US Army, Pacific Theater Geospatial Database: A Model for Synergistic Geospatial Intelligence

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Abstract:
As the U.S. Pacific Command's Executive Agent for all Pacific Theater terrain analysis and geospatial production, U.S. Army, Pacific has established a Pacific Theater Geospatial Database (TGD). A collaborative effort with U.S. Army, Europe, SAIC, and ESRI, the TGD provides a unique geospatial data production, archive, and storage capability at a resolution not currently offered by any other Department of Defense system or agency. The TGD addresses key Homeland Security intelligence analysis requirements by consolidating and disseminating extensive Pacific Theater-unique digital geospatial data and products under a unified data model. In addition, the TGD allows intelligence analysts, planners, and operators to integrate seemingly disparate data to aid in pattern recognition, modeling, and visualization of the battle space.

Introduction

With over 52% of the earth's surface, 2/3 of the world population, and encompassing 43 countries, 16 time zones, and thousands of languages, the US Pacific Command (USPACOM) stands at the confluence of politics, social change, and geography. Despite these challenges, USPACOM also competes for scarce resources against other requirements that currently occupy the world's attention. Nonetheless, situational awareness remains an ever-present requirement. In an area where the oldest (but "current") topographic products date back as far as 1940s, a current geographic assessment is essential. The need for timely and relevant geospatial data runs like a thread through every possible operation, most of which involve operational US, ABCA commonwealth nations (American, British, Canadian, Australian), and allied military forces as well as state and local "first responders" (as is the case of Homeland Security). Therein lays the challenge: establish an enterprise-level GIS with multiple user inputs and outputs, and deploy the same across multiple security domains.

An Initiative

The initiative to tackle this problem has come to be known as the Pacific Theater Geospatial Database or TGD, the responsibility for which has come to rest on the 5th Engineer Detachment (Planning and Control). Functioning as the Geospatial Information and Services (GI&S) staff planner for US Army, Pacific[1], the 5th Engineer Detachment is a small cell of 22 military, government civilian and contractors; the detachment serves as the PACOM Commander's

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[1] US Army, Pacific (USARPAC) is one of four Service Component Commands in USPACOM; other Service Component Commands are MARFORPAC (Marine Forces, Pacific), PACFLT (Pacific Fleet), and PACAF (Pacific Air Forces). In addition, is doctrinal for an Army Theater Topographic Battalion to provide a planning and control detachment to the Army Service Component Command. In the case of USARPAC, the theater topographic battalion is the 29th Engineer Battalion (Topographic), also located at Ft Shafter, Hawaii.

executive agent for all in-theater geospatial analysis and production[2]. As a whole, these functions consist of managing geodetic survey, photolithographic production, and geospatial analysis. Thus, USARPAC geospatial forces are charged to coordinate with government and non-government entities as well as consume, value-add, and disseminate varied geospatial data sources and analysis products over multiple security layers and miles of ocean. This is an extremely broad task for a discipline largely focused on military applications of national geospatial data sources.

In addition to obvious difficulties such a scale, distance, and application, the following issues were addressed in this initiative:

1. Sustaining the initiative. Does the command have the requisite commitment to continue the program over the long-haul? Is the organization committed to providing skilled workers and periodic system upgrades?

2. Value adding. Can we be a co-producer of data to national agencies? How do we insure the quality gates are met from the Soldier on the ground all the way to central national geospatial databases?

3. Mapping versus analysis. Is it possible to build a spatial database for both cartographic mapping and analysis? What do we need to know about the data? What is the optimal balance between a robust and a graceful data model?

4. Disparate data sources. How do we incorporate the myriad of different data sources, formats and schemas? Our solution must be better than throwing everything imaginable format from USGS DLG (Digital Line Graph) to NOAA shapefiles to NGA Vector Product Format (VPF) data at a first responder during the initial hours of a homeland crisis.

5. Dissemination, sharing, releasability, and disclosure. How do we get this data to the user? What is the method to passing data back and forth? How do we address security constraints with respect to showing the data as well providing to users?

Sustaining the Initiative

A focus on sustainability was the centerpiece of our solution. Thus, we sought acceptance across Army and Joint Community domains, technology adaptation, and training. Satisfying the first requirement saw an early partnership with our peers in US Army, Europe (the 60th Engineer Detachment (Planning and Control)[3]). Although our contracting vehicles differed slightly[4], we jointly conducted requirements assessments and developed a data model. (Note: USARPAC and USAREUR remain committed to this effort by also standardizing all aspects of the TGD from technology versioning to architecture configuration management). Although seemingly academic in nature, the data modeling process was more than just a building block approach; it was an essential backwards translation of product output to business processes and workflow. As we

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[2] See UCINCPACINST 3881.1F

[3] The 60th Engineer Detachment (Planning and Control) forms our equivalent for US European Command (USEUCOM); they are headquartered in Schwetzigen, Germany.

