Significance
- SS	Sums of Squares

NUMBER OF ALL REPORTS RECEIVED

EFFECT .. ECHELON BY STAGE
Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	2.27986	3017.25505	1.13993	22.35004	.05100	.950
NBC	.06021	58.54798	.03011	.43369	.06942	.933
FREE TEXT	4.85454	525.18687	2.42727	3.89027	.62393	.537
CFF	5.02647	2831.80303	2.51324	20.97632	.11981	.887
CONTACT	45.03098	2219.44949	22.51549	16.44037	1.36952	.258
SHELL	49.77792	3878.22222	24.88896	28.72757	.86638	.423
SITREP	31.86858	5432.25505	15.93429	40.23893	.39599	.674
SPOT	33.50913	2831.89899	16.75457	20.97703	.79871	.452
INTEL	.57139	77.67677	.28569	.57538	.49653	.610
FRAGO	.01723	15.51768	.00861	.11495	.07494	.928
OVERALL	523.90730	36572.5758	261.95365	270.90797	.96695	.383

EFFECT .. STAGE
Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	1031.98198	3017.25505	515.99099	22.35004	23.08681	.000
NBC	183.43610	58.54798	91.71805	.43369	211.48358	.000
FREE TEXT	1413.53539	525.18687	706.76769	3.89027	181.67560	.000
CFF	964.79952	2831.80303	482.39976	20.97632	22.99735	.000
CONTACT	772.32176	2219.44949	386.16088	16.44037	23.48858	.000
SHELL	1155.36657	3878.22222	577.68329	28.72757	20.10902	.000
SITREP	2339.69837	5432.25505	1169.84918	40.23893	29.07257	.000
SPOT	4383.97722	2831.89899	2191.98861	20.97703	104.49471	.000
INTEL	169.08203	77.67677	84.54101	.57538	146.92986	.000
FRAGO	33.43567	15.51768	16.71783	.11495	145.44108	.000
OVERALL	58715.6803	36572.5758	29357.8402	270.90797	108.36832	.000

EFFECT .. ECHELON
Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	11.95446	3017.25505	11.95446	22.35004	.53487	.466
NBC	.03011	58.54798	.03011	.43369	.06942	.793
FREE TEXT	40.51178	525.18687	40.51178	3.89027	10.41361	.002
CFF	6.40454	2831.80303	6.40454	20.97632	.30532	.581
CONTACT	70.92378	2219.44949	70.92378	16.44037	4.31400	.040
SHELL	692.89347	3878.22222	692.89347	28.72757	24.11946	.000
SITREP	4691.49339	5432.25505	4691.49339	40.23893	116.59092	.000
SPOT	51.27273	2831.89899	51.27273	20.97703	2.44423	.120
INTEL	.68801	77.67677	.68801	.57538	1.19575	.276
FRAGO	.03956	15.51768	.03956	.11495	.34418	.558
OVERALL	12461.4744	36572.5758	12461.4744	270.90797	45.99892	.000

NUMBER OF ALL REPORTS RECEIVED

EFFECT .. CONSTANT
Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	3663.86935	3017.25505	3663.86935	22.35004	163.93124	.000
NBC	91.71805	58.54798	91.71805	.43369	211.48358	.000
FREE TEXT	8183.49051	525.18687	8183.49051	3.89027	2103.57738	.000
CFF	6309.78043	2831.80303	6309.78043	20.97632	300.80495	.000
CONTACT	9367.37768	2219.44949	9367.37768	16.44037	569.77912	.000
SHELL	9470.87929	3878.22222	9470.87929	28.72757	329.67907	.000
SITREP	29198.0466	5432.25505	29198.0466	40.23893	725.61694	.000
SPOT	14449.2302	2831.89899	14449.2302	20.97703	688.81202	.000
INTEL	99.41142	77.67677	99.41142	.57538	172.77420	.000
FRAGO	176.91899	15.51768	176.91899	.11495	1539.15207	.000
OVERALL	560189.701	36572.5758	560189.701	270.90797	2067.82290	.000

- - - - - - - - - - -

NUMBER OF UNIQUE REPORTS RECEIVED

EFFECT .. ECHELON BY STAGE
Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	2.06236	2993.33838	1.03118	22.17288	.04651	.955
NBC	.34401	33.10101	.17200	.24519	.70150	.498
FREE TEXT	.26159	138.26768	.13079	1.02421	.12770	.880
CFF	5.51590	2644.64899	2.75795	19.58999	.14078	.869
CONTACT	41.20206	1516.83333	20.60103	11.23580	1.83352	.164
SHELL	38.25321	3404.42677	19.12660	25.21798	.75845	.470
SITREP	27.56247	4729.23485	13.78123	35.03137	.39340	.676
SPOT	17.36589	1708.93182	8.68295	12.65875	.68592	.505
INTEL	.02708	32.09091	.01354	.23771	.05696	.945
FRAGO	.01723	15.51768	.00861	.11495	.07494	.928
OVERALL	301.00906	25384.6591	150.50453	188.03451	.80041	.451

EFFECT .. STAGE
Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	1019.50917	2993.33838	509.75458	22.17288	22.99001	.000
NBC	141.84755	33.10101	70.92378	.24519	289.25733	.000
FREE TEXT	1156.43180	138.26768	578.21590	1.02421	564.55094	.000
CFF	1025.34569	2644.64899	512.67285	19.58999	26.17014	.000
CONTACT	763.89709	1516.83333	381.94855	11.23580	33.99388	.000
SHELL	1031.07590	3404.42677	515.53795	25.21798	20.44327	.000
SITREP	2317.37807	4729.23485	1158.68904	35.03137	33.07576	.000
SPOT	3553.19568	1708.93182	1776.59784	12.65875	140.34539	.000
INTEL	112.87814	32.09091	56.43907	.23771	237.42782	.000
FRAGO	33.43567	15.51768	16.71783	.11495	145.44108	.000
OVERALL	54124.8672	25384.6591	27062.4336	188.03451	143.92269	.000

NUMBER OF UNIQUE REPORTS RECEIVED

EFFECT .. ECHELON
Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	12.93968	2993.33838	12.93968	22.17288	.58358	.446
NBC	.17200	33.10101	.17200	.24519	.70150	.404
FREE TEXT	.15159	138.26768	.15159	1.02421	.14800	.701
CFF	8.60106	2644.64899	8.60106	19.58999	.43905	.509
CONTACT	24.43270	1516.83333	24.43270	11.23580	2.17454	.143
SHELL	630.42641	3404.42677	630.42641	25.21798	24.99909	.000
SITREP	4466.98992	4729.23485	4466.98992	35.03137	127.51400	.000
SPOT	11.14910	1708.93182	11.14910	12.65875	.88074	.350
INTEL	.05222	32.09091	.05222	.23771	.21970	.640
FRAGO	.03956	15.51768	.03956	.11495	.34418	.558
OVERALL	8854.41695	25384.6591	8854.41695	188.03451	47.08932	.000

EFFECT .. CONSTANT
Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	3646.98223	2993.33838	3646.98223	22.17288	164.47943	.000
NBC	70.92378	33.10101	70.92378	.24519	289.25733	.000
FREE TEXT	6832.49201	138.26768	6832.49201	1.02421	6671.01989	.000
CFF	6007.57979	2644.64899	6007.57979	19.58999	306.66575	.000
CONTACT	8037.14192	1516.83333	8037.14192	11.23580	715.31534	.000
SHELL	8830.53988	3404.42677	8830.53988	25.21798	350.16846	.000
SITREP	28120.5786	4729.23485	28120.5786	35.03137	802.72565	.000
SPOT	12298.5534	1708.93182	12298.5534	12.65875	971.54532	.000
INTEL	66.43520	32.09091	66.43520	.23771	279.47954	.000
FRAGO	176.91899	15.51768	176.91899	.11495	1539.15207	.000
OVERALL	507860.091	25384.6591	507860.091	188.03451	2700.88765	.000

\- - - - - - - - - - -

PERCENT OF DUPLICATE REPORTS RECEIVED

EFFECT .. ECHELON BY STAGE
Univariate F-tests with (2,102) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	.76878	151.04167	.38439	1.48080	.25958	.772
FREE TEXT	44.52273	15552.0835	22.26137	152.47141	.14600	.864
CFF	20.35310	1596.91454	10.17655	15.65602	.65001	.524
CONTACT	66.10293	12003.5347	33.05146	117.68171	.28085	.756
SHELL	240.90400	4635.81527	120.45200	45.44917	2.65026	.075
SITREP	42.91125	1321.54064	21.45562	12.95628	1.65600	.196
SPOT	124.28608	11631.8408	62.14304	114.03765	.54493	.582
FRAGO	.00000	.00000	.00000	.00000	.	.
OVERALL	4.63258	2135.94756	2.31629	20.94066	.11061	.895

PERCENT OF DUPLICATE REPORTS RECEIVED

EFFECT .. STAGE
Univariate F-tests with (2,102) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	.76878	151.04167	.38439	1.48080	.25958	.772
FREE TEXT	123.03623	15552.0835	61.51811	152.47141	.40347	.669
CFF	18.75865	1596.91454	9.37933	15.65602	.59909	.551
CONTACT	482.27100	12003.5347	241.13550	117.68171	2.04905	.134
SHELL	127.59846	4635.81527	63.79923	45.44917	1.40375	.250
SITREP	112.34237	1321.54064	56.17119	12.95628	4.33544	.016
SPOT	49.51594	11631.8408	24.75797	114.03765	.21710	.805
FRAGO	.00000	.00000	.00000	.00000	.	.
OVERALL	2.58805	2135.94756	1.29402	20.94066	.06179	.940

EFFECT .. ECHELON
Univariate F-tests with (1,102) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	.36583	151.04167	.36583	1.48080	.24705	.620
FREE TEXT	2352.81972	15552.0835	2352.81972	152.47141	15.43122	.000
CFF	36.68077	1596.91454	36.68077	15.65602	2.34292	.129
CONTACT	573.51738	12003.5347	573.51738	117.68171	4.87346	.030
SHELL	8.60141	4635.81527	8.60141	45.44917	.18925	.664
SITREP	2.22317	1321.54064	2.22317	12.95628	.17159	.680
SPOT	175.64307	11631.8408	175.64307	114.03765	1.54022	.217
FRAGO	.00000	.00000	.00000	.00000	.	.
OVERALL	176.93362	2135.94756	176.93362	20.94066	8.44928	.004

EFFECT .. CONSTANT
Univariate F-tests with (1,102) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	.36583	151.04167	.36583	1.48080	.24705	.620
FREE TEXT	4263.64300	15552.0835	4263.64300	152.47141	27.96356	.000
CFF	55.63665	1596.91454	55.63665	15.65602	3.55369	.062
CONTACT	3044.47764	12003.5347	3044.47764	117.68171	25.87044	.000
SHELL	822.28733	4635.81527	822.28733	45.44917	18.09246	.000
SITREP	236.54448	1321.54064	236.54448	12.95628	18.25713	.000
SPOT	3452.41749	11631.8408	3452.41749	114.03765	30.27436	.000
FRAGO	.00000	.00000	.00000	.00000	.	.
OVERALL	1445.89500	2135.94756	1445.89500	20.94066	69.04724	.000

PERCENT REPORTS RETRIEVED

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 3 , N = 45 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.30790	1.90053	18.00	188.00	.018
Hotellings	.36987	1.89044	18.00	184.00	.019
Wilks	.71400	1.89564	18.00	186.00	.018
Roys	.19630				

EFFECT .. ECHELON BY STAGE (CONT.)
Univariate F-tests with (2,101) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	676.43200	31816.3503	338.21600	315.01337	1.07366	.346
FREE TEXT	1405.79031	111060.838	702.89516	1099.61226	.63922	.530
CFF	23.41007	24880.7535	11.70504	246.34409	.04751	.954
CONTACT	1684.71215	81625.9092	842.35607	808.17732	1.04229	.356
SHELL	51.13948	35456.9930	25.56974	351.05934	.07284	.930
SITREP	393.24017	54459.3005	196.62009	539.20100	.36465	.695
SPOT	4145.48227	111272.888	2072.74113	1101.71176	1.88138	.158
FRAGO	2875.19345	138440.431	1437.59673	1370.69733	1.04881	.354
OVERALL	917.89438	27701.1134	458.94719	274.26845	1.67335	.193

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 3 , N = 45 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.54611	3.92319	18.00	188.00	.000
Hotellings	.91267	4.66474	18.00	184.00	.000
Wilks	.49916	4.29250	18.00	186.00	.000
Roys	.44419				

EFFECT .. STAGE (CONT.)
Univariate F-tests with (2,101) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	558.59614	31816.3503	279.29807	315.01337	.88662	.415
FREE TEXT	3846.05146	111060.838	1923.02573	1099.61226	1.74882	.179
CFF	274.35121	24880.7535	137.17560	246.34409	.55685	.575
CONTACT	1713.58863	81625.9092	856.79432	808.17732	1.06016	.350
SHELL	2393.77821	35456.9930	1196.88911	351.05934	3.40936	.037
SITREP	4958.09314	54459.3005	2479.04657	539.20100	4.59763	.012
SPOT	3962.27252	111272.888	1981.13626	1101.71176	1.79823	.171
FRAGO	3771.38328	138440.431	1885.69164	1370.69733	1.37572	.257
OVERALL	1563.29390	27701.1134	781.64695	274.26845	2.84993	.063

- - - - - - - - - -

PERCENT REPORTS RETRIEVED

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 3 1/2, N = 45 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.37064	6.08544	9.00	93.00	.000
Hotellings	.58891	6.08544	9.00	93.00	.000
Wilks	.62936	6.08544	9.00	93.00	.000
Roys	.37064				

EFFECT .. ECHELON (CONT.)
Univariate F-tests with (1,101) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	1227.88800	31816.3503	1227.88800	315.01337	3.89789	.051
FREE TEXT	5655.00703	111060.838	5655.00703	1099.61226	5.14273	.025
CFF	1456.08243	24880.7535	1456.08243	246.34409	5.91077	.017
CONTACT	30577.5160	81625.9092	30577.5160	808.17732	37.83516	.000
SHELL	3617.51951	35456.9930	3617.51951	351.05934	10.30458	.002
SITREP	8108.12377	54459.3005	8108.12377	539.20100	15.03729	.000
SPOT	21046.9660	111272.888	21046.9660	1101.71176	19.10388	.000
FRAGO	15175.1058	138440.431	15175.1058	1370.69733	11.07108	.001
OVERALL	11353.6415	27701.1134	11353.6415	274.26845	41.39609	.000

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 3 1/2, N = 45 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.89752	90.49721	9.00	93.00	.000
Hotellings	8.75779	90.49721	9.00	93.00	.000
Wilks	.10248	90.49721	9.00	93.00	.000
Roys	.89752				

EFFECT .. CONSTANT (CONT.)
Univariate F-tests with (1,101) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	4764.70633	31816.3503	4764.70633	315.01337	15.12541	.000
FREE TEXT	446556.794	111060.838	446556.794	1099.61226	406.10387	.000
CFF	10328.6407	24880.7535	10328.6407	246.34409	41.92770	.000
CONTACT	201220.059	81625.9092	201220.059	808.17732	248.98009	.000
SHELL	26367.0800	35456.9930	26367.0800	351.05934	75.10719	.000
SITREP	83653.7722	54459.3005	83653.7722	539.20100	155.14395	.000
SPOT	166559.534	111272.888	166559.534	1101.71176	151.18250	.000
FRAGO	511043.550	138440.431	511043.550	1370.69733	372.83472	.000
OVERALL	110428.990	27701.1134	110428.990	274.26845	402.63104	.000

PERCENT REPORTS RETRIEVED FROM RECEIVE QUEUE

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 1 , N = 21)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.19282	.96027	10.00	90.00	.483
Hotellings	.22442	.96501	10.00	86.00	.480
Wilks	.81243	.96316	10.00	88.00	.481
Roys	.16003				

Univariate F-tests with (2,48) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	34.23372	6519.15498	17.11686	135.81573	.12603	.882
CFF	1746.09481	51315.9725	873.04740	1069.08276	.81663	.448
CONTACT	51.16035	30989.4590	25.58018	645.61373	.03962	.961
SPOT	2643.38053	35837.6040	1321.69026	746.61675	1.77024	.181
OVERALL	211.57471	7937.79113	105.78735	165.37065	.63970	.532

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 1 , N = 21)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.14537	.70543	10.00	90.00	.717
Hotellings	.16507	.70979	10.00	86.00	713
Wilks	.85662	.70801	10.00	88.00	.715
Roys	.13012				

