

Utilizing C/JMTK to Build a Web-Based Common Operational Picture (Joint WebCOP)

Next Generation Command and Control System (NGCCS)
Tactical Operations Center 3-D (TOC 3-D) Program

Concurrent Technologies Corporation (CTC)

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Abstract: *The Joint Web-based Common Operational Picture (Joint WebCOP) effort is being collaboratively developed by the Global Command and Control (GCCS) Family of Systems (FoS) with Concurrent Technologies Corporation (CTC) leading the Commercial/Joint Mapping Toolkit (C/JMTK) integration effort under the Next Generation Command and Control System (NGCCS) Tactical Operations Center 3-D (TOC 3-D) Program. CTC is an independent, nonprofit, applied research and development professional services organization providing management and technology-based solutions to a wide array of clients representing state and federal government and the private sector. The Joint WebCOP initiative integrates advanced Geographic Information System (GIS) technologies, information management solutions, and Internet technologies to create a web-based solution for viewing the Common Operational Picture (COP).*

Joint WebCOP utilizes tools from C/JMTK including ArcIMS, ArcSDE, MapObjects Java Edition (MOJE), and Military Overlay Editor (MOLE). Joint WebCOP displays a visual representation of unit positions and tactical graphics in a browser-based display linked to various Battlefield Functional Assets (BFAs). Providing the Joint community with an extensible WebCOP architecture based on ESRI's proven GIS toolset supports the Army's architecture, as well as the Joint WebCOP architecture.

Introduction

The United States Military's unique mission drives the need for rapid identification, evaluation, and integration of existing, new, and emerging Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) and related technologies to ensure the best mission capability at the lowest risk to personnel. However, Intelligence, Surveillance, and Reconnaissance (ISR) sensor information, as well as other related technologies, are only useful when their integration enables the warfighter to avoid risks and seize opportunities in a dynamically changing battlespace. As new technologies provide the Military with powerful sensor, processing, and communications capabilities, the assessment of these technologies—and their eventual effective operational employment—depends on whether or not the operator can easily and quickly grasp the importance of the information each new sensor technology provides.

Improving U.S. warfighters' abilities to visualize a battlefield in near real-time utilizing web technologies has never been more important. The Global Command and Control System (GCCS) Family of Systems (FoS) Joint WebCOP is an initiative, based on ESRI's proven GIS toolset, that allows combat commanders to accurately view detailed maps and situational awareness using a standard web browser. Joint WebCOP enhances the warfighter's ability to rapidly identify risks to U.S. personnel and exploit combat opportunities in a dramatically changing battlescape.

The Joint WebCOP initiative integrates advanced GIS technologies, information management solutions, evolving communications architectures, and Internet technologies to create a scalable web-based solution for viewing the COP. Joint WebCOP meets requirements to display battlespace-relevant data, including maps, intelligence information, assets, and live feed data in a space that incorporates position, orientation, and time. This provides the capability to overlay data from many battlespace-relevant entities.

The C/JMTK is a standardized, commercial, comprehensive toolkit of software components for the management, analysis, and visualization of map and map-related information. This acquisition replaces all of the existing Joint Mapping Tool Kit (JMTK) functions with commercial-off-the-shelf (COTS) components and provides additional capabilities. JMTK is a suite of government-developed software applications that were consolidated in 1994 to provide a standardized geospatial visualization capability to the DoD Command and Control systems. JMTK provides the Mapping, Charting, Geodesy, and Imagery (MCG&I) functionality for mission applications that run in the Common Operating Environment (COE). It is not an application, but a developer toolkit. In the 1999 Defense Authorization Bill, Congress directed that future versions of the JMTK be based on commercial technology. The C/JMTK is based on a single scalable open architecture, with development environments incorporating industry and open standards, where significant research and development costs are borne mainly by vendors who offer

regular software upgrades, extended functionality, and standard, regular training. The primary commercial component of the C/JMTK is the ESRI GIS software, ArcGIS.

