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14. ABSTRACT

A detailed knowledge of the terrain is an essential element of victory at all levels of war from the tactical to the strategic, and for success across the entire spectrum of conflict. Terrain expertise and products are especially important at the operational level of war, as terrain will have a direct impact on the operational factors of space, time, and force. The operational commander must have a thorough and complete understanding of the geography within his area of operations in order to understand its effects on the operational factors, and the interactions between them. Unfortunately joint force geospatial doctrine, primarily addressed through Joint Publication 2-03: Joint Tactics, Techniques, and Procedures for Geospatial Information and Services Support to Joint Operations, is vague and has many shortcomings. In particular it does not adequately address shortfalls in database management and in the dissemination of terrain products. Additionally, there are several force structure problems within the services that contribute to the inefficiencies in geospatial information management. Finally, there is glaring need to integrate geospatial assets from all services across the joint force in order to better capitalize on available geospatial technology. This paper offers solutions to these problems, and suggests ways to maximize the potential of geospatial engineering and intelligence as a force multiplier for the Joint Commander.

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Mapping the Future: Optimizing Joint Geospatial Engineering Support to the Warfighter

by

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A paper submitted to the faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

A detailed knowledge of the terrain is an essential element of victory at all levels of war from the tactical to the strategic, and for success across the entire spectrum of conflict. Terrain expertise and products are especially important at the operational level of war, as terrain will have a direct impact on the operational factors of space, time, and force. The operational commander must have a thorough and complete understanding of the geography within his area of operations in order to understand its effects on the operational factors, and the interactions between them. Unfortunately joint force geospatial doctrine, primarily addressed through Joint Publication 2-03: Joint Tactics, Techniques, and Procedures for Geospatial Information and Services Support to Joint Operations, is vague and has many shortcomings. In particular it does not adequately address shortfalls in database management and in the dissemination of terrain products. Additionally, there are several force structure problems within the services that contribute to the inefficiencies in geospatial information management. Finally, there is glaring need to integrate geospatial assets from all services across the joint force in order to better capitalize on available geospatial technology. This paper offers solutions to these problems, and suggests ways to maximize the potential of geospatial engineering and intelligence as a force multiplier for the Joint Commander.

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I. Introduction

A detailed knowledge of the terrain is an essential element of victory at all levels of war from the tactical to the strategic, and for success across the entire spectrum of conflict. A good commander will use his knowledge of the terrain to shape the battlespace to his advantage, and to set the stage for success on the battlefield.[1] Sun Tzu summed this up eloquently in the classic work On War:

> "And therefore I say: 'Know the enemy, know yourself; your victory will never be endangered. Know the ground, know the weather; your victory will then be total."[2]

Terrain expertise and products are especially important at the operational level of war, as terrain will have a direct impact on the operational factors of space, time, and force. The operational commander must have a thorough and complete understanding of the geography within his area of operations in order to understand its effects on the operational factors, and the interactions between them. History is replete with examples of how a lack of terrain knowledge has influenced operations. In World War II a shortage of detailed terrain analysis around Normandy, specifically in not accounting for the effects of the hedgerows, slowed down operational timetables significantly. In Grenada, the lack of any detailed maps wasted planning effort and caused unnecessary casualties. In Desert Storm, part of the success of the "left hook" was due to the Iraqi belief that the Allied Forces weren't capable of navigating through that part of the desert.[3] At the operational level, detailed geospatial knowledge provides the foundation for "military planning, training, and operations including navigation, mission planning, mission rehearsal, modeling, simulation and precise targeting."[4] Unfortunately joint force geospatial doctrine, primarily addressed through Joint Publication 2-03: Joint Tactics, Techniques, and Procedures for Geospatial Information and Services

Support to Joint Operations, is vague and has many shortcomings. In particular it does not adequately address shortfalls in database management and in the dissemination of terrain products. Additionally, there are several force structure problems within the services that contribute to the inefficiencies in geospatial information management. Finally, there is a glaring need to integrate geospatial assets from all services across the joint force in order to better capitalize on available geospatial technology. In short, the current joint force geospatial doctrine and organization does not adequately meet the requirements of the operational warfighter, and both must be adjusted in order to maximize the potential of geospatial engineering and intelligence as a force multiplier for the Joint Commander.

