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SIMULATION AND C4I DATA COLLECTION IN SUPPORT OF FORCE XXI TRAINING

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ABSTRACT

The U.S. Army's Force XXI initiative provides automated C4I systems to commanders and their staffs at the brigade through corps echelons to increase situational awareness and support improved command and control decision making. These systems provide extensive automation support, including local area networks for data communications within command post structures and wide area communications linking geographically dispersed force structure echelons. The introduction of these systems into the field generates new challenges in the planning and conduct of large-scale command post exercises using simulations. A major new problem area that this paper addresses is the interface between the C4I systems and the simulation.

This paper describes the Data Collection, Analysis, and Review System (DCARS) and its two principal components, the C4I Data Collection System (DCS) and the Archiving and Enhanced Retrieval (ARCHER) system. DCARS collects C4I data (perceived and available truth) from command post structures and stores it in the ARCHER after action review system (AARS), along with data from the simulation (ground truth), to support collective training of military staffs. DCARS' non-obtrusive C4I data collection provides analysts and trainers with data on a near real-time basis, in forms that enhance examination of information threads, processing time, critical paths, and throughput. It uses a variety of graphical displays to provide near real-time and historical comparisons of data resident on operational systems and simulation data. It automates standard query language and web site queries and makes the results available for analysis. It facilitates record output analysis by employing a sophisticated message dissemination system that allows key word message profiling. Analysts can identify quantifiable strengths and weaknesses in collective training of the staffs, and provide training feedback using standard data products automatically created from the ARCHER AARS.

1 INTRODUCTION

The Army's Division Advanced Warfighting Experiment (DAWE), held in November, 1997, marked the first use of the Force XXI equipment suite at the division echelon. An Army division was issued a complete suite of the Army Tactical Command and Control System (ATCCS) and trained in its use. The 4th Infantry Division and its subordinate units were selected as the Force XXI experimental division and participated in a Battle Command Training Program (BCTP) Warfighter exercise (WFX) as part of the DAWE. Planning for the conduct of the WFX posed several significant technical challenges that were previously not experienced in any similar training event. The Corps Battle Simulation (CBS) was used as the exercise driver and an interface mechanism was needed to provide a seamless data communications linkage between the simulation and each of the C4I systems. The simulation support modules (SSMs) developed by the Army's Electronic Proving Ground to support C4I testing were adapted to provide the simulation to C4I systems linkage. The collection of C4I data from the 4th Infantry Division command post structures posed a larger challenge since no existing technology provided this capability. The Data Collection, Analysis, and Review System (DCARS) was designed to collect, transmit, store, and analyze message/report, database, and web page data from each of the ATCCS subordinate systems (e.g., the Advanced Field Artillery Tactical Data System, AFATDS). DCARS is made up of two principal elements: the C4I Data Collection System (DCS) and the Archiving and Enhanced Retrieval (ARCHER) system. It was developed in response to requirements defined by the National Simulation Center, the Army's combat developer for simulations. DCARS integrated existing C4I data collection devices developed by the Army's Electronic Proving Ground with new capabilities to attain its overall functionality. DCARS was successfully used to support the BCTP WFX during the DAWE, and along with the SSMs provided the first fully automated linkages between CBS and the C4I systems. This paper discusses the designs of the two DCARS components and highlights their principal functional capabilities.

2 C4I Data Collection Overview

The DCS provides the capabilities to collect data used in making critical command and control decisions. It allows both training specialists and test engineers to analyze the flow of data within the C4I infrastructure and to determine if there is a common relevant picture of the battlefield shared at all echelons. It collects available truth (total set of data resident on the C4I systems) and perceived truth (subset of available truth used in decision making). Figure 1 shows an overview of the DCS architecture used at the recent DAWE. It contains three principal elements—Multifunctional Data Collector, Real-Time Aggregator/Data Processing Unit, and Data Collection Processor—and uses portable laptop computers located in the command posts to collect the following information types:

- Message traffic. This includes United States Message Text Format (USMTF), AFATDS, Combat Service Support Control System (CSSCS), and file transfer protocol (FTP) exchanges. The system accomplishes this collection without interference with the flow of information to or from the command post.