Objectives/Guidelines

The objective of the Joint WebCOP is to provide a web-enabled view of the COP through the use of standard web browsers, such as Internet Explorer and Mozilla. The system is being built using industry and government standards, such as Java 2 Enterprise Edition (J2EE) and the C/JMTK. The design for the Joint WebCOP system is based on a ‘thin-client’ model where web pages are composed strictly of HTML and Java Script. Therefore, no executable browser plug-in is required by clients to access the system. For secure communications, all requests from the client to the server are made through HyperText Transfer Protocol Secure (HTTPS). Although the primary target client is a web browser, the Joint WebCOP J2EE application server is built with the ability to host multiple web applications, including Java Applets and PDA viewers.

Viewing the COP in an Internet/Intranet environment requires the transfer of a large amount of geographic data to the client. Therefore, it is desirable to minimize the amount and frequency of data sent. To achieve this, the application server performs the drawing of all geographic layers and sends a compressed image to the browser. The browser receives the image and displays it to the user.

The storage and dissemination of Joint WebCOP data, including maps, imagery and data service layers, needs to be fast and efficient. Therefore where necessary, this data is stored in an Enterprise GeoDatabase using ArcSDE. This provides a common data model and interoperability mechanism within the Joint WebCOP architecture, as well as a high-performance repository of GIS data that is capable of efficiently handling a large number of concurrent users. In support of this open architecture, the Joint WebCOP is compatible with Open GIS Consortium (OGC) standards by providing the ability for external systems to retrieve maps and data using Web Map Server (WMS) and Web Feature Server (WFS) standards.

MIL-STD-2525B defines a customary way for displaying battlefield information. To display this symbology, Joint WebCOP utilizes the Military Overlay Editor (MOLE), which adheres to and implements MIL-STD-2525B. Joint WebCOP also provides the ability for the user to display the Navy Tactical Data System (NTDS) symbology, if desired.

Server Architecture

An overview of the Joint WebCOP server architecture is shown in Figure 1. This architecture utilizes the following components:

Map Server—to generate maps

- ArcIMS 9.0
- Java Runtime Environment 1.4.1

Application/Web Server—to host the Joint WebCOP web application

- BEA WebLogic Application Server 8.1
- J2EE 1.3
- MOJE 2.0
- MOLE

Structured Data Store—store map and other Command and Control data

- ArcSDE 9.0
- Oracle9i

Web Client Application

- Compatible with Internet Explorer 6.0 and Mozilla 1.6 (and higher)
- HTML/JavaScript thin-client GUI

The system receives data from various data sources (i.e., Publish and Subscribe Services (PASS)) as geographic features representing Units (MIL-STD-2525B Appendix A), Tactical Graphics (MIL-STD-2525B Appendix B) and other tabular mission data. Each data source stores this information in the relational GeoDatabase via the ArcSDE API in one or more overlays. Overlays are defined by Joint Pub (JP) 1-02 for digital displays as, “sets of graphical data which can be placed or removed from another set of graphical data without causing the distortion of or damage to either set of graphical data.”

