Assessment of the Enterprise Geographic Information System (EGIS) at Yuma Proving Ground (YPG)

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Table of Contents

1. Executive Summary – Page 3

2. Introduction – Page 5

3. Background and History of EGIS at YPG – Page 6

4. Assessments – Page 9

5. Recommendations – Page 20

6. Conclusions – Page 26

7. References – Page 28

8. Appendices – Page 31

1. Executive Summary

The U.S. Army Yuma Proving Ground (YPG) requested an external assessment of the status of the Enterprise Geographic Information System (EGIS) employed at YPG. This assessment included the YPG Headquarters (Garrison), Yuma Test Center (YTC), Cold Regions Test Center (CRTC) and Tropic Regions Test Center (TRTC). For each of these organizations, a detailed evaluation was made, focusing on three areas: (1) identification and assessment of GIS personnel (assignments, qualifications and training); (2) identification and assessment of GIS systems (hardware, software, connectivity of both and employed applications); and (3) identification and assessment of GIS data (availability, structures, storage and management). The evaluation was conducted from May 2006 through July 2006. This report, having been reviewed by personnel at both YPG and USMA (Department of Geography and Environmental Engineering), documents the findings of the assessment and provides specific recommendations to improve the success of the overall GIS operation within the command. The following key findings were identified:

Yuma (YPG Headquarters and YTC) --

- **The EGIS responsibility has now been placed properly within the command (under the Plans/Operations Directorate) as the EGIS is an operations function. The command has not yet published a vision for EGIS to the command. When published, this document should mandate implementation steps.**
- **There is limited GIS cooperation between departments and the effectiveness of the EGIS is not trusted by many individuals/organizations within the command.**
- **The GIS staff has insufficient technical training and knowledge of YPG to effectively manage the EGIS.**
- **When implemented, basic GIS management practices are not followed. Clear objectives and matching solutions to those objectives are not well defined.**
- **The hardware and core software in place are a good foundation, however, much of the hardware, software and applications are not used properly or are inoperable.**
- **Development and use of GIS applications/functions are limited to the GIS group. When needed, the user community relies on the GIS group to generate all EGIS solutions.**
- **There is a wealth of digital geospatial data within the command that is not being shared by the entire EGIS user community.**
- **The implementation of planned data standardization (SDSFIE) and quality assurance / quality control (QA/QC) procedures have not been properly implemented.**

CRTC --

- **There is routine cooperation between departments. The EGIS is not valued as an important part of the command's operation.**

- **The GIS expert (one part-time GIS employee) has insufficient technical training to manage the EGIS. Experienced GIS personnel are resident at regional offices (USARAK).**
- **When implemented, basic GIS management practices are not followed. Clear objectives and matching solutions to those objectives are not well defined.**
- **The hardware and core software in place are not sufficient. The power of current technology in the field is not being leveraged.**
- **There appears to be a substantial amount of digital geospatial data available at the regional level yet it has not been "tapped" by the CRTC user community.**
- **Data standardization (SDSFIE), quality assurance / quality control procedures have only been partially realized.**

TRTC --

- **There is great cooperation between departments. There is, however, no EGIS or access to an EGIS existent within the command.**
- **There are no GIS staff and/or supporting EGIS hardware, software, peripherals or management systems in the command.**
- **There appears to be a limited amount of geospatial data available upon conducting coordination with host nation agencies.**
- **Data standardization (SDSFIE), quality assurance / quality control procedures within the command have not been initiated.**

Recommendations --

- **Immediately solidify and publish an EGIS strategic plan with implementation milestones. A synchronization matrix that allows for some flexibility as the command becomes educated on the use of an EGIS will help facilitate this requirement. Empower the Plans and Operations Directorate within YPG to continue to directing EGIS development and full use of GIS tools within the command.**
- **Build an effective EGIS staff. Through contract hiring, build educate and train critical GIS personnel (both permanent and temporary [as needed]) at all three locations (YPG/YTC, CRTC and TRTC). As necessary, transfer personnel from the EGIS office to other offices within the command to ensure effective EGIS growth within the command.**
- **Leverage work done by other GIS-type agencies outside of YPG, insuring that all collaborative work is done in support of the YPG plan and not other's interests.**
- **Upgrade hardware and core software as needed to stay synchronized with changing technologies and facilitating data transfer between commands.**
- **In that there is a large amount of digital geospatial data that is not being shared by the entire EGIS user community, implement data sharing and standardization policies that will provide effective quality assurance and quality control implementation procedures.**

2. Introduction

General. This report provides a strategic Enterprise GIS assessment and recommendations for the US Army Yuma Proving Ground (YPG). It is intended to summarize the critical elements of GIS implementation, provide background on the history of EGIS at YPG, communicate the current status of EGIS across YPG and provide recommendations to the command on "ways ahead" to enable EGIS success for all users. The scope of this report is limited to Enterprise GIS Implementation for YPG and is not intended to address other ATEC organizations. However, the concepts, technologies, and techniques discussed also apply to ATEC, other Army Developmental Test Centers and Federal GIS operations in general.

Conduct of Assessment. Over the past five years, the EGIS at YPG has been evaluated many times by numerous organizations. In this review, many documents were evaluated (as provided by Yuma Proving Ground and, by extension, the Denver office of ESRI). These included: (1) Yuma Proving Ground GIS Requirements Report (draft from ESRI-Denver); (2) Yuma Proving Ground GIS Requirements Report (draft created by David Lashlee); (3) Enterprise GIS Implementation at Yuma Proving Ground: A Strategic Plan for Geospatial Data Management and Administration; (4) Performance Statement of Work, Task Order 9T4ZJAIS109; (5) The US Army DTC Enterprise GIS Model: Draft Architecture and Implementation Recommendations in Support of Virtual Proving Ground (VPG) Digital Terrain and Garrison Mapping Requirements; (6) Aberdeen Test Center (ATC) GeoDatabase Migration; (7) Contract Modifications for # GS-23F-0278M / W9124R-04-F-3067; (8) The VPG Draft Digital Terrain Concept Paper; (9) ESRI Consulting 2004 Status Reports; (10) 2005 Assessment of Enterprise GIS at YPG by Moosepoint Technologies; and (11) 2006 Enterprise GIS Implementation at YTC (DRAFT). From this list of reviewed documents, the last two documents provided useful information in the development of this report as they were the most current documents available. To better understand the working environment and organizational relationships within YPG and the YPG GIS Lab, site visits and interviews/discussions with key staff within the command were conducted. The Denver office of ESRI was not contacted directly as recent dialog with ESRI was well documented. These discussions were held during the YPG on-site visits (Yuma – May 2006; CRTC – June 2006; TRTC – July 2006), via e-mail and communications through telephone conversations.

Contents of Report. This report is divided into three major areas: (1) background and review; (2) assessments; and (3) recommendations. In that general knowledge of EGIS data might be helpful but not essential for the intended audience of this report, appendices are provided to give some detailed information in clarifying major concepts.

3. Background and History of EGIS at YPG

General GIS Background. In providing general background for this assessment, Executive Order 12906 defines geospatial data as "information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth". Sources of geospatial data are critical to the success of an EGIS. They include: (1) raster scanned topographic and geologic maps, (2) installation infrastructure in Computer-Aided Drafting and Design (CADD) files, (3) attributes of geographic features in databases and spreadsheets, and (4) field mapping coordinate data collected with Global Positioning System (GPS) receivers. Other important terrain data include remotely sensed data in the form of satellite and aerial imagery, and Digital Elevation Models (DEM) and their derivatives—slope, aspect, and landform surface models (Figure 1). Appendix A provides a glossary of EGIS terms that support this report.

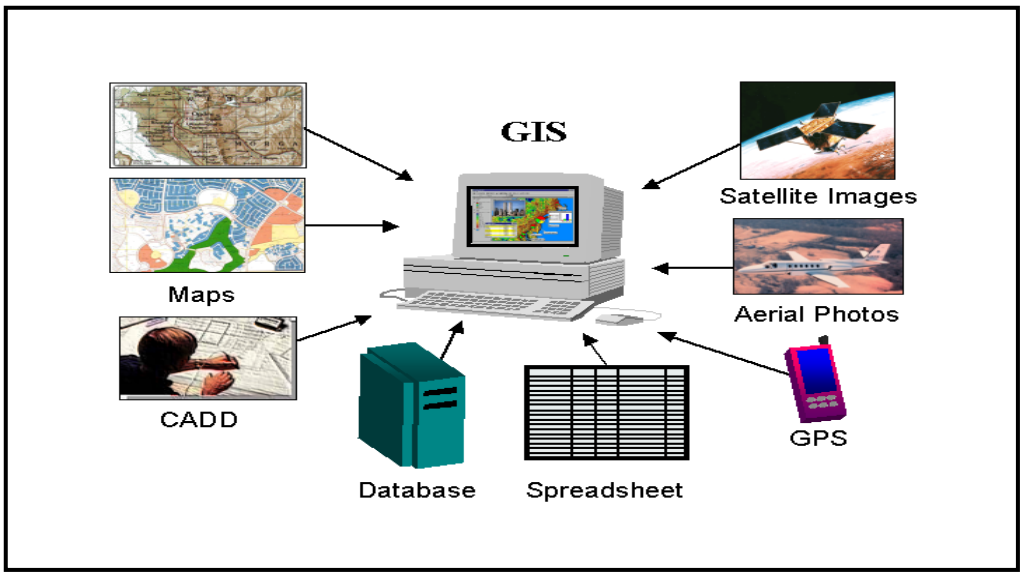

Figure 1. Geospatial Data Are Stored, Managed, Analyzed, and Distributed Using GIS.

As much as 85 percent of all data collected in the world are spatial in nature (Antenucci et al., 1991). That is, most data are associated with a location on earth and have coordinates defining their geographic position. The United States Geological Survey (USGS) estimates that the U.S. Federal Government spent more than 4 billion dollars annually on the production, management, and dissemination of geospatial data at the turn of the 21st Century. (National Spatial Data Infrastructure, 2001). Based on the emergence of new information technologies, some have predicted that more data will be collected in the next three years than has been generated over the entire course of human history (Logicon FDC, 2001). There are many indications the immediate future will be a time of explosive growth in the development and use of geospatial data and technologies. Proper management of these data and deployment of effective information technologies are important steps toward obtaining the goal of using these data for efficient decision support for YPG.

Once geospatial data is properly organized, EGIS functions can be implemented. An EGIS is an organized collection of computer hardware, software, data, personnel, and procedures designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (Figure 2). As detailed earlier, this report focused on these areas: people, systems (hardware, software and methods) and data.

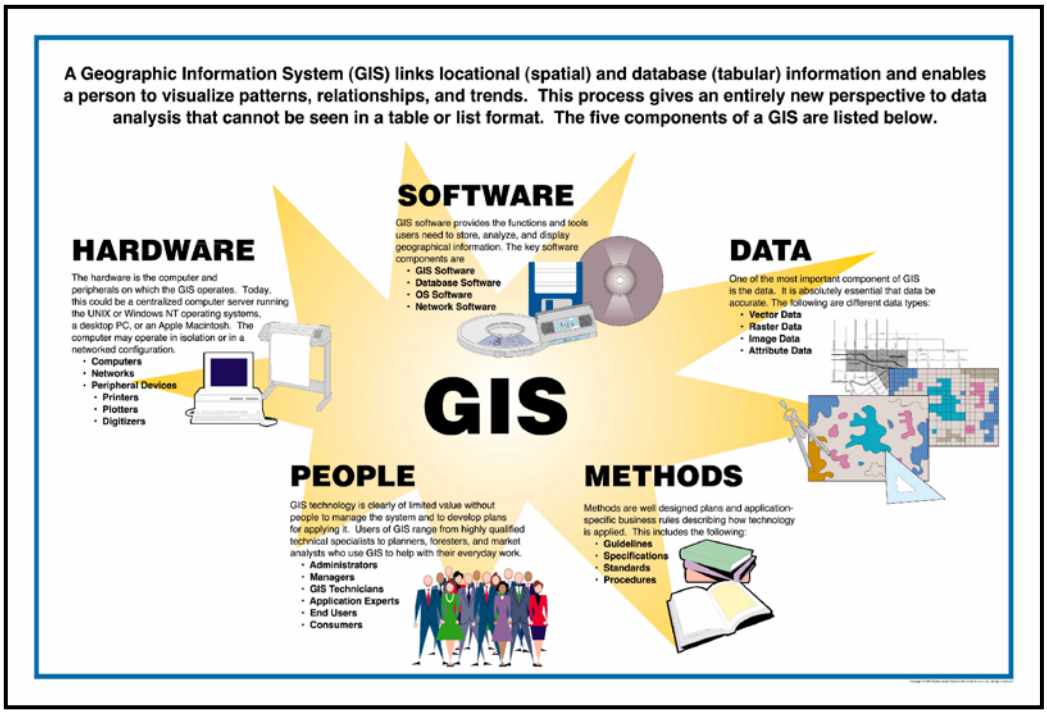

Figure 2. Five Components of a Successful GIS.

History of EGIS at YPG. In many respects, YPG can be compared to a small or medium-sized city with very similar needs and requirements with respect to its EGIS systems. Environmental Systems Research Institute (ESRI) defines a Municipal Enterprise GIS in the following manner:

"A municipal enterprise GIS consists of technology, personnel, and other resources to create, maintain, visualize, search, and share geospatial data and services. At a minimum, the municipal EGIS provides these capabilities to all departments of the municipality. Usually the municipal EGIS extends many of these capabilities to the general public, external private entities, and external public agencies as well. EGIS is a fundamental element of e-government because it adds the critical elements of location and visualization to interaction between the municipal departments and the public. The resources comprising the municipal EGIS reside at the most suitable government, department, or enterprise level for achieving the most effective delivery of data, products, and services to internal and external GIS customers. Also inherent to the concept of EGIS is the integration of GIS data and functionality (analysis and visualization) with other municipal information systems, such as permitting, work order processing, and customer service,

that have traditionally not included visualization and mapping as part of their capabilities. Using GIS as an enterprise information technology resource along with these other more traditional enterprise resources leverages the inherent geographic nature of the data within legacy as well as new municipal business systems. Municipal EGIS is founded on three distinct but related concepts. First, municipal EGIS focuses on the development and sustained operation of business critical systems. Creating and managing GIS data that is fundamental to specific business processes of the municipality or individual departments are often elements of these business critical systems. However, with EGIS, these systems often rely on GIS data that originates in other systems. Second, municipal EGIS involves the development of an information infrastructure to support data sharing and cross-departmental, multipurpose operations. This infrastructure is essential for disseminating data among departments, as mentioned above, and to the public. Third, the municipal EGIS relies on the development and upkeep of a governance structure through which the needs of user agencies can be met in a coordinated manner. Important to this is establishing standards that ensure the interoperability and integration of data and other GIS resources used to support individual project, departmental, or enterprise initiatives."

