# Counter-trafficking Integrated Display System (CIDS):
# A GIS-Based Command & Control Environment for Coalition Nations


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## ABSTRACT

Coalition nations involved in the global war on narco-terrorism may rely on an inadequate foundation upon which to base command and control activities. The inability to exploit multiple levels of information overlaid on a geospatial background and the lack of a robust communication system to share inherently large datasets all contribute to reducing the quality and quantity of decision making among front-line forces. As the fidelity of data sources continues to improve, users continue to search for an effective ability to fuse sensor, infrastructure, map and intelligence feeds in a near-real time environment. While several robust solutions are available to US agencies, many coalition countries do not have access to these applications due to issues of reliability.

As part of the U.S. Government's strategy to equip selected coalition forces with better tools to improve their ability to analyze, formulate, prosecute and evaluate activities which support counter-trafficking missions, the U.S. Department of Defense Counter-Narcoterrorism Technology Program Office has developed a customized command & control tool built upon COTS-based software. By using an industry standard GIS application, the value of public domain mapping data is leveraged and interoperability between the US and coalition nations is enhanced.

### Introduction

Consider the following realistic scenario involving a South American country treated as a coalition partner by the United States government in the Global War on Narcoterrorism.

A member of that country's military places a Request For Information (RFI) with one of the U.S. Tactical Action Teams (TAT) to analyze the possibility that illegal narcotic labs and cultivation areas may be in a specific area of the country. Using U.S. imagery collected by National Technical Means (NTM), qualified imagery analysts from the Joint Interagency Task Force South (JIATF-S) evaluate the area and identify three potential areas of interest (AOI). Because the coalition country does not have access to the normal products used to communicate this information to U.S. Government agencies, a 'sanitized' version of the imagery is released to the South American country's military leaders. The image (a JPEG graphic) contains coordinate information for the AOI's and some reference information such as the presence of a nearby river. Latitude / Longitude graticules, surrounding geographic landmarks, elevation and ground cover information as well as nearby population centers and transportation paths are not shown. Due to the security guidelines in place, this RFI may take a week or more to be delivered to the coalition nation. In order to conduct reconnaissance, the coalition nation deploys a surveillance aircraft to the area. The subsequent video footage is reviewed using a commercial VCR player and the tape is stored for future access. Video of the same area had been collected 6 months earlier, but because of the difficulty in cataloging and geo-referencing the image data, a valuable change detection capability was lost. Additionally, it was known that insurgents near the AOI's had conducted operations within the last year, but because this information existed only in a spreadsheet, it was not apparent that these events were related to the establishment of the narcotics labs. In short, the country's military analysts and decision makers had no "common operational picture" on which to display either the RFI results, the video footage nor any other supporting command and control information considered necessary in the U.S. to conduct counter-narcoterrorism operations.

Command and Control ($C^2$), in the military sense, involves the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission.[1] Functions which support $C^2$ typically include the arrangement of personnel, equipment, communications, facilities and processes which in turn are used by decision makers to plan, direct, coordinate and control forces and operations in the accomplishment of a mission. In the scenario above, we have added an element of intelligence to support the traditional $C^2$ functions.

The role of the paper map to support military commanders' decision making processes with spatial information has existed for over 1000 years at the strategic level and at least 250 years at the tactical level.[2] Within the last two decades, access to digitally-formatted geographic information, coupled with more robust database management systems, visualization tools, and the reliance on the world wide web as a communication channel has positioned the Geographic Information System (GIS) as the standard for military intelligence analysis and operational planning. Use of commercial off-the-shelf (COTS) products such as Environmental Services Research Institute's (ESRI) ArcGIS™ family of products allows military commanders and their staffs to have better situational awareness of a constantly-changing situation. "Seeing" data with geo-location content, such as one's own forces, threat assets, geo-political information – and being able to evaluate this information using contextual data – has only recently been possible. Indeed, the U.S. military's movement to embrace this capability is demonstrated by the decision to create a "Commercial Joint Mapping Toolkit" using ESRI's ArcGIS family of products. The use of commercial GIS tools presents a unique opportunity for the U. S. Department of Defense Counter-Narcoterrorism Technology Program Office (CNTPO) to develop and deploy a GIS-based Counter-trafficking Integrated Display System (CIDS) for use by both U.S. Government agencies as well as coalition partner nations. Development of such a system is fully consistent with CNTPO's charter to develop technology which is releasable to coalition nations.

