GeoGlobe and the Seven Layers of Analysis

By SPC Matthew C. Gossard, GEOINT Analyst, First Cavalry Division and RC-E/CJTF-1

Foreword

The RC-E/CJTF-1 GEOINT team has achieved a truly innovative approach to the visualization of our Afghanistan Operating Environment during our rotation as the headquarters for coalition forces in Eastern Afghanistan. The incorporation of a common visualization tool and the ability to underpin all source analysis with a visual, on demand, tailored presentation is a fundamental element of our approach to creating decision quality actionable intelligence. The complexity of the Afghan operating environment demands both a structured analytic process and a user friendly visual presentation capability to display layered, interrelated data sets for the both the analyst and the operator. Through tailored display of relationships, patterns and knowledge emerges, without cluttering the picture with lesser relevant facts that serve to create con-fusion rather than fusion. Specialist Gossard, a key member of the division's GEOINT team, captures the First Cavalry Divisions process and technical framework in this article and offers the GEOINT community an excellent primer on placing GEOINT at the forefront of intelligence and operations support for combat forces currently in Afghanistan and provides insight applicable for operating forces involved in future conflicts.

LTC David Pendall, G2 First Cavalry Division and CJ2 for RC-E/CJTF-1

Introduction

The difference between data and information is context. Without background or basis for comparison, the value of the data is limited to a single scope. The goal of the Seven Layers of Analysis is to consolidate a vast array of both current and historical data into a single user-friendly platform to create a common operating picture for the Afghanistan operational environment, removing the need for multiple systems or software applications. The Seven Layers builds its data from the most fundamental geospatial layers up to the active threats operating throughout the country, providing the user the ability to visualize a comprehensive, tailored view of the current condition of the operational environment. This paper will cover the origins of the Seven Layers of Analysis, the analytical process behind the development of each layer, the technical processes necessary to maintain the system, and potential expansion beyond its current operations.

The Seven Layers of Analysis has already impacted an extraordinary amount of users within Regional Command – East (RC-East) through it remains at a relatively early stage. Users of the Seven Layers structure for analysis span from decision makers at the Regional Command

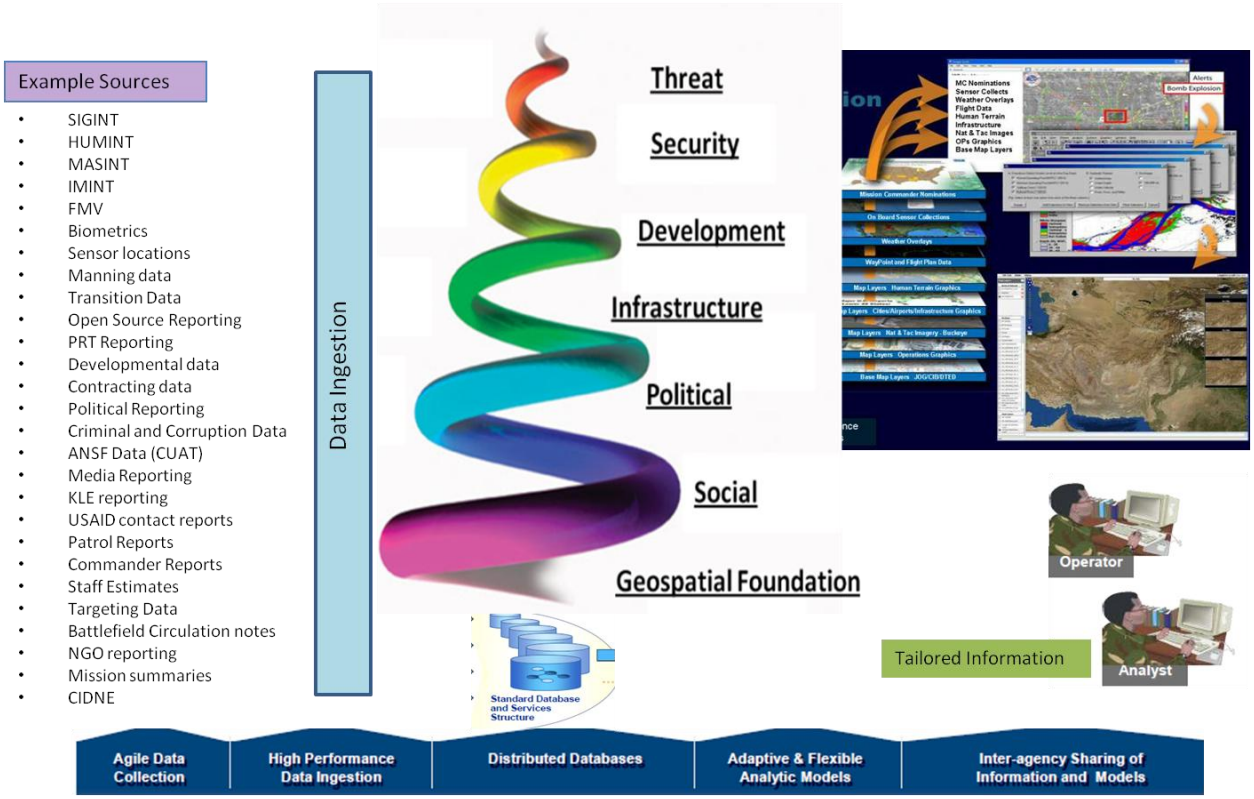
Headquarters to the Company Intelligence Support Teams (COIST) in the most austere areas of the battle space. Paired together with the Army Geospatial Center's (AGC) GeoGlobe, the Seven Layers have given users an unprecedented ability to users throughout Afghanistan for on-demand access to a wealth of information, which in the past would have required extensive preparation and multiple systems to visualize. The structure also provides endless possibilities to how the data can be visualized, analyzed, and create fuller understanding of complex problem sets, all contextualized and customized by the user.