While the above general definition can be applied to the EGIS efforts at YPG, several key concepts within that definition are particularly relevant here: (1) sharing of centralized GIS resources; (2) integrating infrastructure to support data sharing; (3) linking GIS data and functionality with other information systems; (4) focusing on business-critical systems; and (5) enforcing standards of interoperability and integration. Significant amounts of time, energy and money have been spent over the last 3 to 5 years on beginning to build an EGIS for the YPG. From this, the start-up EGIS is now comprised of a number of systems, databases and applications. One primary focus of this assessment was to examine how well these systems, databases and applications comprising the current Enterprise GIS meet the original goals and objectives defined in documents provided by Yuma Proving Ground. This was difficult to assess as there was sparse documentation detailing the process of transitioning from high level goals in the GIS Implementation Plan to actual deliverable products. Much of the intermediate objectives were apparently inferred from the vendor proposals. While a number of additional supporting documents were also provided, two key documents contained the major high-level description of YPG EGIS Vision: (1) the Yuma Proving Ground GIS Requirements Report and (2) the Enterprise GIS Implementation Plan at Yuma Proving Ground. These documents and key goals and objectives derived from them are briefly described here.

<u>Yuma Proving Ground GIS Requirements Report.</u> A needs assessment completed by ESRI-Denver in 2002 provided the key findings contained in the GIS Requirements document. The following offices participated in the needs assessment: Virtual Proving Ground Project, Conservation, Environmental, Tropics, Public Works, Fire Safety, Geodetics, Range Control, Munitions and Weapons, Air Combat, Jason Associates, Information Management, Ammunition Management and Meteorology. Each of these offices identified their functional requirements and use for spatial data at a high level. Short on

specific next steps, the main conclusion of the GIS Requirements Report was for YPG to develop "a centralized database, implementing the standards imposed by SDSFIE (Spatial Data Standard for Facilities, Infrastructure and Environment) for GIS implementations on military bases, which will result in sharing and consistency of data."

<u>Enterprise GIS Implementation Plan at Yuma Proving Ground.</u> An EGIS Implementation Plan, based on a sound technical foundation, outlined: (1) a GIS Requirements Analysis that documented geospatial data requirements of YPG Test Directors and aligned implementation goals directly with the many test missions; (2) a standardized Database Design and Schema based on those requirements; (3) a formal GIS Quality Control Program; and (4) a custom Intranet Map Service that planned to distribute geospatial data and custom spatial analysis tools like Surface Danger Zone generators, Line of Site tools, Emergency Service Routing, and Maps-on-Demand to every desktop at Yuma Proving Ground. These tools should have allowed for the YPG EGIS to incorporate many different departments and divisions working from a central GIS knowledge base so that they could benefit from each other's work, consistently providing customers with the most recent, most accurate, and greatest depth of spatial information available. Essentially, organizational support of this GIS Implementation Plan would make a transformation from a paper-based decision making process to a quantitative, digital Spatial Decision Support System. According to various reports and inquiries, five different versions of this document were on-hand at Yuma Proving Ground, each published at a different period of the Enterprise GIS implementation: September 2002, July 2003, April 2004, July 2004 and September 2004. The document from September 2004 was referenced for this assessment. It is interesting to note that most key elements of the strategic plan appeared to not change substantially over the 2 years from September 2002 to September 2004. While providing more detailed information than the needs assessment document, this document contains more general GIS philosophy than specific business objectives. Many of the deliverables requested from ESRI, GIS SouthWest and Applied Research Associates appear in this document as implementation steps but with no reference to the business objectives they hoped to meet.

4. Assessments

Assessments were made of the three components of an Enterprise GIS: systems, personnel and data at three locations - YPG/YTC, CRTC and TRTC. As a general statement, most all of the time and funding dedicated to EGIS development within the command over the past 5 years has been focused at Yuma, Arizona. Very little "investment" has been made in Alaska and Panama (field HQs to CRTC and TRTC respectively). From this, an assessment of EGIS progress *(as measured against an implementation plan)* was made of the Yuma site, whereas an assessment of EGIS *(as measured against possibilities)* was made of the latter two organizations and locations. Implementing and administering effective information technologies are important steps toward improving geographic decision support at any command. Many milestones have been achieved toward that end. The

command has combined the GIS resources of Engineering Division and Command Technology into a single, improved GIS Laboratory. Within the laboratory, GIS software has been standardized (eliminating redundant programs and reducing maintenance and technical support costs) and an initial GIS training program for that software has been partially developed. Hardware has also been standardized with next-generation geospatial technologies, including PC-based servers and workstations for data management and analysis, respectively. A survey-grade GPS system, high-resolution map-sized digital scanner for data input and a professional 6-color plotter used with raster image processing software for professional cartographic output has been acquired. Finally, a very basic but useful Intranet web page was initially published that automates and audits GIS service and data requests. In summary, an initial EGIS has been built at YPG (Yuma), providing a secure, scalable, and distributed multi-user GIS infrastructure using Intranet Map Services to publish geospatial data, cartographic products, and analysis tools to every desktop at YTC. By industry standards, this is no small task. There is, however, much more to be done and, in some locations, much to be started. The following provides the detailed assessment of YPG's EGIS – each of the components at all three locations.

Systems - YPG/YTC

From the documentation and interviews, the value of GIS is recognized within Yuma Proving Ground and appeared well funded. It is the implementation that appears to have failed to deliver on many promises. In this, support for EGIS Implementation in Federal, State, and Local government are well understood and widely accepted. Most personnel within the command recognize that an effective EGIS provides a common geographic framework that enhances data sharing and integration, builds bridges across departmental and discipline boundaries, standardizes reporting and presentations (Tang and Selwood, 2003) and facilitates consensus throughout the organization and to customers. The EGIS Implementation Plan at YPG (see Figure 3) displayed this understanding. Reviewed documents seem to be well written, however they predominately contain general GIS concepts and philosophy with only a few specifics. They describe desired outcomes only at a very high level. None of the documents reviewed provide clearly defined, achievable objectives linked to set timelines with detailed planning requirements that described how to meet those objectives. There appears to be somewhat of a focus in the documentation on output of standardized, high-quality maps by the GIS staff. This is not the critical output provided by the GIS staff at YPG as maps should be user-produced once the EGIS is operating properly. This emphasis on GIS as a "map service" has likely hurt the complete adoption of GIS in other areas of the organization.

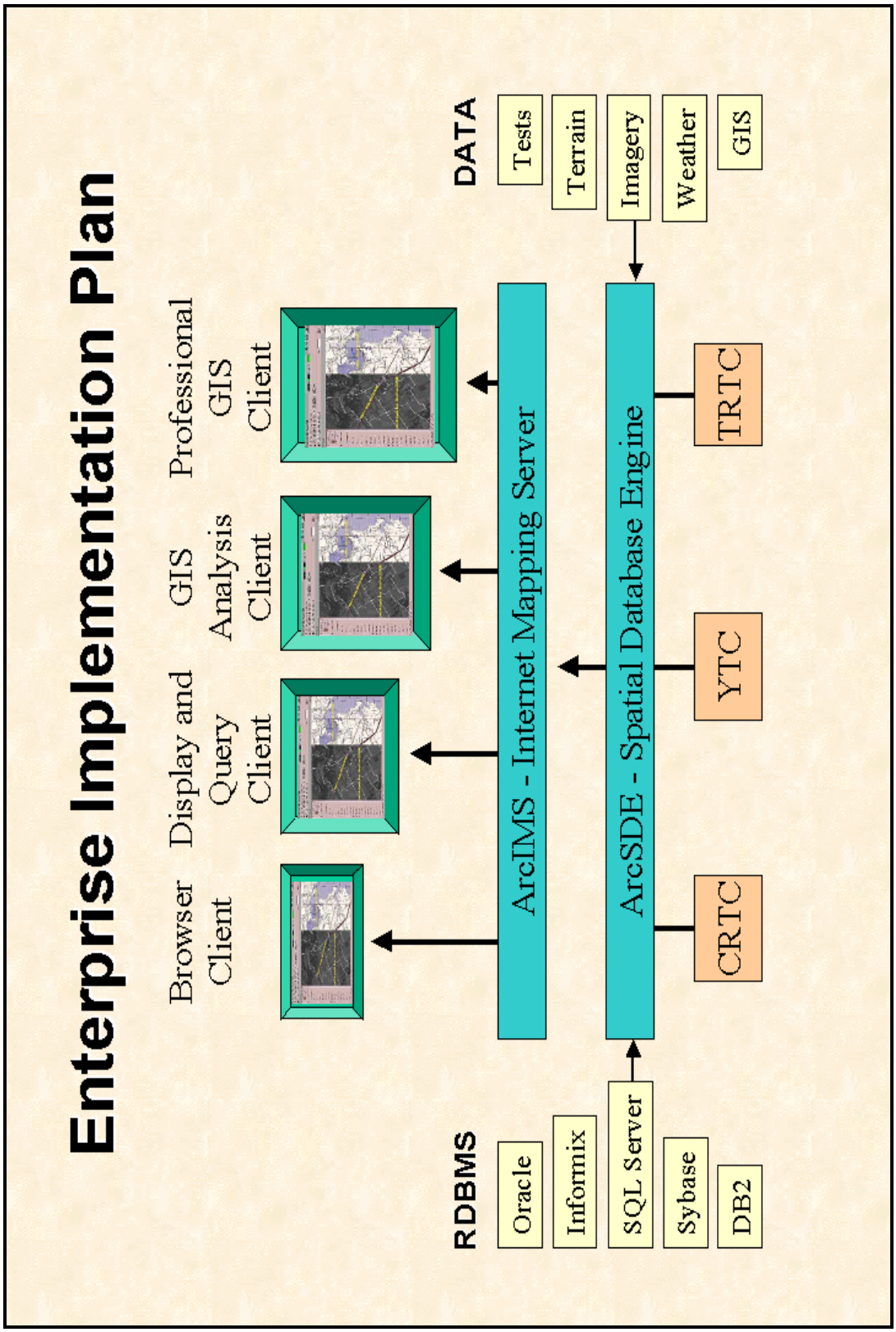

Figure 3. Planned YPG Enterprise GIS Architecture.

Reaching consensus on placement of the GIS facility at YPG has been a difficult decision. The lack of ownership of the EGIS (which, in many discussions, translates into "lack of leadership of the EGIS") has caused tremendous problems for the system's success. Over the last decade, the GIS location has been "owned by" Advanced Technologies, Test Support, Optics and Engineering. As an example end result, it was reported that Public Works made an independent CADD investment and contracted the development of a GIS/stand-alone Geodatabase of the YPG Main Post in FY02. Reported inspection of these Legacy datasets identified the usual common problems (e.g., lack of attributes, inconsistent geospatial data standards and limited metadata). Software and resulting data formats have been equally inconsistent, including the use of Gen-a-Map, GRASS, AutoCAD, Intergraph, ArcView, ArcInfo and custom in-house and contracted software programs. From these many findings, it is clear that the EGIS at YPG needs long-term organizational stability.

Test Directors and range support personnel at YPG require different levels of GIS functionality, ranging from simple browsing, to querying, to professional spatial analyses. YPG streamlined operations by standardizing GIS software. Over the last 2 years, the command implemented a set of software tools developed and marketed by the industry leader, Environmental Systems Research Institute (ESRI). ESRI developed the first commercially available GIS software, currently has about 75% of the Federal GIS market (including most Test Centers), and is the *de facto* GIS standard for the ITAM Program. As a result, YPG's EGIS has the ability to be powerful, flexible and scalable. The potential to migrate data to a centralized Geodatabase enhances security, performance and data quality. ArcGIS software is rich in functionality, built on industry standards and is modular in design so that YPG only needs to purchase the software applications needed to support its mission. It's also scalable—able to be distributed to every computer connected to the YPG Intranet. The command has a number of floating licenses of ArcInfo, (were people can run ArcGIS concurrently) and single licenses of several other ESRI software extensions. ArcGIS can be installed on any or all YPG personal computers, but is primarily used by core GIS professionals needing advanced capabilities. Appendix B provides a description of known licensed software to YPG. At the time of publication, the licensing agreement is adequate. Additional software licenses should be added as required to support the mission.

A key element to a successful Enterprise GIS implementation is effective hardware platforms, consisting primarily of a robust and reliable server/network environment and sufficient desktop computing systems. Overall, the hardware platforms at YPG (specifically YTC) are a good foundation for providing access to the centralized EGIS resources. Some of the servers are older models however additional high-powered servers are available and sitting idle. Appendix C provides an assessment of the GIS servers available at YPG. The current architecture does not take into account data sharing with outside partners such as other test centers or Army installations. Operational requirements (24/7 uptime) and security requirements need to be addressed for the current architecture as well as a

separate server cluster to meet data sharing requirements. ArcSDE for SQL Server is still at the 8.3 version. At the start of a previous assessment, this version of ArcSDE was not operational due to problems with ESRI License Manager 8.3. After the issues with License Manager were resolved, this version was made operational. As an example of the management challenges of the EGIS at YPG, during a previous assessment, it was noted that server installation was completed by Applied Research Associates as part of the "Aberdeen Test Center (ATC) GeoDatabase (GDB) Migration" project. In this, the GeoDatabase was migrated from Oracle to SQL Server. In order to bring SQL Server into compliance for the license, ArcSDE was uninstalled and then reinstalled after a correct SQL Server installation. It is planned that this function will be managed in conjunction with the upgrade to ArcSDE 9.0. SQL Server is Microsoft's product for Relational Database Management (RDBMS). During the installation of Microsoft SQL Server, a valid license was not obtained. The database repository for the ArcSDE GeoDatabase is not presently backed up on a regular basis. Data backups can be automated however disk space limitations on the server prevent a backup from occurring. Switching RDBMS systems from Oracle to SQL Server was a directive from Developmental Test Command (DTC). The purchase of Oracle 8i and a second license of ArcSDE was costly (est. $40,000.00). Until recently, none of the GIS staff at YPG had knowledge of administering the SQL Server. The skills necessary to successfully administer the SQL Server will be addressed in the Personnel section of this document.

With servers operational, EGIS and internet functions can be combined. The convergence of GIS and the Internet technologies has changed GIS and map-making tremendously (Harder, 1998). ArcIMS software is a powerful new technology that connects GIS customers to the centrally-administered Geodatabase by distributing both geospatial data and custom analysis tools on YPG's Intranet. Essentially, ArcIMS is a GIS delivery system to the Browser, Display, and Query Clients (as shown in Figure 3). It provides for delivering dynamic maps and GIS data and services via the web. At YPG, implemented on a Dell PowerEdge 2500 server, ArcIMS consists of both client and server components that handle incoming requests, load balancing and performing service management. According to the Implementation Plan, the intent is to "spatially enable" YPG via ArcIMS by publishing reliable data and custom range operation and analysis tools to every desktop. Appendices D and E provide vendor/application data currently employed at YPG, supporting their EGIS Systems.

Systems -- CRTC

From Figure 3, the intent of the YPG EGIS is to provide the CRTC with connectivity and access to the system (software, data, applications, etc…). To date, no progress has been made in accomplishing this. With respect to GIS operations, the CRTC currently acts as a stand-alone command, working from a single, old desktop version of ArcView. No sharing of geospatial data via a server architecture is accomplished. The only additional GIS software and application support provided to the command comes from the USARAK GIS/ITAM personnel (HQs at Fort Richardson, Fort Wainwright and some at

Fort Greely). Contrary from the intended system design (see Figure 3), the EGIS connection to CRTC from YPG is currently non-existent.

