ARMY RESEARCH LABORATORY

Development and Engineering of a Distributed Interactive Simulation System

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13. ABSTRACT *(Maximum 200 words)*

The Depth and Simultaneous Attack (D&SA) Battle Lab and the Fort Sill Field Element of the Human Research and Engineering Directorate (HRED), U.S. Army Research Laboratory (ARL), collaborated to establish a fire support command and control (FSC2) test bed. The core of the FSC2 test bed is an interface that allows fire support command and control tactical equipment to interact in a seamless manner with computer-generated equipment and forces on the synthetic battlefield. The interface was accomplished using communications protocols that comply with the requirements outlined in the distributed interactive simulation (DIS) protocol data unit (PDU) standards 2.0.3. The objective of the project was to establish an environment that could be used to support the development of simulations-based training initiatives and to support the concept development process, and the research, development and acquisition phase of the materiel acquisition process through the development of a methodology for testing and evaluating materiel, organizational, and doctrinal alternatives during depth and simultaneous attack. Included in this report is a description of the design and development of the FSC2 test bed and an interface control document that describes in detail the hardware and software necessary to establish the interface.

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DEVELOPMENT AND ENGINEERING OF A DISTRIBUTED INTERACTIVE SIMULATION SYSTEM

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U.S. ARMY RESEARCH LABORATORY

Aberdeen Proving Ground, Maryland

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EXECUTIVE SUMMARY

To exploit the current revolution in simulations technologies, the U.S. Army Research Laboratory (ARL) and Canadian Aviation and Electronics (CAE)-Link developed an interface that allows fire support command and control tactical equipment to interact in a seamless manner with computer-generated equipment and forces on the synthetic battlefield. The interface was accomplished using communications protocols that comply with the requirements outlined in the distributed interactive simulation (DIS) protocol data unit (PDU) standards 2.0.3.

The interface is a software program that operates on a standard "486" personal computer (PC). Thus far, the PC interface unit (PIU) has been used to establish DIS compatibility for the following tactical equipment: the forward entry device, digital message device, fire direction data manager, and the lightweight computer unit that runs the fire direction system software of the multiple launch rocket system (MLRS). Additionally, a DIS-compatible fire control panel trainer for both the MLRS and the Army tactical missile system (ATACMS) has been placed on the network.

Scenarios were developed to demonstrate and evaluate the network. A DIS-compatible constructive simulation was used to generate the synthetic battlefield. Computer-generated weapon systems and soldier-in-the-loop simulators and training devices populated the synthetic environment. Targets were detected by sensors in the simulation and fire missions were forwarded to command centers, where they were processed and sent to firing batteries for execution. Occasionally, the calls for fire were processed and executed by the distributed soldier-in-the-loop simulators and training devices. In these instances, fire missions were sent to the battalion fire direction data manager or the battery fire direction system (FDS), where operators processed the messages and forwarded missions to the MLRS or ATACMS training device. Thus, automated and distributed entities operated in an interactive manner on a single synthetic environment linking live, virtual, and constructive simulations.

The current project was done in support of the Depth and Simultaneous Attack (D&SA) Battle Lab and their requirement to expand the use of simulations to (a) streamline training and (b) evaluate materiel, organizational, and doctrinal alternatives during depth and simultaneous attack. The D&SA Battle Lab is developing a simulation facility that contains a collection of DIS-compatible simulations, simulators, and training devices that will provide the necessary infrastructure to conduct mission-related training and analysis events. The Fort Sill Field Element of the Human Research and Engineering Directorate, ARL, is supporting their work

through the execution of a comprehensive research program focused on the development of procedures to conduct "soldier-in-the-loop" investigations throughout the concept development process and the research, development and acquisition phase of the materiel acquisition cycle. The utility of this work is its ability to support training, research and development, and warfighting operations--allowing questions related to doctrine, training, leadership, organizations, and materiel to be addressed before "metal is bent" or soldiers are deployed.

DEVELOPMENT AND ENGINEERING OF A DISTRIBUTED INTERACTIVE SIMULATION SYSTEM

INTRODUCTION

The U.S. Army Research Laboratory (ARL) requested Canadian Aviation and Electronics (CAE)-Link to instrument the ARL and Depth and Simultaneous Attack (D&SA) Battle Lab with fire support command and control equipment using the distributed interactive simulation (DIS) protocols on a local area network (LAN) to simulate realistic battlefield communications conditions for research and development and training. Devices that have been integrated into this simulation capability include the CIMUL8™/SPECT8™/DISIP8™ simulation system, two (2) forward entry devices (FEDs), a lightweight computer unit (LCU) running the multiple launch rocket system (MLRS) battery fire direction system (FDS), and the MLRS/Army tactical missile system (MLRS/ATACMS) fire control panel trainer (FCPT).

The integration of these devices onto an instrumented LAN will permit realistic fire support command and control exercises to be conducted in conjunction with the target acquisition fire support model (TAFSM), Janus, or any other simulation system, using real soldiers performing tasks in the laboratory as they would in the field. It will also allow for the evaluation of the MLRS/ATACMS FCPT. With the eventual installation of a wide area network (WAN), personnel will be able to participate in DIS exercises with participants at remote locations.

The DIS network interface developed for the FEDs and the FDS represents the first time that real, unmodified battlefield command and control equipment has been interfaced to the synthetic environment using DIS (see Appendix A for a complete list of acronyms).

Requirement

The technical requirements for the project have been changed because of system operation and equipment availability. Initially, the project had the following technical requirements:

a. Procure the desktop MLRS/ATACMS FCPT and CIMUL8™/SPECT8™/ DISIP8™.

b. Provide a DIS-compatible interface for several FEDs and an LCU (operating the interim fire support automation system [IFSAS] software).

c. Integrate the devices on a common DIS LAN that would eventually be connected to the defense simulation internet (DSI) (see Figure 1).

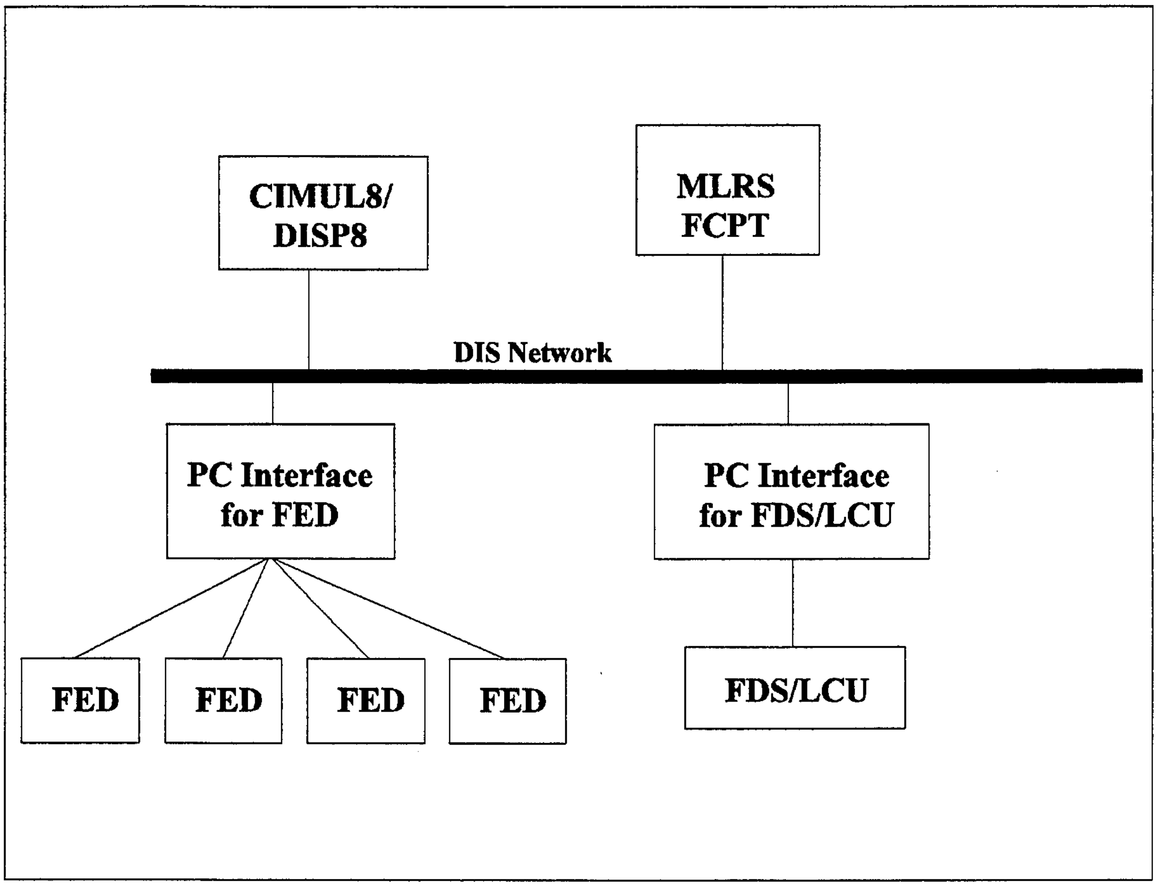

Figure 1. Network configuration for ARL and D&SA Battle Lab.

Initial Design

In the initial design, the network was to include four FEDs, one IFSAS, and the fire support automated test system (FSATS). During the interim progress review, it was determined that the IFSAS did not have the capability to communicate with an MLRS launcher (represented on the network by the FCPT). To demonstrate a fully interactive network, the IFSAS software was replaced by the battery FDS software. The FDS software communicated with the MLRS launcher and like the IFSAS, executed on an LCU. In addition, the number of FEDs was initially limited to two since only two FEDs were available for testing.

It was initially believed that information sent by the FEDs and the FDS could be accessed using the RS-232 port on a personal computer (PC). It was determined, however, that the software running on the LCU and FEDs could not be modified to transmit messages through the RS-232 port and that access would have to be gained either through the radio ports or the wire interface.

The solution to this problem was to communicate with the FEDs and FDS using a modem connected to the wire interfaces of the FEDs and FDS. Since the devices used frequency shift keying (FSK), a commercial off-the-shelf (COTS) modem could not be used. The Telos® signal master board was chosen as the FSK modem for the PCs. Since the disk operating system (DOS™) version was just becoming available and the board was not yet produced, two beta version boards, each with two channels, were obtained.

DIS Requirements

DIS Protocol Data Unit (PDU) Standard

Systems on the ARL and D&SA Battle Lab network are required to be DIS compatible. DIS protocol data unit (PDU) version 2.0.3 was chosen for implementation because of its widely installed base (used for the Warbreaker demonstration among other projects).

Only the DIS PDUs required to simulate the integrated system were implemented. DIS PDUs were implemented in the following manner for the integrated system:

1. Command and control messages are communicated using transmitter and signal PDUs. Receiver PDUs are not used in this implementation.

2. Entity state PDUs are issued on behalf of the entity containing or controlling the transmitting device. Articulated parts are not represented.

3. Fire and detonation information associated with the munition fired by the MLRS/ATACMS FCPT is communicated using the fire PDU and detonation PDU. In addition, positional information and movement of the launcher represented by the FCPT is represented using entity state PDUs.

DIS Communication Architecture Standard

The communication architecture for DIS (CADIS) draft standard version 1.0 was chosen for use with this interface. Protocols to be used on the local area network are

Application, presentation & session layers:	DIS 2.0.3
Transport & network layer:	UDP/IP (CADIS 1.0)
Data link layer:	Ethernet
Physical layer:	Ethernet

DIS Radio Simulation

Simulation of the actual radios, along with associated jamming, noise, interference, and so forth, is not represented in this integrated system. It is assumed that the devices send and receive perfect signals. It is also assumed that for this application, all devices are tuned to the same radio frequency.

DIS Entity Information for Command and Control Entities

Entity information for the entities associated with the transmitter are issued in accordance with the DIS PDU 2.0.3 standard. The FEDs and the FDS are associated with either dismounted infantry or a specific vehicle. The MLRS/ATACMS FCPT is associated with the MLRS carrier vehicle. CIMUL8™ provides entity representation for those entities that it is simulating.

The FED and the FDS related entities do not maneuver while the simulation is running. There is an off-line capability to "beam" the FED and FDS entities to various locations on the battlefield. An on-line capability to beam entities is also available, based on latitude-longitude location.

ENGINEERING DESIGN

Hardware Design

The hardware selected for the DIS interface uses 80486 personal computers (PCs). PCs were selected for the ARL network interfaces since the FEDs simplified hand-held terminal unit (SHTU) and the FDS lightweight computer unit (LCU) are both PC-compatible devices. In addition, the PC solution represented a low cost approach from a hardware and software development perspective. The use of the PCs also allowed the use of existing Government-owned software produced by the University of Central Florida's (UCF) Institute for simulation and training (IST). An additional PC was procured to host IST data-logging software and to serve as a spare. The hardware, software, and Government-provided equipment required to complete this project are described in Appendix B.

To provide the interface to the network without modifying the software on the FEDs, FDS, or fire direction data manager (FDDM), the interface used the two-wire communications interface for communication between the PC interface and the devices. Since the command and control equipment uses FSK in its communications, it was necessary for our interface to have an FSK modem to establish lower layer communications. The text messages that are sent between command and control devices were then sent as the data portion of a signal PDU on the DIS network. The PC interface is shown in Figure 2.

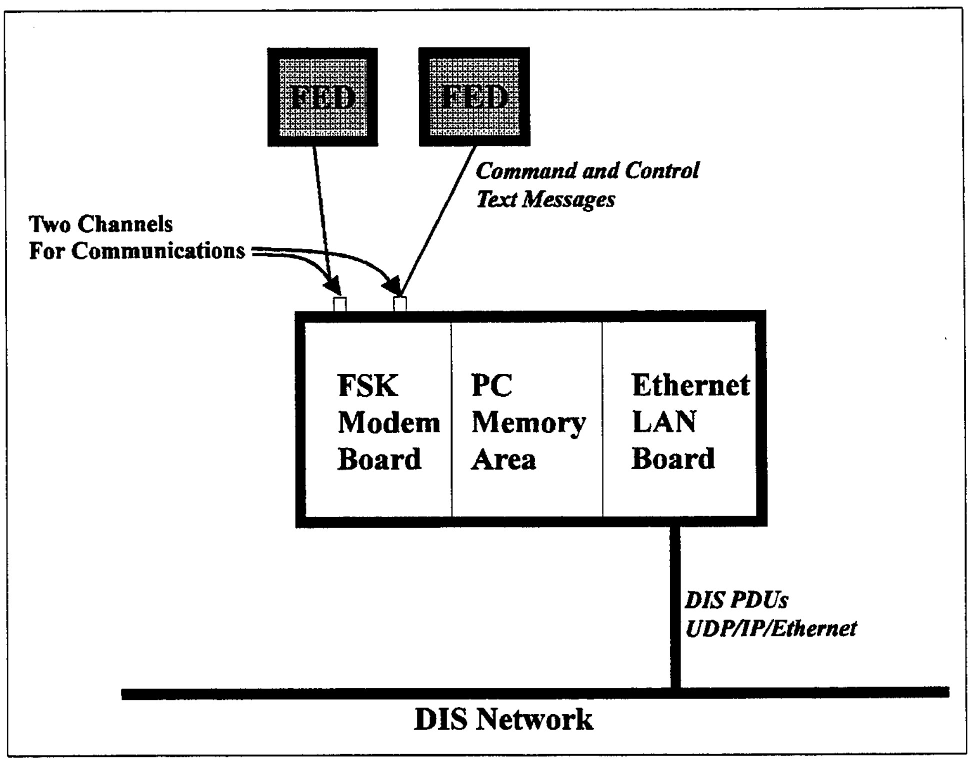

Figure 2. PC interface with FSK modem board.

In addition to the PC interface devices, the hardware and cables required to activate the LAN were procured. Figure 3 shows the hardware configuration for the ARL and D&SA Battle Lab network.

