

Army ITAM GIS: Utilizing ArcSDE and SDSFIE to Support the Enterprise

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ABSTRACT

The U.S. Army Integrated Training Area and Management (ITAM) program focuses on the sustained use of training and testing lands. The application of GIS within the program provides for the effective integration of stewardship principles into training land and conservation management practices. To assist in managing the program's vast GIS resources, an enterprise GIS is currently being implemented that incorporates both ArcGIS8/ArcSDE and SDSFIE. This paper describes the Enterprise structure and how it currently provides for a full-functioning GIS that encompasses data from more than twenty feature classes ranging from military operations to property and environmental management.

INTRODUCTION

This paper details the implementation of an enterprise GIS at the U.S. Army's Integrated Training Area Management (ITAM) Geographic Information System (GIS) Regional Support Centers (RSC). Elements of an enterprise GIS will be defined and discussed. Also discussed is the technology used to support an enterprise GIS, the implementation and use of enterprise GIS at the RSCs, and how the RSC enterprise GIS is used to support the broader ITAM community.

RSC OVERVIEW

The U.S. Army ITAM Program oversees the operation of the two GIS regional support centers. The Army ITAM RSCs provide a variety of GIS support to the Army ITAM program. This support is to installations, Major Commands (MACOMS), and Headquarters, Dept. of the Army (HQDA). GIS support includes GIS database development, cartography, spatial analysis, and technical support. Implementation and use of enterprise GIS at the RSCs is critical to successfully supporting the GIS needs of the ITAM program. In order for the RSCs to support enterprise GIS in the broader ITAM community, it is important that they themselves work in such a GIS environment.

ENTERPRISE GIS DEFINED

In general terms, enterprise GIS can be considered, at its core, GIS data stored centrally and managed for multi-entity use, i.e. the enterprise. For a GIS to be considered an

enterprise-class GIS, a standard data model must be utilized, the data must be managed for enterprise use, and access to the data must be granted to the enterprise.

Standardized Data Model

For a GIS system to be considered enterprise class, the way in which features are represented with respect to data structure must be standardized at some level. Standardized data with respect to name of the data set and the associated attributes makes it easier to understand. It also has implications in the use of the data by individuals within the enterprise. Having a standard data model makes it more efficient to develop analysis and visualization tools for that data. One such example of a data standard is the Spatial Data Standards for Facilities, Installation, and Environment (SDSFIE).

In addition to a standard data model, maintaining information about the data, or metadata, is a critical element of an enterprise GIS. Using a metadata standard, such as the Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM), is important in an enterprise GIS environment. Not only is it important that metadata is created and maintained for each data set, standardizing the format and content of the metadata provides for consistent metadata which facilitates its application for enterprise users.

Data Management

GIS data must be managed for use in the enterprise. An enterprise GIS data management approach is formal in that policies regarding who manages and who has access to the data are necessary. To facilitate the management of the GIS data, a relational database management system (RDBMS) is typically employed. As most RDBMS don't provide spatial data management tools, middleware is necessary to accomplish this. The enterprise GIS becomes a combination of a back-end RDBMS server for storing the data, the desktop client for using the data. In between these is the intermediary or middleware used to spatially enable the RDBMS and facilitate data interaction between the client software and the data server.

An important aspect of data management is the organization of the GIS data within the enterprise GIS storage environment. A RDBMS has been identified as a suitable enterprise storage environment. When working within a RDBMS it is very important to organize the data in a manner which serves the enterprise efficiently and with flexibility. Using Oracle 8i RDBMS as an example, there are "users" and "user tablespaces". The data must be organized so that it provides for management of the data with respect to enterprise accessibility and supports the adopted standardized data model. Again, this is driven by the definition of the enterprise and the standard data model. Issues to be considered include how to store data for many locations, data projection, and data analysis and visualization requirements.

The most critical element with enterprise GIS data management is identification of the roles and responsibilities within the enterprise GIS. Roles and responsibilities must be clearly defined and must include who is responsible for data management.