Systems – TRTC

From Figure 3, the intent of the YPG EGIS is also to provide the TRTC with connectivity and access to the system (software, data, applications, etc…). As with CRTC, to date, no progress has been made in accomplishing these tasks. With respect to GIS operations, the TRTC currently has no digital GIS capability. There are no approved software or hardware systems working within the command. As a result, no sharing of geospatial data via a server architecture is done. No GIS software and application support is provided to the command from national agencies or host nation support relationships. As with the relationship with CRTC, the EGIS connection to TRTC from YPG is currently non-existent.

Personnel -- YPG/YTC

The largest EGIS implementation demand at YPG is effective system business practices – a task that requires acceptance by personnel at many different levels. It will take time for YPG to adopt the technology and realize that EGIS is not just automating what has been done in the past, but, rather, changing how things are done. The success of YPG's EGIS implementation depends to a large extent on the commitment, technical ability, and enthusiasm of those who manage and administer the system throughout the long, iterative process of successful technology implementation. GIS technology users at YPG can be conceptualized as belonging to three distinct categories—Data Managers, Data Producers, and Data Users. A team of GIS professionals is resourced on the staff. Their time should be dedicated to the collection, storage, management, administration, analysis and distribution of geospatial data. These personnel are the foundation of YPG's GIS capability and must develop, maintain and distribute the Geodatabase for use by the command. Noteworthy among these personnel are the GIS Manager and Database Administrator. The GIS Manager is responsible for the People and Systems components of the GIS. The Database Administrator (working for the GIS Manager) is responsible for the Data component. These positions are both managers of technology (hardware and software) and database components who work together to assure the timely, reliable access to data and information services for authorized system users. Other members of the core GIS Team are GIS Analysts and Technicians who are dedicated to tasks associated with the conversion, collection, compilation, and validation of both legacy data management and new data collection efforts. The number of GIS personnel is scalable; easily able to increase with future YPG mission requirements if necessary, and may be augmented occasionally with contract personnel and student interns on an "as needed" or "special project" basis. A dedicated core team is needed to evolve with constant rapid advancement of technology and the resource commitments it demands. YPG's investments in GIS technology and data are of limited value without a professional staff to manage the system and develop plans for applying them (ESRI, 2002). Detailed position descriptions for the core GIS Staff are found at Appendix F.

The GIS Manager is the most critical position within the GIS Organization. Previous GIS Managers responsible for the implementation of Enterprise GIS have not been successful at YPG. These managers have had some success in establishing the vision of Enterprise GIS and the overall benefits to YPG as described in the documents created over the years. The largest deficiency in this area has been the management of the vision (project management and/or personnel management). A consistent "missing link" found during this assessment was the translation of the YPG EGIS vision into concrete, well-defined objectives and creating implementation strategies to achieve those objectives. In addition to strong project management skills, communication and personnel management skills are essential in the GIS Manager. The GeoDatabase Administrator is another important position necessary to support the Yuma Proving Ground Enterprise GIS Vision. Over recent years, various staff members have been given the responsibility for administration of the GeoDatabase. Most have had very limited training in the administration of Oracle and/or administration of Microsoft SQL Server. Very few have been formally trained in the administration and management of ArcSDE. This position requires one who is technically focused and has been trained or has been given the time required to learn these skills. The positions of GIS Analyst and GIS Technician have recently been filled, one under contract and one as a temp hire as part of a summer internship. Due to their recent hiring, an assessment of their successes in the organization cannot yet be made. In total, however, these positions should *not* be mixed between contract and government personnel. In some cases, this personnel working arrangement can be counterproductive. More importantly, given the rapid growth in this industry field and the technical requirements of personnel doing this type of work, contract personnel are best suited for this organizational function.

With the proper manning of the GIS staff, it is clearly beneficial to have GIS-trained personnel (contract or government) in other organizations within the command who are both familiar with YPG operations and understand the power of the technology. According to the personnel manning roster, Mr. John Hawk and Ms. Barbara Bowles are two such individuals. Having previously worked in the GIS laboratory, both are now in adjunct offices (NETO and ITAM/SRP, respectively) where they can employ their skills and knowledge.

As one would expect, training of core and adjunct EGIS personnel is essential in a distributed enterprise environment. The GIS Manager, Administrator and staff should receive the most intense training, but application specialists using the technology in other divisions must also be trained. The GIS training challenge is twofold: (1) personnel must be willing and able to learn/use the system; and (2) the organization must provide ample opportunities for training (Demers, 1997). Over the past three years, a very limited GIS training program was incorporating, attempting to provide the following options but with little success: (1) Virtual Internet-Based Training Courses; (2) On-Site Group GIS Training Courses; (3) Off-Site Individual GIS Training Courses; (4) Certification Programs in Mapping Sciences; and (5) Advanced Academic Degrees from Universities.

As a final comment, it appears that as the YPG EGIS has evolved over the last five years, a lack of trust in the system by YPG personnel has developed. A number of different, often unrelated, reasons account for this condition. In some cases, a sense of "possessiveness" of GIS knowledge on the part of some GIS staff was noted in interviews. Whether this was a general unwillingness or perhaps inability to share GIS knowledge with end-users outside of EGIS is not known. In some cases, failures appear to be linked to limited or no project management by the often rotating GIS Managers and other GIS staff members. In this, change control, a key area in successfully managing technical implementation of the system, is clearly missing. The scope of projects has often changed throughout their lifespan with little to no written communication to the vendors regarding the change. Some projects were managed by inexperienced GIS Technicians In addition to poor management of the projects, initial design of the projects was occasionally not well defined, and, thus, had little chance of success. With these poorly scoped projects, the resulting products either could not be delivered or if delivered, did not match the scope in nearly every instance. In some cases, there has been an inexperienced GIS staff member managing a critical part of the system. While there have been some recent improvements in technical knowledge of the staff, limited knowledge within the staff regarding the server-based technologies, specifically ArcIMS, ArcSDE and Microsoft SQL Server have hindered overall success. Only recently has a staff member attended a course on ArcSDE/SQL Server administration. The limited ArcIMS and database administration performed at Yuma Proving Ground by the GIS Staff have been acquired through "on the job training" and used only sporadically as it is not in anyone's primary job description. The knowledge of what software is installed and on which servers have access to the same is limited as well. On one particular occasion, the GIS staff could not locate the applications that they had implemented (with ESRI's assistance) 2 months prior. In some cases, applications stopped working and could not be immediately fixed (without external assistance). During the last 2 years, applications or software systems occasionally stopped operating. The disappearance or movement of required files and services could not be explained. In some cases, this inoperability had an impact on acceptance testing of vendor deliverables. In a few cases, the vendor would implement an application and leave it in a working state while months passed after delivery of these working applications before YPG commenced acceptance testing. As a result, the application sometimes would not operate due to changes in the YPG environment. In response, the vendor needed to return to Yuma to re-implement the application for testing. Though few end-user applications were implemented over these past years, it seems that the users of these applications were not fully trained to utilize the GIS tools provided to them. It was described that the GIS staff kept the knowledge to themselves. As a result, untrained users had difficulty with the GIS software. One user had complained of an inability to complete basic tasks. Once the user was trained on the proper sequence of steps necessary to complete a task, he/she understood it right away. When viewed in total, as a function of many reasons, the YPG EGIS has not had many successes over the past five years. The EGIS is not well trusted within the organization. This will take time to correct. One thing is certain -- the only possible way that an EGIS at YPG will

survive is that all PERSONNEL in the entire organization must embrace the system with the intent, desire and dedication to see it succeed.

Personnel – CRTC

There was only one member on staff (Mr. Mike Nickols) that had working knowledge of a GIS. He had done some work with GIS on a very limited basis. His knowledge was not sufficient for detailed GIS work as he did not have the resources, education/training or time required to do the GIS work. He "wears many hats" within the command, only one of which is the GIS technician.

Personnel – TRTC

There were no GIS-educated/trained personnel on staff. This is not to say that the potential does not exist for successful implementation within the command as there are many extremely gifted and motivated members within the organization that could quickly become GIS experts and technicians.

Data – YPG/YTC

Managing a corporate database is an active, dynamic and constantly evolving task of ensuring that data and other system components/resources are securely administered, efficiently updated, maintained in good working order and published in a timely manner (Tang and Selwood, 2003). These are the primary tasks of the GIS Manager and Geodatabase Administrator, who together actively promote access to the geodatabase, identify performance issues and find new ways of disseminating, integrating and publishing data. The benefits of an Enterprise GIS solution to data collection processes and management are many. Coordinating data acquisition and distribution throughout the organization increases data security, integrity and reliability. Elimination of redundant data greatly reduces propagation of errors introduced by maintaining multiple datasets. As well, the uncertainty of using the inconsistent, conflicting data layers and costs associated with multiple departments maintaining the same data are reduced. As part of an EGIS, geographic features that need to be added or updated can be changed in the database one time and instantly distributed to all system users.

In FY04, the Army Geospatial Data Integrated Master Plan (AGDIMP) Working Group was formed to define an end-to-end process for supporting Digital Terrain requirements for FCS and the Future Force (Figure 4) and to define standards and policies to support all Army users. YPG participated in this process as the Army Test and Evaluation Command representative of the group. In this plan, raw, unprocessed spatial data are acquired from various sources. These data are geoprocessed to form a spatially coherent and usable geospatial database. Validation and documentation with metadata are next required prior to migration into an Enterprise GIS. In most applications, the final step requires terrain analysis where the resulting terrain datasets are converted to a variety formats for modeling and simulation uses.

It is critically important to recognize that a reliable geospatial database is the foundation needed to perform all GIS applications. It is a critical spatial framework for supporting Developmental and Operational Testing at YPG. Three levels of scope are currently used to categorize GIS data and data management at YPG: (1) single-purpose projects; (2) department-level applications; and (3) multi-department enterprise systems. Historically, single-purpose data collection projects were common throughout the 1980s. Department-level efforts characterized the late 1980s through the 1990s, continuing today. The result at YPG is multiple departments independently maintaining their own datasets for their own use. However, technologies now exist to improve upon these dated data collection and management strategies. Enterprise GIS has the power to be a coordinated, program management technique designed to maximize organizational return on investments by supporting centralized geospatial database development, administration and distribution of resources. Development/use of resulting products across organizational boundaries should result where data is shared among governmental agencies that have common interest in local/regional land. Appendix G provides the latest version of Yuma Regional Data Share Agreement.

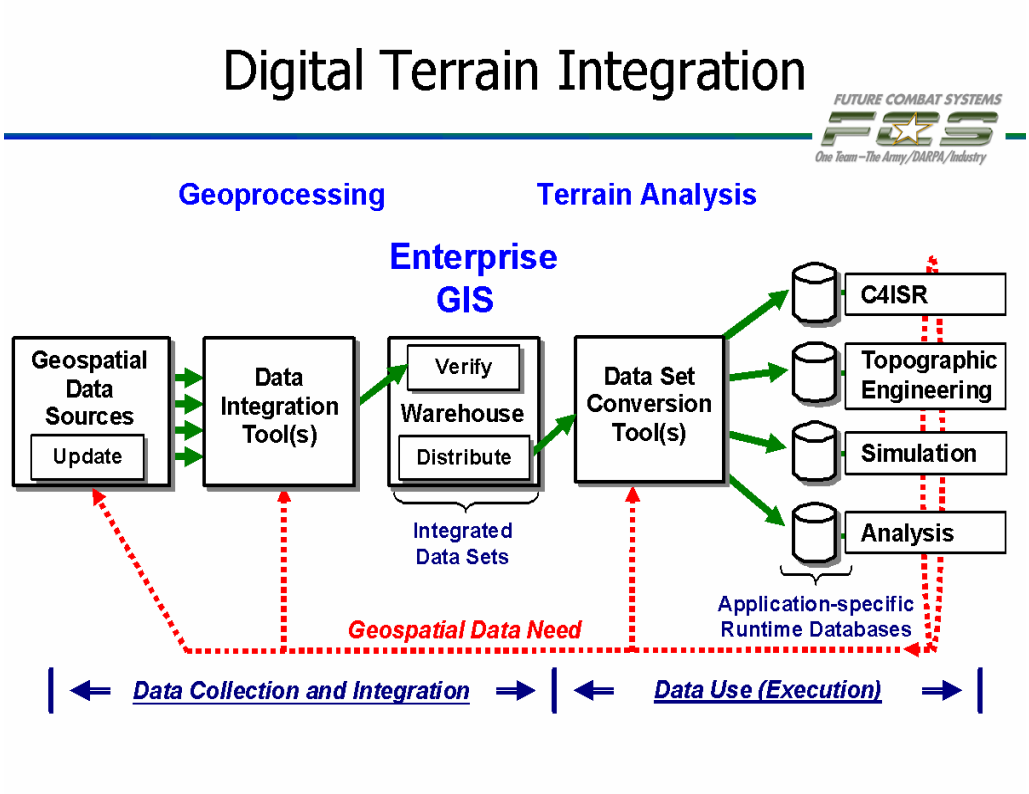

Figure 4. The Army Digital Terrain End-to-End Process Required to Support the Future Force. Modified from original source-- the U.S. Army AGDIMP Working Group, chaired by COL George Stone (DAMO-ZS/ZT) and COL David Kingston (TPIO-TD).

Although a thorough review of the spatial data within YPG was outside the scope of this assessment, some general observations were noted during other assessments and confirmed during this assessment. In early 2004, ESRI-Denver delivered to YPG a Working GeoDatabase Design document with a first attempt at compliance with Spatial Data Standards with regards to table naming conventions. Validation of that GeoDatabase Design by YPG has not been completed. It appears that the current database does not meet federal standards for spatial accuracy and metadata. Nearly all of the feature classes (map layers) within the YPG data are described in some form within their respective metadata. Compared to the data received from the other test centers, the YPG data is not as well documented and many required metadata attributes are not yet populated. Initial attempts in 2004 to standardize the data were limited to a test data set from Aberdeen Test Center (ATC). The remainder of the data was imported into the GeoDatabase "as is". Over the past few years, attempts have been made to ensure that all YPG spatial data meets Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE). Completion of this task for YPG is still ongoing. The current QA/QC practices are limited but appear to be improving. Data update practices seem to be inconsistent. At times, data is updated directly in GeoDatabase while at other times these updates occur in shape files. Much of the organization's legacy digital terrain data exists in a variety of GIS and CADD file formats located on individual computers across the command. There is no plan in place as to how to update this data in the GeoDatabase or how often the data should be updated. All discussions regarding existing applications and Enterprise GIS seem to focus on spatial data only. There appears to be little to no discussion regarding associating relational data in other RDBMS Systems. Tying spatial data to other systems and non-spatial data is a key component to a successful Enterprise GIS. As evidenced by some of these disjointed findings of the Geodatabase operations at YPG, much work is still needed to fix the problem. Toward this end, a simple truism is offered -- *one key to successful GIS implementation is for YTG to take responsibility for and ownership of its own geospatial databases.*

Data – CRTC

Digital data at CRTC was provided primarily by the GIS staff of USARAK. Limited data was on-hand at the CRTC. Of this data, it was found to be old, not updated and not located in a GeoDatabase managed by the command. All data was on a stand-alone computer where no other users could access the information. It was apparent that the GIS staff of USARAK was fully supportive of the CRTC geospatial data needs and were very responsive of requests when asked.