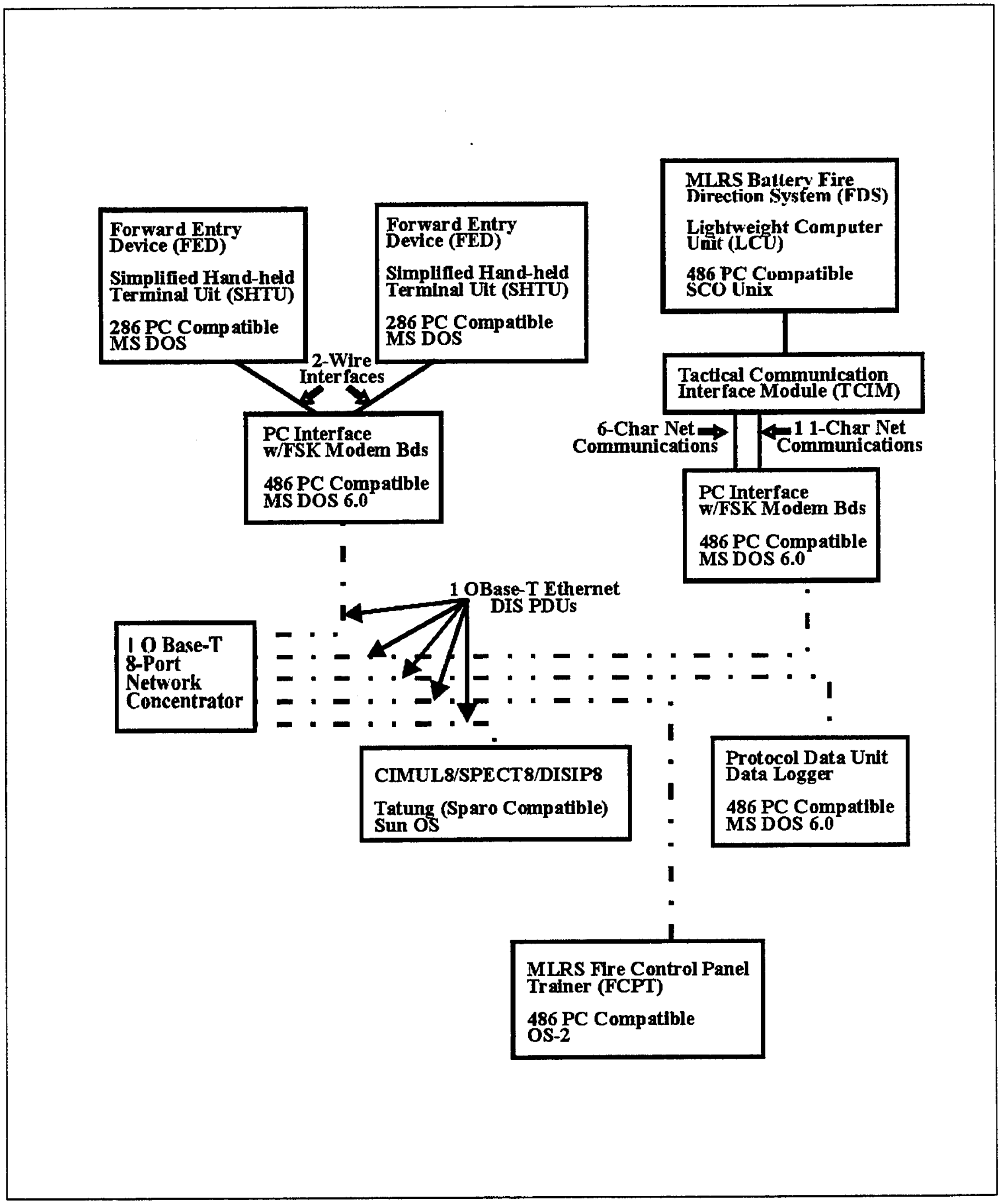

Figure 3. Network hardware configuration.

Software Design

Software delivered with this system included COTS software purchased for use with the PCs and the CAE-Link developed interface software (see Appendix B).

COTS Software

Hardware drivers purchased with the Ethernet board and the modem board were used as part of the interface to use the hardware. Other software packages were used for word processing, figure creation, and remote login to the Tatung® machine. Commercial software purchased for this project included Microsoft (MS) DOS™, Windows™, Borland C++® compiler, Borland Office for basic word processing and data base capabilities, CorelDraw®, and network interface tools.

PC Interface Software

CAE-Link has developed software that provides the DIS network interface for the FED and the FDS. This software performs two basic functions. First, it performs necessary DIS simulation functions needed for operation in the synthetic environment. This includes sending entity state PDUs representing the entity housing or controlling the command and control equipment that is on the network. The software also processes detonation PDUs in order to determine if the entity related to the equipment has been affected by weapons fire. Secondly, the interface software handles the transport of digital command and control information over the DIS network. This is accomplished by receiving the command and control input from the field wire interface through the PC modem board, extracting the text message, including the text information as data in a DIS signal PDU, and sending the signal PDU and its associated transmitter PDUs on the DIS network to the receiving device. The interface on the receiving end does the opposite, extracting the text information from the signal PDU and sending the information to the command and control devices on the field wire interface through the modem board.

User Interface

The PC interface software has a user interface that can display a number of different screens. These screens show information such as received and issued signals, entity information, packets received, processed and lost, and so forth. This interface could easily be adapted to provide other valuable DIS network-related information for the user.

Devices That May Use the PC Interface

This interface is very flexible and may be used with other digital command and control equipment that uses a field wire interface. This was demonstrated during integration when a digital message device (DMD) was interfaced to the DIS network using the same interface. Additional modem boards are required if the number of communication channels increases with the addition of further equipment.

Network Data-Logging Software

The ARL network also includes limited data-logging capabilities available through the use of the IST software. This software allows the collection of network information for analyzing the DIS packets being sent by the various DIS network devices. The logger also features playback capabilities that can be used in the training studies to be performed in the next phase of this project.

Additional data-logging capability has been added, allowing the researcher to gather time-specific data without having to review the entire PDU structure.

Interface Design

Primary development of the DIS interfaces took place at the CAE-Link facilities in Binghamton, New York. To support the Binghamton development, two FEDs and the FDS software were provided by ARL. These devices were returned to the Government with the rest of the system hardware and software.

Integration of Devices

After the DIS interfaces were developed in Binghamton, the hardware and software were shipped to the ARL and D&SA Battle Lab facility at Fort Sill for setup and integration with other laboratory devices. Integration proceeded at Fort Sill with CIMUL8™ and the MLRS/ATACMS FCPT.

It was assumed that these systems would be DIS compatible when integration began. Discussions about which version of DIS would be used and how the integrated system would operate were held throughout development of the interface. An interface control document (ICD) was developed, which describes how the various systems interface and how the DIS PDUs would be created and interpreted. This ICD was distributed to the developers of CIMUL8™ and the FCPT for use in developing their DIS capabilities. The final ICD reflecting the actual interfaces used for the demonstrations is provided in Appendix C. The developers of CIMUL8™ and the FCPT were present on site during the integration phase to support their devices.

DIS Simulation Concepts

Two scenarios are supported by the network of devices that were delivered. The first scenario uses CIMUL8™ or the target acquisition fire support model (TAFSM) to stimulate the FDS software with an FR GRID message (providing target information). The FDS then sends a call for fire to the MLRS/ATACMS FCPT. The MLRS/ATACMS FCPT is responsible for firing the weapon. The second scenario uses a Janus simulation or CIMUL8™ to produce combat events that will prompt a commander to enter fire missions in the FED. These missions are sent to the FDS and the rest proceeds as in the first scenario. In both cases, the DIS network is used to send the command and control information. The DIS network also supports entity information in the form of entity state PDUs and the firing and detonation events of the MLRS launcher in the form of fire and detonation PDUs.

To support these operational requirements, the following DIS PDUs from DIS PDU version 2.0.3 were used (see Appendix D for a detailed listing):

Entity State PDUs: Entity state PDUs (ES PDUs) are issued to represent the simulated operator or vehicles hosting the field artillery FED.

Fire PDUs: The MLRS/ATACMS FCPT sends a fire PDU when it fires the launcher.

Detonation PDUs: Detonation PDUs are sent by the MLRS/ATACMS FCPT when the munition it fired detonates or impacts. The FED and FDS also receive detonation PDUs from unfriendly forces in order to determine if they are affected by enemy fire (killed).

Transmitter and Signal PDUs: These PDUs are used to transmit digital command and control message information between devices.

IMPLEMENTATION

The implementation of the integrated system resulted in the successful demonstrations that are described next.

Results of Phase II

Two scenarios were demonstrated with the system described in the preceding sections. The first scenario demonstrated close operations beginning with target identification by a forward observer (FO) through an MLRS rocket launch sequence. In this scenario, one FED was used to represent the communications of an FO, and the other FED was used to represent the fire support team (FIST). The MLRS fire battery fire direction center was represented with the LCU running the MLRS battery FDS software. The MLRS launcher actions were simulated by the MLRS/ATACMS FCPT. CIMUL8™ provided a graphical view of the battle, using icons to show the location of the various participants (FO, FIST, fire direction center [FDC], and launcher) along with the simulation of other friendly and opposing forces. In addition, communications and weapon firing were graphically displayed using the DIS PDUs received on the network.

The sequence of events for the first demonstration is shown in Figure 4.

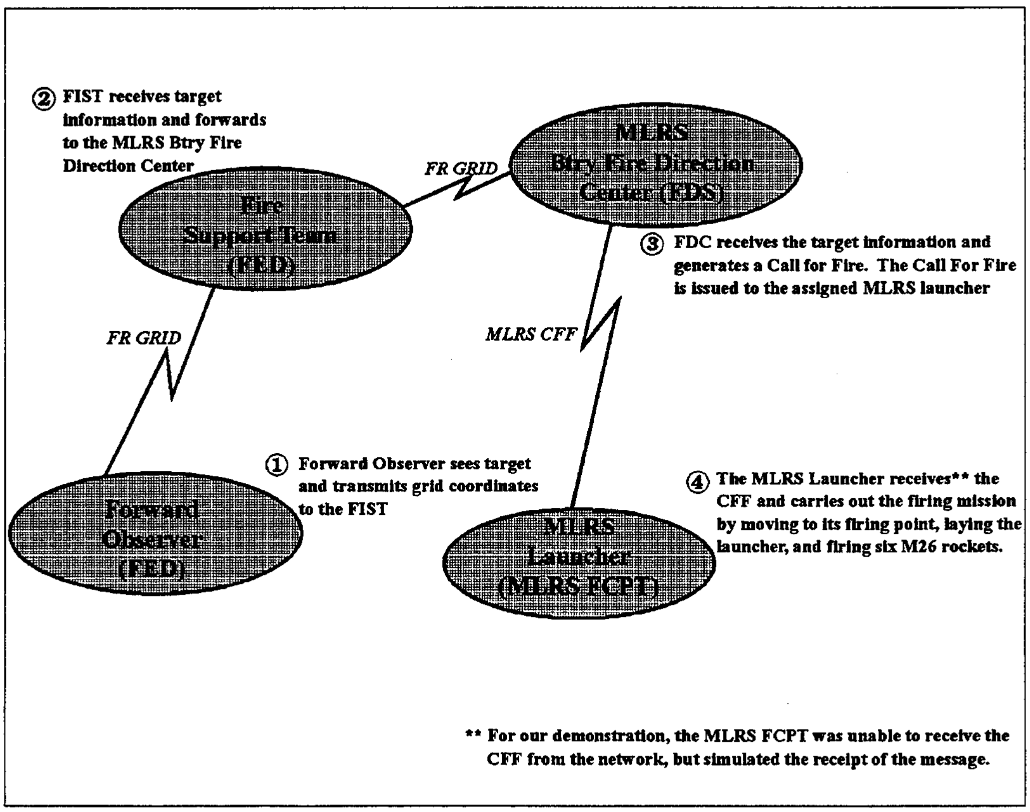

Figure 4. Scenario events for demonstration No. 1.

To represent the deep battle, we added other devices to the network to be used in the second demonstration. Added were the FDDM and the DMD. The final network configuration with the added devices is illustrated in Figure 5.

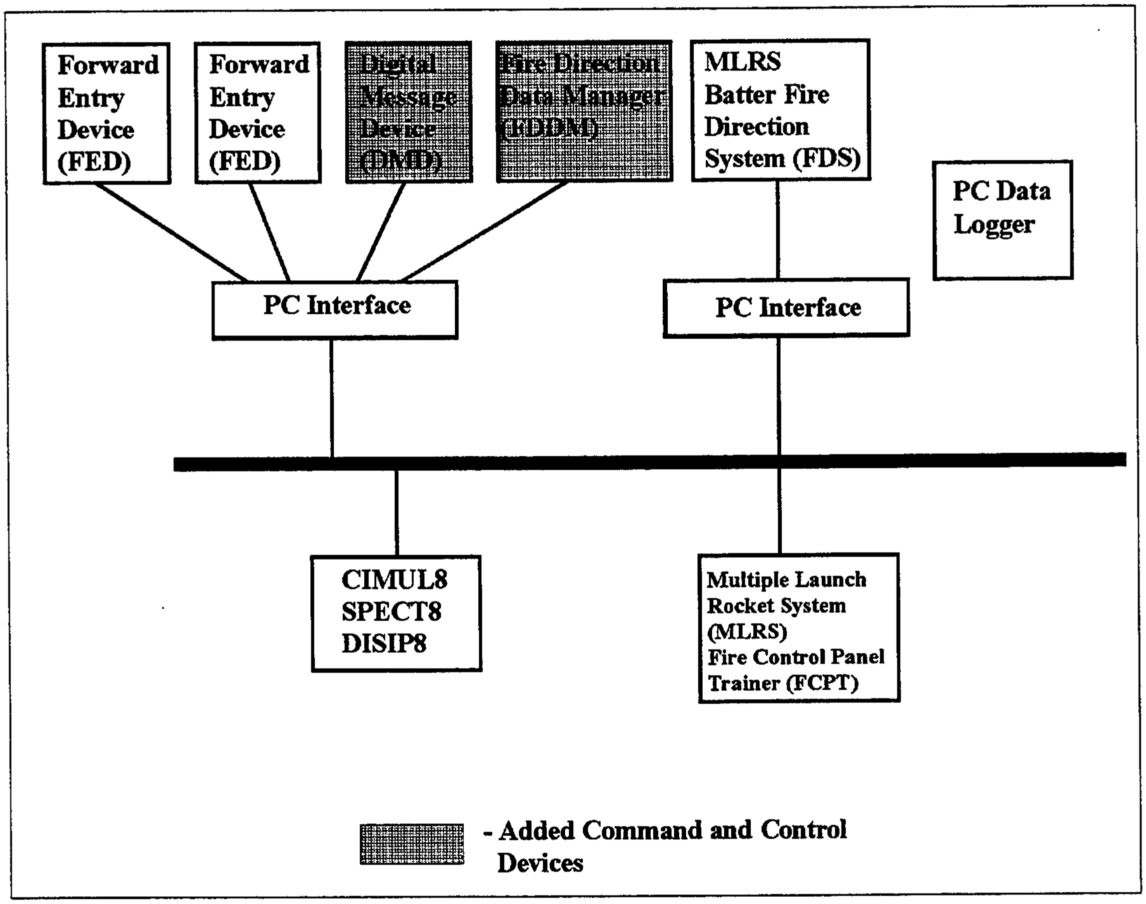

Figure 5. Demonstration configuration with FDDM and DMD.

The second scenario representing the deep battle simulated target engagement began with simulated fire finder target detection and ended with simulated launcher rocket fire. The demonstration began with the simulated fire finder radar identifying a target within CIMUL8™. The DMD was used to send command and control information that would normally be done within the fire finder system. Target information was entered on the DMD and sent to the battalion FDDM. The FDDM then sent the appropriate call for fire (CFF) to the MLRS battery FDS. The FDS then sent a CFF to an MLRS launcher that was simulated in CIMUL8™. This scenario is shown in Figure 6. The CFF format to guide preparation of correct tactical fire direction system (TACFIRE) message formats is presented in Appendix E.

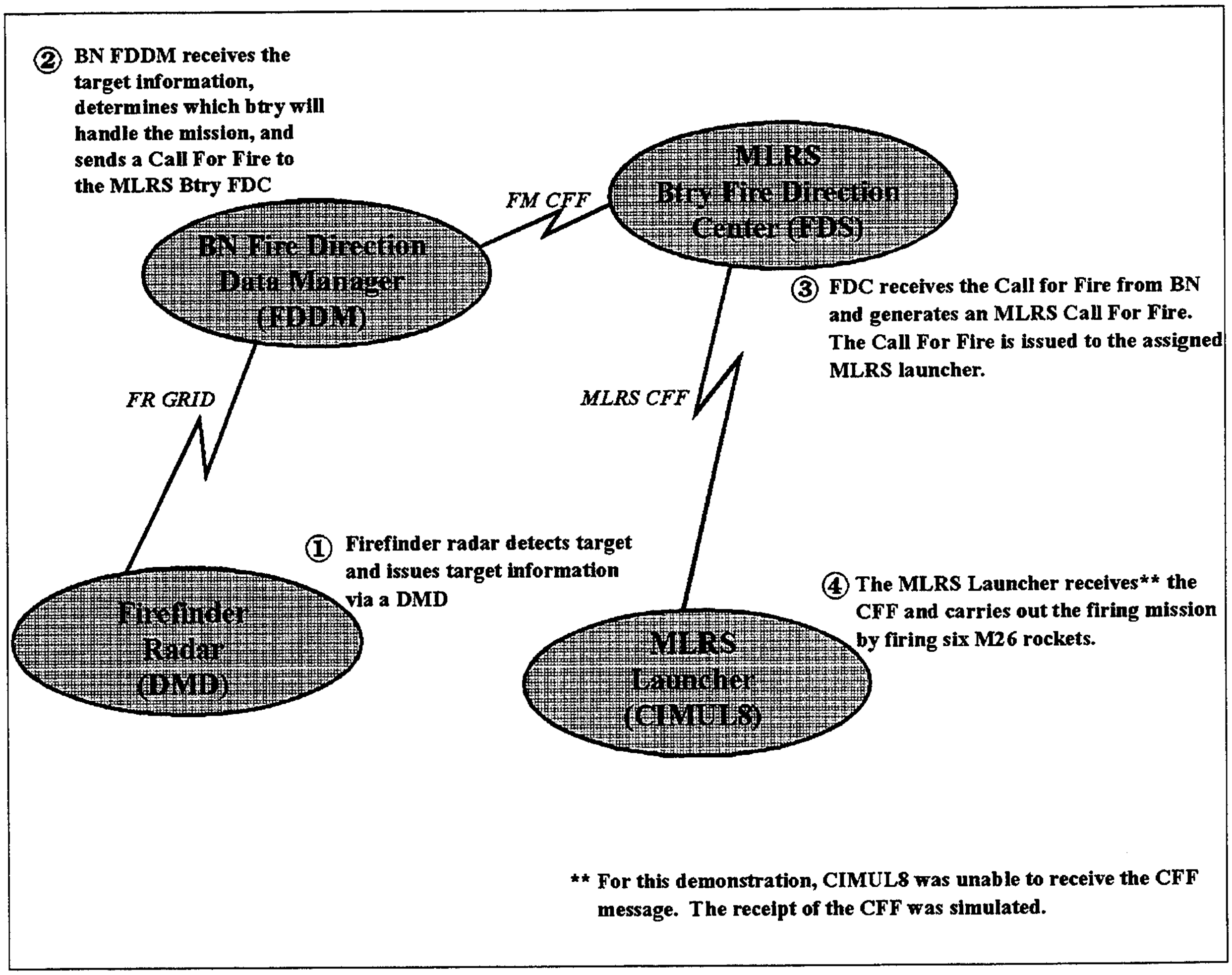

Figure 6. Scenario events for demonstration No. 2.