Univariate F-tests with (2,48) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	310.39891	6519.15498	155.19945	135.81573	1.14272	.327
CFF	246.62768	51315.9725	123.31384	1069.08276	.11535	.891
CONTACT	388.62366	30989.4590	194.31183	645.61373	.30097	.741
SOIT	1851.67884	35837.6040	925.83942	746.61675	1.24005	.298
OVERALL	62.11414	7937.79113	31.05707	165.37065	.18780	.829

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 21)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.11743	1.17091	5.00	44.00	.339
Hotellings	.13306	1.17091	5.00	44.00	.339
Wilks	.88257	1.17091	5.00	44.00	.339
Roys	.11743				

Univariate F-tests with (1,48) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	63.89426	6519.15498	63.89426	135.81573	.47045	.496
CFF	4083.27362	51315.9725	4083.27362	1069.08276	3.81942	.057
CONTACT	1098.42852	30989.4590	1098.42852	645.61373	1.70137	.198
SPOT	1082.66801	35837.6040	1082.66801	746.61675	1.45010	.234
OVERALL	530.18642	7937.79113	530.18642	165.37065	3.20605	.080

PERCENT REPORTS RETRIEVED FROM RECEIVE QUEUE

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 21)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.98635	635.88064	5.00	44.00	.000
Hotellings	72.25916	635.88064	5.00	44.00	.000
Wilks	.01365	635.88064	5.00	44.00	.000
Roys	.98635				

Univariate F-tests with (1,48) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	349889.515	6519.15498	349889.515	135.81573	2576.20762	.000
CFF	279369.806	51315.9725	279369.806	1069.08276	261.31729	.000
CONTACT	317264.194	30989.4590	317264.194	645.61373	491.41488	.000
SPOT	259352.912	35837.6040	259352.912	746.61675	347.37087	.000
OVERALL	316639.482	7937.79113	316639.482	165.37065	1914.72601	.000

- - - - - - - - - - -

MEAN TIME TO RETRIEVE REPORTS FROM THE RECEIVE QUEUE

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 1/2, N = 47 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.01782	.22026	8.00	196.00	.987
Hotellings	.01801	.21610	8.00	192.00	.988
Wilks	.98225	.21818	8.00	194.00	.987
Roys	.01264				

Univariate F-tests with (2,100) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	1529.61646	450042.475	764.80823	4500.42475	.16994	.844
CONTACT	1805.20392	468296.307	902.60196	4682.96307	.19274	.825
SITREP	586.52297	244662.268	293.26149	2446.62268	.11986	.887
OVERALL	500.44521	140663.688	250.22261	1406.63688	.17789	.837

MEAN TIME TO RETRIEVE REPORTS FROM THE RECEIVE QUEUE

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 1/2, N = 47 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.20803	2.84428	8.00	196.00	.005
Hotellings	.25826	3.09908	8.00	192.00	.003
Wilks	.79352	2.97285	8.00	194.00	.004
Roys	.20029				

Univariate F-tests with (2,100) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	30328.8534	450042.475	15164.4267	4500.42475	3.36955	.038
CONTACT	16112.5136	468296.307	8056.25678	4682.96307	1.72033	.184
SITREP	70.71550	244662.268	35.35775	2446.62268	.01445	.986
OVERALL	20768.6336	140663.688	10384.3168	1406.63688	7.38237	.001

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 1 , N = 47 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.07127	1.86102	4.00	97.00	.123
Hotellings	.07674	1.86102	4.00	97.00	.123
Wilks	.92873	1.86102	4.00	97.00	.123
Roys	.07127				

Univariate F-tests with (1,100) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	23022.2261	450042.475	23022.2261	4500.42475	5.11557	.026
CONTACT	12610.7968	468296.307	12610.7968	4682.96307	2.69291	.104
SITREP	9741.08620	244662.268	9741.08620	2446.62268	3.98144	.049
OVERALL	6847.70581	140663.688	6847.70581	1406.63688	4.86814	.030

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 1 , N = 47 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.74450	70.66193	4.00	97.00	.000
Hotellings	2.91389	70.66193	4.00	97.00	.000
Wilks	.25550	70.66193	4.00	97.00	.000
Roys	.74450				

Univariate F-tests with (1,100) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FREE TEXT	480332.616	450042.475	480332.616	4500.42475	106.73051	.000
CONTACT	278267.152	468296.307	278267.152	4682.96307	59.42117	.000
SITREP	340123.721	244662.268	340123.721	2446.62268	139.01764	.000
OVERALL	371669.801	140663.688	371669.801	1406.63688	264.22583	.000

- - - - - - - - - - -

PERCENT REPORTS POSTED TO TACTICAL MAP

EFFECT .. ECHELON BY STAGE
Univariate F-tests with (2,110) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	43.57982	54617.9905	21.78991	496.52719	.04388	.957
FREE TEXT	.00000	.00000	.00000	.00000	.	.
CFF	353.62479	173531.844	176.81240	1577.56222	.11208	.894
CONTACT	317.38908	108070.367	158.69454	982.45788	.16153	.851
SHELL	675.44284	24168.4078	337.72142	219.71280	1.53710	.220
SITREP	702.57214	16189.0921	351.28607	147.17356	2.38688	.097
SPOT	1984.44516	68088.6829	992.22258	618.98803	1.60298	.206
OVERALL	118.96000	10801.8957	59.48000	98.19905	.60571	.547

EFFECT .. STAGE
Univariate F-tests with (2,110) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	336.45008	54617.9905	168.22504	496.52719	.33880	.713
FREE TEXT	.00000	.00000	.00000	.00000	.	.
CFF	2816.08362	173531.844	1408.04181	1577.56222	.89254	.413
CONTACT	2216.89413	108070.367	1108.44706	982.45788	1.12824	.327
SHELL	992.68377	24168.4078	496.34188	219.71280	2.25905	.109
SITREP	1312.52231	16189.0921	656.26115	147.17356	4.45910	.014
SPOT	4869.95638	68088.6829	2434.97819	618.98803	3.93380	.022
OVERALL	628.64439	10801.8957	314.32220	98.19905	3.20087	.045

EFFECT .. ECHELON
Univariate F-tests with (1,110) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	454.92115	54617.9905	454.92115	496.52719	.91621	.341
FREE TEXT	.00000	.00000	.00000	.00000	.	.
CFF	42.78101	173531.844	42.78101	1577.56222	.02712	.870
CONTACT	25051.6017	108070.367	25051.6017	982.45788	25.49891	.000
SHELL	548.59882	24168.4078	548.59882	219.71280	2.49689	.117
SITREP	3747.65273	16189.0921	3747.65273	147.17356	25.46417	.000
SPOT	22443.5200	68088.6829	22443.5200	618.98803	36.25841	.000
OVERALL	6194.44584	10801.8957	6194.44584	98.19905	63.08051	.000

PERCENT REPORTS POSTED TO TACTICAL MAP

EFFECT .. CONSTANT
Univariate F-tests with (1,110) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	1602.02262	54617.9905	1602.02262	496.52719	3.22645	.075
FREE TEXT	.00000	.00000	.00000	.00000	.	.
CFF	12664.8325	173531.844	12664.8325	1577.56222	8.02810	.005
CONTACT	144244.616	108070.367	144244.616	982.45788	146.82015	.000
SHELL	6690.41866	24168.4078	6690.41866	219.71280	30.45075	.000
SITREP	7399.01451	16189.0921	7399.01451	147.17356	50.27407	.000
SPOT	115702.308	68088.6829	115702.308	618.98803	186.92172	.000
OVERALL	25638.2307	10801.8957	25638.2307	98.19905	261.08430	.000

\- - - - - - - - - -

NUMBER OF DIGITAL REPORTS SENT

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 2 1/2, N = 59 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.15610	1.29106	16.00	244.00	.203
Hotellings	.17428	1.30713	16.00	240.00	.193
Wilks	.84805	1.29924	16.00	242.00	.198
Roys	.12211				

Univariate F-tests with (2,128) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	.86581	442.25000	.43290	3.45508	.12529	.882
NBC	1.09126	10.97222	.54563	.08572	6.36524	.002
CFF	1.72636	534.86984	.86318	4.17867	.20657	.814
CONTACT	1.41693	346.57857	.70846	2.70765	.26165	.770
SHELL	2.95718	168.68651	1.47859	1.31786	1.12196	.329
SITREP	1.76028	243.25714	.88014	1.90045	.46312	.630
SPOT	5.76240	391.55873	2.88120	3.05905	.94186	.393
OVERALL	67.66973	4198.92937	33.83487	32.80414	1.03142	.359

NUMBER OF DIGITAL REPORTS SENT

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 2 1/2, N = 59 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.17861	1.49544	16.00	244.00	.102
Hotellings	.20004	1.50028	16.00	240.00	.100
Wilks	.82789	1.49798	16.00	242.00	.101
Roys	.12771				

Univariate F-tests with (2,128) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	14.34507	442.25000	7.17253	3.45508	2.07594	.130
NBC	1.09126	10.97222	.54563	.08572	6.36524	.002
CFF	9.50886	534.86984	4.75443	4.17867	1.13779	.324
CONTACT	1.38238	346.57857	.69119	2.70765	.25527	.775
SHELL	5.52718	168.68651	2.76359	1.31786	2.09702	.127
SITREP	1.54132	243.25714	.77066	1.90045	.40551	.667
SPOT	1.88897	391.55873	.94448	3.05905	.30875	.735
OVERALL	50.37149	4198.92937	25.18574	32.80414	.76776	.466

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 3 , N = 59 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.25829	5.26706	8.00	121.00	.000
Hotellings	.34824	5.26706	8.00	121.00	.000
Wilks	.74171	5.26706	8.00	121.00	.000
Roys	.25829				

Univariate F-tests with (1,128) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	24.15381	442.25000	24.15381	3.45508	6.99081	.009
NBC	.50993	10.97222	.50993	.08572	5.94877	.016
CFF	22.83917	534.86984	22.83917	4.17867	5.46566	.021
CONTACT	42.01711	346.57857	42.01711	2.70765	15.51795	.000
SHELL	11.17193	168.68651	11.17193	1.31786	8.47731	.004
SITREP	24.26010	243.25714	24.26010	1.90045	12.76547	.000
SPOT	25.48100	391.55873	25.48100	3.05905	8.32970	.005
OVERALL	912.01649	4198.92937	912.01649	32.80414	27.80188	.000

NUMBER OF DIGITAL REPORTS SENT

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 3 , N = 59 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.47338	13.59577	8.00	121.00	.000
Hotellings	.89889	13.59577	8.00	121.00	.000
Wilks	.52662	13.59577	8.00	121.00	.000
Roys	.47338				

Univariate F-tests with (1,128) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ADJUST	48.03766	442.25000	48.03766	3.45508	13.90349	.000
NBC	.50993	10.97222	.50993	.08572	5.94877	.016
CFF	100.13863	534.86984	100.13863	4.17867	23.96423	.000
CONTACT	104.77896	346.57857	104.77896	2.70765	38.69745	.000
SHELL	42.07937	168.68651	42.07937	1.31786	31.93000	.000
SITREP	35.95197	243.25714	35.95197	1.90045	18.91765	.000
SPOT	176.00167	391.55873	176.00167	3.05905	57.53470	.000
OVERALL	2922.87070	4198.92937	2922.87070	32.80414	89.10068	.000

- - - - - - - - - -

PERCENT TIME VEHICLE COMMANDERS USED TACTICAL MAP (CCD) AND PAPER LAP MAP

CCD Tactical Map

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	1823.078	3	607.693	.251	.861
ECHELON	419.172	1	419.172	.173	.678
STAGE	1403.907	2	701.953	.290	.749
2-way Interactions	251.405	2	125.702	.052	.949
ECHELON STAGE	251.405	2	125.702	.052	.949
Explained	2074.483	5	414.897	.171	.973
Residual	310355.226	128	2424.650		
Total	312429.709	133	2349.096		

Lap Map

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	361.287	3	120.429	1.331	.267
ECHELON	33.500	1	33.500	.370	.544
STAGE	327.787	2	163.894	1.811	.168
2-way Interactions	220.356	2	110.178	1.217	.299
ECHELON STAGE	220.356	2	110.178	1.217	.299
Explained	581.643	5	116.329	1.285	.274
Residual	11583.946	128	90.500		
Total	12165.590	133	91.471		

PERCENT TIME VEHICLE COMMANDERS USED VISION BLOCKS, GPSE, CCD, & CITV

Vision Blocks

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	201830.898	4	50457.724	185.993	.000
ECHELON	1389.570	1	1389.570	5.122	.025
CONDITION	201003.184	1	201003.184	740.923	.000
STAGE	58.761	2	29.380	.108	.897
2-way Interactions	392.197	5	78.439	.289	.918
ECHELON CONDITION	213.295	1	213.295	.786	.377
ECHELON STAGE	73.523	2	36.761	.136	.873
CONDITION STAGE	98.930	2	49.465	.182	.834
3-way Interactions	258.663	2	129.331	.477	.622
ECHELON CONDITION STAGE	258.663	2	129.331	.477	.622
Explained	202481.757	11	18407.432	67.852	.000
Residual	33097.086	122	271.288		
Total	235578.843	133	1771.269		

GPSE

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	6428.017	4	1607.004	11.806	.000
ECHELON	803.623	1	803.623	5.904	.017
CONDITION	4672.104	1	4672.104	34.325	.000
STAGE	619.176	2	309.588	2.274	.107
2-way Interactions	1218.427	5	243.685	1.790	.120
ECHELON CONDITION	599.650	1	599.650	4.406	.038
ECHELON STAGE	109.795	2	54.898	.403	.669
CONDITION STAGE	472.111	2	236.055	1.734	.181
3-way Interactions	119.843	2	59.922	.440	.645
ECHELON CONDITION STAGE	119.843	2	59.922	.440	.645
Explained	7766.287	11	706.026	5.187	.000
Residual	16605.773	122	136.113		
Total	24372.060	133	183.249		

PERCENT TIME VEHICLE COMMANDER USED VISION BLOCKS, GPSE, CCD, & CITV

CCD

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	792.152	3	264.051	.195	.899
ECHELON	195.851	1	195.851	.145	.704
STAGE	596.301	2	298.151	.221	.802
2-way Interactions	88.443	2	44.222	.033	.968
ECHELON STAGE	88.443	2	44.222	.033	.968
Explained	880.595	5	176.119	.130	.985
Residual	172953.226	128	1351.197		
Total	173833.821	133	1307.021		

CITV

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	795.240	3	265.080	.723	.540
ECHELON	788.246	1	788.246	2.149	.145
STAGE	6.994	2	3.497	.010	.991
2-way Interactions	24.546	2	12.273	.033	.967
ECHELON STAGE	24.546	2	12.273	.033	.967
Explained	819.785	5	163.957	.447	.815
Residual	46942.849	128	366.741		
Total	47762.634	133	359.118		

- - - - - - - - - - -

PERCENT TIME EACH MAP SCROLL FUNCTION IN EFFECT

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 0, N = 65 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.03658	.83228	6.00	268.00	.546
Hotellings	.03794	.83458	6.00	264.00	.544
Wilks	.96343	.83349	6.00	266.00	.545
Roys	.03608				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FOLLOW	3165.09105	166436.669	1582.54552	1232.86422	1.28363	.280
JUMP	3463.26050	148543.477	1731.63025	1100.32205	1.57375	.211
MOVE	21.19527	927.91772	10.59764	6.87346	1.54182	.218

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 0, N = 65 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.18822	4.64025	6.00	268.00	.000
Hotellings	.22105	4.86314	6.00	264.00	.000
Wilks	.81573	4.75258	6.00	266.00	.000
Roys	.16416				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FOLLOW	9567.49326	166436.669	4783.74663	1232.86422	3.88019	.023
JUMP	9206.94604	148543.477	4603.47302	1100.32205	4.18375	.017
MOVE	4.28207	927.91772	2.14104	6.87346	.31149	.733

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 1/2, N = 65 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.01701	.76710	3.00	133.00	.514
Hotellings	.01730	.76710	3.00	133.00	.514
Wilks	.98299	.76710	3.00	133.00	.514
Roys	.01701				

Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
FOLLOW	214.53772	166436.669	214.53772	1232.86422	.17402	.677
JUMP	563.28970	148543.477	563.28970	1100.32205	.51193	.476
MOVE	7.84913	927.91772	7.84913	6.87346	1.14195	.287