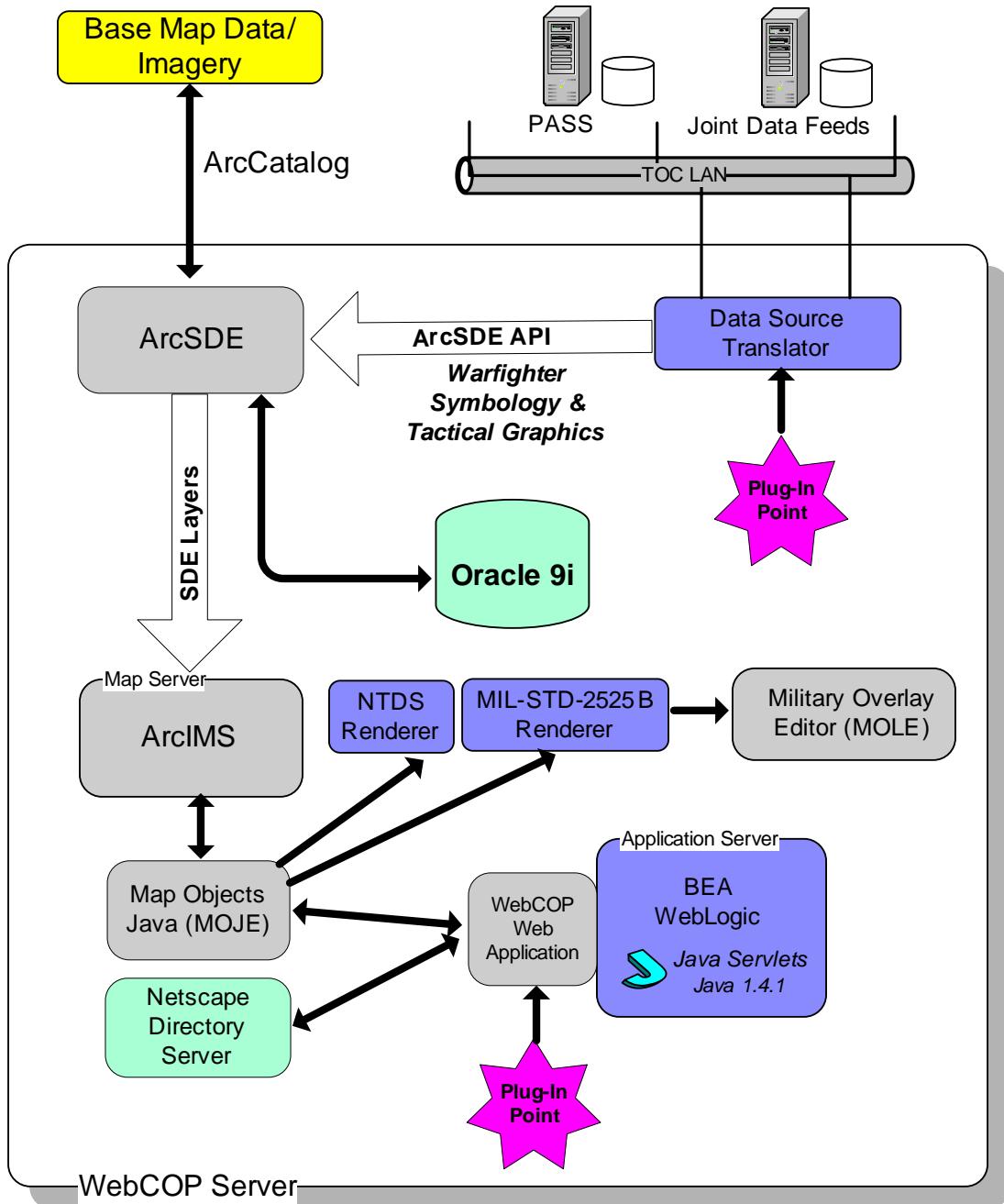


Figure 1. Joint WebCOP Server Architecture

Storing all collected C2 data in the relational database provides for two advantages. First, clients can access data directly on the server by using ArcSDE, ArcCatalog, ArcMap, WFS, WMS and Map Objects Java to request a snapshot of data for any of the data source overlays. Second, users can develop their own client applications and communicate with the Joint WebCOP server directly. The Joint WebCOP data model stores all data in decimal degrees using the WGS84 Datum. Geometry must be converted to this coordinate system for use within Joint WebCOP.

Static data contained in known geographic data formats such as Imagery (Raster Product File, CIB, CADRG, etc) and Overlays (Vector Product File, VMAP, DNC, etc.), is imported directly into ArcSDE using the ArcCatalog tool. Storing all data in ArcSDE has the following advantages:

- Database portability—Joint WebCOP data can be stored in DB2, Oracle, SQLServer or Informix on various platforms.
- Spatial Indexing—ArcSDE provides additional “spatial indexing” capabilities over and above traditional file-based GIS formats, including the ability to tune the efficiency of data access in ways specific to geographic data.
- Concurrency—ArcSDE provides the infrastructure required to manage multiple users editing the same spatial database with long transactions, alternate versions and history.
- GIS Business Logic—ArcSDE provides the business logic for not only creating simple geometric data, but also for supporting advanced GIS data types such as images, networks, features with integrated topology and shared geometry, and associating them with rules, behavior and other object properties.
- Performance—Significant performance gains are achieved by accessing images from the ArcSDE database versus accessing those same images via the file system.
- Data Repository—ArcSDE can act as a data repository so that the entire enterprise can access the data concurrently and efficiently.