- Database information from each of the C4I systems. The collection system queries each targeted database using standard query language (SQL) scripts, which reside on each C4I workstation and are activated by command from the Multifunctional Data Collector (MFDC). The operator generally orders the queries on a scheduled basis to meet analyst or trainer requirements. However, the user can execute queries on demand at any one or multiple sites.

- Web page information from the C4I systems. The MFDC activates queries using Hypertext Transfer Protocol (HTTP) to collect web pages from selected C4I systems, primarily AFATDS. The user can also perform these queries on a scheduled or demand basis.

Using packet network data radios or a virtual LAN, the MFDCs at the command posts transmit the data to the exercise control center where data processing occurs. The initial processing converts USMTF and CSSCS messages from packets into whole messages and sends them to the Data Collection Processor (DCP) for profiling and archiving on the APACHE web site. The DCP searches the remaining messages for usable AFATDS messages and further processes them into usable fire support information. The DCP discards extraneous FTP traffic, heartbeats, and miscellaneous traffic.

DCARS normalizes all database data, most web site data, and some USMTF messages for location, unit, and item nomenclature, allowing comparison between the C4I systems and the simulation data. The DCARS places this data in tables in ARCHER where it is available to analysts and trainers using established reports, plots on the GIS, spreadsheets, and comma-delimited files. The analyst can select particular products, times, and C4I nodes.

2.1 Data Collection Configuration and Control

During the DAWE, collection devices were operational at eleven command posts and the simulation center, linking to 44 C4I nodes and providing data distribution over a virtual LAN. Over 18,000 unique messages were collected in near-real time and recorded. The overall DCS configuration consists of one MFDC computer per command post node which interfaces with the local ATCCS router. Each MFDC computer is a Pentium 166 or better, using NT operating system and contains three LAN cards. The collector uses one card for message collection, one for database and web page collection, and one for transporting the data on an instrumentation virtual LAN. The MFDC uses CAT5-capable LAN cards to collect messages at command posts equipped with high-speed data switches. When the command post cannot connect to the instrumentation LAN via cabling due to distance or other factors, the system uses packet network radios to transmit the collected data. These radios provide 115,200 bits per second throughput and connect to the MFDC serially. During the DAWE, the MFDCs operated at the unclassified security level. Work is underway to utilize FORTEZZA Plus cards to permit the transmission of data up to the level of security for top secret, special compartmented information (TS-SCI). In this configuration, the MFDC will collect all traffic going into or out of a command post node.

The DCS uses SQL scripts to extract the specific tables, and in some cases, specific fields, from the C4I system databases. These scripts are installed prior to system usage and are activated when called by the MFDCs. The MFDC runs its own set of scripts, either on a scheduled or demand basis, to enable scripts in the C4I systems which collect the desired tables and files and send them to the Real-Time Aggregator/Data Collection Processor (RTA/DPU). The scripts can collect any desired data from the C4I system databases. Current collection requirements include friendly and hostile unit locations, equipment and supply information, and operational graphics. Machine time required for executing these scripts is negligible for all C4I systems (1-2 seconds), except for the CSSCS, which requires approximately 55 seconds, every 2 to 6 hours. HTTP scripts collect web pages that have standardized file names. In the AFATDS, for example, the web pages of each workstation automatically display the target lists