The remainder of this paper will discuss the development of CIDS in its current form, including the development of specific user requirements, system description and architecture, implementation considerations and plans for future enhancements.

## CIDS User Requirements

CNTPO identified potential users of the CIDS to be both military and civilian law enforcement agencies. Within both communities, three classes of user profiles were further designated: data analysts, mission planners and operational decision-makers. In addition, support of these users would require technical expertise in the form of system

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[1] www.jfcom.mil/about/glossary.htm
[2] The Role of Geographic Information Systems on the Electronic Battlefield, ESRI White Paper, 1998

administrators. While it is often difficult to develop truly open inter-agency organizations, the CIDS architecture was designed from the beginning to include the sharing of information in a secure, but configurable system and therefore, to enhance the ability of multiple agencies (with their attendant analysis, planning and decision-making) to operate in a teaming environment. It is envisioned that as the capabilities of CIDS improve and as agencies become more comfortable in speaking a common C2 language, this sharing of information can be expanded to include multi-national scenarios.

Input from a user community focus group identified five basic CIDS objectives:

- To provide a $C^2$ tool which can create, manipulate, integrate and share geo-referenced information to provide the foundation for a new common operational picture (COP)
- To enhance situational awareness of operational decision makers
- To improve value of legacy, public domain and internal data sources; e.g., to provide an 'indigenous' GIS capability
- To create a scalable, flexible system architecture to provide for immediate and future $C^2$ requirements
- To allow data access to a wide range of users, especially in countries with an under-developed telecommunication infrastructure.

From these broad objectives, more precise requirements were generated which defined the basic tasks required of CIDS. These tasks included:

- The ability to display geo-referenced data on an interactive 2-D or 3-D map using pan, zoom and query tools and to distribute this information remotely
- The ability to edit map data to show changes in geography over time
- The ability to user layer controls to overlay various types of data using geo-referenced coordinates such as
  - Ground and airborne sensor data
  - Points and regions of interest
  - Geo-political events
  - Weather
  - Topographical data
- The ability to hyperlink a 2-D reference point with other data files such as images, video, audio, documents, URL's and 3rd party applications
- The ability to take all-source data and translate into a mission plan
  - Determine optimum routing
  - Reference geographic/map features while displaying waypoint data
  - Remotely access and print mission plots

- The ability to take all-source data and translate that information into a mission plan with formatted mission execution documents

Applying systems engineering principles to these tasks, additional derived requirements were identified, including the need to provide a robust database management system, the need to pre-load U.S. releasable and open source map backgrounds onto the system, the need to use open architecture standards in developing a reliable, scalable IT system and the need to consider limitations in available telecommunications bandwidth in designing the architecture for information flow.

**System Description**

In considering the selection of an appropriate architecture for use in building CIDS, CNTPO looked at a number of key criteria. Included in this criteria were the availability and suitability of the computer operating system, the reliability of candidate hardware systems, the relative maturity of COTS-based GIS solutions, the familiarity of government and contractors with web-supported programming languages, the features and limitations of enterprise level database management systems and the level of expertise required by potential operators, including system administration.

Driven primarily by the requirement to develop a scalable solution and influenced by previous IT systems developed by CNTPO, the decision was made to choose ESRI's ArcGIS™ family of solutions as the core of the GIS. Being considered nearly ubiquitous in the world of GIS providers, ESRI also offers a number of application extensions which extends the basic capabilities. A subset of these extensions allow users to analyze spatial intelligence, perform 3-D computation and display of data, and support the use of MIL-Standard nomenclature for communicating battlefield operations.