II. Background – The Evolution of the Map

> "So much has happened in mapmaking in the last two decades that mapmakers themselves, I discovered, are as astonished as anyone by the transformation."[5]

Throughout most of history, maps were simply two dimensional representations of our three dimensional world. Map makers became more skilled over the years, but making accurate paper maps was difficult, and the maps were subject to many shortcomings. First, they were limited on the amount of information they could display while ensuring readability. Second, the requirement for accuracy and precision further limited the amount of information that could be incorporated on the map. Third, key areas of interest often took place on the intersections of several map sheets, with no guarantee of compatible datum. Fourth, it was difficult to transfer information from one scale to another. Finally maps were difficult to update and couldn't keep up with dynamic changes on the battlefield.[6] Much of the world remained unmapped to military standards; often those remote areas in which the U.S. military were inevitably called upon to fight were not adequately charted. Fortunately,

the 1990's spawned a revolution in map making that has made terrain analysis more dynamic and responsive to the needs of the Joint Force Commander.

The merging of three technologies contributed to this radical change in map making. With the meshing of remote sensing imagery (RSI) technology, geographic information systems (GIS), and the Global Positioning System (GPS), the world entered the geospatial era and fundamentally changed the way maps are made.[7] Interactive maps were now possible – maps that could be tied directly to databases that would allow the commander to create tailor made maps and terrain products that were responsive to his queries about the battlespace. Geospatial Information and Services (GI&S) provide the framework and foundation for how the commander visualizes the battlespace. JP 2-03 defines GI&S as follows:

> "The concept for collection, information extraction, storage, dissemination, and exploitation of geodetic, geomagnetic, imagery (both commercial and national source), gravimetric, aeronautical, topographic, hydrographic, littoral, cultural, and toponymic data accurately referenced to a precise location on the earth's surface."[8]

Simply put geospatial information is the multi-source interoperable data used to make geospatial products while geospatial services are those tools used to manipulate the data.[9] In sum, GI&S provides the foundation for a new way of generating maps.

The National Geospatial-Intelligence Agency (NGA) has the lead in providing geospatial information to the warfighter through the Geospatial Information Infrastructure (GII) concept. There are three types of data that fall under the GII framework: Foundation Data (FD), Mission Specific Data Sets (MSDS), and Qualified Data Sets.[10] Foundation Data will be available with near worldwide coverage at a scale of 1:250,000 and is designed primarily for initial planning and support operations.[11] Mission Specific Data Sets augment the

Foundation Data base in response to the warfighter's needs and meet the tactical and operational requirements at an approximate 1:50,000 scale. While FD is available near worldwide, MSDS must be generated based upon specific requirements. This process may be time consuming, based upon the availability of terrain data for the requested region. However, MSDS lets the warfighter tailor his map to his specific needs, which in turn will allow for a more streamlined production effort and a quicker turn around time for a map product. The final component of the GII structure is Qualified Data. Qualified Data is data generated though outside sources that "value add" to the current FD or MSDS.[12] With data from this framework, the military geospatial engineer or analyst can tailor make geospatial products and dynamic decision aids that meet the Joint Commander's needs.

Unfortunately, the production timeline for this GII framework was disrupted somewhat due to the unforeseen contingencies that followed on the heels of the September 11th attacks. Terrain analysts at all levels have focused almost exclusively on meeting the geospatial requirements of Afghanistan and Iraq, with a resultant decrease of effort in generating FD and MSDS in other areas of responsibility. This fact, combined with budget shortfalls, forced NGA to modify its initial GII concept.[13] Instead of producing FD and MSDS on a near global basis, NGA will develop country databases comprised of the best data available for the given country. NGA will develop the country databases with priority given to current operations and OPLANS. The goal is to develop a "just in time" data delivery system by contracting out to commercial sources to populate inadequate country databases when necessary. The "just in time" concept will be difficult to achieve for contingency operations in remote locations. NGA contracted out the country database for Afghanistan, and the process took over eleven weeks before the products reached the in-theater geospatial units.[14]

All available geospatial assets, both civilian and military, must work at peak efficiency to reduce shortfalls in country databases. In order to take full advantage of the current limited DOD geospatial assets needed to populate the current data voids, it is critical that the DOD geospatial system becomes more efficient – eliminating redundancy and taking full advantage of "value added' data capabilities at all levels.

The level of detail intrinsic in Foundation Data is usually adequate for the Air Force, who relies primarily on small scale maps with relatively less detail in order to travel over vast distances. Similarly, the Navy's geospatial needs are fairly well met through existing bathymetry and navigational charts.[15] The Army and Marines represent the greatest geospatial challenge, as they rely on the detailed information found on large scale maps.[16] Foundation Data rarely satisfies the level of detail required for the land component, necessitating a greater need for MSDS for the ground warfighter. The land component, therefore, has the larger geospatial structure and assets and represents the component with the greatest need and potential for effective change. As a result, this paper will primarily focus on current structure available to the Joint Force Land Component Commander (JFLCC).

