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Cross-Service Investigation of Geographical Information Systems

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CROSS-SERVICE INVESTIGATION OF GEOGRAPHICAL INFORMATION SYSTEMS

THESIS

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Abstract

The Department of Defense (DOD) has seen its mission change since the end of the Cold War. Now, the DOD must respond quickly to smaller actions around the world from fewer permanent forward locations. As a result, the planning phase of the forward deployment from home station becomes more important. To aid in this planning and execution, the separate services have begun to invest in geographical information systems (GIS). This research investigated the armed services' current uses of GIS. It also asked the question whether or not a joint GIS program could benefit the DOD, and an information technology implementation model was presented as a framework to implement a joint GIS program.

It was found that all four armed services use GIS for forward deployments. The Army has its Combat Terrain Information System (CTIS). The Navy's digital nautical charts are a GIS. The Marine Corps has created their Geographically Linked Information Display Environment (GLIDE) program, which is similar to a map repository. Finally, the Air Force has its GeoBase program for installation GIS, and GeoReach is the expeditionary deployment base-planning subset.

The research methodology was a combination of a case study and a Delphi study. The case study research examined a single Army GIS unit for current GIS implementation methods and uses. The Delphi study asked eight DOD GIS experts their opinions about current GIS uses and the possibility of a joint GIS program. Through the case study and Delphi research, it was found that information flow between the services is limited and that a joint GIS program may bring improved and new planning and executing capabilities for the DOD.

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I. Introduction

1.0 Background

After the attacks of September 11, 2001, Secretary of Defense Donald Rumsfeld "was embarrassed in front of the President by the Pentagon's slow and tentative response" [1, 26]. President George W. Bush wanted troops on the ground in Afghanistan quickly. The Central Intelligence Agency was able to insert a team of paramilitaries within two weeks, but the armed services said that they could not respond quickly with the current plans or forces in the area [1, 28]. The United States (US) Department of Defense (DOD) had recognized the need for change in the soon to be published 2001 Quadrennial Defense Review (QDR), but had not enacted many of the recommendations.

The DOD's mission is "to provide the military forces needed to deter war and to protect the security of our country" [2]. This protection is accomplished by having a military presence around the world to deter or defeat adversaries. As seen after September 11th, occasionally military forces must be deployed quickly to previously unplanned locations. The Air Force uses geographical information systems (GIS) to aid in this deployment planning process. It is envisioned that GIS will significantly improve the speed and efficiency of the deployment planning process. The purpose of this research is to determine the extent of GIS use in the DOD for deployment preplanning and possible opportunities for including GIS technologies across service boundaries.

This research will take a joint look because the DOD is deploying more frequently as a joint force.

The DOD is impressive with its physical size and presence around the world, consisting of 1.4 million active duty forces, 1.19 million ready and stand-by reserves, and 654,000 civilian employees [3, 14]. Since the signing of the National Security Act on 26 July 1947, the three military departments within the DOD have been the Army, Navy, and Air Force; the Marine Corps is a second armed service of the Navy [2]. These four armed services have a total of 302 bases within the US and 330 permanent bases outside of the US. Excluding possible bases constructed for Operation Iraqi Freedom, the armed services could be operating from as many as 119 bases to support Operation Enduring Freedom and sustained operations in the Middle East [4]. This large overseas presence has its roots in the Cold War. However, since the end of the Cold War, the threat to the US has changed from a global war with the Soviet Union to several smaller regional conflicts. Since the end of the Cold War, the DOD has seen a reduction in total personnel but an increase in demands on smaller forces [5, 8].

The 2001 QDR called for a change in the planning and posturing of US forces. The Cold War mentality had been to defend against the threat of other nations, including the Soviet Union, initiating a future war. However, the 2001 QDR calls for posturing the DOD against the capabilities of other nations and organized combative groups. This capabilities-based planning looks at how a potential adversary might fight rather than specifically who the DOD will be fighting. As a result, the DOD planners must identify the capabilities of other nations and groups and be prepared to deter or defeat any enemy that relies on surprise, deception, and asymmetric warfare [5, iv]. Part of this mind set change requires the DOD to posture itself to respond quickly and cost effectively to the smaller regional conflicts based on an adversary's capability rather than just theater campaigns against stationary threats.

Combine the change in how the DOD plans for threats against the US with the fact that many main operating bases overseas are being closed and many foreign nations are reluctant to allow foreign militaries to establish permanent bases on their soil, and the result is the DOD must and is changing how personnel and resources are positioned [6, 8]. Permanent forward stationing of personnel is giving way to deploying forces from the US to temporary bases called Forward Operating Locations (FOLs) located near the regional conflict [7]. A FOL may either be a previously-used site or a new site that meets minimal requirements, commonly called a bare base.

A bare base is a site that has a water source that can be made potable; and if flying operations are planned for the location, it must also have a usable runway, taxiways, and aircraft parking areas. The location must have the potential for logistical support to resupply personnel and materiel. Under the bare base concept, the military will bring the required mobile facilities either in trailers or tents with necessary utilities and support equipment. The result is the transformation of undeveloped real estate to an operational base [6, 6]. However, this transformation cannot occur quickly or effectively without some level of planning.

The task of planning which FOLs to use for a particular mission requires considering several factors. First, the US State Department must coordinate with host nations for permission to base personnel and assets in their country. Second, the potential sites must be visited to determine the possibility of basing forces at the location, evaluating existing assets and determining necessary improvements. Third, for flying operations, the available ramp space, hangars, and possible fuel sources must be considered. Finally, the logistical services must be available to house, support, and resupply the personnel that will be located at the base [8, 7].

When this FOL preplanning is not quickly and effectively accomplished prior to forward deploying troops, the military's ability to operate is diminished. An example of diminished capability was during Operation Allied Force in Kosovo. The Government Accounting Office reviewed after-action reports from Operation Allied Force, and its report cites several undesirable results of limited planning before deploying units.

First, no single unit or command maintained a database of information on possible FOLs in the European theater. So after the operation began, the US Air Forces Europe (USAFE) had to use over 200 personnel in small teams traveling to 27 potential sites over three weeks to gather the necessary information. The host nation usually allowed the teams into the possible location for only one day, and many of the members of these quickly compiled teams had never been on a site survey team previously [8].

In addition to the Air Force accomplishing site surveys, the Marine Corps accomplished its own surveys. The commander in charge of the Marine Corps' site survey teams did have access to the Air Force information on the potential locations, but he still felt that Air Force information was incomplete and additional information was needed for Marine Corps operations [8, 11].

Since the base planning was still occurring at the opening of the operation, decision makers were making decisions without knowing future basing requirements. The aircraft-basing plan was changed 70 times in the 78-day operation. The constant change forced the initial planners to send aircraft to bases not knowing what other planes or support units would follow. In one example, the 48^{th} Fighter Wing from Lakenheath, England, was forward deployed to Cervia, Italy; however when additional units were added to Cervia, the 48^{th} had to return to Lakenheath because there was not enough space at Cervia for all the units [8, 8].

When forces did forward deploy, the lack of combat aircraft basing plans allowed the first units into the FOL to take the space they thought they needed without regard to future units' arrival or overall base operations. The units also did not consider land use, safety, utility access, or airfield obstructions. The lack of preplanning resulted in unnecessary duplication of facilities and overlapping of functions between services [8, 10]. The GAO concluded that "Operation Allied Force demonstrates that the lack of at least some planning has the potential to result in costly and unnecessary problems and inefficiencies" [8, 15].

However, it also must be recognized that the military cannot maintain military action plans for every situation in the world [8, 8]. The DOD does maintain plans for possible FOLs and operations, but regional conflicts may still occur that do not have previously planned FOLs. Thus, the military services must still retain the ability to quickly plan for the forward deployment of troops if a plan does not exist.

Proper deployment preplanning can improve the speed and effectiveness of the FOL. The armed services continue to look for ways to improve planning and execution. The historical way of planning for a FOL is a multiple step process. First, planners list all potential FOLs and coordinate with the US State Department as to which countries are willing to receive US forces and which countries the DOD should consider sending forces to. Then, the planners acquire all existing information on the refined list of locations before visiting any of the sites (e.g., any satellite images, flyover pictures, existing base plans). With this information, the planners make rough estimates on possible locations for assets. If time and the host nation allow it, survey teams are sent to the shortened list of FOLs to verify existing information and collect any additional required information.

The next major step is deploying forces to build facilities on the base to support the operation. The base build up team arrives on station, and historically uses pencils, design manuals, and any maps available augmented with on-site surveying to plan the base layout. Computer Aided Design (CAD) and satellite photography have improved the accuracy of the preplanning and on-site surveying and design.

This planning process has sufficed for many contingency base build-up operations. However, the Air Force has taken a stance that further technology integration may improve the process by decreasing time to plan a new base and increasing the accuracy and depth of planning before committing personnel to the location. Currently, the Air Force is investing in GIS technology.

GIS is "a system of computer software, hardware, data, and personnel to help manipulate, analyze and present information that is tied to a spatial location or geographic location" [9]. The database information is presented in a visual form resembling a map with the database linked to points on the image. The result is a map that can be used to find the information in the database by anyone familiar with maps and has a basic understanding of computers. This access allows all users on a base or in an operation to be working and planning from the same information and map.

The specific GIS program that the Air Force is pursing to enhance planning for FOL construction is GeoReach [7]. GeoReach is a GIS program used to aid in the acquisition of information for FOLs. The informational database is tied to an image taken by plane or satellite. This compiled information is used to create a common geographic framework for the base or location and is called a Common Installation Picture (CIP). The CIP, a geo-referenced database, includes information about existing buildings and facilities, communication layout, and existing and potential aircraft parking plans. For example, a user selects a building from the image and its dimensions and other relevant data stored in the database are displayed. Once the initial CIP has been developed, additional program add-ins can be used to aid in designing a tent city or laying out aircraft parking [10]. GeoReach and its associated add-ins will be further discussed in Chapter 2.

2.0 Opportunity Statement

In today's DOD, the armed services are not deploying alone; joint service deployments and operations are becoming more common and critical to mission success. However, the transfer of information and knowledge for forwarding deployment planning is difficult at best. As seen in the GAO report on Operation Allied Force, each service may be minimally aware of what the other services are accomplishing, but each service is still collecting its own information and planning its own FOLs. The lack of information cross-flow leads to redundancy, which costs time and money.

The Air Force's choice to use GeoReach affects the other services' information flow capability both as individual services and during joint operations. In joint deployments, the Air Force still plans to use GeoReach to preplan the deployment. If the other services are going to provide input for the deployment plan, all the services must be working with compatible technology and mindset about the capabilities of the technology.

The armed services may benefit from increased GIS information flow between the services, whether the benefit is from being able to access information that the Air Force has stored via GIS, or mission improvements for their own operations. The Air Force has already seen benefits from using GIS for planning; the other services may have similar success stories, but the successes might not be shared across the DOD.

3.0 Research Objectives

This research has two objectives. First, the research will investigate how GIS is being used by the armed services currently, and highlight any redundancies or shortfalls. Second, this research provides a cross-service investigation of the desire for, and possible capability improvements of, a joint GIS program.

4.0 Methodology

The research begins with a review of each service's current missions and deployment techniques. Next, it investigates each service's use of GIS technology for deployment planning and execution. Then, a two-part study is used for further research.

The first part of the methodology is a Delphi study to determine if experts in the DOD think a joint GIS program is needed and/or possible. Eight GIS experts participated in the research. These eight GIS experts are a combination of GIS managers and technicians. The Army, Navy, Air Force, and the National Geospatial-Intelligence Agency (NGA) were represented.

The second part of the research methodology is a case study of an operational Army GIS unit. The unit's current GIS usage was observed, and the individuals were interviewed about their past information technology integration experiences. An Army GIS unit was selected for the case study because the unit is responsible for fielding, training, and updating of the Army's terrain analysts system. The two parts of the study are analyzed separately and then combined for further analysis.

This research is intended to provide a preliminary look at how GIS is used across the DOD. The literature review summarizes current GIS uses within the DOD. The case study and Delphi study provided preliminary additional information. The case study and Delphi study participants did not include the logistical planners or senior leadership that would be required to implement a joint GIS program.

5.0 Relevance

This research has two areas of relevance. First, the review of each service's current GIS will allow each service a better understanding of how other services are using GIS. This increased knowledge may result in sharing existing programs or capabilities. This cross-service review may also aid future cross-service GIS researchers.

Second, the armed services of the DOD no longer deploy or fight separately. Information about forward locations must be shared and planning must occur in a joint environment. For FOL planning, GIS offers a way to manage the information and knowledge in a manner that all participants can work from the same map. When planning for a FOL, working from a common map could improve efficiency in information gathering. Separate site visits by each service would not be required; thus, all the services will be able to work from a common database of acquired information.

Planners would be able to make better decisions based on more accurate information, which could increase the capability of the FOL. Thus, the collective work environment could decrease planning time while increasing the accuracy of responses to the changing world.

6.0 Thesis Overview

The remainder of this thesis contains four chapters: literature review, methodology, results, and conclusions. Chapter 2 presents background information on each armed service's mission, current deployment planning and execution techniques, and describes an information technology integration method. Chapter 2 also contains a deeper discussion of GIS technology. Chapter 3 describes the methodology used to develop and implement the combined Delphi study and case study methodology. Chapter 4 details the application of the Delphi and case studies, contains the results of the combined research methodology, and evaluates the results. Chapter 5 summarizes the research results, identifies the limitations of the research, and provides recommendations for future research in the area of GIS technology use across the DOD for forward deployment planning and execution.

II. Literature Review

1.0 Introduction

This chapter will review the current structure of the DOD and how military operations are planned and conducted both by the individual services and the Unified Commands. Then, GIS as a technology will be reviewed, followed by a discussion of how GIS is being used in the armed services for planning and use during military forward deployment operations. Finally, an information technology (IT) implementation process will be proposed for use during the research phase of this thesis.

2.0 Definition of Deployment

The DOD is a key element in enabling the US to project power around the world. Power projection is defined as "the ability of a nation to apply all or some of its elements of national power – political, economic, informational, or military – to respond to crises, to contribute to deterrence, and to enhance regional stability" [11, vii]. The DOD enables the US to project force around the world. "Force projection is the military element of national power that systematically and rapidly moves military forces in response to requirements of war or military operations other than war" [11, I-2]. In other words, deployment of military personnel and assets is force projection.

Deployment is defined in Joint Publication (JP) 3-35 as "the movement of forces and their sustainment from their point of origin to a specific operational area to conduct joint operations outlined in a given plan or order" [11, I-4]. The primary objective of deployment is to provide personnel, equipment, and materiel when and where required by the commander's concept of operations [11, ix]. This quick movement gives a commander the ability to employ combat power that will either force an adversary to react from a position of disadvantage, or quit [12, 20]. The deployment process is complete when forces are at the location and are combat ready [11, I-11].

The DOD has recognized that its requirements for force projection have changed since the Cold War [5, 3]. The threat of war with the former Soviet Union has diminished and smaller radical groups have begun to threaten the US. The DOD can not support enough combat forces in all parts of the world constantly to deter and/or confront these new adversaries. Thus, the DOD must be able to move and concentrate forces quickly when and where potential conflicts arise. The result is an increase in the number of deployments for the DOD [5, 6].

3.0 DOD Organization

This section reviews the structure of the DOD as it relates to decision making and deployment responsibilities. It begins at the National Command Authority (NCA) level and continues to the roles and responsibility of the Chairman of the Joint Chiefs of Staff (CJCS), Unified Command, and the Military Departments (Air Force, Army, and Navy).

The DOD deployment process begins with a NCA directive that requires a military mission to be accomplished. The NCA is comprised of the President of the United States and Secretary of Defense or their duly appointed alternates or successors [13, 335]. A directive from the NCA states the operational mission and the deployment process for forces [11, I-11].

Within the DOD, authority and responsibilities are divided among the CJCS, the Unified Commands, and the Military Departments. The CJCS plans and coordinates actions between different services and commands. The Unified Commands conduct military operations, and the Military Departments are responsible for training and equipping personnel for use by the Unified Commands [2, 13]. Each of the organizations' roles is discussed in greater detail in the following subsections.

3.1 Role and Responsibilities of the CJCS

The CJCS and associated Joint Chiefs of Staff (JCS) do not hold any regulatory authority over the Unified Commands, which are discussed in the next section. The JCS are military advisors to the President, National Security Advisory, and Secretary of Defense. The CJCS, through the Joint Staff, is responsible for DOD policy. During wartime, the CJCS coordinates with the war-fighting commanders and the armed services to (1) determine mission priorities, (2) establish or validate the capabilities' requirements, (3) assess resource availability, and (4) develop allocation options for the Secretary of Defense [14, 8].

The CJCS uses the Joint Strategic Capabilities Plan (JSCP) to prepare joint operation plans. The JSCP is the strategic direction for the operation planners and combatant commanders and lets them know where to concentrate planning efforts. The JSCP is the link between strategic planning and joint operation planning [15, xii]. With the JSCP, the CJCS assigns the planning tasks to the combatant commanders, and apportions major combat forces and resources. The JSCP also issues planning guidance to integrate the joint operation planning activities of all stakeholders within a coherent, focused framework and is the beginning of the deployment planning process [15, xii]. However, during a specific military operation, the combatant commander retains primary responsibility for all activities as assigned by the JSCP or NCA [15, xii].

The Joint Staff has divided the planning process, which includes force deployment planning, into two types—deliberate and crisis action situations [11, A-2]. Deliberate planning is designed to be a cyclic process during peacetime. The process allows planners to develop and refine plans to be used during war [11, A-2]. Deliberate planning relies on assumptions and best guesses about the possible political and military environment during an operation [15, ix]. The resultant plan is based on predicted conditions that will exist in the given situation. The plans are documented in operational plans (OPLANs), contingency plans (CONPLANs), and functional plans or time-phased force and deployment data (TPFDD) [11, A-2]. The TPFDD contains all the information required for the movement of personnel and cargo for an operation including the following:

1. In-place units
2. Units planned for deployment with a priority indicating the desired sequence for their arrival at the planned location
3. Routing for deploying forces
4. Movement data about the deploying units
5. Estimates of non-unit-related cargo and personnel movements to be conducted concurrently with the deployment of forces
6. Estimates of transportation requirements [13, 536]

The deliberate planning accomplished during peacetime can aid in crisis action planning (CAP) by anticipating potential crises and developing joint OPLANs that "facilitate the rapid development and selection of a course of action (COA) and execution planning during crises" [11, A-2]. If no OPLAN existed for the required military operation, then CAP is accomplished quickly so that the military operations can occur. CAP is an expedient method of planning possible military COAs in response to an immediate threat and is, therefore, time sensitive planning [15, ix]. The possible COAs are reviewed by the NCA, who then issues a decision and associated COA to the combatant unified commander (discussed in the next section) [11, A-5]. If an OPLAN exists, the CAP planners use it to conduct the operation; otherwise, the planners have to either modify another plan or create an entirely new plan [11, A-2].

Table 1 compares CAP and deliberate planning in several areas of the planning process. The greatest difference for the planners is the time allotted for the two types of planning. Deliberate planning can take 18-24 months, but CAP occurs over only a few hours or maybe days because of the time sensitive nature. Also, the type of notification differs for each of the two types of planning.

Table 1. Comparison of Crisis Action Planning and Deliberate Planning [11, A-4]

Planning Segment	Crisis Action Planning	Deliberate Planning
Time available to plan	Hours or days	18-24 months
Phases	Six phases from situation development to execution	Five phases from initiation to supporting plan
Document assigning task	Warning order to combatant commander, who assigns task with evaluation requests message	JSCP to combatant commander, who assigns tasks with planning or other written directive
Forces to Planning	Allocated in warning, planning, alert, or execute order	Apportioned in JSCP
Early Planning guidance to staff	Warning order from CJCS; combatant commander's evaluation request	Planning Directive issued by combatant commander after planning guidance step of concept development phase
Decision of COA	NCA decide COA	Combatant commander decides COA with CJCS review
Execution Document	Execute Order	When operation plan is implemented, it is converted to an operational order and executed with an Execute order
Products	Campaign plan and TPFDD	OPLAN with supporting TPFDD or CONPLAN with or without supporting TPFDD

For CAP, the warning order comes from the CJCS, where in deliberate planning, the combatant commander issues a planning directive. The product of the two planning cycles also differs. CAP's result is a campaign plan and TPFDD. The product of a deliberate planning is an OPLAN or CONPLAN with or without a TPFDD.

3.2 Unified Commands

This section discusses the role of Unified Commands. It also reviews the planning process at the Unified Command level which, with the aid of a Joint Task Force (JTF), determines the actual deployment and employment of forces.

The Unified Commands have the authority, according to Title X of the United States Code, to conduct military operations such as forward deploying. There are nine Unified Commands in the DOD: Northern Command (USNORTHCOM), European Command (USEUCOM), Central Command (USCENTOM), Southern Command (USSOUTHCOM), Pacific Command (USPACOM), Transportation Command (USTRANSCOM), Special Operations Command, Strategic Command, and Joint Forces Command. The first five commands listed have geographic responsibility while the other four have mission responsibilities worldwide [11, viii]. The area of responsibility (AOR) for each geographic command is shown in Figure 1.

During a military operation, the commanders of the Unified Commands take on either the supported commander role or supporting commander role. The supported commander, also known as the combatant commander, is the commander who is responsible for conducting military operations in his/her AOR to directly counter an adversary's actions. The other eight commanders become supporting commanders that provide the personnel and other assets that the supported commander needs to conduct the operation [11, II-6]. The combatant command role used to be limited to the five geographic commands, but Special Operations Command has recently been tasked as the lead command for the global war on terrorism.

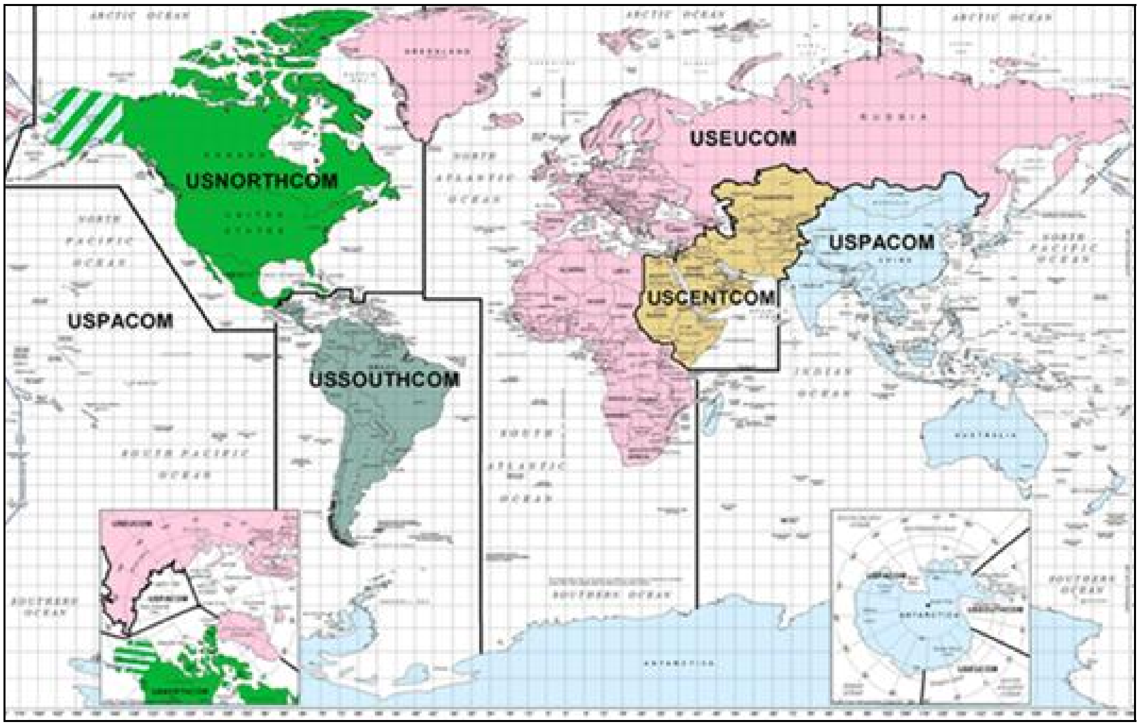


Figure 1. Geographic Unified Command Areas of Responsibility [16]

The five geographic commanders are required by the JSCP to prepare specific plans for possible conflicts within their AOR. These plans specify the level of mobilization needed to support the planned operation and identify any requirements for reserve component forces [11, I-6]. Supporting combatant commanders are tasked under the JSCP to support the combatant commander by mobilizing assets and personnel.

The deployment planning between the NCA's initiation directive and forces being combat ready is extensive. The Unified Commander established a JTF to conduct the planning operations required by the specified NCA directive. The JTFs are established for a geographic region or functional responsibility [11, II-17]. Deployment planning "encompasses all activities from origin or home station through destination, specifically including intra-continental United States, inter-theater, and intra-theater movements legs, staging areas, and holding areas" [13, 154]. The personnel who accomplish this planning are commonly referred to as military planners, or planners for short.

The planners take input from the US State Department, which also plays a key role in deployment planning. The State Department coordinates possible host nation support or assistance, possible combined operations, and judges national will and political risk of the possible operation. The department is responsible for negotiating agreements with other nations to allow forces to travel through or be based in other nations [11, II-6].

While the State Department is coordinating other nations' support, the planners are looking at geographic areas based on the theater commander's vision, goals, and priorities, which are driven by the NCA directive. The planners make assessments of possible FOLs, while also assessing the allocation of strategic activities and resources [11, VI-2]. The planners must consider several variables including warning time the units will have before deploying, current unit mobilization levels, which personnel and materiel are to be deployed, what enemy forces are in the proposed area, delivery schedules, and distances for the deployment [11, III-14]. The following excerpt from JP 3-35 shows only part of the demands placed on the planners during this deployment planning.

> "Analysis of the physical infrastructure in the host nation (HN) is critical to understanding force sustainability. Physical infrastructure in the HN should be evaluated both in terms of what is there and what the multinational force will be allowed to use. First, assess the ability of the available HN infrastructure to receive US and/or multinational force

> personnel and equipment (e.g. ports and airfields). Second, determine the capability of available transportation systems to move forces once they arrive in the theater. Third, evaluate availability of logistic support. Quick evaluation of these three items will determine the extent to which HN infrastructure can be used to support planned operations. HN support may dramatically increase the timeliness of response to a developing situation and reduce the strategic airlift and sealift requirements necessary to deploy forces to the AOR and/or JOA" [11, VI-6].

During this entire process, planners are still trying to keep several layers of commanders informed of the most current plan.

The planners develop the TPFDD for the employment of forces. This time-phasing is essential to allow the correct units to arrive on station to continue growth of the operation [11, I-15]. All of these forces and equipment must be scheduled on the TPFDD based on the planners' estimate of when they will be required and when the base commander wants units to arrive [11, I-15]. This scheduling is necessary because airlift and sealift to transport the deploying units is limited [11, III-3]. Therefore, the operational commanders and planners must find the proper balance of projecting force rapidly with the right mix of personnel and equipment for the assigned mission. The JTF handles this mixing of requirements [11, II-17].

Once the operation is approved, the TPFDD is checked again to ensure it is still current based on changing requirements from the services and functional component commands. The verified TPFDD is then provided to the original JTF establishing authority or supported combatant command for "sourcing of shortfalls, validation, and forwarding to USTRANSCOM for transportation feasibility analysis and movement scheduling" [11, II-18].