The demonstrations showed the success of using the DIS network for communicating digital command and control information.

Problems That Were not Resolved

Acknowledgment Messages

Although the network design with the original group of devices (not including the DMD and the FDDM) operated successfully on the LAN, it was noted that network traffic and preamble settings on the command and control devices could affect the ability of the receiving devices to provide acknowledge (ACK) messages in time for the sending device to "know" that the transmission was successful. The devices have a built-in mechanism as part of their communications protocols, which will attempt to retransmit the message as many as three more times after the first message fails (no ACK received within the specified ACK window time).

For the program network devices, the preamble settings were set so that the ACK window was larger, thus allowing the FEDs more time to return the ACK to the FDS. Even with increased network traffic loads (CIMUL8™ representing as many as 30 entities actively engaged in combat), these settings worked.

When the FDDM and the DMD were added to the network, we were unable to adjust the settings on the FDDM and the FDS so that they could provide the needed ACK over the network in time. This also highlighted the problem that could occur if the system were used over a long-distance network such as DSI. The transport times for the DIS PDUs would be such that the ACK window would be impossible to meet.

In addition, the MLRS/ATACMS FCPT software did not send an ACK at all when a signal PDU was received. To prevent the FDS from attempting to resend the same CFF message to the FCPT, an ACK is needed for the FDS software.

The short-term solution was to design the PC interface so that it provided the necessary ACK to the sending device so that the device would not attempt to resend. This approach has been implemented for the FDS. The FDS PC interface will provide an ACK to the FDS device for command and control messages sent to the MLRS/ATACMS FCPT. This ACK is on the 11-character net. An ACK has not been implemented for the 6-character net, but with minimal effort, it could be added.

The long-term solution is to allow the PC interface to act as a "relay" for messages. Digital command and control communication devices have the capability to automatically relay or forward messages received from one device. When this function is implemented, the relayer provides the ACK needed by the sender. The advantage is that the PC interface would not have to generate different ACK messages for the different types of messages sent through the interface.

MLRS/ATACMS FCPT DIS Capabilities

The MLRS/ATACMS FCPT has DIS PDU version 2.0.3 capabilities. However, the capabilities are limited and not fully DIS compliant. These are described as follow:

1. Issues entity state PDUs on behalf of the MLRS launcher vehicle. The sending of the PDUs is event driven rather than time driven. These are sent when the system is started and before and after moving (this does not follow the once-every-5-second rule in the standard).

2. Issues a fire PDU for each rocket fired in the exercise. Currently configured to fire six rockets.

3. Issues a detonation PDU after the fuse time has expired. The demonstration version used only a single detonation for all six rockets fired. The delivered system sends detonation PDUs for each of the six rockets.

4. Transmitter and signal PDUs are used to send related command and control message formats. The messages sent included response to CFF (WILCO or CANCO) and a mission-fired message.

5. The FCPT receives transmitter and signal PDUs with CFF messages from the FDS. An acknowledge message is not provided.

CIMUL8™ Use of the FR GRID Message

The FR GRID message issued by CIMUL8™ operates well for the evaluation of the trainer. At this point, it is a fixed message. More work will be required to make the message more flexible.

Potential Problems

Until the remainder of the ACK problem is addressed, transmission problems could occur if the network becomes loaded or if the long-distance network incurs excessive delays. The effects of network loading on the PC interface, CIMUL8™, and the FCPT have not been studied. The point at which the interfaces begin to lose DIS packets has not been determined. During conditions created during the demonstration week, it was shown that the system (without the FCPT) worked well with approximately 35 entities actively engaged in combat (maneuvering and firing). In this scenario, the PC experienced no lost network packets.

RECOMMENDATIONS

Following the successful demonstrations, several recommendations for improvements were made. These recommendations are explained next.

Addition of Other Command and Control Systems

A significant step has been taken toward bringing real-world command and control systems into the synthetic environment for training, testing, evaluation, and data collection purposes. The same interface used in the demonstration discussed previously can also be used with other existing command and control devices and could serve as a means to test the interaction of new and developing command and control equipment.

The interface developed for ARL and the D&SA Battle Lab has been shown to work with FEDs, DMDs, FDDM and battery FDS systems. Unmodified, it is anticipated that the same interface will also work with other command and control computers. These include FDS at the platoon and battalion levels, TACFIRE, lightweight TACFIRE (LTACFIRE), the cannon battery computer system (BCS), the all-source analysis system (ASAS), the airborne target hand-over system (ATHS), IFSAS, the ground station module (GSM), and the commander's tactical terminal (CTT). Some of these devices are shown in Figure 7.

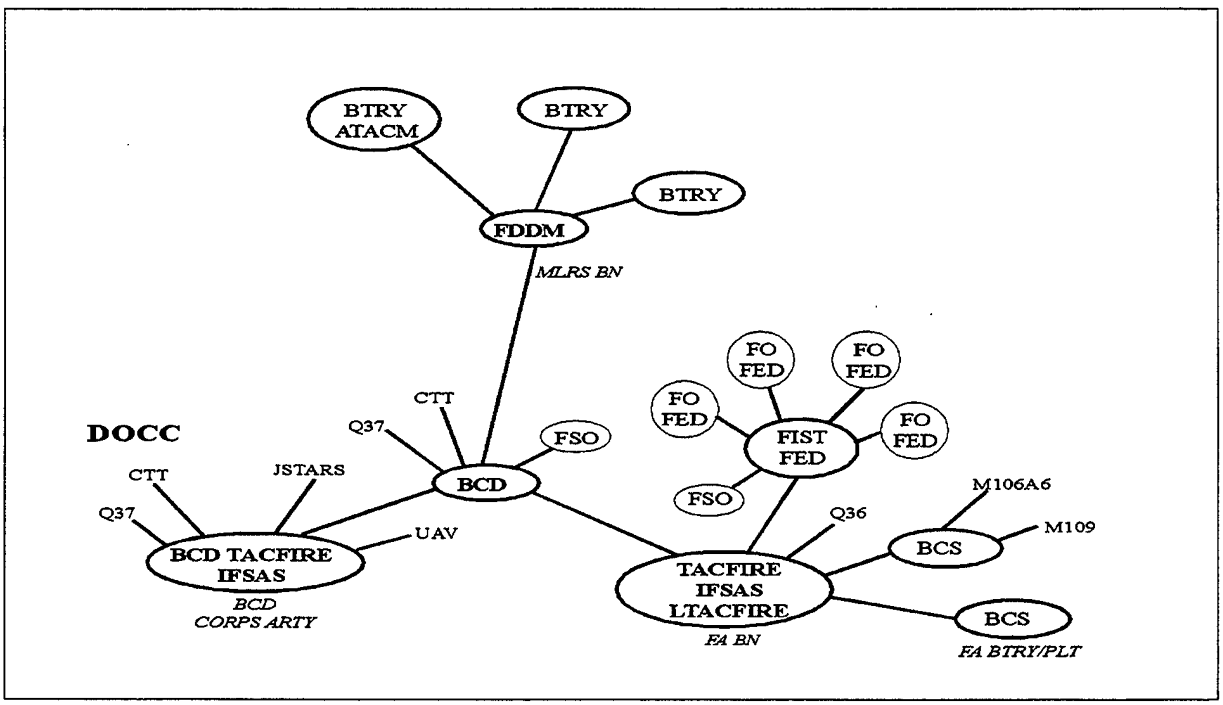

Figure 7. Expanding the command and control network.

Interface with the GSM and the CTT provides a digital communications link to Air Force and Army sensor systems such as the joint surveillance target attack radar system (JSTARS), the OV-1D Mohawk side-looking airborne radar (SLAR), and the guardrail signals intelligence (SIGINT) system. Other systems communicating with the GSM include maneuver control system (MCS) and the forward area air defense command and control (FAADC2).

In addition, the interface could be used to allow new and developing systems to test their capabilities with existing systems in the DIS environment. These include the advanced field artillery tactical data system (AFATDS), the improved data modem (IDM), and the aviation mission planning system (AMPS).

Compatibility with Television Network (TNET)

The existing network could work over the TNET, provided TNET has an Ethernet interface and is able to transmit local area network information to remote Ethernet networks.

One possible solution is to add a PC interface for TNET, which has an Ethernet card and an RS-232 interface to the COMSEC. In addition to passing information to and from TNET, the PC can serve as a filter for the local area network. One possible configuration is shown in Figure 8.

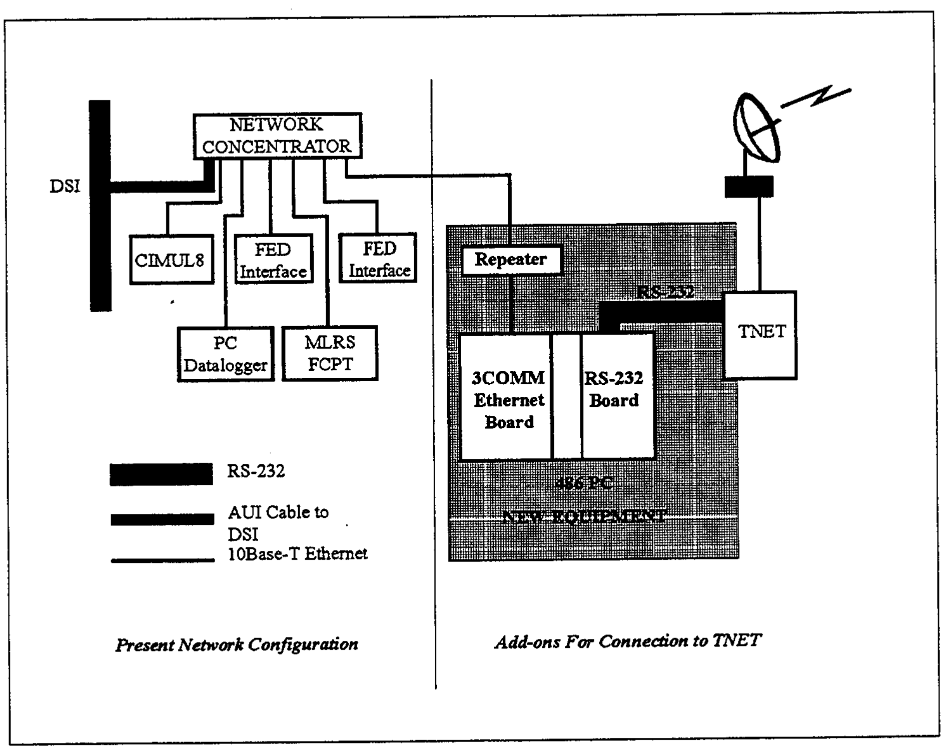

Figure 8. TNET network configuration.

A repeater is required for this configuration because of the distance between the network and the TNET COMSEC. A PC would be used to connect the Ethernet network with the COMSEC through the COMSEC 9-pin RS-232 port. A similar setup would be required at the receiving end. There are some bandwidth limitations with using the 9-pin RS-232 port (128 Kbps). If possible, the COMSEC RS-422 port could be used to employ more bandwidth.

Enhanced Data Collection Capabilities

Based on the development already performed, one area needing further capabilities is data collection. The IST-developed data logger, already a part of the ARL network, can capture DIS PDUs and provides human readable text files for reading the values of the fields in the PDUs. The data logger does not process this data, nor does it allow for data collection of specific information.

To upgrade the data collection capabilities of the ARL network, a first step could be to develop software to process the data-logged information for presentation to the user. This could be accomplished by modifying the data logger to save only the necessary information instead of the entire PDU. This information would be saved directly into a relational data base for easy report generation. Certainly, any data sent on the DIS network could be captured and processed in this manner.

For data that cannot be captured on the DIS network, a number of capabilities would need to be developed to collect the needed data. The device from which the data need to be collected would have to have the capability to provide that information upon request. The request for the data could be made over the DIS network using the simulation management PDUs. These PDUs allow a simulation manager to request certain parameters or event information from a participant on the DIS network, provided the participant has the ability to provide the information. The simulation management PDUs also provide simulation control capabilities such as simulation start, entity creation, and simulation freeze, restart and stop. These capabilities would have to be supported by the participants on the DIS network to use the simulation management PDU set.

Another possible enhancement of the ARL network would be to add support for the simulation management PDUs. This would be a significant development effort since no full implementations of the simulation management PDUs exist today. It could serve as a model for other systems and provide valuable feedback to the DIS standards as they continue in their development.

Enhanced Support for Command and Control Devices

To support long-distance networking of a large variety of command and control systems, the interface software already developed needs further refinement. The existing interface allows the digital communication devices to communicate through their field wire interface, allowing them to use the same physical, data link, network and transport layer protocols that are used in the field. Part of the transport layer protocol is to ensure reliable communications by requiring the receiving system to send an ACK indicating that the message was successfully received. If the ACK is not received by the sender within a certain predetermined period of time, the sender attempts to retransmit the message, returning an error message to the operator after three unsuccessful attempts to resend. On the original demonstration network, ACKs were successfully sent by the receiving system over the network. There is concern that additional network traffic and the introduction of the long distance will cause enough delay in the sending of the ACK so that it will not be received in time by the sender of the message.

Since this project does not modify the software on the command and control devices, the interface for the sending system will need to provide the ACK for the sending communication device in order for the ACK to be returned to the sender in time.

Enhanced Entity Representation

The completed demonstration system does not do detailed entity representation. The DIS entity operating the command and control equipment using the interface is stationary. The entity movement is not modeled, although an instant move is possible. To provide realistic entity movement, a terrain data base will be necessary for realistic representation in a three-dimensional view of the battlefield. Movement models would also be necessary.

A possible solution would be to add these capabilities in the interface software. Terrain information, along with movement models, would be required. Another solution would be to use an existing computer-generated forces (CGF) system to control the appearance and movement of the entity in the synthetic environment. The PC interface would then be used for communications and radio representation only. This represents a step toward distributed representation of a single entity--a fairly new concept in the DIS world.

CIMUL8™ might be used as the CGF for entity control and movement. This system already exists on the ARL network. A PC-based system such as IST's CGF (software already existing in D&SA and DIS compliant) might also be used to move command and control entities, provided some modifications are made to adapt it for the ARL situation. This would provide a PC-based solution that is relatively low cost and available to other sites. A third possibility would be to obtain a system such as the DIS-compatible interactive tactical environment management system (ITEMS™). ITEMS™ can provide simulation for the command and control entities and can provide a three-dimensional stealth view of the battlefield. In addition, the flexibility of the ITEMS™ data base management system (DBMS) allows for user definition of vehicles, weapons, and their characteristics--ideal for an experimentation and testing environment.

All the CGF systems mentioned previously would require the development of terrain data bases for the area to be used for maneuvers. Data bases may already exist for many areas of interest.

Enhanced Radio Representation

Command and control devices typically communicate using FM radios and encryption devices. Representations for use of these devices in a radio environment could be further enhanced by allowing transmitted signals to be jammed or masked by terrain. Currently, the system assumes perfect transmissions.

Terrain representation is required to determine line of sight. Other environmental factors may be required, depending on the fidelity of the propagation model to be used. Detection and jamming should also be allowed.

CONCLUSION

The development of an interface for fire support command and control tactical equipment into the synthetic environment represents the first time soldiers operating live equipment have been able to interact with soldiers operating training devices in a virtual arena on a computer-generated battlefield populated by computer-generated equipment and forces produced by a constructive simulation, linking live, virtual, and constructive simulations in a seamless manner. Currently, the potential to link within and between simulation categories varies from good (in the case of constructive-to-constructive simulations) to very limited (in the live-to-live category). Improvement in this area is critical to the utility of this concept to support Department of Defense (DoD) readiness requirements.

Decreasing resources and environmental restraints and the increasing amount of land required by advances in mobility and weapon system lethality are limiting our ability to effectively and efficiently conduct tough and realistic field exercises for training, testing, or research and development. The Army must apply major technological advancements to the training, testing, and research and development arena just as it has to the operational arena. Just as digitization is revolutionizing command, control, communications, computers, and intelligence (C4I) for the field forces, advances in computer capabilities are revolutionizing the training battlefield and the way that testing and research and development are conducted.