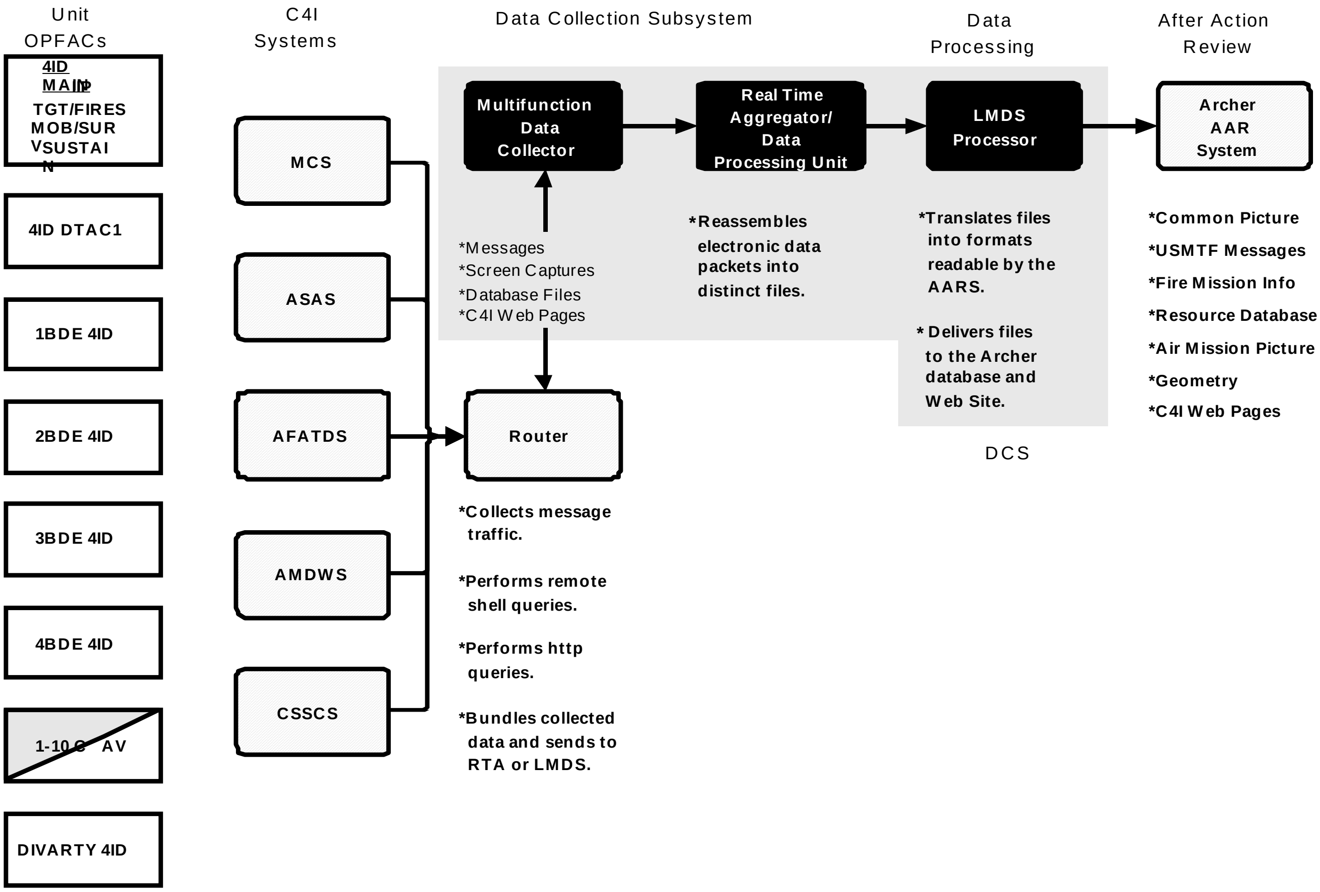

Figure 1: Architecture of the Data Collection System (DCS)

for the command echelon. After the data is collected and archived, the analyst or trainer can review the target list history using DCARS, whereas the AFATDS operators cannot do so because AFATDS does not maintain a listing of which targets were actually fired.

Depending on the filter options, the MFDCs will cull unwanted data and messages and immediately transport them to the RTA for decryption (is used) and distribution to the DPU. The MFDS also forwards database and web site data to the Data Collection Processor (DCP), without processing. The packets sent to the DPU will be reassembled into messages and a header is placed on each message which shows the time and place of collection. The DPU bundles the files and forwards them to the DCP for profiling, fusion, database insertion (select messages), and archiving.