III. Databases, Data Base Management and the TGD

> "Mapping is not the issue, the real issue is producing and distributing databases and systems."[17]

The backbone to any GI&S system is the geospatial database. A database is "a well-organized, useful collection of information. You not only have the data, you also know you have it, and you can find it when you need it."[18] If you don't have the correct geospatial data available at the onset of a crisis, chances are you will not be able to find it or produce it in time to affect Crisis Action Planning (CAP) without a well structured database hierarchy. Designing and maintaining a database is a complicated task. Many agencies fail to design

their databases effectively, which results in a system that is costly, inefficient, and that may cause more problems than solutions.[19] JP 2-03 describes a system of geospatial databases that are designed to provide geospatial information and products to specific levels of command.[20] These databases must mirror each other to a great extent and must be able to share data quickly across theater boundaries, therefore an efficient design for the system is paramount to its success. Ideally, a database system should have a plan for connectivity, a common data structure, common software, clear methodologies for validating and updating data, and a standard interface for users.[21] Regrettably, there was little planning put forth in developing the overall database structure as outlined in JP 2-03. As a result, there is currently no "joint geospatial system that provides the necessary capabilities for the joint force headquarters to generate, conflate, and manage geospatial data."[22]

Under current doctrine, NGA is responsible for maintaining a Geospatial Data Warehouse. This data warehouse is the foundation for a DOD-wide distributed network of geospatial information and consists of elevation and bathymetric data, foundation feature data, and imagery.[23] During the Deliberate Planning or Crisis Action Planning Process, the combatant command's GI&S officer must identify and task a theater database manager and a unit to maintain the Theater Geospatial Database (TGD).[24] Unfortunately, there has been no universal agreement on what this TGD actually looks like, where it should be located, and who has responsibility for it. In addition, no geospatial units within the services initially were fielded the equipment necessary to host a database.

Conventions and standards are critical to efficient operations. Generally speaking, current geospatial operations are product-based in nature. A request for a product is received, data is produced to build that product, the final product is delivered to the customer and the critical

source data that was used to create that product (taking hours or days to produce) gets filed some place on the system or is archived. If lucky, someone will remember where it is the next time a similar product is requested for the same area. Most often the same data is generated all over again because no one can find the original data and/or no one has updated the original data. In the initial stages of operations in Iraq, many geospatial products were independently produced at the Theater, Corps, and Division level – all because the analysts at each respective level couldn't locate the product that already existed at a higher level.[25] The lack of a common naming conventions and standards leads to duplication of effort, inefficiency, and the squandering of limited geospatial assets.

The United States Army Topographic Engineering Center (TEC) in Alexandria Virginia fixed the database hardware shortfall by fielding the Digital Topographic Support System – Base (DTSS-B) to the 29th Engineer Battalion in Hawaii, the 30th Engineer Battalion in North Carolina, and the 60th Engineer Detachment in Germany. The DTSS-B consists of multiple workstations designed to operate at Theater level in a base-production, garrison environment.[26] These systems were fielded to provide database and warehousing capabilities to USARPAC, USAREUR, and ARCENT. Although the fielding of the DTSS-Base represented a great technological advancement for theater armies, it was deficient in some critical capabilities needed to truly support data-centric operations. The DTSS-B lacked a standardized geospatial database and production tools to create, capture, manage, analyze, and disseminate critical geospatial data within a theater. In addition, these TGD were fielded only at the Army Service Component Command (ASCC) level. If fielded at a joint level, the TGD could leverage and support all services components more readily. Another shortcoming is that the systems are non-deployable by nature, and therefore not as efficient if

the supported force deploys into a theater of operations. The systems were fielded with standard software, but without an overall storage plan, naming convention, or user interface. As a consequence each owner developed their own conventions, storage, and display structures which inhibited interoperability. Finally, the three fielded DTSS-B's are capable of supporting only three Combatant Commands. Southern Command, Joint Forces Command, and Northern Command are left without TGDs.

The 30th Engineer Battalion, with support from NGA, made a leap forward in meeting the TGD shortfall in Iraq. 30th Engineer Battalion recognized that there was no single-source database for standard data and nonstandard geospatial products in Iraq, and no common digital baseline for all geospatial products. They teamed up with NGA to construct a deployable TGD using commercial "off-the-shelf" servers. By the end of the deployment, they had a viable and proven TGD that had accessibility across the Iraqi Theater of Operations (ITO), that supplied standardized geospatial baselines, and that provided an asset capable of collecting and archiving geospatial products.[27] This concept proved successful during the battalion's mission to Iraq, and should be used as a model for future contingency operations that have a need for a deployable TGD.