- - - - - - - - - - -

PERCENT TIME EACH MAP SCALE IN EFFECT

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 1/2, N = 65)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.07427	1.28228	8.00	266.00	.253
Hotellings	.08007	1.31113	8.00	262.00	.238
Wilks	.92580	1.29688	8.00	264.00	.245
Roys	.07333				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
25 K	29.71482	40530.9901	14.85741	300.22956	.04949	.952
50 K	2889.94519	142468.170	1444.97260	1055.31978	1.36923	.258
125 K	1705.16579	48136.6347	852.58290	356.56766	2.39108	.095
250 K	30.47450	654.43919	15.23725	4.84770	3.14319	.046

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 1/2, N = 65)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.20196	3.73465	8.00	266.00	.000
Hotellings	.25065	4.10436	8.00	262.00	.000
Wilks	.79890	3.92051	8.00	264.00	.000
Roys	.19762				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
25 K	168.81895	40530.9901	84.40947	300.22956	.28115	.755
50 K	11458.3507	142468.170	5729.17534	1055.31978	5.42885	.005
125 K	2320.70746	48136.6347	1160.35373	356.56766	3.25423	.042
250 K	35.01659	654.43919	17.50830	4.84770	3.61167	.030

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 1 , N = 65)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.43493	25.39954	4.00	132.00	.000
Hotellings	.76968	25.39954	4.00	132.00	.000
Wilks	.56507	25.39954	4.00	132.00	.000
Roys	.43493				

Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
25 K	998.13212	40530.9901	998.13212	300.22956	3.32456	.070
50 K	20880.0011	142468.170	20880.0011	1055.31978	19.78547	.000
125 K	33785.3853	48136.6347	33785.3853	356.56766	94.75168	.000
250 K	17.41065	654.43919	17.41065	4.84770	3.59153	.060

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 1 , N = 65)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.80972	140.43005	4.00	132.00	.000
Hotellings	4.25546	140.43005	4.00	132.00	.000
Wilks	.19028	140.43005	4.00	132.00	.000
Roys	.80972				

Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
25 K	4275.61292	40530.9901	4275.61292	300.22956	14.24115	.000
50 K	211934.537	142468.170	211934.537	1055.31978	200.82495	.000
125 K	45683.2344	48136.6347	45683.2344	356.56766	128.11940	.000
250 K	42.04148	654.43919	42.04148	4.84770	8.67246	.004

- - - - - - - - - -

PERCENT TIME EACH MAP FEATURE IN EFFECT

EFFECT .. ECHELON BY STAGE
Multivariate Tests of Significance (S = 2, M = 1 , N = 64 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.03158	.42359	10.00	264.00	.935
Hotellings	.03234	.42036	10.00	260.00	.936
Wilks	.96855	.42199	10.00	262.00	.935
Roys	.02659				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
CONTOUR	1858.70272	224514.194	929.35136	1663.06810	.55882	.573
GRID	68.45783	135366.245	34.22891	1002.71293	.03414	.966
RIVER	420.63741	165949.261	210.31870	1229.25378	.17109	.843
ROAD	371.90107	148234.102	185.95053	1098.03038	.16935	.844
VEGETATION	3869.75157	221531.324	1934.87579	1640.97277	1.17910	.311

EFFECT .. STAGE
Multivariate Tests of Significance (S = 2, M = 1 , N = 64 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.18006	2.61200	10.00	264.00	.005
Hotellings	.21385	2.78000	10.00	260.00	.003
Wilks	.82207	2.69661	10.00	262.00	.004
Roys	.16731				

Univariate F-tests with (2,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
CONTOUR	17204.2412	224514.194	8602.12062	1663.06810	5.17244	.007
GRID	25356.7477	135366.245	12678.3738	1002.71293	12.64407	.000
RIVER	23967.0688	165949.261	11983.5344	1229.25378	9.74863	.000
ROAD	23767.9011	148234.102	11883.9506	1098.03038	10.82297	.000
VEGETATION	7876.96218	221531.324	3938.48109	1640.97277	2.40009	.095

PERCENT TIME EACH MAP FEATURE IN EFFECT

EFFECT .. ECHELON
Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 64 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.14009	4.26847	5.00	131.00	.001
Hotellings	.16292	4.26847	5.00	131.00	.001
Wilks	.85991	4.26847	5.00	131.00	.001
Roys	.14009				

Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
CONTOUR	2261.89234	224514.194	2261.89234	1663.06810	1.36007	.246
GRID	143.59836	135366.245	143.59836	1002.71293	.14321	.706
RIVER	43.65252	165949.261	43.65252	1229.25378	.03551	.851
ROAD	523.29967	148234.102	523.29967	1098.03038	.47658	.491
VEGETATION	15773.2520	221531.324	15773.2520	1640.97277	9.61214	.002

EFFECT .. CONSTANT
Multivariate Tests of Significance (S = 1, M = 1 1/2, N = 64 1/2)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.80629	109.05133	5.00	131.00	.000
Hotellings	4.16226	109.05133	5.00	131.00	.000
Wilks	.19371	109.05133	5.00	131.00	.000
Roys	.80629				

Univariate F-tests with (1,135) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
CONTOUR	286613.740	224514.194	286613.740	1663.06810	172.34035	.000
GRID	556332.444	135366.245	556332.444	1002.71293	554.82724	.000
RIVER	482302.015	165949.261	482302.015	1229.25378	392.35349	.000
ROAD	505163.304	148234.102	505163.304	1098.03038	460.06314	.000
VEGETATION	197285.957	221531.324	197285.957	1640.97277	120.22500	.000

- - - - - - - - - -

PERCENT TIME IN EACH CITV MODE

CITV Mode

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	135866.450	6	22644.408	39.997	.000
ECHELON	.000	1	.000	.000	1.000
STAGE	.000	2	.000	.000	1.000
MODE	135866.450	3	45288.817	79.994	.000
2-way Interactions	7927.435	11	720.676	1.273	.236
ECHELON STAGE	.000	2	.000	.000	1.000
ECHELON MODE	3538.771	3	1179.590	2.084	.101
STAGE MODE	4388.664	6	731.444	1.292	.259
3-way Interactions	1313.334	6	218.889	.387	.888
ECHELON STAGE MODE	1313.334	6	218.889	.387	.888
Explained	145107.219	23	6309.010	11.144	.000
Residual	305720.763	540	566.150		
Total	450827.981	563	800.760		

NUMBER OF TIMES CITV LASER USED

CITV Laser

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	3721.373	3	1240.458	3.134	.028
ECHELON	1949.997	1	1949.997	4.926	.028
STAGE	1840.362	2	920.181	2.325	.102
2-way Interactions	101.461	2	50.731	.128	.880
ECHELON STAGE	101.461	2	50.731	.128	.880
Explained	3822.834	5	764.567	1.931	.093
Residual	53044.052	134	395.851		
Total	56866.886	139	409.114		

NUMBER OF TIMES DESIGNATE USED

CITV Designate

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	33.020	3	11.007	3.428	.019
ECHELON	14.282	1	14.282	4.448	.037
STAGE	18.738	2	9.369	2.918	.057
2-way Interactions	2.872	2	1.436	.447	.640
ECHELON STAGE	2.872	2	1.436	.447	.640
Explained	35.891	5	7.178	2.236	.054
Residual	433.442	135	3.211		
Total	469.333	140	3.352		

Appendix C

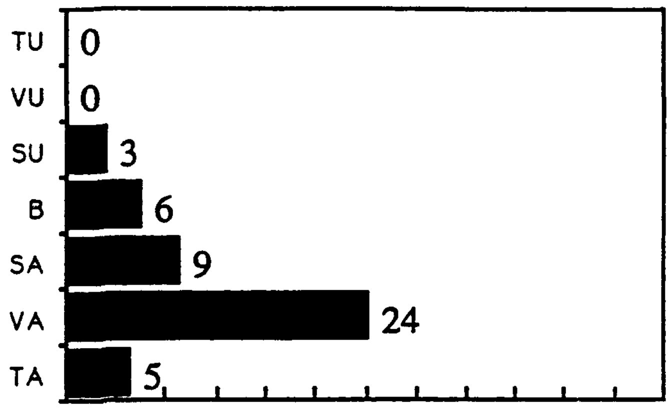
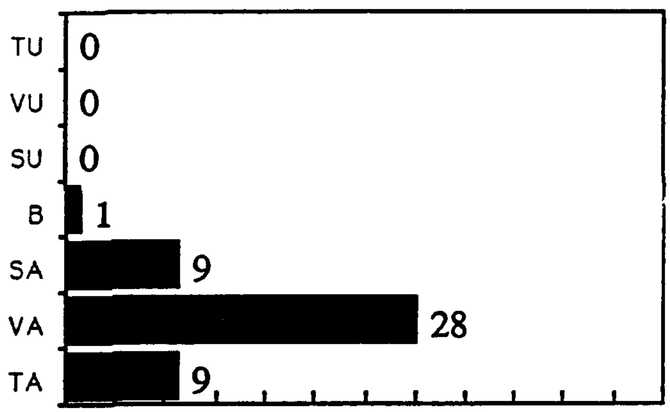
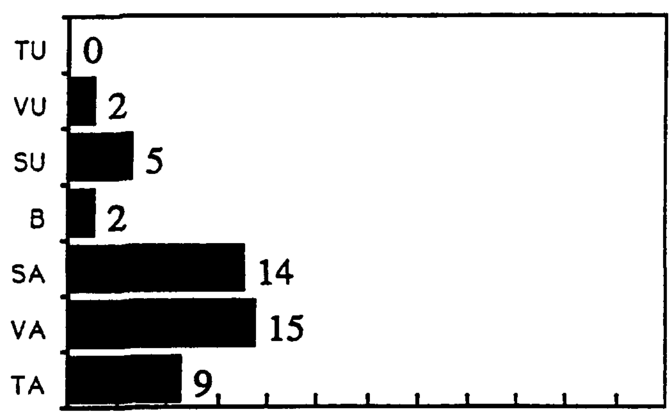
CCD and CITV SMI Questionnaire Data

The following data are included in Appendix C:

Pages	Data
C-2 through C-13	CCD SMI Questionnaire Ratings
C-14 through C-19	CITV SMI Questionnaire Ratings

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items

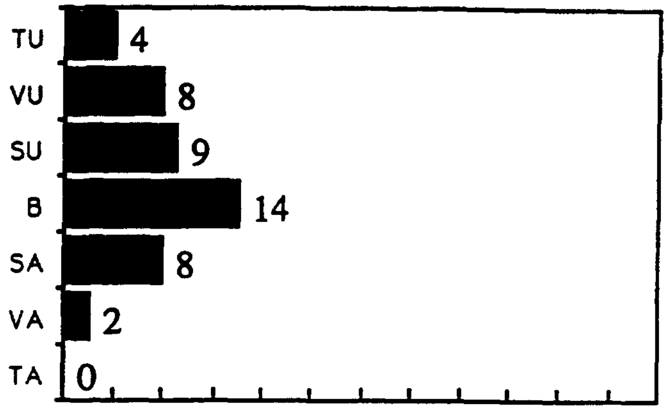
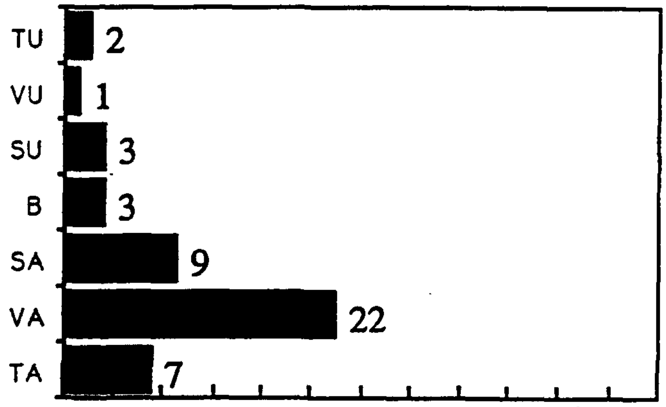
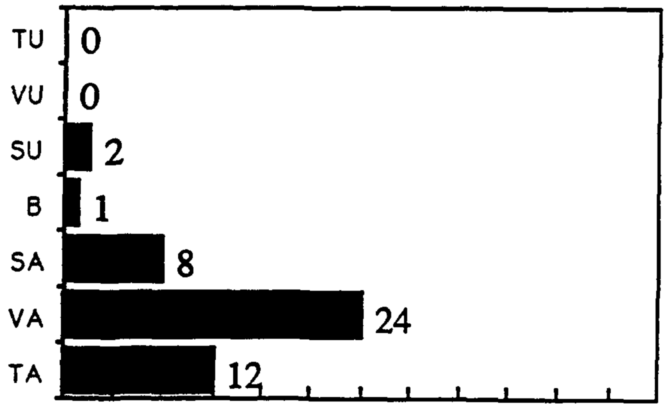
Questionnaire Item	M	S.D.	Response Distribution
Location of the CCD	5.47	1.06	
Fidelity of the Information	5.96	.69	
Touch Screen	5.32	1.37	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

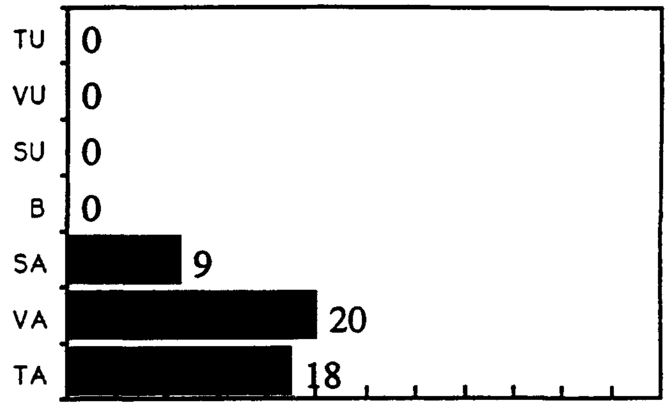
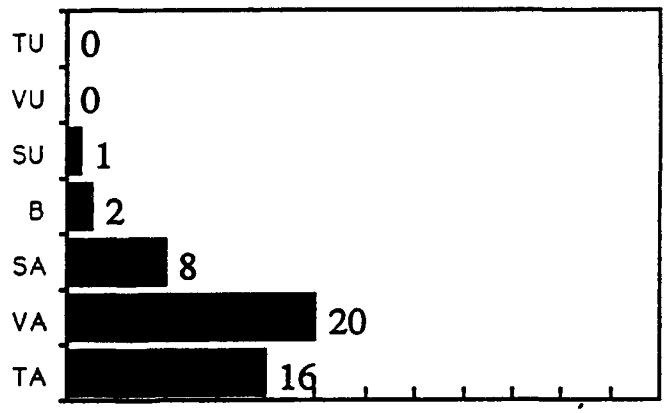
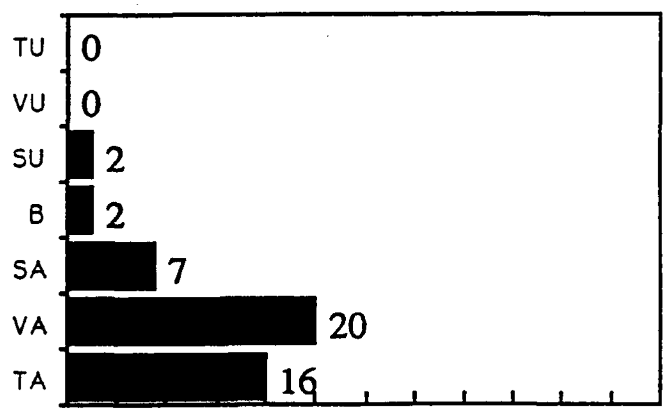
Questionnaire Item	M	S.D.	Response Distribution
Thumb cursor n=45	3.44	1.34	
Feedback (confirmation of actions)	5.34	1.48	
Understandability of Information on the Tactical Map	5.92	.95	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