The underlying database management engine chosen was the enterprise level solution by Oracle's 8.0*i* product. Oracle's mature, industry-standard approach to managing large volumes of data together with its ability to read a variety of legacy database formats was considered ideal for the CIDS application. ESRI's ArcSDE (Spatial Database Engine) provides the front end for the GIS database calls.

To provide a robust web service, ESRI's ArcIMS (Internet Mapping Service) was chosen to publish map services to remote users accessing CIDS with an internet browser.

Server and workstation hardware solutions from U.S. manufacturer Dell Computing, Inc. were selected. Recognizing the significant processing which is required by the ArcGIS software, PC and server performance configurations were specified accordingly. A storage area network system with fourteen 72 GB drives provides just under a terabyte of disk space. Large format Hewlett-Packard plotters and color laser printers were included as well.

Figure 1 shows a representation of the physical architecture for an enterprise (client-server) implementation of CIDS. Dual rack-mounted domain servers handle user authentication and control. Additional servers for database management, web, application

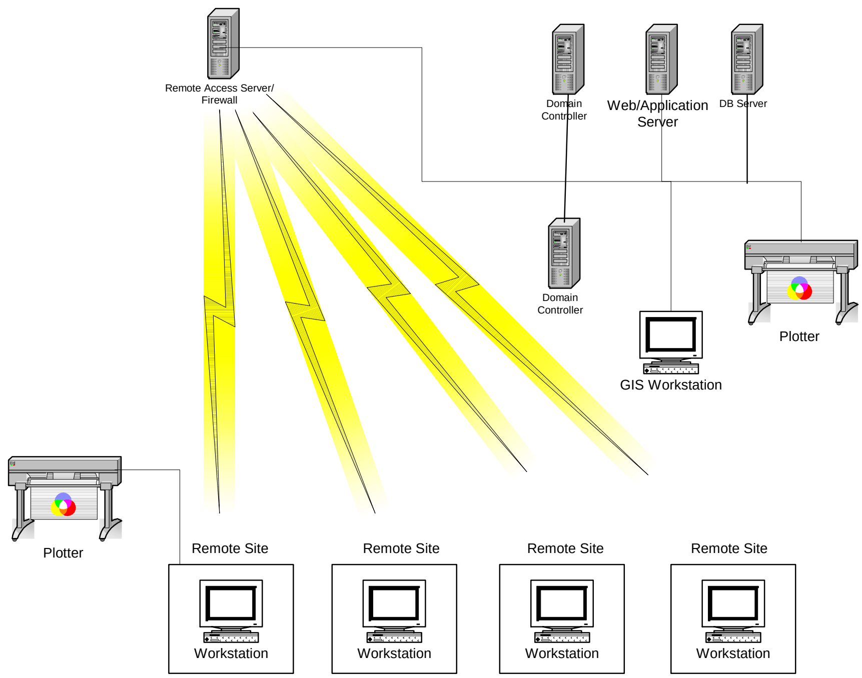


Figure 1

and ArcIMS servers read GIS data from the spatial database engine as well as authenticates web users. The GIS workstation indicated both at the corporate server location as well as remote locations is a Windows 2000-based Pentium 4 PC with 1GB of memory and at least 200 GB local storage. Installed on the workstations is ESRI's ArcGIS V8.2 application with selected user extensions. Remote connectivity is indicated using commercial broadband capability as the host nation's infrastructure permits. It is CNTPO's experience that bandwidth in excess of T1/DS1 (1.54 Mbps) will be required when two or more remote workstations are collaborating on typical map and imagery files. Not shown in this figure are the individual remote users accessing prepared map services using a browser.