If the planning is time sensitive and CAP must be used, the JTF can not plan the operation fully before needing to execute the first stages of the operation. The planners may have to create the initial TPFDD supporting planned operations based on their best judgment of what forces and support will be required for the first few days of the operation. Hopefully, this initial deployment of assets will allow the JTF time to assess the situation more thoroughly and begin making adjustments to the TPFDD based on actual requirements. The operational commanders must work with the planned order of equipment and personnel for the first several days of this type of operation. If the commanders try to change the first few days of the TPFDD after it has already been executed, the flow of personnel and equipment might be slowed because of the required asset rerouting. This may impact the overall operation [11, II-19]. Thus, the information and prior deliberate planning that the JTF bases their initial decisions on must be as accurate as possible to ensure the appropriate force structure and support assets are included on the TPFDD.

3.3 Armed Services within the DOD

This section will review the roles and responsibilities of the armed services within the DOD organization. The services are the source of personnel and assets that the Unified Commanders use to project force around the world through deployments. It is within the armed services that GIS is being developed for deployment planning and execution. The armed services are the Army, Navy, Marine Corps, and Air Force. The Army, Navy, and Air Force are the three Military Departments with the Marine Corps being an armed service within Department of the Navy.

3.3.1 Army

The US Army is the first armed service to be reviewed. The Army's mission is to "preserve the peace and security, and provide for the defense of the United States, the Territories, Commonwealths, and Possessions, and any areas occupied by the United States; support national policies; implement national objectives; and overcome any nations responsible for aggressive acts that imperil the peace and security of the United States" [17]. These combative forces make up the force structure that is currently conducting operations in more than 50 countries worldwide [2, 21]. The Army is broken into corps, division, brigade, and battalion as shown in Figure 2. The organizational

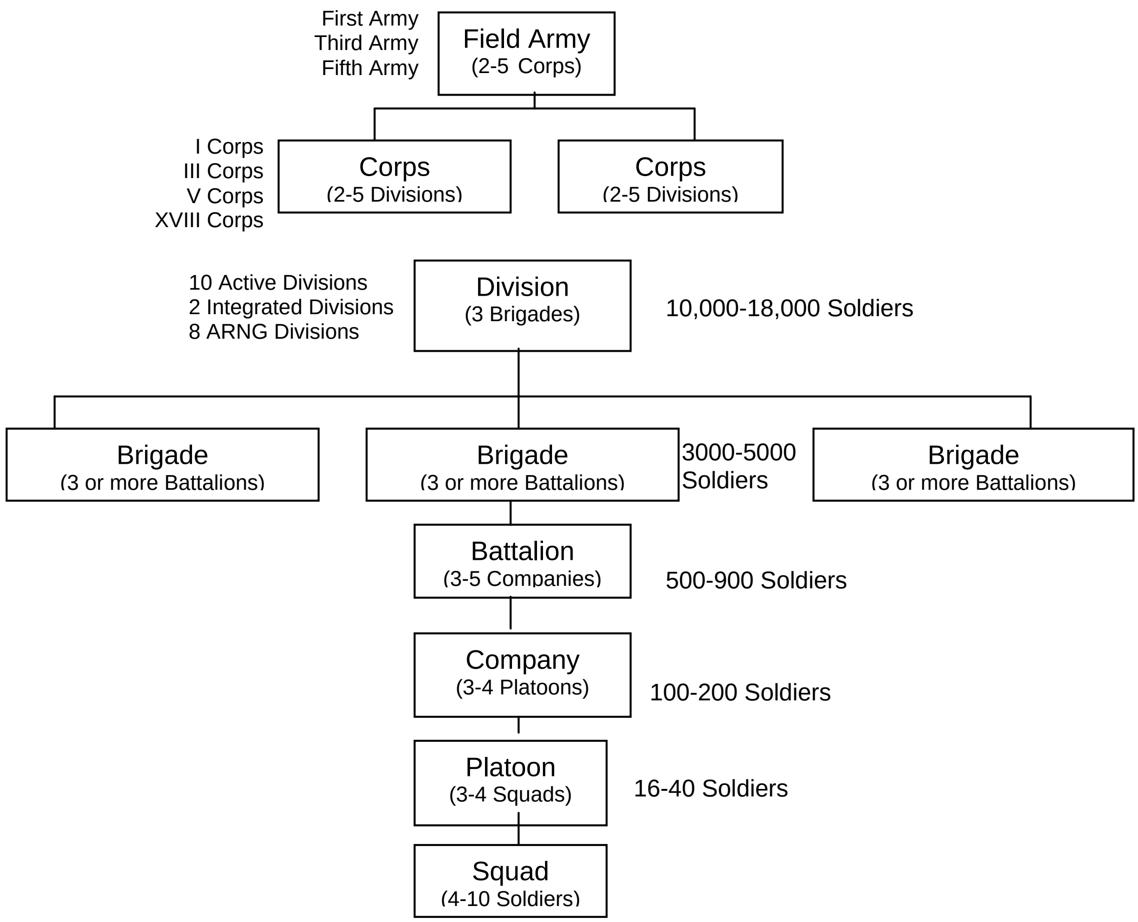


Figure 2. Army Organizational Chart [17]

structure is shown on the left side of the figure, and the right side shows the rank of the commander at that level. There are only three field armies: the First, Third, and Fifth US Army. This is the largest tactical field unit that can be employed. General Schwarzkopf commanded a field army during Operation Desert Storm. However, during Operation Iraqi Freedom, the largest unit deployed was only a corps which has between 20,000 and 40,000 personnel. The Army currently has four active corps of which three are headquartered in the US (I, III, and XVIII Corps) and one in Germany (V Corps). Below the corps, a division is the next sized unit, which has between 10,000 and 16,000 personnel. A division can conduct major tactical operations and sustained battles and engagements. Five types of divisions are light infantry, mechanized infantry, armor, airborne, and air assault. The Army currently has 10 active duty divisions and eight reserve divisions. A brigade contains between 1,500 and 3,200 personnel. Armored cavalry of this size are referred to as regiments [17]. The Army currently has one active armored cavalry regiment and one light cavalry regiment [5, 22].

The Army deployment plan is to have the corps be self supporting with airborne and vertical capability. The first brigade of the corps is to be on the ground four days after the initiation order. The first division is to be in position 12 days after the order. The two heavy divisions are sea lifted from stateside bases and are to start arriving by day 30. The two heavy divisions can consist of armored, mechanized, or air assault units, with the mix determined as required by the operation. The two divisions are to be in position within 75 days of the initiation order [18, 3].

The Army has recently fielded a new expeditionary war unit, the Stryker Brigade Combat Team (SBCT). The SBCT is designed to “bridge the gap between the Army’s light and heavy forces" [19]. The Stryker is an eight-wheeled medium weight armored vehicle. "The Stryker fulfills an immediate requirement to equip a strategically and tactically deployable brigade, capable of rapid movement worldwide" [19]. The Army is currently working to field six operational SBCTs and one training SCBT. The vehicle is air-transportable in any of the Air Force's transport aircraft [20]. The medium weight SBCTs are the Army's answer to the changes in the DOD to a more expeditionary mindset.

In an effort to reduce the amount of equipment that must be deployed forward for a conflict, the 1997 QDR called for a pre-positioned cargo capacity of four million square feet for both the Army and Marines with complementary land-based pre-positioned equipment [18, 4]. This cargo, including equipment and supplies, is placed at or near where it is planned to be used during military operations. The purpose of pre-positioning is "to reduce reaction time, and to ensure timely support of a specific force during initial phases of an operation" [13, 416]. Prior to Operation Iraqi Freedom, the Army had six brigade sets pre-positioned—three in Europe, two in Southwest Asia, and one in Korea [18, 4]. Additional assets were afloat around the world as part of the Army Pre-positioned Stock (APS) program. Part of the assets that were afloat included a heavy combat brigade with sufficient supplies to sustain a corps until lines of communication and resupply are established [18, 3].

3.3.2 Navy

This section will review the Navy's role in force projection. Since the end of the Cold War, the Navy's role has evolved due to threat changes, and this change will be highlighted. This section also covers the current force structure and deployment method for the Navy whose mission is "Maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas" [2, 22].

During the Cold War, the Navy was focused on finding, attacking, and defeating naval forces in the deep-blue ocean. However, since the end of the Cold War, there has been no global threat to the Navy or US interests. As a result, the Navy changed to meet new threats. The Navy published the documents *…From the Sea* and then *Forward…From the Sea* to show the change of a blue water navy to a one that operates in the littoral or coastlines of the world to allow for continued forward presence [21, 4]. Littoral regions are areas adjacent to an ocean or sea that are within control of and striking distance of sea-based forces.

Now, the Navy is able to project power to land adjacent to the seas and oceans of the world [22, 1]. By changing to include littoral regions, the Navy and Marine forces could now seize and defend forward bases, including ports and airfields, for follow-on forces from other services. This control of the littoral regions comes in addition to, not replacement of, control of the seas around the land which provides theater commanders great flexibility [22, 7]. In other words, the Navy provides a critical link between peacetime operations and the initial requirements during a developing crisis anywhere in the world [22, 2].

The Navy now has five roles in force projection: (1) project power from sea to land, (2) control the sea and maritime supremacy, (3) strategic deterrence, (4) strategic sealift, and (5) forward naval presence [22, 10]. The DOD says the Navy is "America's forward deployed force and a major deterrent to aggression around the world" [2, 22].

The Navy accomplishes these five roles with a smaller force than during the Cold War. The 1997 QDR concluded that the Navy needed to sustain a force of 346 ships for US security. However, as of 2001, the projected resource limitations will only allow the Navy to maintain about 300 ships over the next decade [21, 10]. The Navy's current combative force size is shown in Table 2.

Table 2. Navy Combative Forces [5, 22]

Aircraft Carriers	**12**
Air Wings	
Active	10
Reserve	1
Amphibious Ready Groups	**12**
Attack Submarines	**55**
Surface Combatants	
Active	108
Reserve	8

This combative force structure reflects the Navy's way of deploying. The Navy bases its deployment strategy around the warship. In *Forward…from the Sea*, the Navy said:

> "A US warship is sovereign US territory, whether in a port of a friendly country or transiting international straits and the high seas. US naval forces, operation form highly mobile "Sea bases" in forward seas, are therefore free of the political encumbrances that may inhibit and otherwise limit the scope of land-based operations in forward theaters" [22, 5].

The Navy again states its reliance on warships in the Navy Strategic Planning Guidance, which lists the aircraft battle group (ACBG) and the amphibious ready group (ARG) as the key elements of forward Naval presence [21, 8]. The ARG will be discussed in Section 3.3.3 along with the Marine Corps.

The Navy's most basic and important part of the forward presence is the ACBG [22, 4]. The ACBG is very flexible because of its naval tactical aviation wings and several support ships. The Navy deploys ACBGs around the world in potential hotspots, currently including the Far East, the Persian Gulf, and the Mediterranean Sea. A carrier battle group provides a quick response from the sea to any crisis worldwide [2, 22]. Combatant commanders can combine multiple ACBGs into a carrier battle force. When the carrier battle force is combined with Marine ARG and pre-positioned assets, the combatant commander has an impressive power projection tool [22, 5].

The majority of Navy combat assets are self deploying, meaning they deploy with all the assets needed to conduct military operations [11, II-22]. However, the Navy still has sustainment stocks, shore-based logistic support augmentation personnel, fleet hospital personnel and equipment, and engineering personnel and equipment that must be included in the TPFDD to support Navy operations [11, II-22].

Like the Army, the Navy also has pre-positioned ships around the world to reduce the Marine's Corps response time for contingency operations. The 16 Maritime Prepositioning Ships (MPS) carry US Marine Corps vehicles, equipment, and ammunition throughout the world. The MPS ships are assigned to three squadrons located in the Mediterranean, the Indian Ocean at Diego Garcia, and the Western Pacific at Guam and Saipan. The ships in each squadron can support 17,000 personnel for 30 days and are able to unload their own cargo. In 2000, three additional ships were added to increase capacity to carry expeditionary airfields, Seabee construction equipment, and field hospital cargo [23].

The Seabees are the Navy's expeditionary construction force. In August 2002, the Naval Construction Force (NCF), which is the Seabees, was reorganized under the First Naval Construction Division, which reports to Commander, Fleet Forces Command. The First Naval Construction Division (1NCD) has operational and administrative control over the active and reserve components of the NCF

The active component consists of two Naval Construction Regiments (NCRs), each with four Naval Mobile Construction Battalions (NMCBs) and one Underwater Construction Team (UCT). The majority of the Seabee force structure is within the NMCBs, which have a peacetime manning of approximately 625 personnel, and increase to 813 personnel during wartime [24]. The NMCBs:

> "provide responsive military construction support to Navy, Marine Corps and other forces in military operations, construct base facilities and conduct defensive operations. In addition to standard wood, steel, masonry and concrete construction, NMCBs also perform specialized construction such as water well drilling and battle damage repair. They are able to work and defend themselves at construction sites outside of their base camp and convoy through unsecured areas. In times of emergency or disaster, NMCBs conduct disaster control and recovery operations" [25].

The active duty NMCB's deployment rotation consists of a 10-month homeport training period, followed by a 6-month deployment to one of three forward deployment sites: Okinawa, Japan; Rota, Spain; or Guam. The UCTs have 75 divers and support personnel and have a similar deployment rotation, only on a smaller scale [24]. UCTs are trained and equipped to inspect, repair, maintain, and construct piers, wharfs, underwater sensor and training systems, underwater cable systems, mooring systems, underwater utility systems, and conduct underwater geotechnical and hydrographic surveys [26, E-18].

The Seabee reserve component of the NCF consists of four NCRs, 12 NMCBs, two Construction Battalion Maintenance Units (CBMUs), and one Naval Construction Force Support Unit (NCFSU). The CBMUs have 350 personnel assigned and tasked with performing as a deployable public works department in support of Navy and Marine Corps shore facilities. The NCFSU is a 460-person unit, which possesses a wide range of heavy construction equipment (batch plants, heavy cranes, line haul vehicles) to augment the capabilities of other NCF units [24].

As an example of the Seabees' capability, during Desert Storm, the Seabees provided initial construction support for the First Marine Expeditionary Force. The Seabees built facilities at four airfields for the Marine air units. Work included parking aprons, facilities to house the incoming units, operations areas, and ammunition supply areas [27]. By the end of Desert Storm, the Seabees had built 10 camps for more than 42,000-personnel; 14 galleys capable of feeding 75,000 people, and 6 million square feet of aircraft parking apron [28]. Similarly, during Operation Iraqi Freedom the Seabees provided direct support to Marine Corps forces ability to maneuver by constructing bridges, repairing and maintaining main supply routes, and constructing forward operating bases. After the initial combat push into Iraq, Seabees constructed force protection structures for security forces and were key in commencing the reconstruction of public schools, courthouses and police stations, and reestablishing power, water, and waste water services [24].

3.3.3 Marine Corps

This section reviews the Marine Corps combative force structure. This force structure is designed around the amphibious attack role that the Marine Corps fills in force projection. The Marine Corps mission is to “maintain ready expeditionary forces, sea-based, integrated air-ground units for contingency and combat operations, and stabilize or contain international disturbances” [2, 23]. The Marine Corps is able to “respond across the spectrum of conflict in the littoral and, as part of a joint force, in the execution of sustained land operations” [29, 4]. The Marine Corps combat force is the Marine Air-Ground Task Forces (MAGTAFs). Under a single commander, a MAGTAF is an integrated, combined arms force including air, ground, and combat service support units [29, 3]. As discussed during the Navy review, the MAGTAF is embarked on forward-deployed ships and provides deterrence and power projection. Since the MAGTAF is afloat, the units can be flexibly placed to respond to potential threats [21, 13].

The largest example of the MAGTAF is the Marine Expeditionary Force (MEF) [30]. As shown in Figure 3, a MEF is comprised of one or more Marine Aircraft Wings, one or more Force Service Support Groups, and one or more complete Infantry Divisions. A MEF can range between 20,000 and 90,000 Marines with an average of around 40,000 Marines [30]. The Marine Corps has three active duty MEFs [31]. A MEF is task-organized to fight and win a conflict up to the size of a major theater war [29, 3].

A MEF can be tailored to respond to a smaller conflict as a Marine Expeditionary Brigade (MEB). A MEB is sized to respond to smaller actions ranging from forcible entry into another country to humanitarian assistance [29, 3]. A MEB deploys on 15 amphibious ships with 30-day sustainment capability. The MEB’s organizational structure is shown in Figure 4. The ground combat element is built on an infantry regiment from the MEF. The aviation combat wing can conduct offensive air support, assault operations, electronic warfare, control of aircraft and missiles, anti-air warfare, and air reconnaissance [30].

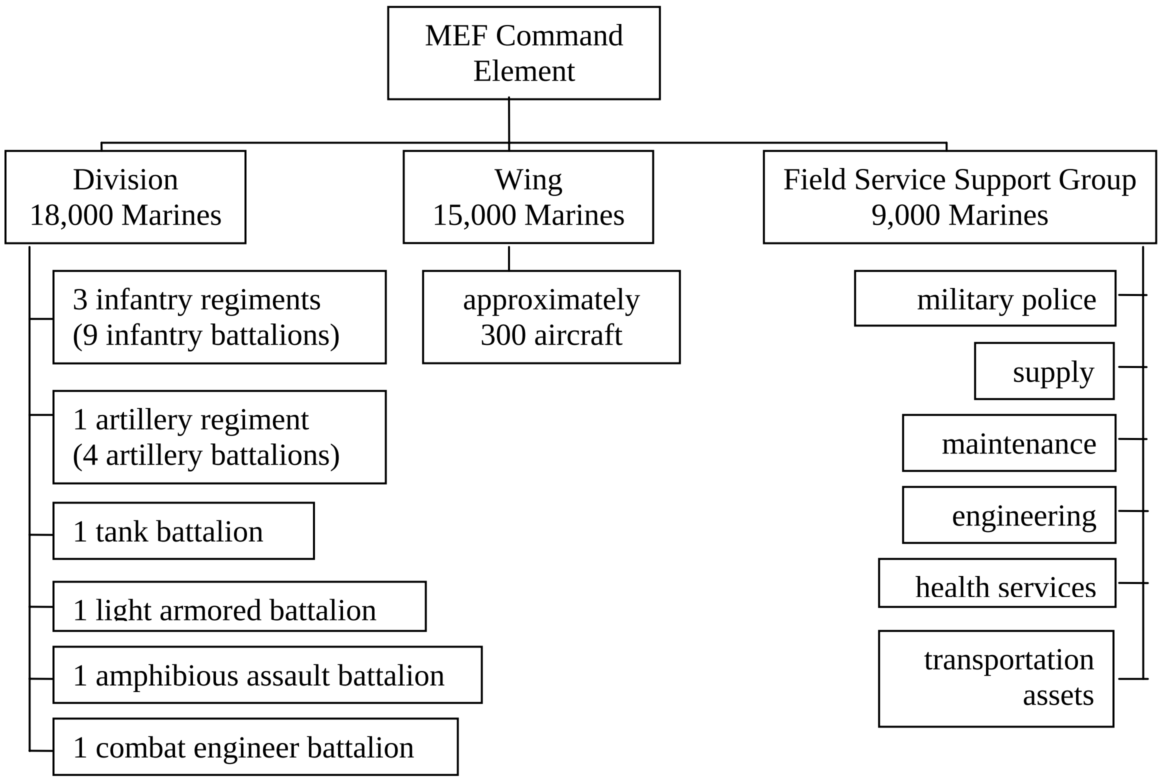


Figure 3. Marine Expeditionary Force Organization [30]

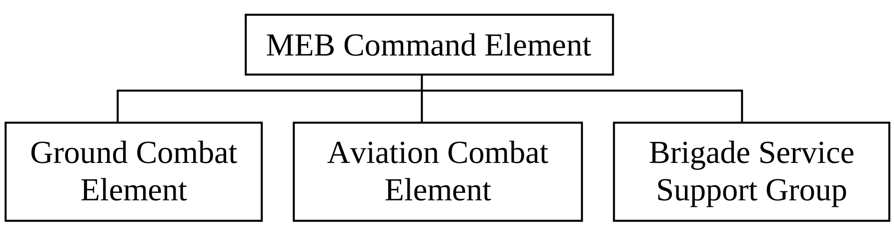


Figure 4. Marine Expeditionary Brigade Organization [30]

The Marine Expeditionary Unit (MEU) is an even smaller deployment package than a MEB. Its organizational structure is shown in Figure 5. The ground component of the MEU is comprised of an infantry battalion, which becomes a battalion landing team when tanks, artillery, engineers, amphibious vehicles, light armored vehicles, and other combat support vehicles are added to it. The aviation combat element consists of both fixed and rotary wing aircraft. The combat service support element contains 2,200 troops, 4 tanks, 13 amphibious assault vehicles, 22 helicopters, 6 tactical aircraft, and 6 artillery howitzers [30].

The unique deployment method of the Marine Corps over the other services is the Marine Corps ability to enter land directly from the ocean or conduct an amphibious

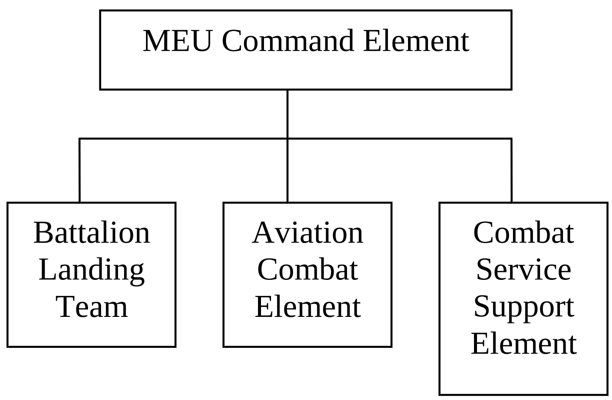


Figure 5. Marine Expeditionary Unit Organization [30]

operation. The new V-22 aircraft, which has vertical take-off and landing capability while still flying like an airplane, will extend the reach from the water of the Marine Corps past the current helicopter range [21, 13].

The current guidance for joint amphibious operations is JP 3-02, Joint Doctrine for Amphibious Operations. JP 3-02 identifies four types of amphibious operations: amphibious assault, amphibious raid, amphibious demonstration, and amphibious withdrawal. Amphibious assault is the most common amphibious operation which involves establishing a landing force on a hostile or potentially hostile shore. During an amphibious withdrawal, military forces or civilians are extracted by sea in naval ships from a hostile or potentially hostile force [32, 11-12].

Planning for the amphibious assault begins when a combatant commander issues an initiating directive to the Commander Amphibious Task Force (CATF). Once the order is received, the CATF and the Commander, Landing Force (CLF) step through 12 predetermined basic decisions for committing amphibious units [32, 14]. The 12-step process includes the following:

1. Selection of Amphibious Task Force (ATF) general COA
2. Selection of ATF objectives
3. Determination of Landing Force (LF) Mission
4. Designation of Landing Sites
5. Determination of LF objectives
6. Selection of beachheads
7. Selection of landing area
8. Formulation of landing team concept of operations ashore
9. Selection of landing beaches
10. Selection of helicopter landing zones
11. Selection of fixed-wing aircraft landing zone for airborne and air-transported operations
12. Selection of tentative date and hour of landing [32, 50].

Steps 4, 6, 7, 9, 10, and 11 are of particular interest to this research effort. Each of these stages requires the CATF and CLF to use imagery and other information to make a decision.

3.3.4 Air Force

The third Military Department in the DOD is the Air Force. Its mission is to "defend the US through control and exploitation of air and space" [2, 24]. The Air Force provides a rapid and flexible lethal air and space capability wherever necessary. The Air Force has a worldwide presence, and annually flies into all but five nations in the world [2, 24]. However, the Air Force, similar to the other services, has seen force and base size reductions while mission requirements have increased. The Air Force is operating with two-thirds fewer permanent overseas bases, one-third fewer people, and a 400 percent increase in the number deployments since the end of the Cold War [33, 6]. The current authorized combat strength for the Air Force is 46 active fighter squadrons, 38 reserve fighter squadrons, four air defense squadrons, and 112 bomber aircraft [5, 22].

A combat flying wing is organized as shown in Figure 6. The wing is broken into four groups by function—operations, maintenance, mission support, and medical. The

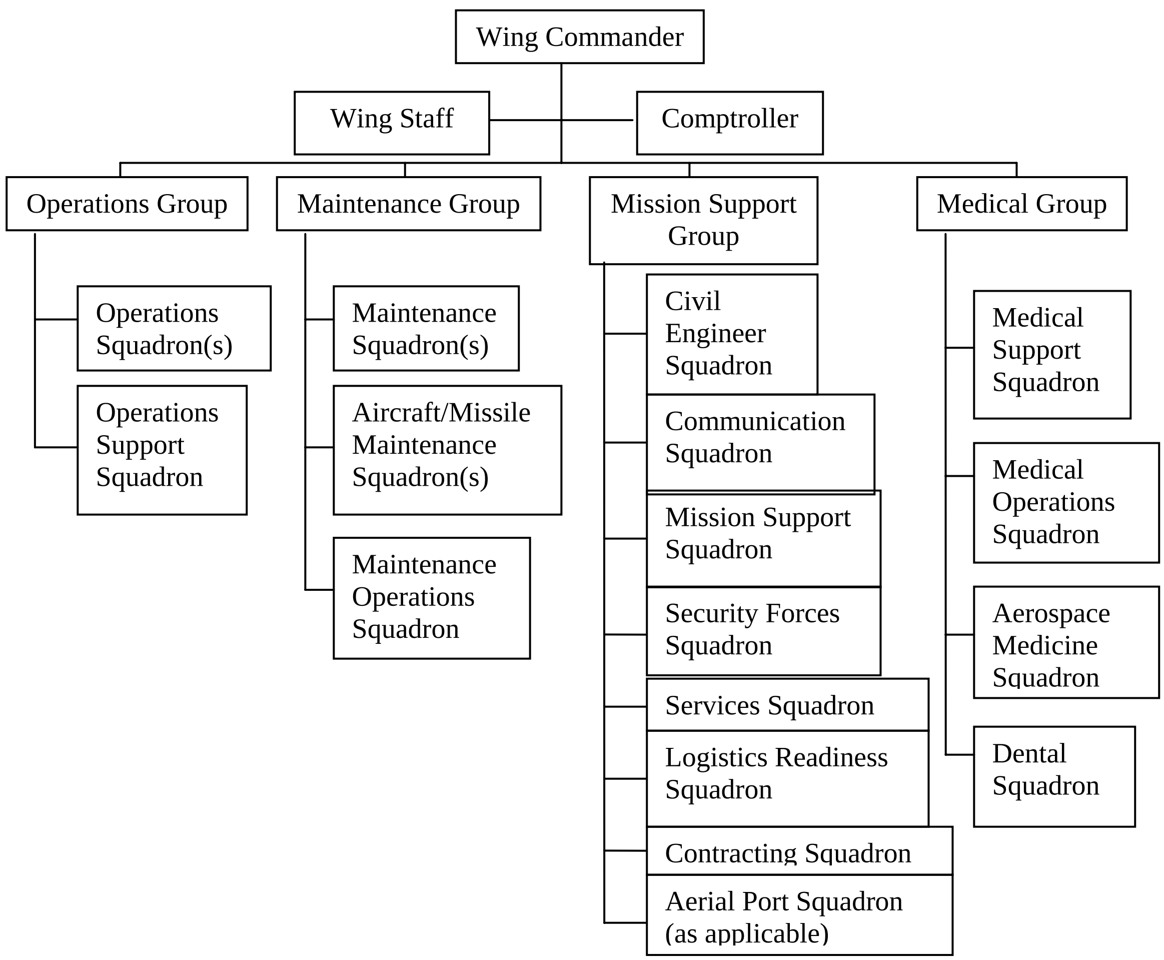


Figure 6. Air Force Combat Wing Organization [34, A-1-1]

operations group contains the flying squadrons and operations. The maintenance group is responsible for keeping the planes in flying condition. The mission support group provides the necessary support other than maintaining aircraft that is necessary for a base to function. Finally, the medical group contains the hospital or clinic and the dental offices.