Data – TRTC

Digital data at TRTC was extremely limited. The data that was available was found for the MANPAC course and only in EXCEL spreadsheet format. Presently, there was no plan to build or use a GeoDatabase within the command. It appears as though host nations (e.g., Panama) have extensive data sets that can be leveraged, assuming proper procedures are followed

and respected. Host nation assistance appears to be an important avenue to successful future development of GeoDatabases for TRTC.

5. Recommendations

From the previously provided assessments, the following recommendations are provided for the EGIS Systems, Personnel and Data at YPG/YTC, CRTC and TRTC. As detailed earlier, the majority of time and funding dedicated to EGIS development within the command over the past five years has been focused at Yuma, AZ. As a general statement, more equitable allocation of resources will be required by YPG for the EGIS to be effective for the command. EGIS successes at YPG/YTC can be leveraged by the other commands which will provide some cost savings. However, it must be recognized that each command has unique challenges that will require individual solutions to be implemented by one or a few individuals.

Systems – YPG/YTC

Successful GIS implementation does not happen by accident and it does not happen quickly. It is the result of rigorous planning, database design, administration, maintenance, and program management. The temptation to buy software, build a database "on-the-fly", and get started quickly often results in systems introduced with great expectations (Antenucci, et al., 1991) with little to no return on the investment.

Placement of the GIS staff within the organizational structure is not trivial since its location defines the authority, responsibility, chain of command, staffing level and other management characteristics (Antenucci et al., 1991). It also impacts the level of service provided to system users (Arnoff, 1989). The current location of the EGIS – the Plans and Operations Directorate – is the correct place for it. From this location, it can service the command as the responsible organization for long-term management of geospatial technology implementation, collection and administration of reliable geospatial data and the appropriate and professional use of these data for decision support within YPG.

The GIS staff cannot think of GIS in isolation. The team must focus on shared GIS resources to rebuild confidence in GIS and win back clients. Strong vocal sponsorship up the chain of command is vital. That sponsorship and support seemed to be present at YPG 2-3 years ago. A key aspect to winning back support is to tie GIS objectives with business objectives, thereby joining with other departments to accomplish common needs. Also key is to connect GIS data and functionality with other systems (RDBMS). Sharing GIS knowledge with end-users is critically important. The GIS staff cannot afford to keep knowledge to themselves. Instead, they must empower the users. Business practices that develop redundant, undocumented, individual and department-level datasets fall short of the goal of achieving meaningful decision support for YPG. Strategies from the past are increasingly less likely to adequately support customers in the future. Geospatial technologies change rapidly and

YPG must now look ahead and determine what data files, attributes and analysis tools are needed to support the test mission now and in the future.

With today's inexpensive personal computers, powerful database software, and high-speed networks, it is rare to see a GIS implementation fail due to technology; more often they fail because a responsive organizational model is not developed (Oppman, 1999). In other words, a GIS operation that is entirely successful from a technical standpoint may fail without organizational support. Some factors that make an organizational environment conducive to successful GIS implementation include "strong leadership and enthusiasm from management" and "expertise and commitment to information technology and the use of databases in digital form" (Clark, 1991). Where these cultural characteristics don't already exist at YPG, they will need to be developed and maintained. Resistance to change must also be addressed within the context of the organization to ensure success (Faucett, 2002). The most significant component missing in the implementation of the Enterprise GIS at YPG is basic project management. Project management practices promote implementation success. Project teams should be established, individuals should be assigned specific responsibilities, task plans should be developed to support implementation planning, configuration control plans and change control processes should be established. An implementation schedule (synchronization matrix) should be published to support project deployment milestones. A draft of this schedule is provided at Annex H. From this, a system architecture design can provide the framework for establishing an implementation plan. Specific decision milestones should be included on the schedule, and each major task effort clearly identified. An implementation project manager should be assigned to make sure all tasks are well defined and every participant has a clear understanding of their responsibilities. A clear set of acceptance criteria should be developed for each implementation task and a formal acceptance process followed to ensure integration issues are identified and resolved at the earliest opportunity.

In the applications area, YPG should look to do more with web services like ArcIMS. The current server hosting the ArcIMS services is under-powered. A first step is to move ArcIMS to one of the more robust servers currently sitting idle. Next, it is important to develop some quick "wins" to regain support and trust for GIS within the organization. A phased approach to implementation reduces risk and promotes success. Start with simple, focused web-based applications using ArcIMS. The functionality of these applications should not be overly complicated yet must ensure added value to the organization. More business-focused applications should follow which include more complex GIS functionality, connecting other systems and data. Be realistic regarding the capabilities of the various development platforms. Not all applications are appropriate for development using web technologies. Web-based applications are easier, less expensive and quicker to deploy. Desktop applications are typically more expensive and require a more experienced user to operate. Focused applications with very specific tasks can be very successful utilizing ArcSDE. For more complex applications, a training plan to build the confidence of the end-users is a key requirement. The most

important aspect of developing these GIS application is to define clear objectives with fixed deliverables, hard, fixed dates and hard, fixed acceptance testing procedures.

Finally, a user needs analysis should be conducted within the year. It has been over four years since a user needs analysis study was completed. A vast majority of those needs are still unmet. Consider if those needs are still relevant today; most of them probably still are. Building allies with other departments and addressing critical business needs is a necessary element to success and should be a focus of the next phase of YPG's GIS efforts.

Systems – CRTC

YPG should invest in linking the YPG/YTC EGIS systems to CRTC. This would require server set-up and possible server purchase (at CRTC). Once enabled, the YPG software site licensing agreements should be extended to CRTC. Computer hardware should be evaluated to insure the systems are capable of hosting the software. Software upgrades then should be made to provide the latest ESRI ArcGIS versions (and any other GIS software used by the YPG command). Applications that are built, functioning and available at YPG should be migrated to CRTC to insure efficiency of work effort.

Systems – TRTC

Like with CRTC, YPG should invest in linking the YPG/YTC EGIS systems to TRTC. This would require server set-up. The servers at TRTC are capable of hosting the required software with minor memory upgrades. Once enabled, the YPG software site licensing agreements should again be extended to TRTC. As with CRTC, computer hardware should be evaluated to insure the systems are capable of hosting the software. Software upgrades then should be made to provide the latest ESRI ArcGIS versions (and any other GIS software used by the YPG command). Applications that are built, functioning and available at YPG should be migrated to TRTC to insure efficiency of work effort. As a function of the limited development of the EGIS in Panama, it is recommended that educational avenues be used to help to begin the program. Meaningful and beneficial counsel and assistance in-country will likely prove to be extremely valuable. In this, the relationships with the Poly Technical Institute (UTP) as well as the Panama Canal Authority (APC) should be aggressively fostered. Dr. Martin Candanedo (UTP) and Dr. Luis Carlos Berrocal (APC) appear to be valuable resources in establishing the systems at CRTC. The sharing of ideas, methods and, in time, data between TRTC and these organizations will benefit the command tremendously.

Personnel – YPG/YTC

YPG must hire a permanent, experienced GIS Manager with knowledge of and experience in Enterprise GIS implementation. Good project management skills are critical. Consider hiring an individual with an I.T. background and good communication skills. Although important, strong GIS-user skills are secondary for this position. Secondly, the hiring of a GIS database manager

must be done immediately. This individual must have formal education and training in order to be effective. Once selected, the duties of this individual cannot be diluted through the assignment of other tasks within the GIS staff. As well, routine refresher training (educational courses) is critical to the success of the individual selected for this position. In the selection for this position, a formal evaluation of needs/capabilities should be conducted before assigning these duties and/or hiring. YPG should consider hiring a GIS Application Programmer or GIS Analyst/Technical Lead with strong technical skills in both GIS and I.T. This is a position that does not currently exist at Yuma Proving Ground but is one that should be considered. As has been noted within this assessment report, there is a lack of strong technical abilities within the GIS organization. Depending on the skill sets of personnel filling the GIS Manager and GeoDatabase Administrator positions, another position with strong technical skills should be strongly considered. Depending on the person, this position could be combined with the GIS Analyst position. Some proposed responsibilities for this position are: (1) develop custom mapping related solutions (i.e., analysis and mapping); (2) understand and translate specific business need to GIS analysis perspective; (3) identify the right tool, spatial data and relational data to satisfy business need; (4) develop, test, deploy and maintain general desktop mapping applications; (5) develop, test, deploy and maintain general web-based mapping applications; and (6) support automation (tools and work flow). The mix of GS and contracted personnel is often difficult to manage. Given the rapidly chaning environment of the GIS industry, it is recommended that the team be primarily, if not completely, contract personnel.

In that more technical training of the current GIS staff is needed, it is recommended that a training plan be developed to help GIS staff become proficient in the technologies they are responsible for implementing.

Personnel – CRTC

Additional personnel should be considered to augment the command to provide for effective EGIS support. At a minimum, if a current staff member has some foundation training in place, it is conceivable that one could take on the primary responsibilities of managing the GIS functions for the command. If this is the case, the staff member must have limited other additional duties and be trained routinely in order to stay current with changing software applications and capabilities. A GeoDatabase manager must be hired or trained so that the GIS coordinator/technician at CRTC is not encumbered with data management and data base issues.

Personnel – TRTC

It appears as though the command has sufficient staffing to meet the GIS coordinator/technician needs. In accomplishing this, a current staff member with some foundation mapping/geospatial knowledge, could take on the primary responsibilities of managing the GIS functions for the command. As with CRTC, if this is the case, the staff member must have limited to no other additional duties and be trained routinely in order to stay current with

changing software applications and capabilities. In that this is a start-up effort, it is recommended that this individual attend educational classes at the Universidad Technologica de Panama (UTP) with the goal of acquiring a GIS certificate or possibly a Master's Degree. While this is ongoing, a GeoDatabase manager must be hired or trained so that the GIS coordinator/technician at TRTC is not encumbered with data management and data base issues. The Panamanian governmental agencies and universities were very interested in leveraging education as a means to train and educate their staff/students alongside staff/students from CRTC. In this, it is recommended that a long-term relationship (~ 4 to 5 years) be established between CRTC and UTP/APC so coordinated efforts to build share databases and manage EGIS applications can be accomplished. Evaluated each year, there is potential for USMA to assist in this effort by leveraging graduate student and cadet involvement in planned projects with CRTC.

Data – YPG/YTC

Digital terrain integration at YPG requires reliable, topologically-coherent databases developed with a consistent database schema, a single data storage model, a common set of quality control procedures for data automation/maintenance and a standardized data file and attribute naming convention. In addition, Federal law requires that these data be documented with FGDC compliant geospatial metadata. From this, the metadata should be made available to the National Geospatial Data Clearinghouse. YPG geospatial data should be developed and maintained according to Army regulations. The following recommendations are given to expedite these goals.

The current implementation of ArcSDE with Microsoft SQL Server should be evaluated for effective operation and re-installed if necessary. Restructuring the database to separate YPG data from data received from the other test centers is a simple yet important next step. A plan should be developed to update the data from the other test centers on a regular basis. At some point, sharing data directly between the test centers will be possible and should be the short term goal. The collection of spatial data contained within the geodatabase has grown tremendously over the past three years. The data that has been added "as-is" from new and existing shape files and coverages has been done with little consideration for standards. A new look at database schema for YPG data is underway with a focus on SDSFIE compliance. When completed, other departments in YPG that collect spatial coordinates of geographic features should provide spatial data in an accepted format for migration into the geodatabase so as not to delay subsequent distribution to all YPG personnel via the Intranet Map Service (ArcIMS). This recommendation calls for Geodetics and the GIS staff to eliminate duplications of effort by maintaining surveying and mapping scale data in a single centralized geodatabase.

Maximum efficiencies and long-term stability will be sustained when all departments focus their resources on administering a single corporate database and publishing those data to YPG desktops. Adoption of a common coordinate

system (where possible) should be mandated. ArcGIS Desktop can quickly re-project differing coordinate systems to provide a common view (for those that need alternative map projections). ArcIMS can re-project differing coordinate systems as well. As more ArcIMS-based applications, this constant re-projection will be a performance issue. Quality assurance practices are improving though not documented. Focusing on QA/QC practices and data accuracy needs to be done. Ultimately, the key to successful GIS implementation is for YPG to take responsibility for its own geospatial databases. Previously, the YPG GIS group began systematically inspecting YPG's Legacy GIS and CADD data, identified problems encountered and then developed a Quality Control Program to assure that consistently high-quality GIS data and maps are generated in the future. CADD and GIS are related, but fundamentally different technologies. CADD data are graphic files best used for making drawings or engineering plans of graphic phenomena. These data are literally the digital equivalent of a paper drawing, figure or schematic. As such, there is no explicitly encoded coordinate system, no associated database tables containing attribute information and no capability to perform quantitative spatial analysis. Alternatively, GIS data are geographic, with explicitly defined map coordinates. Well-prepared GIS data are also topologically correct (geometrically configured) to allow computer analyses based on geographic regions, attribute values or combinations of both, using multiple input files or layers. CADD systems are not well suited for spatial analysis because spatial relations are not defined in the data structure (Korte, 2001) and features are referenced to a Cartesian (x, y) coordinate system, rather than georeferenced to map projection coordinates. YPG has a preponderance of legacy CADD data that have implied coordinates and few attributes. These data require significant effort to repair graphic line work to construct the spatial integrity and attribute tables required for quantitative decision support. Rigid quality control procedures should be used when converting GPS data to CADD data to GIS data. One solution is to remove CADD from the process entirely and migrate GPS coordinates directly into the GIS Geodatabase (field-to-finish). It is recommended to use the technologies for what they were designed to do—make drawings with CADD—manage geospatial data, perform spatial analyses and make maps with GIS.

The Geodatabase should be fully documented with a master data inventory, a data dictionary defining data structure and geospatial metadata for each data file. The YPG Metadata Editor tool created by ESRI is providing a good standardized approach to describing the geospatial data and should be used to populate the metadata. This information should be published to YPG via an online metadata server so Test Directors can determine the fitness-for-use of datasets for their individual test applications. The ability to query database attributes, perform sophisticated spatial analysis, produce consistent, professional maps and synthesize information in a productive way will encourage communication and cooperation between departments, enhance decision support of Test Directors and improve support to customers. The Enterprise GIS should ensure a robust spatial data infrastructure for YPG now and well into the future and, in so doing, maximize the return on the GIS investments.

More thought and design of the server and network architecture is required whereby the command can consider making GIS data and metadata accessible to other test centers and Army installations. It is recommended to defer the "DTC Spatial Clearinghouse Node" for a year or two. Consider looking at something like the Geospatial One Stop (http://www.geodata.gov) for use by all test centers.

Data – CRTC

Geospatial data for CRTC is likely available to the command but needs to be accessed through proper and available channels. USPACCOM, USARPAC and USARAK are great sources of data that should be resourced immediately. Improved data links will need to be established in order to do this as the current configuration does not facilitate movement of high volumes of data. YPG should serve in an advisory role in data collection and dissemination. Data collection projects should be established and funded on a needs basis. It appears that the command currently requires data that updates road and trail networks. This is an example of great project work for temporary of summer hires. As of this report, USMA will assist in some data collection in Summer, 2007.