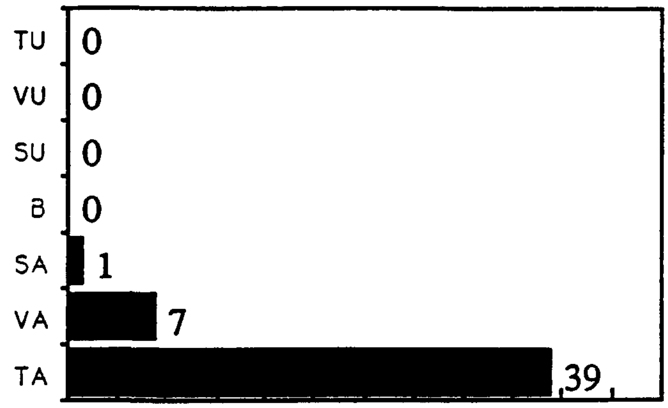
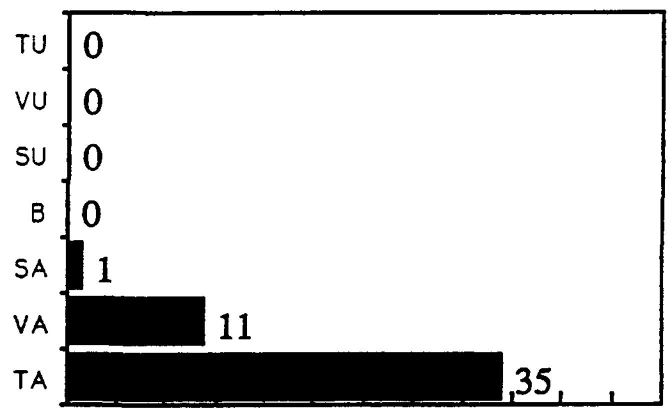
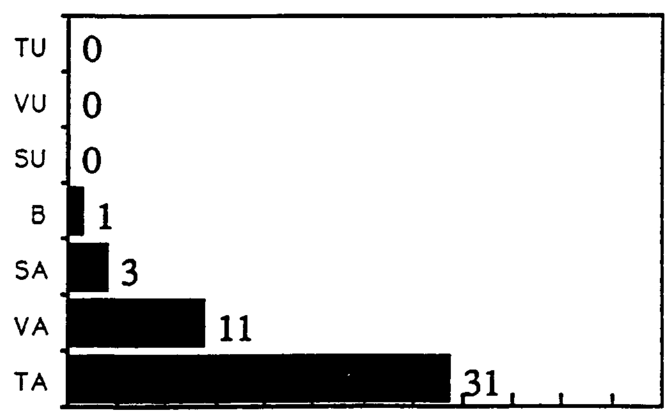
Questionnaire Item	M	S.D.	Response Distribution
Usefulness of Information on the Tactical Map	6.19	.74	
Scrolling the Map (Move, Jump, Follow)	6.02	.94	
Aggregation of Vehicle Icons	5.98	1.03	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

Questionnaire Item	M	S.D.	Response Distribution
Ability to Navigate with POSNAV	6.81	.45	
Creating Routes	6.72	.50	
Changing Waypoints in a Route n=46	6.57	.72	

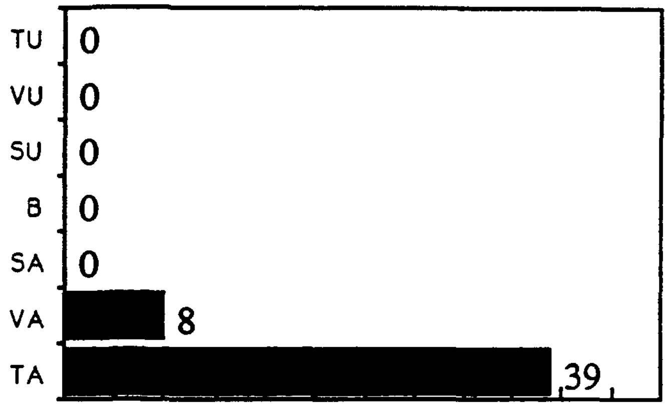
(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

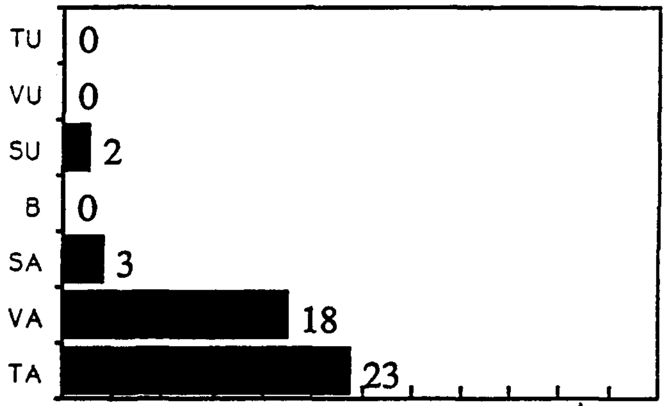
Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

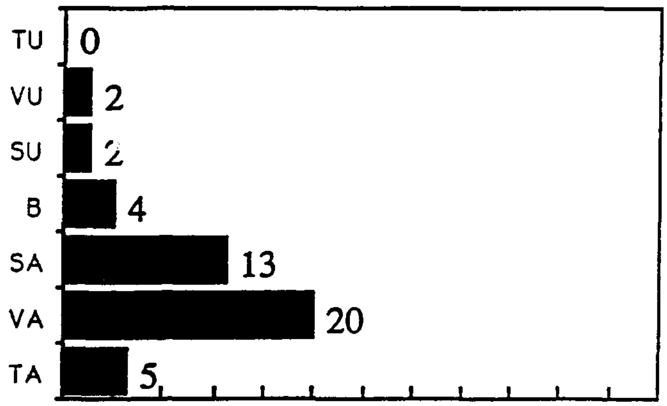
Questionnaire Item	M	S.D.	Response Distribution
Sending Waypoints to Driver	6.83	.38	



Questionnaire Item	M	S.D.	Response Distribution
Appearance of Overlays on the Tactical Map n=46	6.30	.94	



Questionnaire Item	M	S.D.	Response Distribution
Amount of Information in Menu/Report Area n=46	5.35	1.20	

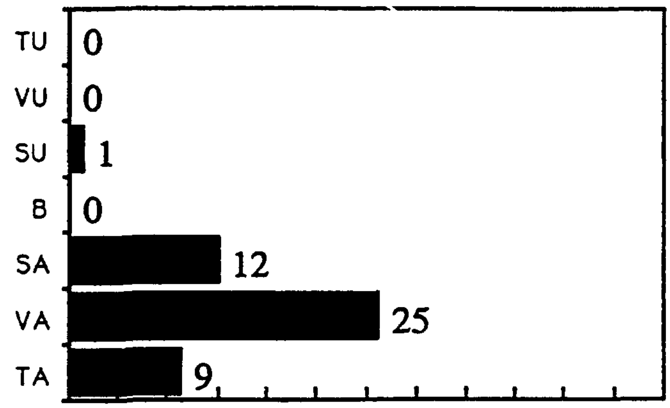
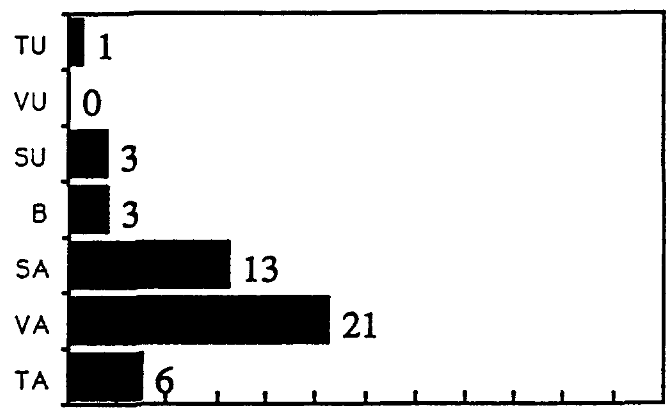
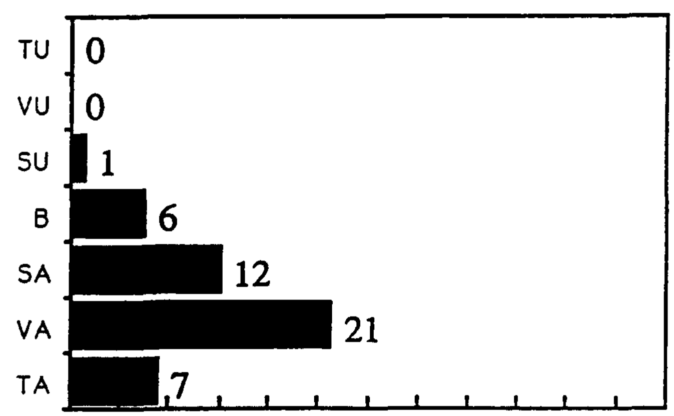


(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

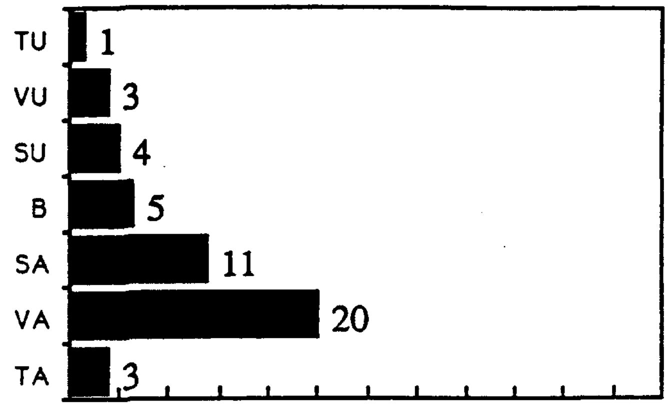
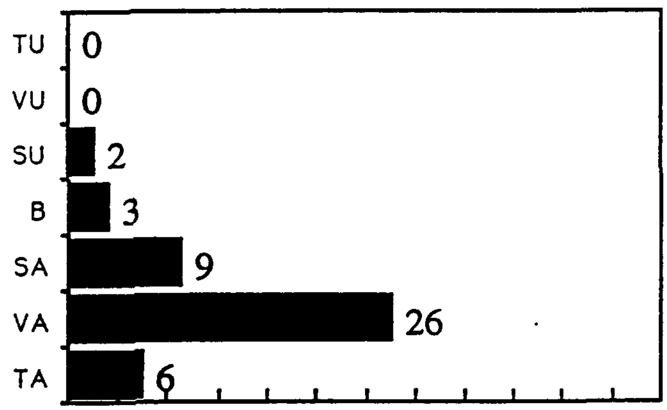
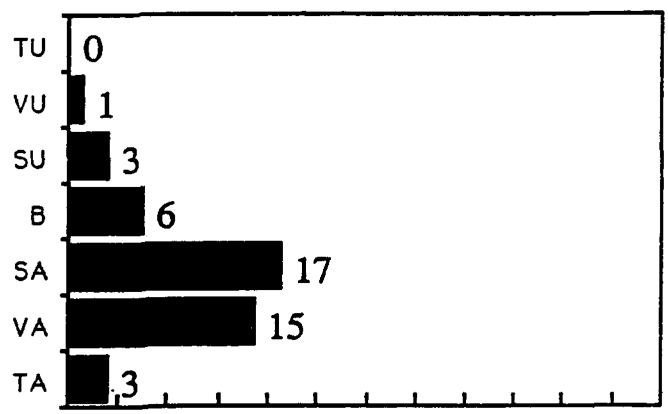
Questionnaire Item	M	S.D.	Response Distribution
Understandability of Information in Menu/Report Area	5.87	.80	
Size of Menu/Report Input Field	5.43	1.21	
Reading Reports	5.57	.97	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

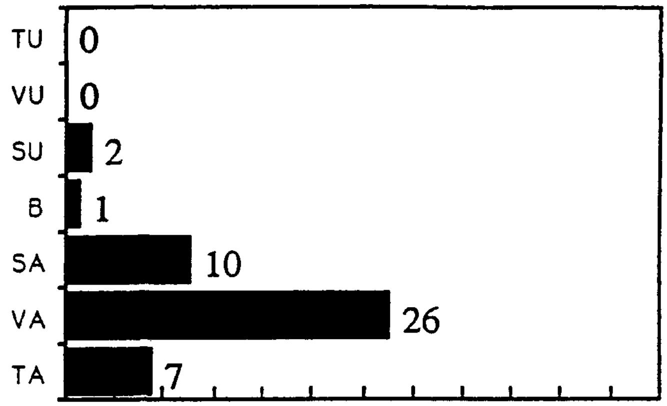
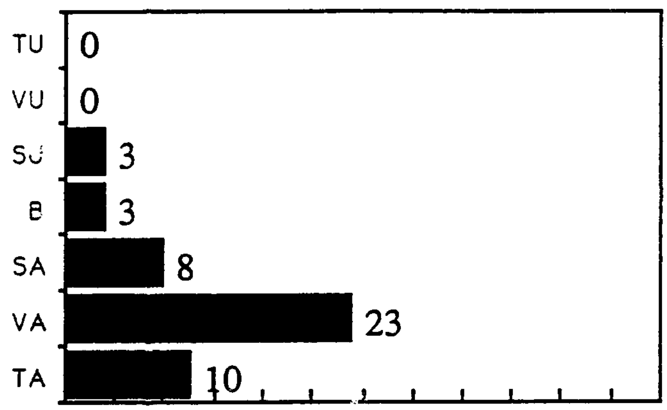
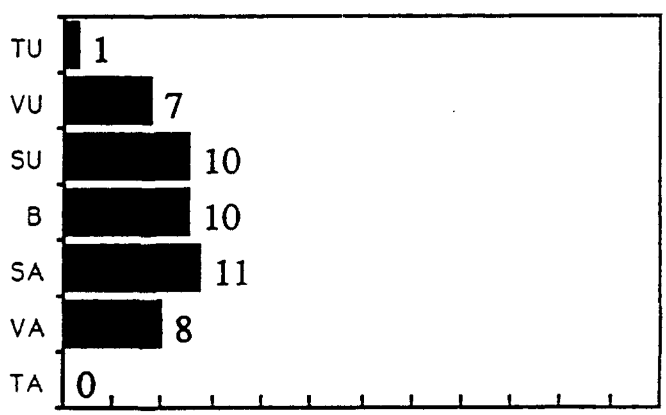
Questionnaire Item	M	S.D.	Response Distribution
Creating Reports	5.00	1.45	
Automatic Advance of Highlighted Input Fields n=46	5.67	.94	
Report Formats n=45	5.13	1.10	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

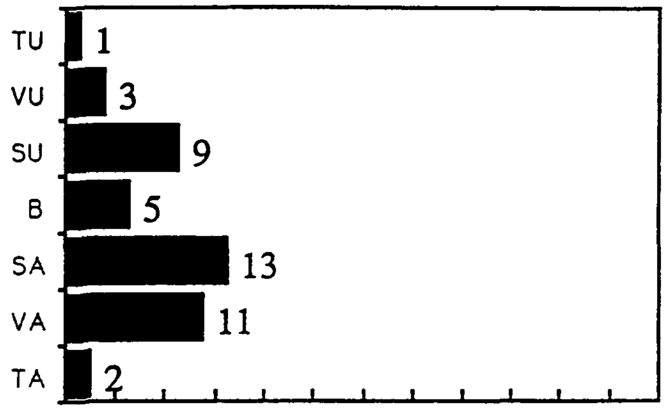
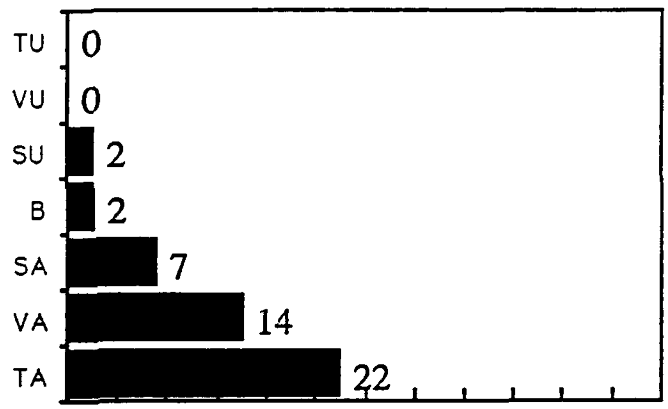
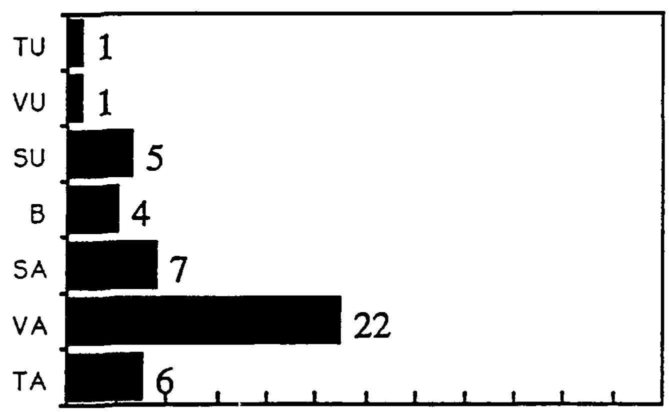
Questionnaire Item	M	S.D.	Response Distribution
Report Icons n=46	5.76	.90	
Report Status Information	5.72	1.08	
Number of Reports Received	4.00	1.40	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