2.2 Data Collection Processing and Distribution

The DCS performs file translation and transfers files and database updates to ARCHER. The Logicon Message Dissemination System (LMDS™) processes messages and archives them for use by analysts and trainers using one of two web sites. The LMDS compares incoming messages against user-developed profiles and includes message header information in an archival database. Analysts can set the LMDS to place particular types of messages in discrete inboxes for viewing later. This eliminates the need to run new searches or to read all messages. The analysts develop and maintain message screening profiles using a simple GUI. Key word and 14 other zones are available for profiling. The DCP parses some messages and places the extracted data into the ARCHER database for retrieval using Report Tool (Reptool) products. The analysts can perform *ad hoc* searches on all messages using the same zones used for profiling.

The DCP also serves as the fusion database to normalize the collected data. If the analyst wants to compare simulation to C4I system data, normalization is required because the C4I systems use unit identification codes (UIC) to identify units in their databases while CBS and other simulations use a short name. To ensure that the analyst is comparing the same units, the DCP converts the UIC into the appropriate short name prior to inclusion in the ARCHER database.
Likewise, the C4I systems and the simulations use different conventions for identifying equipment and supplies.

The DCP maps, converts, and aggregates the items to make appropriate comparisons.

Analysts have full access to all information collected at their workstations. A web site for the C4I systems operates with access to the messages, screen captures of C4I system screens, system status pages, and a page for special data collection activities. Analysts do not have to rely solely on collection patterns. They have the ability, through a firewall into the tactical network, to browse the web pages and files on any C4I node and to download files using FTP.

3 After Action Review System Overview

ARCHER captures data from the simulation and the C4I systems to answer the question relating to what happened during command post exercises. Analysts can collect and analyze data and create a standard set of products based on the Army's Standard After Action Review System (STAARS). As shown in Figure 2, ARCHER retrieves data through a C4I DCS and interfaces with the Corps Battle Simulation (CBS). Depending on the exercise, it can also interface with the Battlefield Intelligence Collection Model (BICM). ARCHER uses both local and wide area communications to link geographically dispersed training units and web server technology for information distribution.

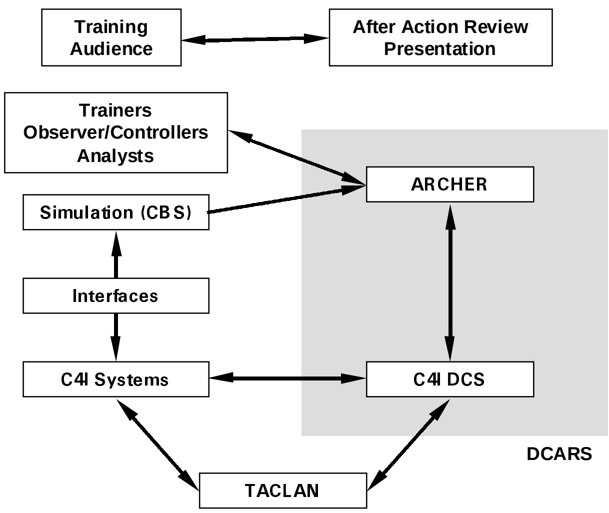

Figure 2: DCARS System Interfaces

ARCHER can accept input from a variety of data sources, process the input, and generate output. ARCHER supports the capability to extract specific unit attributes from the simulation at regular intervals throughout the course of a WFX. The system collects simulation spot reports to support production of specific after action review products throughout the exercise and stores them as time-tagged data. Users can display information in a report format, import it into a spreadsheet, or plot it on the map of a geographical information system (GIS).

ARCHER collects and archives three data sources: ground truth, available truth, and perceived truth. Ground truth serves as a basis of comparison for command and control training and is the data set resident in the simulation. Available truth is the total data set resident in the C4I systems, while perceived truth is the subset of available truth actually used by the training audience in command and control decision making. Unlike other AAR systems, ARCHER collects both situational and event data from each of these sources. Situational data is a snapshot of the battle situation at a given time and includes all objects in the simulation and their attributes, such as units, aircraft, terrain, combat systems, and supplies. Event data relates to critical points in the scenario timeline and represents the cause and effect of changes to the battle situations. The ability to collect and identify key events is crucial to providing relevant after action review information.