The inspiration and planning of the Seven Layers of Analysis began well before Geoglobe was selected as the geospatial visualization service of choice for the project. Lieutenant Colonel David Pendall, the First Cavalry Division G2, envisioned creating a structured analytical process spanning the entire operational environment. The goal was to form a method of analysis incorporating multiple information and intelligence sources into a single platform. Almost as important as the data, however, would be the way it was structured. The data needed to be structured in a manner that was conducive to an analytical mindset. Information needed to be categorized according to its type, but placed in a user friendly environment that allowed the different layers to be integrated on demand for a variety of analytical assessments.

Developing the Seven Layers Concept

The core of the Seven Layers process revolves around creating contextual relationships between differing categories of information. The critical requirement is the capability to easily display and compare the selected data sets by the analyst or staff user. Each of the seven layers are overarching categories (meta layers) to catalog information. When a particular layer is opened a wide range of data sets (micro layers) become available that can be individually turned on and off (visualized) at the analyst's discretion. This feature provides the user the ability to evaluate and relate information that at first look may have not appeared to correlate. Compiling a vast data set and including it within a 3D environment removes the data mining and organizational process for the user and allows immediate comparison, analysis, presentation, and most importantly, understanding.

The Seven Layers concept begins with the geospatial foundation. Annotated natural features such as valleys, mountain passes, and rivers provide the foundational datasets within the geospatial layer. Also included are slope maps that based off of terrain, display areas that can be traversed by vehicle or foot traffic and areas that are level enough to be used as a helicopter landing zone. Weather data also plays a role in the geospatial layer. Within the first layer, the user can view a variety of dynamic information on the weather not just in Afghanistan but in the entire region including air transit corridors.



Initial Seven Layers concept

The second layer centers on the social framework of the country. The data focuses not just on where people live, but also their organization. Basic social data such as city and village locations are supplemented with population density and annotated areas of specific tribal, ethnic, and religious groups. This layer also contains atmospherics measuring the populace's support for the Afghan Government, Afghan Nation Security Forces, and Coalition Forces.

Infrastructure comprises the third layer, which ties in heavily with the social aspect. Infrastructure consists of anything man made that causes or supports human interaction. Lines of communications as well as essential structures such as dams, bridges, and karez systems (or underground irrigation channels) are included within the third layer. Infrastructure also includes cell phone tower data with detailed information on specific nodal locations and signal propagation coverage.

The fourth layer consists of both formal and informal political information at all levels of the Afghan Government and society (local powerbrokers, tribal elders, village councils). International boundaries as well as provincial and district boundaries for both Afghanistan and

Pakistan are annotated. The political layer also contains detailed information about the primary members of the provincial and district government with an included assessment for each of them, providing the user an immediate review of the governance structures in the selected province, district or village.

Development and infrastructure construction for the country is the focus of the fifth layer. The data within this layer displays information regarding public works projects that benefit the people at the district and provincial level, as well as changes in the community brought about by development which impact the way people will interact such as new roads, electrification, schools, etc. The layer not only contains current projects but also historical locations and information about past works. Each category is based on the status of the project and is color coded allowing a quick look of the stages of projects in an area. Selecting a point provides detailed information on the project type, goals, priority, and cost. The development layer also allows the user to view where Commanders Emergency Relief Program funds are being utilized and how these relate to the situation and populous of the area.

The subject of the sixth layer is security. The most important and necessary component to the security layer are Afghan National Security Forces and Coalition Force mentorship locations throughout the country. The layer also contains boundaries for major task forces, minor task forces, and the Afghan National Security Forces. To accompany the task force boundaries there are also named areas of interest for each of the battle space owners. Operational graphics for named operations of concern to the division and campaign plans have also been added to the layer to allow interaction with other datasets in order to enhance what has traditionally been a static product.

The seventh layer contains the current enemy situation (confirmed and templated) for the region, developed by CJ2 analysts and vetted with each Battle Space Owner (BSO). The seventh meta-layer of the Seven Layers is intentionally the last. The seventh layer visualizes the threat throughout the battle space and is best understood when viewed in context of the previous six meta-layer relational analysis. To further enhance the enemy visualizaton, both current and historic densities of kinetic events are provided, available by month, season, and year. Gaining understanding the threat necessitates the use of the other six layers in order to gain perspective on why and where events occur. Without integrating the threat with supplementary data, the relevance and significance diminishes as the context is lost.