For the success of Joint WebCOP, the required data source adapters must developed and integrated so end-users have relevant, actionable information. To ensure that this is done efficiently and correctly, Joint WebCOP allows the data source experts themselves to develop their own data adapters by using a provided Software Development Kit (SDK). This “Data Plug-In SDK” contains an ArcSDE helper API that makes it easier for third-party developers to integrate their data into the Joint WebCOP. This API is used to create layers in the ArcSDE database from non-standard data formats that are not directly importable into ArcSDE using existing ArcGIS/ArcSDE tools. Such data is stored in the following layer types:

- MIL-STD-2525B
 - Warfighter Symbols (points)
 - Tactical Graphics (points)
 - Tactical Graphics (lines)
 - Tactical Graphics (polygons)
- Normal (non MIL-STD-2525B)
 - Point layers
 - Line layers
 - Polygon layers
- ArcSDE tables containing attribute data only (cannot be rendered)

Joint WebCOP Application

Application Architecture

The Joint WebCOP Application (Figure 2) is hosted within the BEA WebLogic Application Server. This application utilizes a Model View Controller (MVC) design pattern to deliver web pages to the client. The selected MVC implementation is Jakarta Struts. All web pages within the Joint WebCOP application are in the form of Java Server Pages (JSP).

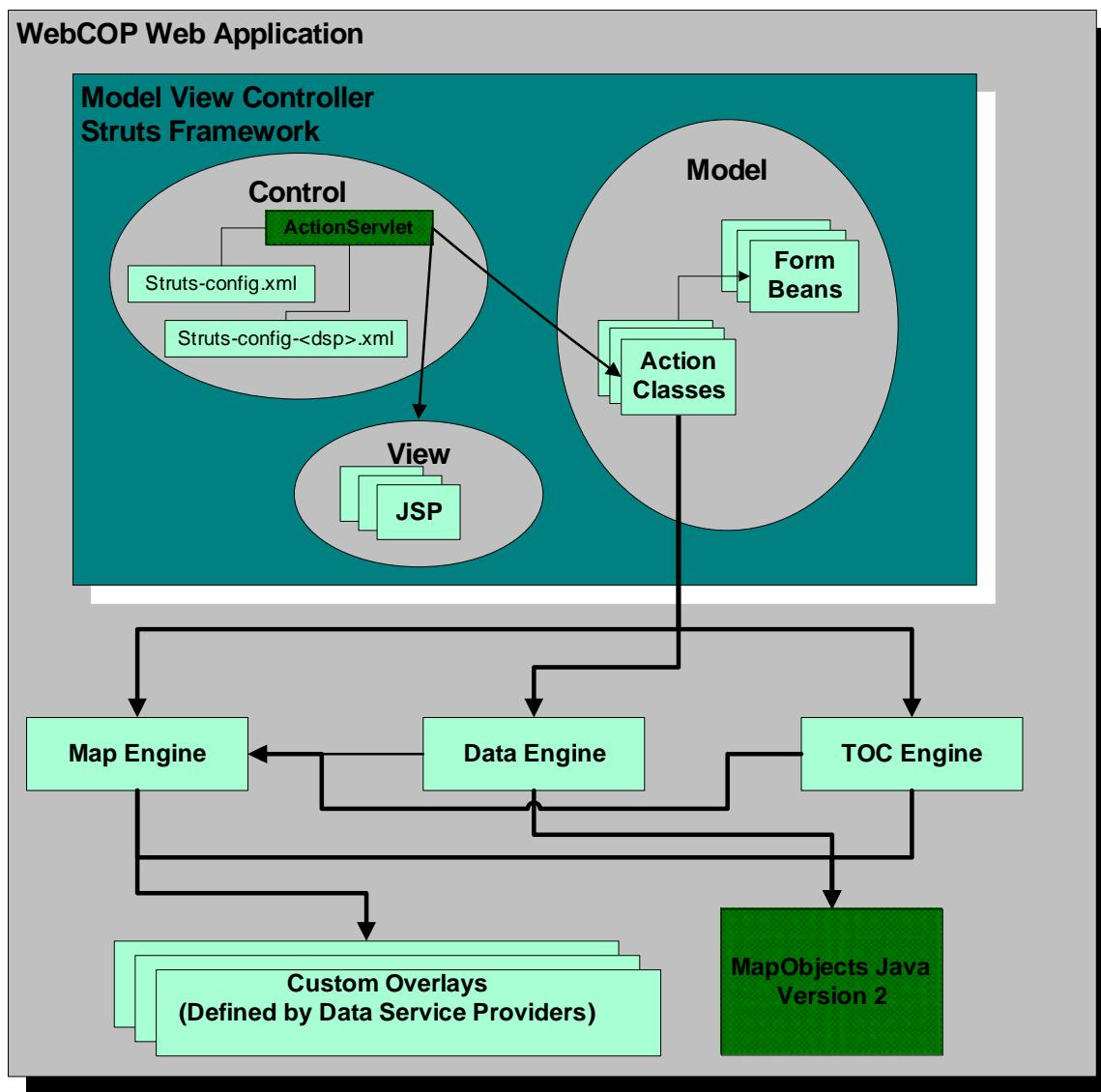


Figure 2. Joint WebCOP Application Architecture

Map Generation

The Joint WebCOP application interacts with MapObjects Java to draw the maps and convert them to an exportable image format, more specifically, JPEG files. Once created, the JPEG files are sent to the client for display. Published maps can contain optional items such as grid lines, a compass rose, a date/time stamp, and/or a scale bar. Each user can customize his or her display.

MapObjects Java provides the ability to render vector, raster and C2 data from a variety of data sources, including ArcSDE, ArcIMS and shapefiles. This can also include custom data sources, given a Content Provider is implemented.