On August 4, 1998, the Secretary of the Air Force announced the adoption of the Expeditionary Aerospace Force Concept for deploying forces to crises and ongoing contingency operations. Under the concept, combat, mobility, and support forces (active, Air National Guard and Air Reserves) are placed into one of the 10 Air Expeditionary Forces (AEFs). The AEFs are paired up and given set rotational time periods, or vulnerability windows, when the units are vulnerable to deploy [33, 4].

The size of each pair of AEFs was based on historical contingency deployments. Each pair of AEFs was planned to support at least the five ongoing contingencies at the time: 1) Northern Watch in Iraq, 2) Southern Watch in Iraq, 3) Operation Deliberate Force in Bosnia, 4) counter-drug operations in South America and the Caribbean, and 5) North Sea operations in Iceland [33, 7]. Each AEF has roughly the same capability with similar compositions of fighters and bomber squadrons, airlift and refueling squadrons, and combat support from active and reserve units. Assets in each AEF are not identical; however, the capability in each AEF is equivalent [33, 8].

Under the planned rotation cycle, each pair of AEFs covers 90-day vulnerability windows. During this window, the AEF will be deployed as required to support contingency operations; otherwise, the unit remains at home station. At the end of the 90-day period, the plan is to have deployed units be replaced by the next AEF. It does not matter at the end of the window whether the forces deployed or not; all the forces that were vulnerable during the window are unavailable for contingency operations for the next 12 months. For the first 10 of the 12 months, the AEF forces conduct normal training and operations. The last two months of the 12, the units prepare for their upcoming vulnerability window through exercises and training [33, 9].

During the vulnerability window, if the units are deployed to a new FOL, the civil engineering unit uses the Air Force's planning guidance for bare bases, Air Force Pamphlet (AFPAM) 10-219: Bare Base Conceptual Planning Guide, as a starting point to lay out the new FOL. The guide "highlights key features and considerations associated with bare base planning, describes the types of shelters, utilities, and support items available for bare bases, and addresses the general procedures for installing and erecting these assets" [6, 9].

The Air Force uses mainly two types of deployable units for forward deployment construction: Prime Base Engineer Emergency Force (Prime BEEF) and the Rapid Engineering Deployable Heavy Operational Repair Squadron Engineers (RED HORSE). Prime BEEF teams are organized to provide initial FOL construction and then provide the sustainment forces required for continued operation of a combat wing. A initial deployment team contains 104 engineers and 24 firefighters with additional follow-on teams adding another 46 engineers and 12 firefighters [26, E-8]. A Prime BEEF team is able to provide the following:

- command and control for all engineering functions
- operations and maintenance for facilities, utilities, and the airfield
- minor construction including force protection projects
- 24-hour aircraft crash fire rescue support

- limited base recovery operations to include rapid runway repair (RRR), expedient facility and utility repairs, and coordination of airbase defenses against conventional, nuclear, biological or chemical (NBC) attack [26, E-8]

The team deploys with a team kit of tools required for all operations and weapons [26, E-8].

A RED HORSE team is capable of heavy construction and repair. Each RED HORSE squadron has 404 personnel and is organized around 4 echelons (R1-R4). Each echelon has its own personnel and equipment based on mission requirements. The squadron deploys to a central location within the AOR. Then, teams are deployed from the central location to locations around the AOR to accomplish projects. This type of deployment is called a hub and spoke method. Each team deploys with its own force protection [26, E-10]. **Table 3** summarizes the four echelon's deployment time, capabilities, weight, and transportation time required. R1's 16 personnel are deployed with 16 hours of notification while R3's 120 personal take 6 days. R1 does not have any construction ability. R2 is setup to accomplish initial base beddown construction requirements. R3 and R4 are capable of heavy horizontal and heavy vertical construction respectively.

The squadron also contains six equipment sets (H-1 through H-6) to augment the R-1 through R-4 echelons. H-1 is used to supplement R-2 and R-3. The set includes bulldozers, scrapers, front end loaders, graders, excavators, compaction machinery, and tractor trailers for transporting equipment. H-2 contains equipment for specialized building construction including a large crane, forms for footings, and concrete placement tools. H-3 contains the equipment necessary for shallow and deep well drilling. H-4 is an asphalt batch plant, H-5 is a concrete batch plant, and H-6 has the equipment necessary to conduct quarry operations. H-6 is used when the local area cannot provide the necessary volume or quality of gravel for horizontal construction projects [26, E-11].

Table 3. RED HORSE Deployment Teams [35, 12] and [26, E-10]

Team	**R1**	**R2**	**R3**	**R4**
Personnel	16	148	120	120
Time required to deploy	16 hours	96 hours	6 days	8 days
Mission	Initial surveys and advance planning	Base development and beddown	Heavy horizontal construction	Heavy vertical construction
Construction capabilities	None	Beddown construction, rapid runway repair, aircraft arresting systems, essential utility work, earthwork, pavement repair and upgrade	Site development; construct, repair or expand runways, taxiways, ramps, roads, and revetments; heavy earthwork, and limited vertical construction capability	Construction and repair of existing facilities, large frame building erection, utility and electrical equipment setup and operations. Limited horizontal capability
Additional capabilities		Minor vehicle maintenance, supply, food services, and mortuary affairs	Minor vehicle maintenance and supply	Supply
Weight	25.2 tons	546.9 tons	950.5 tons	
Transportation required	2 C-130 or 1 C-141	45 C-130s and 3 C-5s or 15 C-141s and 3 C-5s	Surface transportation	

4.0 Geospatial Information Technology

This section reviews a few fundamentals of GIS which is necessary before a discussion of current DOD GIS use can be accomplished. For this review, GIS is broken into three parts: the Global Positioning System (GPS), remote sensing, and imagery. GPS is used to determine an exact location on the earth. Then, remote sensing is used to gain information about that position without having to travel there. Finally, imagery is used to produce an image to be used in the GIS.

4.1 Global Positioning System

Part of GIS is knowing exactly what part of the earth is being viewed. This knowledge can be gained through detailed land surveys, but more commonly, GPS is used. The DOD developed GPS to provide all-weather, round-the-clock navigation capabilities for military units on land, sea, and in the air. GPS has grown past its initial military roots to be extensively used in civilian applications ranging from the corporate world to personal recreation [36].

GPS uses 24 satellites in 20,200 km circular orbits inclined at 55 degrees. The satellites are in six orbital planes with four satellites working in each plane. The initial satellite constellation was completed on March 9, 1994 [36]. The constellation is shown in Figure 7. These satellites are used to determine an exact location on the earth. Until 2000, the military scrambled the higher resolution signal and only provided a lower resolution signal to the public. However, in 2000, President Clinton ordered that the higher resolution signal not be scrambled anymore [37]. This decision allows all GPS users to know their exact location, within 20 meters, anywhere on the earth [36]. A new round of GPS satellites is under development with scheduled completion in 2012. The newer satellites will improve the accuracy to sub meter resolution, allow for precision timing for high speed communication capabilities, and have enhanced signal levels to resist jamming [38, 11].

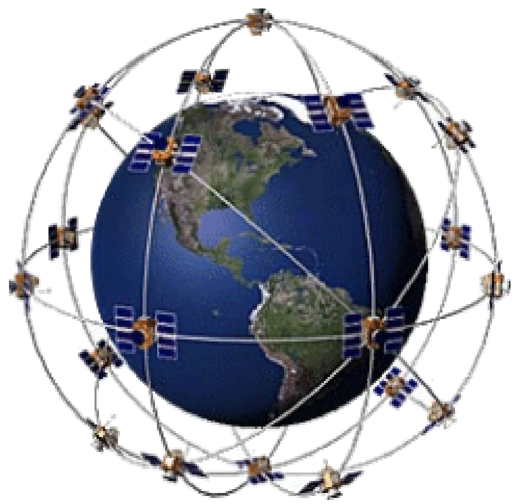


Figure 7. GPS Satellite [39]

4.2 Remote Sensing

The next key part in GIS is to remotely image the location of interest. Often, the DOD is interested in mapping and understanding areas that are controlled by adversaries or are large enough that a land survey of the terrain is not efficient. Remote sensing is defined as acquiring "information about an object without contacting it physically" [40]. In regards to GIS, the purpose of remote sensing is to produce an image—discussed in the next section—without actually having to physically touch the terrain or area of interest. The necessary information for the image can be remotely obtained from aerial photography or satellite imaging [40].

Aerial photography involves a plane flying over a specified area with reference marks on the ground. The plane flies at a predetermined altitude, and has a camera mounted looking down taking pictures of the terrain under or off to one side of the plane. The plane flies over an area several times to cover the entire area. The multiple pictures are placed together and a scale can be determined based on the reference marks in the pictures [41, 19].

Aircraft can also use Light Detection and Ranging (LiDAR) sensors. LiDAR uses a laser attached to the aircraft to determine the elevation and location of features under the plane. The result is a three dimensional image. LiDAR can be combined with spectral imagery to produce horizontal and vertical feature information [41, 19].

Remote sensing by satellite is accomplished by having satellites in orbit around the earth looking down with sensors. The satellites have predictable orbits that can accurately document the Earth's surface [42]. Satellite sensing is classified into two types: passive and active remote sensing [43]. Passive sensing uses sensors that detect the reflected or emitted electro-magnetic radiation naturally occurring in the visible and near infrared wavelength. This radiation is reflected by different materials on the Earth's surface [43]. Different materials such as soil, water, trees, buildings, and roads all deflect the light in different, but predictable ways. This reflected light is then interpreted based on previous knowledge of materials, and the result is an image that resemble a photograph taken from space [42]. Active remote sensing detects the reflected energy from the satellite. The energy emitted is microwave radiation, which is used to illuminate the areas to be imaged. The sensors measure the microwave energy that is reflected back to the satellite. This allows the satellites to work day or night and can penetrate cloud cover [43].

4.3 Imagery

Remote sensing produces an image that is either photographic or digital. An image is a “graphic representation or description of a scene, typically produced by an optical or electronic device” [40]. The photographic image works like a regular camera by using light sensitive film to record the image. The digital image is collected on electronic sensors and stored electronically rather than on film. The image is stored as a set of data values that represent the intensity of reflected light, heat, or other responses from electromagnetic radiation [40]. Both methods create an image that can be used for GIS applications.

The images produced can be black and white, infrared, color, and color infrared. The initial photographic image will have alterations of the geographic features either in size or shape, which are commonly called image distortion. Distortion is usually measured by spatial resolution, which in the smallest identifiable feature in an image. For example, a one-meter resolution means that objects of one meter or greater can be identified in the image [41, 19].

Once the image is collected, it must be stored for later use. The focal point for the DOD imagery, imagery intelligence, and geospatial information is the National Geospatial-Intelligence Agency [11, II-24]. DOD organizations can request imagery from NGA at little or no cost to support operations. NGA was formerly named the National Imagery and Mapping Agency (NIMA); however, in the 2004 Defense Appropriations Bill, the Agency was renamed NGA [44, 2].

4.4 Geographic Information System

Geographic Information System (GIS) is defined as "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information" [9]. GIS allows a user to access geospatial information in a timely and accurate manner. With the aid of computers, several separate sources can be combined into a single database based around the geospatial information.

The information in a GIS is stored in layers. Layers are used to overcome the technical difficulties that would result from trying to store and retrieve the large amounts of information that are stored in a geodatabase. It is also easier to work and sort information in layer format because layers of relevant information can be selected while non-relevant layers can be hidden [45]. An example of some layers used on a typical map may include the following:

1. Layer 1: basic image
2. Layer 2: vegetation (stored as areas)
3. Layer 3: land contours (spot-height or contour maps)
4. Layer 4: facilities (lines and shapes)
5. Layer 5: underground water (area)
6. Layer 6: location of water valves (points)

Figure 8 illustrates the combined layers. Information for the layers is stored in a database format. The two types of storage are vector and raster models. In a vector model, the image and information are stored as geometric objects such as points, lines, or polygons. In a raster model, the data is stored in image files composed of grid-cells known as pixels [45]. Spatial information can be stored in one or both formats by using specialized software.

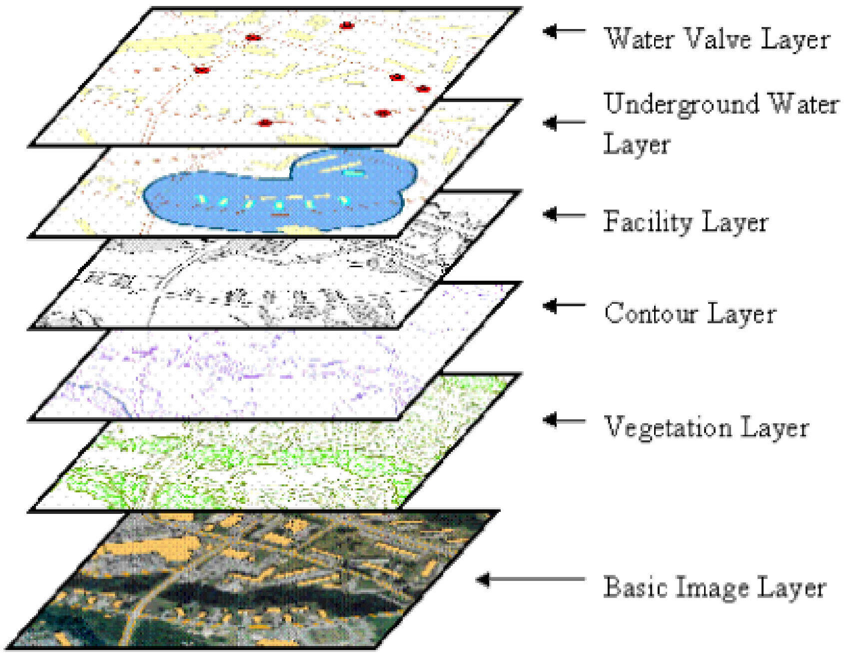


Figure 8. Layers of a GIS [46, 20]

The leading GIS software provider is Environmental Systems Research Institute (ESRI), which offers one of the broadest ranges of software products [47]. ESRI was started in 1969 [48], and launched its first commercial GIS software in the 1980s [49]. ESRI software is now used by over 300,000 organizations worldwide "including most US federal agencies and national mapping agencies, 45 of the top 50 petroleum companies, all 50 US state health departments, most forestry companies, and many others in dozens of industries" [48].

Currently, 70 percent of ESRI's sales are to government agencies. "The company's offerings are the de facto standard for government GIS and were of critical importance during recovery efforts after the September 11, 2001, terrorist attacks and, more recently, the space shuttle Columbia disaster" [49]. ESRI has also started funding a grant program that gives GIS devices to state and local agencies. A grant requirement is that the receiving organization must show an intent to share the information with other organizations that might need it in the interest of homeland security [49].

5.0 Armed Services' Use of GIS

The Armed services of the DOD have been pursuing GIS technology through many different avenues. Much of the underlying technology is similar, but the desired outcomes are different based on the missions of the separate services. This section presents an overview of each service's current GIS uses. The overview begins with the Army, then continues with the Navy and Marine Corps, and ends with the Air Force.

5.1 Army

The Army has both an installation GIS capability and a deployable GIS capability. The level and maturity of the installation GIS is not entirely clear. The Army's installation GIS capability was summarized during the 2003 GeoBase conference. The presentation indicated that there was no centralized GIS program for installations. The installation efforts were stove-pipe implemented, not accessible to most Army offices, and were not consistent or standardized [50, 4]. The presentation also stated that the Office of the Assistant Chief of Staff for Installation Management (OACSIM) was the lead for Army Enterprise (installation) GIS [50, 18].

The GIS homepage for OACISM says that in November 2002, an Army GIS manager was hired. Currently, the OACISM GIS office is developing a GIS roles and responsibilities letter, a GIS implementation strategy, and a data call and inventory letter. The data call letter will require installations to submit data to the HQDA annually. The layers that will be required are accident potential zones, noise contour lines, base boundaries, explosive safety quantity distance arcs, wetlands, 100-year flood plains, range complex, and 1-meter or better imagery [51]. If successful, this annual requirement should lead to all Army installations using some level of standardized GIS.

The Army has established the CADD/GIS Technology Center to help installations start and maintain GIS applications. The center provides a full range of technical and professional services for CADD and GIS including “the development and implementation support for data format standards, centralized procurement of products and applications, provisions of a clearinghouse for information exchange, and furnishing technical assistance to managers and users of these systems” [52].

The Army’s GIS use for deployment planning and execution is more mature and well defined. The USACE maintains the Army’s GIS system is the Combat Terrain Information System (CTIS) Project. The mission of CTIS is “the materiel development and acquisition of topographic support systems to meet the terrain geospatial information requirements of the Army Warfighter” [53]. It was recognized that the previous terrain analysis, topographic, and reproduction support provided by the Army Engineer Terrain Teams did not meet the requirements of the more digital Army. In the new digital Army being developed, each commander must have the ability to quickly access terrain information and topographic support [53]. CTIS is working to meet the needs of the evolving Army through the use of GIS. CTIS will allow the commanders to use digital maps for planning, rehearsing, and executing military operations. It also includes automated terrain analysis and visualization, terrain database management and distribution, and map reproduction [53].

The CTIS program includes not only GIS software, but also specially built consoles for military vehicles and tent conditions. Digital Topographic Support System

(DTSS) uses the commercial software of ESRI's and ERDAS Imagine to generate tactical decision aids (TDAs). TDAs are meant to provide the tactical level commander additional information to aid in making decisions. DTSS gives a user the ability to generate a variety of inter-visibility and mobility TDAs. For example, the mobility TDA shows on a digital map the quickest route across a given terrain. The user may also customize the TDA based on the AOR mission requirements. TDAs can be placed over an image as a layer to create a map-like product. The TDAs produced can be output to other Army systems [53].

The two systems fielded on military vehicles are the DTSS-Heavy (DTSS-H) and the DTSS-Light (DTSS-L). Each vehicle is a fully autonomous terrain analysis and graphics reproduction facility. The DTSS-H is field deployed on a 5-ton military truck, and can receive, format, create, manipulate, merge, update, and store digital topographic data. The system can produce hard or soft copies of any of the topographic information. The DTSS-L is sized to fit on a HMMWV. Both setups are shown below in Figure 9. The DTSS-H's fielding was completed in the first quarter of 2000; however, it is being replaced by the more mobile DTSS-L. The DTSS-L is capable of supporting the full range of military operations [53].

DTSS-H

DTSS-L

Figure 9. DTSS-H and DTSS-L [53]

The DTSS-Deployable (DTSS-D) uses commercial-off-the-shelf (COTS) hardware for terrain analysis and operates all types of software. The DTSS-D is a set of transportable workstations and peripherals that are housed in transit cases. The DTSS-D, shown in Figure 10, does not include tactical shelter facilities or communication ability. This system is used to "quickly produce maps products from multispectral imagery when standard products were unavailable or unsuitable for reasons of content or currency" [53].

Figure 10. DTSS-D [53]

The DTSS-B is a theater level configuration of desktop computers and plotters. The system is designed to provide quick response mapping, terrain analysis, and terrain-related for integrated battle planning. The system is a standalone server for geospatial information, which can be updated as required from other sources. The goal of the system is to limit the amount of information that the forward units must retrieve and rely on from stateside locations. As a result, this system provides quicker response times when geospatial information is requested at the theater level. The system is meant to augment the capabilities of NGA. The system is also able to produce copies of maps and other geospatial information required by a commander [53].

The CTIS was also developing the DTSS-Survey (DTSS-S). The DTSS-S consists of an automated integrated survey instrument, GPS-Survey, a digital level, a laptop/docking station computer to support survey computations, and a large-format, low-volume plotter. However, further development and production of this system is not scheduled currently [53].

One of the current TDAs available within DTSS is Battlespace Terrain Reasoning and Awareness (BTRA). BTRA is designed to “integrate terrain and weather effects and develop predictive decision tools to exploit those products” [54]. BTRA consists of six information generation components and five decision tools for addressing terrain and weather effects. The components use terrain feature data, digital elevation models, current and forecasted weather, and information regarding tactics, techniques, and system performance. BTRA outputs information about the following:

1. Observation, cover and concealment, obstacles and mobility, key terrain avenues of approach
2. Integrated products defining operational positions of advantage
3. High fidelity weather/terrain effects of mobility and signature physics
4. Advanced mobility analysis
5. Digital ground and air maneuver potential
6. Tactical structures relating information produced by the other components [54]

Figure 11 shows an example image from BTRA. For this example, the military units are starting in the lower right hand corner and traveling to the objective in the middle of the figure. The BTRA suggests a route and displays the maneuver corridor. It also suggests suitable locations for artillery and areas that should be controlled to cover the corridor. The Army has field BTRA Version 2.0 in DTSS Version 8.0. However, the research and development is scheduled to continue through 2006 [54].

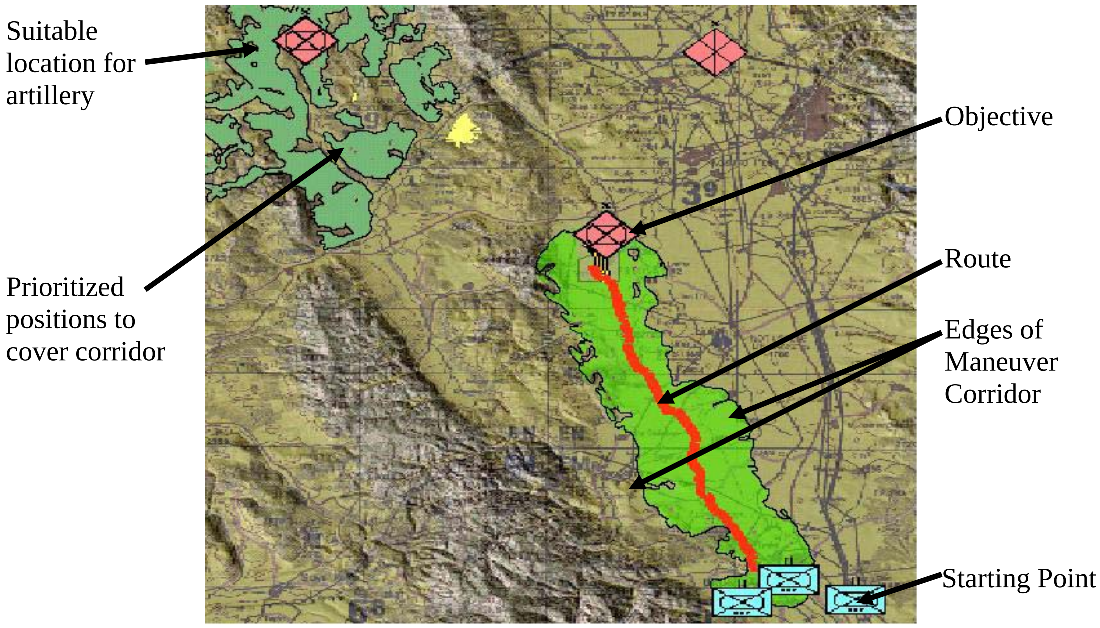


Figure 11. BTRA Graphic [54]

5.2 Navy

The Navy has pursued GIS for installation and deployment purposes. At the installation level, the Navy uses GIS for decision and planning support. The uses range “from utility and building maintenance and management, environmental planning, restoration, and compliance, construction planning, and requirements prioritization” [55, 33]. Installation security also uses GIS for public safety, force protection, and anti-terrorism support. “Security patrol routes, emergency dispatch, natural disaster response, consequences management, explosive safety and surveillance video arcs, and vulnerability assessments are all enhanced by visualization through common applications delivered to desktops” [55, 33]. The Naval Facilities Engineering Command is also one of the charter members and sponsors of the CADD/GIS Technology Center for Facilities, Infrastructure, and the Environment described in the previous section [56].

One example of the Navy's installation GIS was when the Public Work Center (PWC) Japan began implementing GIS technology in their command in 1995. The command encompasses the Japanese islands of Honshu, Kyushu, and Okinawa. In 1998, the PWC became the GIS provider for Naval Complexes (NC) in the Japan Region. For GIS purposes, the Navy consolidated its 26 geographically separated locations in Japan into five Naval Complexes for more centralized control. The regional office consists of one American Civil Service manager and four Japanese nationals. The separate NCs have a point of contact that the regional staff for coordination. The regional staff accomplishes all contract support, data development, training, and related equipment procurement. Each of the remote sites maintains a GIS server for use by the NC. This allows direct access and editing. The remote sites are backed up to the regional data servers regularly. Then, the regional server provides access to the majority of users in the region. The program attempts to integrate information from planning, utilities, environmental, housing, life/safety, natural and cultural resources, and engineering [57].

The Navy's operational GIS use reflects the mission focus of water and littoral operations. The Navy has developed Digital Nautical Charts (DNC®) to support Navy electronic navigation goals [58, 3]. DNCs are a vector-based digital database with selected maritime significant physical features from hydrographic charts. Layers within the DNC are data boundary, boundaries, hydrographic features, population, transportation, vegetation [58, 9]. Other examples of information included in the DNC are shown in Table 4.

Table 4. Information included in Digital Nautical Charts [59, 12]

Culture	Land features of human origin (roads, buildings, industrial areas)
Earth Cover	Topographic shoreline, islands, and foreshore boundaries
Environment	Ocean currents, tides, and magnetic anomalies
Hydrography	Depth curves, soundings, bottom characteristics, depth areas
Inland Waterways	Inland hydrographic features (rivers, lakes, and canals)
Land Cover	Shore features significant to navigation (trees, glaciers, swamps, marshes)
Limits	Significant to navigation (pilot boarding locations, restricted maritime areas, and traffic separation schemes)
Navigation Aids	Marine navigation aids (buoys, lights, beacons, etc.)
Obstructions	Features that are considered a hazard to navigation safety (rocks, wrecks, bridges, etc.)
Ports	Unique features common in most ports (breakwaters, piers, wharves, jetties, berths, bollards)
Relief	Topographic spot elevations and contours
Data Quality	Everything you wanted to know about the paper source chart or survey used in the compilation of the DNC. Provides historical data, edition, Datum information, and related notes
Library Reference	Small scale depiction of the chart coverage for use in selecting a geographic reference position for viewing

The geospatial information is either obtained from the NGA, other nations, or from the Navy's fleet of eight survey ships that collect hydrographic and bathymetric data [59, 2]. Figure 12 shows the availability of DNCs. The dots show locations of specific information about harbor or approaches. The larger blue areas show areas of general information, and the pink areas contain coastal information.

The Navy uses vector data because the International Maritime Organization (IMO) only recognizes vector data, and vector data offers technical advantages over raster format [59, 7]. With over 80,000 civil ships in the IMO expected to use electronic charts, the Navy's small number of ships did not justify a different standard [59, 15]. Also, vector data also supports grounding avoidance software. The grounding avoidance

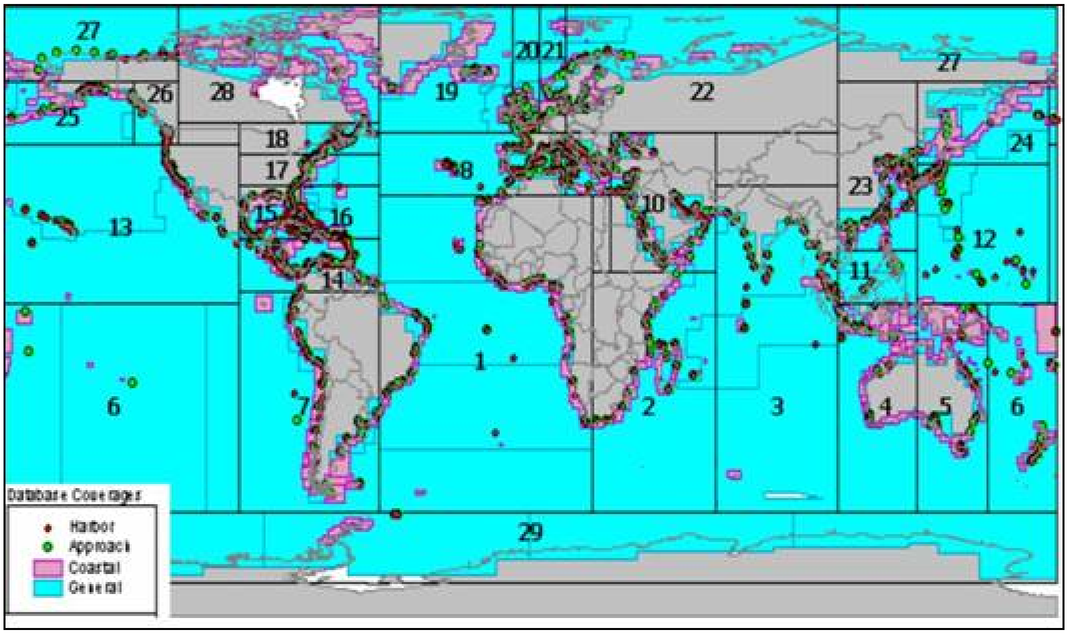


Figure 12. Digital Nautical Chart Footprint [59, 42]

system can alert a mariner of an area and features that are a danger to his vessel based on user-defined ship's parameters (i.e., ship draft) and course [59, 10]. The Seabees reported that they do not currently use GIS for deployment planning or execution. However, they have expressed interest in the Air Force's GIS programs that are discussed in section 5.4 [24].