Because ArcGIS requires some expertise to use, a two-tiered approach to communicating information in CIDS was designed and is shown in figure 2. In this diagram, we make the distinction between the functions performed by the analyst/planner using the ArcGIS Analysis workstation, and the decision maker, who references ArcIMS image-based products with an internet connection and a browser. Supplying information to both applications is the data infrastructure layer, represented by the ArcSDE application and the actual infrastructure data (baseline vector and raster map products as well as point, line and shape data associated with those map products). Additional information, referred to in the diagram as 'local intel data' represents another channel for data importation. Finally, the ability to create customized models and scripts within the ArcGIS and Web Services environment provides a final means to add content value to both the analyst/planner as well as the decision maker. These scripts are available as third party extensions or can be custom configured using ESRI's ArcObjects toolbox and simple HTML code.

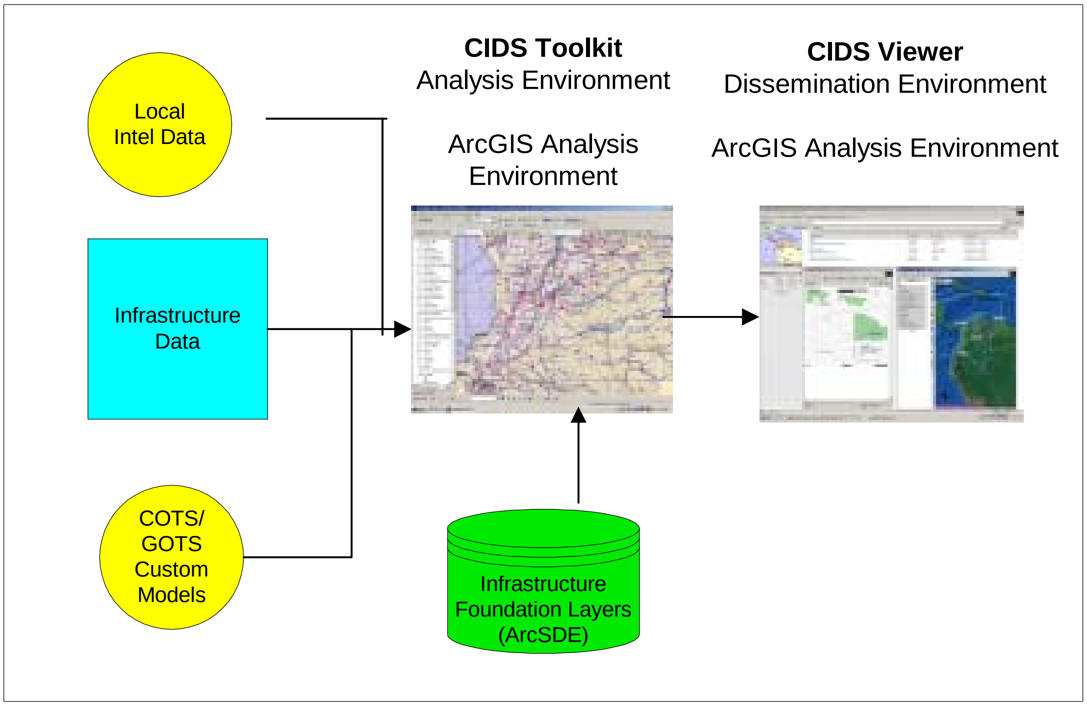


Figure 2

A summary of the information flow and functional capabilities of this two-phased approach is shown in figure 3.