[4] USARPAC contracted SAIC who, in turn, subcontracted ESRI; USAREUR contracted ESRI through US Army Topographic Engineer Center (TEC) who executed the contract.

moved into prototype delivery, regular collaboration continued between the two theaters over 12 time zones stretching from Hawaii to Germany.

In addition, through community input, we also mandated the following which we saw as essential for sustainability: dissemination at the lowest network domain possible[5], integration into C/JMTK-capable programs, and continuous capabilities-based marketing. For a military organization unfamiliar to such business functions, we found that focusing on niche markets and continual reinvention of our offerings as a service provider to been essential. Also essential was a strict enforcement of the "how" of data sharing across the community. Quite often we found passing CD-ROMs of large clusters of shapefiles to be the only possible solution. As the TGD effort grow, we see greater acceptance in more organized data sharing workflow: direct connection to the TGD geodatabases, disconnected editing, or extracts from the TGD. Lastly, with the assistance of the USARPAC Deputy Chief of Staff for Intelligence (G2), we firmly nested the TGD in the USPACOM Commander's Integrated Priority List (IPL), NGA's budgeting POM (Program of Merit) process, and the Army FY06-11 POM process.

Value Adding

In our design process, we were extremely cognizant of a typical analyst workflow that included data discovery, data extraction, and data preparation (most often clipping and reprojecting). Thus, we knew we needed a system design that would capture these preprocessing efforts while also imposing some degree of control and assurance over data accuracy and attribution. Moreover, we desired to work in a direction where, if further feature attribution can be ground verified, we should endeavor to bring that information back to national databases. It is for this and other reasons why we extended portions of National Geospatial-Intelligence Agency's (NGA) Geospatial Intelligence Feature Database (GIFD). Enabling this process was introduction of ESRI Production Line Tool Set (PLTS) which allowed not only mapping of feature classes and attributes into our TGD data model, but also the reverse. Thus, any improvements we made on original GIFD data (to include inclusion of other qualified data sources such as USGS, NOAA, FEMA, and local government data) could also be passed back to NGA in GIFD format. Additionally, PLTS tools enable us to capture all data in the TGD so that any data produced, whether it is extracting a road near a building target, is captured in the TGD and extracted with the same standards (extraction, accuracy, and attribution) as any other feature in the data model.

Mapping versus Analysis

As much as we desired to adapt from NGA's GIFD, we were unable to use the GIFD model "out of the box." GIFD feature geometry is not scale dependent—all features remain in one database. As such, adjoining feature segments of the same feature class might originate from vastly different sources and intended uses. For instance, one road line segment might be captured at 1:50,000 and be appropriate for that scale; an adjacent segment might have been captured at 1:250,000 or

[5] The three primary domains of interesting this article are JWICS (Joint Worldwide Intelligence Communication System) at the Top Secret level, SIPRnet (Secret Internet Router Protocol Network) at the SECRET level, and NIPRnet (NNN Internet Router Protocol Network) at the For Official Use Only level. Of these three domains, JWICS is of primary use within our segment of the intelligence community.

1:1,000,000 and be mapped to the 1:50,000 scale unless additional densification took place. More over, although we stand hopeful for the day when all data is captured at a 1:10,000 scale, automatic feature generalization currently does not exist that would allow appropriate processing and mapping at significantly smaller scales.[6] Lastly, we plainly needed to simplify our workflow processes and thus required a certain degree of unity between the cartographic mapping and analysis geodatabase.

Disparate data Sources

Although some data being ingested into the TGD will originate from local feature extraction, a majority of baseline data will derive from existing data sources. Why not just use existing NGA data as it exists today? One shortcoming of this practice is that most NGA data in the VPF (Vector Product Format) which must undergo preprocessing much in the same way a zipped Microsoft Word document ™ must be unzipped before use. Additionally, due to our Homeland Security requirements, there are a plethora of better data sources originating from USGS, NOAA, local government, and commodity data[7]. However, these data sources differ greatly in format and attribution. Envisioning taking all this data in multiple formats and schemas and providing it to an analyst is harrowing. Thus, a majority of our efforts focused on preprocessing this data, migrating it to a familiar data model and schema, and then disseminating the data as an extract or disconnected editing session.