Much progress has been made in regards to developing the system of databases as envisioned by JP 2-03, however, much still needs to be done to make the system more efficient. First, a DTSS-B type TGD should be fielded at the Joint level for each Regional Combatant Command to better leverage the geospatial assets of the other services, serve as a hub to the NGA warehouse, while providing more responsive geospatial intelligence to the joint commander. USJFCOM should have a TGD as well, along with a deployable DTSS-B (-) TGD for its standing joint force headquarters. USARCENT, USARNORTH, USAREUR,

USARSO, and USARPAC should manage deployable DTSS-B (-) TGD that mirrors the COCOM TGD for use in the event of a contingency. Additionally, an organization such as USJFCOM, NGA, TEC, or the Army Engineer School must take on a leadership role in establishing the working conventions for the system of TGDs. USJFCOM and NGA have recently teamed up to develop the Joint Geospatial Enterprise Service (J-GES), which may help solve many of the standardization and data structure issues. J-GES is an Army sponsored program designed to standardize format, architectures, data structures, and common core software capabilities for the military services.[28] If successful, J-GES can help alleviate many of the current database system problems that exist today. The systems of TGDs will not be efficient unless clear guidelines on connectivity, software, data structures, naming conventions, and standard interfaces are published and enforced.

IV. The Challenge of Dissemination

> "The objective of geospatial information and services support is to provide the commander with timely, complete, and accurate information about the battlespace."[29]

In order to provide the operational commander with timely geospatial information, planners must establish a robust dissemination system for geospatial products in the theater of operations. This system must include a plan for distributing not only hardcopy products, but digital products as well. Unfortunately, the distribution and dissemination of maps and geospatial products has historically been a problem.[30] The emergence of digital maps exacerbates the dissemination problem. Digital terrain data is generally packaged in large files, which cannot easily be transmitted through existing communications systems.[31] This digital data must travel along the same overtaxed communications structure already in existence in a theater, and must be accessible to all

levels of command. The shortage of bandwidth and available means to transmit data make electronic dissemination of geospatial products an extremely complicated process.[32]

In order to lesson the strain on existing communications systems, the digital geospatial dissemination plan must be efficient and incorporate additional and redundant means for getting data to the various users. A standardized TGD structure is the first step in the process, as it will shorten the search time necessary for geospatial consumers to search for and find a product. Upon entry into theater, geospatial units should receive a direct hard data link from the DTSS-B (-) theater database. Updates to the geospatial data should be routinely pushed from the TGD to subordinate geospatial units via CDs, tape, or Firewire technology. Value added information from subordinate units should be periodically sent to the TGD using the same hard data system. Maximizing the use of CDs, tape, and Firewire technology along with establishing a common web interface will serve to lessen the strain on an overburdened electronic communications system while still providing timely geospatial support to the customer.

Disseminating digital products is only one facet of the distribution problem. Soldiers and planners at all levels must still have access to paper map products.[33] Geospatial units at the Corps level and above have limited capability to produce hard copy maps with the High Volume Map Production System (HVMP). The HVMP has the ability to produce 2,500 full color large format maps a day, but this is clearly not enough to keep up with demand at all levels.[34] In April of 1998, the Defense Logistics Agency (DLA) assumed responsibility for geospatial distribution operations. Conceptually, units should deploy with a basic load of maps, and may draw additional stocks from theater and regional map depots.[35]

According to doctrine, an Army Quartermaster general supply company is responsible for maintain a theater army map depot, and for distributing geospatial products within a theater.[36] In reality, they have often been reluctant or unable to meet this requirement. Engineers, as the proponent for geospatial intelligence, are often called upon to fill the resultant void. As an example, the 30th Engineer Battalion in a recent deployment to Iraq established Theater Geospatial Distribution Center (GDC) and maintained it with internal engineer assets.[37] The GDC was functional, but not optimal. Engineers do not have the proper assets or doctrinal mission to manage a map depot. At the operational level, it is incumbent upon the GI&S staff planner to identify a trained and capable quartermaster unit to carry out their doctrinal map distribution function in order to maximize the supply flow of geospatial hard copy products.[38]