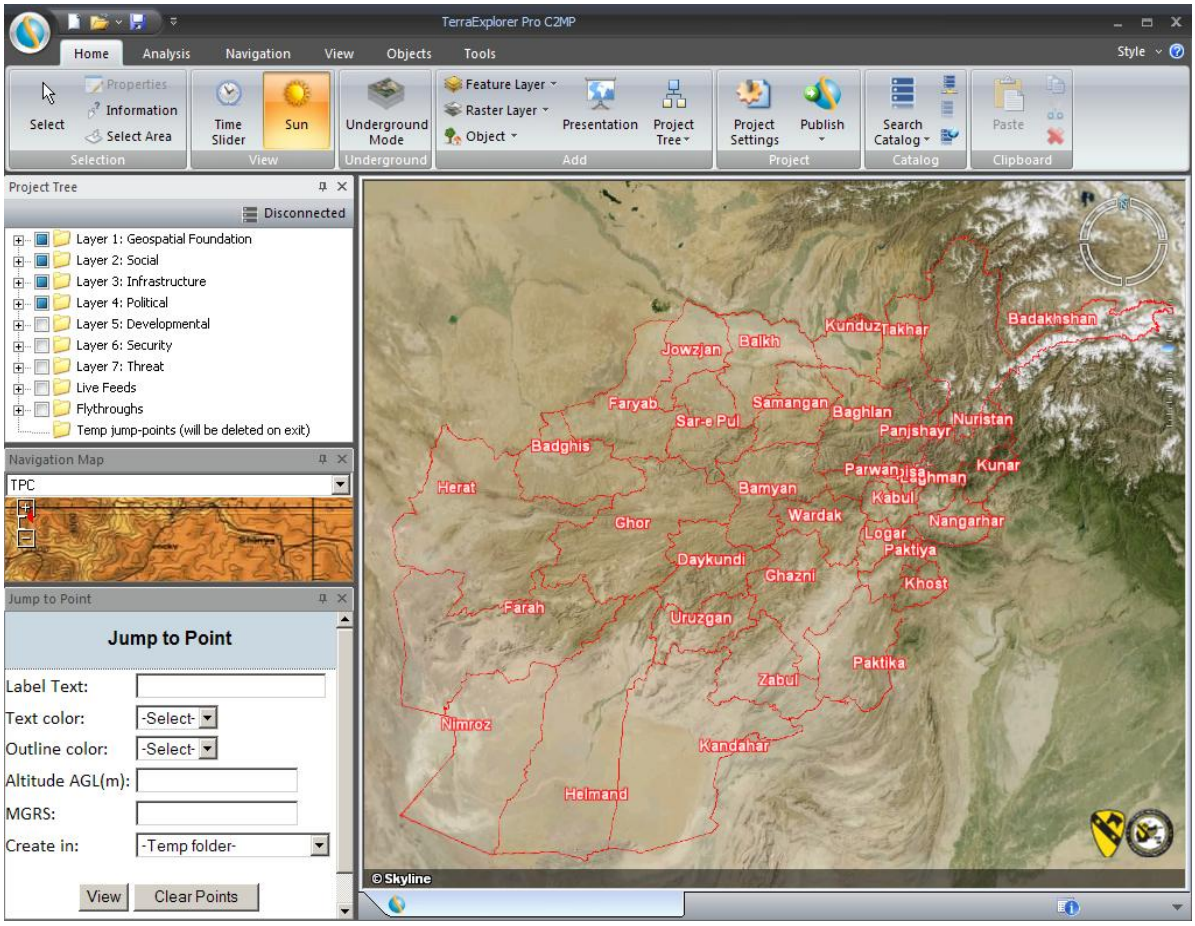
The Seven Layers process was initially tested during the First Cavalry Division headquarters Military Readiness Exercise (MRX) in preparation for deployment to Afghanistan as the RC-East Headquarters. During the MRX six paper maps were created, each representing one of the first six layers. The seventh layer, threat, was a transparency that could be overlaid on any of the other layer maps. By overlaying the threat on any of the other maps the benefit

of the concept was immediately evident. An example of its effectiveness was when the threat layer was overlaid to the security layer. Instantly there was a visible correlation between the gaps in Coalition Force presence and their effectiveness, where governance was strong or weak, and where demographics trended in support or opposition to the government or the insurgency, etc., viewed in relation to where the insurgency was actually operating. At that point it became clear to the staff that this tool would be crucial in providing a greater understanding of not just the enemy situation, but how it relates to every other dataset that was displayed in this manner. The concept was proven to be successful, though a highly manually intensive effort, but the actual system in which it would be employed was still undetermined. The solution wasn't clear until the Division arrived in Afghanistan.

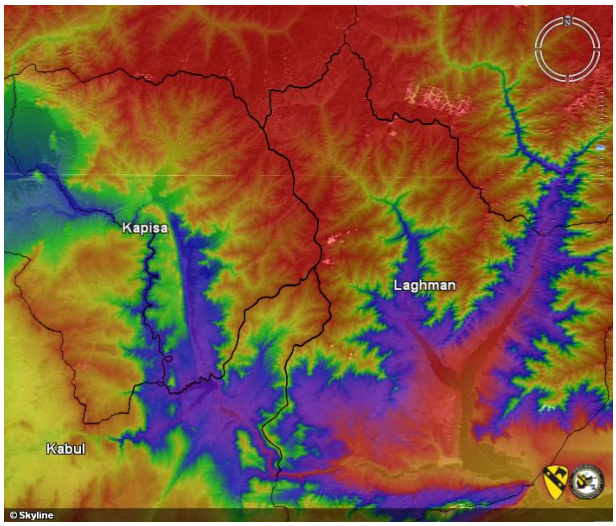
The first time the GeoGlobe software and servers were used by First Cavalry Division was upon arrival in theater. The outgoing unit's geospatial intelligence cell was using the software heavily for 3D geospatial visualization. The 101st Airborne Division was relying on the GeoGlobe platform more than the established Google Earth servers already available. The capabilities of the tools within GeoGlobe were explained and its impact was evident by the extensive use of the software in daily imagery production. The division G2 and the GEOINT team critically examined the software and server infrastructure already in place. The power and utility was clearly apparent; GeoGlobe was the ideal software for visualization of the Seven Layers.