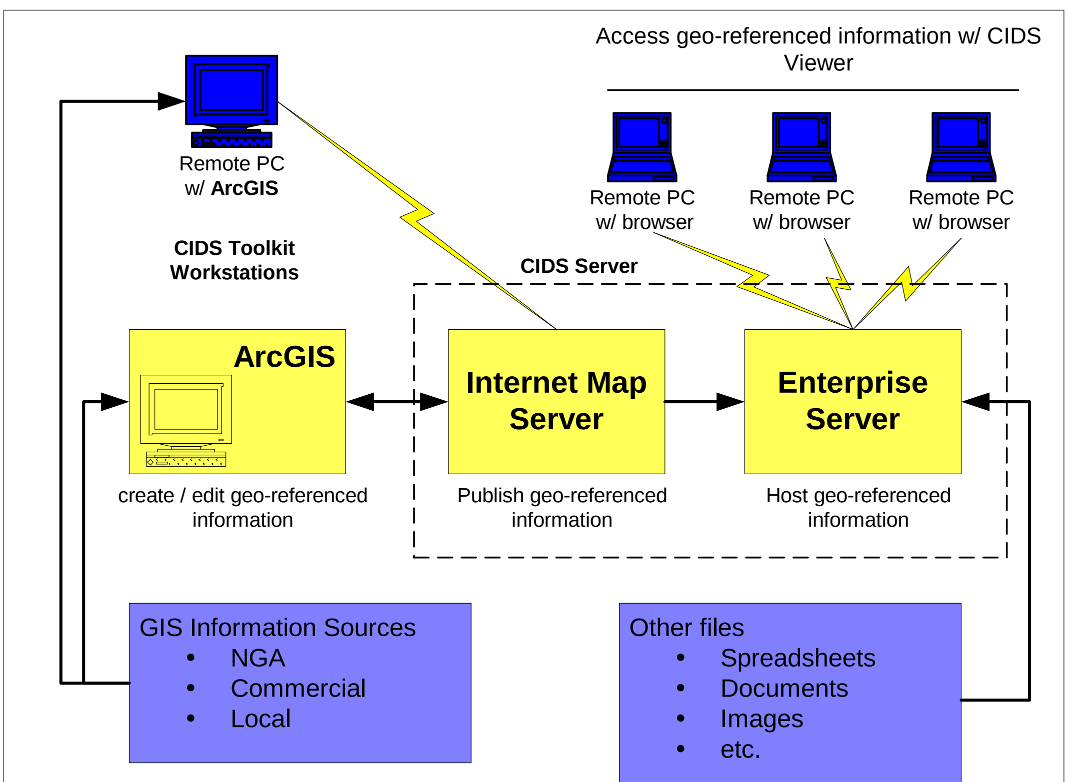


Figure 3

The remainder of this section outlines some of the features associated with the viewer portion of CIDS. Recall that an analyst or mission planner will use the CIDS toolkit workstation to design and customize a map service for access by a remote user. This map service can be queried by a non-ArcGIS trained person to learn about the underlying attribute and metadata. In addition, this user can modify what data is displayed against the various mapping layers embedded in the map service and conduct basic map navigation including pan, zoom in/out, measure distances, select features by attribute or query. Finally, the user can use the CIDS viewer to search for all types of files that have been associated with a geographic region. Using this feature, for instance, a decision maker could search for all still images and MS Word documents associated with a particular province.

Access to the CIDS Viewer application is controlled with user IDs and passwords and a roles-based logic is used to define user permissions and functionality. Roles for Administrator, Analyst/Planner and User are currently included in the system. Administrative privileges cover user maintenance, adding/editing new data, and including ArcIMS map services for access by analysts and users. Analyst privileges allow the editing of existing data sources and users may only view previously created data sources.

Following a successful log on, a user with analyst privileges will be directed to a home page which allows the following actions to occur:

- Manage individual files (add, edit or delete) and associate them with a specific geographic region
- Search for and display documents and maps which have been associated with a specific geographic region

Searching for data products is shown in figure 4. By dragging a box to include the geographic region of interest (shown as the cross-hatched box) and clicking the search button, a list of all files which have been associated to a point within the search extent is presented to the user. Clicking on the files will launch the appropriate application necessary to view the information.