Combined operations at the joint level add an additional layer of complexity to the dissemination of geospatial products. Our multi-national coalition partners often lack the technology to exploit geospatial information, or lack the clearances to access many geospatial products. The security issue is not limited to coalition partners – our own uncleared soldiers may be denied access to mission essential geospatial products if classification requirements aren't adequately managed. It is therefore incumbent upon the joint GI&S planner to identify possible disclosure and/or release problems early, and request geospatial release exceptions through NGA when appropriate.[39]

V. Improvements in Structure

With the Army's new modular force design, many needed geospatial structure changes have already been implemented. Four soldier geospatial teams have been fielded at the Brigade Combat Team (BCT) level, giving the tactical commander a responsive geospatial

capability that he did not possess before. At the division and corps level, nine soldier geospatial teams will provide terrain analysis capabilities at both the tactical and operational levels. At the army and theater level a twenty-seven soldier Geospatial Planning Cell (GPC) will provide the operational support previously given by a Topographic Battalion consisting of over 300 soldiers. Three corps geospatial companies will be available to augment geospatial support to both Corps and Army level, as the operational situation dictates.[40] These changes are necessary to ensure the right geospatial assets are immediately available to warfighting commanders across all levels of war.

Unfortunately, these changes do not go far enough. There are only four GPCs currently assigned to support the 3rd, 6th, 7th, and 8th Armies. The 5th Army staff needs a dedicated GPS and TGD in order to properly provide and manage terrain data in support of Homeland Defense, Civil Support, and Theater Security Cooperation activities. In addition, there is no standard coordination of geospatial effort at the joint level. To fill this need, the services should create a Planning and Control Element (PCE) at the COCOM level. This PCE should coordinate the geospatial work effort for the Combatant Commander across the theater, manage the TGD, and be truly joint in nature. Furthermore, it will provide an augmentation base for other non-service specific assets, such as NGA support teams. This PCE could help eliminate duplication of effort by prioritizing work, and to help capture and share joint mission specific data in a more efficient fashion.

Most importantly, the geospatial community needs to put someone in charge of managing the joint geospatial organization. While there are many groups available to provide input to geospatial training, structure, communications, equipment, and standards, there is no clear cut “owner” of the community authorized to make decision and enforce decisions across the

organization. A community in which standardization, accuracy, and efficiency are keys to success needs a strong leader empowered to make decisions and recommend policy. Ideally this leader should be an O-6 or SES, and have experience in both NGA and JFCOM.[41] A strong and empowered leader is necessary to unite the community at the joint level, and to help resolve the standardization, doctrine, and training issues that result in inefficiencies and redundancy in a field with limited assets.

VI. Conclusion

> "No negotiations can be conducted, no forces can move, no weapons can be brought to bear, no forces can be protected, and no support and supplies can move without a sense of location, an understanding of surroundings, and an understanding of the influence of mission space on the operation."[42]

With the explosion of geospatial technology over the last few decades, the ability and potential to envision the battlespace rapidly has similarly grown. As a joint force we have made great strides forward in developing systems and procedures to help to manage and capitalize on geospatial intelligence, but we still have much room for improvement. A recent article in the Army Times provided information on a company charging $350 for electronic downloadable "smart maps" of Iraq.[43] This in itself supports the need for change – the joint force should be able to provide this information down to the user level. If the military joint geospatial community was truly working at peak efficiency, then the civilian geospatial community would not be stepping into this market. More importantly, purchasing maps from sources not subject to validation can "cause interoperability issues, which can cost lives".[44]

In the words of COL Kingston, former director of the TRADOC Program Integration Office for Terrain Data:

> "Evolving joint operations rely on service interdependence more than ever, so the lines separating the types of data each service requires are becoming blurred. The bottom line is that battlespace awareness and our ability to

> conduct joint operations as envisioned in Joint Vision 2020 simply cannot be accomplished without robust, accurate, and timely digital geospatial information."[45]

We must therefore develop a robust and standard data management system that allows timely and accurate updating of joint geospatial information. The USJFCOM/NGA Joint Geospatial Enterprise Service is an excellent starting point, and should be fully funded and supported. We must revamp our dissemination procedures for both hard and soft products, to ensure geospatial data flows quickly to all echelons. We must look critically at our force structure to ensure the right capabilities are available across all levels of command. Finally we must leverage the geospatial assets of all services in a joint fashion by establishing joint Planning and Control Elements and Theater Geospatial Databases. By implementing these changes, the joint geospatial community will ensure it is giving the Joint Commander the best geospatial engineering and intelligence available so that he can be successful on the operational battlefield.

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