GeoGlobe Architecture

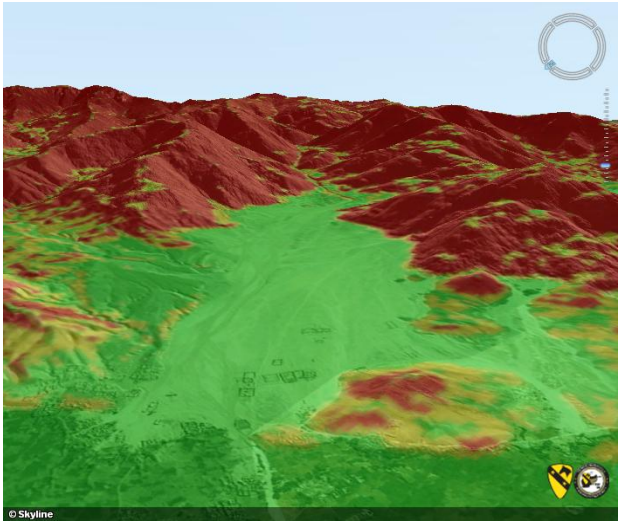
The primary interface for the user is the software TerraExplorer. TerraExplorer contains an abundance of unique features that made it the leading candidate program to incorporate and visualize the Seven Layers. The built-in GIS capabilities in TerraExplorer proved far more comprehensive than what is available in other visualization tools. Unlike most GIS software that requires extensive training and experience for even the most simple of functions, TerraExplorer provides a set of intuitive tools to complete a variety of geospatial tasks. The user can easily create contour maps, slope maps, and terrain profiles on the fly providing instant visualization of the terrain. The flood analysis tool can be used to quickly calculate the area affected and water depth in the event of a flood. TerraExplorer also provides a critical capability to create line of sight viewshed analysis in a matter of seconds. The viewshed tool allows the user to create a range fan that depicts what area is and is not viewable from a precise point and height specified by the user. This tool has been utilized extensively to create accurate portrayals of view from possible enemy positions and Coalition Force locations, enhancing force protection and predicting enemy courses of action. These comprehensive tools are simply not built-in features found in commonly fielded visualization platforms.