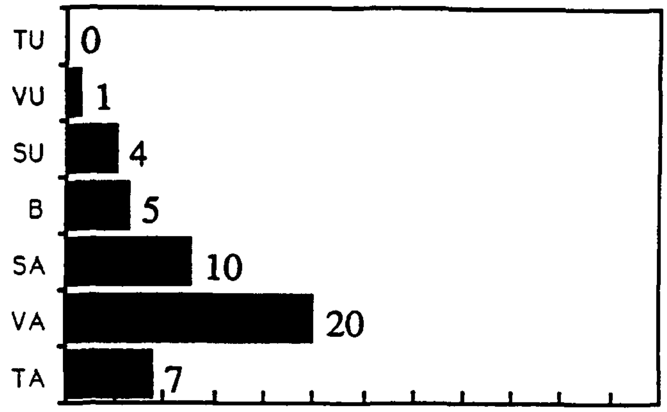
Questionnaire Item	M	S.D.	Response Distribution
Reports from SAFOR Vehicles n=44	4.52	1.47	
Capability to Receive/Send Overlays	6.11	1.09	
Auditory Signals of Received Messages n=46	5.28	1.43	

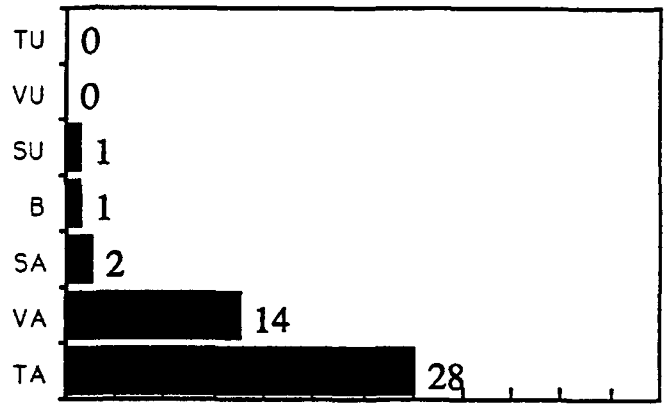
(Figure continues)

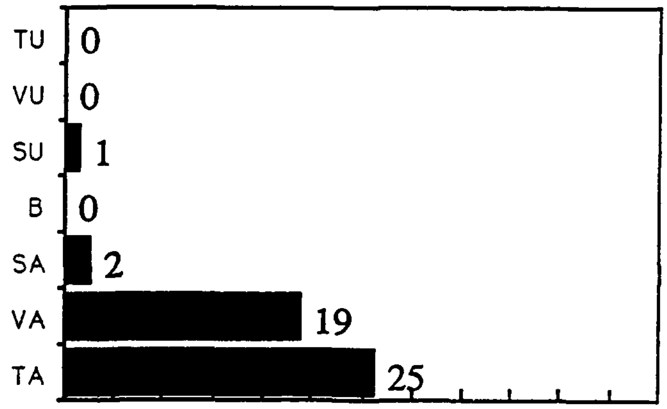
Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

Questionnaire Item	M	S.D.	Response Distribution
Visual Signals of Received Message	5.38	1.24	

Questionnaire Item	M	S.D.	Response Distribution
Integration of CCD with CITV n=46	6.46	.86	

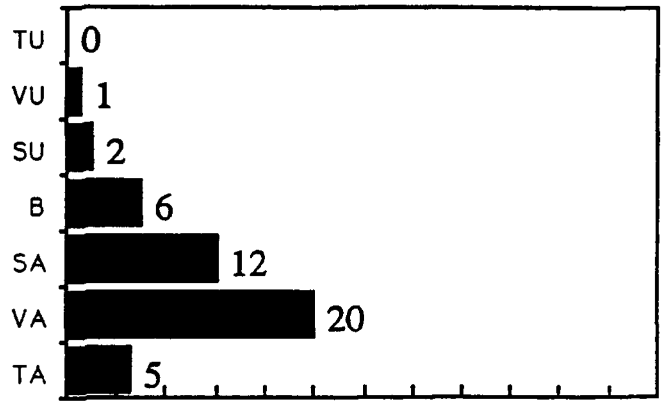
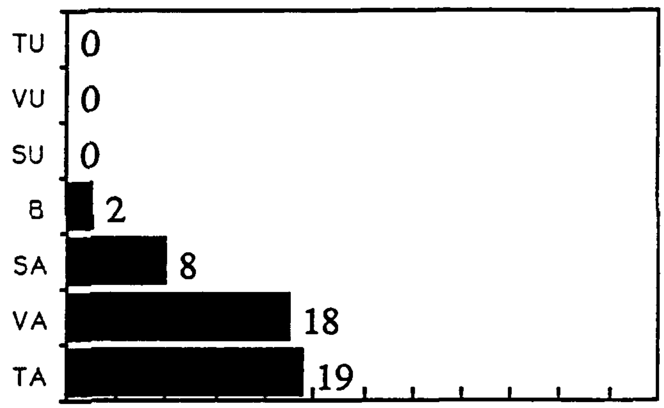
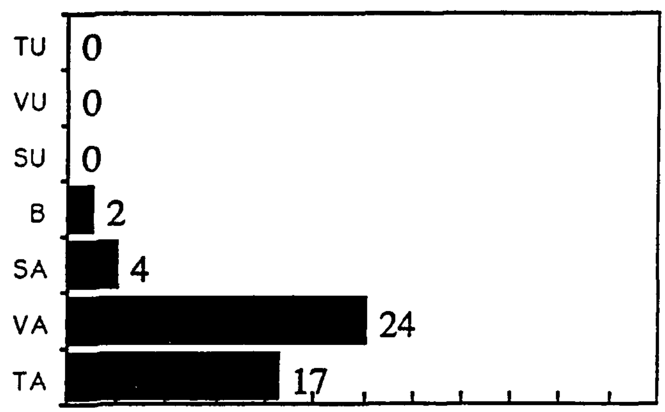
Questionnaire Item	M	S.D.	Response Distribution
Ability to Allocate More Responsibility to the Driver	6.43	0.77	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

Data for Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

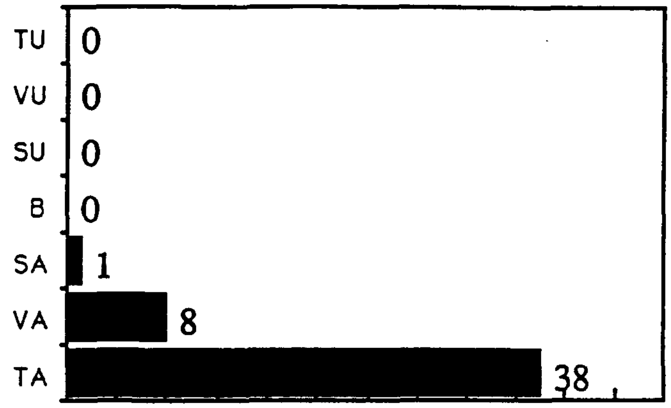
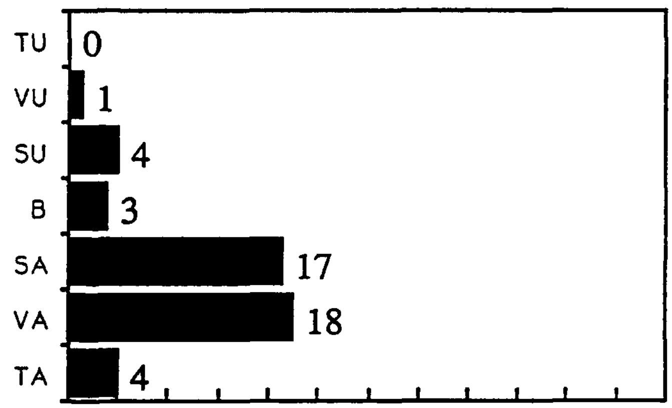
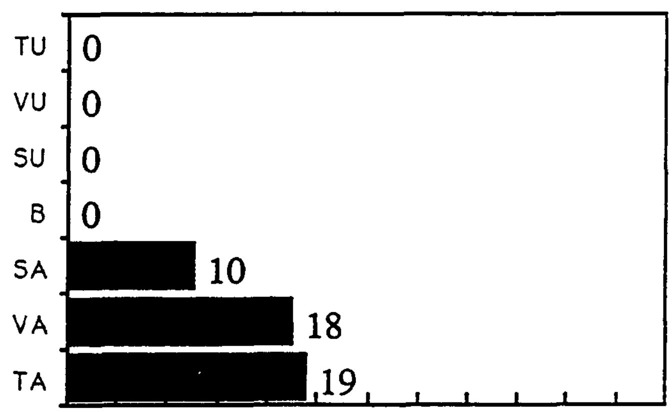
Questionnaire Item	M	S.D.	Response Distribution
System Response Time n=46	5.37	1.12	
CCD Contribution to Performance of Your Duties	6.15	.86	
Overall Rating of Tactical Map	6.19	.77	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-1

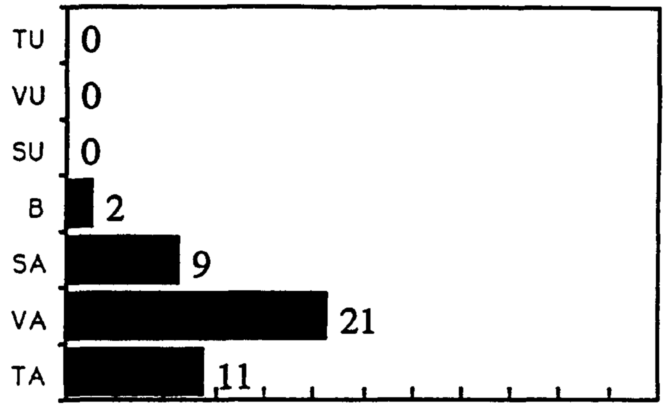
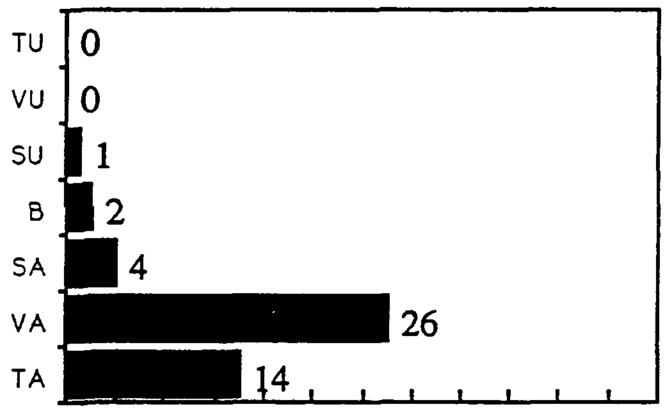
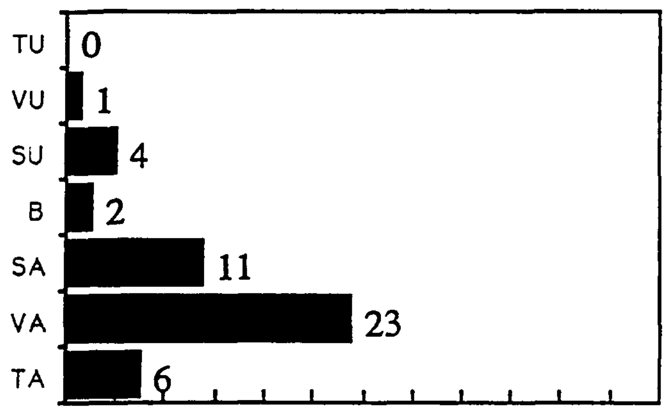
Soldier-Machine Interface CCD Questionnaire Items (Cont'd)

Questionnaire Item	M	S.D.	Response Distribution
Overall Rating of Navigation	6.79	.46	
Overall Rating of Reports	5.26	1.13	
Overall Rating of Overlays	6.19	.77	

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items

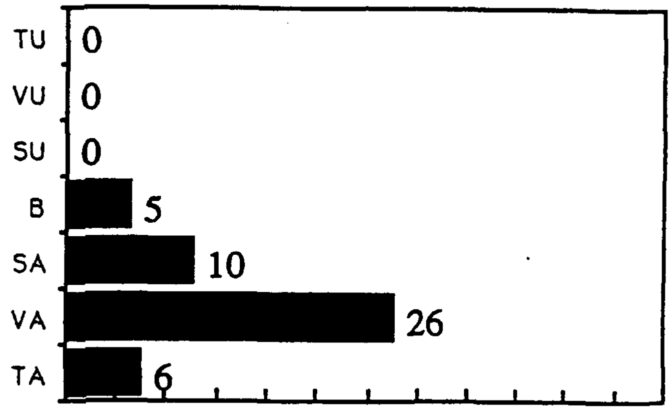
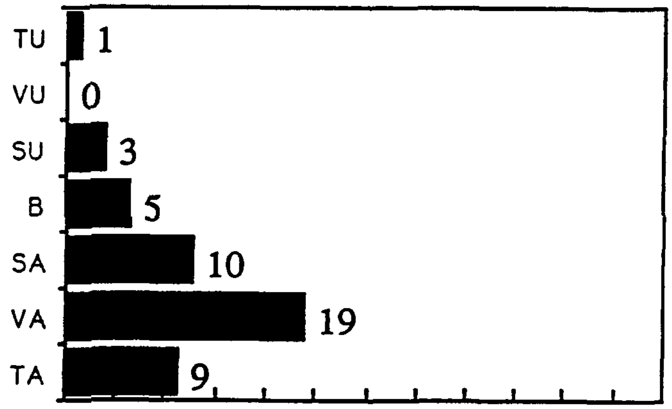
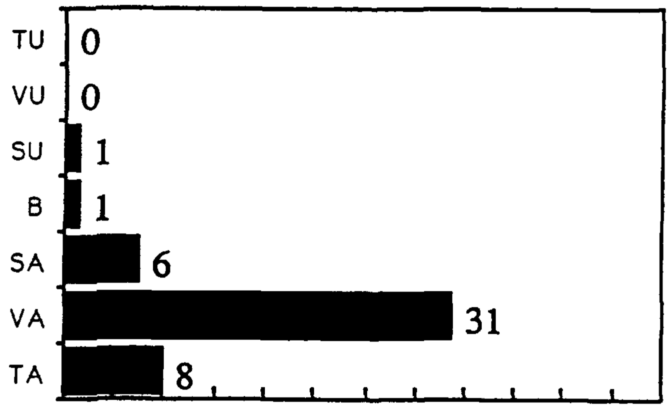
Questionnaire Item	M	S.D.	Response Distribution
Fidelity of Information on on the CITV n=43	5.95	.82	
Understandability of Information on the CITV	6.06	.87	
Location of Operating Controls and Switches	5.47	1.18	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items (Cont'd)

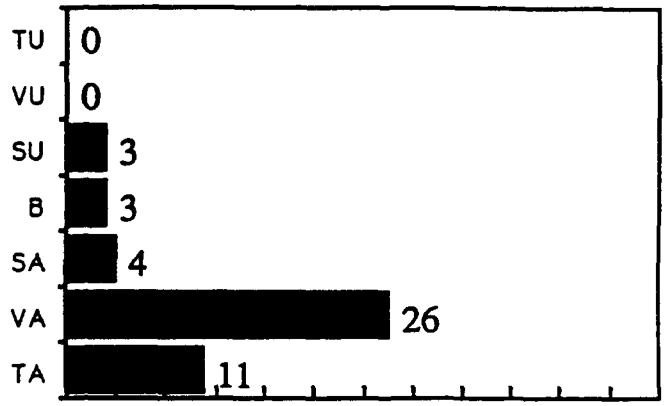
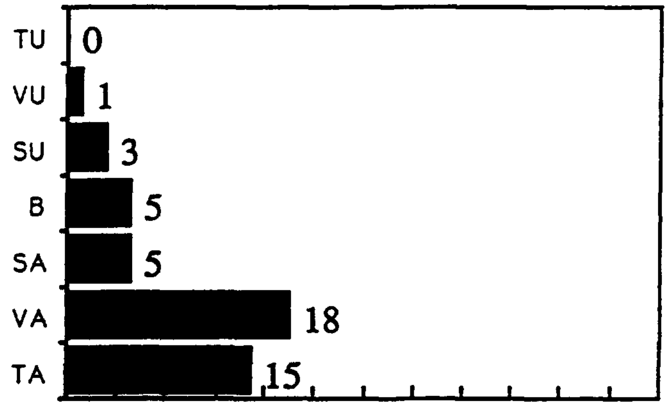
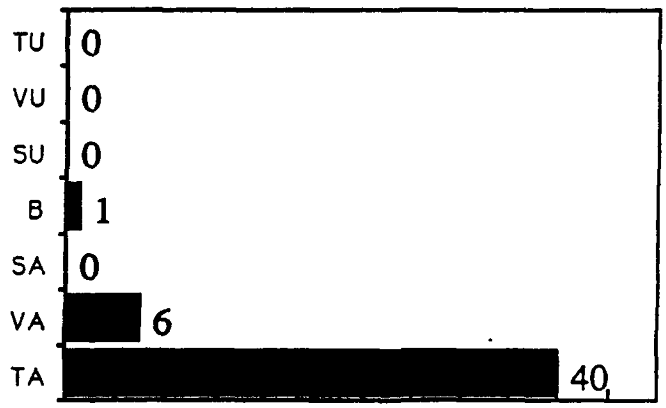
Questionnaire Item	M	S.D.	Response Distribution
Complexity of Operation	5.70	.83	
Commander's Control Handle	5.47	1.30	
Operating Modes (Autoscan, Manual Search, GLOS)	5.94	.76	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items (Cont'd)