3.1 Tactical Situation and Battlefield Displays

The ARCHER GIS graphically depicts battlefield situations, including unit locations, control measures, and obstacles, on a selection of map backgrounds for user-specified regions. The GIS includes National Imagery and Mapping Agency (NIMA) digital map data and requires the following data to produce all available displays: Digital Terrain Elevation Data (DTED), Level 1; Digital Feature Analysis Data (DFAD), Level 1; World Vector Shoreline (WVS); and Arc Digitized Raster Graphics (ADRG). The latest version of GIS allows the user to view terrain on three levels: tactical (up to 200km), operational (100–1,000km), and strategic (500–5,000km). The user can choose digital map backgrounds appropriate to the product being displayed. These include the plain Universal Transverse Mercator (UTM); ADRG in a scale of either 1:50,000 or 1:250,000; slope; contour plan view; or 3-dimensional views. The system can display terrain features, including road, river, and urbanization data, over any map background.

The GIS generates multicolored graphics overlays and displays them on any of the available map backgrounds. The system also can display military unit symbols on a map image in the format defined by Army doctrine. The user can specify symbol size, color, and echelon for every branch of the Army for symbols in the system library. Additionally, the user can create custom symbols and store and modify them. The GIS provides the user with a variety of graphics aids for creating overlays, including lines of various colors, styles, and widths; geometric figures; text of various fonts and colors; tactical symbols; and freehand drawings. The GIS permits the user to save operation order tactical control measures to an overlay for recall or sharing with other users. An example is shown in Figure 3.

An interface with the simulation allows ARCHER to record unit data from CBS in snapshots, normally taken every 15 minutes. The user can recall these snapshots and display them on selected map backgrounds. The query interface allows the user to tailor the display by unit type, echelon, and side (friendly or hostile). For example, using the query for the display of unit data, the user can select and plot range fans for weapon and radar systems for display on a map background. The user can edit these displays to change orientation or range of the system, or to highlight a particular fan.

Using the unit data snapshots, the user can create an animation sequence over any time interval available in the simulation. The sequence can be customized by type, side, and echelon of unit, or by specified unit names. Once set in motion, the creation of an animation sequence takes place as a background process, freeing the user to do other things. The user can play back the animation at a custom speed or one frame at a time, and can stop, reverse, or reset the sequence.

3.2 After Action Review Automation Support and Products

The ARCHER system includes Applixware office automation tools, which operate within the Logicon Environment for Decision Support (LEDS™), to facilitate data analysis and create briefing materials. Briefings can include animation sequences prepared by integrating the GIS into the presentation. As part of the ARCHER move toward platform independence, in the future the user will be able to select a preferred COTS package appropriate to the platform in use.