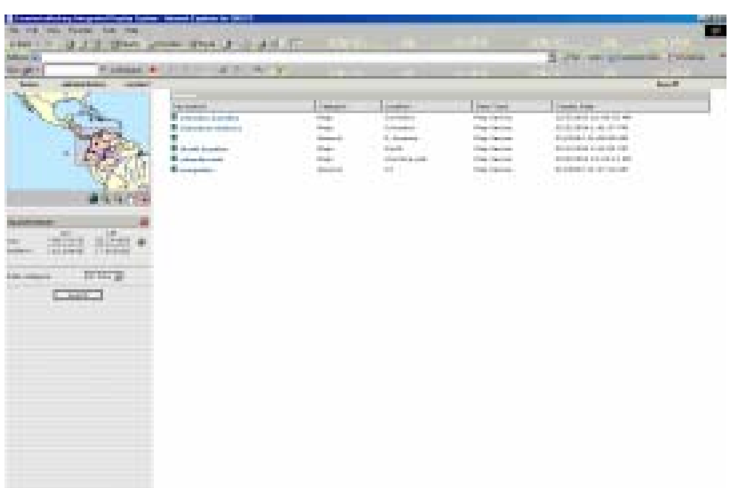

Figure 4

If the file associated with a region is a map service which has been created using the CIDS toolkit, a set of specialized map functions is available to the user. Without any knowledge of ArcGIS, a user can perform a range of operations, including:

- Zooming in/out by fixed amounts or by drawing a box
- Pan up/down and left/right
- Measure distance between two points or along a multi-point path
- Perform basic queries on underlying map data
- Select / De-select map layers to display
- Draw buffer regions around selected attributes (e.g., “highlight all primary roads within 50km of airport X”
- Identify features on a map by accessing its underlying metadata

These are a subset of the functions available in the current release of the CIDS viewer. Future planned capabilities will be discussed in a later section of this paper.

**Implementation**

The CNTPO initially developed CIDS to assist the Colombian Air Force in the development of their own organic command and control platform; however, the CIDS concept was designed to apply to any coalition nation host. Foreign language support was considered in the development of the graphical user interface (GUI) and emphasis on icon-driven controls was given. Since the implementation of the Colombian system, one additional installation of CIDS has been completed in a middle eastern country. In that installation, a specific requirement for Russian language support was fulfilled.

Besides designing and deploying the CIDS enterprise system, the program office was responsible for pre-loading available mapping products to serve as a background upon which the coalition nation could begin building data layers. Where specific geo-spatial sharing agreements exist, selected products available via the U.S. Department of Defense’s National Geospatial Intelligence Agency (NGA – formerly NIMA) were loaded. In many cases, however, these map products are not releasable to U.S. foreign nationals and CNTPO relied on the purchase of commercial mapping products and imagery. In many cases, the host nation will provide paper maps which can be scanned, geo-referenced and made available as raster-based map products. In the case where available infrastructure data is available (such as road networks, geo-political boundaries, census data, industrial facilities, etc.), that information was loaded as well.

Using a U.S. government contractor, a custom-designed training course was developed for the initial group of Colombian Air Force users. CNTPO worked with the Colombian Ministry of Defense to define the required competency for both system administrators and GIS analysts. From this list, an elite group of Air Force officers traveled to the U.S. to receive approximately 40 hours of classroom training. Training was delivered in Spanish and instructors from ESRI and CNTPO were used.

Following the classroom training, the CIDS enterprise servers, two CIDS toolkit work stations and two large format plotters were shipped to Colombia. One of the toolkit workstations was installed in a remote city several hundred miles from the location housing the main CIDS server rack. Access to that workstation was delivered via a dedicated broadband connection; however, future consideration is planned by CNTPO to provide broadband connectivity via Very Small Aperture Satellite (VSAT) service. This will address a significant limitation on other world regions involved in narco-terrorist activities.

Additional on-site training in ArcGIS skills and CIDS publishing has been completed since the original installation. CNTPO continues to use the feedback from this contact to refine and enhance the capabilities for future versions.