5.3 Marine Corps GLIDE Program

The Marine Corps' GIS technology is used to maintain and find geographic information for Marine field operations. The Marine Corps has established the Geographically Linked Information Display Environment (GLIDE) program. The system combines geospatial data such as maps, video fly-through, and other data sets. The information is combined using map coordinates to line up different information. The information can then be searched by place name or map coordinates [40].

Unlike other GIS applications, GLIDE does not use a layer system. Instead, information is searched for by geographic name or a map search. The user refines the search until a list of information available is presented. At this point, the user may choose what information to download and view or may view the product in a separate graphic window. The maps are compressed at a 20:1 ratio to allow easier download. All information posted on GLIDE is checked for correct grid coordinates and projection/ coordinate data. Over the next few years, the user will gain the ability to download only the data [60].

A prototype portable GLIDE program has also been created. The program allows the user to pre-load data sets prior to deployment or operation for a specific AOR. Currently, the MEUs deploy with this portable GLIDE program on digital video disks so that they only have to access the classified GLIDE program site for updates [60].

5.4 Air Force GeoBase

GeoBase is the over-arching name for the Air Force's GIS installation program. The vision of the Air Force's Geo Integration Office is "One Installation…One Map" [10]. The program's mission is to "attain, maintain and sustain one geospatial infostructure supporting all installation requirements" [10]. GeoBase is supported by the existing base communications network using GIS software, and will allow the base personnel to use the same GIS database for decision making and asset location [10].

GeoBase is broken into two major areas: Garrison GeoBase and Expeditionary GeoBase. Garrison GeoBase is the program used at home station bases. A growth of Garrison GeoBase is Strategic GeoBase. Strategic GeoBase is planned for use in the 2005 Base Realignment and Closure (BRAC) Committee. When the information is presented for the 2005 BRAC, it becomes public record. Thus, the information that is included in Strategic GeoBase must be of a sensitivity level that can be released to the public.

Within Expeditionary GeoBase, there are also two divisions based on the information classification. The system on the classified network is GeoReach, which is used for pre-planning FOLs. However, once the units arrive at the new FOL, information needs to flow more freely, and this is when Expeditionary GeoBase is used over a non-classified network at the new FOL [46]. GeoReach is discussed in the next section.

Figure 13 is an example of a Common Installation Picture (CIP) from Garrison GeoBase. The GIS database includes imagery of the base as a background layer. Then, the roads, facilities, and utilities are overlaid on the imagery to provide a whole picture of the base. This same database is available to all members using the base network.

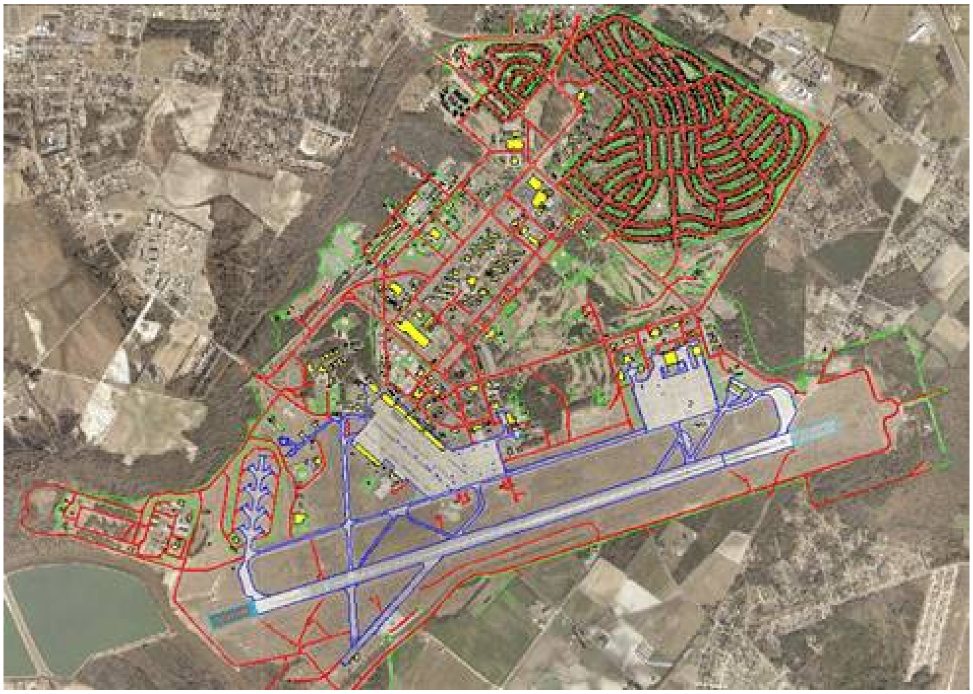


Figure 13. GeoBASE CIP [61, 4]

5.4.1 GeoReach

The Air Force's GIS program for aiding in FOL pre-planning is GeoReach. GeoReach is the step between Garrison GeoBase for a unit at home-station and a forward deployed unit using Expeditionary GeoBase. The purpose behind GeoReach is to "minimize basing risk by empowering decision-makers with forward knowledge of the immediate environs on and around the FOL during contingency operations" [10].

> "GeoReach is currently targeted by the Headquarter Air Force Expeditionary Site Survey Process IPT [Integrated Project Team] to be the visual rallying point for compiling all expeditionary site survey data requirements into a single, integrated process. This will result in fewer Air Force survey teams going forward prior to deployment, reduced risk in exposing airmen to hostile conditions, and new economies of scale in mobilizing expeditionary planning knowledge across the Air Force operational planning spectrum" [10].

The use of GeoReach begins with a preliminary list of possible FOLs. Information is gathered on this initial list and a CIP is constructed for each of the possible FOLs. This initial information is obtained from Air Force intelligence, NGA, the Defense Intelligence Agency (DIA), or other military departments. The CIP that is created is then used with the bare-base planning tools described in the following subsections for base optimization and to gain initial situational awareness about the possible FOL [10]. Once the initial list of possible FOLs is narrowed down, Air Force site survey teams are then deployed with portable GPS capability to validate existing data and collect any additional needed data [7]. As units are deployed to the new FOL and start building on-site GIS capability, the CIP transitions from GeoReach to Expeditionary GeoBase [10].

Air Combat Command (ACC), Pacific Air Forces (PACAF), and United States Air Forces Europe (USAFE) each maintain individual classified web-accessible GeoReach libraries on the SECRET Internet Protocol Router Network (SIPRNET). Each library contains GeoReach CIPs and associated information about possible FOLs in the command's AOR. The information stored on these systems is provided on a need to know basis to Air Force personnel and other services via the SIPRNET [10]. The separate pages are linked on the SIPRNET.

Figure 14 through Figure 21 are screen shots of GeoReach. These images were taken from unclassified presentations about GeoReach. Figure 14 is of the ACC GeoReach homepage. The actual capability to move and manipulate data is reserved for the ACC planning team. The web site access allows others to view the information in a web page layout which enables anyone on the classified net to view the imagery without be required to have the GIS software (i.e., the ESRI suite). The initial web page allows the user to key in on parts of the world to search for information. By zooming into a specific area on the map, the user can view available geospatial information for the given area. The toolbar on the left side contains the navigation tools for the user. The options on the right side are the different layers that can be selected or deselected.

Figure 15 is an example of what a user can choose to view. The location of the base is shown geospatially correct in relation to the nearby town and associated roads. This particular screen shot has the layers for infrastructure, tent city, aircraft maintenance, flight line, C-130 apron, and final approach selected as indicated in the menu bar on the left. The final approach layer shows the area that planes fly during take off and landing. On the image below, it is the hatched area extending towards the top and

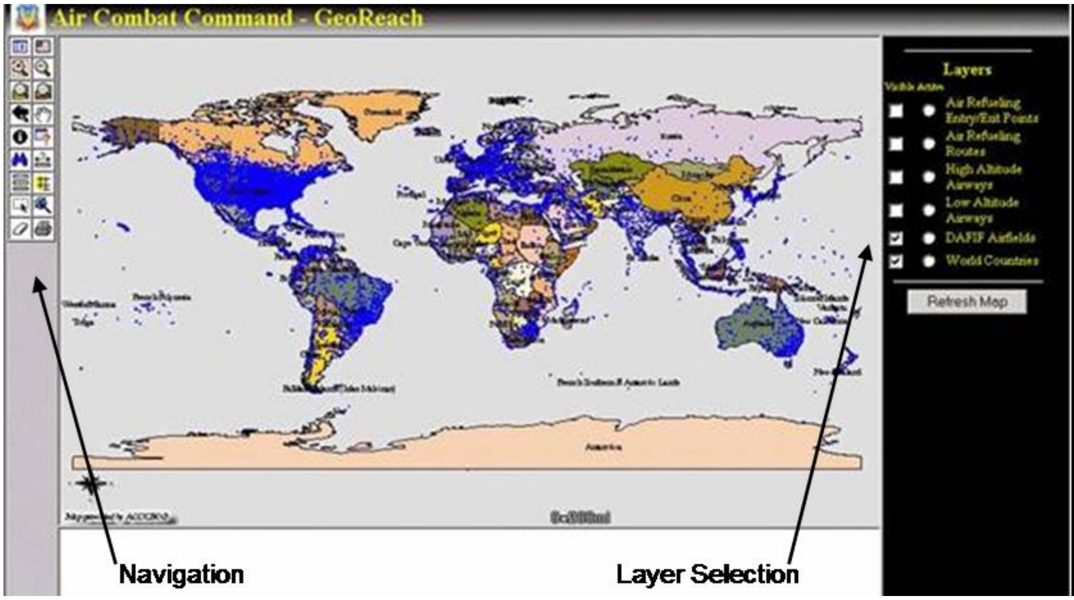


Figure 14. GeoReach Homepage [62, 10]

bottom of the image. Because this is GIS data, a person viewing this image on the web can determine the distance between any two points by clicking on them. The resultant distance is shown at the bottom of the menu on the left. The user is able to adjust the picture as required by using the commands at the bottom of the page.

Figure 16 shows a zoomed in screen shot of the existing facilities with proposed facilities. Work area in the image includes maintenance and day-to-day operations areas for base personnel. The tent city is the lodging area for base personnel.

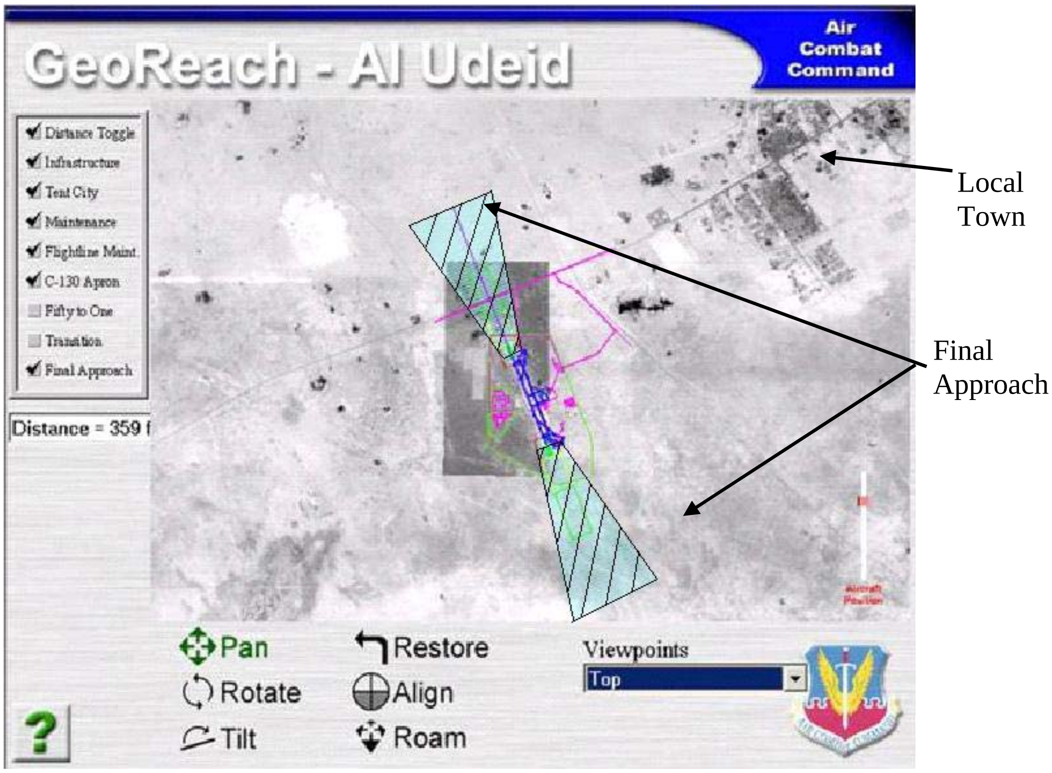


Figure 15. GeoReach Command Menu [62, 14]

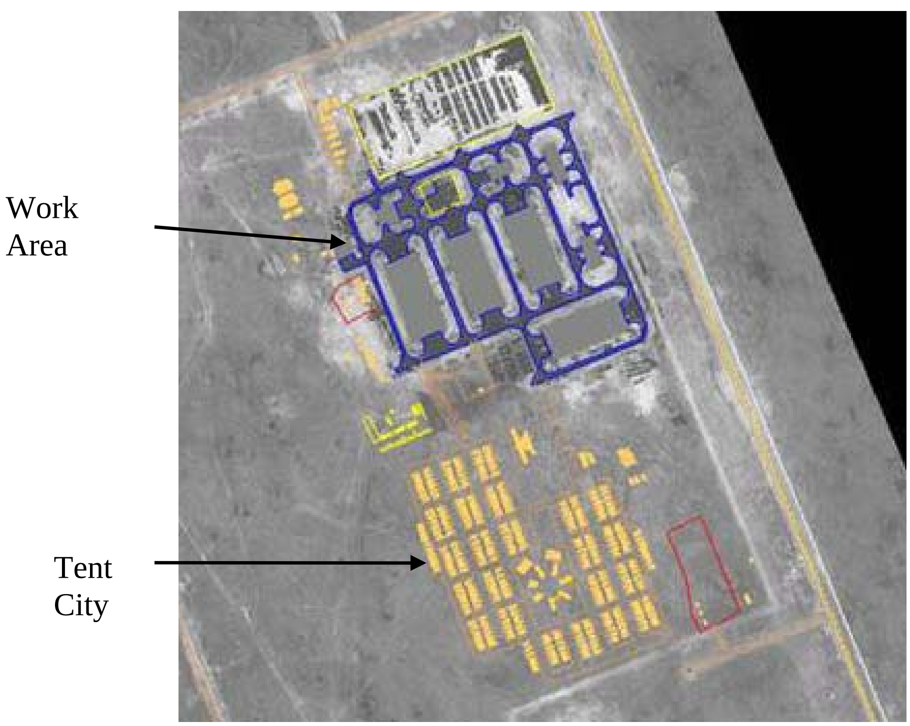


Figure 16. Base Setup [62, 12]

The following figures show capabilities that are not available through the SIPRNET. These functions are available to the planners using GeoReach. The screen shots show a three dimensional view of a plane approaching the airfield and then flying through the base. This presentation ability can be used during briefings about the proposed base to leadership, or it may be used to familiarize pilots with the airfield and runway prior to his/her first flight into it. This particular image shows a flat area; however, if the surrounding terrain included tall antennas or mountains, the fly through would show the pilot these hazards, three dimensionally. Figure 17 shows the plane on final approach to the airfield.

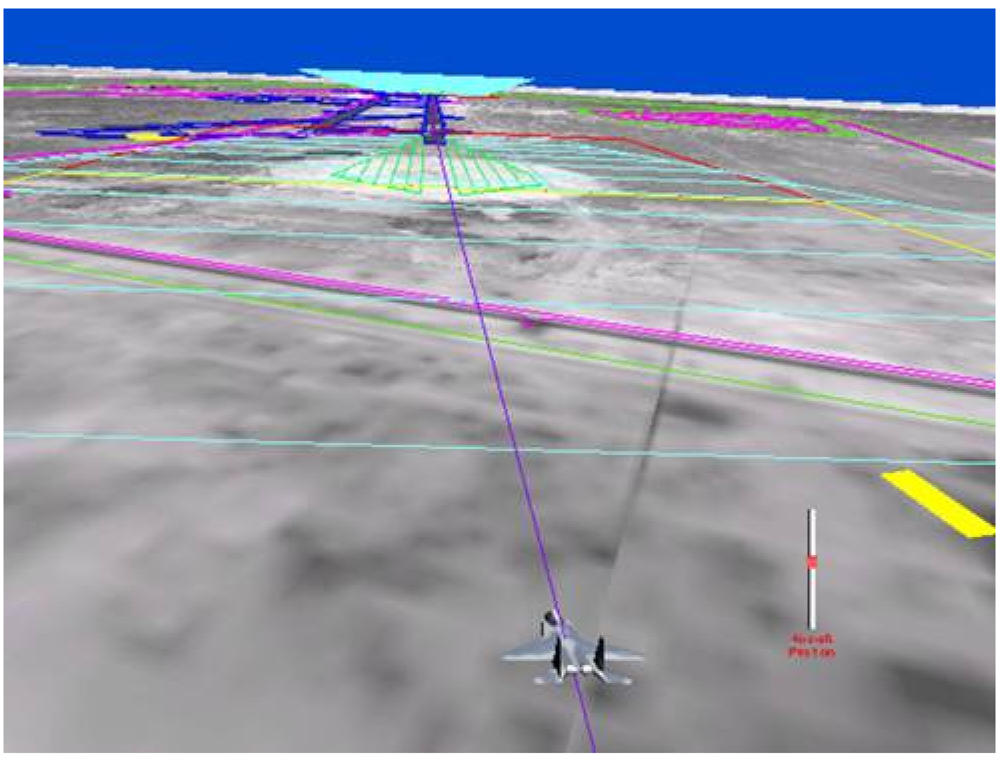


Figure 17. GeoReach Aircraft on Final Approach [62, 9]

Figure 18 shows the user the view of the end of the runway as if circling the airfield.

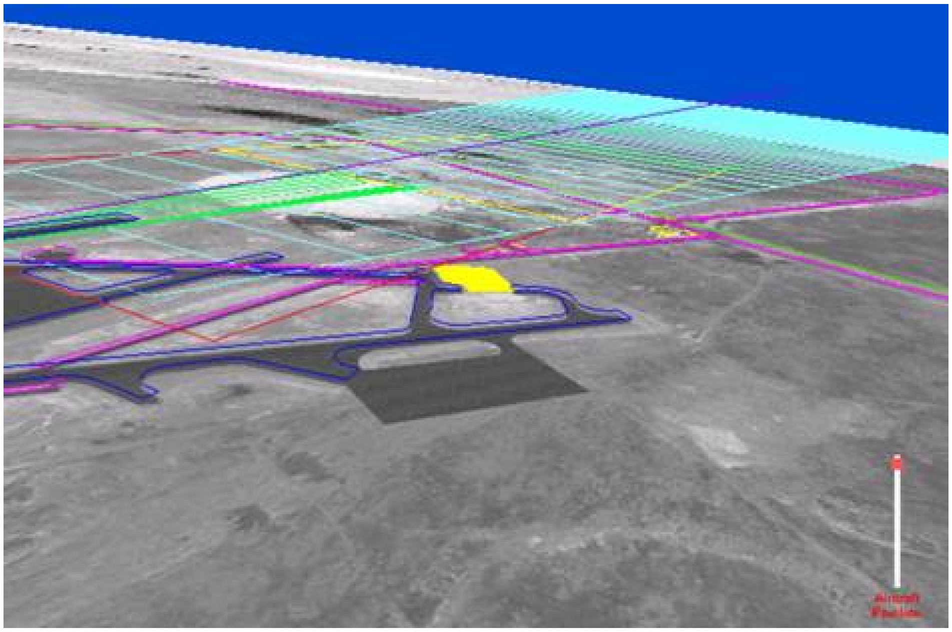


Figure 18. GeoReach Fly Through [62, 16]

Figure 19 shows the versatility of the GeoReach program. The user is able to leave the approach/departure path of the runway and “fly-through” the operations and maintenance facilities.

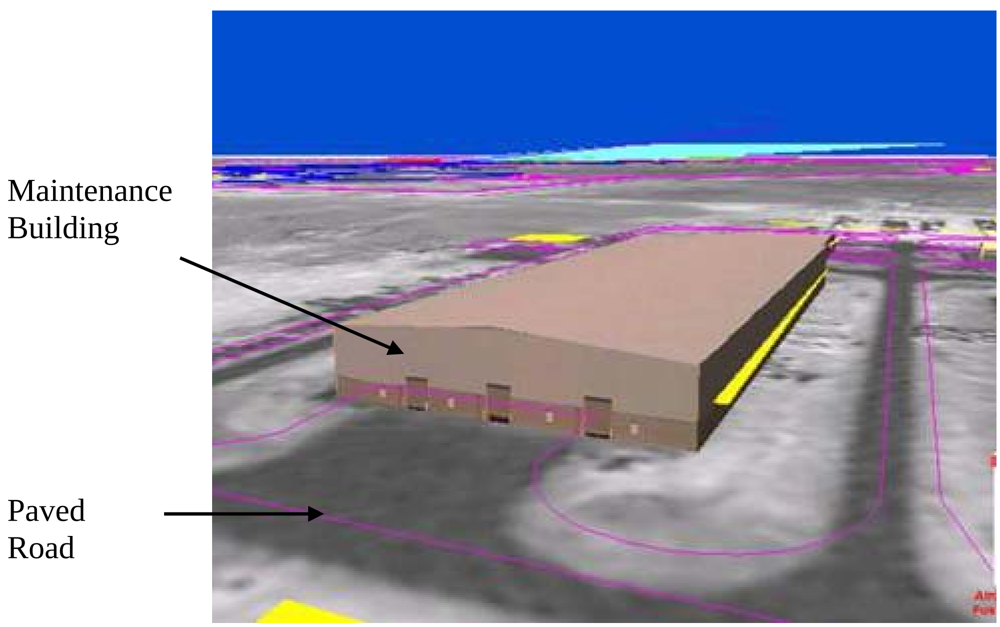


Figure 19. GeoReach View of Operations and Maintenance [62, 17]

Figure 20 shows a proposed tent city as laid out by a beddown planner. This allows the planners to visualize the proposed tent city in three dimensions.

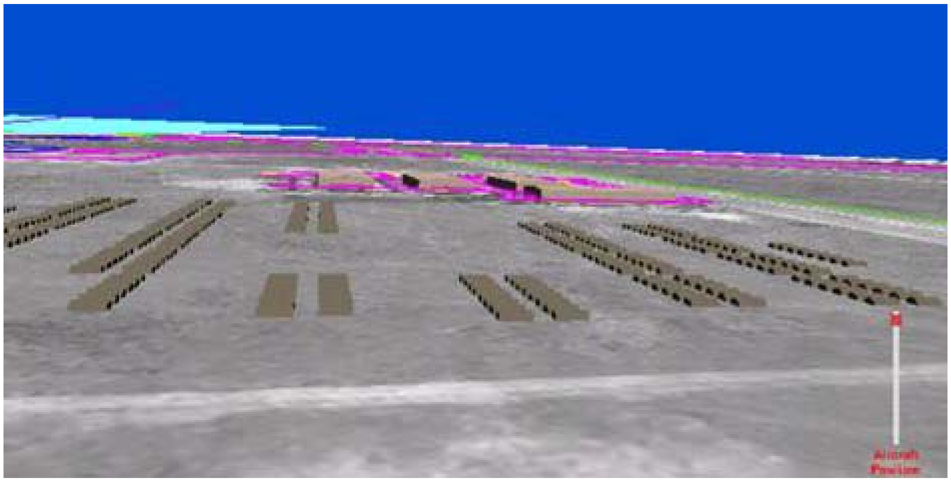


Figure 20. GeoReach Tent City View [62, 18]

All of the previous images are from the ACC GeoReach office. Figure 21 shows an example of the USAFE GeoReach homepage. The homepage initially appears

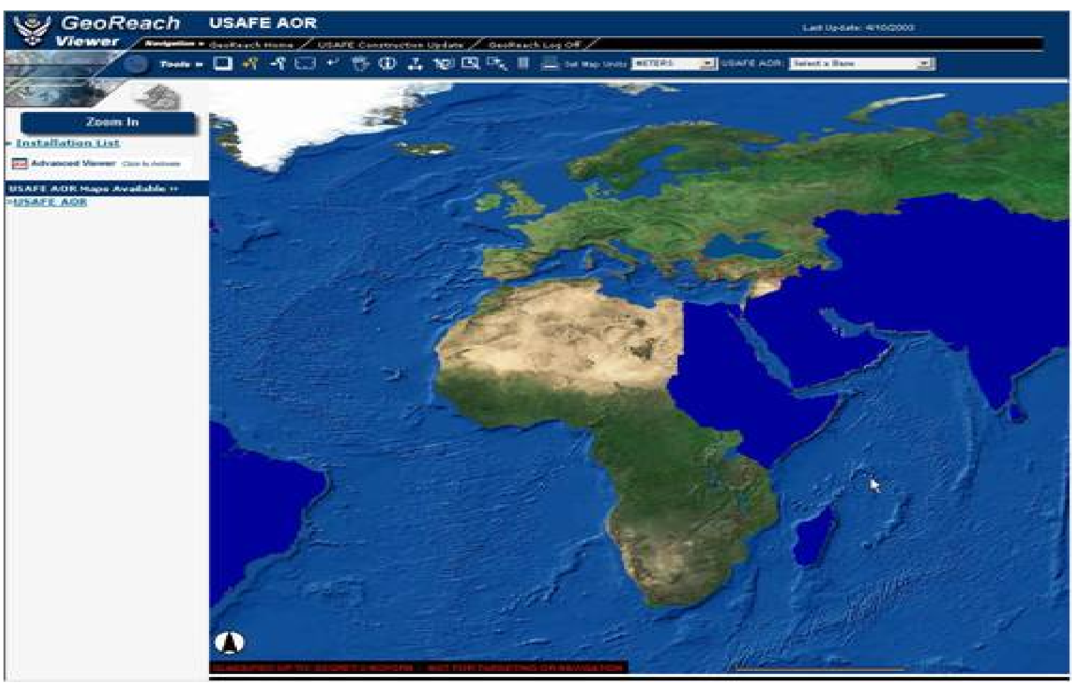


Figure 21. USAFE GeoReach [63, 10]

different than the ACC homepage, but offers the same functions and features as the ACC GeoReach web site. The user selects an area or a base to view, and then is able to zoom in as required.