Described in this report was the formation of a fire support command and control test bed that centered around the development of a software interface that allowed live tactical command and control equipment to interact in a seamless fashion with computer-generated forces arrayed on the synthetic battlefield. The next step will be to evaluate this technology to determine its feasibility to support training, testing, and research and development. The ARL and the D&SA Battle Lab will demonstrate and begin to assess the utility of the technology during advanced warfighting experiments and during Battle Lab experimentation initiatives such as intrepid vision, digitization experimentation in the Janus battle simulation center, synthetic theater of war initiatives, and prairie warrior.

APPENDIX A

ACRONYM LIST

ACRONYM LIST

ACK	type of signal that acknowledges receipt of a command and control message
AFATDS	advanced field artillery tactical data system
AMPS	aviation mission planning system
ADDS	Army data distribution system
ARL	Army Research Laboratory
ARP	address resolution protocol
ASAS	all-source analysis system
ATACMS	Army tactical missile system
ATHS	airborne target hand-over system
BCS	battery computer system
CADIS	communication architecture for DIS
CFF	call for fire
CGF	computer-generated forces
COTS	commercial off the shelf
CTT	commander's tactical terminal
D&SA	Depth and Simultaneous Attack
DBMS	data base management system
DIS	distributed interactive simulation
DMD	digital message device
DSI	defense simulation internet
EPLRS	enhanced position location reporting system
ES	entity state
FAADC2	forward area air defense command and control
FCPT	fire control panel trainer
FDC	fire direction center
FDDM	fire direction data manager
FDS	fire direction system
FED	forward entry device
FIST	fire support team
FO	forward observer
FOCC	forward observer command and control
FO CMD	type of message used by a forward observer to report changes in fire mission commands. (Also used by a firing unit to report firing status.)

FR GRID	Type of message used to initiate a fire request by reporting a target location using grid coordinates.
FSATS	fire support automated test system
FSK	frequency shift keying
FSO	fire support officer
GSM	ground station module
ICD	interface control document
IDM	improved data modem
IFSAS	interim fire support automation system
ISO	International Organization for Standardization
IST	Institute for Simulation and Training
ITEMS	interactive tactical environment management system
Janus	a two-sided, interactive, closed, stochastic ground combat simulation capable of portraying virtually any tactical situation or the effects of any weapon system.
JSTARS	joint surveillance target attack radar system
LAN	local area network
LCU	lightweight computer unit
LTACFIRE	lightweight TACFIRE
MCS	maneuver control system
MLRS	multiple launch rocket system
OSI	open systems interconnection
PC	personal computer
PDU	protocol data unit
PIU	PC interface unit
SIGINT	guardrail signals intelligence system
SLAR	side-looking airborne radar
SPECT8™ CIMUL8™ DISIP8™	a proprietary simulation software program that provides information, display and a digital simulation capability
SHTU	simplified hand-held terminal unit
TACFIRE	tactical fire direction system
TAFSM	target acquisition fire support model
TCIM	tactical communications interface module
UCF	University of Central Florida
UDP/IP	user datagram protocol/internet protocol
WAN	wide area network
WILCO	will comply

APPENDIX B

HARDWARE, SOFTWARE, AND GOVERNMENT-PROVIDED EQUIPMENT REQUIREMENTS

HARDWARE, SOFTWARE, AND GOVERNMENT-PROVIDED EQUIPMENT REQUIREMENTS

NETWORK REQUIREMENTS		
QTY	MODEL	DESCRIPTION/MINIMUM SPECS
	HARDWARE	
3	486 PC 50Mhz (Intel DX Processor)	256 Cache
		8MB RAM
		200MB Hard Drive
		5.25" (1.2MB) Floppy Drive
		3.5" (1.44MB) Floppy Drive
		Etherlink III Network Interfaces (by 3COM)
		8 Port RS-232 Interface
		2 - Serial Ports
		1 - Parallel Port
		VGA Card
		14" VGA Monitor
		101 Key Keyboard
		Microsoft compatible mouse
2	Telos® Signal Master	Programmable Communications Controller
1	10BaseT Concentrator or Wiring Hub	8 Node Minimum
8	10BaseT (802.3)UTP Cables	50' Length
1	Super Compstation 7/30 36MHz (SPARC compatible)	19" Tatung® Color Monitor
		GX Graphic Accelerator
		32MB Main Memory
		1.08 GB Internal Hard Drive
		8 Memory Slots (max. 256 MB memory)
		Ethernet interface
		107-key Keyboard
		Mechanical Mouse
		Solaris 2.1 software installed (includes: open Windows, open Look, XIIR5 MOTIF)

NETWORK REQUIREMENTS (cont'd)		
QTY	MODEL	DESCRIPTION/MINIMUM SPECS
1	Super Compstation 7/30 36Mhz (SPARC compatible)	19" Tatung® Color monitor
		GX Graphic accelerator
		32MB Main memory
		1.08 GB Internal hard drive
		8 Memory slots (max. 256MB memory)
		Ethernet interface
		107 Key Keyboard
		Mechanical mouse
		Solaris 2.1 software installed (includes: open Windows, open Look, XIIR5 MOTIF)
		150MB _" External Cartridge Tape Drive
		680MB CD-ROM External SCSI Drive
1	Desktop MLRS/ATACMS Fire Control Panel Trainer	(by LORAL/Vought Systems)
1	Ethernet Transceiver	Vampire Tap
1	Ethernet Accessories	Transceiver plenum cable (50 ft), Coring Tool & Allen
1	Dot Matrix printer	(on loan from CAE-Link)
SOFTWARE		
3	MS-DOS 6.0	
3	MS-WINDOWS 3.1	
3	Norton Desktop Utilities	
2	Borland C++® Compiler	
3	HEAP Expander	(by The Tool Makers) memory management software
2	Communications Library	Communications Library for communications with RS-232 & Ethernet (Company as recommended by manufacturer of the 8 port cards)
1	Borland Office	(Includes: WordPerfect for Windows 5.2, Paradox for Windows, QuattroPro for Windows)
1	CorelDraw® 3	
3	PC/TCP 4	(By FTP software, version as recommended by the manufacturer of the 3C503 board)

NETWORK REQUIREMENTS (cont'd)		
QTY	MODEL	DESCRIPTION/MINIMUM SPECS
2	SPECT8™/CIMUL8™/DISIP8™	(By BDM International Inc)
2	GKS-X-X-X-RT	"Right to Use" license for SUN GKS
	GOVERNMENT FURNISHED EQUIPMENT	
2	Forward Entry Device (FED)	Including power and data cables
1	Lightweight Computer Unit (LCU)	(with Fire Direction System (FDS) software installed)
N/A	TACFIRE Interface specifications	(From Software Engineering Directorate, Fire Support Software Division)
1	Fire Support System Simulation (FS3) software	(From Software Engineering Directorate, Fire Support Software Division)
1	Digital Message Device	Added for Demonstration #2
1	Fire Direction Data Manager	Added for Demonstration #2

APPENDIX C

INTERFACE CONTROL DOCUMENT

INTERFACE CONTROL DOCUMENT

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1.0 INTRODUCTION

This interface specification was developed in support of the Army Research Laboratory (ARL) sponsored project to instrument the Depth and Simultaneous Attack (D&SA) Battle Lab with Fire Support command and control equipment using the Distributed Interactive Simulation (DIS) protocols on a Local Area Network (LAN). The purpose of this laboratory is to simulate realistic battlefield communications conditions for research and training. Devices to be integrated into this simulation capability include: Forward Entry Device (FED), Fire Direction System (FDS), and the Multiple Launch Rocket System/Army Tactical Missile system (MLRS/ATACMS) Fire Control Panel Trainer (FCPT).

The integration of these devices onto an instrumented LAN will permit the conduct of realistic Fire Support command and control exercises to be conducted in conjunction with JANUS, or any other simulation system, using real soldiers performing tasks in the laboratory as they would in the field. This simulation capability will be further augmented with the integration of SPECT8™/CIMUL8™/DISIP8™.

With the eventual installation of a Wide Area Network (WAN), laboratory personnel will have the capability to participate in DIS exercises with participants located at remote locations.

1.1 BACKGROUND

1.1.1 Operation of the Integrated System

There are two applications for which the integrated system will be utilized to support laboratory experiments. One application will call for a Forward Observer (FO) or Fire Support Team (FIST) to enter target information or calls for fire through the FED. This information will be transmitted to the FDS (serving as a battery FDS) via a DIS network rather than through conventional means such as a radio or two wire communications. The FED message will be received by the battery FDS and the battery FDS operator will then assign the mission to the MLRS/ATACMS FCPT. The FDS will make the assignment by passing on the call for fire to the launcher via the DIS network. When the MLRS/ATACMS FCPT receives the mission it presents the mission information to the operator to be acted on accordingly. Finally, the MLRS/ATACMS FCPT operator will enter the correct inputs in response to the message (usually to fire the launcher), at which time the launcher interface will issue the appropriate DIS Protocol Data Unit (PDU) for firing and detonation of munitions.

The second application is similar to the first, except the FED and the FDS are not included as part of the scenario. The SPECT8/CIMUL8/DISIP8 software will produce the proper launcher messages to stimulate the MLRS/ATACMS FCPT. The MLRS/ATACMS FCPT operator will respond to the inputs in the appropriate manner.

The functional configuration for the integrated network is shown in Figure C-1.

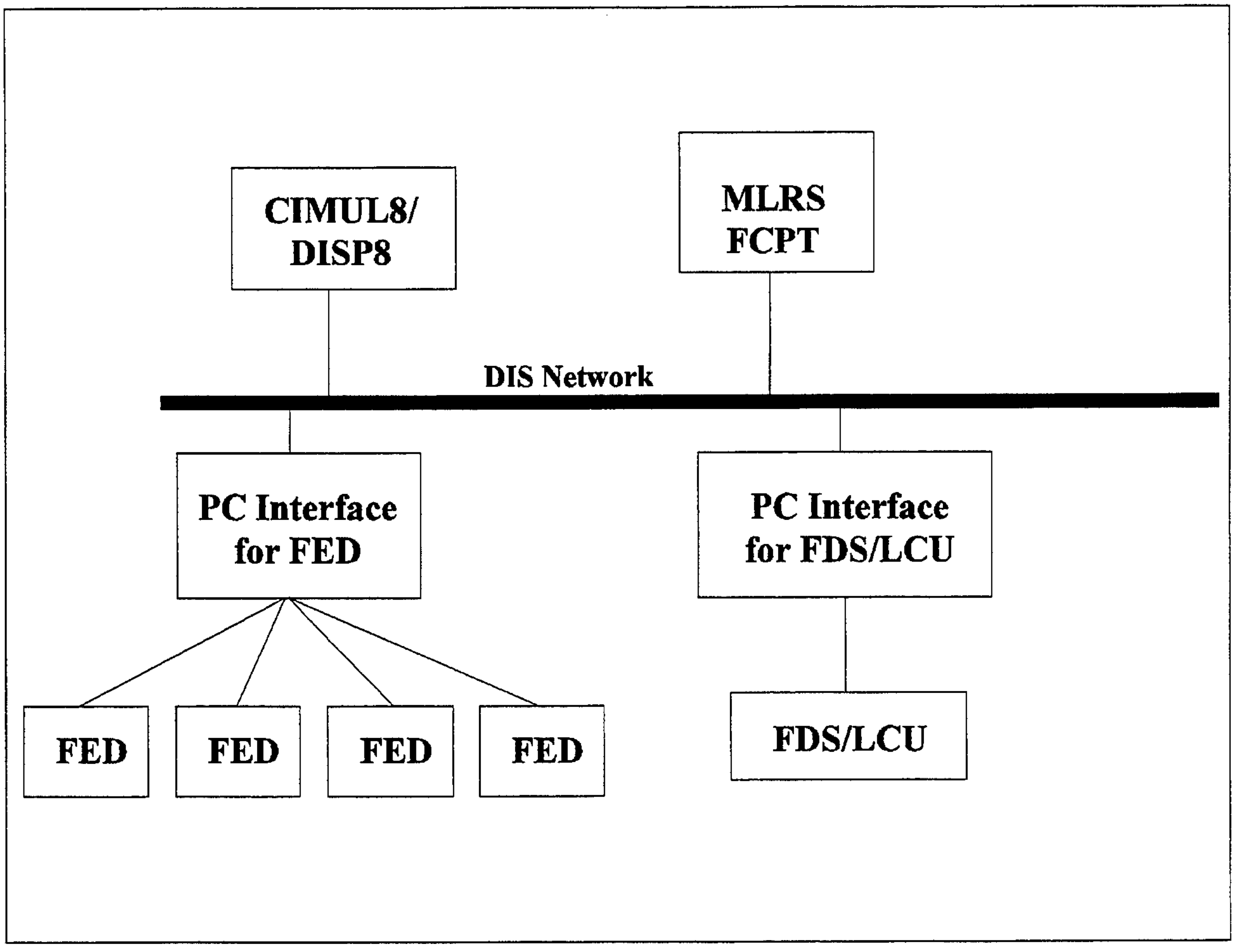

Figure C-1. Network configuration for ARL/Ft Sill.

A description of the various devices on the network is included in the paragraphs that follow.

1.1.2 Forward Entry Device

The FED Forward Observer Command and Control (FOCC) device is a hand-held digital device that is used to compose, edit, transmit, receive, display, store, or recall digital messages. The FED FOCC is used by FO's, FIST's, and FSO's to conduct and plan fire support operations and by survey parties to display and transmit manually entered survey command and control data to another FED FOCC. The FED FOCC also has a graphics capability that enables the display of pertinent tactical military symbols and other graphical information.

The FED FOCC has the capability for two-way communications through the use of a single communications port using either the Frequency Shift Keying (FSK) communications protocol over standard army tactical communications equipment or the Army Data Distribution System (ADDS) communications protocol over the Enhanced Position Location Reporting System (EPLRS).

The FED software is executed on a standard AN/PSG-7 Simplified Handheld Terminal Unit (SHTU).

1.1.3 Fire Direction System

The FDS is the computer system that provides tactical fire control for the MLRS platoon, battery, and battalion levels. For the purposes of the Fort Sill laboratory interface, our FDS will be operating at the battery level. The FDS is responsible for determining those targets to be fired upon, those fire units capable of firing at the target, and the amount of ammunition to be used against a given target.

The FDS software is executed on a standard AN/GYK-37V, Lightweight Computer Unit (LCU). FDS equipment also includes a printer, AC/DC Converter/Charger, a Tactical Communications Interface Module (TCIM), and a TCIM wire-line adapter.

1.1.4 Multiple Launch Rocket System Fire Control Panel Trainer

The MLRS/ATACMS FCPT is a desk top device for training soldiers in the use of the MLRS/ATACMS Fire Control Panel. This training has traditionally been accomplished on a larger, more expensive institutional training system. Installed on a 486 PC compatible computer running an OS/2 operating system, this device is less expensive and more portable than the institutional trainer.

A DIS interface capability has been added to the FCPT for this project. The trainer plugs directly into the 10-Base T Ethernet network.

1.1.5 SPECT8/CIMUL8/DISIP8

SPECT8/CIMUL8 is a computer simulation model for addressing military problems at several, user-selected, levels of detail. It is a graphics tool that assists the user in setting up scenarios, observing the model's operation, interacting with the model, and post-processing. SPECT8/CIMUL8 can also be used in a stand-alone mode for analyzing other model output, field test data, etc. DISIP8 provides the capability for SPECT8/CIMUL8 to interact with other simulations using DIS.

SPECT8/CIMUL8/DISIP8 runs on a Tatung (SPARC compatible) workstation.

1.1.6 PC Interfaces

Two PC interfaces, called PC Interface Units (PIU's), are used to provide a connection to the DIS network for the FED and the FDS. The PIU's are responsible for creating and sending DIS PDUs, including PDUs containing the TACFIRE messages exchanged between devices. The PIU also receives and interprets DIS PDUs from the network and, when necessary, provides TACFIRE information from the Signal PDUs to the FED or FDS.

The PIU's are hosted on IBM™ compatible PC's with Intel™ 80486 processors.

1.2 DOCUMENT OVERVIEW

Section 1 has provided an overview of how the integrated system operates and briefly described its individual parts. Section 2 describes the high level interface concept for the system. Section 3 provides the details for the various interfaces discussed in Section 2, including the DIS PDU interface, UDP/IP usage, and Ethernet usage.

2.0 GENERAL INTERFACE CONCEPT

The present interface design supports two concepts of operation for the integrated system. The first consists of using the FED and the battery FDS to provide firing events for the MLRS/ATACMS FCPT on the network. The second uses SPECT8/CIMUL8/DISIP8 to provide firing events directly to the MLRS/ATACMS FCPT.

2.1 GENERAL ASSUMPTIONS

This section describes the assumptions for development of DIS interfaces for the ARL/Fort Sill laboratory.

2.1.1 Use of DIS PDU Version 2.0.3

DIS PDU version 2.0.3 shall be used for this interface. Only DIS PDUs required to simulate the integrated system will be required. DIS PDUs shall be used in the following manner for the integrated system:

1. TACFIRE message traffic shall be communicated using Transmitter and Signal PDUs. Receiver PDUs are not required.

2. Entity State PDUs shall be issued on behalf of the entity containing or controlling the transmitting device. Articulated parts are not required.

3. Fire and Detonation associated with the munition fired by the MLRS/ATACMS FCPT shall be communicated using the Fire PDU and the Detonation PDU respectively.