Custom renderers were developed to operate within MapObjects Java to render the MIL-STD-2525B and NTDS symbol sets. The MIL-STD-2525B renderer interacts with the Java bindings for MOLE to render symbols. The NTDS renderer utilizes a set of image files that represent the symbols and draws them on the map. Each user can choose which symbology set he or she wishes to view. The MIL-STD-2525B and NTDS renderers are reusable components that can be used in any MapObjects Java implementation.

Map Manipulation

The Joint WebCOP allows each user to show specific layers on the map with a specified z-order. The z-order of the map layers is shown in the table of contents where the top map layer is at the top of the table of contents.

Joint WebCOP also provides common GIS mapping functions within the web browser. It shows zoom and select rubberbands, as well as a moving map when panning. When a user utilizes the measure distance tool, lines are drawn between selected points, and the distance is calculated between the points, all within the client browser for quick response time. Joint WebCOP provides common GIS mapping functions such as zoom in/out (single point and rubberband), fixed pan (north, south, east, west), drag pan, zoom to full extent, select and measure distance.

Each Joint WebCOP user can maintain a list of bookmarks for easy navigation to specific locations on the map. A URL is also provided with each bookmark so it can be shared with another Joint WebCOP user. Bookmarks are retained across user sessions and are stored within the user's preferences.

User Preferences

Joint WebCOP users can also maintain their own preferences which are used to initialize the map and the table of contents each time they log into Joint WebCOP from any browser on any machine. The saved preferences include layer visibility and z-order, military symbology (MIL-STD-2525B or NTDS), bookmarks, grid line display, scale bar display, compass rose display, date/time display, zoom factor, pan factor, map units (miles, feet or kilometers) and coordinate system (Lat/Lon, MGRS or UTM/UPS).

System Extensibility

Joint WebCOP allows third-party service providers to develop plug-ins for adding functionality to the GUI, as well as adding data to the Joint WebCOP ArcSDE data repository. This allows Joint WebCOP to be extensible and open.