Currently, the Air Force civil engineering community is working with the logistical community to combine site survey methods. The logistical planners use Logistics Capability Assessment Tool (LOGCAT), which stores pertinent logistical information about a possible FOL. The goal is to combine the two systems, GeoReach and LOGCAT, into one GIS database. Thus, when a site survey team goes to a potential FOL, a smaller team can collect all the information for both the engineers and logisticians with geospatial data attached [61, 21]. GeoReach includes planning tools to aid in aircraft parking, fuel and munitions storage, and other force beddown requirements [7]. The force beddown tool is discussed in the next subsection. The second subsection discusses the contingency aircraft parking planner (CAPP).

5.4.1.1 GeoBest

GeoBEST, Base Engineering Survey Toolkit (BEST), allows a user to view a specific area for potential beddown of forces and place assets over the image and/or CIP. The program estimates the resources required and then the user is able place the resources over the image. The program uses Air Force and Army standards for estimating the correct number of assets required based on the aircraft or other combat assets the base is planned to support [64].

The rationale behind automating the beddown planning software was to provide the planners a computer-based tool for rapid development of base layout plans [64]. GeoBEST allows the planners to do the following:

1. Geospatially visualize a layout plan for the facilities and equipment for a specific plan.
2. Interactively change the plan based on users' knowledge or other input.
3. Interface with other modules that contain critical information and/or spatial configurations for facilities and equipment for the plan.
4. Use standard regulations for spacing requirements [64].

To decrease beddown layout time, the program includes templates of typical asset layout. These templates allow the user to copy and paste into the current scenario without having to place each individual asset. All of the information is then stored as a scenario for future access.

Figure 22 is from GeoBEST. On the left side of the image is the table of contents of assets that the program has estimated will be required to support the mission. This

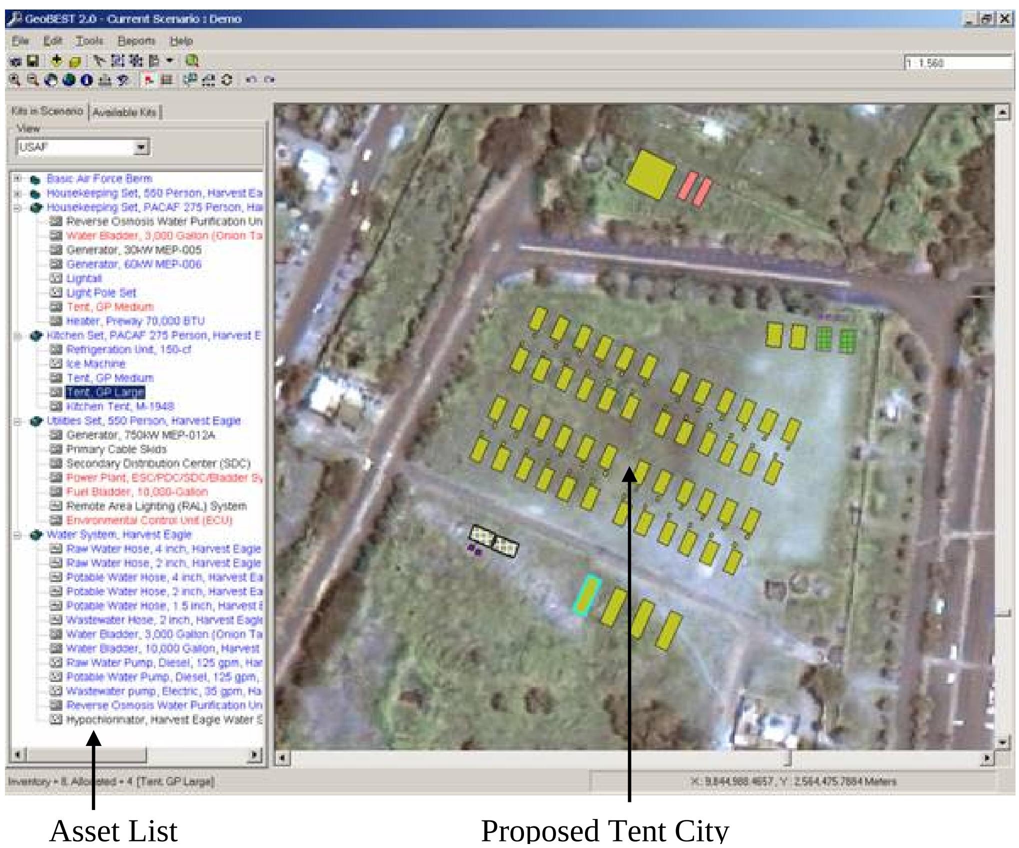


Figure 22. GeoBest [65]

asset list is based on asset deployment packages already prepared by the Air Force or Army. The user selects an asset from the left menu and places it on the image on the right. The asset may be moved, rotated, copied, pasted, or deleted. The image on the right shows the proposed layout of assets including billeting tents, shower and shave facilities, and the power plant for electricity.

The menu on the left keeps a running total of assets placed. An item will show as red in the menu when all the available units of that asset have been placed. The user knows that in order to use more of this asset, he/she will have to request more than is available in the predetermined kit. As with other GeoReach programs, the user navigates through the image with the commands at the top of the screen.

The user is also able to determine if any constraints between facilities are violated. For example, the distance between two tents must be 12 feet. Figure 23 shows the constraints feature turned on for a group of billeting tents. GeoBEST will notify the

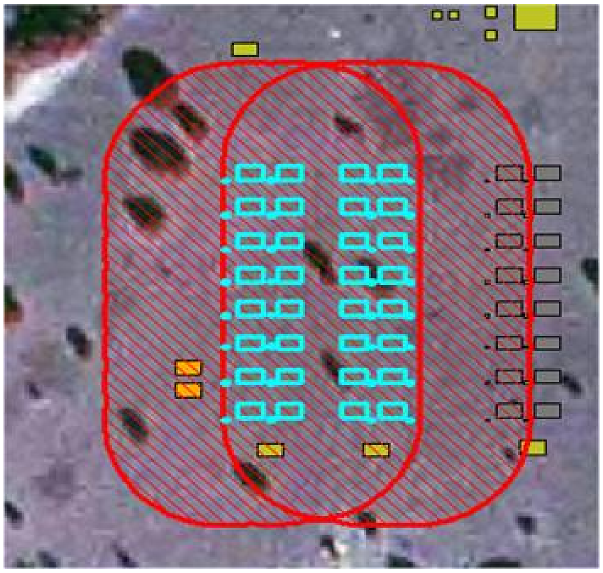


Figure 23. GeoBEST Constraints [66, 6]

user of any assets within the hatched region that are in conflict based on the Air Force's or Army's spacing regulations. Beside the constraints feature, GeoBEST also has tools that will calculate and report the required labor, utilities, and power to physically construction a given scenario [64].

GeoBEST is only an aid to a planner. The program does not tell the user where to place the assets; it only tracks the placement that the user has selected. Thus, a knowledgeable bare-base planner must still determine the layout of assets.

5.4.1.2 CAPP

The CAPP is a tool used in GeoReach to determine the optimal parking layout for aircraft in contingency operations. The factors in designing how aircraft will be positioned are the lateral clearance standards, grade changes, and aircraft maneuverability since it is desired that aircraft can taxi under their own power [67, 1].

The old process of aircraft layout design was to have an engineer attempt to optimize the layout by hand based on manuals and a map of the proposed parking area. The planner determined the parking area with physical and material characteristics of the runway, taxiway, and aprons. Next, the planner determined the requirements for each type of aircraft to be parking including aircraft access, safety clearances, and required storage. Then, the engineer attempted to fit the most aircraft into an area. This process may have been repeated several times for a specific location as the mission may change several times during the planning phase of a military operation [67, 2]. CAPP automates the aircraft parking process.

CAPP is based on ESRI software. The software package uses a two-dimensional approach to aircraft layout that is based on the commercial application of cutting shapes out of sheet metal while minimizing waste. The program places rectangles around aircraft based on a number of factors and then determines the best location of each rectangle. The program considers the following:

1. Clearance distances between parked and moving aircraft
2. Taxiways that are reserved for entrance and exit from parking positions
3. The parking priority for different aircraft
4. The direction the aircraft are parked
5. Pavement requirements for parking different aircraft
6. Pavement strength and width requirements for taxiing aircraft
7. Safety clearances around the runway, hazardous cargo, and storage areas [67, 3].

Figure 24 is a screen shot of an example output from CAPP. On the left side of the screen is the menu for selecting the type and number of aircraft. On the right is the area selected to park the aircraft.

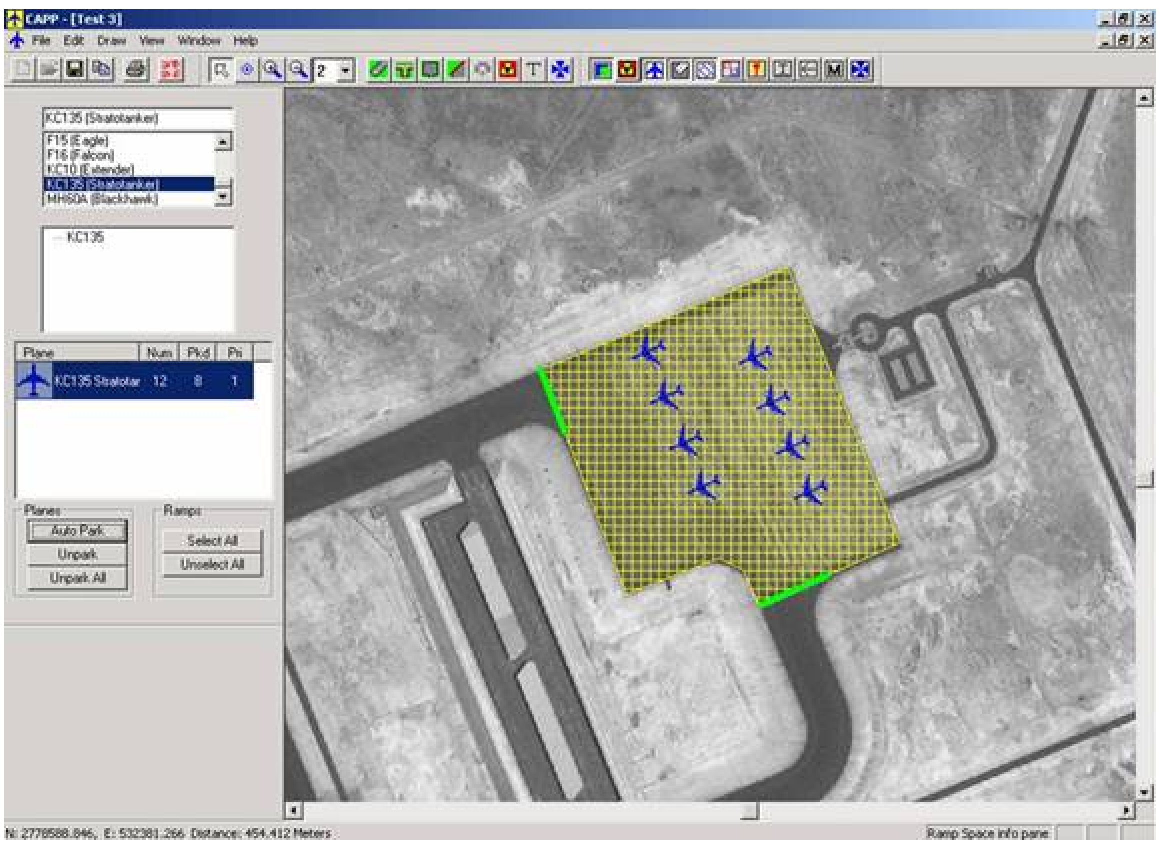


Figure 24. CAPP Screen Shot [62, 13]

5.4.2 Expeditionary GeoBase

After the unit has deployed to the new FOL, GeoReach transitions to Expeditionary GeoBase for easier access for all base personnel. The Expeditionary GeoBase CIP will combine the satellite imagery with onsite surveys. The refined CIP will aid in emergency response planning such as perimeter defense or nuclear, biological, and chemical detection. Expeditionary GeoBase will also aid in tracking for operations and maintenance of facilities, airfield management, and inventory of logistical assets [10]. The eventual goal of Expeditionary GeoBase is to have a GIS capability that mirrors Garrison GeoBase capabilities. The GIS database will include imagery of the base as a background layer. Then, the roads, facilities, and utilities are overlaid on the imagery to provide a whole picture of the base. This same database will be available to all members using the base network.

5.4.3 Operational Uses of GeoReach

GeoReach was used during Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF) to select possible FOLs and create beddown plans for deploying forces. For OIF, military leadership tasked the planners with assessing potential Iraqi staging sites. The engineers developed a weighted matrix of requirements for a FOL. Using GeoReach, the engineers evaluated more than 60 sites [68, 17]. CAPP was used for the notional aircraft parking plans, and GeoBEST was used for the notional force beddown plans[68, 18]. The engineers forwarded a list recommending five possible FOL for final decision to the command. The tasking only took two people 48 hours without ever setting foot on any of the locations [68, 17]. Also as part of the planning, the planners provided the Office of the Secretary of Defense a list of over $500 million of infrastructure requirements to use the possible FOLs in the AOR. [69, 17]. The leadership then used the recommend list and web-enabled visualization to support basing decisions in the AOR. The planners were also able to better tailor the TPFDD based on the proposed FOL. The planning was said to be a "ground breaking synergy between civil engineering, intelligence, logisticians, and security forces" [68, 14]. Two of the five sites currently have US forces at them [68, 17].

The information created for basing decisions was also provided to deploying units. This allowed the preliminary site beddown plans to be created for follow-on forces [68, 15]. Initial airbase security forces were provided with potential seizure site imagery and related feature data. Airbase recovery teams were provided with airfield obstruction and support data prior to landing at the FOL [68, 16]. Two of the comments received from deployed civil engineer commanders about the planning process were "Amazing detail without having put anyone in harm's way" and "Outstanding 75% solution, a critical time-saver for my troops" [68, 18].

5.5 Summary of Armed Services' Current GIS Uses

Table 5 shows a summary and comparison of the current operational GIS uses reviewed in this chapter. Each of the services is currently using GIS for installation mapping with varying levels of maturity. All the services are also using GIS for deployments. As should be expected, the mission of each service drives the focus of the GIS applications. The Army's GIS use looks at the terrain a soldier must cross during combat. The Navy is concerned about where to navigate a ship. The Marine Corps wants to know what the Marine on the ground must cross. The Air Force is concerned about the locations used to launch missions. The Army's is the only service that has modified existing vehicles for GIS use. The Army also currently uses standard Army computers for field GIS applications, but they are trying to integrate more commercial off-the-shelf (COTS) computers in the future. The Navy has integrated GIS capability into the ship. The Air Force and Marine Corps both already use COTS computers.

Table 5. Armed Services' GIS Use Comparison

	Army	**Navy**	**Marine Corps**	**Air Force**
Installation GIS Capability	Yes	Yes	Yes	Yes
GIS Technology for Forward Deployment	DTSS	Digital Nautical Charts	GLIDE	GeoReach
Unit Responsible for Deployment GIS	TEC	Oceanographer of the Navy		HAF GIO, ACC/PACAF/USAFE GeoReach
Focus	Terrain for the soldier to cross	Ship navigation	Terrain for the Marine to cross	Location for airplanes to launch from
User Access	Uses deployed workstations, SIPRNET, can use DVDs for specified areas		SIPRNET moving to using DVDs	SIPRNET
Software Used	ESRI and ERDAS			ESRI and ERDAS
Equipment Used	5-ton, HMMWV, military workstations, but moving to COTS	Integrated into the Ship	COTS computers,	COTS computers
Additional Tools for Forward Deployment Planning	BTRA			CAPP, GeoBEST

6.0 Information Technology Implementation

The following subsections first review the types of change so that the changes caused by GIS can be classified correctly. Then, an IT implementation model and a change model are reviewed and incorporated into a single model for use during chapters 3, 4, and 5. Finally, a few barriers to IT implementation are discussed, which are also used in later chapters.

The pressure to implement an information technology (IT) change, such as GIS integration, can come from within the organization or as a result of a changing environment. Pressure from within the organization can occur when the organization recognizes that the new IT would improve current capabilities or processes. Conversely, an example of environmental pressure is when the industry has made or is making the change and the organization must also make the change to remain competitive. Studies have shown that military organizations recognize the need to implement IT change, which means the pressure to change comes from within the organization. However, studies have also shown that the leading reason for IT investment failure on defense installations was a lack of knowledge regarding how to manage the many changes necessary to support the desired outcome [70, 31]. Thus, an IT change method must be used when implementing new IT such as GIS.

6.1 Classification of Changes Caused by GIS

According to the research of Col Brian Cullis, there are three levels of IT induced change in an organization. First order changes are the simplest and are rarely disruptive. The change increases efficiency, but only limited change is required in personnel structure or the way people accomplish their work. An example of first order change is the use of a networked laser printer in an office rather than smaller individual printers. People now have to walk to a central printer that has higher quality and quicker prints, but the employees do not have to change how they work [70, 16].

A second order change also replaces the standard way of accomplishing a task, but it is more complex than a first order change. The second order change alters the way in which people accomplish the task. This may be the automation of a process like the automation of the military leave process with LeaveWeb. The process does not replace the steps required for taking leave; however, the paperwork is now filled out online and routed electronically for signatures. The same people review and approve leave, but now they must do it on their computers. This change required limited training, but it did not require the organizational structure already in place to change [70, 16].

Third order changes are the most difficult type of IT change to implement. Third order change affects the task and the personal accomplishing the task by radically changing the way the process is completed. The unit's organization will require adjustment or complete change in response to the new way of completing the task. The best way to deal with this type of change is to empower the people that have to change. The change is too broad for any one person, or even a small group, to try to manage the change. To accomplish radical improvements in an organization with the introduction of IT, third order changes to the process are typically required [70, 18].

Using GIS software seems like a simple automation of an existing process, or a second order change, but the technology actually causes changes to the way that work is accomplished in an office. A person no longer has to go back to the drawing vault, sift through all the maps of the base, and then still have to combine several different utility-specific maps to show the existing conditions. After all that work, the combined image is only as current as the last update that was put on paper and fielded in the correct drawer. With GIS, the requirement for the trip to the drawing vault is gone. Everyone is now working from the same electronic map at their desks. The map is continuously updated by organizations around the base. Each user can now view the location of all existing assets based on the layers; and therefore, an individual can make a more informed decision about the location of new assets. Thus, the change from GIS implementation is more than just a simple second order automation of a process that the organization is prepared to implement; GIS implementation is a third order change and must be treated as such.

6.2 Change Model

Now that GIS has been identified as a third order change, an effective IT insertion method must be chosen. According to Col Brian Cullis, for an IT insertion to be effective:

1) a thorough study of the IT innovation must be accomplished to appreciate the order of change,
2) the organization subject to the change and user resistance must be understood, and
3) an appropriate strategy for the insertion must be used to minimize risk, secure funding, and ensure the strategy is capable of accomplishing the stated IT objective [70, 19].

The first two requirements have already been discussed in this chapter. For the first requirement, Section 4.0 reviewed GIS which is the innovation of interest. In regards to the second requirement, Section 3.0 reviewed the organizations that may be subject to the change, and Section 5.0 discussed the services' current uses of the technology. However, Col Cullis' third requirement has yet to be discussed. This section discusses how the change resulting from GIS could be handled in an organization. The IT diffusion model proposed by Rogers [71] and later adapted by Chan and Williamson [72] is used as a foundation, and the change model proposed by Armenakis [73] is used to build upon Roger's model. The refined model will be used in following chapters.

Rogers' IT innovation decision process is shown in Figure 25. The five major phases are knowledge, persuasion, decision, implementation, and confirmation. The following subsections discuss the specifics about each phase.

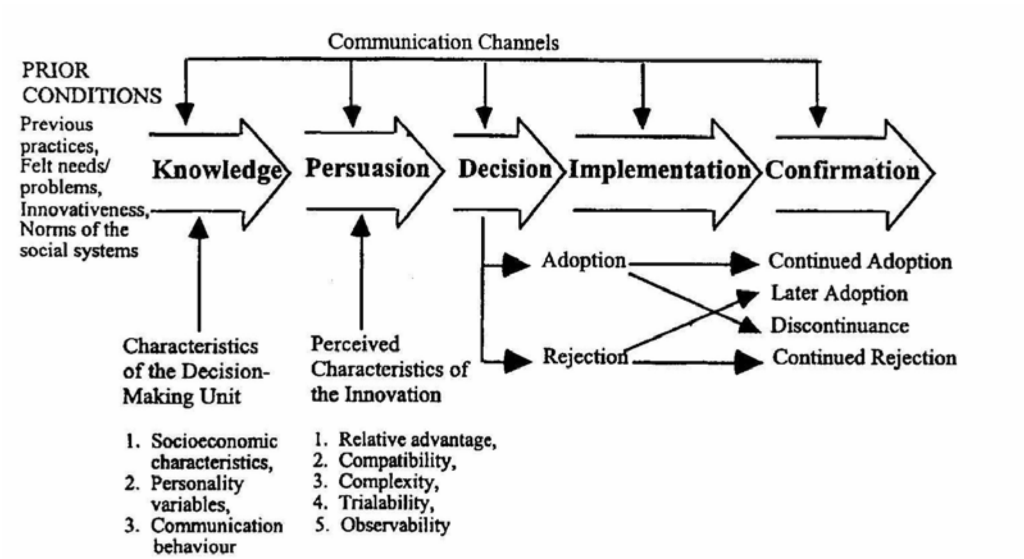


Figure 25. Innovation-Decision Process [72, 268]

Communication is required throughout the process. The organizational members must be able to provide feedback and input into decisions during the implementation process [73, 108]. Rogers notes that a key determinant to the likelihood of an IT implementation being successful is the degree to which employee questions are adequately answered [73, 104].

Armenakis' change model emphasizes some areas not emphasized in the Rogers model. Armenakis created a generic change model for organizations to assist change agents in planning and assessing the process of moving towards and institutionalizing a change [73, 97]. A change agent is any person involved with initiating, implementing, or supporting the proposed change [73, 105]. Rogers notes that a high level of communication between the change agent and the senior management is essential [74, 331]. The Armenakis model also helps focus the efforts of the organization to study the change process by defining three important components that fit around the actual change implementation: (1) the change message, (2) the change agent and organizational membership attributes, and (3) the reinforcing strategies, institutionalization, and assessment of the change [73, 101].

Now that the Roger's IT diffusion model and Armenakis' change model have been briefly introduced, the following subsections selectively review the phases of Roger's model (prior conditions, knowledge, persuasion, decision, implementation, and confirmation) with the Armenakis model adding detail as required to create a GIS integration model for the DOD and its agencies.

6.2.1 Prior Conditions

With Rogers' model, prior conditions include previous practices, perceived needs or problems, innovations, and norms of the organization. All of these are important for the change agent to understand; however, the readiness of the organizational membership to change is not discussed. The organizational membership is the "collection of individuals who must modify their cognitions and behavior to achieve the objectives of the change effort" [73, 105]. Armenakis' model includes an organizational membership readiness term. Organizational readiness is the cognitive state comprising beliefs, attitudes, and intentions to implement the change. The organization must be ready to change to reduce resistance to the change [73, 103].

6.2.2 Knowledge

According to Rogers, the two most important components of "knowledge" in the model are the organizational membership and the change agent. The organizational membership's knowledge of the proposed change will have the greatest affect on how well the IT change is implemented because they are the individuals that must implement and sustain the change [73, 105].

The change agent is the second most important component of "knowledge" in Roger's model. Selecting a change agent is essential to successfully implementing change. A change agent must have credibility with members of the organization. Credibility starts with preconceived impressions of the person or group but is further refined during the change process. "Researchers investigating diffusion of agricultural innovations found that individuals who were highly respected influenced the willingness of others to institutionalize change" [73, 106]. The change agent must communicate the shared vision through presentations and documents that show the organization is committed to the change [73, 105].

The social distance between the change agent and the organizational members instituting the change must be considered [73, 124]. If the change agent is significantly higher than the employees, they may be less willing to buy into the change and recommend further changes. If the change agent is at the same level as the changing members, the change agent may not have enough power to force the change.

6.2.3 Persuasion

Persuasion is the step when the change agent and senior leadership try to convince the organizational membership that the change is necessary. To effectively communicate the reason for the change, Armenakis says that a change message is required. The parts of the change message are discrepancy, appropriateness, self-efficacy, principal support, and personal valence [73, 102].

According to Armenakis, the change message creates core sentiment in employees by answering five basic questions. The first question is "Is the change necessary?" This question is answered by the discrepancy component of the change message. Discrepancy will show the difference between the current state of operations and the ideal situation [73, 103]. "The superiority of the new way should be obvious" [73, 116]. Discrepancy sources from within the organization and from outside the organization will help reinforce the change [73, 111]. The second key question is "Is the change that is being introduced an appropriate reaction to the discrepancy?" The appropriateness component of the change message will answer this question. The third question is "Can we successfully implement the change?" The efficacy part of the change model answers this by providing information and building confidence among the employees about the group's ability to successfully implement the change. The fourth question is "How long is this change going to last?" This question deals with the organizational resistance produced by skepticism based on previous change fads. The principal support message will show that leadership is committed to successfully implementing and institutionalizing the change permanently [73, 103]. The organizational support should be clear through the expenditure of funds and by allowing employees to use company time for any required training [73, 116]. The fifth and final question asked by the employee is “What is in it for me?” The personal valence component clarifies the intrinsic and extrinsic benefits to the individual [73, 103].

During the persuasion phase, it should not be forgotten that an organization is not necessarily homogeneous. Different sections of the same organization may perceive and respond to the same message differently. Section A may see a change they proposed as a great idea and be willing to fully implement it. However, if section A proposes the same change for aection B, section B may consider the change a threat because it is being suggested by section A. The perceived threat only increases when the proposed change originates outside of the organization [73, 106].

6.2.4 Decision

As seen in Rogers’ model in Figure 25, the company has four options during the decision phase: continued adoption (implement now), later adoption (implement later), discontinuance (start, but not complete, implementation), or continued rejection (no implementation). This decision is made by the organization. Different organizations will include the organizational membership in this decision in various ways; however, their input is essential to making the correct decision

If the deciding body chooses adoption, then the process can continue to implementation. If rejection is chosen, the company may give up the implementation effort entirely or choose to shelf it for possible later adoption.

6.2.5 Implementation

Rogers broke down the implementation step even further, as shown in Figure 26, into initiation and implementation. As the terms imply, initiation is the start of the procedures to allow the implementation to occur.

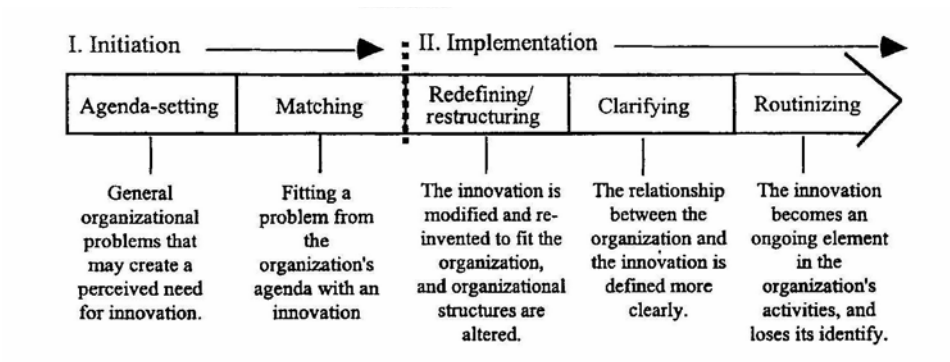


Figure 26. Implementation Breakdown [72, 269]

During the initiation phase, the organization is setting the agenda for the implementation in response to the organizational needs. The organization, with the help of the change agent, is also trying to match an IT and an IT implementation strategy to their given organization. Ines and Simpson identified the following five principles of a successful IT integration strategy:

1. Simplicity
2. Observable benefits
3. Relative advantage
4. Ability to make small trials
5. Compatibility [75, 3]

Simplicity means that the technology must be understandable and useful to the organizational members who are designing it, using it, and making decisions about it. The members do not need to know exactly how the system works, but they do need to understand its essential capability [75, 3]. Observable benefits is the requirement that the benefit from the new technology must be easily seen. The organizational members responsible for the change must understand what the benefit is expected to be and be able to asses the improvement [75, 4]. Relative advantage is the cost to the individual and the organization. The change must benefit both more than it costs either. The change process has both monetary and human costs and benefits [75, 4]. The organization should be able to test the new technology in small trials before implementing it across the organization. The initial changes should be reversible, and the initial trials should show the benefits of the IT. “A complex technology that requires large-scale change at the outset is unlikely to be implemented” [75, 5]. Finally, the new IT should be compatible with the organizations current culture, language, skills, practices, understandings, and organizational and social structures of the community that is to use it [75, 5].