Data – TRTC

Geospatial data for TRTC will be difficult to collect as most of the land where the data is needed (with the exception of Hawaii) is in foreign countries. USSOUTHCOM may be able to assist in some of this data collection work. Improved data links will likely be required in order to do some of this work from Yuma. It is undetermined if the current configuration meets the requirements to facilitate the movement of high volumes of data. YPG should serve in an advisory role in data collection and dissemination. Data collection projects should be established and funded on a needs basis. It appears that the command currently requires data that updates the entire MANPAC course. As with CRTC, this is an example of great project work for temporary of summer hires. As of this report, USMA will assist in some data collection in Summer, 2007.

6. Summary

This assessment of Yuma Proving Ground's Enterprise Geographic Information System (EGIS) included an evaluation of the YPG Headquarters (Garrison), Yuma Test Center (YTC), Cold Regions Test Center (CRTC) and Tropic Regions Test Center (TRTC). For each of these organizations, a detailed evaluation was made, focusing on three areas: (1) identification and assessment of GIS personnel (assignments, qualifications and training); (2) identification and assessment of GIS systems (hardware, software, connectivity of both and employed applications); and (3) identification and assessment of GIS data (availability, structures, storage and management). From the findings, a detailed assessment was made with specific recommendations to the command. The command should immediately solidify and publish an EGIS strategic plan with implementation milestones where a

synchronization matrix (that allows for some flexibility as the command becomes educated on the use of an EGIS) helping to facilitate this requirement. The Plans and Operations Directorate within YPG should be empowered to direct EGIS development and full use of GIS tools within the organization. An effective EGIS staff must be built. Primarily through contract hiring, build educate and train critical GIS personnel (both permanent and temporary [as needed]) at all three locations (YPG/YTC, CRTC and TRTC). As necessary, transfer personnel from the EGIS office to other offices within the command to ensure effective EGIS growth within the command. Leverage work done by other GIS-type agencies outside of YPG, insuring that all collaborative work is done in support of the YPG plan and not other's interests. Upgrade hardware and core software as needed to stay synchronized with changing technologies and facilitating data transfer between commands. Finally, in that there is a large amount of digital geospatial data that is not being shared by the entire EGIS user community, implement data sharing and standardization policies that will provide effective quality assurance and quality control implementation procedures.

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8. Appendices

Appendix A: Glossary of EGIS Terms

Appendix B: Licensed YTC EGIS Software Programs

Appendix C: Initial Assessment of Servers at YPG/YTC

Appendix D: YPG GIS Vendors

Appendix E: YTC EGIS Design Applications

Appendix F: EGIS Staff Position Descriptions

Appendix G: Yuma Region GIS Data Share Agreement

Appendix H: Draft Implementation Schedule (Synchronization Matrix)

Appendix A: Glossary of EGIS Terms

attribute - 1. A characteristic of a geographic feature described by numbers, characters, images and CAD drawings, typically stored in tabular format and linked to the feature by a user-assigned identifier (e.g., the attributes of a well might include depth and gallons per minute). 2. A column in a database table.

base map - A map containing geographic features used for locational reference. Roads, for example, are commonly found on base maps.

CADD - Computer-Aided Design and Drafting. An automated system for the design, drafting, and display of graphically oriented information.

coordinate system - A reference system used to measure horizontal and vertical distances on a planimetric map. A coordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions to locate x,y positions of point, line, and area features. In ArcInfo, a system with units and characteristics defined by a map projection. A common coordinate system is used to spatially register geographic data for the same area.

database - A logical collection of interrelated information, managed and stored as a unit, usually on some form of mass-storage system such as magnetic tape or disk. A GIS database includes data about the spatial location and shape of geographic features recorded as points, lines, areas, pixels, grid cells, or tins, as well as their attributes.

database design - The formal process of analyzing facts about the real world into a structured database model. Database design is characterized by the following phases: requirement analysis, logical design and physical design.

data dictionary - A catalog of all data held in a database, or a list of items giving data names and structures. Also referred to as DD/D for data dictionary/directory. Commercial RDBMSs have online data dictionaries stored in special tables called system tables.

data model - 1. The result of the conceptual design process. A generalized, user-defined view of the data related to applications. 2. A formal method of describing the behavior of the real-world entities. A fully developed data model specifies entity classes, relationships between entities, integrity rules and operations on the entities.

database management system (DBMS) - A set of computer programs for organizing the information in a database. A DBMS supports the structuring of the database in a standard format and provides tools for data input, verification, storage, retrieval, query, and manipulation.

datum - A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g., as a spheroid). The datum is the basis for a planar coordinate system. For example, the North American Datum for 1983 (NAD83) is the datum for map projections and coordinates within the United States and throughout North America.

Digital Elevation Model - 1. A digital representation of a continuous variable over a two-dimensional surface by a regular array of z values referenced to a common datum. Digital elevation models are typically used to represent terrain relief. Also referred to as

'digital terrain model' (DTM). 2. An elevation database for elevation data by map sheet from the National Mapping Division of the U.S. Geological Survey (USGS).

entity - A collection of objects (persons, places, things) described by the same attributes. Entities are identified during the conceptual design phase of database and application design.

FGDC - Federal Geographic Data Committee. Composed of representatives of several federal agencies and GIS vendors, the FGDC has the lead role in defining spatial metadata standards, which it describes in the Content Standards for Spatial Metadata

FIPS - The Federal Information Processing Standards. FIPS deals with a wide range of computer system components including the components of most GISs: hardware, storage media, data files, codes, interfaces, data transmission, networking, data management, documentation, programming languages, software engineering, performance, security, and so forth. FIPS 173 is the precursor to the SDTS (Spatial Data Transfer Standard), which includes standardized definitions for a variety of digital mapping terms, addressing federal requirements for accuracy. FIPS provides a U. S. government standard state and country identification code; standards approved for use by U.S. government agencies. FIPS 152-2 includes POSIX.1 Compliance.

geographic data - The locations and descriptions of geographic features. The composite of spatial data and descriptive attribute data.

geographic database - A collection of spatial data and related descriptive data organized for efficient storage and retrieval by many users.

geographic feature - A user-defined geographic phenomenon that can be modeled or represented using geographic data sets in ArcInfo. Examples of geographic features include streets, sewer lines, manhole covers, accidents, lot lines, and parcels.

georeference - To establish the relationship between page coordinates on a planar map and known real-world coordinates.

geospatial metadata - Digital Geospatial Metadata. DGM was approved in June 1994 by the Federal Geographic Data Committee (FGDC). DGM describes the specifications for the content, quality, condition, and other characteristics of metadata (data about data). The standard provides a common set of terminology and definitions for the documentation of geospatial data. DGM establishes the names of data elements and groups of data elements to be used for these purposes, definitions of these data elements and groups, and information about the values that are to be provided for the data elements.

GIS - Geographic information system. An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.

image - A graphic representation or description of a scene, typically produced by an optical or electronic device. Common examples include remotely sensed data (e.g., satellite data), scanned data, and photographs. An image is stored as a raster data set of binary or integer values that represent the intensity of reflected light, heat, or other range of values on the electromagnetic spectrum.

map - An abstract representation of the physical features of a portion of the Earth's surface graphically displayed on a planar surface. Maps display signs, symbols, and

spatial relationships among the features. They typically emphasize, generalize, and omit certain features from the display to meet design objectives (e.g., railroad features might be included in a transportation map but omitted from a highway map).

map projection - A mathematical model that transforms the locations of features on the Earth's surface to locations on a two-dimensional surface. Because the Earth is three-dimensional, some method must be used to depict a map in two dimensions. Some projections preserve shape; others preserve accuracy of area, distance, or direction. Map projections project the Earth's surface onto a flat plane. However, any such representation distorts some parameter of the Earth's surface be it distance, area, shape, or direction.

map scale - The reduction needed to display a representation of the Earth's surface on a map. A statement of a measure on the map and the equivalent measure on the Earth's surface, often expressed as a representative fraction of distance, such as 1:24,000 (one unit of distance on the map represents 24,000 of the same units of distance on the Earth). Map scale can also be expressed as a statement of equivalence using different units; for example, 1 inch = 1 mile or 1 inch = 2,000 feet.

minimum mapping units - For a given map scale, the size or dimension below which a long narrow feature is represented as a line and a small area as a point. For example, streams and rivers will be represented as lines if their width is less than .10 inch, and polygons smaller than .125 inch on a side will be represented as a point.

model - A representation of reality used to simulate a process, understand a situation, predict an outcome, or analyze a problem. A model is structured as a set of rules and procedures, including spatial modeling tools available in a geographic information system (GIS).

NIST - National Institute of Standards & Technology is the agency that produces the Federal Information Processing Standards (FIPS) for all U.S.A. government agencies except the Department of Defense.

NMAS - U.S. National Map Accuracy Standards: Accuracy standards for published maps in English units defining measurements for horizontal and vertical accuracy. It is described in absolute terms; however, it is not described in statistical terms and some inconsistencies have been noted, thereby making it unusable for engineering mapping (large-scale mapping), and is not convenient to use in conjunction with mapping from space (remote sensing).

precision - Refers to the number of significant digits used to store numbers, and in particular, coordinate values. Precision is important for accurate feature representation, analysis and mapping. For example, ArcGIS supports both single and double precision.

RDBMS - Relational database management system. A database management system with the ability to access data organized in tabular files that can be related to each other by a common field (item). An RDBMS has the capability to recombine the data items from different files, providing powerful tools for data usage.

relational database - A method of structuring data as collections of tables that are logically associated to each other by shared attributes. Any data element can be found in a relation by knowing the name of the table, the attribute (column) name, and the value of the primary key.

remote sensing - Acquiring information about an object without contacting it physically. Methods include aerial photography, radar, and satellite imaging.

resolution - 1. Resolution is the accuracy at which a given map scale can depict the location and shape of geographic features. The larger the map scale, the higher the possible resolution. As map scale decreases, resolution diminishes and feature boundaries must be smoothed, simplified, or not shown at all. For example, small areas may have to be represented as points.

SDTS/TVP - Spatial Data Transfer Standard/Topological Vector Profile. A United States Federal standard designed to support the transfer of different types of geographic and cartographic spatial data. This standard specifies a structure and content for spatially referenced data in order to facilitate data transfer between dissimilar spatial database systems. TVP addresses a wide variety of vector data types, models, and structures, as well as associated attribute data. Also known as Federal Information Processing Standard (FIPS) 173.

spatial analysis - The process of modeling, examining, and interpreting model results. Spatial analysis is useful for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding. There are four traditional types of spatial analysis: topological overlay and contiguity analysis, surface analysis, linear analysis, and raster analysis.

spatial data - Information about the location and shape of, and relationships among, geographic features, usually stored as coordinates and topology.

table - A set of data elements that has a horizontal dimension (rows) and a vertical dimension (columns) in a relational database system. A table has a specified number of columns but can have any number of rows. A table is often called a relation. Rows stored in a table are structurally equivalent to records from flat files in that they must not contain repeating fields.

Appendix B: Licensed YTC EGIS Software Programs

Yuma Proving Ground has standardized ESRI products for desktop and server-based GIS applications. While a number of configuration issues and changes in the Yuma Proving Ground environment have drastically limited the success of the Enterprise GIS Systems, the core software environment provides a sound foundation to build upon. Some of the installed GIS services are non-operational at the time of this assessment. A description of the planned products used at YPG is reviewed below:

ArcGIS -- ArcGIS is a scalable family of software comprising a complete geographic information system, built on industry standards, that is rich in functionality and works out of the box. Organizations deploy the software of ArcGIS- ArcView, ArcEditor, ArcInfo, ArcSDE, and ArcIMS- in a configuration appropriate for their needs. ArcGIS is used for the creation, management, integration, analysis, display, and dissemination of spatial data. Strong visualization, editing, and analysis, along with advanced data management, distinguish the ArcGIS software family as the leading GIS software. ArcGIS is modular and scalable. It is modular in the sense that you acquire the system in pieces. ArcView provides data visualization, query, analysis, and integration capabilities along with the ability to create and edit simple geographic features. ArcEditor, a brand new software product, includes all the functionality of ArcView and adds the power to create and edit features in a multi-user geodatabase or coverage. ArcInfo includes all the functionality of ArcEditor and adds advanced geoprocessing capabilities. ArcSDE adds database services to the ArcGIS family, while ArcIMS adds Internet services. ArcGIS is scalable since it can be deployed on an individual desktop or across a globally distributed network of people. Built out of modern object-based components, the range of software programs share the same core applications, user interface, and operating concepts. After you learn one, you understand how to use the others. If you extend one, your custom tool or application works with the others. This makes it easier to learn, teach, program, and produce maps.

ArcInfo -- ArcInfo is the complete GIS data creation, update, query, mapping, and analysis system. Professionals use ArcInfo for spatial data automation since it includes the most comprehensive collection of GIS tools available. As part of the ArcGIS software family, ArcInfo includes all the functionality of ArcView and ArcEditor and adds the advanced geoprocessing and data conversion capabilities that make it the de facto standard for GIS. ArcInfo is composed of ArcInfo Desktop and ArcInfo Workstation. ArcInfo Desktop includes all the functionality of ArcEditor and adds a complete set of data management, analysis, and conversion tools. With these tools, you can perform data conversion, generalization, aggregation, overlays, buffer creation, statistical calculations, and much more. ArcInfo Workstation provides geoprocessing via the classic user interface. In addition to providing the user environment familiar to many ArcInfo users and found in countless existing GIS applications, ArcInfo Workstation includes fundamental and matchless geoprocessing functionality.

ArcView -- ArcView is the world's most popular desktop GIS and mapping software, with more than 500,000 copies in use worldwide. ArcView provides geographic data visualization, query, analysis, and integration capabilities along with the ability to create and edit geographic data. ArcView is designed with an easy-to-use, Windows-like user interface and includes VBA for customization. ArcView consists of three

desk top applications: ArcMap, ArcCatalog, and ArcToolbox. ArcMap provides data display, query, and analysis. ArcCatalog provides geographic and tabular data management, creation, and organization. And ArcToolbox provides basic data conversion. ArcView 8.1 is an exceptional stand-alone GIS as well as the entry point to ArcGIS, an integrated and scalable family of GIS software products. ArcGIS consists of ArcView, ArcEditor, ArcInfo, ArcIMS, and ArcSDE. The scalable family of ArcGIS products extends ArcView by providing advanced multi-user RDBMS data management (ArcEditor), advanced spatial data analysis (ArcInfo), Internet services (ArcIMS), and high-performance spatial database services (ArcSDE). Together the ArcGIS family of products represents the most comprehensive, configurable, and flexible suite of GIS software available on the market today.

ArcSDE -- ArcSDE is the tool that allows you to store and manage spatial data in your chosen DBMS. ArcSDE is open; it works with a variety of different databases-including Oracle, Informix, IBM DB2, and Microsoft SQL Server-that scale from work groups to large enterprise databases. ArcSDE plays a fundamental role in a multi-user GIS. With ArcSDE, your ArcGIS software (ArcInfo, ArcEditor, ArcView, and ArcIMS) can work directly with spatial data managed in your DBMS. ArcSDE also works as an application server, delivering spatial data to many kinds of applications and serving spatial data across the Internet. ArcSDE provides the gateway between the GIS and the DBMS to share and manage your spatial data as tables. In a heterogeneous database environment, where a number of different departmental or personal database systems are used, ArcSDE provides a common model for geographic information. This allows you to take full advantage of the facilities your DBMS has to offer for integrating your GIS information with the rest of your organization's data holdings. The ArcSDE server runs on Microsoft Windows NT and Windows 2000 and leading UNIX platforms including Sun Solaris, SGI IRIX, IBM AIX, HP-UX, and Compaq Tru64. ArcSDE operates over any local area, wide area, or wireless Transmission Control Protocol/Internet Protocol (TCP/IP) network.