TerraExplorer



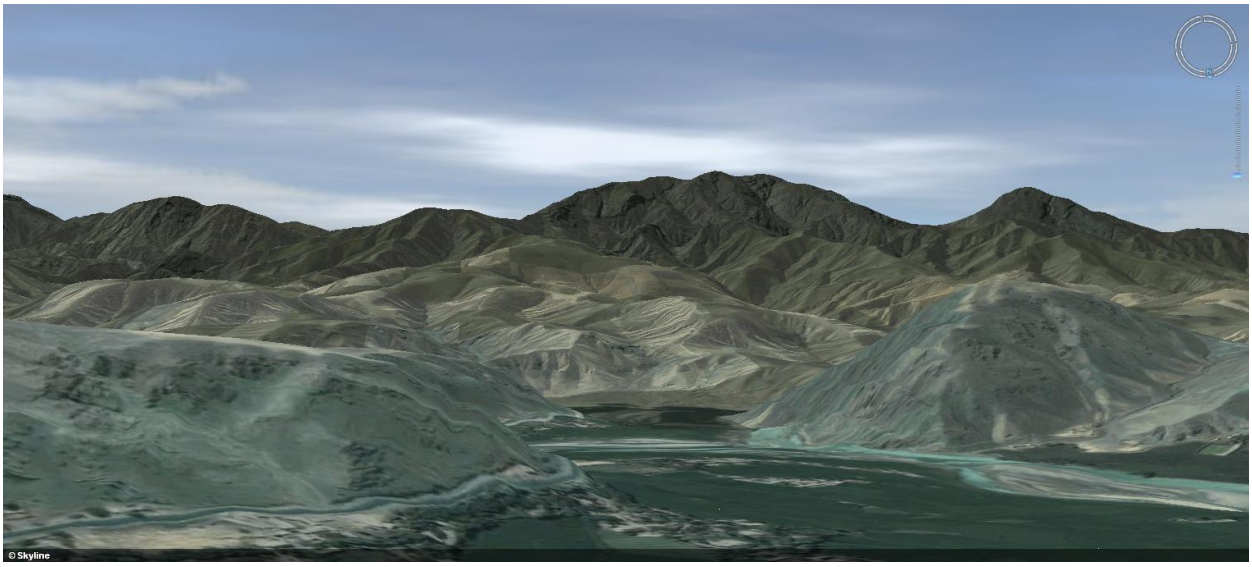
Contour map



Slope map

The software required to update and maintain the globe was also an important aspect to GeoGlobe's selection. The GeoGlobe package contains Skyline Software's SkylineGlobe Enterprise Bundle, which includes specific tools to maintain and manage data and server applications. The primary software for development and management is the TerraGate Manager, which controls all major functions for the globe. Through the TerraGate, both the terrain service and the spatial framework service (SFS) is monitored and maintained. The terrain service distributes all of the imagery and digital elevation models (DEM) on the globe. Within the TerraGate, imagery and DEM directories can be added as well as the cache size for terrain data adjusted to facilitate lower bandwidth connections. Additionally, TerraGate logs the primary functions and errors occurring within the service and prominently displays the last error for immediate notification to the system administrators. The SFS maintains all static data sets stored in the Seven Layers. The static data fed into the SFS consists of caches created from ArcGIS shapefiles. Converting shapefiles into caches is another step to improve streaming speed and reduce bandwidth load to the user. The caches are fed into the SFS and are configured to provide optimum streaming size for maximum efficiency. The SFS interface also tracks requests for each data set within the Seven Layers, allowing the system administrators statistics on how frequently particular data sets are used in comparison to others. The SFS also contains the ability to connect to and leverage external databases and stream dynamic data through the Seven Layers to the user.

TerraBuilder is another essential piece of software in the SkylineGlobe bundle, as it allows for the system administrator to easily view, edit, and upload imagery. The software provides a simple user interface to view the specifics and location of each tile of imagery. Imagery can be quickly edited and the maximum and minimum viewing height set to facilitate faster imagery streaming to the user. TerraBuilder also supports several common formats of imagery, a feature not found in most geospatial visualization tools. Having the flexibility to support numerous imagery formats creates a much more diverse set of imagery available for upload to the globe. The simple and immediate ability to modify and update imagery has allowed the system administrators to accept ad hoc imagery update requests during time sensitive engagements and events in theater, providing users with the most recent ortho-rectified, or terrain corrected imagery available.



Terrain visualization

Local Data Integration

The data loaded to the Seven Layers locally consist of two major categories, raster and vector. Rasters consist of all the imagery, maps, and elevation data currently viewable on the globe. Traditionally, imagery streaming has been a challenge in remote locations with reduced connection capacity. The tool wouldn't be effective if it couldn't be used by locations with limited bandwidth. The proprietary imagery format and the design of GeoGlobe's imagery streaming service allows for low bandwidth locations to utilize the software with full capability. The globe displays only lower resolution imagery initially and as the user zooms into a specific area, high resolution imagery streams and comes into view, eliminating the loading of superfluous images and decreasing bandwidth strain.

The high resolution imagery used on the globe is primarily BuckEye provided by the Army Geospatial Center. BuckEye provides the user with 10cm high resolution, ortho-rectified, color imagery. Panchromatic or black and white imagery would also have provided high resolution, but was not utilized in order to maintain a more natural appearance for users without an imagery analysis background. In areas where BuckEye coverage is lacking, SPOT and Landsat commercial imagery is used to fill in the gaps. Another important aspect to the imagery on the globe is the classification. All imagery available within the Seven Layers is unclassified, allowing for the classification of the product being built to be determined by the data presented, and not to be limited by the classification of the imagery background. This piece is essential to the joint environment operating within Afghanistan due to the critical need

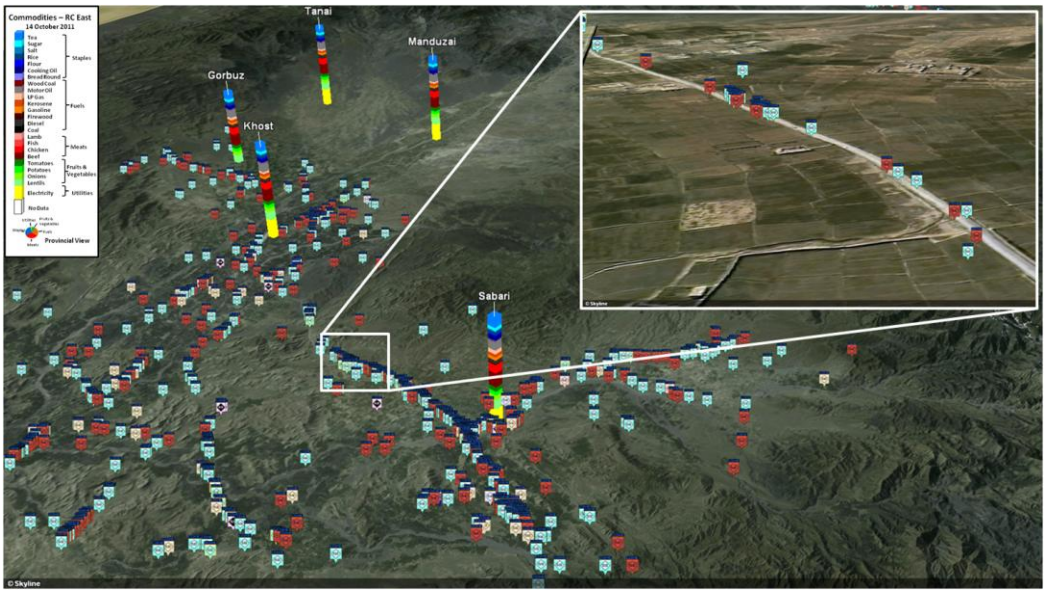
to cooperate and share information and intelligence with our coalition partners. A globe is also maintained on the Afghan Coalition Mission Network (CENTRIX) to provide coalition partner's accessibility to the Seven Layers.