The strategy or method used to implement the change will ultimately determine the successfulness of the IT integration. The two largest field studies of geospatial IT adoption showed that the brute force, or downward directed, method of implementing IT will fail unless an even stronger emphasis is placed on the issues of the organization and individual employee [73, 117]. Equally unsuccessful is a tactic in which the change agent does not discuss the change with organizational members, does not justify the need for the change, and uses control and personal power to mandate the change [73, 104].

An approach that is more likely to succeed is diffusion of the technology. “Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” [71, 5]. Diffusion is able to effectively communicate the five message components [73, 104]. There are two main types of GIS diffusion: focused and dispersed [72, 267]. A focused scenario is used to address a very specific or a set of specific problems [72, 270]. This allows the change agent to specify the exact type of GIS that should be implemented [72, 273]. A dispersed scenario addresses problems that are often strategic and have broad implications for the organization. Corporations often use this scenario to eliminate duplication, accelerate development, and/or promote data sharing [72, 270]. In a dispersed scenario, the problem is so broad and vague that there is no exact answer to what GIS technology is required, how it should be composed, or how it should function [72, 273].

Several factors should be assessed during the implementation process to ensure the implementation is being effective. The two most common perspectives to assess the factors of an organizational implementation progress are technological and organizational. The technological perspective only monitors the technical capabilities of the IT being integrated, it does not account for the ability or understanding of the users. This perspective is especially useful for focused GIS diffusion integration when technological achievements and milestones can be measured [72, 274]. The organizational perspective is better suited for the dispersed diffusion IT integration; because with dispersed diffusion, the emphasis is on ability achieved by the end user. However, the organizational perspective cannot discern one element of the integrations from another. This lack of discernment is a result of the perspective looking at the organizational and end user abilities rather than the individual steps to the integration [72, 273].

During the diffusion process, the senior managers must be educated about the capabilities and possible improvements the change will bring to the organization. Field research into IT implementation shows that when senior managers are educated about the benefits of GIS, the IT implementation is smoother. This is because the senior managers can continue championing the improvements the change will bring to the organization and help it push through the period of greatest implementation difficulties: the switch-over period [74, 331-333].

The change agent must include active learning for the organizational members. It must also remember that the IT will require new skills from the employees. Part of the IT implementation process must be training development. Vicarious learning of respected colleagues performing the new behavior is one method of learning [73, 108], but hands-on training is even better. The training program must be focused to the particular IT being implemented to aid in gaining new knowledge, skills, and abilities [73, 115].

6.2.6 Confirmation

For the purposes of this thesis, the discussion of routinization has been delayed until the confirmation section because an organization can not be sure that routinization, or institutionalization, has occurred until it is confirmed. Confirmation of institutionalization is required to make sure that the organization will not return to prior ways after the change process is complete.

The level of institutionalization is shown in the level of resistance against changing from the new technology. Three types of commitment to the change are compliance, identification, and internalization. Compliance commitment occurs because an individual expects to receive specific rewards or is trying to avoid punishment by conforming. In identification commitment, an individual wants to establish or maintain a satisfying self-defining relationship to another person or group. Finally, internalization commitment occurs because the reason the change is introduced is appealing to the individual and is seen as the correct choice [73, 99]. Armenakis includes the statement:

> "We suggest that the process of institutionalization at the system level is the process of building commitment to the changed state (or building resistance to changing from it) is at the individual level. To create compliance-based commitment, a change agent must tie the change to organizational structure, inter-organizational agreements, sunk costs, and reward systems. In order to create identification-based commitment, a change agent must time changes to association with their supervisor and membership in their work group. Furthermore, to create internalization-based commitment reflected in individuals' paradigms, a change agent must tie changes to current employee beliefs and values as they relate to the organizational culture" [73, 100].

Armenakis also states that the extent to which the organizational members have heard and understand the five core questions from the change message should be determined to aid in the assessment of organizational commitment [73, 122]. Armenakis even went so far as to make a checklist to ensure institutionalization in his model.

The National Science Foundation (NSF) conducted a mail survey in 1995 to determine the reinforcing factors for use of GIS in an organization. The NSF's results seem to agree with the adapted Roger's model just presented. The main factors found were:

- "Organizational support- this factor took into account several key issues driving personal use and satisfaction with the geospatial IT: 1) Top management support and supervisory appreciation for the geospatial IT and its cost effectiveness; 2) availability of skilled IT manpower; 3) fiscal commitment to the IT insertion effort; 4) the extent to which use of the geospatial IT was integrated within the organizational standard operating procedures
- Training and education
- Awareness of benefits- user awareness of how geospatial IT could lead to increased productivity, higher quality products, reduction in decision risk, and ability to perform new tasks
- Easy access- users need to have both the time available to use the system as well as easy physical access to the geospatial IT

- Confidence in data quality- users confidence in the currency as well as positional and attribute accuracies of the geospatial information" [70, 41]

6.2.7 Barriers to IT Implementation and Reasons for Failure

The previous sections stepped through an IT implementation process as if there is only resistance from the organizational membership that must be overcome, and all IT integrations will be successful. However, several barriers outside of the actual organizational body exist and must be dealt with during change/IT implementation, and IT implementations that are attempted occasionally do fail. This section only covers a few of the possible barriers a change agent may face when implanting a new IT and reasons for IT implementation failure.

Armenakis tackled the reasons for failure of change in his model. He states that there are two primary reasons that an organization fails to change:

1. An organization's impatience and assumption that successful change introduction and implementation guarantees institutionalization
2. The organizations simply neglect seeing the change through to institutionalization [73, 98]

Armenakis suggests that the success rate for change implementation could be improved by better educating the change agent about the institutionalizing phase [73, 98].

Tom Wilson of the Department of Information Studies at the University of Sheffield, United Kingdom, adds to Armenakis' reasons why change in the form of IT implementation fails. Wilson sent surveys to all the Times 500 companies and 50 financial service companies in the United Kingdom. He had a 35% response rate which would have been higher except for a postal strike during his survey. He asked companies what were the greatest barriers during the design of the implementation phase and the actual implementation phase for the new IT integration [76, 40]. The responses he received, shown in Table 6, are in order of occurrence. The left most column is the rank during the design phase of the IT implementation strategy. The middle column shows how the barriers' importance changes during the implementation phase. All 11 barriers must be dealt with during the design and implementation of a new IT. It needs to be noted that the top three difficulties for companies designing a new IT and the top three difficulties in implementing the new IT remained the same. The order of the barriers changed, but measuring benefits, the nature of business, and difficulty in recruiting still ranked in the top three for both stages.

Table 6. Wilson Barriers to IT [76, 40]

Rank of Importance		**Barrier**
During Implementation Design	During Implementation Execution	
1	3	Measuring benefits
2	2	Nature of business
3	1	Difficulty in recruiting
4	6	Political conflicts
5	5	Existing IT investment
6	4	User-education resources
7	11	Doubts about benefits
8	9	Telecommunication issues
9	7	Middle management attitudes
10	8	Senior management attitudes
11	10	Technology lagging behind needs

These same barriers could be expected by any change agent during an implementation process. In a DOD organization, a change agent may be able to decrease the difficulty in recruiting and end-user resources by using contractor support, but this would increase the overall cost of the IT implementation. The DOD change agent would still have to overcome the other 10 barriers within the implementation process.

Wilson presented two of the additional points of interest in regard to the change agent and the need for more meetings. First, the change agent was most likely to report to a senior management, and the involvement of this senior manager was recognized as one of the major contributing factors to successful implementation. IT implementation was found to be most successful in companies where senior management maintained interest throughout the implementation process. Conversely, implementation was less successful when senior level management started strong and then left the change agent to carry the implementation through to completion. Second, Wilson found that planned, formal performance reviews were needed to monitor the effectiveness of strategies as recognized by almost two thirds of the companies [76, 43].

7.0 Summary

This chapter reviewed the structure of the DOD and how the different services within the DOD currently forward deploy forces. Also, the concept of GIS technology was introduced, which allowed a discussion of how each armed service currently uses GIS to plan for and conduct forward deployment operations. The Army uses DTSS. The Navy uses digital nautical charts. The Marine Corps has the GLIDE program for forward deployed soldiers to access geospatial information. The Air Force has the overarching GeoBase program for all facility GIS requirements, and GeoReach is the specific program used for forward deployment planning. The final part of this chapter used Armenakis' change model to add to Rogers' IT implementation model to create a more detailed IT implementation model that is used in this research effort.

III. Methodology

1.0 Introduction

This chapter builds on the GIS and IT implementation foundation presented in Chapter 2 and develops the methodology that will be used for this research. First, the Delphi and case study methodologies are reviewed. Then the methodologies are tailored for this research.

The overall purpose of research is to logically step through the process of connecting the initial research question to the empirical data and ultimately to a study's conclusion [77, 21]. There are several well established methods of completing this process, such as experiments, surveys, histories, case studies, and analysis of archival information. Each type of research method has its own advantages and disadvantages [77, 1].

Three parts of research should be considered when choosing a methodology:

1. Type of questions being posed
2. Level of control that the researcher has over the actual behavior being researched
3. Whether research is focused on current or historical events [77, 5]

The type of question, or questions, being posed is very important. "What" questions are exploratory and require development of pertinent hypotheses and propositions for research [77, 5]. "How many" and "how much" questions usually require surveys or archival research [77, 6]. "How" and "why" questions are more explanatory in nature, which case studies, histories, and experiments are best suited to answer.

For this research, the researcher can not control how GIS is currently being used in the armed services. However, the proposed research does involve how and why questions. These two types of questions led to the use of the Delphi and case study methodologies. The Delphi research is used to further explore how GIS is currently being used in the armed forces, possible reasons why a joint GIS program should be established, and how it should be implemented. The case study methodology looks at an individual military GIS unit and answers how GIS is being used at the unit, how IT has been implemented in the past, and how should it be implemented in the future.

2.0 Delphi Methodology

This section reviews the Delphi methodology with its associated advantages and disadvantages. The name Delphi is derived from the Greek myth of the "Delphi Oracle," which was able to predict the future with infallible accuracy. The Delphi was initially used to forecast new technological developments. However, in 1963, the RAND Corporation transformed the method into an experimental research method to predict possible outcomes from Soviet nuclear attacks on the US [78, 4]. Since this first experiment, the method has been applied to a wide variety of research.

With the Delphi method, a predetermined number of experts are surveyed through structured questionnaires and controlled feedback. The participants are surveyed individually and responses are anonymous. Communication between the participants is controlled by the researcher and only allowed by written questionnaires and feedback reports [78, 3]. A Delphi methodology may be appropriate under the following conditions:

- "The problem does not lend itself to precise analytical techniques but could benefit from subjective judgments on a collective basis
- The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise
- More individuals are needed than can effectively interact in a face-to-face exchange

- Time and cost make frequent group meetings infeasible
- The efficiency of face-to-face meetings can be increased by a supplemental group communication process
- Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and/or anonymity assured" [79, 4].

The anonymous responses also remove the social-emotional behaviors sometimes seen in other research methods. For example, a face-to-face meeting might be dominated by a few outspoken individuals who monopolize the discussions. Individuals may also feel pressure to conform with the group even when they may otherwise consider the decision unacceptable; and as a result, they will not voice any protests because they are not in the majority [78, 3]. Finally, the anonymous method eliminates any halo affect that might occur because the opinions of the well-respected individual's might overshadow less known members of a group. The result of a Delphi study is a group of experts effectively communicating to deal with a complex problem without many of the social difficulties of a face-to-face group meeting [79, 3].

Many different views exist on the exact procedures for the best, most accurate, or most useful Delphi study [79, 3]. However, most agree on the three common types of Delphi studies being conventional, real-time, and policy. A conventional Delphi uses written questionnaires sent to a chosen expert panel. Responses from the panel are combined by the researcher who then modifies the existing questionnaire or develops a new questionnaire based on the expert responses. The revised questionnaire and combined answers are given back to the same panel. Each iteration of this process is called a round, and the process is continued until the group comes to some consensus [78, 4].

The second method, the real-time Delphi, uses a computer to compile the individual responses. The computer compares the individual's responses to the group's responses and gives immediate feedback. This type of model requires a higher level of preparation because, and unlike a conventional method that allows time between each round for changes, the computer survey can not be changed once started [79, 5].

These two types of Delphi try to establish a consensus among the expert panel; however, the third type, policy Delphi, is used to ensure all possible options have been explored rather than trying to come to a group consensus. This method is used when a decision maker wants all options brought forward, evidence presented, and then the options discussed. The selected panel is often from dramatically different backgrounds, which prevents the group from reaching a consensus, but the discussion will greatly benefit the decision maker [79, 84]. The objective of a policy Delphi should be one, or a combination, of the following:

- Ensure all options have been presented
- Assess the impact and consequences of the options
- Determine the acceptability of any particular option [79, 87].

As with all methodologies, Delphi has limitations. The greatest limitation of the method is the dependence on the expert panel selection. The research is resting on the knowledge and expertise of the panel and its limited size. If the panel is ill-informed, then the outcome will be less useful [78, 5]. Also, the panel members must be motivated to complete the entire Delphi process. Because of the very nature of being an expert, the experts are usually busy working within their own fields. The experts must be willing to commit time to completing the several rounds of questionnaires. [78, 5].

The final drawback of the Delphi process is the time required to complete all the rounds and compile responses. Each round requires individuals to respond; and based on the expert's schedule, responses may be quick or slow. During a conventional Delphi, the researcher must wait for all of the responses before proceeding to the next round. Thus, the process becomes quite lengthy and participation may wane [80, 30].

Not all Delphi studies are successful. Some of the reasons that previous Delphi studies have failed include the following:

- "Imposing monitor view's and preconceptions of a problem upon the respondent group by over specifying the structure of the Delphi and not allowing for the contribution of other perspectives related to the problem
- Assuming that Delphi can be a surrogate for all other human communications in a given situation
- Poor techniques of summarizing and presenting the group response and ensuring common interpretations of the evaluation scales utilized in the exercise
- Ignoring and not exploring disagreements, so that discouraged dissenters drop out and an artificial consensus is generated
- Underestimating the demanding nature of a Delphi and the fact that respondents should be recognized as consultants and properly compensated for their time if the Delphi is not an integral part of their job function" [79, 6].

Even with the limitations of the Delphi, the conventional Delphi methodology is best suited to review the existing use of GIS in the armed services and then make predictions about the future possibility of a joint GIS program. Thus, it is used as part of this research.

3.0 Case Study Methodology

The case study methodology is used to determine current GIS implementation methods, possible future GIS integration techniques, and barriers that might occur from trying to implement a single DOD GIS program. This section provides a summary of the case study methodology, why the methodology is used in research, and the correct method for designing a case study (including protocol, data types, and data analysis).

To aid in selecting a research method, Table 7 lays out the three key research questions as they are related to the five research methods. The first column in the table lists the types of research strategies. The second column lists the form of questions the research strategy is trying to answer. The third column asks if the researcher can control the behavior being studied, and the last column asks if the research is looking at current or past events.

Table 7. Types of Research [77, 5]

Strategy	**Form of Research Question**	**Requires Control of Behavioral Events?**	**Focuses on Current Events?**
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	How, why?	No	No
History	How, why?	No	No
Case Study	How, why?	No	Yes

The case study is an appropriate methodology to answer “how” and “why” questions when the researcher has no control over the current behavioral events being studied. There are at least five ways for the case study to answer the “how” or “why” questions. The case study can explain, describe, illustrate, explore, or meta-evaluate the reasons how or why an event has occurred [77, 15]. This thesis explores how GIS is currently being used and explores how a joint GIS program could be implemented for future use.

To properly answer the “how” and “why” questions, the case study methodology has been designed with five components:

1. Study question(s)
2. Propositions, if any
3. Units of analysis
4. Logic linking the data to the propositions; and
5. Criteria for interpreting the findings [77, 21]

The first two components are well known in research. The study question is the “how” or “why” question that originated the study, but it does not say what to study. The study’s propositions “directs attention to something that should be examined within the scope of the study” [77, 22]. The proposition is similar to a hypothesis in defining what will be studied. Sometimes, a proposition is not required as in the case for an exploratory study which should, instead, have a purpose [77, 24].

The third component, units of analysis, is sometimes difficult to define. It is related to the initial study question definition and is the level of the organization or individual unit that will be investigated [77, 26]. The unit of analysis may have several smaller parts embedded within it. The researcher may choose to study the organization as a whole, which is called a holistic study, or may need to study each individual piece, which is called an embedded study. An example of an embedded study is a case study of a hospital. The organization being studied is the hospital, but embedded within that organization are the doctors and nurses that must be studied to understand the organization. If only the overall nature of the organization is needed to be examined, then a holistic study is used to study the group as a whole [77, 43].

The fourth and fifth components, logic link and criteria for interpreting results, are the least developed in case studies. The logic link connects the empirical data to the proposition. One method of creating a logic link is pattern matching. With this method, several pieces of data from the same study are compared and then related to the proposition. The criteria for interpreting the results is not clearly defined and varies by the study [77, 27].

There remains one critical design element of a case study—whether to use a single or multiple-case design. The single case study only studies one occurrence of an event for the research; while, a multiple case design studies several occurrences and compares the research results. The decision of which type of case study to use must be made prior to data collection since the decision will drive the type of data and the data collection method.

A single case is useful for many reasons. The first reason to use a single-case study is the test represents the critical case to test a well-formulated theory. The proposition and circumstances of the test are well defined, and the test is used to confirm, challenge, or extend the theory [77, 40]. The second reason is that the case may represent an extreme or unique case. Both of these situations commonly occur in psychology and medical research where a specific injury or disorder is so rare that a single case is worth documenting and analyzing [77, 41]. The next reason is that a single case is representative of a typical case. The objective of the study is to document the circumstances and conditions of a routine situation [77, 41]. The fourth reason is that the study is a revelatory case. This type of study is used when the researcher has the opportunity to observe, document, and analyze a phenomenon previously inaccessible to other researchers [77, 42]. The fifth reason to use a single-case study is that the test is a longitudinal study, and it requires the researcher to document observations over time [77, 42]. Finally, a pilot study might also use a single-case study to determine requirements for future studies [77, 42].

A multiple case study is simply repeating a single case study several times. The purpose is to either replicate previous results that further prove the findings, or find contrasting results which then brings doubt to the research. The results from a multiple case study are considered more compelling and the overall study is considered more robust [77, 46]. Two major drawbacks exist for multiple case studies. First, a multiple case study can not address rare critical cases, which are addressed by a single case study. Second, multiple case studies can require more extensive resources and time that may be beyond the means of a single student or independent researcher [77, 47].

4.0 Design of Delphi Method Study for this Research

Now that the background of the Delphi and case study methodologies have been presented, the way that the methodologies will be used for this research is detailed in the next two sections. The following subsections step through the selection of the Delphi expert panel, the design of the questionnaire, and the actual process used. The purpose of the Delphi methodology is to further research how GIS is being used in the armed services and try to reveal potential capability improvements that would result from a joint GIS program.

4.1 Delphi Panel Member Selection

Selection of the expert panel is instrumental to a successful Delphi study. "An expert is someone who possesses the knowledge and experience necessary to participate in a Delphi" [78, 4]. The actual selection of the experts may be random or nonbiased selection by the researcher. The goal of the selection process is a panel that can offer different, well-informed views about a problem [78, 4]. Depending on the specific study and complexity of the problem, the expert panel may be large or small. There are no set rules about the size of the panel. However, a general guideline is that homogeneous (experts from the same field) panels usually require 15-30 participants, and heterogeneous panels require 5-10 [78, 5].

The expert panel members selected for this research are to be a heterogeneous representation of the DOD and NGA. NGA was specifically included because of its mission to provide geospatial data to all of the services. Each expert will work in a GIS office that is central to his/her armed service or agency. The experts will be the managers of the offices and have technicians working for them. These managers will have an understanding of how their GIS support is used within their armed services and what is required for initial setup, training, daily operations, and upgrading the system. Two members from each armed service will be included in the panel, allowing redundancy in case one member is unable to finish the Delphi. The redundancy will also aid in validity in the results of the research by providing two separate views about the same topic.

Originally, this research was to include the FOL planners and senior leadership that make the decisions as to which FOLs to pick. However, after extensive research and numerous phone calls and emails, it was determined that finding and obtaining a commitment from all these experts within these organizations would be beyond the time limits for this research. Therefore, this research was scoped down to the group of current GIS users. Thus, the research may be baised by using a group that already uses GIS and not a group of logisticians and senior leadership.

4.2 Delphi Study Phases

There are four distinct phases in a Delphi study. The first phase is the exploration of the subject under discussion. During this phase, each individual contributes initial information that he/she thinks should be included in the Delphi study. The second phase, or round one of the study, is determining how the group views the issue under discussion. If there is significant disagreement among the group, then a third phase, round 2, is required to determine the differences and possible reasons for the disagreement. The final phase of a Delphi is when all of the information has been combined, analyzed, and returned to the panel for consideration [79, 6]. These four stages will be used to conduct the Delphi study.

4.2.1 Preliminary/Validation Round

During the preliminary phase of the Delphi, experts were contacted by phone and email requesting their participation in the research. A brief explanation of the study was given, and the experts were asked for any areas they would like to have specifically addressed during the study.

Also during this time of assembling the panel, the researcher drafted the initial questionnaire for the experts. The questionnaire was in Microsoft® Word and was designed to only take the expert 15 minutes to answer and then reply electronically. The questionnaire was a combination of Likert scale questions on a one to five scale and short answer questions.

The questionnaire was broken into three sections: background, current organizational GIS use, and possible future joint GIS uses. The background section asked a few questions about the expert's background in GIS and experience with the organization. This section is intended to give the researcher a deeper understanding of the expert's knowledge about GIS. Also, when the responses were returned in round 2, the other experts will have an idea of the expert level involved in this Delphi.

The current organizational GIS section was designed to look at how the expert's organization uses GIS currently. This information was of benefit in two ways. First, it reveals a service's use of GIS for deployments that the researcher missed during Chapter 2's review of existing GIS uses. Second, this section established a baseline for how each expert is currently using GIS and any benefits or limitations of the existing deployment planning and executing GIS.

The third and final section of the Delphi was the key part of the questionnaire. This section began trying to determine if the experts think a joint GIS system could benefit the DOD. Then, if the experts reached a consensus that a joint GIS system would benefit the DOD, the next few questions began to explore how a joint GIS system should be established and what capabilities will be required. The detailed question construction is presented in Chapter 4, Section 3.1.

Before sending the questionnaire to the expert panel, it was pretested with AFIT graduate students. The goal of this preliminary questionnaire use was to identify any unclear questions or mistakes within the questionnaire.

4.2.2 Round 1

Once the questionnaire was complete and the experts had been identified, the questionnaire was sent to the expert panel members via email requesting a response within two weeks. The participant names were hidden in the email to maintain anonymity as required during a Delphi study. The experts were told that the researcher will correct any format changes that resulted from their typing on the questionnaire.

After the two weeks had elapsed, the responses were to be combined and any areas of consensus will be noted. Areas of differing opinion were reviewed and further questions were included in round 2 to explore possible reasons for non-consensus. The questionnaire for round 2 included the responses and any additional questions from round 1. The questions for the round 1 questionnaire are described in detail in Chapter 4, Section 3.1. The round 1 questionnaire is attached in Appendix B.

4.2.3 Round 2

Round 2 began by emailing the questionnaire to the same expert panel. Again, the experts were asked to respond within two weeks. This questionnaire allowed the experts to see how the other experts answered the same questions and allowed each expert a chance to comment on other responses or further define his/her own answers. The responses were combined into one document upon return to the researcher. The round 2 questionnaire was the last questionnaire for this research. The responses were combined for analysis and sent to the expert panel as a courtesy, but not for further discussion.

5.0 Case Study Design for this Research

While the Delphi was used for asking experts their opinions, the case study examined an individual GIS unit's current IT implementation techniques and evaluated the possible problems and advantages of implementing a joint GIS program. A case study was best suited for this exploratory research to answer the question of how to implement a joint GIS program. The following subsections step through the case study protocol, data, and data analysis used for this research.

The three key parts to a case study are study questions, units of analysis, and criteria for interpreting the results. The other two components of a case study were described earlier, the proposition and the logic linking the data to the proposition, did not apply because this case study is an exploratory case study. The study questions are listed below:

1. How are DOD units using GIS for forward deployment planning currently?
2. Would a joint GIS program bring any additional capability to the DOD?
3. If a joint GIS program is needed, what IT techniques should be used to implement such a program?

The unit of analysis was the GIS unit being studied. However, the study also had embedded elements because each person will have a unique perspective about the usefulness and potential success of a joint GIS program for planning and executing forward deployment operations.

The researcher was an Air Force civil engineer with experience in the Air Force's GeoReach process. With his experience and the information presented in Chapter 2, the Air Force's implementation of GIS in forward deployment planning was known and understood. However, the researcher's knowledge of other service's GIS implementation was limited to that which is presented in Chapter 2. Thus, the logical step was to conduct the case study research with military units other than the Air Force. Therefore, this case study methodology was applied to a GIS unit within the US Army. The Army was the best choice because the Army had more similar deployment methods to the Air Force than the Navy or Marine Corps. Both the Air Force and Army deploy to locations on land and have to establish bases. The Air Force uses the bases for aircraft basing. The Army uses bases as logistical hubs to resupply advancing forces or as positions of forward presence. The following subsections step through the process of the case study as applied to the GIS unit.

5.1 Protocol and Data

The protocol of the study is the design of data collection in preparation for conducting the case study. A well-formed protocol that is followed during the research will increase the reliability of the research [77, 67]. A well-formed case study protocol contains the following sections:

- An overview of the case study project including project objectives and possible case study issues
- Case study questions: the specific questions that the case study investigator must ensure are answered during the study and the potential sources of information for answering each question
- Field procedures: access to the case study locations, general sources of information, and procedural reminders for the researcher
- A guide for the case study report: outline of the case, a format for the data, any documentation that would be required, and bibliographical information [77, 69]

The overview of the case study has already been provided in this chapter. The questions for this case study are more research objectives which include the following:

1. Further explore GIS uses in forward deployment at a single GIS unit
2. Investigate current IT integration methods being used
3. Evaluate the possible costs, problems receptiveness and success of a joint GIS program for forward deployment planning and execution
4. Evaluate if the IT implementation methods described in Chapter 2 could be effective in implementing a joint GIS program

The case study protocol also includes the specific questions to be researched and asked during a case study, and this section is the most important part of the protocol. These questions need to cover the entire range of the study. Yin (2003) established five levels of questions for single and multiple case studies. The three levels that apply to this research are:

- Level 1: questions to be asked of specific interviewees
- Level 2: questions to be asked of a single case study
- Level 5: normative questions to be asked about policy recommendations that will go beyond the limited scope of this research [77, 74]

Yin also reviews the types of data to answer case study questions. The choice of data source will affect the type of questions asked. The six most common data sources for case studies are documentation, archival records, interviews, direct observation, participant-observation, and physical artifacts [77, 83]. The types of data are shown in Table 8. The first column lists the six most common sources of evidence. The other two columns list the strengths and weaknesses of each type of evidence.