ArcIMS -- ArcIMS® software is the foundation for distributing geographic information system (GIS) data and applications on the Internet. By providing a common platform for exchanging and sharing GIS resources, ArcIMS provides unique opportunities to leverage data from within the organization and to integrate information from other agencies. ArcIMS is a powerful technology that adds geographic data and analysis to such diverse applications as e-commerce, enterprise resource planning, data warehousing, customer care and support, location services, and field data integration. With ArcIMS allows one to: combine data from multiple sources; perform a wide range of GIS capabilities; serve geographic information to a variety of clients; integrate services with ESRI's ArcGIS Desktop products; provide secure access to map services; create a central repository for publishing and browsing metadata; offer routing and point-to-point driving directions; publish ArcGIS documents

Spatial Analyst -- ArcGIS Spatial Analyst provides a broad range of powerful spatial modeling and analysis features. The user can create, query, map, and analyze cell-based raster data; perform integrated raster/vector analysis; derive new information from existing data; query information across multiple data layers; and fully integrate cell-based raster data with traditional vector data sources. ArcGIS Spatial Analyst

provides the tools needed to support a variety of spatial modeling and application requirements. With ArcGIS Spatial Analyst the user can perform capability modeling, sensitivity modeling, predictive modeling, site suitability modeling, site location analysis, hydrologic modeling/analysis, trade area mapping, land use analysis, crop yield analysis, demographic analysis, and much more.

3D Analyst -- ArcGIS 3D Analyst is an ArcGIS extension that provides advanced tools for three-dimensional visualization, analysis, and surface generation. ArcGIS 3D Analyst enables users to examine the visual impact of building new structures; analyze atmospheric, surface, and subsurface pollution dispersion; visualize the income distribution in their community; and much more. ArcGIS 3D Analyst includes advanced tools for three-dimensional modeling and analysis such as view-shed and line-of-sight analysis, spot height interpolation, profiling, steepest path determination, and contouring. In addition, users can perform surface area and volumetric calculations, slope, aspect, and hill shade. ArcGIS 3D Analyst also provides a rich suite of tools for interactive perspective viewing.

Military Analyst -- The ArcGIS Military Analyst extension incorporates a suite of tools tailored to meet the special needs of the defense user and significantly enhances the effectiveness of core ArcGIS as a tool set foundation for the military planner and intelligence analyst. ArcGIS Military Analyst maximizes the use of the standard suite of the National Imagery and Mapping Agency (NIMA) data products by allowing direct use and rendering of NIMA's vector and raster products, line-of-sight (LOS) assessments, Military Grid Reference System (MGRS) conversion, and Digital Terrain Elevation Data (DTED) analysis. ArcGIS Military Analyst also includes the Military Overlay Editor (MOLE), which supports MIL-STD 2525B and custom war fighting symbologies.

Geostatistical Analyst -- ArcGIS Geostatistical Analyst is an ArcGIS extension that provides a powerful suite of tools for spatial data exploration and optimal surface generation using sophisticated statistical methods. Geostatistical Analyst allows users to create a surface from data measurements occurring over an area where collecting information for every possible location would be impractical. From improving estimation of temperature values to assessing environmental risks to predicting the existence of any geophysical element, ArcGIS Geostatistical Analyst gives anyone with spatial data the freedom to investigate, visualize, and create optimal surfaces. Geostatistical Analyst enables users to take advantage of these tools and techniques in a friendly and dynamic user interface.

ARC GRID -- ARC GRID is a raster- or cell-based geoprocessing toolbox that is integrated with ARC/INFO. ARC GRID provides tools for both simple and complex grid-cell analyses. It represents space from a locational perspective (dividing space into discrete units called cells) and can accurately portray continuous surfaces. The commands and functions of ARC GRID have been designed to optimize these representations; such a design allows for greater analytical capabilities. In conjunction with the other spatial representations and tools available in ARC/INFO, ARC GRID provides a powerful environment in which to explore spatial problems.

ARC TIN -- ARC TIN(TM) software is the surface modeling extension package used to create, store, analyze, and display surface information in the ARC/INFO GIS software environment. The acronym TIN stands for Triangulated Irregular Network-a set of adjacent, non-overlapping triangles computed from irregularly spaced points with x,y coordinates and z values. The TIN data model stores the topological relationship between triangles and their adjacent neighbors (i.e., which points define each triangle and which triangles are adjacent to each other). This data structure allows for the efficient generation of surface models for the analysis and display of terrain and other types of surfaces. The ARC TIN extension package supports two data models for representing surfaces: TINs and lattices. Both data structures are digital abstractions or approximations of a surface in the real world. The TIN data structure is based on irregularly spaced point, line, and polygon data interpreted as mass points and breaklines. The lattice data structure is an array of regularly spaced sample points. ARC TIN provides a suite of software tools for surface analysis and display of these geographic data models.

ArcPress -- ArcPress for ArcGIS is a PostScript-based Raster Image Processor (RIP) for fast and high-quality printing and exporting of maps. ArcPress for ArcGIS translates maps into industry-standard export formats or the native language format of your printer. Because ArcPress for ArcGIS does all of its processing on your computer, you do not need to rely on the printer to interpret, translate, and store data. ArcPress for ArcGIS allows printers to do what they do best-print. ArcPress for ArcGIS saves you money because there is no need to employ printers with extended memory, hard disks, or onboard PostScript to efficiently produce high-quality maps. It easily renders high-quality images on either high-end or low-end devices.

MrSID -- The MrSID imaging technology integrates seamlessly with our GIS software and allows YTC personnel to view compressed MrSID files within ESRI programs lke ArcInfo, ArcView, MapObjects, ArcIMS, ArcExplorer, and ArcPad. Batch processing makes easy work of image conversion and you have complete control over compression ratios, image quality, and metadata content. MrSID is much more than a simple compressor, it is a comprehensive imaging environment that uses patented selective decompression features to deliver only the pixels necessary to display or print the requested portion of the image. No longer is high-resolution imagery synonymous with huge data files. We can create, display, explore, manipulate, distribute, archive and print high-quality imagery in a truly portable format. For example, a 16GB image will fit on a single CD, allowing imagery to be easily used in field situations.

AutoCAD 2002 -- AutoCAD is a powerful 2D and 3D design and drafting platform that automates your design tasks, and provides software tools to digitize your designs. Architects, engineers, drafters, and design-related professionals use AutoCAD to create, view, manage, plot, and share information-rich drawings.

Appendix C: Initial Assessment of Servers at YPG/YTC

Due to Yuma Proving Ground security issues, a current, detailed network diagram could not be provided for this assessment. There are five servers are physically in the same location and connected to a single switch using a Gigabit Ethernet. The speed and path for network connection speeds to the servers from within the Yuma Proving Ground network are unknown. At present, the Enterprise GIS systems are not deemed "mission critical". At such a time as they are utilized for critical systems, supplementing the current servers with a redundant set of servers at a separate location should be considered. One of the requested deliverables during the last two years was to develop a DTC Spatial Data Clearinghouse Node so that Yuma data could be accessible by other agencies. This objective could not be met as the current network and server infrastructure was not designed with this implementation in mind. Additional server hardware likely located at a separate location with access from outside YPG will be required. Detailed specifications as well as current status for each server are provided below.

Server YPG2YTCCB146

Bar Code CB146
Serial Number 22HYJ11
I.P. Address 6.1.12.141
OS Name Microsoft Windows 2000 Server
Version 5.0.2195 Service Pack 4 Build 2195
OS Manufacturer Microsoft Corporation
System Name Yuma Proving GroundRC2YTCCB146
System Manufacturer Dell Computer Corporation
System Model PowerEdge 2500
System Type X86-based PC
Processor x86 Family 6 Model 11 Stepping 1 GenuineIntel ~1390 Mhz
Processor x86 Family 6 Model 11 Stepping 1 GenuineIntel ~1390 Mhz
BIOS Version Phoenix ROM BIOS PLUS Version 1.10 A04
Windows Directory C:\WINNT
System Directory C:\WINNT\system32
Boot Device \Device\Harddisk0\Partition2
Locale United States
Physical Memory Total: 3,931,632 KB, Available: 3,438,372 KB
Virtual Memory Total: 9,791,048 KB, Available: 9,007,328 KB
Page File Space 5,859,416 KB
Drive C Size: 15.99 GB, Free Space: 8.91 GB
Drive D Size: 85.67 GB, Free Space: 58.84 GB
Software Installed: ArcIMS, ENVI 4.0, ENVI License Manager, Terra Vista Computer Node
Findings: This server is one of 2 older models using Pentium III CPUs. The ArcIMS software installed on this server would benefit greatly from more powerful hardware. To date the ArcIMS services have not been utilized to a great extent. As the services continue to grow in use, this server will likely be underpowered. It is recommended that the ArcIMS services be migrated to one of the more powerful servers not currently

being utilized. This server could be reallocated to another task not requiring intensive processing power. This server is also the Web services (using IIS) used for the GIS Intranet pages. It is possible to continue running the Web services on this server and utilize the ArcIMS services running on another server.

Server YPGYTCBU723

Bar Code BU723
Serial Number H95PY01
I.P. Address 6.1.12.139
OS Name Microsoft Windows 2000 Server
Version 5.0.2195 Service Pack 4 Build 2195
OS Manufacturer Microsoft Corporation
System Name Yuma Proving GroundRA4YTCBU723
System Manufacturer Dell Computer Corporation
System Model PowerEdge 2500
System Type X86-based PC
Processor x86 Family 6 Model 11 Stepping 1 GenuineIntel ~1125 Mhz
Processor x86 Family 6 Model 11 Stepping 1 GenuineIntel ~1125 Mhz
BIOS Version Phoenix ROM BIOS PLUS Version 1.10 A04
Windows Directory C:\WINNT
System Directory C:\WINNT\system32
Boot Device \Device\Harddisk0\Partition2
Locale United States
Physical Memory Total: 2,096,624 KB, Available: 1,526,456 KB
Virtual Memory Total: 6,131,120 KB, Available: 4,099,428 KB
Page File Space 4,034,496 KB
Drive C Size: 19.82 GB, Free Space: 9.75 GB
Drive D Size: 115.74 GB, Free Space: 29.05 GB
Drive F Size: 820.33 GB, Free Space: 339.25 GB
Software Installed: ArcSDE, ESRI License Manager, Oracle 8i, MrSid Geo 1.5, UltraBac 7
Findings: This server is one of 2 older models using Pentium III CPUs. The primary software installed on this server (Oracle 8i and ArcSDE 8.3) is no longer used. This server could be reallocated to another task not requiring intensive processing power. Moving the geoprocessing tasks currently on server Yuma Proving GroundRA7YTCBW731 to this server should be considered.

Server YPGYTCBW725

Bar Code BW725
Serial Number 70DVW31
I.P. Address 6.1.1.13.64
OS Name Microsoft(R) Windows(R) Server 2003, Standard Edition
Version 5.2.3790 Build 3790
OS Manufacturer Microsoft Corporation
System Name Yuma Proving GroundRA4YTCBW725
System Manufacturer Dell Computer Corporation
System Model PowerEdge 2600
System Type X86-based PC

Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
BIOS Version Dell Computer Corporation A10, 10/7/2003,
SMBIOS Version 2.3
Windows Directory C:\WINDOWS
System Directory C:\WINDOWS\system32
Boot Device \Device\HarddiskVolume5
Locale United States
Physical Memory Total: 4,096.00 MB, Available: 1.58 GB
Virtual Memory Total: 9.34 GB, Available: 5.12 GB
Page File Space 5.59 GB
Drive C Size: 20.00 GB, Free Space: 14.76 GB
Drive D Size: 115.42 GB, Free Space: 11.05 GB
Drive F Size: 170.89 GB, Free Space: 25.05 GB
Drive G Size: 170.89 GB, Free Space: 28.71 GB
Drive K Size: 410.70 GB, Free Space: 55.04 GB
Software Installed: ArcSDE, MS SQL Server 2000, Terra Vista Computer Node
Findings: This server seems well suited for the Microsoft SQL Server and ESRI ArcSDE software running on it. The primary concern with this server is limited disk space. The F, G and K partitions are on a SCSI RAID array. The K partition is primarily being used as a backup for Dave Lashlee's personal files. Once these files are removed, the ArcSDE database could be migrated to this K Partition. Depending on the growth in data stored in the GeoDatabase, additional or larger disk drives can be added to the RAID Array.

Server YPG7YTCBW728

Bar Code BW728
Serial Number 90DVW31
I.P. Address 6.1.1.13.66
OS Name Microsoft(R) Windows(R) Server 2003, Standard Edition
Version 5.2.3790 Build 3790
OS Manufacturer Microsoft Corporation
System Name Yuma Proving GroundRA7YTCBW728
System Manufacturer Dell Computer Corporation
System Model PowerEdge 2600
System Type X86-based PC
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
BIOS Version Dell Computer Corporation A10, 10/7/2003, SMBIOS Version 2.3
Windows Directory C:\WINDOWS
System Directory C:\WINDOWS\system32
Boot Device \Device\HarddiskVolume2
Locale United States
Physical Memory Total: 4,096.00 MB, Available: 3.40 GB
Virtual Memory Total: 11.47 GB, Available: 10.74 GB

Page File Space 7.60 GB
Drive C Size: 20.00 GB, Free Space: 13.20 GB
Drive D Size: 115.42 GB, Free Space: 115.35 GB
Software Installed: Terra Vista Computer Node
Findings: This server is not currently used and would be an excellent platform for ArcIMS. It is recommended that the ArcIMS 9.0 software be migrated to this server.

Server YPGRA7YTCBW731

Bar Code BW731
Serial Number 30DVY31
I.P. Address 6.1.1.13.69
OS Name Microsoft(R) Windows(R) Server 2003, Standard Edition
Version 5.2.3790 Build 3790
OS Manufacturer Microsoft Corporation
System Name Yuma Proving GroundRA7YTCBW731
System Manufacturer Dell Computer Corporation
System Model PowerEdge 2600
System Type X86-based PC
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
Processor x86 Family 15 Model 2 Stepping 9 GenuineIntel ~3056 Mhz
BIOS Version Dell Computer Corporation A10, 10/7/2003,
SMBIOS Version 2.3
Windows Directory C:\WINDOWS
System Directory C:\WINDOWS\system32
Boot Device \Device\HarddiskVolume2
Locale United States
Physical Memory Total: 4,096.00 MB, Available: 3.30 GB
Virtual Memory Total: 11.47 GB, Available: 10.62 GB
Page File Space 7.60 GB
Drive C Size: 20.00 GB, Free Space: 12.33 GB
Drive D Size: 115.42 GB, Free Space: 113.86 GB
Software Installed: ESRI Geoprocessor, ArcGIS, ENVI 4.0, Feature Analyst, Terra Vista Computer Node
Findings: This server is currently used for intensive geoprocessing such as batch conversion of imagery. The need for these types of tasks appears to be infrequent at present. It is recommended that this server be considered for utilization for a second installation of ArcSDE or ArcIMS as the use of Enterprise GIS services continue to increase.