**Future Capabilities**

Following the basic demonstration of CIDS to create and publish highly interactive, detailed map products and to attach a wide range of data files to geographic locations, focus for future enhancements to CIDS has shifted to address three priorities. One priority is the need to integrate dynamic data streams into the basic map background, thereby improving the value of CIDS as a $C^2$ platform. Another priority is to design and deploy a commercial broadband communication capability to extend the functionality of CIDS to remote locations. Finally, a priority was placed on improving the ability of CIDS to geo-reference visual media, including reconnaissance video collected from aircraft.

Dynamic data include features with a temporal component. Displaying data which changes over time is considered extremely important to both analysts and operational commanders and is considered an integral part of a common operating picture. Typical dynamic data sources currently planned for demonstration in future versions of CIDS includes:

- Radar track data
- Other $C^2$ systems
- GPS-enabled sensing devices
- Contact messages from a variety of intelligence sources

Since most dynamic data reporting systems can be configured to output track data in a delimited format, the data handling routines are relatively straightforward. The challenge lies in obtaining access to these usually well-protected systems. Once access is granted by the data owner, an appropriate scripting utility can be used to periodically update track information and append the data to a contact database. In CIDS, a set of functional requirements has been developed which defines what capabilities are desired regarding the manipulation and display of time dependent data. Some of these requirements include:

- Displaying multiple data sources as independent layers on a map background

- Displaying a history of one or more sets of dynamic data which can be "played back" using VCR-like icons
- Filtering track data based on a natural language dialog (for instance, modifying a display of all air tracks to show only tracks below a specific flight level and traveling less than a designated speed)
- Adding specialized data to the original dynamic data record (for example, adding an aircraft call sign, radio frequency or threat level)

A fully implemented CIDS engagement calls for a central server and toolkit workstations to be located in a central location such as a counter-narcoterrorism operations center or intelligence fusion center. Additional CIDS toolkit workstations would then be placed in other remote areas corresponding to that particular nation's command and control structure. The third tier of CIDS presence would be demonstrated by web-connected users (principally decision-makers and collaboration partners). Because remote sites with toolkit workstations (represented by a full installation of ArcGIS™ products) will need to transfer files between their site and the central server, a significant bandwidth requirement needs to be met. CNTPO calculates that at least 1.5 Mbps/per second of data transfer speed will be required for effective collaboration between analyst/planners. CIDS viewer customers will also represent a significant demand on data transfer capabilities because of the large file sizes associated with typical map files. As a result, CNTPO is evaluating several commercial satellite broadband solutions which could address this requirement.

An early expectation of CIDS customers was to be able to leverage the GIS capabilities in the toolkit workstation to add value to legacy video collection systems. In particular, it was felt that the ability to geo-reference video imagery and to display this video as a selectable layer in the CIDS common operating picture would be of great benefit to analysts and operational commanders. Using commercially-available technology, CNTPO is developing such a solution for the next release of CIDS. In the current concept of operations (CONOPS), reconnaissance video collected by an aircraft during a mission of up to 6 hours in duration would be stored digitally on the plane and removed upon landing. This video would be processed to correlate the plane's location with each frame of the video. This geo-referenced, digital file would then be converted into a map element which would display the path of the aircraft during its mission. By selecting various points along the flight path, a viewing window will open and begin playing the video corresponding to that coordinate location. Besides fusing video imagery with other data layers on a map, this capability will allow for the archiving of hundreds of hours of mission video which can be accessed by any CIDS viewer user with appropriate access.

**Summary**

The introductory section of this paper described a realistic scenario in which a U.S. coalition nation in the Global War on Narco-Terrorism could be hampered by the lack of an effective and scalable command and control tool. Central to the effectiveness of a world-class COP is the ability to display multiple and configurable layers of infrastructure, threat and intelligence data. While the U.S. and several other nations have had considerable success in developing robust common operational pictures, CNTPO and its Combatant Command customers felt that a GIS-based $C^2$ system built with commercially-procured technology would be of great benefit to those nations who do not have access to such proprietary systems. Following a successful implementation of the CIDS architecture in at least one country, future capability enhancements are planned to deliver even more value to the U.S.' partner nations.