Joint WebCOP User Interface

Figure 3 is a screenshot of the Joint WebCOP client application. This application provides a simple, intuitive user interface that requires minimal training for end-users. Standard functionality within ArcGIS desktop products such as zoom in/out, pan and measure distance have been developed to work in a similar fashion within this user interface. A Joint WebCOP demo site is available at <http://webcop.toc3d.com>.

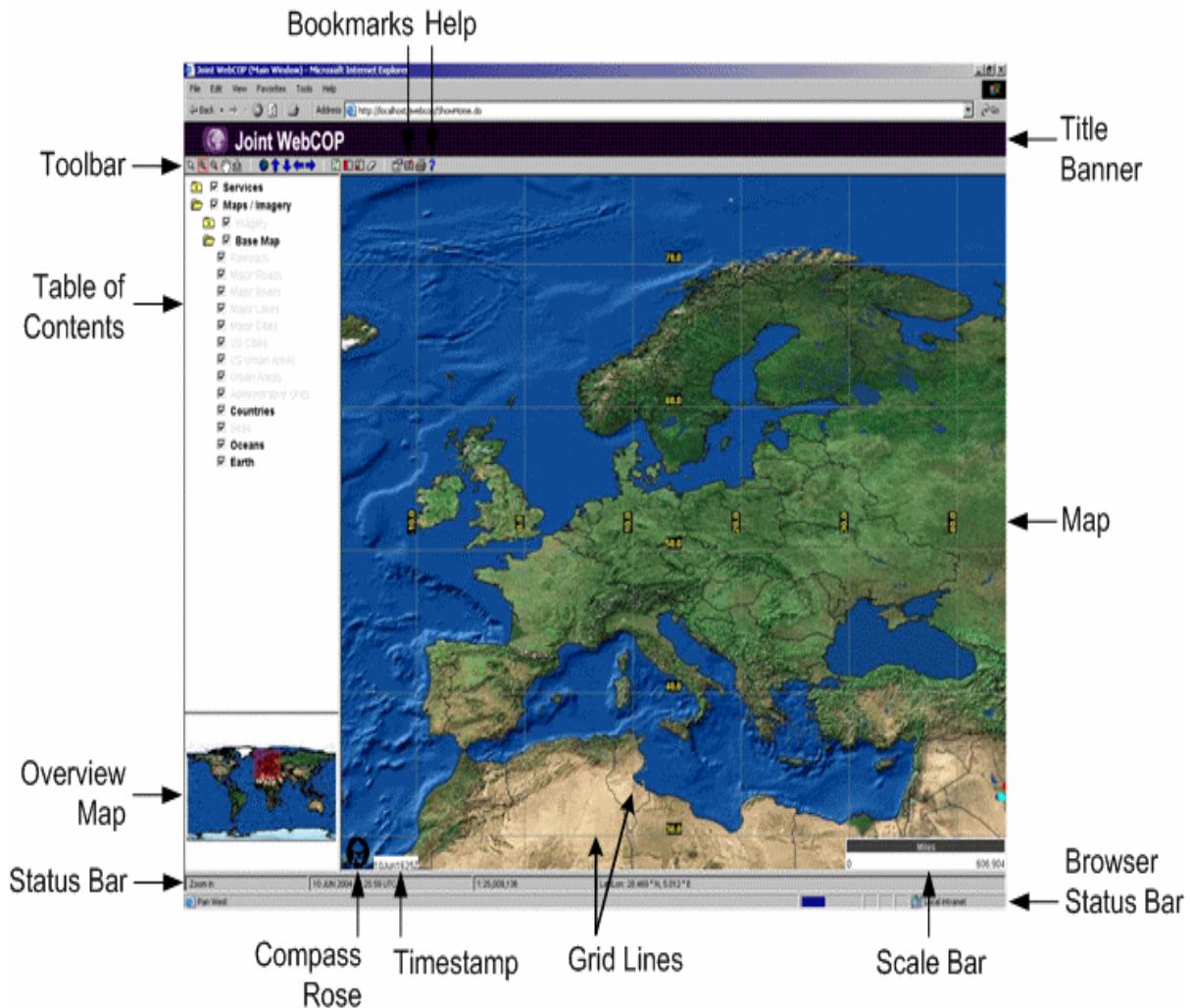


Figure 3. Joint WebCOP Client

Figure 4 demonstrates a screenshot of the Joint WebCOP client application while displaying imagery and MIL-STD-2525B symbology.