The Seven Layers utilizes digital elevation models derived from a technique known as inter-ferometric synthetic aperture RADAR, or IFSAR, to visualize the terrain of the country. Use of IFSAR in the Seven Layers provides a more detailed and realistic topographic representation of the country and allows greater precision in line of sight viewshed analysis and slope map creation. The level of precision provided with IFSAR is not generally found in similar geospatial visualization tools.

Vector data for the Seven Layers is compiled from a range of sources. Vector data consists of all the points, lines, and polygons viewable on the globe. The CJ2 GEOINT Terrain Team provided a majority of the initial vector information from their databases to the layers. As development progressed, supplementary geospatial information from ISAF Joint Command was introduced as well as intelligence shapefiles built within the CJTF-1 CJ2 section. Live feeds, one of the most important features, were the last critical pieces to be added.

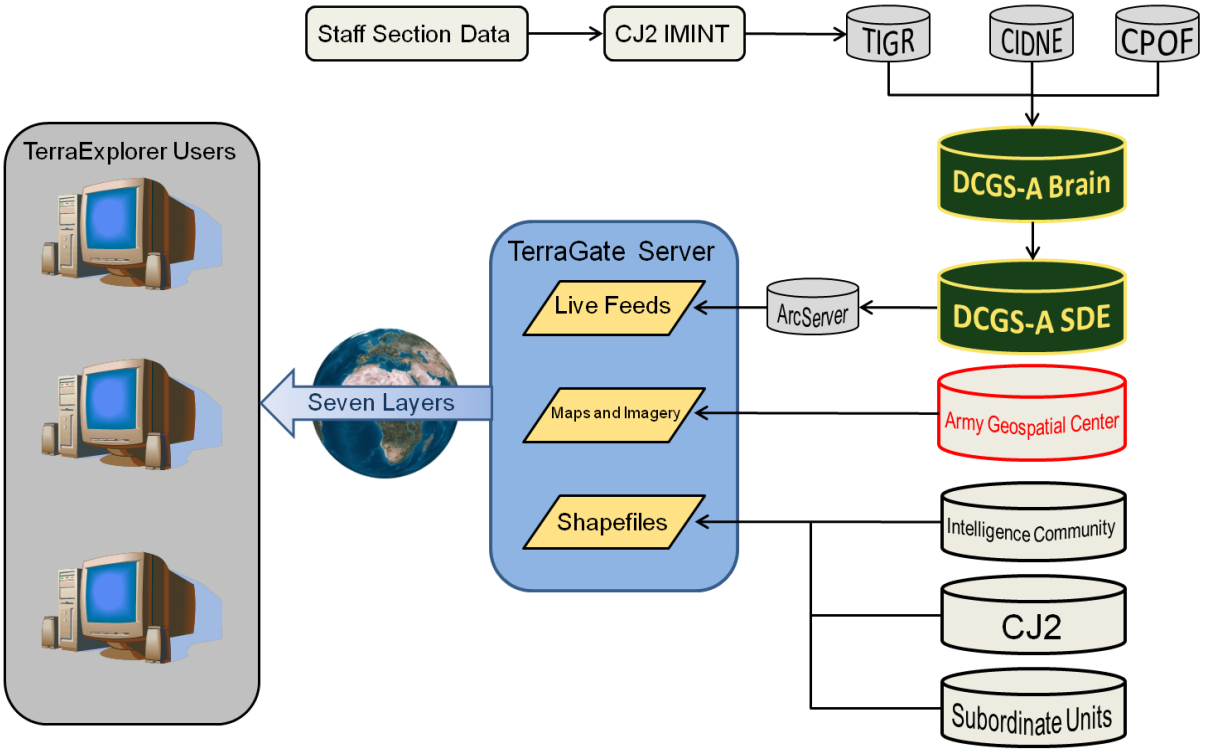
Database Reporting Integration

A majority of the live feeds integrated into the Seven Layers are from two distinct sources. CIDNE (Combined Information Data Network Exchange) hosts an abundance of reporting and is also the reporting tool of record for Significant Activity, Human Intelligence, Explosives Ordinance Disposal, and Weapons Intelligence Teams within Afghanistan. TIGR (Tactical Ground Reporting System) offers tactical level information and intelligence from the company level and below. TIGR differs significantly from CIDNE in the sense that data is directly reported from the lowest echelon. While CIDNE offers finalized reporting, TIGR provides immediate raw data from service members on the ground. Blue Force Tracker is also currently ingested through the Seven Layers, providing the user detailed, geo-referenced information on air and ground assets in real time throughout the battlespace. Other independent sources integrated into the Seven Layers include tactical interrogation reporting (TIR), IED maker locations, and Commanders Emergency Relief Program (CERP) sites. Incorporation of these databases provide an extensive array of live reporting to augment the static data the Seven Layers already contains and establishes a single location to view multiple sources concurrently, all within an interactive 3D environment and without requiring data mining for the user.



Live feeds

These databases are linked to the Seven Layers through the Distributed Common Ground System-Army, better known as DCGS-A. DCGS-A ingests several types of reporting and provides an intelligence repository for the Army. Live feeds in the Seven Layers are possible by using the DCGS-A repository through a spatial database engine (SDE). The SDE provides a central location to access the live reporting feeds, or web feature services (WFS), and view them through several types of geospatial software. The GeoGlobe software is able to consume WFS and display the data on the globe in near real time. Through pre-existing infrastructure, GeoGlobe and the Seven Layers are able to receive and further disseminate live feeds from external databases and geo-reference them for the user.