2.1.2 Use of CADIS Version 1.0

The Communication Architecture for DIS (CADIS) draft standard version 1.0 shall be used with this interface. Protocols to be used on the local area network are:

<u>Application, Presentation & Session Layers:</u>	DIS 2.0.3
<u>Transport & Network Layer:</u>	DP/IP (CADIS 1.0)
<u>Data Link Layer:</u>	Ethernet
<u>Physical Layer:</u>	Ethernet

2.1.3 Radio Simulation

Simulation of the actual radios along with associated jamming, noise, interference, etc. will not be represented in this integrated system. It is assumed that the devices send and receive perfect signals. It is also assumed that for this application, all devices are tuned to the same radio frequency.

2.1.4 Entity Information

Entity information for the entities associated with the transmitter shall be issued in accordance with the DIS PDU 2.0.3 standard. FEDs and FDS will be associated with either dismounted infantry or a specific vehicle. The MLRS/ATACMS FCPT will be associated with the MLRS carrier vehicle. CIMUL8 will represent its entities with the appropriate Entity State PDUs.

FED and FDS related entities will not maneuver while the simulation is running. There will be an off line capability to "Beam" the FED and FDS entities to various locations on the battlefield. CIMUL8 entities may maneuver during the simulation. Movement will be communicated using Entity State PDUs.

2.2 INTEGRATED SYSTEM USE WITH THE FED, FDS, AND MLRS/ATACMS FCPT

Simulation of the battle may be represented by CIMUL8, JANUS or any other simulation on the LAN or DSI. Battle information is available to the simulation controller via visual interface (not necessarily through the network). Based on the battle information presented, a forward observer enters fire missions on a FED and sends the missions to the battery FDS for resource allocation. The FDS then communicates with the MLRS/ATACMS FCPT, indicating that it has been assigned a mission.

2.2.1 BATTLE SIMULATION to FED Forward Observer Operational Concept

The forward observer views the battle via the simulation screens for a simulation application such as JANUS or CIMUL8. Based on this information, a Forward Observer determines that a call for fire is required. The FO enters the call for fire in the FED and issues the message to the battery FDS.

2.2.1.1 Assumptions

- Communications between a simulation (*i.e.*, JANUS) and the Forward Observer with the FED are not on the network but are visual via the simulation's user interface screens.
- Communications between the Forward Observer and the simulation providing battle information is not defined in this document.
- The integrated system may be used without simulation battle information using predetermined values.

2.2.1.2 Battle Simulation Actions

The purpose of the battle simulation is to provide battlefield information for the forward observer. The battle simulation may also provide a view of the location of participating entities based on received network information. This is for the benefit of the researcher who can determine which devices are present and what actions the entities are performing. In the integrated configuration described in this document, the simulation is not required to send DIS information on the network. The battle simulation has no required actions relative to the DIS network although, if the simulation is displaying other entities, it should be able to receive DIS PDUs from the network for display purposes.

2.2.1.3 Forward Observer/FED Actions

The Forward Observer uses the battle information to determine which fire missions should be ordered. The Forward Observer may also enter fire missions with predetermined values independent of a battle simulation. These missions with the appropriate information are entered into the FED.

2.2.2 Forward Observer FED to FDS Operational Concept

The Forward Observer, having entered the appropriate fire mission into the FED, transmits the mission to the FDS. The FDS, upon receipt of the command and control message from the FED, shall issue the appropriate acknowledgment.

2.2.2.1 Assumptions

• FED communications with the FDS will be in the form of command and control messages containing fire missions to be executed.

• FDS communication with the FED will be in the form of acknowledgments to command and control messages received from the FED.

2.2.2.2 FED Actions

The FED operator transmits the command and control message requesting a particular fire mission. This message is then received by the FED PIU.

2.2.2.3 FED PIU Actions

When the FED PIU receives the call for fire message from the FED, the PIU shall create and send the appropriate DIS PDUs necessary to send the command and control message to the FDS. These PDUs are sent to the FDS PIU.

When the FED PIU receives command and control acknowledgments from the FDS, the PIU shall receive and interpret the DIS PDUs. The PIU shall then send any relevant command and control information to the FED.

2.2.2.4 FDS PIU Actions

When the FDS PIU receives the DIS PDUs from the FED PIU, it receives and interprets the DIS PDUs. It then sends any relevant command and control messages to the FDS.

When the FDS sends command and control information either back to the FED or to the MLRS/ATACMS FCPT, the FDS PIU receives this information from the FDS, creates the proper DIS PDUs for sending the information, and sends the DIS PDUs onto the network to the proper recipient.

2.2.2.5 FDS Actions

Upon receipt of the command and control information from the FDS PIU, the FDS software receives and processes the command and control message. The FDS shall then issue the appropriate command and control acknowledgment to the FED. This ACK is sent to the FED via the FDS PIU.

2.2.3 FDS to MLRS/ATACMS FCPT Operational Concept

The operator of the FDS receives the fire mission from the FED via the network and the associated PIU's. Displayed is information concerning the mission in the form of a Call For Fire. The operator determines the resource allocation for the mission (in this case, the MLRS/ATACMS FCPT) and sends the mission on to MLRS/ATACMS FCPT.

2.2.3.1 Assumptions

- FDS communications with the MLRS/ATACMS FCPT will be in the form of an MLRS Call For Fire.
- MLRS/ATACMS FCPT communication with the FDS will be in the form of acknowledgments to calls for fire, response messages, and launcher status reports.

2.2.3.2 FDS Actions

The operator of the FDS shall input any additional information required concerning the fire mission and shall process target information received from the FED. When ready, the operator transmits the MLRS Call for Fire command and control message.

2.2.3.3 FDS PIU Actions

Upon receiving the Call for Fire message from the FDS, the PIU shall create and send the proper DIS PDUs in order to send the command and control information to the MLRS/ATACMS FCPT.

The FDS PIU shall also be able to receive DIS PDUs with TACFIRE information relevant to the FDS. These PDUs contain TACFIRE information from the launcher concerning launcher status and acknowledgments to FDS issued calls for fire. The PIU shall process the DIS PDUs and issue the TACFIRE data to the FDS.

2.2.3.4 MLRS/ATACMS FCPT Actions

Upon receipt of DIS PDUs from the FDS PIU, the MLRS/ATACMS FCPT network interface shall process the DIS PDUs and send the command and control information on to the MLRS/ATACMS FCPT software. The MLRS/ATACMS FCPT software shall then process the received command and control information and take appropriate actions to present the information to the FCP trainee.

In response to the receipt of the command and control messages, the MLRS/ATACMS FCPT shall issue appropriate acknowledgments to the FDS. In addition, the MLRS/ATACMS FCPT shall issue a message responding to the Call for Fire (e.g. WILCO). The MLRS/ATACMS FCPT network interface shall create and issue the appropriate DIS PDUs for sending out command and control message ACK's and launcher status reports as required.

2.2.4 MLRS/ATACMS FCPT to DIS Network Operational Concept

The operator of the MLRS/ATACMS FCPT receives the fire mission from the FDS via the FDS PIU, the network and the MLRS/ATACMS FCPT network interface. The operator carries out the mission and the weapon is fired.

2.2.4.1 Assumptions

- Entity State PDUs are issued for the launcher carrier vehicle.
- Fire, Detonation, and appropriate Entity State PDUs are issued for the munition fired.

2.2.4.2 MLRS/ATACMS FCPT Actions

The MLRS/ATACMS FCPT shall simulate the munitions fired by the MLRS/ATACMS FCPT. This simulation shall include representation of the firing, trajectory, and detonation of the munition. A Fire PDU shall be issued when the MLRS/ATACMS FCPT is fired. In addition, a Detonation PDU shall be sent upon munition detonation.

Entity State PDUs shall also be issued representing the MLRS/ATACMS FCPT's launcher carrier vehicle.

2.3 INTEGRATED SYSTEM USE WITH SPECT8/CIMUL8/DISIP8

The integrated use of the system using SPECT8/CIMUL8/DISIP8 to provide command and control events to the network replaces the use of the FED with CIMUL8. This provides a simulation generated event into the networked system instead of FED equipment generated events. The operator of the SPECT8/CIMUL8/DISIP8 system enters the appropriate events for use in the simulation experiment. When the experiment begins, the entity information is generated by SPECT8/CIMUL8/DISIP8 and sent to the DIS network in the form of DIS PDUs. Command and control events are simulated within SPECT8/CIMUL8/DISIP8 and communicated to the FDS through an FR GRID command and control message. The FDS then processes the message as described in 2.2 and sends the appropriate Call For Fire to the FCPT.

The operator of the MLRS/ATACMS FCPT, upon receiving command and control information from the FDS will carry out the appropriate actions.

2.3.1 Assumptions

- SPECT8/CIMUL8/DISIP8 communication with the FDS will be in the form of FR GRID messages.
- MLRS/ATACMS FCPT does not communicate with CIMUL8 but communicates with the FDS as described in 2.2.

2.3.2 SPECT8/CIMUL8/DISIP8 Actions

When the SPECT8/CIMUL8/DISIP8 simulation application is ready to send the FR GRID message, it shall create the proper command and control message for use by the FDS. This command and control message shall be sent onto the DIS network using the appropriate DIS PDUs.

Although ACK's will be sent to SPECT8/CIMUL8/DISIP8 from the FDS upon receipt of the FR GRID, SPECT8/CIMUL8/DISIP8 is not required to process these messages.

2.3.3 MLRS/ATACMS FCPT Actions

See section 2.2.4.2 for MLRS/ATACMS FCPT Actions.

3.0 INTEGRATED SYSTEM INTERFACE DETAILS

This section contains the details for implementing the integrated system interfaces described in Section 2. These interfaces can be described using the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) Reference Model. The OSI Reference Model with the protocol selection for our integrated system is shown in Figure C-2.

3.1 NETWORK INTERFACE REQUIREMENTS

The following interface requirements apply to all devices that are part of the integrated system.

3.1.1 Physical and Link Layers - Ethernet Network

All devices shall support an interface to an Ethernet (not IEEE 802.3) network. This includes utilization of the Ethernet physical and data link layer protocols. The addressing mode for sending information shall be broadcast.

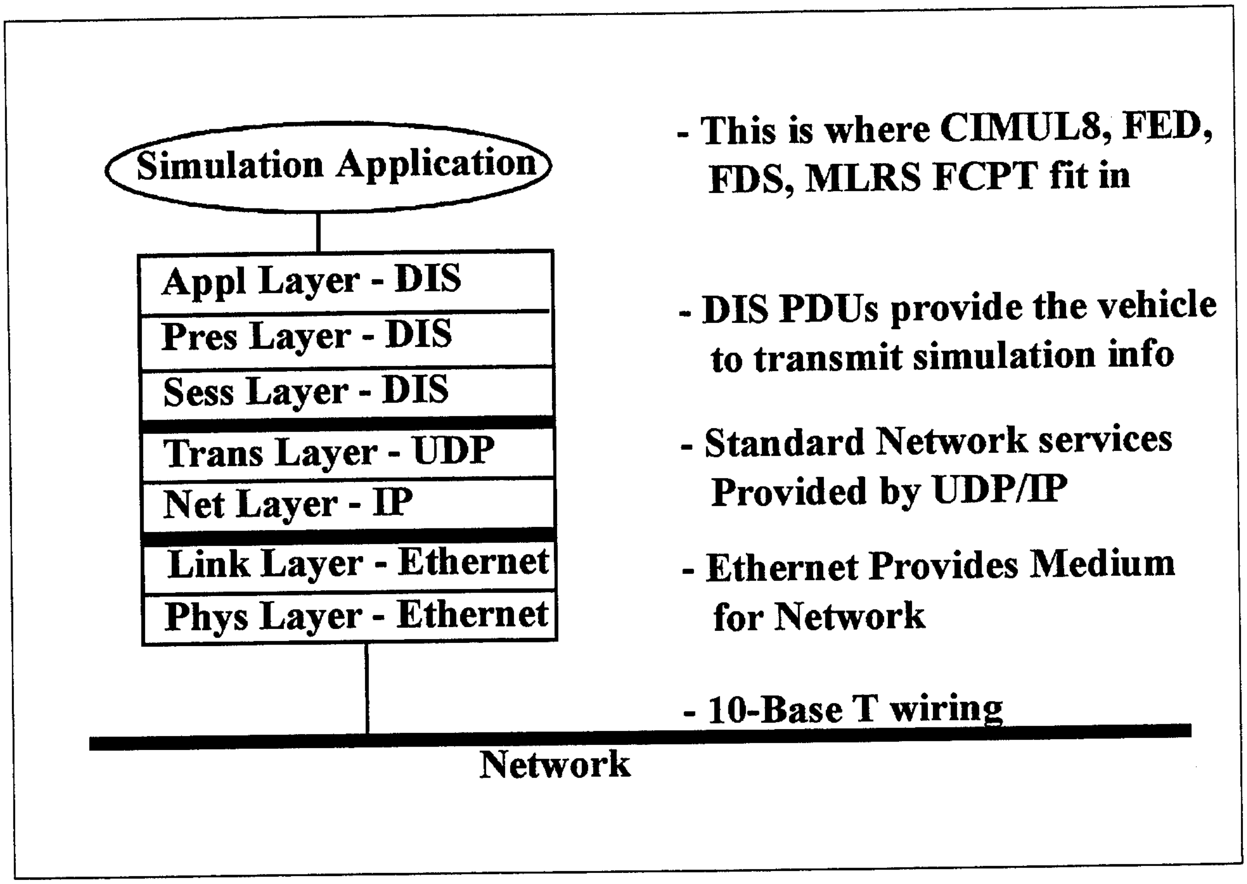

Figure C-2. Integrated system layers.

Octet ordering shall conform to the DIS standard of little endian.

The physical media for Ethernet shall be 10-BaseT cabling. This cabling shall be attached to the Ethernet concentrator.

This network hardware configuration is illustrated in Figure C-3. Figure C-4 shows the peer-to-peer communications established by the requirements of 3.1.1.

3.1.2 Network and Transport Layer

All devices on the network shall utilize UDP/IP as specified by the CADIS 1.0 standard.

3.1.3 Session, Presentation, and Application Layer

All devices shall utilize the DIS PDU standard as specified in version 2.0.3. Table C-3 shows which of the devices on the network are required to support which PDUs.

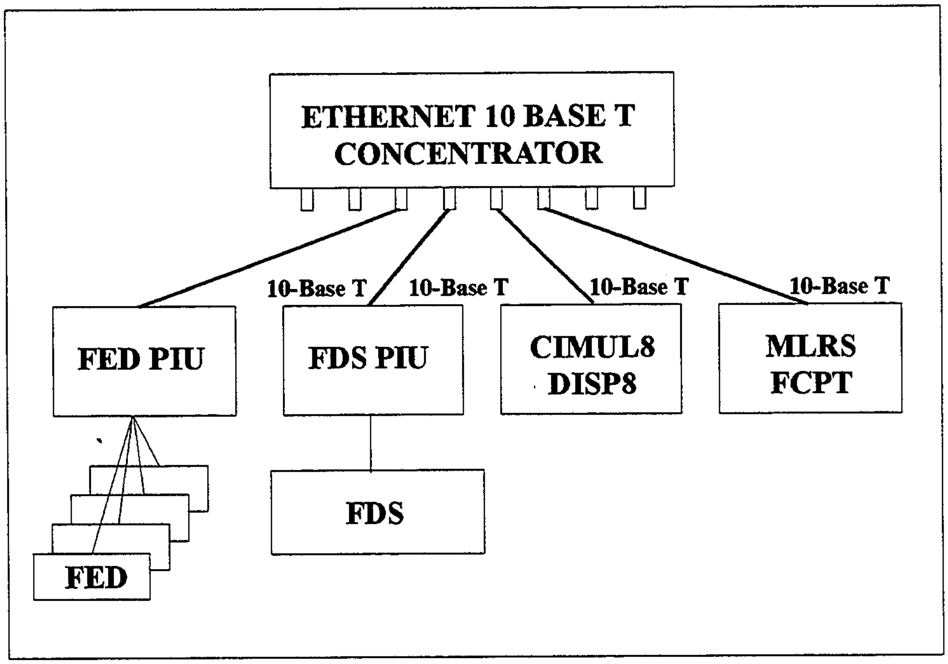

Figure C-3. Hardware configuration.