For this research, the documentation, participant-observation, and interview methods of data collection were used. During the research for Chapter 2, the researcher reviewed the documentation that was available from the Army GIS unit being studied. The participant-observation and interview methods allowed the researcher to observe existing methods, question why the existing procedures are used, and then propose the idea of a joint GIS program. As stated in Table 8, the disadvantages of this method were the possible bias due to poorly constructed questions, potential response bias, and reflexivity which are when the interviewee gives the interviewer want he wants to hear.

Table 8. Sources of Evidence [77, 86]

Source of Evidence	Strengths	Weaknesses
Documentation	• Stable—can be reviewed repeatedly • Unobtrusive—not created as a result of the case study • Exact—contains exact references and details of an event • Broad coverage—long span of time	• Retrievability—can be low • Biased selectivity, if collection is incomplete • Reporting bias—reflects (unknown) bias of author • Access—may be deliberately blocked
Archival Records	• Same as above for documentation • Precise and quantitative	• Same as above • Accessibility due to privacy reasons
Interviews	• Targeted—focuses directly on case study topic • Insightful—provides perceived causal inferences	• Bias due to poorly constructed questions • Response bias • Inaccuracies due to recall • Reflexivity
Direct Observations	• Reality—covers events in real time • Contextual—covers context of event	• Time-consuming • Selectivity—unless broad coverage • Reflexivity • Cost—hours needed by human observers
Participant-Observation	• Same as above for Direct Observation • Insightful into interpersonal behavior and motives	• Same as above for Direct Observations • Bias due to investigator's manipulation of events
Physical Artifacts	• Insightful into cultural features • Insightful into technical operations	• Selectivity • Availability

Similar to the Delphi questionnaire, the questions for the case study were broken into three sections:

- Initial observation of GIS unit
- Observation of current IT integration/implementation methods
- Response to joint GIS program idea, and joint GIS implementation phase

The initial observations and predetermined questions were used to establish the context that the GIS unit operates within. The questions included unit responsibilities, who their customer was, and how that customer received the information. The observation of the unit's current IT integration process looked at how the unit is getting their technology out to the field. GIS is a relatively new and quickly advancing technology for the military; therefore, no service has had time to fully implement the technology at all levels.

The third section of the case study was where the researcher introduced the unit to an idea of a joint GIS process and presented the Air Force's GeoReach process as an example to encourage discussion. Chapter 4**,** Section 4.1 discusses the development of the case study questions, which are shown in Appendix D.

The field procedures for this case study required the researcher to visit a service's GIS integration office to answer the case study questions. Initially, the researcher observed how the unit currently uses GIS and what services they provided for their respective service. Then, the researcher interviewed personnel within the unit to determine the unit's current IT integration and implementation methods. The data was recorded by the researcher taking notes during the observation and recording interviews with a voice recorder.

Next, the researcher determined potential receptiveness to a joint GIS program by giving the same interview group a short presentation that illustrated about the Air Force's GeoReach program. The brief reviewed the capability improvements that have resulted from GeoReach and current uses. To create this presentation, the researcher worked with HAF GIO, ACC GeoReach, and USAFE GeoReach offices. The presentation remained unclassified and was loaded on a laptop. Once the presentation was completed, the researcher asked the group additional questions and recorded their responses.

5.2 Data Analysis

Once the case study data has been collected, it had to be analyzed, and the method differs based on the individual case study. The most common data analysis techniques use theoretical propositions, rival explanations, or descriptive frameworks [77, 112]. The "theoretical proposition" looks for causal relationships such as the answer to the "how" and "why" questions, which will guide the analysis [77, 112]. The "rival explanation" method tries to show that the rival proposition rather than the original proposition is correct [77, 112].

The "descriptive method" is the least desirable method of the three, but is still the most applicable for this research. This method is applied to studies that were either designed to be descriptive or turned out to be descriptive. With this method, the researcher describes the logical relationship found during the research [77, 118].

6.0 Social Test Validity

During the design and execution phases of research, the researcher must consider the quality of the test. Four tests have been commonly used to establish the quality, or validity, of any empirical social research. Because the Delphi and case study methodologies are forms of such research, the four tests also are relevant to this thesis. The four methods that can be used during research are listed below:

- Construct validity: establishment of the correct operational measures for the concept being studies
- Internal validity: (used for explanatory and causal studies only) establishment of a causal relationship where certain conditions lead to certain outcomes

- External validity: establishment of a domain to which a study's findings can be generalized
- Reliability: demonstration that the operational steps can be repeated with the same results, i.e., data collection procedures [77, 34]

In Table 9, the types of validation tests are shown with the associated testing tactic and which phase the test should be accomplished during. The first column is the type of validity test. The second column is how the validity test is included in the research, and the final column is when the test should be conducted.

Table 9. Validation Methods [77, 34]

Validity Tests	Case study tactic	Phase of research in which tactic occurs
Construct	Use multiple sources of evidence Establish a chain on evidence Have key informants review draft report	Data collection Data collection Composition
Internal	Do explanation building Address rival explanations Use logic models	Data analysis Data analysis Data analysis
External	Use theory in single-case studies Use replication logic in multiple-case study	Research design Research design
Reliability	Use methodology's protocol	Data collection

Appropriate validity test are included in several stages of this research. Since this research is exploratory in nature, internal validity does not apply because that type of validity is used for explanatory and causal studies.

Construct validity is designed into this research by having a thesis committee review and provide input during the research process. The research uses information from two main sources: published documents and interviews of GIS users. Also, the construct validity was accomplished by using previously proven research methodologies; the Delphi and case study methodologies are common for social studies. Additionally, the results from the Delphi study and the case study will be compared. Since the groups being researched are separate, the requirement for multiple evidence sources increases the validity. Finally, the Delphi research methodology requires construct validity because the initial results are sent back to the same expert panel for their review in the second questionnaire. However, due to time constraints, the final compiled responses will be sent back to the expert panel as a courtesy and not for review.

The external validity for this research is limited due to the limited sample from the Delphi and case studies. Even though GIS is used in many different applications in the civilian and military sector, inferences from this research may only be extrapolated to the greater DOD GIS community for consideration.

Reliability validity is maintained because the protocol of the Delphi and case study methodologies have been followed. This will allow other researchers to accomplish similar research. Future researchers can reuse the methods of data collection; and even though opinions about GIS may vary, the process will still work and result in quality data.

7.0 Summary

In this chapter, the Delphi and case study methodologies were described. Then, the two methodologies were tailored to this specific research. The Delphi study will be used to obtain the opinions of a small sample of GIS experts in the DOD about current GIS uses and the possible need for a joint GIS program. By using the Delphi method, the geographically separated GIS experts can anonymously discuss the topics presented on the questionnaire. The case study will be used to explore how an Army GIS unit currently uses GIS, current IT integration methods, and the possible demand for a joint

GIS program. Even though both methodologies use a small sample group for the research, the information gathered will still provide some insight into current GIS uses, IT implementation methods, and possible capability benefits from a joint GIS program.

IV. Research Results

1.0 Introduction

This chapter documents the execution of the methodology described in Chapter 3. Initially, the approval process for the research is summarized. Then, the Delphi study execution is reviewed by stepping through the preliminary questionnaire design and testing, accomplishments of round one and round two, and the response combination and analysis after each round. Next, the case study protocol used for this research is presented with the resultant data summarized and analyzed. Finally, the results of both studies are compared to highlight similarities and differences. Integrated into the discussion of Delphi study, case study, and combined analysis is a comparison of the research results with the IT implementation model presented in Chapter 2.

2.0 Research Approval Process

This section summarizes the approval process required for the case study and Delphi study research methodologies. It was determined that both methodologies required an exclusion from the human subjects review procedures. The combined methodology, including the Delphi study and the case study, was forwarded to the Human Subjects Review Board (AFRL/HEH). The request for an exemption required an overview letter and example of the research method. The preliminary Delphi questionnaire and preliminary case study questions were submitted for review. Even with the request for exemption being rushed, the review process still took about three weeks. The exemption letter is dated 22 Oct 03 with clearance number 04-02-E.

Additionally, since the Delphi questionnaire could be considered a survey, it required a survey clearance from Air Force Personnel Command (AFPC). The approval process was accomplished by sending AFPC/DPSAS an email including the preliminary Delphi questionnaire and preliminary case study questions. The case study questions were included to ensure the entire methodology was approved. After a clarification that personnel information on the Delphi Questionnaire was voluntary, the survey clearance number (SCN) 03-107 was received on 16 Oct 03.

3.0 Execution of Delphi Study

This Delphi study was accomplished in four phases: initial questionnaire development, preliminary test/expert panel selection, round 1, and round 2. The following sections will step through the study process. The first section reviews the development of the initial questionnaire. The second section describes how the experts were selected for this research. The third section reviews selective questions from the first round questionnaire that were used in developing the second round questionnaire. The final section reviews the results of the entire Delphi research.

3.1 Initial Delphi Questionnaire Development

The initial questionnaire was developed based on knowledge gained during the research for Chapter 2, several discussions with GIS experts prior to commencing this research effort, and input from this research's advisory committee. The questionnaire was designed in Microsoft® Word with blocks for the experts to type in their responses. The round 1 questionnaire is available for review in Appendix B.

A cover page was placed at the beginning of the questionnaire for two reasons. First, the cover page provided an explanation about the questionnaire and its purpose as an academic research tool. Even though all the experts had already been contacted and had agreed to participate in this research, the possibility still existed that this questionnaire could be forwarded or otherwise seen by another person who was not involved in the research. Second, the cover page included instructions to the experts on types of questions asked and where to send responses. It also asked the experts if they wanted to be included in this document by name. This personal information inclusion was entirely optional. The rest of the questionnaire was broken into three sections: background information, organizational GIS implementation and use, and possible future joint uses of GIS.

The first section of questions on the questionnaire was the background section. This section was meant to gain a little more insight into the experts that had been selected and document that all three military services were included in the research. The background information would also provide general information to the other experts in round 2 as to what other types of experts were involved in this research. The following questions were included in this section:

1. How many years have you been using GIS?
2. What other organizations have you worked with, i.e., military organizations, contractor, or civilian?
3. What is the highest level of education you have achieved (i.e., BS, MS, PhD) and identify your area(s) of study?

The second section of the questionnaire covered organizational GIS implementation and use, which was used to establish a baseline for the later discussion about future uses of GIS. The following questions were included to establish this baseline:

4. How useful has GIS been in your Service for forward deployment planning and execution (1 - not useful, 5 - very useful)?
5. How long has your organization and Service been using GIS?
6. How long has your Service been using GIS for forward deployment planning?

7. How difficult has the implementation of GIS technology been in your Service (1 - very easy, 5 - very difficult)?

The 1 to 5 Likert scale was used to help show any variation in opinion.

This section also allowed the researcher to verify that all the current GIS uses known by the experts had been discussed in Chapter 2 and that the information in Chapter 2 was still current. GIS is a rapidly changing field, and it can take years to get papers published in journals. These GIS experts have the most current information regarding their services current and planned GIS uses, well before it is published in a journal. This information check was accomplished with the question:

8. How does your Service use GIS for forward deployment (basic map capabilities, planning, etc.)?

The next two questions asked the experts to list the three most beneficial results from using GIS and the three greatest problems with GIS use in their areas. These two questions were intended to create a list of benefits and problems with GIS use. Then, during round two, the experts could discuss which benefits and problems were the most important. This question could also reveal possible benefits of GIS use that could be used during the IT implementation change analysis.

The final question in the second section asked the experts what new GIS applications were planned by their organizations. The purpose of this question was to develop a list of GIS applications being planned and highlight any redundancies.

The third section of the questionnaire was possible future joint uses for GIS. This section was the prediction part of the Delphi study. It was trying to predict possible reasons for and outcomes of a joint GIS program.

The first question asked "*How would you rank the cross-flow of GIS information between the Services (1 - very poor, 5 - very good)?*" This question was used to establish if there was a problem with GIS information flowing between the different services of the DOD. The next question asked what type of problems they had encountered with cross-service information flow. The third question asked "*How useful do you think a joint GIS would be (1 - not very useful, 5 - very useful)?*" This question was intended to measure the potential need and receptiveness to a joint GIS program. The following question asked "*What capabilities would you require from a joint GIS program?*" The purpose of this question was to generate a list of capabilities required, compare the types of capabilities required, and determine if there was any consensus about the most important capability. The final question of this section and the questionnaire asked the experts "*What new capabilities do you think a joint GIS program would bring to the DOD?*" This question was intended to generate a list of potential benefits of a joint GIS program. Finally, at the end of the questionnaire, a block was provided for any additional comments or suggestions for questions that should be included in the second round questionnaire.

3.2 Expert Panel Selection and Questionnaire Pretesting

The selection of Delphi members began by contacting authors of published documents, known GIS experts, and recommendations of other GIS experts. Per Chapter 3, two GIS experts within each service and NGA were contacted and asked if they would participate in this research. The initial contact was accomplished by email and followed up by phone. It was stressed that participation was voluntary, as required by the exemption to human subjects requirements.

The final expert panel is composed of three Air Force members, two Army members, three Navy personnel, and one NGA expert. The Air Force experts were from the Air Force Civil Engineering Support Agency (AFCESA) Force Development (CEOF); the Geo Integration Office for Royal Air Forces (RAFs) Alconbury, Croughton, and Fairford; and Headquarters US Air Force ILEX. The AFCESA expert is the Career Field Manager for Engineering. At the Geo Integration Office for the RAFs, the expert is establishing a GIS capability for the British; this expert was previously at the US Pacific Air Forces' GeoReach office. The last Air Force member was added based on the recommendation of the research sponsor because the expert works with the Joint Staff on Air Force GIS issues. The Army experts were at the US Army's Corps of Engineers Topographic Engineering Center (TEC) and the Directorate of Simulation, Terrain Simulations, 7th Army Training. As described in Chapter 2, TEC is responsible for providing all topographic support for the Army. The Directorate of Simulation is responsible for the terrain simulation capabilities for the 7th Army in Europe. The Navy experts were assigned to the US European Command and Naval Facilities Engineering Command (responsible for engineering standards and facilities throughout the Navy). The NGA expert is at the National Geospatial Intelligence School. Appendix A is a list of research participants that agreed to have their name and information included in this document. The Marine Corps was not represented in this research; however, several Marine Corps GIS experts were contacted via phone and email. After several follow-up messages, the experts had not responded to the questionnaires even though two of the experts had agreed to participate in the research.

The preliminary questionnaire described in the previous sections was pretested using AFIT graduate students while the expert panel was being assembled. The preliminary questionnaire was sent to eight AFIT graduate students. These students were working on research in related topics such as organizational change, survey methodologies, or GIS topics. This allowed the questionnaire to be reviewed from several different perspectives that were related to this research effort. Their inputs were included in the first round questionnaire for the expert panel.

3.3 Development of Round Two Questionnaire

This section reviews the administration of the round one Delphi questionnaire and presents selected responses to the questionnaire that were used in developing the round two questionnaire. The next section, Section 3.4, reviews the complete results of Delphi research.

The first round questionnaire was sent out via email to the expert panel with a request to respond via email within a week. After the initial questionnaire was sent out, the two additional experts (a Marine Corps and an Air Force GIS expert) were recommended for inclusion in the research. They were sent the same round one questionnaire, and response time was extended by two weeks.

Finally, after three weeks, eight of the ten experts had replied and the research needed to continue. Thus, the round two questionnaire was created using only eight responses. The format of the round one responses was not a problem. The Microsoft® Word document was flexible enough for all the experts' responses. Per the Delphi method, the responses were combined and organized in a manner to allow discussion during the second round. The second round questionnaire can be found in Appendix C with the combined responses. The rest of this section steps through the round one questionnaire as it pertains to the development of the second round questionnaire.

The first question that allowed for a follow up question was *"How useful has GIS been in your service for forward deployment planning and execution (1 - not useful, 5 - very useful)?"* Figure 27 displays the experts' responses. The chart layout was used because it is easy for the experts to read during the second questionnaire. The vertical axis is the count of a particular type of response, and the horizontal axis represents each possible response (1-5). For example, on this particular question, four experts responded with a 5 (very useful) to the question. This same figure layout is used throughout the discussion of scaled Delphi responses.

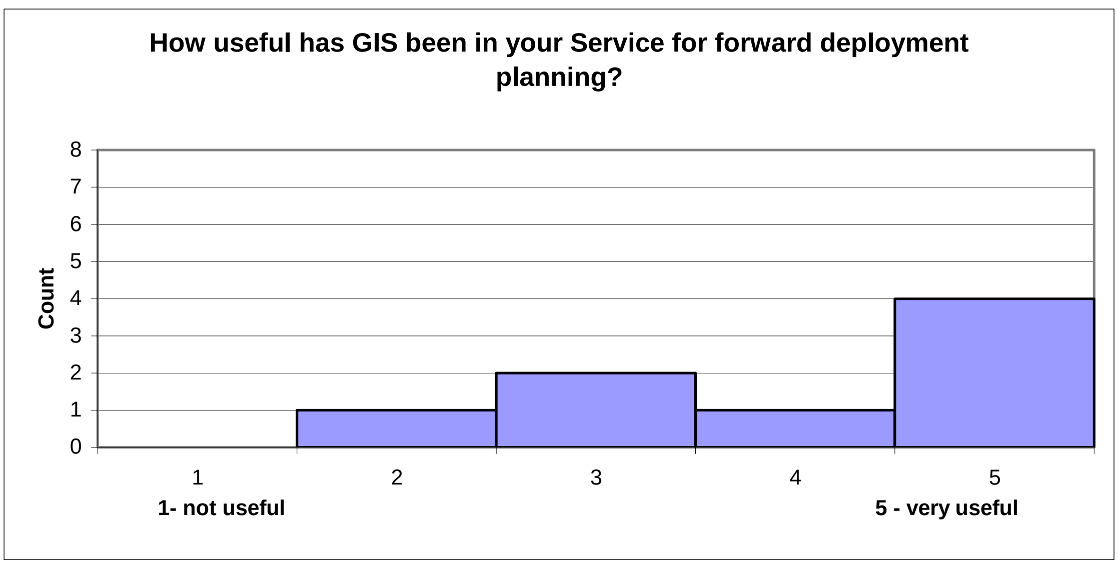


Figure 27. Usefulness of GIS

The responses show that GIS has been very useful to four of the experts. However, three experts have seen limited or moderate usefulness of GIS. Thus, the follow-up question was added to the round 2 questionnaire: "*Why has GIS use not had the same level of usefulness across the DOD?*" The purpose of this question is to start some discussion among the experts as to why different services are experiencing different levels of GIS usefulness.

The next question of particular interest to this research was "*How difficult has the implementation of GIS technology been in your service (1 - very easy, 5 - very difficult)?*" A key part of this research is an attempt to understand how difficult a new GIS technology could be to implement. The responses are shown in Figure 28. This question was meant to judge the apparent difficulty and possible resistance to the IT change that occurred within each expert's service during GIS implementation.

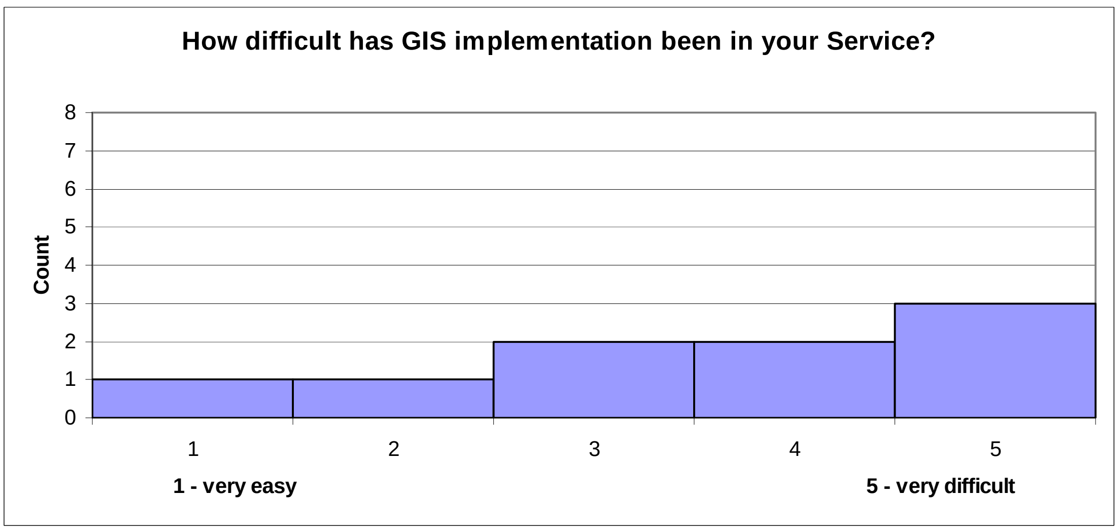


Figure 28. Difficulty of GIS Implementation

This shows that the experts are experiencing different difficulties in implementing GIS. Of particular note is that the "very easy" responder has recently moved jobs and has begun starting a new GIS office. This prompted the follow-up question: "*Why could some organizations be finding GIS implementation easier than others?*" Again, this question is meant to encourage some discussion among the experts.

The questions "*What are the three most beneficial results you have seen from using GIS?*" and "*What are the three greatest problems you have seen with GIS in your area?*" provided responses ranging from operational to technical benefits and problems. To allow for discussion and comparison, all the responses were categorized into broad categories. In the second round questionnaire, the experts were asked to rank order the categories during two follow-up questions. Rank order allowed the experts to pick one benefit or problem over another and create an order of importance.

The question *"What new applications does your organization have planned for GIS?"* resulted in several examples of how GIS is planned to be used in the future. For the second round questionnaire, the responses were sorted by service or agency. The experts are asked the follow-up question "*Could any of the applications being developed by another organization benefit your service?*" The purpose of this question was to identify any areas where a service is currently creating a GIS that another service might be able to use.

The question "*What type of problems have you encountered with cross-flow of information between the services*" provided several examples of how the cross-flow of information was difficult. However, since the original question was open ended, it could not be determined how often or how many of the experts had also experienced the problem. Thus, the follow-up question asked the experts to rate each response based on how often he/she has experienced the problem. Rating was chosen because the frequency of these types of problems was of interest.

The open ended question: "*What capabilities would you require from a joint GIS program?*" also provided a wide range of responses. The responses were arranged into six categories. For the second round questionnaire, the experts were asked to rank order the categories. One of the round one responses said that the entire DOD needed to use a single commercial company for GIS applications to allow for easy information flow. Knowing that there has been some discussion about this at GIS conferences, the question *"Is it necessary to only use one software company to create a common data standard?"* was asked to this panel of GIS experts.

The experts were also asked "*What new capabilities do you think a joint GIS program would bring to the DOD?"* This open ended question was meant to identify possible areas of improvement across the DOD that would result from a joint GIS program. To create some discussion, the question: "*Do you think a joint GIS program would bring all these benefits to the DOD?*" was asked as a follow-up question.

Three new questions were added to the round two questionnaire. These were questions that should have been included in the previous round or questions the expert panel recommended.

The first new question was "*If your service has used GIS for forward deployment planning or operating, please provide an operational example."* This question was added on the recommendation of one of the panel members. The question is aimed at gaining more specific examples of how GIS has been used within each service for forward deployment planning and execution.

The second question was *"How would you rate the flow of GIS information within your service (1- very poor, 5 - very good)?"* This question was added based on the recommendation of the researcher's thesis committee. This question will be used to identify whether the cross-service flow of GIS information is a just a problem between the services or if it might be an extension of in-service problems.

The third new question asked was "*Have you been in situations where a joint GIS program would have improved the mission or enable a new capability? Please provide examples and specifics where possible.*" This question attempts to identify specific cases where a joint GIS program would have benefited the expert.

3.4 Results from the Delphi Study

This section steps through the responses of the second Delphi questionnaire. The second questionnaire was sent to the same 10 GIS experts used for the round 1 questionnaire. Again, after several follow-up messages, only 8 of the 10 experts had replied and the process continued. In the second round, a Navy expert that had not replied to the first round questionnaire replied to the second round questionnaire, and an Army expert that did reply during the first round did not respond during the second round. Thus, the total number of participants remained the same even though one person dropped out and one person returned to the research. The combined responses are in Appendix C.

The background section of the questionnaires provided information about the expert panel members. The experts range from 2-15 years of experience using GIS; however, this time does not include time spent in related fields such as surveying or drafting. Between the members of the Delphi panel, all of the armed services are represented and many of the panel members have worked with other services. Also, the experts have worked with numerous GIS contractors. The education level of the experts includes an Associates in Engineering, a BA working towards an MA, three BSs, and three MSs. During the second round, the experts listed a few more contractors that they had worked with and noted that NIMA changed to NGA.

The follow up question, "W*hy has GIS use not had the same level of usefulness across the DOD?"*, provided several perspectives about possible reasons. Table 10 shows the responses to the question. Three experts said it might be because of a lack of education and exposure. These responses show that the knowledge step required in an IT change has not been addressed effectively. Another expert said that GIS has a high cost that people do not way to pay. This response shows that the perceived relative advantage is not thought to be enough for the actual cost of the IT implementation. Finally, one expert said the different usefulness was because of different mission focuses; the Navy does not plan beddowns because they deploy with aircraft carriers.

Table 10. Reasons for Differing GIS Usefulness

- Education, Lack of Exposure, Lack of Understanding. If more people were informed and educated on the power of GIS then I think you would find the level of usefulness increasing exponentially across the DOD
- Lack of Executive Level education as to its utility.
- Looked upon as a techie thing vice a knowledge management – command and control tool
- Can be costly and some folks don't want to pay for the additional capability it provides.
- GIS has come a long way in the last few years; some aversion to GIS from past users because it was more difficult to use 5-10 years ago
- Differing levels of acceptance and funding
- Have you evaluated the background of your responders? Just because a CE dude says GIS hasn't been useful to the Army doesn't mean it hasn't been useful for an infantry troop… To different specialties it may have been useful in varying degrees across the DoD
- The level of usefulness is directly proportional to the level of data availability!
- Different mission focus. Navy doesn't beddown aircraft. We bring our own airport

The next new question, "*Why could some organizations be finding GIS implementation easier than others?*", was a follow-up question to the round one question asking how difficult has GIS implementation been in the expert's service. The second round question resulted in several responses that have been combined into four categories—education, leadership, organizational costs, and data availability. Table 11 lists all the experts' responses to this question.

Table 11. Responses to Implementation Difficulties Question

Education

- The services do not do a very good job with GIS training. Leaders often assume vendors will do the training on commercial data even though commercial data does not resemble military data sets. Also, new GIS organizations do not know that NGA provides GIS training.
- Executive education and support.

Organizational Costs

- Funding
- Manning
- Service priorities for funding (need to have vs. nice to have)
- Return on investment—need to produce results

Leadership

- Commander emphasis and vision
- Different Leadership—those that see the technology helping them meet capabilities tend to embrace it.
- High level support is needed to ease implementation
- Goes back to Executive Level Education and "what's in it for me?"
- Data availability! Forwardly deployed units do not have time to create their own data!

One expert said the services do not do a very good job with GIS training. Leaders often assume vendors will do the training on commercial data even though commercial data does not resemble military data sets. Also, new GIS organizations do not know that NGA provides GIS training. This problem fits within Armenakis' second reason for IT failure, the organization simply neglects to see the change all the way through. The organization has put forth the effort to start the change, but has not continued with the effort required to properly educate the users on the new IT. Another expert narrowed it down to executive education.