Dissemination and Sharing; Releasability and Disclosure.

How do we share our rich spatial feature database with our broad array of users? From analysis of our user community, we surmised that only about 10-20% of our users require access for heavy analysis as well as read/write permission. However, the remaining 80-90% of our users are what we call "just draw me a map" crowd. Thus, for the former we envision direct connection into the geodatabases (such as through ArcMap or ArcCatalog). This implies operating on the same domain, which is not always possible. For those heavy users without sufficient bandwidth or connectivity, we are able to disseminate extracts of the larger spatial databases for the "disseminate/do not need the data back" users or check-in/check-out disconnected editing for those who plan to value-add to the TGD using our schema and data dictionary and return the same to us for value adding. For the latter crowd, a thin-client web interface with a handful of tools is wholly sufficient.

From Vision to Prototype

Although several years in the making, USARPAC and USAREUR TGD initiatives are being realized today. In essence, the TGD initiative consists of four primary segments: 1) civilian hires,

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[6] Under GIFD rules, a newer 1:10,000 segment would replace all smaller scale segments (1:50,000, 1:250,000, 1:5,000,000). Programmatic generalization currently is insufficient since such efforts fail to apply cartographic business rules. For instance, if we deleted every other vertices on a road segment where it crosses over a bridge, that road segment might no longer be correctly portrayed as coincident with a bridge line feature. Note: 1:10,000 scale segment used as example only.

[7] Commodity data is privately purchased data such as NAVTECH's ™ NAVSTREETS.

2) database design (includes data modeling and data schema), 3) database population and 4) data dissemination.

Civilian Hires. Although Moore's Law leaves us constantly amazed with new hardware and software tools, people have been—and will be—the cornerstone of art and science of the geospatial intelligence. Moreover, the demands placed on the analyst-Soldier are both great and varied. Every Soldier, be it an aviator or artilleryman, must dedicate time and effort to "soldiering" essentials—firing their weapon, physical training, road marches, etc. Military geospatial analysts are no exception to that rule. Thus, the hours remaining after mandatory Soldier training are few; technical training and production tasks are often minimized. It was fully apparent from the onset that, in order to establish this geodatabase, full-time civilian expertise was essential. Not only does civilian expertise comprise the corps capability, these experts also function as the continuity of processes and procedures. We cannot over estimate that is not a "throw me the keys, I'll figure it out" type operation; again, this effort requires commitment and sustainability.

Data Modeling. As previously stated, much of our schema finds its roots in NGA's GIFD. However, we found the GIFD's 6000+ possible feature classes and 2122 possible FACC-C combinations far too broad to suit our purposes. In addition, owing to the unscaled nature of the GIFD, as well as its use for both analysis and mapping, we adopted four broad resolution scales: global, strategic, tactical, and urban. It is worthwhile to note that these four data models do not differ just in scale, but also content and usage. As a result, although we may produce a 1:50,000 map from the urban geodatabase, this geodatabase has different usage and data behavior as well as topology. Broadly scoped, the TGD consists of four geodatabases, each used for cartographic and analysis purposes: global (1:5,000,000 to 1:1,000,000), strategic (1:500,000 to 1:250,000), tactical (1:100,000-1:25,000) and urban (1:25,000 to 1:5000).

Database Construct/Establishment. The TGD system architecture is shown in figure 1. Built side-by-side with our current analysis system called the Digital Topographic Support System or DTSS-Base[8], we made a small number of system improvements in additional hardware and connectivity. This ArcSDE implementation is made possible with Microsoft SQL-Server 2000 using one license: one SDE instance is used which passes data for each of the four SQL Server databases by adding configuration code words through the DBTUNE table. We selected Microsoft SQL Server 2000 for two primary reasons: 1) there is a current Army-wide SQL Server license making its use free-of-charge to us and 2) Microsoft SQL Server 2000 was maintenance and training is relatively simple and readily available.