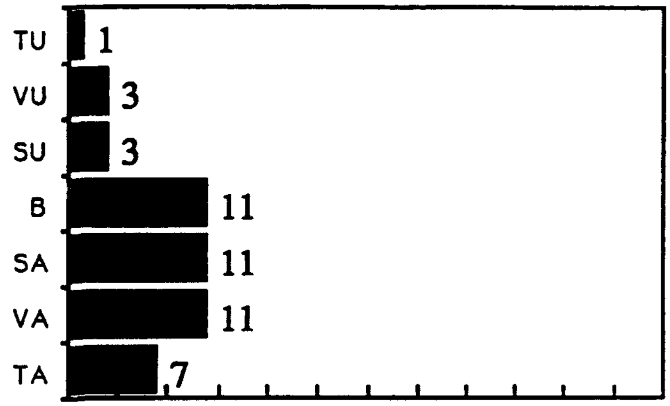
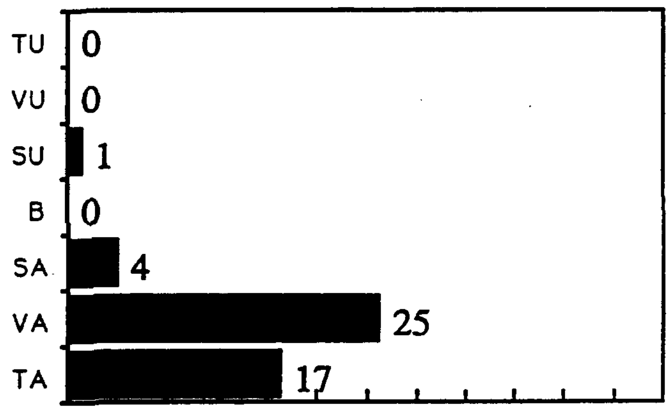
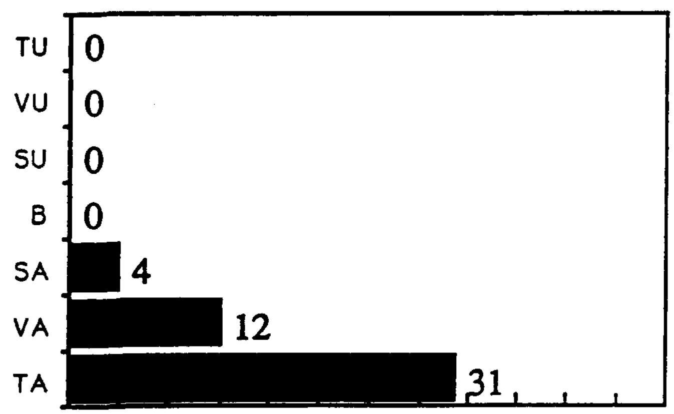
Questionnaire Item	M	S.D.	Response Distribution
Viewing Modes (Black Hot, White Hot, 10X, 3X)	5.83	1.07	
Setting Sectors	5.72	1.31	
Ability to Scan Independently	6.81	.54	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, *n*=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items (Cont'd)

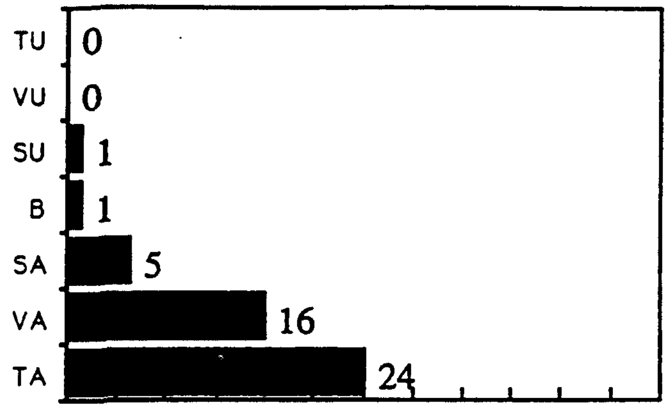
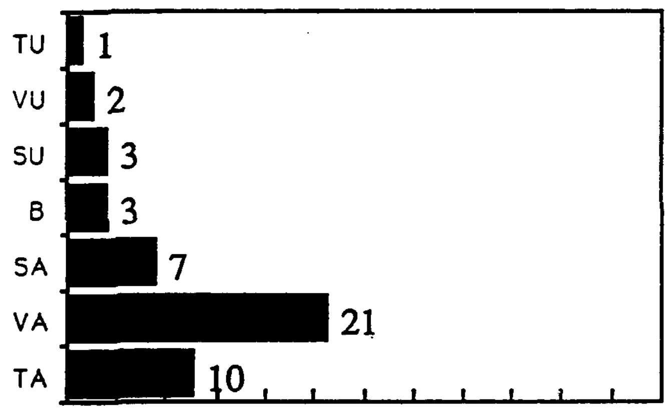
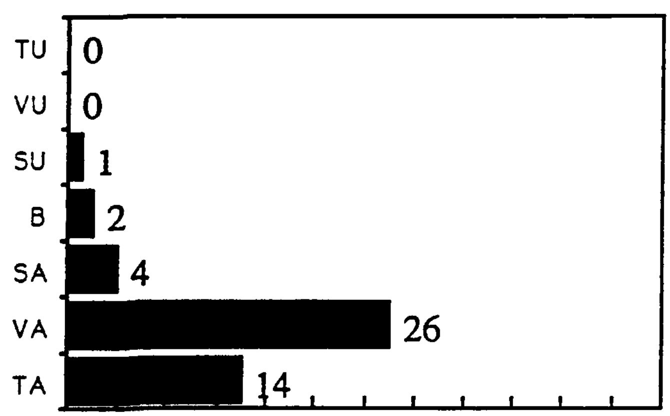
Questionnaire Item	M	S.D.	Response Distribution
IFF	4.89	1.51	
Ability to Acquire Targets	6.21	.78	
Designate Function	6.57	.65	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items (Cont'd)

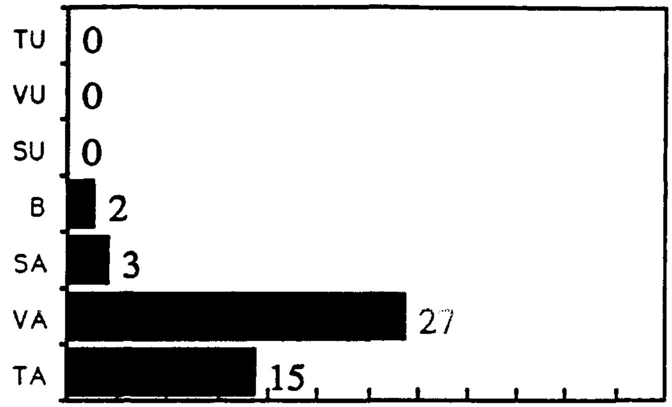
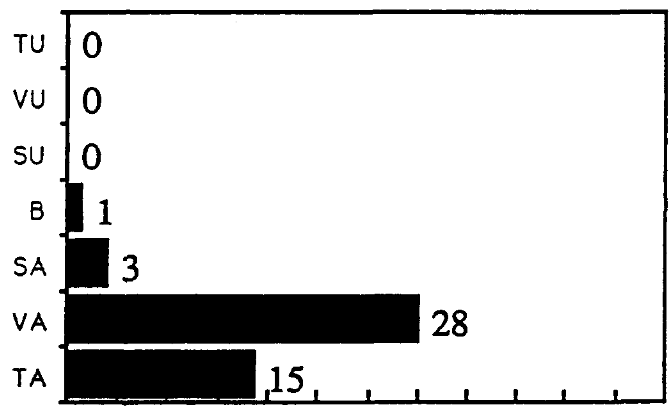
Questionnaire Item	M	S.D.	Response Distribution
Target Hand Off Using Designate	6.30	.91	
Abilility to Allocate More Responsibility to Gunner	5.47	1.47	
CITV Contribution to Command and Control	6.06	.87	

(Figure continues)

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Figure C-2

Soldier-Machine Interface CITV Questionnaire Items (Cont'd)

Questionnaire Item	M	S.D.	Response Distribution
CITV Contribution to the Performance of Your Duties	6.17	.73	
Overall Rating of the CITV	6.21	.66	

Note. TU=Totally Unacceptable (1), VU=Very Unacceptable (2), SU=Somewhat Unacceptable (3), B=Borderline (4), SA=Somewhat Acceptable (5), VA=Very Acceptable (6), and TA=Totally Acceptable (7). Unless otherwise indicated, n=47

Appendix D

Data Collection Instruments

The following data collection instruments are included in Appendix D:

Pages	Instrument
D-2 through D-4	Biographical Questionnaire
D-5 through D-19	SIMNET, CCD, and CITV Skills Tests
D-20 through D-25	Baseline Training Evaluations for Vehicle Commanders, Gunners, and Drivers
D-26 through D-36	CVCC Training Evaluations for Vehicle Commanders, Gunners, and Drivers
D-37 through D-45	CITV and CCD SMI Questionnaires

ADMIN: Date ________ Partic # _____ Dty Pos __________ Revised 1/14/92

* *

BIOGRAPHICAL QUESTIONNAIRE

Name ______________________________ SSN _____-_____-______

1. Age _____ years
2. Current Army Rank __________
3. Current unit of assignment ______________________________
4. Military Specialty: 12A 12B 12C 19E 19K Other__________
5. Total time on active duty: ______ years/______ months
6. Total active duty time in Armor units (include Cavalry): _____ yrs/_____ months
7. How much experience as a crewmember have you had with the following families of vehicles?

   a. M1 _____ yrs / _____ mos

   b. M60 _____ yrs / _____ mos

   c. M113 _____ yrs / _____ mos

   d. M2/M3 _____ yrs / _____ mos

8. Circle your present Duty Position in your current unit:

   Plt Ldr Co Cdr Co XO Bn S2 Bn S3 Bn XO Student

   Driver Loader Gunner Tank Cdr Plt Sgt Instructor

   Other ______________________________

9. How much experience do you have in each of the following TO&E (combat maneuver unit) positions?

   a. Driver _____ yrs / _____ mos

   b. Loader _____ yrs / _____ mos

   c. Gunner _____ yrs / _____ mos

   d. Tnk Cdr _____ yrs / _____ mos

   e. Plt Sgt _____ yrs / _____ mos

   f. Plt Ldr _____ yrs / _____ mos

   g. Spec Plt Ldr _____ yrs / _____ mos

   h. Co XO _____ yrs / _____ mos

   i. Co Cdr _____ yrs / _____ mos

   j. Bn S2 _____ yrs / _____ mos

   k. Bn S3 _____ yrs / _____ mos

   l. Bn Staff (S1, S4, BMO) _____ yrs / _____ mos

   m. Bn XO _____ yrs / _____ mos

   n. Bn Cdr _____ yrs / _____ mos

10. **Which of the following formal military courses have you completed?** (check all that apply)

a. ____ **PLDC** d. ____ **TCCC** g. ____ **AOAC**

b. ____ **BNCOC** e. ____ **SPLC** h. ____ **CAS3**

c. ____ **ANCOC** f. ____ **AOBC** i. ____ **C&GSC**

11. How long has it been since you participated as a **trainee** in an **actual field training exercise (not counting NTC and training support)?** _______ months

12. How many times have you participated as a member of a rotating unit in NTC or CMTC exercises? _______ times

13. How many days have you previously spent in CCTT (SIMNET-T)? ______days. In CCTB (SIMNET-D)? _______ days (if none, skip question 14)

14. In which of the following CCTB (SIMNET-D) equipment evaluations have you participated? (check all that apply)

a. _____POSNAV b. _____IVIS c. _____CITV

d. _____CVCC (Co Level) e. _____CVCC (Bn TOC)

f. Other____________________

15. Check your previous experience with computers (do not count SIMNET experience):

_____ no experience at all

_____ limited experience (ie. limited word processing or computer games)

_____ moderate experience (ie. some programming experience or frequent use of commercial computer programs)

_____ considerable experience (ie. fluent in more than one programming language or extensive experience using commercial programs such as spreadsheats)

16. People commonly report feeling uncomfortable using computers. Please circle below the value that best describes how you feel (in general) about using computers.

1	2	3	4	5	6	7
Very Uncomfortable			Neutral			Very Comfortable

17. Highest civilian education level:

_____ High School Diploma/GED

_____ Some College

_____ College Degree (BA/BS)

_____ Postgraduate work

18. Total active duty time in combat maneuver units (for example, 194th AB, 2d AD): (Please list years/months)

CONUS _____ / _____ **USAREUR** _____ / _____ **KOREA**_____/_____

SAUDI ARABIA _____/ _____

RA NAME: ______________________________
DATE: _____ SIM DUTY POS: _____________ SIM CALL # ________

SIMNET SKILLS TEST

Notes to the RA:
- **All answers are below the questions**
- **Time limit for SIMNET questions is 1 minute 30 seconds.**
- **Provide your TC with a protractor, scrap paper and a pencil.**
- **Do not assist the TC with his answer.**

GO NO GO

____ ____ 1. What would the tank's heading in mils be if it were headed in a southwestern direction? (Note: may use a protractor.)

- Answer can range anywhere between 3200 and 4800 mils.

____ ____ . What direction is the tank headed if it has an azimuth of 2400 mils?

- Southeast.

____ ____ 3. Orient the gun tube due East using the Grid Azimuth Indicator.

- Engage palm switch.
- Press Grid Azimuth Indicator button.
- Observe the azimuth change through the GPSE.
- Slew gun tube to approx. 1600 mils by monitoring Grid Azimuth Indicator.
- (RA) Check his azimuth reading when he is finished.

____ ____ 4. Using the TURRET REFERENCE DISPLAY, put the gun tube over the back deck.

- Engage palm switch.
- Traverse gun tube while observing Turret Reference Display change.
- Stop when gun tube is over back of tank.

____ ____ 5. The last digit on the simulator odometer measures what distance?

- Tenths of a kilometer or 100 meters

____ ____ 6. The odometer reads 12450. What will it read when you have travelled 400 meters?

- 12454 or 1245.4 km

____ ____ 7. The odometer reads 45882. What will it read when you have travelled 1.6 km?

- 45898 or 4589.8 km

____ ____ 8. The odometer reads 98548. What will it read when you have travelled 1100 meters?

- 98559 or 9855.9 km

SIMULATOR TRAINING
MODULE 3.2.8 - CCD SKILLS TEST SCRIPT

At this time, we would like to take a look at how well our training assisted you in learning how to use the CCD. First, you will work through a hands-on evaluation concerning the CCD. Later, when we have completed CITV training, we will work through one on the CITV.

The purpose of the evaluations is to judge the quality of the training you've received up to this point. We want to know whether we've trained you well enough to operate the systems and what functions you found particularly difficult. We hope to use the results to improve our training for future research.

The evaluations consist of a set of questions or problems which will require you to use the equipment. First, I'll read the question or problem to you. I will also give you a copy of the questions for reference. Then, you'll have an opportunity to perform the skill on the equipment. Since we have limited time to go through the entire evaluation, I may have to ask you to go on to the next question. Then we'll come back to any questions you didn't finish at the end.

For this CCD evaluation, you may enter grid coordinates into the report location fields by touching the tactical map any place you wish.

Note to Y06 and Y03: During this evaluation only, radio communication to Brigade will be prohibited. Please send all reports on Bn net via the CCD, even when it is unrealistic to do so.

Do you have any questions before we start? Okay, then let's begin.