Enterprise Data Access

To be an asset to the enterprise, the enterprise will need access to the GIS data. These users are identified in the design phase of the enterprise GIS. The access is either direct or indirect. Direct access is such that the user connects directly to the ArcSDE data for display and analysis. Direct access can provide for a full complement of access type to the data from storing, editing, and displaying the data. Direct access will typically have “higher” desktop client software requirements.

Indirect access is such that the user does not directly connect to the data for display and analysis but must access the data via middleware. ArcIMS services are considered an indirect access method to enterprise GIS data. Indirect access generally is limited to read-only data access. Additional indirect access methods might include data extracted from the enterprise GIS for use in a stand-alone environment. Indirect access software requirements can be minimal and include internet browser or freely-licensed simple desktop client software. Examples of freely-licensed software would include ESRI’s ArcExplorer and ArcReader.

As mentioned earlier, policies, roles, and responsibilities for data access must be developed. These need to address not only who shall be granted access to the enterprise GIS data but also what type of access they will have.

ITAM GIS RSC ENTERPRISE GIS

To appropriately design and effectively implement an enterprise GIS, the enterprise must first be defined. The enterprise for the ITAM GIS RSCs consists of three distinct entities: 1) the two RSCs, 2) HQDA and NGB, and 3) the broader ITAM community primarily located on Army and Army National Guard installations and various state Army National Guard Headquarters.

Inherent within the enterprise definition are the users of the enterprise GIS. The design of the enterprise GIS must not only take into account the structure of the enterprise, but also the various users, and their particular requirements. The primary users of the RSC Enterprise GIS are RSC analysts and technicians. Their activities include GIS database development, cartographic production, and spatial analysis and modeling. Other users include those outside the RSCs at various Army and Army National Guard locations throughout the United States, Republic of Korea, and Germany. Among these users are GIS analysts, GIS technicians, and Army range managers. These users rely on the analysts and technicians of the RSC to perform GIS database development, cartographic production, and spatial analysis at the RSCs and provide the resulting products to them. As part of the defined enterprise, these users also have access to the enterprise GIS data by either direct or indirect means.

The RSC Enterprise GIS consists of hardware and software for the storage, analysis and display of GIS data. Beyond the hardware and software, the RSC enterprise GIS has numerous policies, and identified roles and responsibilities. Various tools and cartographic templates have been developed and deployed which take advantage of the centralized data storage and standardized data model.

RSC REPOSITORY

The ITAM GIS RSCs collect, develop, and maintain large amounts of GIS data and metadata. Thus, the RSCs need a central place in which to store, maintain, and manage this data. The RSCs maintain such a GIS data repository at each of their respective locations. Although these two repositories are independent, they utilize the same policies and standard operating procedures which enable them to replicate each other's GIS data.

General Repository Configuration

The Repositories serve as a central place in which to store, maintain, and manage each RSCs GIS data. They are implemented using ESRI ArcSDE and Oracle RDBMS. Each RSC is responsible for storing and maintaining data for their installations for which they provide support. The Repositories will be considered duplicate, with responsibility for data collection, development, and maintenance relegated to the respective RSC for which an installation is assigned. Regional data is generally project-driven and collection, development, and maintenance of such data will be the responsibility of the originating RSC.

The Repository is implemented in a RDBMS to facilitate management of the Repository data. When practical and possible, the data stored in the Repository is SDSFIE-compliant. All GIS data stored in the Repository will have FGDC-compliant metadata associated with it.

Technical Requirements

The Repository technical requirements include both computer software and hardware. The core software required to operate and maintain the Repository includes Oracle 8i RDBMS and ESRI ArcSDE.

The ArcCatalog component of ArcGIS will be the primary data management tool. Other software required is the RSC-developed SDE Import/Export Tool. This software tool is utilized to facilitate the duplication of RSC Repositories. The SDE Import/Export Tool is a set of scripts which rely on ArcSDE command line utilities and Perl. The use of this tool and its required software components are described in detail in the [SDE Import/Export Tool User's Guide](#) and [SDE Import/Export Tool Install Guide](#).

As there are two RSCs and each are operated by different Army contractors, there are two different hardware and software configurations for the Repository that meet the general computing requirements. One RSC uses Sun Solaris running on SPARC-based Sun

servers. The other RSC uses Microsoft Windows running on Intel-based servers. Both RSCs are using Oracle 8i RDBMS and ESRI ArcSDE.