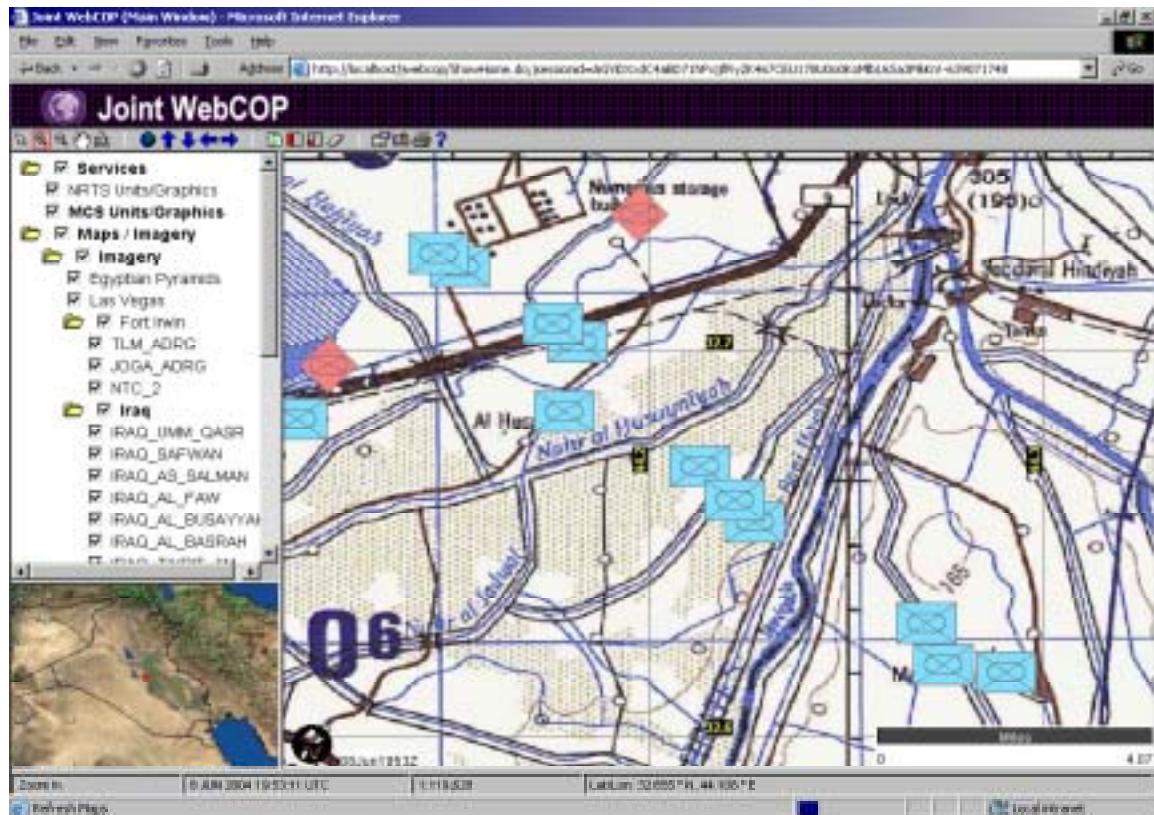


Figure 4. Joint WebCOP Sample Screen Shot

To validate the extensibility of Joint WebCOP and client browsers, a separate web application was developed to support viewing the COP from within a PDA browser (Figure 5). This is an ultra-thin implementation that uses HTML and JavaScript only. As with the other Joint WebCOP clients, there is no custom client software needed on the PDA.