Appendix D: YPG GIS Vendors

The Vendors chosen by Yuma Proving Ground to assist with the Enterprise GIS implementation are all well-established within the GIS Industry. It was not within the scope of this assessment to specifically review the vendors, however some general findings from a previous assessment regarding each are listed below.

Environmental System Research Institute (ESRI) Denver. The Denver office of ESRI located in Broomfield, CO was a key vendor in the GIS implementation. From another assessment, several brief interviews were conducted with the members of ESRI-Denver that were associated with the Yuma Proving Ground projects. The deployment of the GeoDatabase prototype appeared to be successful. However, they commented that after delivering the prototype, they requested testing and validation yet received very little feedback. For the "Interactive ArcIMS Web Portal" proposal, the long list of deliverables seems appropriate for the estimated $145,000 price tag. Unfortunately, it appears many of the deliverables deviated from the original scope. Most of the ESRI-Denver team involved in the Yuma Proving Ground project is still available to support the implemented applications. The ESRI-Denver team appears to have good analytical skills and development skills for delivering the ArcGIS Extensions.

GIS Southwest. GIS Southwest of Phoenix AZ was responsible for delivering the "Map Request Form" application. This vendor was not interviewed and a review of the company's website provided little information regarding their capabilities specifically regarding application development. The comments here are solely reflective of the scope defined for the project compared to the actual delivered application. The "Map Request Form" application is a simple series of web forms with limited value to Yuma Proving Ground. The application is described in the scope as to be based on ArcIMS, yet there is no mapping functionality in the final product.

Applied Research Associates (ARA). Applied Research Associates has their corporate offices in Albuquerque, NM. Bob Shankle, the primary consultant for this project is based in Raleigh, NC. This vendor was not interviewed. The comments here are solely reflective of a review of the scope defined for the project and the delivered "final report". While ARA and specifically Bob Shankle appear to have a long history of providing services to Yuma Proving Ground, the delivered final report suggests that this vendor was poorly suited for many of the tasks assigned. This appearance of "on-the-job" training is derived from a few key statements from that report including: "we reviewed the class notes from January 2002 SDSFIE training" and "the tasks became straight forward after we attended the ArcSDE – SQL Server Admin class in May". One member of the Yuma Proving Ground GIS team commented that the vendor used a "SQL Server for Dummies" book when implementing Microsoft SQL Server. The document "The US Army DTC Enterprise GIS Model: Draft Architecture and Implementation Recommendations in Support of Virtual Proving Ground (VPG) Digital Terrain and Garrison Mapping Requirements", is a good though limited first attempt at defining the requirements. The document provides few additional details or new recommendations not already included in the Yuma Proving Ground Enterprise GIS Strategic Plan provided to the vendor.

Appendix E: YTC EGIS Design Applications

The "Web Portal" Prototype application was not clearly defined in the proposal from ESRI-Denver but was part of the "Phase One - Finalize Functionality, Establish Server Connectivity, and Develop Prototype Design". The estimated cost in the proposal for this "Phase One" including the prototype design was $30,800.00 which was paid to ESRI-Denver in 2003-2004. This prototype was the first deliverable from ESRI and the one most "on-target" with regards to web-enabled applications. This is the only delivered application that utilizes the ArcIMS server. While the intent was to build a portal or web kiosk, this single application was merely a building locator. The functionality is extremely limited and of questionable value. At the start of this assessment, this application was non-functional due to several changes within the Yuma Proving Ground server environment.

The SDZ Viewer ArcIMS Application was deemed "not operational". No specific description of this application was provided in any of the documentation. From a documented discussion with ESRI-Denver, it was explained that this application was intended to integrate the Surface Danger Zone (SDZ) Tool described below with the GIS Web Portal. Though it was implemented by ESRI in February 2004, during a review of the ArcIMS server in February 2005, there was no indication that this application was operational or accessible to users via the web.

The Maps On Demand and Published Map Gallery applications are described as follows in the proposal from ESRI-Denver: *"The web portal application will provide the ability for users to produce map products through either a Maps on Demand method or by providing access to a Published Map Gallery. The application will include access to existing geospatial and attribute database information by utilizing the ArcIMS software and Web Browser technology. ArcIMS will access the attribute and geospatial data residing in Oracle by utilizing the ArcSDE product. The web portal will support standard ArcIMS product functions such as on-the-fly data projections and use of the Yuma Proving Ground Local Map Projection. An ArcIMS AXL file will be set up with the common projection environment utilized at Yuma Proving Ground and additional data themes will automatically be projected to this system. ESRI will assist with the creation of a set of map templates and the use spatial bookmarks to automatically zoom to specific areas. These 'areas of interest' will include individual ranges, drop zones, airfields, gun positions, and observation towers."* The estimated cost in the proposal for these applications was $33,821.00 which was paid to ESRI-Denver in 2003-2004. It appears that the "Maps On Demand" application was never delivered. The Published Map Gallery does not use ArcIMS nor is it web-based. It utilizes another ESRI desktop product ArcReader. The ArcReader map files connect directly to the ArcSDE GeoDatabase. With the migration of the ArcSDE from Oracle to SQL Server, many of the links to the data within these map files were broken. Many are still broken at the time of this assessment. These links must be reestablished in each of the map files. In addition, ArcSDE has been upgraded to version 9.0 yet the ArcReader software available for download is version 8.3 resulting in possible incompatibilities. No reason could be identified why these maps were implemented with ArcReader instead of ArcIMS. Each of these maps could be replaced with web-based applications using ArcIMS.

The CADD Data Warehouse and Static Image Library applications are described as follows in the proposal from ESRI-Denver: *"ESRI will assist Yuma Proving Ground with the development of a CADD Data Warehouse and viewing images from a Static Image Library. These data assets will be provided for viewing and printing and the CADD data will have the ability to be re symbolized using the standard ArcIMS and ArcGIS symbol sets. ESRI will also provide an evaluation of the use of a document management system to retrieve and display this information. Documents, CADD files, images, and other data, can be associated based on a geographic location, or by any additional indexing method such as by year, contractor, project, etc. ESRI will help with identifying a product that will function with the ArcIMS application developed for this project."* The estimated cost in the proposal for these applications was $39,678.00. While it appears that this entire sum was paid to ESRI-Denver in 2003-2004, it is believed that these funds were re-allocated to other aspects of the project. There is no indication that the CADD Data Warehouse and Static Image Library applications were ever developed as defined in the proposal. The "Find A Map" section of the GIS website has similar functionality to the Static Image Library. However, the Find A Map section was first developed in 2002 prior to the commencement of the Web Portal Project with ESRI-Denver. The "maps" available through the Find A Map function are predominately PDF documents with a few static images in JPEG and MrSID formats. Nearly all of the PDF documents are designed for large-format printers/plotters (e.g. 34x44 inches). These large devices are not available to the majority of end users intended to access these documents. The majority of the PDF documents were last generated in mid-2003 and are thus likely out dated.

The Range Analysis Tools are described as follows in the proposal from ESRI-Denver: *"Based on the results of the initial application development meetings, ESRI will develop the following functions for access within the web portal. Surface Danger Zone (Safety Fan) Tool The surface danger tool will provide a digital representation of a danger zone. These zones will be based on the type of weapon being tested and the area of Yuma Proving Ground being utilized for the testing. ESRI anticipates that about ten of these danger zone areas will be developed. ESRI will also assist Yuma Proving Ground with the development of a model to determine the Danger Zone areas. These models can integrate Yuma Proving Ground data specific for a particular device and generate zones as needed. We will work directly with Yuma Proving Ground staff to implement the methods required for your analysis and to have this tool work within your decision support system. Line of Sight Tool The line of sight tool will utilize topography (DEM) data available for the Proving Grounds. This tool will use some of the standard GIS analysis functions available in the core product for this type of analysis. We anticipate the development of an interface to provide Yuma Proving Ground users access to this function and this proposal has not scoped the development of a new set of tools. Feature Query and Display Tool The web portal will provide Yuma Proving Ground users the ability to select a feature(s) and display the attributes corresponding to that feature(s). ESRI will work with Yuma Proving Ground's staff to determine the specific attributes that will be provided. The queries can be performed by selecting a point with the cursor or by selecting features with a geometric shape such as a circle, rectangle, or a polygon. Resource Routing Tool ESRI will assist Yuma Proving Ground staff with the ability to allocate base resources based on current and future projections. The initial design meeting will provide a better understanding as to how these resources are allocated and what conditions exist for the proper routing decisions. We*

anticipate that the resource requirements and the Danger Zone fan will provide guidelines for this tool in assisting Yuma Proving Ground staff with resource routing. The specific requirements for these tools will be clarified during the initial project definition meetings." The estimated cost in the proposal for these applications was $17,536.00. This entire sum as well as funds re-allocated from other aspects of this project was paid to ESRI-Denver in 2003-2004 for development of the Surface Danger Zone Tool and the Line of Sight Tool. None of these applications were developed utilizing a web portal. Two of these applications, the Feature Query and Display Tool and the Resource Routing Tool were never developed. Two of the applications, the Surface Danger Zone (Safety Fan) Tool and Line of Sight Tool, were developed as ArcGIS Extensions. Deploying desktop GIS applications is counter to the Enterprise GIS goals expressed in the Yuma Proving Ground Enterprise GIS Strategic Plan.

The Surface Danger Zone (Safety Fan) Tool was developed extensively. ESRI devoted significant effort to create the SDZ Tool with multiple versions created over 1½ years. As of November, 2004 the application was being used but with a number of critical flaws. Several of these issues are outlined here. This application was written for ArcGIS version 8.x. Now that all ArcGIS Desktops have been upgraded to version 9.0, the current code base does not work. To continue use of this application, some components must be rewritten to work with the revised A.P.I. of ArcGIS 9.0. The effort required to rewrite this application is unknown. The most current version of source code for this application (October, 2004) is apparently not in Yuma Proving Ground's possession. An older version of source code was being used (August , 2004). Yuma Proving Ground personnel stated that the links to the old ArcSDE database (using Oracle) are hard-coded in the source code and thus the application would need to be modified to access the newest ArcSDE database (using SQL Server). Security issues were raised regarding this application. Insufficient security allows any user to overwrite another user's work. This could have extremely detrimental consequences out on the test range.

The Line of Sight Tool was also developed by ESRI. ESRI delivered 3 tools with the Line of Sight application. The input for the Line Of Sight (LOS) Telemetry tool includes a shapefile that holds one or more telemetry tower features and a raster – DEM representing the topography. The output will include a new raster which records the number of times each of its cells can be seen by the telemetry towers. A value of (0) in one of the output raster's cells signifies that none of the telemetry towers can see that cell. A value of (1) means that one telemetry tower can see that cell. A value of (2) means that (2) towers can see that cell and so on. It becomes clear when viewing the output raster which areas are visible by which towers. Cells that can be seen jointly by two or more towers are potential locations for repeater towers.

The Metadata Server and Clearinghouse Node applications are described as follows in the proposal from ESRI-Denver: *"ESRI will utilize procedures consistent with the Federal National Spatial Data Infrastructure (NSDI) Standards to develop a Metadata Server and a DTC Spatial Data Clearinghouse Node. The initial implementation for Yuma Proving Ground will be populated with the Proving Ground's data, but this implementation will accommodate GIS datasets provided in the future by other Test Centers."* The estimated cost in the proposal for these applications was $21,535.00. While it is appears that this entire sum was paid to ESRI-Denver in 2003-2004, it is documented that these funds were re-allocated to other aspects of the project. From a

documented conversation with ESRI-Denver, it was shown that the Metadata Server and a browser-based metadata client (Metadata Explorer) were implemented for Yuma Proving Ground. During the course of previous assessments, however, it was observed that these services were no longer available on the ArcIMS server. The value of these services to other departments within YPG is not known and believed to be limited. If these applications were intended to facilitate the sharing local data with outside agencies, it seems premature to consider these types of endeavors. The true value of efforts such as these will be realized only after Yuma Proving Ground completes the standardization of GIS data to meet SDSFIE standards including complete Metadata describing the data. In addition, security and infrastructure concerns should be fully addressed prior to considering the implementation of the DTC Spatial Data Clearinghouse Node.

The Map Request Form application is described as follows in the proposal from GIS Southwest: *"The Yuma Proving Ground (Yuma Proving Ground) Geographic Information System (GIS) Laboratory has a need for custom Intranet and Internet map services to collect, manage, audit, and report requests for digital geospatial data, cartographic products, and data analysis services. Environmental Systems Research Institute (ESRI) ArcIMS and/or ArcGIS Server and Microsoft (MS) Outlook and Access software will be used to integrate with the existing Yuma Proving Ground GIS Laboratory system architecture. This capability must be flexible, scaleable, and secure, use standard communication protocols, and support a wide range of GIS Customers with an intuitive easy-to-use web browser user interface."* The entire cost of this application, $45,000 was paid to GIS Southwest in 2004. This application is available as a prototype on the vendor's website and has yet to be delivered to Yuma Proving Ground. There appears to be little desire within YPF to complete the implementation. The comments received from Yuma Proving Ground GIS personnel about this application indicate it "does not provide value". As many of the custom map requests require additional information and discussion with the requestor, it is believed that less than 50% of requests could be handled by this application without intervention of Yuma Proving Ground GIS Staff. MoosePoint's investigation of the prototype application resulted in similar conclusions.

Appendix F: EGIS Staff Position Descriptions

GIS Manager:

- Serves as installation Geospatial Information Officer
- Supervises installation-wide Enterprise GIS support
- Director of GIS Laboratory operations
- Oversees execution of short and long-term strategic goals
- Manages projects and funding for GIS efforts
- Ensures quality control procedures are used
- Develops strategy and implementation plans
- Manages the YTC Technical Working Group
- Member the GIS Technical Steering Committee
- Reports to the GIS Executive Oversight Committee
- Participates on external geospatial technical committees and working groups

Geodatabase Administrator:

- Defines the database and its component elements, oversees its creation
- Performs database archives
- Audits database use and statistics
- Supports departmental GIS users and maintains database access
- Provides minor customization assistance
- Ensures connectivity between users and their GIS data
- Member of the GIS Technical Steering Committee
- Principal point of contact with GIS vendors for database operational issues
- Works with System Administrators on GIS servers, workstations, and peripherals
- Maintains operating system and RDBMS software

GIS Coordinator:

- Coordinates meetings, briefings, symposia, and seminars
- Organizes GIS and related technology training courses
- Correlates existing databases with new database information
- Interprets original source documents prior to migration to the Geodatabase
- Creates quality maps and graphics for presentations and reports
- Performs Geodatabase Verification, Validation, and Accreditation
- Works cooperatively and jointly to provide quality customer support
- Tests GIS applications and application executables
- Assists Database Administrator with system security issues
- Keeps abreast of hardware and software technology changes
- Maintains working knowledge of spatial data standards

GIS Analyst(s):

- Provides professional cartographic support
- Performs spatial analysis in support of the YTC test mission
- Processes raw geospatial data into spatially coherent GIS datasets
- Builds and maintains geospatial database topology rules
- Performs Digital Image Processing of remotely sensed data for feature extraction

- **Uses established quality control standard operating procedures at all times**
- **Assists YTC application specialists in using GIS data and software**
- **Provides technical support to departmental coordinators and end-users**

GIS Technician(s):

- **Collects field data using GPS technologies and other relevant instrumentation**
- **Performs verification and validation of the field data prior to Geoprocessing**
- **Works with GIS Analysts toward updating the Enterprise GIS**
- **Digitizes new data from available source materials**
- **Produces maps and graphics as necessary**

Remaining GIS personnel are Applications Specialists— professionals trained in their individual areas of expertise, physically located in the divisions to which they are assigned, and who use GIS when appropriate to perform their jobs more efficiently. An example is a Test Director that uses GIS Intranet distributed resources (Geodatabase, custom software tools) to calculate a Surface Danger Zone (SDZ) around a firing position and then performs Line-of-Sight analyses from several observation towers. Output products are exported to PDF format and e-mailed to potential customers along with a digital copy of the Range Operations Map from the on-line Map Gallery showing facilities and infrastructure for that area. Application specialists are distributed throughout the YPG community that adopt and use the technology. They are primarily Data Users.