Repository Data

The Repository provides for a centralized place of storage for all ITAM GIS data and metadata. Other data considered as a part of the Repository includes such regional and national data sets determined necessary for the operation of the RSCs and as directed by the RSC Managers or the Government. The data primarily consist of vector and raster spatial data and its associated metadata.

Data developed by the RSCs will not be considered part of the Repository until it is considered complete in terms of the requirements under which it is being developed.

The CADD/GIS Technology Center of the Information Technology Laboratory at the U.S. Army Engineer Research and Development Center in Vicksburg, Mississippi has developed a standard for organizing, grouping, and attributing spatial data features. The RSCs utilize this standard where practical and possible. The RSC Repository data encompasses data from more than twenty SDSFIE feature classes ranging from military operations to property and environmental management. Table 1 is a partial list of those features for the RSCs develop and maintain.

By standardizing the spatial feature groupings, names, and attributes, it is possible to develop tools and templates that can refer to standard data structures. This improves the efficiency and productivity of the work performed by the RSCs.

Table 1. Partial list of SDSFIE Entities

| FEATURE | SDSFIE ENTITY NAME |
|---|---|
| Airfield Surface Site (runway, helipad, etc.) | airfield_surface_site |
| Buildings | structure_existing_site |
| Control Point | ngs_control_point or control_point |
| Elevation Contour Lines | elevation_contour_line |
| Flora General Vegetation Area | land_vegetation_area |
| Hazardous Materials Storage Sites | hazardous_materials_storage_location_site |
| Installation Boundary | installation_area |
| Military Ammunition Storage Sites | ammunition_storage_area |
| Military Drop Zone | military_drop_zone_area |
| Military Firing Point | firing_point |
| Military Forward Arming & Refueling Point | forward_arming_refueling_point |
| Military Impact Area, Dudded | dudded_impact_area |
| Military Impact Area, Non-dudded | non_dudded_impact_area |
| Military Landing/Pickup Zone | military_landing_zone_area |
| Military MOUT/MAC Site | Part of live fire or non-firing range feature class |
| Military Observation Points | military_observation_point |
| Military Range (Live Fire) | military_live_fire_range_area |
| Military Range (Non-firing) | military_range_area |
| Military Restricted Access Area | mil_restricted_access_area or land_restriction_area |
| Military Surface Danger Zone | mil_surface_danger_zone_area |
| Military Tank Trail | tank_trail_line |

| | |
|--|-----------------------------|
| Military Training Area | training_area |
| Military Training Sub Area (Sub Training Area) | military_training_sub_area |
| Military Wheeled Vehicle Refueling Point | Non-SDSFIE feature |
| Political Jurisdiction Area (boundaries) | political_jurisdiction_area |
| Railroad Centerline | railroad_centerline |
| Raster -- Digital Elevation Model | Non-SDSFIE feature |
| Raster – Hillshade | Non-SDSFIE feature |
| Road Centerline | road_centerline |
| Spot Elevation Points | spot_elevation_point |
| Surface Water Body Area | surface_water_body_area |
| Surface Water Course Area | surface_water_course_area |
| Surface Water Course Centerline | surf_wat_course_centerline |
| Transmission/Electrical Lines | electrical_cable_line |
| USGS Quadrangle Boundary | usgs_quad_area |
| Wetland Area | wetland_area |

Organization of the Repository Data

The GIS data in the Repository is organized by installation. For each installation's data set, there is a unique Oracle user and associated Oracle tablespace. This enables easy access control and flexible disk storage utilization. Regional data sets are grouped into one or more user/tablespace combinations.

Repository Roles and Responsibilities

The operation of the Repository involves many roles from policy, administration, and data management. Inherent in the various roles are data access rights such that only certain roles have data editing access.