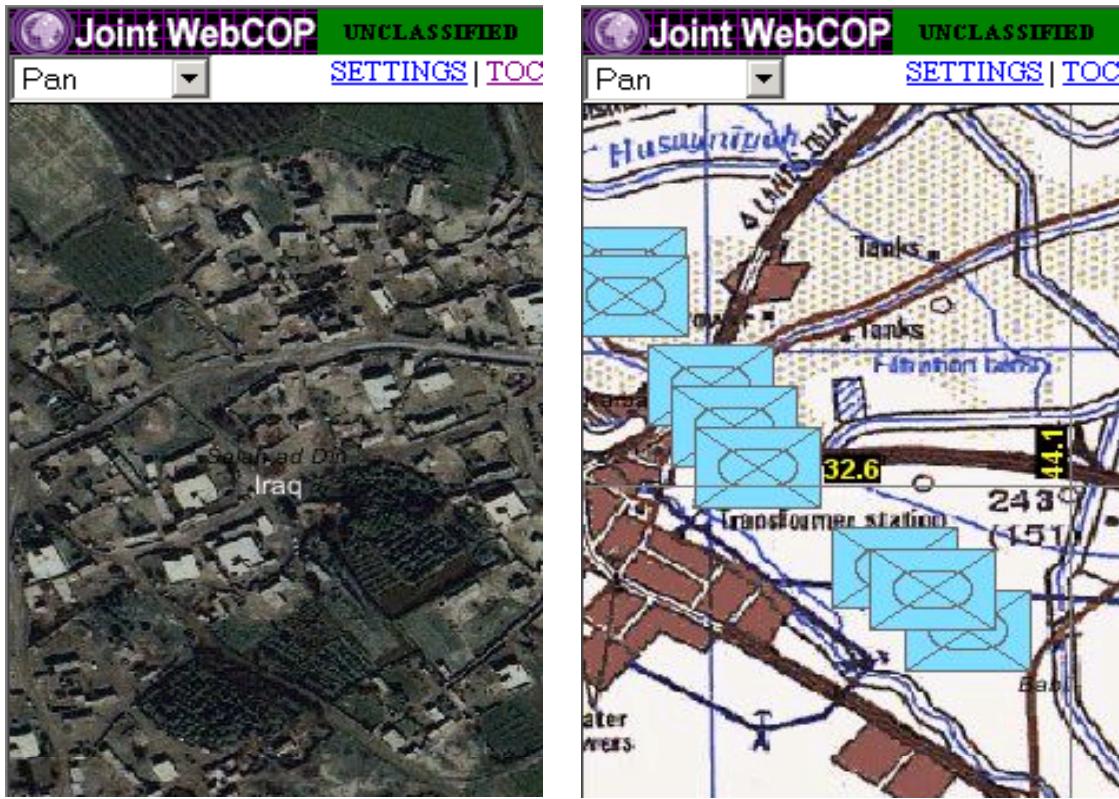


Figure 5. PDA Viewer within Pocket Internet Explorer

Conclusion

The GCCS FoS Joint WebCOP is designed to be a near-term capability that builds on mature technology, yet anticipates future developments. It augments current capabilities by providing a browser front-end to the COP and an open, pluggable infrastructure that can quickly accommodate new data sources and user functionality. Joint WebCOP utilizes the best of prior Service-unique efforts as the foundation to build an open, extensible, and loosely coupled architecture to be shared by all.

Joint WebCOP provides a critical, highly responsive node for a widely distributed and mobile force. It gives users of any platform with network connectivity and a web browser, the ability to view the COP. It minimizes the need for user training, due to the simplicity of using a standard web browser. It provides access to data from Joint data feeds that most users would not otherwise be able to view.

Acknowledgments

Joint WebCOP is collaboration among GCCS-A, GCCS-M, GCCS-J, TBMCS, NGA, and DISA.

The GCCS-A portion of Joint WebCOP is being developed by *CTC* under the direction of LTC Rachel Borhauer, PM GCCS-A. The *CTC* development effort consists of:

- RDBMS/ArcSDE Feature Store
- ArcIMS Map Rendering Services
- MIL-STD-2525B Symbology Rendering Engine
- Web-based GUI
- Java Map Layer Engine
- Web Administration User Interface
- PASS Feature Layer

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