Seven Layers architecture

Staff Data to Command Information

Integrating data from the staff sections is also essential to the Seven Layers process. In many cases the staff sections collect, analyze and create analytical products to meet their ends without further dissemination, resulting in the historical products and analysis being lost when a new unit assumes the mission. Working with TIGR and DCGS-A, a process has been established to disseminate the collected staff information. The process begins with the CJ2 GEOINT cell receiving a quality dataset from the staff section. The GEOINT cell vets the data to ensure it is in the proper format and possesses the required information for ingest. Once the vetting process is complete, the data is then sent to TIGR. TIGR personnel ingest the data into their database and it is automatically ingested by DCGS-A. Once the data is ingested within DCGS-A, it is available through the DCGS-A SDE and can be pulled through WFS into the Seven Layers. Ingest into TIGR and subsequent distribution through the DCGS-A architecture ensures availability of the data outside of the Seven Layers user base.

The ability to integrate and disseminate staff section information through the Seven Layers provides new information and intelligence sources and products to a much wider audience than before. The data that has already been provided by the staff sections has proven to be a tremendous benefit. Information on atmospherics, commodities, and reintegration efforts, detailed to the village level, have already been provided and are currently being distributed through the Seven Layers. As development continues, further collaboration and

integration of information from the staff will continue to improve the user's ability to identify and understand the multifaceted problem sets Coalition Forces face in Afghanistan.

Implementation and Dissemination

On initial implementation, the Seven Layers was only available to a limited number of users. As the project expanded, the need for wider distribution became evident. The Seven Layers in its infancy was server based. If a potential user did not have permissions to the server or was outside of the Afghan domain, then they had no way to access the data. The architecture was modified to a web based format and ports opened to allow open access. In conjunction with the new web based infrastructure launch, a web page has been added to the CJ2 portal and a mass email advertising the product distributed. The user base of the Seven Layers quickly expanded, and in response, teams were forward deployed to provide training to all of the Brigades within RC-E to ensure users were aware of the full capabilities of the data and the software. The Seven Layers are used by units in RC-East, and CONUS units in the planning stages of deployment to Afghanistan. This tool is providing incoming units the ability to visualize the battlefield in a 3D environment along with all of the data maintained within the Seven Layers. This capability to display and interact with a real time, up to date common operating picture of their respective battle spaces at home station has never before been possible.

The Way Ahead

Currently, data ingest is primarily focused within RC-East. Limited server management personnel only allows for the upkeep of the immediate region. An integrated system could be implemented that would consolidate data sets from all regional commands into a combined COP for the entire country. The basis for this country wide integration is the same format used to stream and display the Seven Layers currently.

The file format used to open the Seven Layers is a .fly file. A .fly file simply points to locations of data sets and displays them on the globe. A .fly file can point to any number of different data sets from any location. The .fly file that holds the Seven Layers currently points to data within the local TerraGate server and live feeds from the DCGS-A SDE. It could just as easily point to an additional TerraGate server to pull data from. A network of TerraGate servers at each RC Headquarters could be created to combine and distribute region specific information and intelligence to users throughout the country.

In order for this vision to work, the system would require complete cooperation and sharing throughout every level of command. Without support from the lowest echelons, the effectiveness of the system would be severely hampered. Geo-referenced information and intelligence would have to move upwards up to the IJC data managers and continue to be

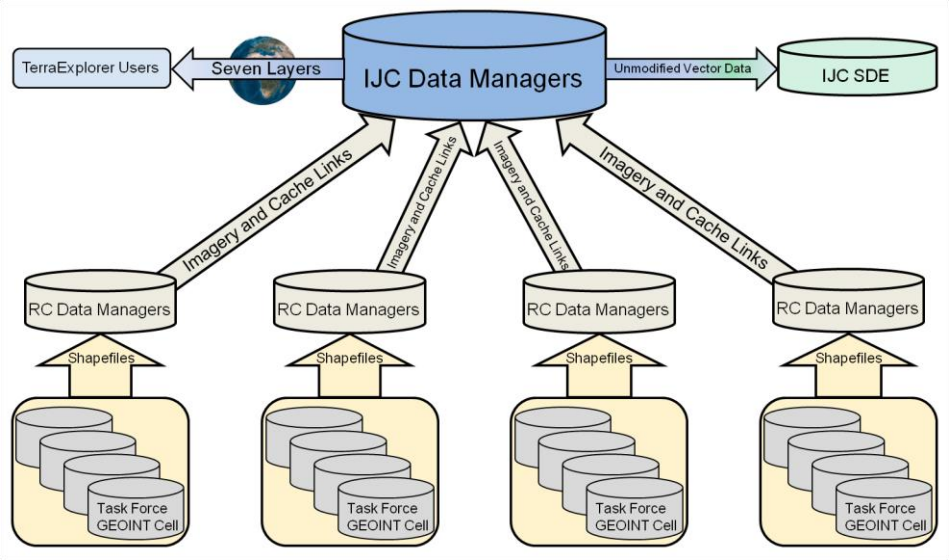
updated as necessary. Positions and data management would be required to be created at Division and Corps echelons to create a combined Seven Layers for the country. There would also be a need for the GEOINT section at each major task force to act as lower level data managers and send pertinent data sets to the RC. The following outline briefly describes the roles and responsibilities each organizational level would have to provide effectively create a country wide Seven Layers.