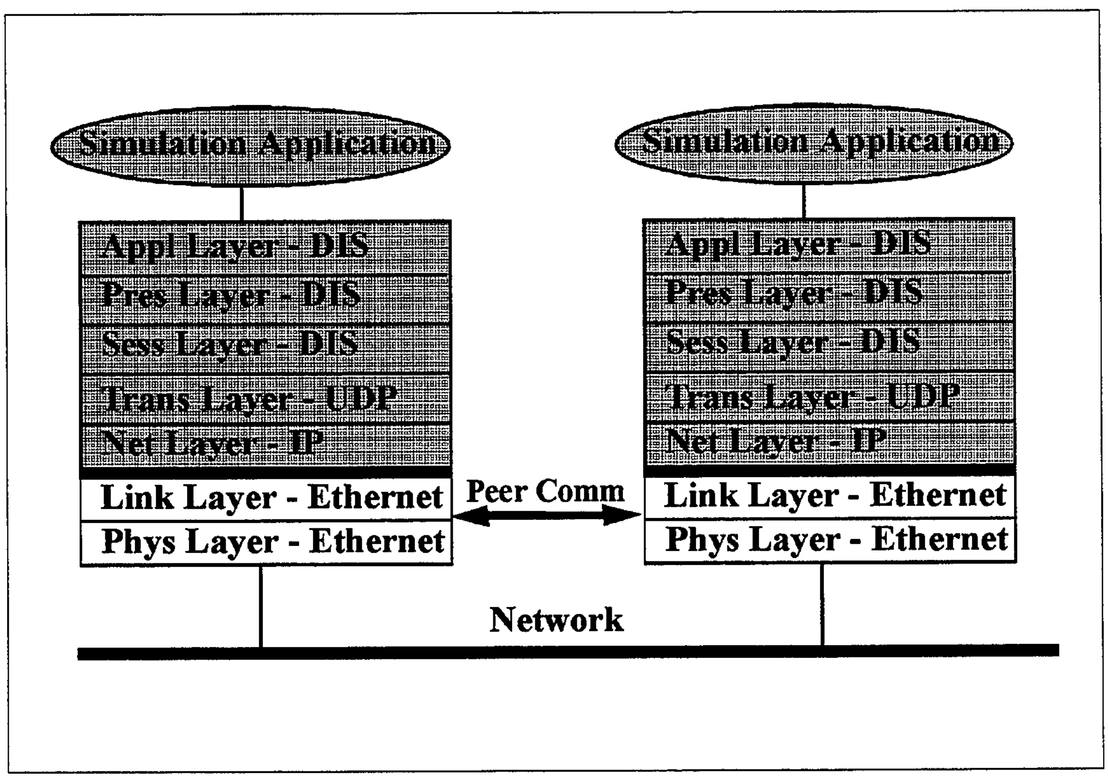

Figure C-4. Physical and link layer communications.

Table C-1. IP Header Information

Internet Protocol shall be implemented with the following header values:

IP Header Field	Bit Numbers	Field Value
Version	1-3	4
Header Length	4-7	5 (no options used)
Service Type	8-15	0
Total Length	16-31	[4*(Hdr Len) + UDP packet len]
Identification	32-47	N+1
Flags	48-50	0
Fragment Offset	51-63	0 (packets not fragmented)
Time to Live	64-71	60
Protocol	72-79	17 (UDP)
Header Checksum	80-95	(set by IP application)
Source IP Address	96-127	(assigned by Ft. Sill lab)
Destination IP Address	128-159	(assigned by Ft. Sill lab)
Options (if any)	N/A	N/A

**Address Resolution Protocol (ARP) is not required for this application.

Table C-2. UDP Header Information

The UDP header shall contain the following values:

UDP Header Field	Bit Numbers	Field Value
UDP Source Port	0-15	3000
Destination Port	16-31	3000
Total Length (in octets)	32-47	8 + length of PDU
UDP Checksum	48 - 63	0 (Checksum not used)

Table C-3. PDU Requirement Summary.

	PDUs Issued					PDUs Processed				
Device	ES*	Fire	Det	Tran	Sig	ES	Fire	Det	Tran	Sig
CIMUL8	X	X	X	X	X	X			X	
FED	X			X	X			X	X	X
FDS	X			X	X			X	X	X
MLRS FCP	X	X	X	X	X			X	X	X

* Key: ES - Entity State PDU Det - Detonation PDU Sig - Signal PDU Fire - Fire PDU Tran - Transmitter PDU

Figure C-5 shows the peer-to-peer communications established by the requirements of 3.1.2.

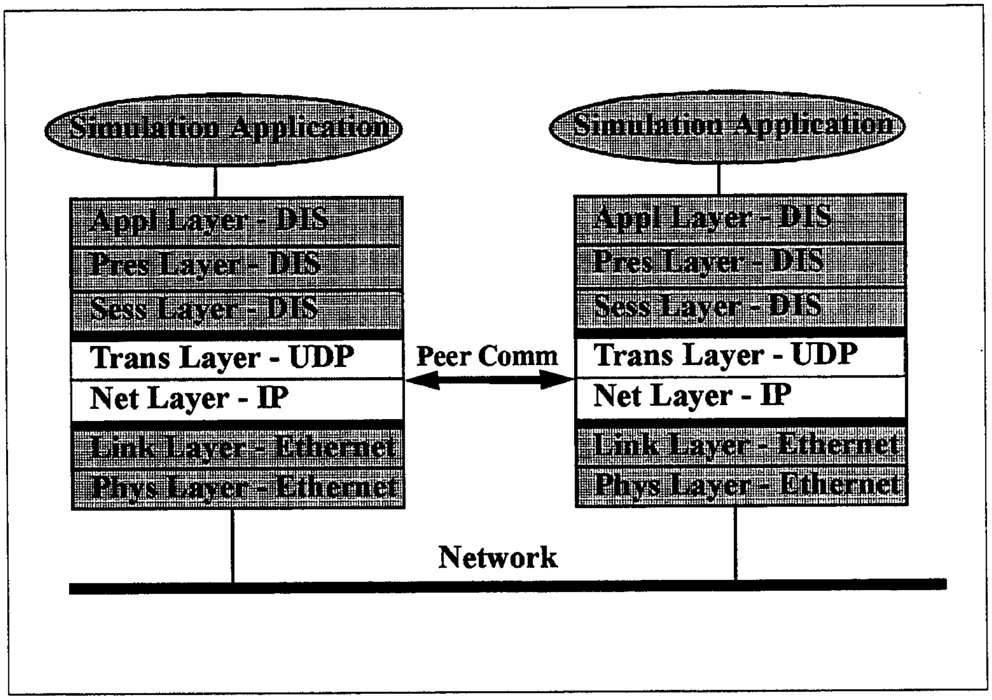

Figure C-5. Network and transport layer communications.

Requirements related to these PDUs are described in the subparagraphs that follow.

3.1.3.1 Entity State PDU

The Entity State PDU shall be issued by all simulation applications to carry entity information pertaining to the entity that is issuing command and control information on the network. This PDU shall be issued in accordance with the DIS PDU standard version 2.0.3. The default time for sending the Entity State PDU is five (5) seconds.[1]

The Entity State PDU shall be processed by simulation applications that require the information for entity representation on the network.

3.1.3.2 Fire PDU

The Fire PDU shall be issued by the MLRS/ATACMS FCPT when the launcher has fired a rocket or missile. For this application, the MLRS shall fire rockets.

The Fire PDU shall be processed by simulation applications that require the information for entity representation on the network. None of the devices on the integrated network are currently required to interpret Fire PDUs.

[1] The MLRS/ATACMS FCPT does not conform to the 5-second rule. It sends an Entity State PDU when it comes on line, when it begins to move to a firing point, and when it arrives at a firing point.

3.1.3.3 Detonation PDU

The Detonation PDU shall be issued by the MLRS/ATACMS FCPT when the rocket launched impacts or detonates.

The Detonation PDU shall be processed by all simulation applications on the network to determine if the entity represented by the device has been affected by incoming fires. The Detonation PDU may also be processed by simulation applications that require the information for visual representation of the detonation. Processing for visual representation is currently done only by CIMUL8.

3.1.3.4 Transmitter PDU

The Transmitter PDU shall be issued by all simulation applications on the network when sending command and control information. The Transmitter PDU shall be used to carry information concerning the radio that, in the real world, would be used to carry the command and control messages. This PDU is issued prior to its associated Signal PDU and after sending its associated Signal PDU.

The Transmitter PDU shall be processed by all devices on the network receiving command and control information.

3.1.3.5 Signal PDU

The Signal PDU shall be issued by all simulation applications to carry the command and control messages on the network. This PDU shall be issued after the initial Transmitter PDU with the simulated transmitting radio information has been issued.

The Signal PDU shall be processed by all simulation applications on the network receiving command and control information.

Figure C-6 shows the peer-to-peer communications established by the requirements of 3.1.3.

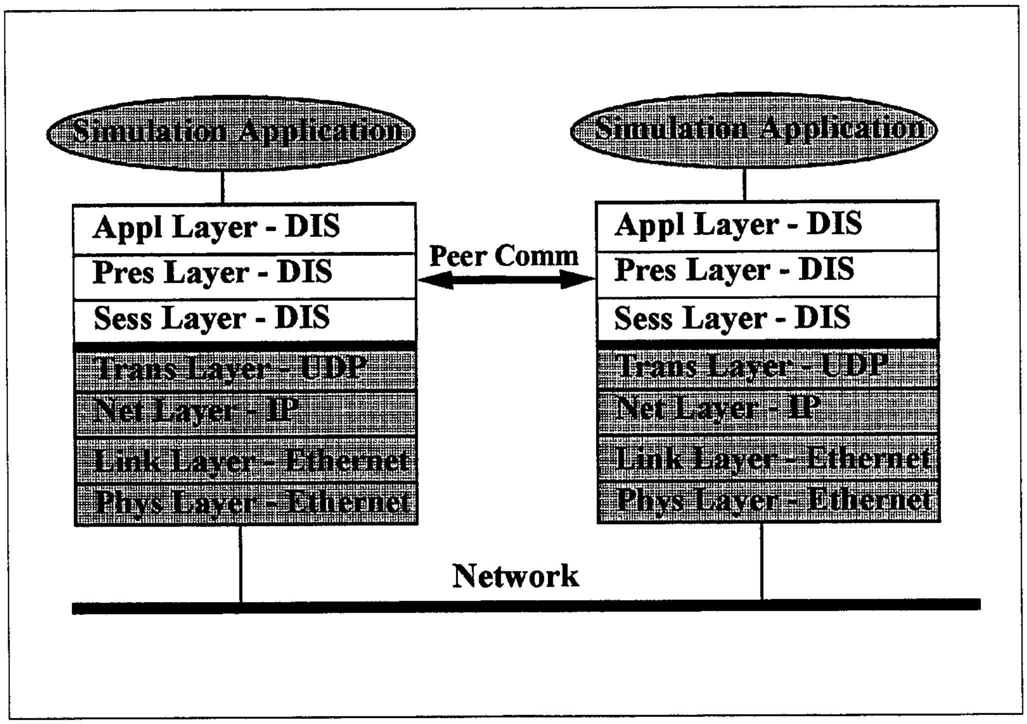

Figure C-6. Session, presentation, & application layer communications.

3.2 SIMULATION APPLICATIONS INTERFACES

This section describes the details of the simulation application interface between various components of the integrated network. The exchange of command and control information is accomplished using the appropriate command and control messages. Simulation Application communications are illustrated in Figure C-7.

3.2.1 Interface From SPECT8/CIMUL8/DISIP8 To MLRS/ATACMS FCPT

The simulation application to which SPECT8/CIMUL8/DISIP8 will be connected is the MLRS/ATACMS FCPT.

3.2.1.1 Messages From SPECT8/CIMUL8/DISIP8

Communications between SPECT8/CIMUL8/DISIP8 and the FDS shall be accomplished using the FR GRID message, typically sent by the FED. The FR GRID message shall be used to transmit fire mission information from SPECT8/CIMUL8/DISIP8 to the FDS. Although the FDS will issue acknowledgment messages to FR GRID messages sent by SPECT8/CIMUL8/DISIP8, SPECT8/CIMUL8/DISIP8 is not required to process them.

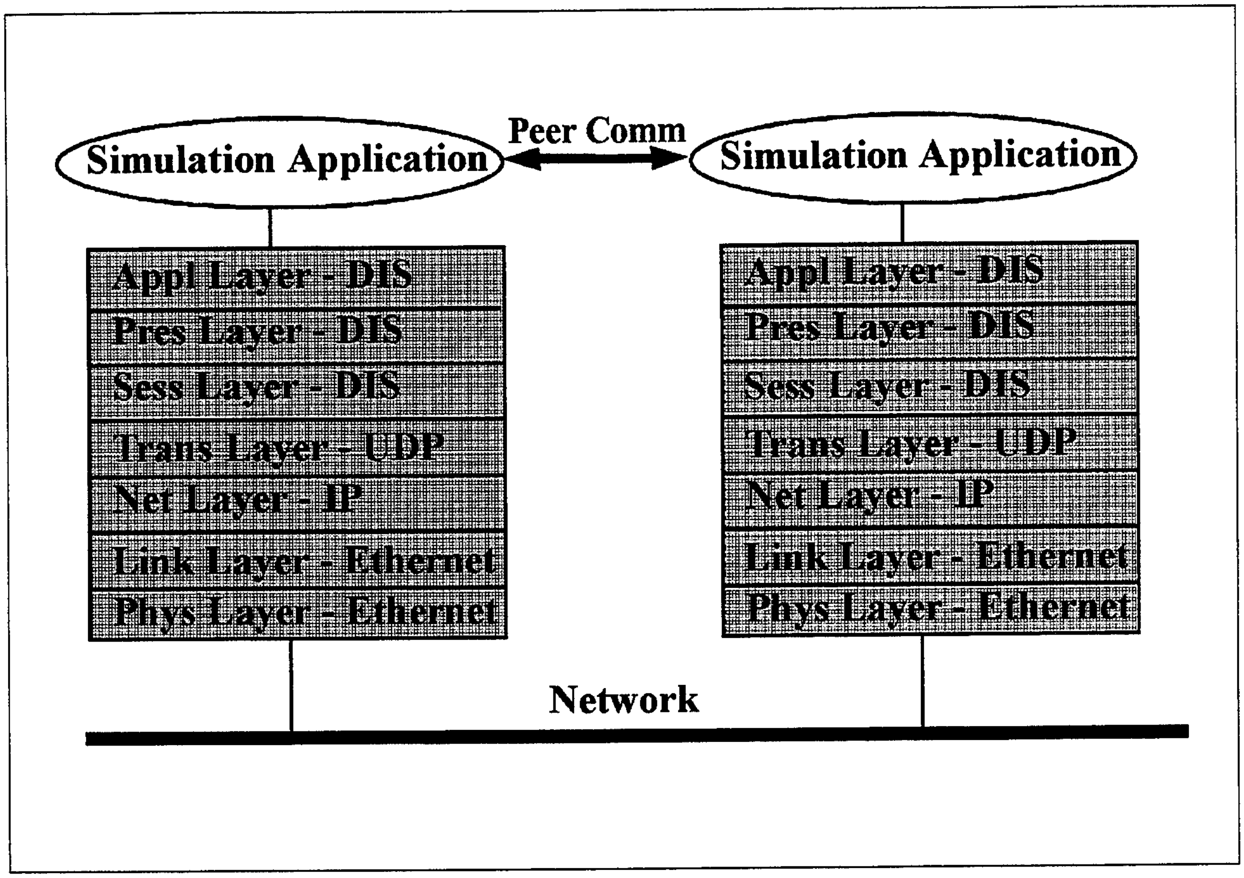

Figure C-7. Simulation application communications.

3.2.1.2 Messages from MLRS/ATACMS FCPT to FDS

The MLRS/ATACMS FCPT is responsible for sending a response to the FDS issued Call For Fire (CFF) messages. This response shall be in the form of a Will Comply message (WILCO). The MLRS/ATACMS FCPT is also required to send launcher status as necessary.

The MLRS/ATACMS FCPT will NOT send acknowledgment messages to the FDS. It is therefore up to the PIU to provide the FDS the proper ACK message to satisfy the FDS communications software.

3.2.2 Interface Between FED and FDS

The simulation application FED has a logical interface to the battery FDS. The FED transmits target information to the FDS.

3.2.2.1 Messages from FED to FDS

Communications from the FED to the FDS shall be accomplished using the FED FOCC command and control messages. The FED shall be able to issue the following messages:[2]

1. *FR GRID*

This message is used to initiate a fire request by reporting target location using grid coordinates.

2. *FO CMD*

This message is used by an observer to report changes in fire mission commands. Also used by firing units to report firing status.

3. *Freetext Message*

This message is used to send text messages to command and control devices. For our system, we used the Freetext message to test interface between devices.

In addition, the FED shall also be capable of receiving the resulting acknowledgments and status reports issued by the FDS. These messages are described in 3.2.2.2.

3.2.2.2 Messages from FDS to FED

The FDS is responsible for providing the FED FO or FIST with acknowledgments to transmitted messages as well as status reports as required. Communications from the FDS to the FED shall be accomplished using FDS command and control messages. This interface shall support the following messages:

1. *Acknowledge Message*

These are automatically generated by the FDS when it receives a message from the FED.

2. *MTO*

The MTO is automatically generated by the FDS after an MLRS CFF has been sent to the FCPT. This may be transmitted back to the FO or FIST if desired but it is not required.

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[2] The interface developed will support any message that the FED is capable of sending. Restriction on which message can be used with this interface is dependent on which messages sent by the FED, are capable of being received by the FDS. During development, FR GRID, FO CMD, and Free Text messages were used.

3.Freetext Messages

This message is used to send text messages to command and control devices. For our system, we used the Freetext message to test interface between devices.

In addition, the FDS shall also be capable of receiving the command and control messages issued by the FED. These messages are described in 3.2.2.1.

3.2.3 Interface From FDS To MLRS/ATACMS FCPT

The simulation application to which the FDS will be connected is the MLRS/ATACMS FCPT.

3.2.3.1 Messages From FDS to MLRS/ATACMS FCPT

Communications between the battery FDS and the FCPT shall be accomplished using the battery FDS to MLRS Launcher interface messages. Of these messages, the FDS shall be capable of issuing the MLRS;CFF (call for fire). The MLRS;CFF message shall be used to transmit a fire mission from the battery FDS to the MLRS/ATACMS FCPT.