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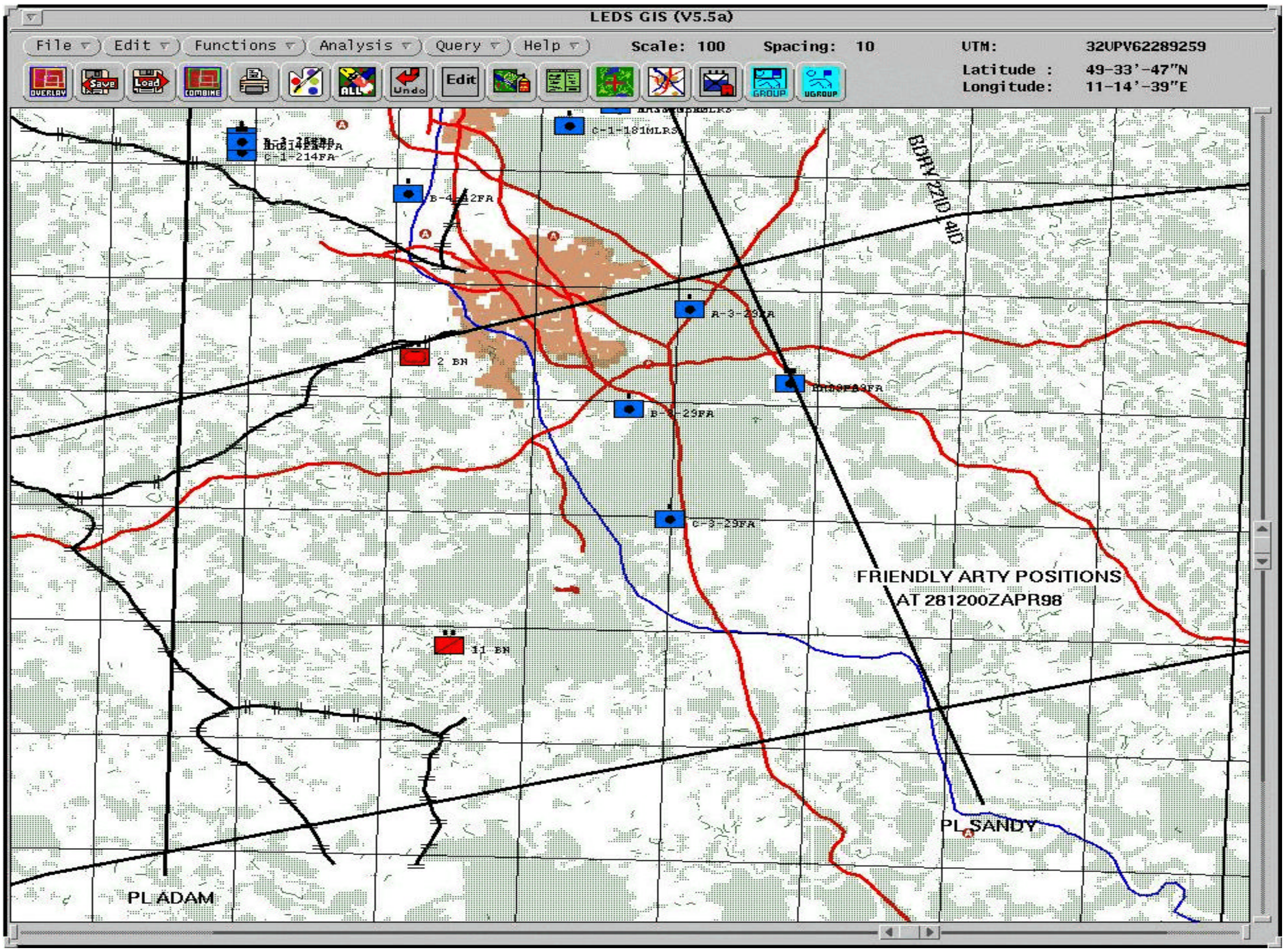

Figure 3: The Geographic Information System Used with ARCHER

ARCHER retrieves pre-formatted reports of data from CBS for review and analysis through its Reptool. By specifying the time frame and type of report desired, the user can view the report on the screen, prepare printed copies, and save the report file for future use. The user can use Reptool to identify important portions of the battlefield and draw reports from that selected area. The most common form of isolation of the battlefield (IOB) is to identify a list of units, either by describing a geographical area in GIS and automatically identifying the units therein, or by building a list of desired units. Other types of IOB include lists of fire missions, air missions, and weapons fired. The user can import the retrieved event data into Applixware spreadsheets to produce either standard or customized products.

The user also can retrieve reports input into the Workstation Reporting System and perform sorts by battlefield operating system, by time, or by reporting station. These reports provide useful and timely insight into actions at the workstation and serve as a valuable tool for analyzing command and control actions. Through a utility in the Reptool, the user can retrieve and automatically plot certain geographical data onto a map in the GIS. Examples include plots of specified minefield data or artillery fire missions by mean point of impact.

Because BCTP has been using ARCHER and its predecessors since 1988, the analysts have created a standard set of products based on simulation information. In many cases, these were cloned and modified to produce similar products for the C4I system sources. This allows accurate comparison between the simulation, or ground truth, and the available truth found on the C4I systems. Most common are spreadsheets and reports of target data and logistics status and plots of unit locations and battlefield geometry. Table 1 lists a few available products.