SIMULATOR TRAINING
MODULE 3.2.8 - CCD SKILLS TEST

RA Name: ______________________________

DATE: _____ **TC CALL SIGN** ____

Notes to RA:
- **Preset one 3-waypoint route into the system and send it on Bn net.**
- **Take off the CCD contour lines.**
- **Create a CONTACT report of an enemy truck, post the icon, and send it over the Bn net.**
- **Fire off five rounds of ammunition.**
- **Before beginning, have the TOC or ECR send two friendly overlays on the Bn net. Post the overlay "OPT5POSB" to your map and let the "FRAGO1" overlay drop to the OLD files.**
- **Do not assist the TC with his answers.**

GO NO GO

___ ___ 1. Point to the CCD "Information Center". Explain the information from left to right.

1. First number is the current date
2. Time of day
3. Tank's call sign
4. Vehicle heading
5. Own-vehicle grid location

___ ___ 2. You have just identified 1 tank and 1 PC at separate locations. Prepare a CCD CONTACT report, post both symbols to your map for future reference, and send the report.

CON *OR*

1. Touch CON
   a. What - tank & PC
   b. Where - touch map at two locations
2. Touch PREP
3. Touch POST TO MAP
4. Touch SEND

REP

1. Touch REP
2. Touch CON
3. Touch NEW
   a. What - tank & PC
   b. Where - touch map at two locations
3. Touch PREP
4. Touch POST TO MAP
5. Touch SEND

GO NO GO

___ ___ 3. View a recently-received CONTACT report from your RECEIVE queue. Save a copy of it in your OLD files, post its icon on your tactical map, but do not forward the report.

1. Touch RECEIVE
2. Touch a report in the queue.
3. Touch SHOW
4. Touch PREP
5. Touch POST TO MAP
6. Touch CANCEL

___ ___ 4. You have just identified a column of T72s. Prepare and send a CCD CALL FOR FIRE on the T72s. Then cancel out of the ADJUST FIRE menu.

CFF	*OR*	REP
1. Touch CFF a. what - tank b. where - touch map 2. Touch PREP 3. Touch SEND 4. Touch CANCEL when ADJUST FIRE comes up.		1. Touch REP 2. Touch CFF 3. Touch NEW a. what - tank b. where - touch 4. Touch PREP 5. Touch SEND 6. Touch CANCEL when ADJUST FIRE comes up.

___ ___ 5. Use the RECEIVE queue to view the most recently received high priority report. Tell the status, who created the report and when it was created. After posting the report icon on your tactical map, forward the report.

1. Touch RECEIVE
2. Touch the first report in the queue.
3. Touch SHOW
4. Tell the status, who created the report, and when it was created.
5. Touch PREP
6. Touch POST TO MAP
7. Touch SEND

GO NO GO

___ ___ 6. Intelligence reports you misjudged the location of the T72 in the CALL FOR FIRE you made earlier. Prepare and send an ADJUST FIRE report so the artillery fire is redirected 100 meters right and add 200 meters. Also, indicate that this adjustment will end the mission whether or not the T72s are destroyed.

1. Touch REP
2. Touch ADJUST
3. Touch NEW
4. Enter "Right 100" in first "Shift" box
5. Enter "Add 200" in second "Shift" box
6. Touch EOM
7. Touch PREP
8. Touch SEND

___ ___ 7. You have just destroyed 10 helicopters out of the 11 observed which were attacking from the air toward the south. You are delaying as of now. Prepare and send a CCD SPOT report, posting the icon to the map for future reference.

1. Touch REP
2. Touch SPOT
3. Touch NEW
4. a. What - helo
   b. Observed - 11
   c. Dest - 10
   d. Where - touch map
   e. Heading - touch map beneath tank icon
5. Touch NEXT
6. EN ACT - "air attk"
7. Own ACT - "delay"
8. As of - "Now"
9. Touch NEXT
10. If all information correct, touch PREP
11. Touch POST TO MAP
12. Touch SEND

GO NO GO

___ ___ 8. Adjust the map scale so it shows the smallest area in the most detail. Have all map features showing.

1. Touch 1:25,000
2. Touch MAP
3. Touch FEATURES
   a. Touch CONTOUR LINES to add them to display.
   b. Touch EXIT.

___ ___ 9. Fifteen minutes ago, you observed four artillery rounds falling at your location. Prepare and send the correct CCD report.

1. Touch REP
2. Touch SHELL
3. Touch NEW
4. a. # - 4
   b. where - touch map
   c. As of - -15
5. Touch PREP
6. Touch SEND

___ ___ 10. Create a three waypoint route for use in the next several questions.

1. Touch NAV
2. Move cursor to WP1 box if not already there
3. Touch map
4. Move cursor to WP2 box
5. Touch map
6. Move cursor to WP3 box
7. Touch map

___ ___ 11. You want to put waypoint #4 of your route off your map to the left. Move your map so that you can see more of the left quadrant and put WP4 somewhere in that area.

1. Move cursor to WP 4
2. Touch FOLLOW key to enter JUMP mode
3. Touch middle left Jump Spot
4. Touch the map

GO NO GO

___ ___ 12. Send WP1 to your driver, save this route, and then send it over an available net.

1. Touch NAV.
2. Touch diamond shape in front of WP1.
3. Touch SAVE
4. Touch PREP
5. Touch SEND

___ ___ 13. Make active a waypoint route that is in your route files. Then delete the previously active route from your files.

1. Touch NAV (if needed)
2. Touch FILES
3. Touch a non-active waypoint route.
4. Touch SHOW.
5. Touch MAKE ACTIVE
6. Touch FILES
7. Touch the formerly active waypoint route.
8. Touch DELETE

___ ___ 14. Approximately 15 minutes ago you were engaged in heavy enemy activity (a ground attack) and lost two members of your crew. Use your CCD POSNAV icons to enter your current unit FLOT. You plan no change in your action at the present time. Prepare and send a report which gives this information.

1. Touch REP
2. Touch SITREP
3. Touch NEW
4. a. As of - -15
   b. FLOT - Touch map on POSNAV icons to enter grids of endpoints.
   c. Enemy Act- "heavy" "gnd attack"
5. Touch NEXT
6. Crit. short - "personnel"
7. Cdr intent - "no change"
8. Touch NEXT
9. If all info. correct, hit PREP
10. Touch SEND

GO NO GO

___ ___ 15. Go to your OLD CONTACT Report files and select a read but unrelayed report. Relay it now.

1. Touch REP
2. Touch CON
3. Touch OLD
4. Touch the report with the "O" status
5. Touch SHOW
6. Touch PREP
7. Touch SEND

___ ___ 16. Unpost overlay "OPT5POSB" that you currently have posted and post "FRAGO1."

1. Go to the MAP screen.
2. Touch OVERLAYS.
3. Highlight "OPT5POSB."
4. Touch UNPOST.
5. Highlight "FRAGO1."
6. Touch POST.

___ ___ 17. Your CCD is becoming cluttered with report icons. Delete a tank icon by pointing.

1. Go to the MAP screen.
2. Touch POSTED ICONS.
3. Highlight a tank icon.
4. Touch UNPOST.

___ ___ 18. View the CONTACT report of the truck in your OLD files via a hot icon. Tell who created the report and the time it was created, who sent you the report, and what net it was sent on to reach you.

1. Open the RECEIVE queue.
2. Touch the truck icon.
   OR
   If truck icon is off the map, highlight the arrow that corresponds with that icon.
3. Read sender/creator and the time created from the message header when message appears.
4. The message was sent on Bn net.
   (Consider the sender ID and the available nets that sender could have sent the report on to reach your CCD on your available nets.

GO NO GO

___ ___ 19. Use your CCD to find out the total number of rounds you have available in your vehicle and the corresponding GARB color.

1. Go to the REPORT function.
2. Select LOGISTICS.
3. Select OWN VEHICLE STATUS.
4. Read total number of rounds and GARB color

SIMULATOR TRAINING
MODULE 3.3.3 - CITV SKILLS TEST

RA NAME: ______________________________
DATE: ____________ TC CALL SIGN: ________

Notes to the RA:
- **Time limit for CITV questions is 1 minute 30 seconds.**
- **Make sure CITV tank icon is headed north.**
- **Make sure six enemy targets have been set on terrain.**

GO NO GO

CITV ICON

____ ____ 1. Point to the following features of the CITV TANK ICON:

a. Gun tube

- Bold line extending from center of tank is the gun tube.

b. CITV Line of Sight

- Thin line extending from center of tank is the CITV line of sight.

c. Front of tank

- Bold line across icon represents tank front.

d. Auto Scan Sectors

- Sector set lines indicate Auto Scan sectors.

____ ____ 2. Which display would you look at to indicate the tank's heading, a) the CITV tank icon; b) the Turret Reference Display; c) neither of the above?

- a) CITV tank icon.

GO NO GO

MANUAL SEARCH

____ ____ 3. Conduct a manual search southwest to northwest, using the CITV tank icon.

- Press MANUAL SEARCH button.
- Engage palm switch.
- Traverse using control handle.
- Monitor icon on CITV screen to ensure scanning from 8 to 11 o'clock.

GLOS

____ ____ 4. Your gunner has asked you to get an IFF on a vehicle he is looking at through his vision blocks. Slew the CITV to the gun tube.

- Press GLOS.

AUTO SCAN & SECTOR SET

____ ____ 5. Your scanning sector is due north to due east and you want a terrain scan. Set AUTO SCAN using the CITV icon, being careful to set the scan along the terrain.

- Press AUTO SCAN button.
- Press Sector Set.
- Slew CITV due north, keeping palm switch engaged and elevation along the terrain.
- Press LEFT arrow.
- Press Sector Set.
- Slew CITV due east, keeping palm switch engaged and elevation along the terrain.
- Press RIGHT arrow.

GO NO GO

____ ____ 6. **You are the lead element of a Battalion diamond. Set left and right AUTO SCAN boundaries (in that order) over the rear of the tank so you can keep an eye on other Battalion elements.**

- Press AUTO SCAN.
- Press Sector Set.
- Slew CITV over to lower right corner of tank, keeping palm switch engaged.
- Press LEFT arrow.
- Press Sector Set.
- Slew CITV over to lower left corner of tank, keeping palm switch engaged.
- Press RIGHT arrow.

* BOTH BOUNDARIES SHOULD NOW BE SET *

RA: Scan should be over the rear fenders.

WHITE HOT/BLACK HOT, 3X/10X

____ ____ 7. Using the previously set boundaries, slow down your rate of scan, ensuring you are in 3X and White Hot.

- Push Auto Scan.
- Push Rate.
- Push Down arrow.
- Push Rate again.
- Make sure in 3X (box reticle).
- Make sure in White Hot.

RA: Press CITV mode if not already there.

CITV VS. GPS MODES

____ ____ 8. Use your normal TC override.

- To use normal TC override, TC should:

    1. Change Operational Mode to GPS.
    2. Depress palm switch and slew turret.

GO NO GO

DESIGNATE/LASE/IFF

___ ___ 9. Go to Manual Search Mode and use DESIGNATE to show your gunner that his scanning sector is from east to southeast.

- Go to CITV mode if not already there.
- Press MANUAL SEARCH button.
- Engage palm switch and move CITV LOS due east.
- Press DESIGNATE button, keeping palm switch depressed until gun tube is lined up with CITV LOS.
- Engage palm switch and move CITV LOS southeast.
- Press DESIGNATE button, keeping palm switch depressed until gun tube is lined up with CITV LOS.

___ ___ 10. IFF an enemy vehicle using CITV, DESIGNATE your gunner on the target, and then give up control of the gun so he may fire.

- Lay CITV reticle on vehicle
- Engage palm switch
- Lase to the vehicle
- Identify symbol in upper left corner of CITV
- Follow the above procedures until you get an enemy symbol.
- DESIGNATE and hold palm switches in until gun tube is lined up with CITV GLOS.
- RELEASE PALM SWITCH. (Important step where gunner is concerned).

GO **NO GO**

____ ____ 11. IFF another enemy vehicle, tell the distance to the vehicle from your CITV Line of Sight, and engage it yourself.

- Lay CITV reticle on vehicle
- Engage palm switch
- Lase to the vehicle and give the distance.
- Identify symbol in upper left corner of CITV
- Follow the above procedures until you get an enemy symbol.
- Switch to GPS mode
- Verify the identification in daylight sight through your GPSE
- Fire using GPSE

Revised 19 March '92

(B) Date:_____ Sim Call #____

Sim Dty Pos (Circle One): Bn Cdr S3 Co Cdr Co XO

VEHICLE COMMANDER'S TRAINING EVALUATION

We are interested in your views about the training you received and the equipment you used during the past week. All responses are **confidential.**

Please indicate your opinions using the five-point rating scale provided.

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the individual training program in preparing you to operate the Simulator?

CLASSROOM TRAINING:

_____ 1a. Overall Effectiveness of Classroom Sessions on Navigation Training

_____ 1b. Instructor's Presentation

_____ 1c. Viewgraphs

HANDS ON SIMULATOR TRAINING:

_____ 1d. Hands On Training

_____ 1e. RA Explanations

_____ 1f. Skills Test

2. How adequate was the basic information on how to operate the simulator? (Use the rating scale from question #1). ______

Please explain any "Poor" ratings (list question # beside response).

____

____

____

VEHICLE COMMANDER'S TRAINING EVALUATION

3. How adequate were the tactical training exercises in preparing you to perform in a tactical situation?

1 Poor	2 Below Average	3 Average	4 Above Average	5 Excellent

_____ 3a. TC Nav Skill Drills

_____ 3b. Crew "Sandbox" Drills

_____ 3c. Company Training Exercise

_____ 3d. First Battalion Training Exercise

_____ 3e. Final Battalion Training Exercise

4. How adequate was the opportunity for hands on practice during the events listed above? (Use the rating scale from question #3.)_____

Please explain any "Poor" ratings in questions 3 and 4 (list question # beside response).

____

____

____

5. Considering the training program as a whole, how clear were the following?

1 Very Unclear	2 Somewhat Unclear	3 Neutral	4 Somewhat Clear	5 Very Clear

_____ 5a. Training Objectives (What you were expected to learn)?

_____ 5b. Feedback on how well you were performing DURING TRAINING?

Please explain any "Very Unclear" ratings (list question # beside response).

____

____

VEHICLE COMMANDER'S TRAINING EVALUATION

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

6. Using the scale above, how would you characterize your level of preparation in performing the tasks during the **final** Battalion training exercise? _______

7. Please identify those tasks which you were not adequately prepared to perform in the **final** Battalion training exercise and explain.

____
____
____
____

8. Rate the quality of the following debriefings (Use the rating scale from question #6):
First Battalion Training Exercise Debrief____
Final Battalion Training Exercise Debrief____

9. Please explain your ratings of the debriefings.

____
____
____

10. Please provide any other comments that would help us understand how you feel about the quality of training you received.

____
____
____
____
____

VEHICLE COMMANDER'S TRAINING EVALUATION

11. What suggestions do you have on how to improve the training program?

____
____
____
____

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

12. Using the scale above, how would you rate the potential contribution of using Semi-Automated Forces (SAFOR) as a training tool?_____

13. Please explain your rating of using SAFOR as a training tool.

____

____

____

Additional Comments (include comments regarding equipment here):

____

____

____

____

____

____

____

____

Revised 19 March '92 (B)

Date______ Sim Dty Pos: GNR Sim Call # _____

GUNNER'S EVALUATION

We would like to get your opinion on the training you received and the equipment you used this week. Your **confidential** responses will be used to improve training and future versions of the M1.

Please indicate your opinions using the five-point scale provided.

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the training program in preparing you to operate the Simulator?

_____ 1a. Classroom instruction

_____ 1b. Hands-on instruction

_____ 1c. The training exercises

Please explain any "Poor" ratings (list question # beside response).

____

____

____

2. Please provide any comments that would help us understand how you feel about the quality of training you received (include comments regarding equipment here).

____

____

____

____

____

Revised 19 March '92 (B)

Date_______ Sim Dty Pos: DVR Sim Call # ______

DRIVER'S EVALUATION

We would like to get your opinion on the training you received and the equipment you used during the past week. Your **confidential** responses will be used to help make improvements in training and future versions of the M1.

Please indicate your opinions using the five-point scale provided.

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the training program in preparing you to operate the Simulator?

_____ 1a. Classroom instruction

_____ 1b. Hands-on instruction

_____ 1c. Training exercises

Please explain any "Poor" ratings (list question # beside response).____

____

____

2. Please provide any comments that would help us understand how you feel about the quality of training you received (include comments regarding equipment here).

____

____

____

____

____

Revised19March'92

(A) Date:_____ Sim Call #____

Sim Dty Pos (Circle One): Bn Cdr S3 Co Cdr Co XO

VEHICLE COMMANDER'S TRAINING EVALUATION

We are interested in your views about the training you received and the equipment you used during the past week. All responses are **confidential.**

Please indicate your opinions separately for the CITV and CCD using the five-point rating scale:

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the training program in preparing you to operate the CITV and the CCD?