- *RSC Managers*
The role of the RSC Managers within the Repository is that of general management oversight. The RSC managers are responsible for ensuring the standard operating procedures of the Repository are developed and implemented.
- *Repository Leads*
Each RSC has a Repository Lead. The Repository Lead at each RSC is responsible for ensuring the Repository is functioning and available. The Repository Lead is responsible for ArcSDE configuration and maintenance, coordinating Repository requirements with the Database Administrator, Repository replication, and internal RSC Repository technical support.
- *Database Administrators*
Each RSC has a designated Database Administrator. The RSC Database Administrator at each RSC is responsible for providing database support for the Repository Lead. Duties of this role include adding users and creating their database profiles.
- *RSC GIS Analysts*

The RSC GIS Analysts are responsible for the management of the repository data. Each installation or other databases is managed by an assigned RSC GIS Analyst. Duties include: Adding data to the Repository, ensuring metadata for each data set has been completed and is included in the Repository, and managing data access rights to the rest of the RSC staff.

- *RSC GIS Technician*
Access by the RSC GIS Technicians is restricted to data editing and access to support RSC tasks such as map production or analysis. RSC GIS Technicians are not responsible for data management but are responsible for complying with established development procedures.
- *Other Contractor staff*
For other Contractor staff performing RSC work, access to specific data is determined by the RSC Manager or GIS Analyst responsible for the particular data of interest.

Repository Duplication and Archival Backup

The RSCs are required to store each other's data so as to provide a complete duplication of the Repository.

The RSC Repository Leads are responsible for bi-weekly incremental repository data exchanges and quarterly full dataset exchanges between the two RSCs.

Full database dumps are kept indefinitely as a long-term archive that also serves as a full data set "snap shot." The quarterly exchange of full data sets also aids in reducing downtime in the event of catastrophic system failure.

Each exchange phase consists of one bi-weekly data set upload from the opposing RSC and one download from the local RSC repository and its delivery on either CDRom or DVD. The bi-weekly extraction consists of only spatial data and its corresponding metadata that has been revised since the last bi-weekly incremental database dump. Incremental dumps of only the changed data reduce database processing overhead and the volume of data necessary to complete the exchange.

The ArcSDE Import/Export Tool is used to facilitate the data transfers between the RSC repositories. This tool serves as the database interface and automation mechanism for all data extraction and importation. With the use of the SDE tool, data files are extracted on a per-installation basis and consist of all raster, vector, and metadata available for the given installation. Once data is transferred between the RSCs, data uploads are completed and reported as part of the QA/QC process in the subsequent bi-weekly exchange phase.

The Repository Leads provide a report of each database synchronization phase to the RSC Managers once the database synchronization efforts are completed. The Database Synchronization Reports include the status of the last database synchronization, the

installation data tables handled during each synchronization process, and the ArcSDE Import/Export Tool log generated during the synchronization process.

ENTERPRISE USE of the RSC ENTERPRISE GIS

Designing and implementing an enterprise GIS is done in order to meet the spatial needs of the enterprise. Some of those needs include cartographic production, spatial analysis, and digital display and query of GIS data. An enterprise GIS can accommodate all of these needs.

The RSCs work within an enterprise GIS environment. The U.S. Army's ITAM community is realizing actual benefits from the implementation and use of an enterprise GIS. The two most notable contributions to the ITAM community are two of the spatial products produced by the RSCs: Military installation maps and internet map services.

The RSC are currently developing high quality military installation maps for a select number Army and Army National Guard installations. The benefit of the RSC enterprise GIS to this initiative is the efficiencies that have been gained through the central storage and standardization of the data. The RSCs have developed ArcMap templates that require standard feature names and attributes.

The RSCs have developed an internet map service called MAGIC. The development of the internet map services is one way in which the larger ITAM community utilizes the RSC enterprise GIS. One advantage that ArcSDE and the enterprise GIS provides in the deployment of internet map services is that when authoring the map services and deploying them, efficiencies are gained by standard features names and attributes. For the deployment of the MAGIC internet map services this is very important in that MAGIC includes between one and ten map services for approximately 60 installations.

CONCLUSION

The RSCs have realized efficiencies by implementing an enterprise GIS. The system is documented and standards are followed to ensure the continuity of the program when the staff of the RSCs change and allow quicker integration into the RSC operations for new staff. The enterprise GIS is an invaluable tool for the RSCs to efficiently produce quality spatial products.

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