The FDS shall also be able to receive response messages and status reports issued by the MLRS/ATACMS FCPT. These messages are described in 3.2.1.2.

3.2.3.2 Messages from MLRS/ATACMS FCPT to Battery FDS

The MLRS/ATACMS FCPT is required to send a response message to the FDS command and control message MLRS;CFF. The FCPT is also responsible to send launcher status as necessary. The MLRS/ATACMS FCPT will currently not be responsible for sending the ACK to the FDS in response to the MLRS;CFF messages. Therefore, the MLRS/ATACMS FCPT shall be capable of issuing the following:

1. *AFU;UPDATE*

The AFU;UPDATE message shall be used to report fire unit status information to the FDS.

2. *MLRS;RESPON*

The MLRS;RESPON message shall be sent by the MLRS/ATACMS FCPT when a call for fire (MLRS;CFF) is received. This message contains a response of WILCO (Will Comply).

In addition, the MLRS/ATACMS FCPT shall be able to receive the command and control messages issued by the battery FDS. These messages are described in 3.2.3.1.

APPENDIX D

PROTOCOL DATA UNITS

PROTOCOL DATA UNITS

1.0 Entity State PDU

The Entity State PDU shall was issued by all simulations participating on the integrated network. These PDUs shall represent the entities that are carrying the radio devices that traditionally issue the command and control message in the real world use of the device. Since entity movement is not supported for a number of the devices, these devices will issue Entity State PDUs once every 5 seconds, according to the default value established in the standard. Dead reckoning will not be performed for these same entities. CIMUL8, which does represent entity movement, shall implement dead reckoning and issue Entity State PDUs that are dictated by the Dead Reckoning algorithm in use. The following subparagraphs describe the values that should be used in the issue of Entity State PDUs:

1.1 CIMUL8 Entity State PDUs

When CIMUL8 is used in the manner described in Section 2 of this document, it will be representing a Forward Observer with a Forward Entry Device. For this entity, it shall issue Entity State PDUs with the following field values:

FIELD SIZE (bits)	PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	1 (ES PDU)
96	HEADER	Padding - 8 bits unused	0
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	144 (bytes)
		Padding - 16 bits unused	0
		Site - 16-bit unsigned integer	100
48	ENTITY ID	Application - 16-bit unsigned integer	300 (CIMUL8)
		Entity - 16-bit unsigned integer	Assigned by CIMUL8
8	FORCE ID	8-bit enumeration	1 (friendly)
8	# OF ARTICULATION PARAMETERS	8-bit unsigned integer	0 (No articulated parts)
		Entity Kind - 8-bit enumeration	3 (lifeform)
		Domain - 8-bit enumeration	1 (land)
	ENTITY	Country - 16-bit enumeration	225 (USA)
64	TYPE	Category - 8-bit enumeration	1 (dismounted infantry)
		Subcategory - 8-bit enumeration	6 (M-60)
		Specific - 8-bit enumeration	1 (single entity)
		Extra - 8-bit enumeration	0 (unused)

FIELD SIZE (bits)	ENTITY STATE PDU FIELDS (cont)		FIELD VALUE
64	ALTERNATE ENTITY TYPE	Entity Kind - 8-bit enumeration	3 (lifeform)
		Domain - 8-bit enumeration	1 (land)
		Country - 16-bit enumeration	225 (USA)
		Category - 8-bit enumeration	1 (dismounted infantry)
		Subcategory - 8-bit enumeration	6 (M-60)
		Specific - 8-bit enumeration	1 (single entity)
		Extra - 8-bit enumeration	0 (unused)
192	ENTITY LOCATION	X-Component - 64-bit floating point	assigned by application
		Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application
96	ENTITY LINEAR VELOCITY	X-Component - 32-bit floating point	0 (not moving)
		Y-Component - 32-bit floating point	0 (not moving)
		Z-Component - 32-bit floating point	0 (not moving)
		Psi - 32-bit floating point	assigned by application
96	ENTITY ORIENTATION	Theta - 32-bit floating point	assigned by application
		Phi - 32-bit floating point	assigned by application
32	ENTITY APPEARANCE	32-bit record of enumerations	(see below)
		Bit 0 - Paint Scheme	1 (camouflage)
		Bit 1 - Mobility Kill	0 (no mobility kill)
		Bit 2 - Fire Power Kill	0 (No fire power kill)
		Bits 3-4 - Damage	0 (no damage) or 3 (destroyed- -if det PDU received for location)
		Bits 5-6 - Smoke	0 (not smoking) or 1 (smoke plume - if smoke part of destroyed appearance)
		Bits 7-8 - Trailing Effects	0 (none)
		Bits 9-11 - Hatch	0 (not applicable)
		Bits 12-14 - LIghts	0 (none)
		Bit 15 - Flaming	0 (none)

FIELD SIZE (bits)	ENTITY STATE PDU FIELDS (cont)		FIELD VALUE
32 (continued)	ENTITY APPEARANCE (continued)	Bit 16 - Launcher	0 (not raised) (not applicable)
		Bits 17-18 - Camouflage Type	0 (Desert camouflage)
		Bit 19 - Concealment	0 (not concealed)
		Bits 20-23	0 (unused)
		Bits 24-31 - Entity Specific	0 (unused)
320	DEAD RECKONING PARAMETERS	Dead Reckoning Algorithm - 8 bit enumeration	selected by CIMUL8
		Other Parameters - 120 bits unused	0 (unused)
		Entity Linear Acceleration - 3x32-bit floating points	0, 0, 0 (not accelerating)
		Entity Angular Velocity - 3x32-bit floating points	0, 0, 0 (not rotating)
96	ENTITY MARKING	Character set - 8-bit enumeration	0 (unused)
		11 - 8-bit unsigned integers	11 x 0 (not used)
32	CAPABILITIES	32 Boolean Fields	all fields = 0 (no capabilities)

Entity state PDUs for other CIMUL8 generated entities shall be generated in the format required for those entities. Field values are selected by CIMUL8 within the guidelines provided in the DIS PDU 2.0.3 Standard.

1.2 FED Entity State PDUs

When the FED is used in the manner described in Section 2 of this document, it shall issue Entity State PDUs with the following field values:

FIELD SIZE (bits)	PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	1 (ES PDU)
96	HEADER	Padding - 8 bits unused	0
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	144 (bytes)
		Padding - 16 bits unused	0
		Site - 16-bit unsigned integer	100
48	ENTITY ID	Application - 16-bit unsigned integer	100 (FED)
		Entity - 16-bit unsigned integer	1
8	FORCE ID	8-bit enumeration	1 (friendly)
8	# OF ARTICULATION PARAMETERS	8-bit unsigned integer	0 (No articulated parts)
		Entity Kind - 8-bit enumeration	3 (lifeform)
		Domain - 8-bit enumeration	1 (land)
	ENTITY	Country - 16-bit enumeration	225 (USA)
64	TYPE	Category - 8-bit enumeration	1 (dismounted infantry)
		Subcategory - 8-bit enumeration	6 (M-60)
		Specific - 8-bit enumeration	1 (single entity)
		Extra - 8-bit enumeration	0 (unused)
		Entity Kind - 8-bit enumeration	3 (lifeform)
		Domain - 8-bit enumeration	1 (land)
	ALTERNATE	Country - 16-bit enumeration	225 (USA)
64	ENTITY	Category - 8-bit enumeration	1 (dismounted infantry)
	TYPE	Subcategory - 8-bit enumeration	6 (M-60)
		Specific - 8-bit enumeration	1 (single entity)
		Extra - 8-bit enumeration	0 (unused)
		X-Component - 64-bit floating point	assigned by application
192	ENTITY LOCATION	Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application
	ENTITY	X-Component - 32-bit floating point	0 (not moving)
96	LINEAR	Y-Component - 32-bit floating point	0 (not moving)
	VELOCITY	Z-Component - 32-bit floating point	0 (not moving)

FIELD SIZE (bits)	ENTITY STATE PDU FIELDS (cont)		FIELD VALUE
		Psi - 32-bit floating point	assigned by application
96	ENTITY	Theta - 32-bit floating point	assigned by application
		Phi - 32-bit floating point	assigned by application
32	ENTITY APPEARANCE	32-bit record of enumerations	
		Bit 0 - Paint Scheme	1 (camouflage)
		Bit 1 - Mobility Kill	0 (no mobility kill)
		Bit 2 - Fire Power Kill	0 (No fire power kill)
		Bits 3-4 - Damage	0 (no damage) or 3 (destroyed- -if det PDU received for location)
		Bits 5-6 - Smoke	0 (not smoking)
		Bits 7-8 - Trailing Effects	0 (none)
		Bits 9-11 - Hatch	0 (not applicable)
		Bits 12-14 - LIghts	0 (none)
		Bit 15 - Flaming	0 (none)
		Bit 16 - Life Form State	3 (prone) or 0 (destroyed - if det PDU received)
		Bit 17 - Weapon 1 State	0 (stowed)
		Bit 18 - Weapon 2 State	0 (stowed)
		Bits 19-23	0 (unused)
		Bits 24-31 - Entity Specific	0 (unused)
		Dead Reckoning Algorithm - 8 bit enumeration	1 (static)
	DEAD	Other Parameters - 120 bits unused	0 (unused)
320	RECKONING PARAMETERS	Entity Linear Acceleration - 3x32-bit floating points	0,0,0 (entity not accelerating)
		Entity Angular Velocity - 3x32-bit floating points	0,0,0 (entity not rotating)
96	ENTITY	Character set - 8-bit enumeration	0 (unused)
	MARKING	11 - 8-bit unsigned integers	11 x 0 (unused)
32	CAPABILITIES	32 Boolean Fields	32 x 0 (no capabilities)

1.3 FDS Entity State PDUs

When FDS is used in the manner described in Section 2 of this document, it shall issue Entity State PDUs with the following field values:

FIELD SIZE (bits)	PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	1 (ES PDU)
96	HEADER	Padding - 8 bits unused	0
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	144 (bytes)
		Padding - 16 bits unused	0
		Site - 16-bit unsigned integer	100
48	ENTITY ID	Application - 16-bit unsigned integer	200 (FDS)
		Entity - 16-bit unsigned integer	1
8	FORCE ID	8-bit enumeration	1 (friendly)
8	# OF ARTICULATION PARAMETERS	8-bit unsigned integer	0 (No articulated parts)
		Entity Kind - 8-bit enumeration	1 (Platform)
		Domain - 8-bit enumeration	1 (Land)
	ENTITY	Country - 16-bit enumeration	225 (USA)
64	TYPE	Category - 8-bit enumeration	6 (Util veh)
		Subcategory - 8-bit enumeration	1 (HMMWV)
		Specific - 8-bit enumeration	0 (unused)
		Extra - 8-bit enumeration	0 (unused)
		Entity Kind - 8-bit enumeration	1 (Platform)
		Domain - 8-bit enumeration	1 (Land)
	ALTERNATE	Country - 16-bit enumeration	225 (USA)
64	ENTITY	Category - 8-bit enumeration	6 (Util veh)
	TYPE	Subcategory - 8-bit enumeration	1 (HMMWV)
		Specific - 8-bit enumeration	0 (unused)
		Extra - 8-bit enumeration	0 (unused)
		X-Component - 64-bit floating point	assigned by application
192	ENTITY LOCATION	Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application
	ENTITY	X-Component - 32-bit floating point	0 (not moving)
96	LINEAR	Y-Component - 32-bit floating point	0 (not moving)
	VELOCITY	Z-Component - 32-bit floating point	0 (not moving)

FIELD SIZE (bits)	ENTITY STATE PDU FIELDS (cont)		FIELD VALUE
		Psi - 32-bit floating point	assigned by application
96	ENTITY	Theta - 32-bit floating point	assigned by application
		Phi - 32-bit floating point	assigned by application
32	ENTITY APPEARANCE	32-bit record of enumerations	
		Bit 0 - Paint Scheme	1 (camouflage)
		Bit 1 - Mobility Kill	0 (no mobility kill)
		Bit 2 - Fire Power Kill	0 (No fire power kill)
		Bits 3-4 - Damage	0 (no damage) or 3 (destroyed- -if det PDU received for location)
		Bits 5-6 - Smoke	0 (not smoking) or 1 (smoke plume - if smoke part of destroyed appearance)
		Bits 7-8 - Trailing Effects	0 (none)
		Bits 9-11 - Hatch	0 (not applicable)
		Bits 12-14 - LIghts	0 (none)
		Bit 15 - Flaming	0 (none)
		Bit 16 - Launcher	0 (not raised) (not applicable)
		Bits 17-18 - Camouflage Type	0 (Desert camouflage)
		Bit 19 - Concealment	0 (not concealed)
		Bits 20-23	0 (unused)
		Bits 24-31 - Entity Specific	0 (unused)
		Dead Reckoning Algorithm - 8 bit enumeration	1 (static)
	DEAD	Other Parameters - 120 bits unused	0 (unused)
320	RECKONING PARAMETERS	Entity Linear Acceleration - 3x32-bit floating points	0,0,0 (not accelerating)
		Entity Angular Velocity - 3x32-bit floating points	0,0,0 (not rotating)
96	ENTITY	Character set - 8-bit enumeration	0 (unused)
	MARKING	11 - 8-bit unsigned integers	11 x 0 (unused)
32	CAPABILITIES	32 Boolean Fields	32 x 0 (no capabilities)

1.4 MLRS/ATACMS FCPT Entity State PDUs

When the MLRS/ATACMS FCPT is used in the manner described in Section 2 of this document, it shall issue Entity State PDUs with the following field values:

FIELD SIZE (bits)	PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	1 (ES PDU)
96	HEADER	Padding - 8 bits unused	0
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	144 (bytes)
		Padding - 16 bits unused	0
		Site - 16-bit unsigned integer	100
48	ENTITY ID	Application - 16-bit unsigned integer	400 (MLRS FCPT)
		Entity - 16-bit unsigned integer	1
8	FORCE ID	8-bit enumeration	1 (friendly)
8	# OF ARTICULATION PARAMETERS	8-bit unsigned integer	0 (No articulated parts)
		Entity Kind - 8-bit enumeration	1 (Platform)
		Domain - 8-bit enumeration	1 (Land)
	ENTITY	Country - 16-bit enumeration	225 (USA)
64	TYPE	Category - 8-bit enumeration	4 (Self-prop artillery)
		Subcategory - 8-bit enumeration	1 (MLRS)
		Specific - 8-bit enumeration	0 (unused)
		Extra - 8-bit enumeration	0 (unused)
		Entity Kind - 8-bit enumeration	1 (Platform)
		Domain - 8-bit enumeration	1 (Land)
	ALTERNATE	Country - 16-bit enumeration	225 (USA)
64	ENTITY	Category - 8-bit enumeration	4 (Self-prop artillery)
	TYPE	Subcategory - 8-bit enumeration	1 (MLRS)
		Specific - 8-bit enumeration	0 (unused)
		Extra - 8-bit enumeration	0 (unused)
		X-Component - 64-bit floating point	assigned by application
192	ENTITY LOCATION	Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application
	ENTITY	X-Component - 32-bit floating point	0 (not moving)
96	LINEAR	Y-Component - 32-bit floating point	0 (not moving)
	VELOCITY	Z-Component - 32-bit floating point	0 (not moving)

FIELD SIZE (bits)	ENTITY STATE PDU FIELDS (cont)		FIELD VALUE
		Psi - 32-bit floating point	assigned by application
96	ENTITY	Theta - 32-bit floating point	assigned by application
		Phi - 32-bit floating point	assigned by application
32	ENTITY APPEARANCE	32-bit record of enumerations	
		Bit 0 - Paint Scheme	1 (camouflage)
		Bit 1 - Mobility Kill	0 (no mobility kill)
		Bit 2 - Fire Power Kill	0 (No fire power kill)
		Bits 3-4 - Damage	0 (no damage) or 3 (destroyed- -if det PDU received for location)
		Bits 5-6 - Smoke	0 (not smoking) or 1 (smoke plume - if smoke part of destroyed appearance)
		Bits 7-8 - Trailing Effects	0 (none)
		Bits 9-11 - Hatch	0 (not applicable)
		Bits 12-14 - LIghts	0 (none)
		Bit 15 - Flaming	0 (none)
		Bit 16 - Launcher	1 (raised)
		Bits 17-18 - Camouflage Type	0 (Desert camouflage)
		Bit 19 - Concealment	0 (not concealed)
		Bits 20-23	0 (unused)
		Bits 24-31 - Entity Specific	0 (unused)
		Dead Reckoning Algorithm - 8 bit enumeration	1 (static)
	DEAD	Other Parameters - 120 bits unused	0 (unused)
320	RECKONING PARAMETERS	Entity Linear Acceleration - 3x32-bit floating points	0,0,0 (not accelerating)
		Entity Angular Velocity - 3x32-bit floating points	0,0,0 (not rotating)
96	ENTITY	Character set - 8-bit enumeration	0 (unused)
	MARKING	11 - 8-bit unsigned integers	11 x 0 (unused)
32	CAPABILITIES	32 Boolean Fields	32 x 0 (no capabilities)

2.0 Fire PDUs

Fire PDUs shall be issued by the MLRS/ATACMS FCPT. Fire PDUs may also be issued by CIMUL8 but it is not required for this application of DIS.