Appendix G: Yuma Region GIS Data Share Agreement

AGREEMENT NO. AZ-050-0305

DATA SHARE AGREEMENT

BETWEEN

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
YUMA FIELD OFFICE

AND

U.S. ARMY YUMA PROVING GROUND,
BUREAU OF INDIAN AFFAIRS,
BUREAU OF RECLAMATION,
U.S. FISH AND WILDLIFE SERVICE,
NATIONAL PARK SERVICE,
U.S. BORDER PATROL,
U.S. GEOLOGICAL SURVEY,
MARINE CORPS AIR STATION - YUMA,
STATE OF ARIZONA – DEPARTMENT OF TRANSPORTATION,
STATE OF ARIZONA – GAME AND FISH DEPARTMENT,
STATE OF ARIZONA – DEPARTMENT OF CORRECTIONS,
CITY OF YUMA,
YUMA COUNTY

FOR

DIGITAL GEOSPATIAL DATA SHARING AND INTEGRATION

I. Purpose:

This Data Share Agreement (DSA) is entered into by the participating agencies listed above, each with designated representation on an existing Regional GIS User Working Group, for the purpose of sharing non-sensitive geospatial information from the region in and around Yuma, Arizona. The participating agencies administer adjacent State and Federal lands in the region and have a need for technology transfer and data exchange in order to enhance operations and effectively serve the public with accurate and reliable geospatial information.

II. Objective:

This DSA expands and clarifies existing agreements that have been the means for participating agencies to share and exchange data in specific project areas. The objective of this DSA is to reduce duplication, incompatibility, and inefficiencies related to collection of geospatial data on an ad hoc basis by the different government entities in the region.

III. Authority:

A. The Federal authorities to enter into this DSA are:

1. The Federal Land Policy and Management Act of 1976 (43 U.S.C. 1737 § 307).
2. The Paperwork Reduction Act, 44 U.S.C. 3501.
3. The Intergovernmental Cooperation Act of 1968 (40 U.S.C. 531).
4. OMB Circular A-130, Management of Federal Information Resources.
5. OMB Circular A-16, Coordination of Surveying, Mapping, and Related Spatial Data Activities.
6. OMB Circular A-119, Federal Participation in the Development and Use of Voluntary Standards.
7. National Spatial Data Infrastructure (NSDI) per Executive Order 12906.
8. Army regulation AR-210-20.

B. The State authorities to enter into this DSA are:

1. Arizona Revised Statute (A.R.S.) 11-952 et seq., Intergovernmental Agreements.
2. A.R.S. 37-173(2) authorizing a GIS system for the State Land Department and other public agencies in the State.
3. A.R.S. 37-173(8) authorizing a liaison relationship with regional Federal mapping organizations.
4. Governor's Executive Order No. 92-17 establishing the Arizona Geographic Information Council (AGIC) to coordinate the management of Statewide geographic information among public agencies in the State.

IV. Benefits:

Costs associated with collection and administration of duplicate databases, in which each agency essentially stores the same data, are unnecessary given the potential for data sharing. This DSA will decrease the duplication of data development, generate

standardized information, and foster communication between agencies in the region. The sharing and exchange of geospatial data to the maximum extent possible will enhance operations and provide the most effective access and use of this information.

V. Definitions:

A. Participating Agencies: The Bureau of Land Management (BLM) and those agencies, Federal, State, or local that have signed this DSA and are members of an existing Regional GIS User Working Group.

B. Geospatial Data: Information that contains the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies.

C. Geographic Information System (GIS): A system of computer hardware, software, people, data, and procedures designed to support the capture, management, analysis, model, exchange and display of spatially referenced data for solving complex planning and management problems.

VI. Project Management Plan:

A. Data Sharing:

1. All Federal agencies are required to participate in the National Spatial Data Infrastructure (NSDI) per Executive Order 12906, which states that all GIS data will be shared to avoid wasteful duplication and promote effective and economical management of resources. Army interim policy and guidance for GIS technologies states "Army GIS personnel shall share data across functional and organizational lines, with other Federal, State and local governments, and non-governmental organizations (NGO's) in accordance with applicable State and Federal laws."

2. The participating agencies agree to share data for mutual benefit in accordance with the conditions set forth in this DSA, in order to minimize duplications of effort and expenditures, and to enhance intergovernmental cooperation and interoperability.

3. The participating agencies will provide digital data in a mutually agreed upon format.

4. Direct communication between participating agencies is authorized to facilitate sharing and exchange of geospatial data.

B. <u>The Data Catalog</u>:

1. The State Geographic Information Database (SGID) Catalog, currently maintained by the Automated Geographic Reference Center and publicly available through the Arizona State Lands Department, will be used to develop a catalog of data generated, or produced, by the participating agencies. Creation and linking of individual agency catalogs will be encouraged for additional relatable data.

2. Once created, the Data Catalog will be made available over the Internet and the State Wide Area Network in compliance with all computer security requirements in affect at the time of deployment. This DSA will be amended to include details regarding the responsibilities of housing and maintaining the Internet site when such determinations are made.

3. Each participating agency will be responsible for providing updates to their agency's information maintained in the Data Catalog, or to create links to locally maintained compatible catalogs, in order to keep the data at its most current level.

4. The Data Catalog will fit within the concepts developed as part of the National Spatial Data Clearinghouse defined in Executive Order 12906.

5. Use of the Federal Geographic Data Committee Content Metadata Standard is mandatory for Federal agencies and recommended for all participating agencies.

C. <u>The Data Repository</u>:

1. At minimum, framework data will be consolidated and integrated as part of the distributed SGID. Framework data includes, but is not limited to, the following layers:

   a. Cadastral Reference Systems and Geodetic Control.

   b. Government Units and Boundaries.

   c. Land and Administrative Ownership.

   d. Demographics.

   e. Transportation Networks.

   f. Digital Ortho-Imagery and other Remotely Sensed Data.

   g. Elevation, Slope, Aspect, and Derivative Surface Models.

   h. Geology, Soils and Hydrology.

   i. Climate.

j. Land Cover and Land Use.

k. Wetlands and Wildlife Habitat.

l. Non-sensitive Cultural Resources.

2. All agency-specific data will be maintained by the responsible agency and made available to the other participating agencies.

3. The participating agencies will provide electronic data in an agreed upon format.

4. The Data Repository will be available over the Internet and the State Wide Area Network in compliance with all Federal computer security requirements in affect. This DSA will be amended to include details regarding the responsibilities of housing and maintaining the Internet site when such determinations are made.

5. Each participating agency will provide updates to that agency's information maintained in the Data Repository in order to keep that data and information at its most current level.

6. The Regional GIS User Working Group will coordinate data collection and standards dealing with attributes, accuracy, currency, completeness, and other elements relating to spatial data quality.

VII. Terms of Agreement:

A. Effective Date: This DSA is effective upon signature of all participating agencies hereto. Additional agencies can become participants by signing at any time the DSA is in effect.

B. Expiration Date: This DSA expires on October 1, 2004, unless terminated earlier by written mutual consent of all participating agencies. Prior to the expiration date, this DSA is subject to review, renewal, or expiration.

C. Termination: Any participating agency may immediately terminate their participation in this DSA at any time before the date of expiration at their discretion by providing written notice of termination to the other participating agencies.

D. Modifications/Amendments: This DSA may be modified or amended only by a written instrument executed and mutually agreed to by the participating agencies.

C. Participation in Similar Activities: This instrument in no way restricts any of the participating agencies from involvement in similar activities with other public or private agencies, organizations, and individuals.

D. Metadata: Geospatial metadata will be included with requested records such as data source, scale, reliability, age, accuracy, etc., to identify data integrity.

E. Exclusive Right to Data: This DSA does not confer an exclusive right to BLM data by the other parties. The BLM is free to negotiate similar arrangements to share or exchange the same BLM data with parties other than the participating agencies.

VIII. Data Not Available for Sharing or Exchange:

No non-public data is to be shared or exchanged under this DSA. Specifically, the BLM may not share or exchange records/data that are either: (1) involved in litigation; (2) covered by a Privacy Act system notice in which the receiving party does not fall under the prescribed "Routine Use" designations; or (3) in which there is proprietary data protected under the Trade Secrets Act, Executive Order 12600, and the Freedom of Information Act (FOIA). Federal records containing information that is exempt from release under the provisions of the FOIA, such as site specific cultural resources protected by Exemption 3 of the FOIA, or information that is confidential or proprietary shall not be provided.

When information deemed to be non-public or sensitive is received from State and local sources, BLM cannot agree to maintain the confidentiality of such information except to the extent that it is permitted by the FOIA.

IX. Disclaimer Statement:

Disclaimers are required for electronic records that are provided to anyone outside the BLM. The BLM disclaimer statement must be included in the header file of any electronic record, or on an accompanying file or separate hard copy when there is no provision for including it in the header file. If computer generated printouts are provided, the BLM disclaimer statement must be either stamped on the printout or placed on a label where clearly visible on the hard-copy products. The following disclaimer language should be used: "NO WARRANTY IS MADE BY THE BLM FOR USE OF THE DATA FOR PURPOSES NOT INTENDED BY BLM."

X. Confidentiality Statement:

Records provided pursuant to this DSA may only contain information available to the public. Records provided by the State of Arizona may be subject to non-release restrictions of applicable State laws. Participating agencies will be informed of such restrictions and the record will be labeled with a confidentiality statement provided by the State. To the extent permissible by Federal and State laws, the participating agencies agree to abide by the restrictions, and shall not disclose such information to the public or other parties, or transmit or otherwise divulge this information, except to the extent permitted by the FOIA.

XI. Indian Trust Clause:

BLM computer servers are certified not to contain any Individual Indian Trust Data (IITD). No IITD will be permitted to be stored on a BLM server unless specifically

authorized by the BLM Chief Information Officer (CIO) and the Department of the Interior CIO. No IITD may be shared or exchanged under this DSA.

XII. Type of Access:

Online access to geospatial data will be available to participating agencies via the Internet and the State Wide Area Network. Online access shall incorporate appropriate site security and access security provisions as required by each agency, require identification and passwords and level of access provisions as determined by system administrators of the participating agencies. Security measures will be in accordance with the Computer Security Act of 1987. This DSA will be amended to include details regarding the responsibilities of housing and maintaining the Internet site when such determinations are made.

XIII. Cost Recovery:

Whenever possible, digital data shall be shared between participating agencies without cost. Reimbursement for actual costs may apply when a requesting participating agency seeks data in a non-standard digital format or in hard copy form. A cost recovery determination will be made at the time such a request is submitted. Any fees collected shall be in accordance with cost recovery guidelines and established fee structures for the applicable participating agency charging the fees. In all circumstances, reimbursement of costs shall cover only the actual cost of providing the information or service.

XIV. Modification:

This DSA may be modified or amended at any time prior to expiration of term, or termination, by a written modification or amendment effective upon signature of all participating agencies hereto.

XV. Key Officials:

Key Officials are the primary points of contact for each participating agency and are responsible for implementing the provisions of this DSA. It is mutually agreed that the Signatory Official for each agency will designate a Key Official for each agency. A list of Key Officials is attached to this DSA.

XVI. Administration:

Administration of this DSA will be accomplished by the participating agencies and their Key Official representatives and coordinated by the Regional GIS Advisory Committee.

XVII. Restriction of Delegates:

Pursuant to Title 41, U.S.C., Chapter 1, Section 22, no member of Congress shall be admitted to any share or part of this DSA, or to any benefit to arise thereupon.

XVIII. Non-Fund-Obligating Document:

This DSA is neither a fiscal nor a funds obligation document. Any endeavor involving obligation or contribution of funds between the parties to this instrument, except as stated above in Section XI. Cost Recovery, shall be handled in accordance with applicable Federal laws, regulations, and procedures including those for procurement and printing. Such endeavors require the execution of separate, applicable agreements authorized by appropriate statutory authority. This DSA does not provide such authority. Specifically, this instrument does not establish authority for noncompetitive award to any of the participating agencies of any future contract(s) or other agreement(s).

Nothing in this DSA shall be construed as obligating the BLM or the Department of the Interior, the Yuma Proving Ground, the Department of the Army, or the Department of Defense, or other participating agencies to obligate funds or otherwise act in any fashion contrary to local, State, or Federal statutes, rules or regulations, including, but not limited to, the Anti-Deficiency Act.

The Parties hereto agree that if any conflicts arise in the implementation of this DSA, Federal statutes, regulations, and procedures shall control as to the resolution of such conflicts.

XIX. General Provisions:

Additional provisions are contained in the following and incorporated by reference:

A. **OMB Circular A-87, Cost Principles for State and Local Governments.**

B. **OMB Circular A-102, Uniform Administrative Requirements for Grants-In-Aid to State and Local Governments.**

C. **OMB Circular A-133 (replaced OMB Circular A-128 on 7/1/97), Audits of State and Local Governments.**

D. **Federal Information Processing Standard 173: (National Institute of Standards and Technology, 1994).**

E. **Executive Order 12906, Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure.**

F. **AR 210-20, "Interim Policy and Guidance for Geographic Information Systems (GIS) Technologies".**

G. **All applicable national policy requirements and administrative management standards as set forth in Office of Management and Budget, Financial Management Division, Directory of Policy Requirements and Administrative Standards for Federal Aid Programs are hereby incorporated by reference.**

XX. Signatures:

Each participant shall receive a copy of the fully executed DSA. Each is deemed an original.

_____ Date:_____

Gail Acheson
Field Manager
BLM - Yuma Field Office

_____ Date:_____

James L. Wymer
Technical Director
US Army Yuma Proving Ground

_____ Date:_____

Bureau of Indian Affairs

_____ Date:_____

Bureau of Reclamation

_____ Date:_____

U.S. Fish and Wildlife Service

_____ Date:_____

National Park Service

_____ Date:_____

U.S. Border Patrol

_____ Date:_____

U.S. Geological Survey

_____ Date:_____

Marine Corps Air Station

_____ Date:_____

State of Arizona, Department of Transportation

_____ Date:_____

State of Arizona, Game and Fish Department

_____ Date:_____

State of Arizona, Department of Corrections

_____ Date:_____

City of Yuma

_____ Date:_____

Yuma County

Appendix H: Draft Implementation Schedule (Synchronization Matrix)

(SEE ATTACHED)