CLASSROOM TRAINING:	**CITV**	**CCD**
1a. Overall Effectiveness of CITV Classroom Session and CCD Large Screen Demo	____	____
1b. Instructor's Presentation	____	____
1c. Viewgraphs	____	NA
1d. Handouts	____	____
1e. Examples of Tactical Equipment Use	____	NA
1f. CCD Large Screen Refresher Training	NA	____
HANDS ON SIMULATOR TRAINING:	**CITV**	**CCD**
1g. Hands On Training	____	____
1h. RA Explanations	____	____
1i. Skills Test	____	____
1j. Directed CCD "Refresher" Tasks	NA	____

2. How adequate was the basic information on how to operate the simulator? (Use the rating scale from question #1). _____

Please explain any "Poor" ratings in questions 1 and 2 (list question # beside response). ________________________________

____

VEHICLE COMMANDER'S TRAINING EVALUATION

3. How adequate were the tactical training exercises in preparing you to use the CITV and the CCD in a tactical situation?

1	2	3	4	5
Poor	Below Average	Average	Above Average	Excellent

	CITV	CCD
3a. Crew "Sandbox" Drills	____	____
3b. Company Training Exercise	____	____
3c. First Battalion Training Exercise	____	____
3d. Final Battalion Training Exercise	____	____

4. How adequate was the opportunity for hands on practice using the equipment during the events listed in question 3? (Use the rating scale from question #3.) CITV ____ CCD ____

Please explain any "Poor" ratings in questions 3 and 4 (list question # beside response).______________________________

____

____

5. Considering the training program as a whole, how clear were the following?

1	2	3	4	5
Very Unclear	Somewhat Unclear	Neutral	Somewhat Clear	Very Clear

	CITV	CCD
5a. Training Objectives (What you were expected to learn)	____	____
5b. Feedback on how well you were performing DURING TRAINING	____	____

Please explain any "Very Unclear" ratings (list question # beside response). ______________________________

____

____

6. **Were there any CITV or CCD functions that you didn't use during the final Battalion training exercise? Yes___ No___**
If yes, which ones and why?

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

7. Using the scale above, how would you characterize your level of preparation in performing the tasks required during the **final** Battalion training exercise? _______

8. Please identify those tasks which you were not adequately prepared to perform in the **final** Battalion training exercise and explain.

9. Did the classroom instructor provide enough information about the operational concepts underlying the new equipment?
Yes___ No___ If no, please explain.

VEHICLE COMMANDER'S TRAINING EVALUATION

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

10. Using the scale above, please rate the quality of the following debriefings: **First** Battalion Exercise Debrief____
Final Battalion Exercise Debrief____

11. Please explain your ratings of the debriefings.

____

____

____

12. Please provide any other comments that would help us understand how you feel about the quality of training you received.

____

____

____

____

13. What suggestions do you have on how to improve the training program?

____

____

____

____

14. We are interested in identifying the training requirements that will be associated with the CCD and CITV when the actual systems are fielded. Can you offer any suggestions for training related to this issue? Please be as specific as possible.

____

____

____

____

VEHICLE COMMANDER'S TRAINING EVALUATION

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

15. Using the scale above, how would you rate the potential contribution of using Semi-Automated Forces (SAFOR) as a training tool?_____

16. Please explain your rating of SAFOR as a potential training tool.

____

____

____

Additional Comments (include comments regarding equipment here):

____

____

____

____

____

____

____

____

Revised 19 March '92 (A)

Date______ Sim Dty Pos: GNR Sim Call # _____

GUNNER'S EVALUATION

We would like to get your opinion on the training you received and the equipment you used this week. Your **confidential** responses will be used to improve training and future versions of the M1.

Please indicate your opinions using the five-point scale provided.

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the training program in preparing you to operate the Simulator?

_____ 1a. Classroom instruction

_____ 1b. Hands-on instruction

_____ 1c. The training exercises

Please explain any "Poor" ratings (list question # beside response).____

____

____

Please respond to the following questions by entering the number of the scale which best represents your opinion.

1	2	3	4	5
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

_____ 2. I liked having my TC designate new targets.

_____ 3. I found it easy to get disoriented when my TC designated a target.

_____ 4. As the number of targets presented increased, the usefulness of the **CITV** increased.

_____ 5. Fewer communications were needed with the TC because of the equipment.

Please explain any "Strongly Disagree" ratings (list question # beside response).

____

____

____

GUNNER'S EVALUATION

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 6. Target hand-offs were smooth and allowed me to acquire targets more quickly.

_____ 7. In a real tank, I feel the **Designate** function would enable me to destroy more targets.

Please explain any "Strongly Disagree" ratings (list question # beside response).

____

____

____

8. What problems, if any, did you have when your TC used the **CITV** to acquire targets?

____

____

____

9. How do you expect the new equipment to impact the level of communication and coordination between gunners and TCs? What suggestions for training can you offer related to this issue?

____

____

____

10. We are interested in identifying the training requirements that will be associated with the new capabilities when the actual equipment is fielded. Can you offer any suggestions for training related to this issue? Please be as specific as possible.

____

____

____

____

GUNNER'S EVALUATION

1. Please provide any other comments that would help us understand how you feel about the quality of training you received (include additional comments regarding equipment here).

Revised 19 March '92 (A)

Date________ Sim Dty Pos: DVR Sim Call # ______

DRIVER'S EVALUATION

We would like to get your opinion on the training you received and the equipment you used during the past week. Your **confidential** responses will be used to help make improvements in training and future versions of the M1.

Please indicate your opinions using the five-point scale provided.

1	2	3	4	5
Poor	**Below Average**	**Average**	**Above Average**	**Excellent**

1. How adequate were the components of the training program in preparing you to operate the Simulator?

______ 1a. Classroom instruction on the **Driver's Display**

______ 1b. Hands-on instruction on the **Driver's Display**

______ 1c. Training exercises

Please respond to the following questions by entering the number of the scale which best represents your opinion.

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

______ 2. I had no difficulty using the **Driver's Display.**

______ 3. I had no trouble receiving waypoints on the **Driver's Display** from my TC.

______ 4. Fewer communications were needed with the TC because of the **Steer-To-Indicator.**

______ 5. In a real tank, I could use terrain features more easily and could maneuver better if I had the **Steer-To-Indicator.**

______ 6. The **Steer-To-Indicator's** response time is acceptable.

______ 7. Drivers would become too dependent on the **Driver's Display** if it were put into a real tank.

Please explain any "Poor" or "Strongly Disagree" ratings (list question # beside response).________________________________

____

____

____

DRIVER'S EVALUATION

1	2	3	4	5
Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**

_____ 8. My TC sometimes forgot to send me new waypoints.

_____ 9. I would prefer to see all the waypoints at once instead of seeing them one at a time.

_____ 10. Having a **Driver's Display** gave me more confidence in moving from point to point.

_____ 11. In a real tank, I feel the **Driver's Display** would improve my performance as a Driver.

Please explain any "Strongly Disagree" ratings (list question # beside response). ____

____

____

12. What problems, if any, did you have using the **Driver's Display** or the **Steer-To-Indicator**?

____

____

____

13. How would you change the **Driver's Display**?

____

____

____

14. How would you change the **Steer-To-Indicator**?

____

____

____

____

____

DRIVER'S EVALUATION

15. We are interested in identifying the training requirements that will be associated with the new equipment (e.g., **Steer-To-Indicator**) when the actual systems are fielded. Can you offer any suggestions for training related to this issue? Please be as specific as possible.

16. What other comments do you have that would help us understand how you feel about the quality of training you received?

SMI Vehicle Questionnaire Instructions

The purpose of the SMI questionnaires is to document the strengths and weaknesses of the CVCC equipment. The results will be used to identify improvements for the system and to guide development efforts, so please answer as accurately as possible.

You will be asked to rate the acceptability of different features of the equipment. Acceptability may mean something different for each person responding to the questionnaires. To try to make that concept mean the same thing for each of you, we would like you to use the following definition of acceptability when responding to individual items.

Something is ACCEPTABLE if it:

Enables you to perform your job

Is easy to use

Is not confusing.

Before rating an item I would like you to consider these three aspects of acceptability and make your rating accordingly. Refer back to this cover sheet, if necessary.

If a feature does not "measure up" on any of these aspects, I would like you to tell us about it. Please indicate which aspect of acceptability the feature does not measure up on. Space is provided, after each rating, for your comments.

For example, if you rated changing map scales with a "2" (Very Unacceptable), we would like you to tell us why. So your answer might look like this:

__2__ Changing map scales.
It was hard to use.

Do you have any questions?

Thank you in advance for your participation.

****
Sim Duty Position: Co Cdr: A B C D Bn Cdr S3
Date:
****

CITV EVALUATION

Place the number from the scale which best reflects your opinion on the space preceding each item.

1	2	3	4	5	6	7
Totally Unacceptable	Very Unacceptable	Somewhat Unacceptable	Borderline	Somewhat Acceptable	Very Acceptable	Totally Acceptable

1. _______ Fidelity ("trueness") of information on the CITV

2. _______ Understandability of information on the CITV

3. _______ Location of operating controls and switches

4. _______ Complexity of operation

5. _______ Commander's Control Handle

6. _______ Operating Modes (Autoscan, Manual Search, GLOS--if you find any of these to be unacceptable, please identify)

7. _______ Viewing Modes (Black Hot, White Hot, 10X, 3X--if you find any of these to be unacceptable, please identify)

8. _______ Setting sectors

9. _______ The capability to scan independently from your gunner

10. _______ IFF

11. _______ The capability to acquire targets

12. _______ The Designate function

13. _______ Target hand off using Designate

1	2	3	4	5	6	7
Totally Unacceptable	Very Unacceptable	Somewhat Unacceptable	Borderline	Somewhat Acceptable	Very Acceptable	Totally Acceptable

14. ______ The capability to allocate more responsibility to the gunner

15. ______ Its contribution to command and control

16. ______ Its contribution to your ability to perform your duties

Now that you have rated the individual CITV items, please rate the CITV as a whole.

17. ______ CITV

18. How would you change the CITV?

____

____

____

____

____

____

19. Did you find the CITV more useful in Defensive or Offensive Operations and why?

____

____

____

____

____

____

20. Which operating mode--Autoscan, Manual Scan, or GLOS--did you prefer and why?

Additional Comments:

****
Sim Duty Position: Co Cdr: A B C D Bn Cdr S3
Date:
****

CCD EVALUATION

Place the number from the scale which best reflects your opinion on the space preceding each item.

1	2	3	4	5	6	7
Totally Unacceptable	Very Unacceptable	Somewhat Unacceptable	Borderline	Somewhat Acceptable	Very Acceptable	Totally Acceptable

1. ______ Location of the CCD

2. ______ Fidelity ("trueness") of information

3. ______ Touch Screen

4. ______ Thumb Cursor

5. ______ Feedback (confirmation of actions)

6. ______ Understandability of information on the Tactical Map

7. ______ Usefulness of information on the Tactical Map

8. ______ Scrolling the Map (Move, Jump, Follow--if you find any of these unacceptable please identify)

9. ______ Aggregation of vehicle icons

10. ______ The capability to navigate with POSNAV

11. ______ Creating routes

12. ______ Changing waypoints in a route

13. ______ Capability to send waypoints to my driver

14. ______ Appearance of Overlays on tactical map

1	2	3	4	5	6	7
Totally Unacceptable	Very Unacceptable	Somewhat Unacceptable	Borderline	Somewhat Acceptable	Very Acceptable	Totally Acceptable

15. ______ Amount of information in the menu/report area

16. ______ Understandability of information in the menu/report area

17. ______ The size of menu/report input fields

18. ______ Reading reports

19. ______ Creating reports

20. ______ Automatic advance of highlighted report input fields

21. ______ Report formats

22. ______ Report icons

23. ______ Report status information (symbols depicting opened, relayed, sent, etc.)

24. ______ The number of reports sent to you

25. ______ Reports from the Semi-Automated vehicles

26. ______ Capability to receive/transmit overlays

27. ______ Auditory signals of received messages

28. ______ Visual signals of received messages

29. ______ The integration of the CCD with the CITV (for example, lasing to an object to input grids in a report)

1	2	3	4	5	6	7
Totally Unacceptable	Very Unacceptable	Somewhat Unacceptable	Borderline	Somewhat Acceptable	Very Acceptable	Totally Acceptable

30. ______ The capability to allocate more responsibility to the driver

31. ______ System response time

32. ______ The CCD's contribution to your ability to perform your duties

Now that you have rated the individual CCD items, please rate the CCD components as a whole.

33. ______ Tactical Map

34. ______ Navigation

35. ______ Reports

36. ______ Overlays

37. How would you change the Tactical Map?

____

____

____

____

____

38. How would you change the Navigation Component?

____

____

____

____

____

39. How would you change the Report Component?

40. How would you change the Overlay Component?

41. Did you find the CCD more useful in Defensive or Offensive Operations and why?

42. Did you find the CCD more useful while in contact with the enemy or prior to/after contact and why?

43. Did you receive multiple copies of the same report? If yes, was it a problem?

44. Did you have any problem with the FREE TEXT messages? If yes, what?

45. Which map scale did you prefer and why?

46. Which vehicle aggregation level did you prefer and why?

47. Did you find the Logistics report to be useful? How would you change the Logistics report?

Additional Comments:

List of Acronyms and Abbreviations

AARS	After Action Reviews
ANOVA	Analysis of Variance
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
BN	Battalion
BMS	Battlefield Management System
BLUFOR	Blue Forces
BP	Battle Position
C2	Command and Control
C3	Command, Control, and Communications
C3I	Command, Control, Communications, and Intelligence
CATS	Combined Arms Training Strategy
CATTC	Combined Arms Tactical Training Center
CB	Citizens' Band
CBI	Computer-Based Instruction
CCD	Command and Control Display
CD-ROM	Compact Disk-Read Only Memory
CFF	Call For Fire
CITV	Commander's Independent Thermal Viewer
COA	Course of Action
CRT	Cathode Ray Tube
CSS	Combat Service Support
CVCC	Combat Vehicle Command and Control
DCA	Data Collection and Analysis
DCD	Directorate of Combat Developments
DCE	Data Collection Exercise
DEST	Destroyed
DIS	Distributed Interactive Simulation
DVI	Digital Video Interactive
ECR	Exercise Control Room
ET	Embedded Training
FBC	Future Battlefield Conditions
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
FRAGO	Fragmentary Order
FSO	Fire Support Officer
GAS	Gunner's Auxiliary Sight
GARB	Green, Amber, Red, Black
GLOS	Gun Line of Sight
GPS	Gunner's Primary Sight
GPSE	Gunner's Primary Sight Extension
HEAT	High-Explosive Anti-Tank
IFF	Identification Friend or Foe
IMEX	Information Management Exercises
INTEL	Intelligence
IVIS	Intervehicular Information System
LOS	Line-of-Sight
LRF	Laser Range Finder
MANOVA	Multivariate Analysis of Variance
MCC	Management, Command and Control
MOS	Military Occupational Specialty
MOU	Memoranda of Understanding

MRS	Muzzle Reference System
MWTB	Mounted Warfare Test Bed
NATO	North Atlantic Treaty Organization
NBC	Nuclear/Biological/Chemical
NETT	New Equipment Training Team
NTC	National Training Center
O/T	Observer/Target
O&I	Operations and Intelligence
OPFOR	Opposing Forces
OPORD	Operations Order
POSNAV	Position Navigation System
PL	Phase Line
PVD	Plan View Display
RA	Research Assistant
RIU	Radio Interface Unit
RTO	RadioTelephone Operators
S2	Intelligence Officer
S3	Operations Staff Officer
S4	Combat Service Support
SAFOR	Semi-Automated Forces
SAT	Systems Approach to Training
SCC	SIMNET Control Console
SICPS	Standard Integrated Command Post System
SINGARS	Single Channel Ground/Air Radio System
SitDisplay	Situation and Planning Display
SIMNET	Simulation Networking
SITREP	Situation Report
SME	Subject Matter Expert
SMI	Soldier-Machine Interface
SOP	Standing Operating Procedure
SPSS/PC+	Statistical Package for the Social Sciences/ IBM Personal Computer
SSI	Specialty Skill Identifier
STX	Situational Training Exercise
TACOM	Tank-Automative Command
TADSS	Training Aids, Devices, Simulators, and Simulations
TC	Tank Commander
TES	Tactical Engagement Simulation
TIS	Thermal Imaging System
TOC	Tactical Operations Center
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures
U-COFT	Unit-Conduct of Fire Trainer
UPAS	Unit Performance Assessment System
USAARMS	United States Army Armor School
UTM	Universal Transverse Mercator
VTT	Video Teletraining
WS	Workstation
XO	Executive Officer