The MLRS/ATACMS FCPT shall issue PDUs of the following format:

FIELD SIZE (bits)	FIRE PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (Version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	2 (Fire PDU)
96	HEADER	Padding - 8 bits unused	0 (unused)
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	96 (bytes)
		Padding - 16 bits unused	0 (unused)
	FIRING	Site - 16-bit unsigned integer	100
48	ENTITY	Application - 16-bit unsigned integer	400 (MLRS FCPT)
	ID	Entity - 16-bit unsigned integer	1
	TARGET	Site - 16-bit unsigned integer	0 (unknown)
48	ENTITY	Application - 16-bit unsigned integer	0 (unknown)
	ID	Entity - 16-bit unsigned integer	0 (unknown)
	MUNITION	Site - 16-bit unsigned integer	100
48	ID	Application - 16-bit unsigned integer	400 (MLRS FCPT)
		Entity - 16-bit unsigned integer	100 (Begin at 100 and increment by 1)
		Site - 16-bit unsigned integer	100
48	EVENT ID	Application - 16-bit unsigned integer	400 (MLRS FCPT)
		Event - 16-bit unsigned integer	1 (Begin at 1 and increment by 1)
32	PADDING	32-bit unsigned integer	0 (unused)
	LOCATION	X-Component - 64-bit floating point	assigned by application
192	IN WORLD	Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application

FIELD SIZE (bits)	FIRE PDU FIELDS (cont)		FIELD VALUE
128	BURST DESCRIPTION	Munition - 64-bit Entity Type Record Entity Kind Domain Country Category Sub-Category Specific Extra	 2 (Munition) 8 (Battlefield Support) 225 (USA) 2 (Ballistic) 16 (227 mm rocket) 0 (unused) 0 (unused)
		Warhead - 16-bit enumeration	1500 (bomblets)
		Fuze - 16-bit enumeration	2000 (timed)
		Quantity - 16-bit unsigned integer	1 (single rocket fired)
		Rate 16-bit unsigned integer	0 (for quantity 1)
		X-Component - 32-bit floating point	assigned by application
96	VELOCITY	Y-Component - 32-bit floating point	assigned by application
		Z-Component - 32-bit floating point	assigned by application
32	RANGE	32-bit floating point	assigned by application

3.0 Detonation PDU

The Detonation PDU shall be issued by the MLRS/ATACMS FCPT. CIMUL8 may also issue the Detonation PDU but it is not required for this application.

The MLRS/ATACMS FCPT shall issue a Detonation PDU in the following format:

FIELD SIZE (bits)	DETONATION PDU FIELDS		FIELD VALUE
		Protocol Version - 8-bit enumeration	3 (Version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
	PDU	PDU Type - 8-bit enumeration	2 (Fire PDU)
96	HEADER	Padding - 8 bits unused	0 (unused)
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	104 (bytes)
		Padding - 16 bits unused	0 (unused)
	FIRING	Site - 16-bit unsigned integer	100
48	ENTITY	Application - 16-bit unsigned integer	400 (MLRS FCPT)
	ID	Entity - 16-bit unsigned integer	1
	TARGET	Site - 16-bit unsigned integer	0 (unknown)
48	ENTITY	Application - 16-bit unsigned integer	0 (unknown)
	ID	Entity - 16-bit unsigned integer	0 (unknown)
	MUNITION	Site - 16-bit unsigned integer	100
48	ID	Application - 16-bit unsigned integer	400 (MLRS FCPT)
		Entity - 16-bit unsigned integer	100 (Begin at 100 and increment by 1. Should correlate with ES PDUs for munition entity if applicable)
		Site - 16-bit unsigned integer	100
48	EVENT ID	Application - 16-bit unsigned integer	400 (MLRS FCPT)
		Event - 16-bit unsigned integer	1 (Begin at 1 and increment by 1)
		X-Component - 32 bit floating point	assigned by application
96	VELOCITY	Y-Component - 32 bit floating point	assigned by application
		Z-Component - 32 bit floating point	assigned by application

FIELD SIZE (bits)	DETONATION PDU FIELDS (cont)		FIELD VALUE
192	LOCATION IN WORLD	X-Component - 64-bit floating point	assigned by application
		Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application
128	BURST DESCRIPTION	Munition - 64-bit Entity Type Record	1500 (bomblets)
		Warhead - 16-bit enumeration	2000 (timed)
		Fuze - 16-bit enumeration	1 (single rocket fired)
		Quantity - 16-bit unsigned integer	0 (for quantity 1)
		Rate - 16-bit unsigned integer	1 (single rocket)
	COORDINATES	X-Component - 32-bit floating point	assigned by application
96	LOCATION IN ENTITY	Y-Component - 32-bit floating point	assigned by application
		Z-Component - 32-bit floating point	assigned by application
8	DETONATION RESULT	8-bit enumeration	4 (ground proximate detonation)
8	# OF ARTICULATION PARAMETERS	8-bit unsigned integer	0 (articulated parts not used)
16	PADDING	16 bits unused	0 (unused)

4.0 Transmitter PDU

The Transmitter PDU shall be issued by all systems on the network that are issuing TACFIRE messages. All Transmitter PDU's shall be issued using the following format:

FIELD SIZE (bits)	TRANSMITTER PDU FIELDS		FIELD VALUE
96	PDU HEADER	Protocol Version - 8-bit enumeration	3 (Version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
		PDU Type - 8-bit enumeration	25 (Transmitter PDU)
		Padding - 8 bits unused	0 (unused)
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	104 (bytes)
		Padding - 16 bits unused	0 (unused)
48	ENTITY ID	Site - 16-bit unsigned integer	100
		Application - 16-bit unsigned integer	100 (FED) 200 (FDS) 300 (CIMUL8) 400 (MLRS)
		Entity - 16-bit unsigned integer	1
16	RADIO ID	16-bit unsigned integer	1
64	RADIO ENTITY TYPE	Entity Kind - 8-bit enumeration	7 (radio)
		Domain - 8-bit enumeration	0 (undefined)
		Country - 16-bit enumeration	0 (undefined)
		Category - 8-bit enumeration	0 (undefined)
		Subcategory - 8-bit enumeration	0 (undefined)
		Specific - 8-bit enumeration Extra - 8-bit enumeration	0 (undefined) 0 (undefined)
8	TRANSMIT STATE	8-bit enumeration	1 (on but not transmitting - after Signal PDU issued) or 2 (on and transmitting - before Signal PDU issued)
8	INPUT SOURCE	8-bit enumeration	0 (other)
16	PADDING	16 bits unused	0 (unused)
192	ANTENNA LOCATION	X-Component - 64-bit floating point	assigned by application
		Y-Component - 64-bit floating point	assigned by application
		Z-Component - 64-bit floating point	assigned by application

FIELD SIZE (bits)	TRANSMITTER PDU FIELDS (cont)		FIELD VALUE
96	RELATIVE ANTENNA LOCATION	X-Component - 32-bit floating point	0 (same as entity location)
		Y-Component - 32-bit floating point	0 (same as entity location)
		Z-Component - 32-bit floating point	0 (same as entity location)
16	ANTENNA PATTERN TYPE	16-bit enumeration	0 (Omni-directional)
16	ANTENNA PATTERN LENGTH	16-bit unsigned integer	0 (no data)
64	FREQUENCY	64-bit unsigned integer	
32	TRANSMIT FREQUENCY BANDWIDTH	32-bit floating point	
32	POWER	32-bit floating point	
64	MODULATION TYPE	Spread Spectrum - 16 Boolean Array	16 x 0 (unused)
		Major - 16-bit enumeration	0 (unused)
		Detail - 16-bit enumeration	0 (unused)
		System - 16-bit enumeration	0 (unused)
16	CRYPTO SYSTEM	16-bit enumeration	0 (other)
16	CRYPTO KEY ID	16-bit unsigned integer	0 (unused)
8	LENGTH OF MODULATION PARAMETERS	8-bit unsigned integer	0 (no data)

5.0 Signal PDU

The Signal PDU shall be issued by all systems on the network that are issuing TACFIRE messages. All Signal PDU's shall be issued using the following format:

FIELD SIZE (bits)	SIGNAL PDU FIELDS		FIELD VALUE
96	PDU HEADER	Protocol Version - 8-bit enumeration	3 (Version 2.0.3)
		Exercise ID - 8-bit unsigned integer	100
		PDU Type - 8-bit enumeration	26 (Signal PDU)
		Padding - 8 bits unused	0 (unused)
		Time Stamp - 32-bit unsigned integer	Relative timestamp assigned by application
		Length - 16-bit unsigned integer	32 + length of TACFIRE msg (bytes)
		Padding - 16 bits unused	0 (unused)
48	ENTITY ID	Site - 16-bit unsigned integer	100
		Application - 16-bit unsigned integer	100 (FED) 200 (FDS) 300 (CIMUL8) 400 (MLRS)
		Entity - 16-bit unsigned integer	1
16	RADIO ID	16-bit unsigned integer	1
16	ENCODING SCHEME	16-bit enumeration	2 (Application Specific data)
16	PADDING	16 bits unused	0 (unused)
32	SAMPLE RATE	32-bit integer	1200 (baud)
16	LENGTH	16 bits integer	length of TACFIRE message sent
16	SAMPLES	16-bit integer	0 (not encoded)
N	DATA	Array of 8-bit unsigned integers	TACFIRE message entered here

APPENDIX E

USER GUIDE FOR INTERFACES-DATA LOGGER

USER GUIDE FOR INTERFACES-DATA LOGGER

1.0 TACFIRE Message Format

The various components of the integrated network exchange command and control information using TACFIRE message formats. The Call For Fire (CFF) format is provided to guide preparation of correct TACFIRE message by offering a means to confirm field values for CFF messages. Other message formats will be provided later as they become available.

Field #	Field Description	Field Size (char)	Field Value	Comments
1	Fire Mission Data Group ID	1	d	Represents Fire Mission Data Group ID
2	Fire Mission Action Code	1	B	Standard Fire Mission
3	Target Number	6	AA0000 (AA0000 - ZZ9999)	Two characters and four digits definable by the observer
4	Fire Mission Control	1	B	Fire When Ready
5	Report Control Code	1	<space>	No control codes used
6	Time I Hour	2	00-23	User defined time of day in hours
7	Time I Minute	2	00-59	User defined time of day in minutes
8	Time I Second	2	00-59	User defined time of day in seconds
9	Time II Hour	2	00-23	User defined time of day in hours
10	Time II Minute	2	00-59	User defined time of day in minutes
11	Time II Seconds	2	00-59	User defined time of day in seconds
12	Observer Identification	2	0A (0-9, A-Z, space)	ID of Observer
13	Fire Mission Warhead Data Group ID	1	e	Fire Mission Warhead Data Group ID
14	Warhead Type	1	A	Rocket High Explosive - M77
15	Number of Rounds	2	01	1 round fired
16	Mission Fired Report Suppression	1	B	Transmit Short Mission Fired
17	AT II Code	1	<space>	Not specified for this case
18	Sheaf Type	1	<space> (A-Z, <space>)	Value defined by manufacturer
19	Sheaf Orientation	3	<3 spaces> (000-639, or 3 spaces)	Represents azimuth in tens of mils or spaces represent blank parking heading

Field #	Field Description	Field Size (char)	Field Value	Comments
20	Target Count Code	1	<space>	Not specified for this case
21	THM Target Element Separation Distance	2	<2 spaces>	Not specified for this case
22	Clutter Code	3	<3 spaces>	Not specified for this case
23	Clutter Code	3	<3 spaces>	Not specified for this case
24	THM Signature Code	2	<2 spaces>	Not specified for this case
25	THM Flight, Altitude	3	<3 spaces>	Not specified for this case
26	Terminal Homing Munitions Scan Limits	3	<3 spaces>	Not specified for this case
27	Target Area Low Level MET ID	2	<2 spaces>	Not specified for this case
28	Time Between Rounds	2	05 - 99	Time between rounds for suppression of fire
29	Quadrant Elevation Option	1	1	Do not use high quadrant elevation
30	Target Data Group ID	1	f	Target Data Group ID
31	Target, UTM 1-Meter Easting	6	0-999999	UTM grid reference for easting in meters
32	Target, UTM 1-Meter Northing	8	0-11000000	UTM grid reference for northing in meters
33	Target, Altitude	5	-9999 to +9999	Altitude of target in meters
34	Target, Grid Zone Designator	3	+1 to +60	Northern Hemisphere Grid Zones
35	Number of Aimpoints	2	01 - 12	Number of aimpoints
35.1	Aimpoint Easting Shift	4	-999 to +999	Aimpoint Easting shift in tens of meters
35.2	Aimpoint Northing Shift	4	-999 to +999	Aimpoint Northing shift in tens of meters
35.3	Aimpoint Altitude	5	-999 to +999	Aimpoint altitude in one meter increments
35.4	Aimpoint, Rounds	2	01 (00-99) (0-9, A-Z, space)	Number of rounds to fire at an aimpoint or spaces represent no statement
36	Location /data Group Identifier	1	a	Location data group identifier
37	Firing Point Location Type	1	A	Type of location for a firing point. In this case, Firing Point
38	Coordinate Identifier	2	A1	Uniquely identifies a particular firing point coordinate. For this case we will use A1.

Field #	Field Description	Field Size (char)	Field Value	Comments
39	Firing Point Data Action Code	1	A	Firing point type action codes, in this case, FIFO
40	Firing Point, Easting	6	0-999999	Easting in 1 meter increments
41	Firing Point, Northing	8	0-11000000	Northing in 1 meter increments
42	Firing Point, Altitude	5	-9999 to +9999	Firing point altitude in 1 meter increments
43	Firing Point, Grid Zone	3	+01 to +60	Grid zone in Northern Hemisphere
44	Parking Heading	3	<3 spaces> (000-639)	Direction from Grid North. We are using a blank parking heading
45	Masking Azimuth, Left	3	<3 spaces> (000-639)	Left edge of the mask, direction from grid north. We are not specifying
46	Masking Azimuth, Right	3	<3 spaces> (000-639)	Right edge of the mask, direction from grid north. We are not specifying
47	Masking Elevation	4	<4 spaces> (0000-1600)	Elevation from the weapon to the highest point of the mask in one mil increments. We are not specifying
48	Range to Mask	4	<4 spaces> (0-9999)	Range in meters to the center of the mask. We are not specifying
49	Submunition Moving Target Data Group Identifier	1	t	Submunition moving target data group ID
50	Sighting Hour	2	00 - 23	Hour of the day when a target's movement is measured
51	Sighting Minute	2	00 - 59	Minutes of the hour when a target's movement is measured
52	Sighting Second	2	00 - 59	The second of a minute when a target's movement is measured
53	Speed, Moving Target	2	00 - 99	Speed of moving target in km/hr
54	Direction of Movement	3	000 - 639	Direction a target is moving in tens of mils
55	Command Data Group Identifier	1	h	Command Data Group Identifier
56	Command Type	1	G	Tactical command data to instruct launcher to move to designated points, stay, go cool or go hot. In this case we will use STAY

Field #	Field Description	Field Size (char)	Field Value	Comments
57	Reload Command Indicator I	1	C	Indicates the coded reload command for LP/C1. We will use the command "No change".
58	Warhead Type I	1	<space>	None specified
59	Number of Rounds for LP/C1	2	<2 spaces>	None specified
60	Reload Command Indicator II	1	C	Indicates the coded reload command for LP/C2. We will use the command "No change".
61	Warhead Type II	1	<space>	None specified
62	Number of Rounds for LP/C2	2	<2 spaces> (000-639)	None specified
63	Effective Hour	2	00 - 23	Effective hour of event or report in units of hours
64	Effective Minute	2	00 - 59	Effective minute of event or report in units of minutes
65	Effective Second	2	00 - 59	Effective second of event or report in units of seconds
66	Parking Heading	3	000-639 or spaces	Direction from grid north in tens of mils or spaces representing blank parking heading
67	Location Data Group Identifier	1	a	Location data group identifier
68	Location Type	1	A	Indicates the type of launcher location. For our use - Firing Point
69	Coordinate Identifier	2	A1	Uniquely identifies a particular firing point coordinate. For this case we will use A1.
70	Data Action Code	1	A	FIFO
71	Coordinate Location UTM 1 Meter Easting	6	0-999999	Easting coordinate in meters
72	Coordinate Location UTM 1 Meter Northing	8	0-11000000	Northing coordinate in meters
73	Coordinate Location Altitude	5	-9999 to +9999	Coordinate altitude
74	Coordinate Location Grid Zone	3	+01 to +60	Grid zone in Northern Hemisphere
75	Park Heading	3	<3 spaces> (000-639 or spaces)	Direction from grid north in tens of mils or spaces representing blank parking heading
76	Masking Azimuth, Left	3	<3 spaces> (000-639 or spaces)	Left edge of the mask, direction from grid north. In tens of mils or spaces indicating blank parking heading

Field #	Field Description	Field Size (char)	Field Value	Comments
77	Masking Azimuth, Right	3	<3 spaces> (000-639 or spaces)	Right edge of the mask, direction from grid north. In tens of mils or spaces indicating blank parking heading
78	Masking Elevation	4	<4 spaces> (0000 to 1600)	Elevation from the weapon to the highest point of the mask in one mil increments
79	Range to Mask	4	<4 spaces> (0-9999)	Range in meters to the center of the mask
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