Table 1: C4I Report Tool Products

Reports
AFATDS-All-Fire-Missions *Fire missions sorted by target number*
AFATDS-FA-Organization-For-Combat *Task organization and mission of artillery units*
AFATDS-http-HVTL *High Value Target List from AFATDS web page*
AFATDS-http-TARGETS *Target lists from AFATDS web page*
AFATDS-Target-Processing-Time *Time to process artillery targets from acquisition to end-of-mission*
ASAS-Red-Order-of-Battle *Perceived task organization of OPFOR units*
Plots
AFATDS-TGTS-ACTIVE *Currently active fire support target locations*
ASAS-Red-Geometry *Locations of enemy graphics*
CSSCS-Host-Nation-Support-Locations *Locations of host nation support facilities*
CSSCS-Supply-Point-Locations *Locations of friendly supply points*
MCS-GEOMETRY *Locations of friendly and enemy graphics*
MCS-SITMAP *Locations of graphics for a specified tactical situation*
Spreadsheets
AFATDS-Ammunition-Status *Ammunition on hand in artillery units*
CSSCS-Chemical-Supply-Status *Roll up of Class I/III/V in chemical units by CBS name*
CSSCS-CLVII-ALL *Unit roll up of Class VII by technical identifier*
CSSCS-Host-Nation-Supply-Available *Class III/V available in host nation units*
CSSCS-Supply-Point-Supply-On-Hand *Supply point roll up of Class III/V by CBS name*
CSSCS-Unit-Major-End-Items *Unit roll up of Class VII by CBS name*
CSSCS-Unit-Personnel-On-Hand *Unit roll up of Personnel by CBS name*
MCS-RESOURCES *Unit roll up of resources by technical identifier*

4 DCARS Future Developments

The results from the DAWE indicate that the availability of more digitized information requires filtering incoming and outgoing data to avoid information overload. Also, data collection from multiple sources has raised data correlation issues that heretofore have not been a problem (e.g., the most obvious of these involves the temporal correlation of events). The scheduled 1998 fielding of DCARS to the National Simulation Center and BCTP staffs will prepare U.S. Army training experts to more thoroughly evaluate the increasing numbers of units equipped with C4I systems.

DCARS is undergoing a version upgrade to capitalize on the lessons learned in 1997. Major improvements include real-time message streaming, staffing and equipment reductions through technology enhancements, and secure data communications to US SECRET HIGH. Additional message parsing will permit full mission thread examination with "imbedded observer controller" type reports.

One area for achieving efficiencies during the support of an exercise is the automated production of after action review data products. We have initiated an effort called AutoSTAARS that will provide extensive after action review automation support by automatically generating standard STAARS products. AutoSTAARS will provide analysts at all levels the ability to generate STAARS products rapidly with little or no analyst intervention. This will reduce the number of analysts needed to produce the required number of quality products, either allowing a reduction in staff or providing the analyst more time to determine why an event happened, rather than just reporting on what happened.

Concurrently with the AutoSTAARS project, we are working to convert ARCHER from a Unix-based Sun environment to one that allows the use of multiple workstation platforms. This move to platform independence will not only allow the use of less expensive hardware, but also capitalize on user familiarity with standard hardware and software.

Another initiative uses the technique of decomposing military missions into the tasks which must be trained during an exercise to meet the commander's training objectives. This Mission-to-Task Decomposition (MTTD) methodology has been proven in principle, and it decomposes missions into combat tasks and staff tasks. By imposing various filters, such as the unit's mission essential task list (METL), the commander's training objectives, and the conditions under which the tasks are to be performed, we can develop a relatively concise list of final tasks to be trained in a particular exercise. These tasks will be linked to ARCHER to support the generation of after action review data collection plans that are consistent with specific AutoSTAARS products. The same filters that result in final combat and staff tasks will allow the exercise planner to develop an exercise scenario which best fits the tasks to be trained.

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