Database Population. Database population consists of two separate possible activities: consuming existing data and/or producing new data from feature extraction. Based on the broad data types we would consume as shown in figure 1 (TGD Functional Architecture), we used ESRI Production Line Tool Set (PLTS) version 3.1, defense solution. PLTS allows us to, given our schema, map at the feature- and attribute-level from known datasets. After ingesting other data into the TGD

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[8] Current DTSS-B build 8.1 consists of ESRI ArcGIS 8.3 (ArcInfo version), ERDAS Imagine 8.7, and SOCET SET 5.0. Thus, gravitating towards ArcSDE 8.3 and ArcIMS 4.0 environment were natural in our skill sets. Notable is our desire to limit our technological horizon to ESRI 8.3 product versions. We saw little to gain in moving forward to 9.0 technologies when we would be unable to provide readable 8.3 personal Geodatabase extracts to our military users still on the 8.3 versions for some time.

model, we then run a series of quality control checks such for valid attribution and topology. After this data has passed the quality gates, it is then brought into a version of the TGD SDE geodatabase where it is reconciled against a current version and posted. We have found this step to be a sword that cuts both ways. Although a strict data model is essential in many ways, it can greatly confound our efforts to get the data into the TGD. Also, this step requires the single-most concentrated effort to screen cross-reference tables and logs—if the analyst consuming the data is not attentive, they may never know what features were retained or dropped. Still PLTS shows great promise for our implementation, but only given the necessary skill sets to see it's fully potential[9]. In stark contrast is creating data by feature extraction. Again, we use PLTS, but more in the lines of managing our workflow. Given the PLTS Job Tracking Extension (or JTX, included as part of the Defense Solution), the floor supervisor is able to define AOI and specific features to extract well in advance. Thus, when an analyst begins a job, he/she is zoomed to a defined AOI, a version of the geodatabase is spawned, and the defined list of features upon which to collect is listed in the table of contents window[10]. During the extraction process, "favorites" for attributes and metadata can be set making extract a fairly simple process. In addition, given an extraction guide and basic photo interpretation rules, the extraction can focus on the task at hand. In this manner, we find that frequent reconciling and posting (hourly or before any break) is essential.

Data Dissemination. Estimating that our user segment is approximately 10-20 % power users and the remaining 80-90% are of the "just build me a map" crowd, a majority of our efforts involved delivery of our data using a thin-client ArcIMS interface. Within the intelligence community lies the JIVA-V (Joint Intelligence Virtual Architecture-Visualization) initiative. Born out of the efforts of the Defense Intelligence Agency (DIA), JIVA-V is an ArcIMS implementation that brings the tools for viewing, querying, and displaying data to the community. JIVA-V implementations are no longer solely belong to DIA. Rather, it is a loose consortium of users that share developments across the community. Thus, if an organization wishes to add a specific customization to a JIVA-V interface, and is willing to share these efforts with the community, these new capabilities are generally rolled into the next JIVA-V revision.

A new and exciting extension of JIVA-V is DGInet (Defense Geospatial Intelligence Network). DGInet is a practice 180 degrees opposite of geographynetwork.com which implements a "mother of all metadata servers" that forces pointers to other data providers. Rather, DGInet uses a system of metadata nodes. Thus, when a user enters a DGInet site, that site queries a UDDI server that executes a discovery of other data currently being served to the community. As a result, the site can function as an onramp to the DGInet, see other content providers, and search of productions (any product with a spatial extent—maps, text files, reports, bulletins, web pages) ACROSS the community. Given like system availability, if the user were to go to a sister DGInet site, they would be given like data choices that he could consume and from which he could build products. (See Figure 5 (TGD/DGInet Node Interface).

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[9] We are currently also evaluating TAIC's Enterprise Data Migrator or EDM for a possible substitute to PLTS based on simplicity alone.

[10] Although we have the ability to extract using stereo imagery in SOCET SET, training and proficiency has been a significant hurdle. Thus, a majority of our feature extraction is using monoscopic imagery, either commercial purchases, NTM, or DPPDB frames.

Dissemination across security domains is relatively straightforward. Since most of our processing occurs on the SIPRnet domain, migration occurs to higher security networks in an air-gap fashion through replication to that network's JIVA server (one web server and one database server on each domain). For migrating data to unclassified domains, replication again is used, but horizontal and vertical filter screens security metadata written in each feature attribute table.

Summary

The US Army, Pacific and US Army, Europe Theater Geospatial Databases allow for migration to a truly enterprise geospatial intelligence system. A cluster of combined mapping and analysis production databases, the TGD provides near-real-time dissemination to formerly disparate data producers and consumers as well as and value-adding to national-level databases. In addition, the TGD allows us to collect and edit features once and cascade updates across dynamic product lines and data streams. With only seven months from concept to implementation across both the Pacific as well as the European theaters, it's easy for others to share our excitement in this burgeoning initiative.

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Attached Graphics:

p21391.jpg	Figure 1. TGD Functional Architecture
p21392.jpg	Figure 2. TGD Software
p21393.jpg	Figure 3. TGD Data Loading
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p21395.jpg	Figure 5. TGD/DGInet Node Interface
p21396.jpg	Table 1. TGD Scale Factors