The GEOINT sections at each major task force would carry the responsibility of maintaining geo-referenced information and shapefiles created at their level and below. This practice is already in use but they would also be required to establish a channel to direct this information to the RC data managers. It would be critical for the GEOINT section to not only pass on the initial data, but also send updates as the original data sets change. This task would be relatively low maintenance and would not require extensive extra responsibilities for the GEOINT section.

The RC level data managers would have two major responsibilities. The first would be establishing a flow of information from all subordinate units. A database at each major task force could be established to add and maintain the minor task force information. That database would be regularly accessed by the RC data managers to retrieve shapefiles for processing. Once the RC managers have the shapefiles they would be converted to caches and uploaded to the TerraGate server. When the data is prepared a hyperlink would then be sent to the IJC Seven Layers data managers that would directly connect them to that particular dataset within the RC level TerraGate server. With that hyperlink the IJC data managers would be able to add the dataset to the Seven Layers .fly file that would be available to the entire country.

The second responsibility of the RC level data managers would be to update imagery for their AO. The RC managers would be required to acquire, format, and upload high resolution imagery into their TerraGate server. Dividing responsibility of imagery updates creates a much more manageable area to maintain, also allowing the managers the opportunity to understand the particular problem sets and distinct characteristics in their respective region and incorporate that knowledge into where and how often the imagery is updated. The freedom to update imagery as necessary would also allow the data managers to update imagery immediately as required during time sensitive events in their battle space, in order to distribute the most accurate imagery available. Imagery streaming would be organized very similarly to the information sharing process. The IJC managed .fly file would link back to the imagery databases of all the RC TerraGate Servers. Lag time from pulling imagery from servers throughout the country would be negligible, as users in CONUS are currently utilizing the Seven Layers server located in theater without issue.

The roles and responsibilities of the IJC data managers would be to incorporate information and intelligence already being created at the highest level and also to consolidate and organize the information coming from the RC TerraGate servers. Separate regional portions of data would come from each RC and would need to be combined and displayed as one complete collection. The IJC managers would also be required to distribute the Seven Layers by maintaining a website with links to both download the software and open the Seven Layer .fly file. Further dissemination would be required by distributing the Seven Layers shapefiles through an SDE to provide maximum dissemination. This could be achieved by either creating and maintaining an IJC SDE, or feeding the shapefiles to the DCGS-A SDE which already receives geo-referenced information from IJC on both CENTRIX and SIPR.



Proposed Afghanistan architecture

Providing a structure that begins at the lowest level to establish data flow would assist both in management and increase the information shared by individual units. Units would be expected to provide data and shapefiles created within their organization through the established information flow hierarchy. Information would be required to be created in a prescribed format to maintain data consistency between RCs when the final product is compiled at IJC. Compelling major and minor task forces to provide information created within their respective AOs is another step in distributing data sets that frequently are never seen outside of the creating organization. Up to date information such as brigade routes and NAIs that are unquestionably valuable to other units are just a few examples of information that, if consolidated, would benefit all users throughout the country. Major task force NAIs in RC-East

are already being displayed in the Seven Layers and have been incredibly beneficial to Division level planning and operations.

Conclusion

In less than a year, the Seven Layers of Analysis has evolved from a concept to an analytical process and tool that has expanded well beyond all original expectations. Use within RC-East and the rest of Afghanistan, as well as pre-deployment preparation in CONUS, have proven the effectiveness, functionality, and versatility of both GeoGlobe and the Seven Layers process. With enormous potential for further expansion of both hardware and user base, the Seven Layers of Analysis will continue to break new ground and foster greater understanding and utilization of geospatial visualization in intelligence, planning, and decision making throughout Afghanistan and beyond. The process and approach developed within RC-E are the true embodiment of modern GEOINT and the future for geospatial visualization.

Specialist Matthew Gossard

SPC Matthew Gossard is from Crowley, Texas and attended the University of North Texas where majored in political science. After completing over two years of college, SPC Gossard elected to postpone his education ambitions in order to enlist in the U.S. Army. He is assigned to Intelligence and Sustainment Company, Headquarters and Headquarters Battalion, First Cavalry Division and is currently deployed to Afghanistan in support of Operation Enduring Freedom as a member of the CJ2 Geospatial Intelligence section, Combined Joint Task Force-1.

Lieutenant Colonel (Promotable) David Pendall

LTC David Pendall is currently the CJ2 for Regional Command-East/CJTF-1 in Afghanistan and concurrently the G2 of the First Cavalary Division. Previous assignments include Deputy Chief of Future Operations and Future Operations Intelligence Plans Chief in the NATO/International Security Assistance Force (ISAF) Joint Command Headquarters in Kabul, Afghanistan, ISR Plans Chief with US Army Europe and the 7th Army, V Corps (MNC-I) and USAREUR ACE Chief, And V Corps G2 Plans Officer in Iraq (MNC-I). LTC Pendall has a Bachelor of Arts in Political Science from Ohio University, a Master of Science in Administration from Central Michigan University, and a Masters in Military Art and Science in Theater Operations from the Army's Advanced Military Studies Program (SAMS).