Within organizational costs, three reasons for implementation difficulties listed were manning requirements, service priorities for funding, and return on investment. These three difficulties addressed are expected per the IT implementation model presented in Chapter 2. Difficulty in recruiting was an expected difficulty per Wilson's IT barriers. Priority for funding and return on investment return to the problem of observable benefits and relative advantage.

Within the leadership category, all the experts said that executive support is necessary for easing implementation. These comments agree with the IT change implementation model, which stated that executive support is required throughout the IT implementation for the implementation to be smooth. Finally, one expert said that the reason for differing levels of GIS implementation was because of data availability. He noted that the forward deployed units do not have time to create data. This was not predicted by the IT model because it is a problem specific to GIS use.

The next question asked the experts *"How does your service use GIS for forward deployment?"* Table 12lists all the round 1 responses to the question. By these responses, it seems that all the services are using GIS technology to some extent.

Table 12. Current GIS Uses

• Planning at HQ level • USAF now uses GIS as part of its Expeditionary GeoBase process to select deployment sites, implement deployment ops, and transition to operational status. NIMA uses GIS for Geospatial Intelligence analysis over potential hotspots globally. • Firewire drives, web based support, custom products, standard and non-standard NIMA products, foreign produced products and maps • Battlespace management and navigation (digital nautical charts) • GIS allows for web-enabled map sharing for collaborative planning. Additionally, GIS facilitates visualization--fuses imagery, mapping, and data. • Planning graphics, basic map capabilities, relief and shaded elevation, line of sight, the full range of Tactical Decision Aids. In the pure sense the greater Army does not use the full range of GIS capabilities, there is a lack of understanding and a lack of clear course of action to fully implement GIS across the service. • All functions or facets of Army operations

The last two responses listed in Table 12 show a possible contradiction as to the level of GIS within the Army; however, a second round follow-up response provided some insight. During the second round, the expert said that the disparity might not be a contradiction. The expert said that to some extent the Army does use GIS across all facets of operations. However, the Army's level of GIS development varies greatly across the service.

The question asking for examples of GIS use during forward deployment planning yielded several examples of GIS use across the services. Most of the examples were of the Air Force's GeoReach program being used in Operation Enduring Freedom and Operation Iraqi Freedom to help leadership make decisions about where to deploy troops forward. European Command used GIS to plan Joint Task Force Liberia in July 2003. The Navy Seabees are currently talking with the GeoReach offices to coordinate future planning. Finally, the Army expert responded that unfortunately their examples were all classified.

The next question asked the experts to rank order the benefits listed in the round 1 responses. The round 1 responses were categorized as shown in. In round 2, the experts were asked to rank order the categories from the most important to least important benefit of GIS. These round 2 responses were analyzed using the average ranking and standard deviation that was calculated for each category..

Table 14 shows the statistics for all of the categories. In the table, the category is the category being ranked. The response of each expert (1-8) is listed to the right of the category, and the total number of responses included in the mean and standard deviation (SD) is shown. This count of responses included is important because one of the experts (shown here as number 4) only ranked the three most important benefits. Therefore, some of the categories have eight expert responses, while others only have seven. The final two columns of the table show the mean and standard deviation for each category. These two numbers were used for the final combined ranking of the categories. This same statistical analysis method was used for all ranking and rating questions for the remainder of this research. For future questions, the statistical calculations can be found in Appendix D – Delphi Responses.

Table 13. Categorized Benefits of GIS

Planning/ Operational Capabilities
- GIS allows for web-enabled map sharing for collaborative planning
- Increased acceptance of Civil Engineer's role in bed down
- Wider use of predeployment information – STEP, GeoReach and BSP
- Analysis based on fact, rather than conjecture or ancient maps and charts, word of mouth, etc. Decision makers respond instinctively to GIS produced analyses as being more credible than traditional manual planning processes.
- You can use GIS to get a good understanding of denied areas, through data collected by remote sensing and other sources.
- Battlespace situational awareness

Visualization and mapping abilities
- GIS facilitates visualization--fuses imagery, mapping, and data.
- Custom product development from digital data (specific products are now tailored to meet specific warfighter needs)
- Digital nautical charts
- Enabling better installation visualization by enabling access to the CIP.

Software Applications
- GIS is COTS--Industry leads development
- ARC GIS software applications
- Ease of use

Data gathering, sorting, and flexibility
- GIS allows you to work with almost any kind of data in a new spatial framework. Now you can marry up huge collections of raw facts about features with accurate spatial reference.
- Compatibility with civilian generated data
- Ability to generate your own data if necessary
- Digital data

Time Savings
- Reduction of time spent by engineer assistants career field on tasks such as map production and copying – users are able to access the CIP via the intranet and fulfill their requirements from there.

Range management/ facilities management

Better access to GPS

Employment Opportunities - Jobs for starving recent Geography graduates.

According to the round 2 responses, the experts combined rank ordering of benefits from most important to least important is:

1. Planning/operational capabilities
2. Visualization and mapping abilities
3. Data gathering, sorting, and flexibility
4. Time savings
5. Software applications
6. Range management/facilities management
7. Better access to GPS
8. Employment opportunities

Table 14. Statistical Analysis of GIS Benefit Rank Ordering

Category	1	2	3	* 4	5	6	7	8	Total # of Responses	Mean	SD
Planning/ Operational Capabilities	1	1	2	1	2	2	1	1	8	1.38	0.52
Visualization and Mapping Abilities	3	2	3	2	4	1	4	2	8	2.63	1.06
Software Applications	7	4	1	3	7	5	6	6	8	4.88	2.10
Data Gathering, Sorting, and Flexibility	2	5	5		3	3	5	4	7	3.86	1.21
Time Savings	6	6	4		1	4	2	5	7	4.00	1.91
Employment Opportunities	8	8	8		8	6	8	8	7	7.71	0.76
Range Management/ Facilities Management	4	7	7		5	7	3	3	7	5.14	1.86
Better Access to GPS	5	3	6		6	8	7	7	7	6.00	1.63

One of the experts only ranked the top three most important benefits and the three greatest problems with GIS. The ranking was still included in the average value for those three categories. For the other five categories, the sample size was reduced to seven, which would not greatly affect the results because the analysis is based on the average response.

The categorized problems with GIS have been analyzed in the same manner as the benefits. The researcher categorized the round 1 responses as shown in Table 15; and in round 2, the experts were asked to rank order the categories. Based on the round 2 analysis, the experts seem to reach a consensus that, of the listed problems, cultural and individual resistance is the greatest problem. The next worst problem appears to be education and training. The remaining three problems could not be ordered because of the variation of responses.

Table 15. Categorized Problems with GIS

Education and training (listed by five panel members)

- GIS is hard. Too many supervisors think you can buy a copy of ArcView, send a guy to a two-week class, and be fully GIS proficient.
- Non user friendly
- “Use it or loose it” software skills
- Lack of understanding of what GIS it’s capabilities.
- You need to be GIS-smart to manipulate the data (e.g. add points, lines, and polygons, or imbed information)

Culture and Individual Resistance

- Acceptance from field
- Lack of executive support
- To many rice bowls, everybody is doing their own thing, no standardization in terms of products or programs.
- Resistance from contractors doing work on the installation to provide as-builts (at all, or in any kind of geospatial format).
- Resistance from CIP users who are accustomed to having engineering assistants do map production and copying for them as we attempt to transition the users to partial or full self-sufficiency.
- Attitude of Civil Engineers who feel that GeoBase is not their ‘deal’ or responsibility; also seeing GIS as a ‘free’ gift from HQ that they do not need to invest in (with financial and/or human resources).

Funding (listed by three panel members)

- NIMA, DIA, [Unified] Commands don't want to fund GI&S hardware/software applications and web based development
- Can get relatively expensive with software upgrades and having to hire contractor support.

Technological/ Development problems

- Lack of data (listed twice): GIS is sometimes oversold by people who have no idea how much work is required to build high-resolution data sets.
- Slow map refresh
- Complexity of the software
- Managing GI&S data. So much is produced and it's difficult to keep track of everything that is out there
- Developing systems that are acceptable in a combined environment, sharing data on systems with coalition partners in a warfighting environment (i.e. LOCE, system used in USFK)

Other Problems

- Bad analysis is not always obvious. People can make a great looking product out of worthless data, and unsuspecting decision makers will fall for it.
- Lack of a definitive approach for implementation of GIS across the service and within DoD.

In Round 1, the experts were asked what GIS applications were planned for their services. Table 16 shows their responses. In round 2, the panel was asked if any of these new applications could be useful in their service, and all the experts said yes. Several of the experts listed specific planned programs that could benefit their service. Other experts listed requirements of the other services' planned programs that would enable the new programs to benefit all the services. For example, "command and control programs should be standardized across all the services; in a joint environment the various services could 'plug-in' their component to the overall C2 system."

Table 16. Planned GIS Applications

Army • My organization builds and maintains large terrain databases used in support of the Army simulations community. We are moving to web based map server and making a significant investment in database technology to support our future growth. • Creation of Army standard products.
Navy -Strategic repository/ portal to spatial data, a Navy Spatial Data Inventory
Air Force: • Integrated Pavements Evaluation tool • Very young program; right now just trying to get off the ground. No new apps are currently planned by my installations. We are currently using applications to track vertical obstructions (AIROBS), and calculate QD Arcs (ASHS). NOTE: However, HQ USAFE is developing a tank tracking application (i.e. utility tanks), asbestos data tracking & viewing application, and electronic Base General Plan.) • Looking to use GIS for Expeditionary Site Planning (includes GeoReach)
EUCOM • I have procured (with Unfunded Requirements) 4 servers, 4 TB SAN and ARC GIS software applications and ARC SDE. We are building a theater wide web based mapping capability. *http://maps.eucom.smil.mil*
Joint Staff developing Joint Engineer Planning and Execution System which will likely include GIS for airfield and port visualization
NIMA is working with civil authorities to develop a common GIS for homeland security
Homeland Defense is looking to use GIS for among other things, mapping air bases for Force Protection

The experts were asked how the GIS information flow was within their own service to help determine if GIS information flow is just a problem between the services or if it might be an extension of problems with the services. Figure 29 shows the responses.

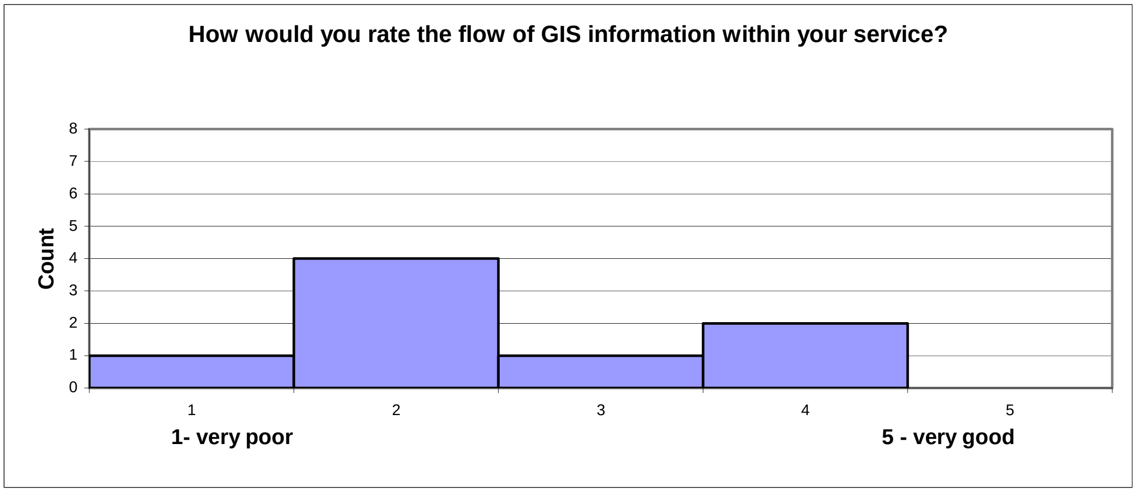


Figure 29. GIS Information Flow Within Each Service

Two of the experts qualified their responses. One expert said that the Air Force information flow is poor as a whole; but within the civil engineering community, it was good. Another expert from a different service said that a year ago, he would have said information flow within his service was poor; but today, the information flow is good.

The question: "*How would you rank the cross-flow of GIS information between the services (1 - very poor, 5 - very good)?*" was used to determine if a potential problem exists between the services. Figure 30 shows the experts' responses. The lack of "4" or

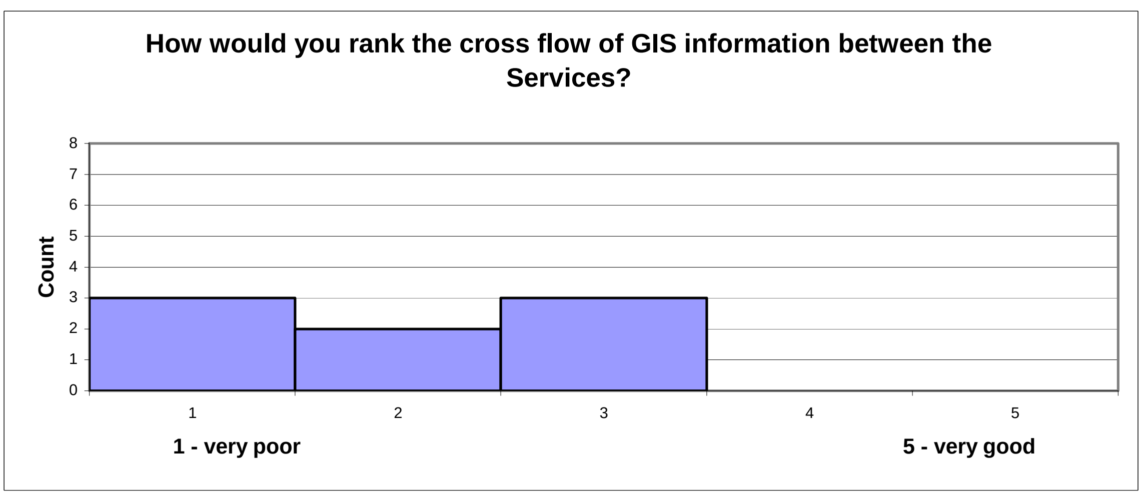


Figure 30. Ease of GIS Information Cross-Flow Between Services

“5” responses seem to indicate there is a problem with the cross-flow of information between the services. When the responses regarding information flow within each service is compared with information flow across services, it appears that the experts think cross-service information flow is difficult.

Next, the questionnaire asked the experts to rate the information cross-service flow problems based on their experiences. The researcher categorized the round 1 responses as shown in Table 17. In round 2, the experts were asked to rate how often they had encountered each type of categorized information flow problem. Several of the experts said that they have trouble knowing who to contact in the other services about GIS issues. Another common problem for the experts is a lack of understanding across the DOD about GIS products that are available. These two problems could be related. If more experts knew who to contact, the increased communication might increase the knowledge of other programs and products available.

The question: “*How useful do you think a joint GIS would be (1 - not very useful, 5 - very useful)?*” was meant to help predict the possible usefulness of a joint GIS program. The responses are summarized in Figure 31.

Table 17. Categorized Problems with GIS Information Cross-Flow Between Services

Knowing who to contact

No agreed-to standards.

- The SDS/FIE data model is a good start, but as far as I know, only the USAF really produces data based on it.
- “do your own thing” with no standards

Identifying what data and products are available.

- There is a lot of production going on out there and keeping track of who’s produced what is overwhelming. Developing Metadata services is critical in keeping a handle on all that is available. Metadata schema is critical for sharing of data and products and assisting the warfighter in finding the best GI&S data to assist them in mission success

Culture

Huge differences in mission, data, and GIS product terminology;

- Data classification; ‘established’ procedures for data use; entrenched established formats for data and products.

BIG contractors who manage and develop (and essentially own) software applications remove the (usually) enlisted GIS ‘operators’ from the underlying technology and knowledge of GIS.

Compartmentalized Applications preventing cross-service discussion. JMTK is an effort to combat this, but more work needs to be done.

Lack of understanding across DoD about the of GIS products available,

- the reluctance of each of the services to look at the progress being made in the GIS community by the other services and leveraging success.
- Somewhat stove-piped. Don’t get to always see what the other services are doing.

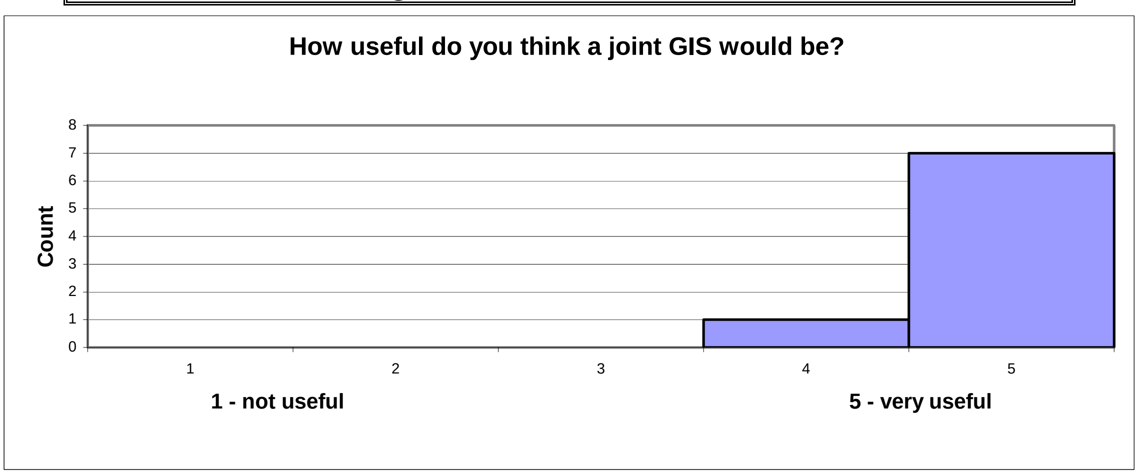


Figure 31. Possible Usefulness of Joint GIS Program

From the responses, it appears that the panel's consensus is that a joint GIS program could be useful to all parts of the DOD. According to the IT implementation model, this shows that the prior conditions exist for a possible IT change to be implemented.

During the second round questionnaire, two experts provided additional comments. The first comment was that joint GIS is "more important now that we are mandated to a common command and control venue for National, Federal, and Civilian Emergency Response." The other expert said that a joint GIS development should be the NGA's responsibility.

In round 1, the experts were asked what capabilities would be required of a joint GIS program. Table 18lists experts' responses as categorized by the researcher. In round 2, the experts were asked to rank order these categories from the most important to least important capabilities.   The combined responses from round 2 show that the most important part of the program would be an organized focus for the program. The least important capabilities listed were a single point of access for the data library and a relevant layer query.

Table 18. Capabilities Required of a Joint GIS Program

Common Data Standard

- Geospatial Data Standard for all DOD organization
- Enforce common data standards and develop a common enterprise architecture that will embrace what each service is doing rather than maintain the stovepipe approach.
- Standardization of data formats, storage and access and visualization methodology, software (yes, probably would end up as a monopoly by ESRI), products, terminology
- Needs to be developed and built on the same software application. All services need to adopt or buy into the ESRI solution. It's the best on the market today.
- *Round 2 Responses:*
    - We already have a content standard for facilities, infrastructure and environment- the SDSFIE; it's being enhanced for Homeland Security Infrastructure and NGA Homeland Security Infrastructure Project (minimum essential data sets for 133 cities)
    - Again, a techie point of view

Joint Training

- Joint training program for all levels of users
- A consistent level and delivery method of education to the (usually) enlisted GIS 'operators' across all the services, also standard list of skill sets for those operators. [Pie in the sky dream would be for there to be GIS people in just one of the services who are shared amongst the others, same goes for GPS people.]

A organized joint focus

- Focus. GIS is already applied to everything from combat ops to facility management. The first the joint world needs is a DoD equivalent of the USAF GeoBase program [Not an AF member].
- Define 'who's in charge'
- 'Who pays?'

Joint Operation Planning Capability

- Integrated planning…all reading off the same sheet of music
- Joint Beddown,
- Executive decision support
- Mission oriented decision support

A single point of access to the data library that houses quality data!
Relevant layer query capability

In round 1, one expert said that a single GIS software company should provide all the the software to the services. In the round 2, the experts were asked what they thought about only having a single company provide all the GIS software. Based on the round 2 responses, the experts reached a consensus that a single software company is not needed to create a common data standard. The responses included comments such as “the industry has already solved that problem” and “not if it is a new data standard.” However, one expert said:

> “NGA needs to build the standard and software companies would then build applications to meet the NGA approved and established standards. NGA is not making any progress in getting the standard established so companies are running in their own direction.”

In round 1, the experts were asked what new capabilities a joint GIS program would bring to the DOD. The responses are listed in Table 19.

Table 19. New Capabilities from a Joint GIS Program

- Cross flow of info
- Rational decision making, vs. emotional knee-jerk reaction. Especially in the BRAC process
- Better management of GI&S data, better display of data and most importantly it would bring GI&S together and eliminate a lot of the stovepipe activity that is currently going on across the services and commands using GI&S applications and data
- Joint enterprise range management
- Joint facilities management
- Joint asset requirements generation – avoid duplication
- A focus to develop a common operating picture across the DoD based on common terrain data.
- Standardization of algorithms
- Standardization of data structures/layers
- DOD contract for COTS GIS software
- Time and money savings from the reduction of: a) time spent on training and re-training, b) efforts to convert data into the formats and products required by each service (FFD is an effort to do this but again more work is needed)

However, in the round 2 follow-up question, the experts did not reach a consensus when asked if a joint GIS program would bring all the capabilities to the DOD that had been identified during the first round. Figure 32 displays the range of responses received to the follow up question.

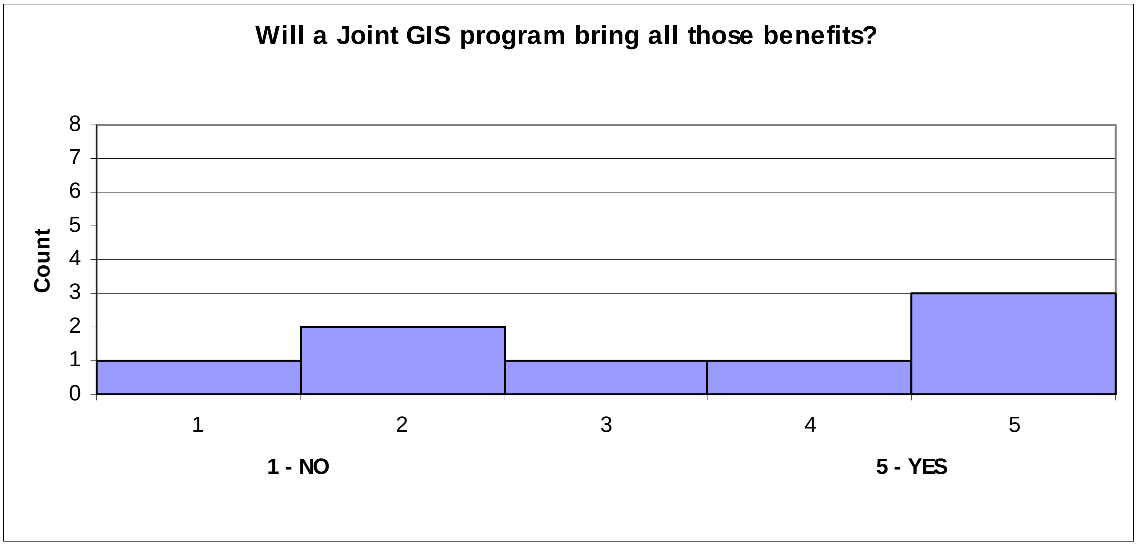


Figure 32. Will Joint GIS Bring Benefits?

One expert said, "No. A GIS will not change human nature." Another expert said that if the joint program was done correctly, it would bring the capabilities; however, the expert said the program is unlikely to occur. Two experts said the capabilities would not be achieved immediately because "there's a huge diversity of GIS uses." Yet another expert said most of the benefits could be achieved. Finally, two experts said the capabilities could be achieved and that the DOD is working towards a joint GIS program with the installation visualization tool (IVT).

The final question asked "*Have you been in situations where a joint GIS program would have improved the mission or enabled a new capability?*" Five experts answered this question. One expert said "continuously," and another said while working at

EUCOM a "joint GIS program makes obvious sense." One expert said that GeoBEST is a good example because it is a coordinated effort between Air Force and Army. Another expert said at USAFE bases that are managed by other services, a shared installation GIS could improve the mission; and a common GIS could be beneficial in situations where the Air Force is forward deployed to Navy or RAF installations. The final response was:

> "Base-level Force Protection planning is generally done with paper charts. The USAF GeoBase operating capability is already addressing how that can be improved with GIS. But so many of our facilities are now dual-use, or joint, etc. Some sort of shared understanding of how to use GIS to manage these for better situational awareness would be a big step forward."

4.0 Case Study Execution

This section reviews the case study execution. First, the design of the case study questions is reviewed. Then, the data collection method is presented. Next, the individual and group interviews are summarized and analyzed. Finally, the necessary interview follow-up questions are reviewed and analyzed. Per Chapter 3, this case study has four objectives:

1. Further explore GIS uses in forward deployment at a single GIS unit.
2. Investigate current IT integration methods being used.
3. Determine the possible receptiveness and success of a joint GIS program for forward deployment planning and execution.
4. Determine if the IT implementation methods described in Chapter 2 could be effective in implementing a joint GIS program.

These objectives will be used to step through the case study. The third and fourth objectives were combined during the research and will be combined during this discussion.

4.1 Development of the Case Study Questions

The questions for the case study were developed for three situations: observation of an office, individual participant interviews, and responses to the GeoReach presentation. The questions were laid out to look like a double sided form. Each question was enclosed by a box with enough room for the interviewer to record the interviewee's response. Each form began with information about the location of the interview or observation, date, and contact information for follow-up questions. The questions used are shown in Appendix D; however, the list of questions in Appendix D has been condensed from the form-like design used during the interviews.

The first set of questions was designed for observing the Army GIS office and documenting current functions and operations. The first questions were designed to understand the responsibilities and organization of the office. These questions included the following:

- What are the responsibilities/mission of your office?
- How many people are in your office? How is it organized? To whom do you report?
- What current GIS applications does your office offer the Army?
- Who are your customers?

The next three questions were designed to look at how GIS information is exchanged within the Army and with other services. The following three questions were asked:

- How often do you have to request information from other services (first on any type of information, second GIS information)?
- How often do you coordinate with other offices inside/outside the Corps?
- How are your products accessed?

The following four questions were meant to look at how the unit actually uses GIS as a technology:

- What are the benefits of GIS and how are they measured?
- What equipment and software is your unit using currently for GIS?
- What are the capabilities and limitations with the current system in regards to GIS?
- What are planned future uses for GIS?

The next section of questions looked at how the unit implemented new technology and updates to existing technology. The responses from these questions were to be compared with the proposed IT implementation model presented in Chapter 2. The questions used included the following:

- How is new technology or updates implemented?
- How was your GIS program implemented throughout the Army?
- What new changes are being implemented?
- Were there any exceptionally good implementations? Why?
- Were there any exceptionally bad implementations? Why?

The final two questions were stand alone questions. The question *"How does your office deal with classified information at the deployed location?"* was to be used to learn how other services deal with the fact that many of the plans for forward deployment are classified, but still need to be used for field use during the deployment. The last question was *"Do you see any benefit from a single GIS program DOD wide?"* This question was meant to create some discussion about the possibility for a joint GIS program prior to the presentation given to the entire group.

The second set of questions for the case study was for each individual interviewed. Although several of the questions were repeated from the office observation questions, this set of questions was more pointed to the individual rather than the office. Only six new questions were added. The first new question asked the individual how long he had been working with GIS. The second new question asked if he had worked with any other services' GIS units, which showed the extent of joint operational experience in the organization. The next new question asked the individual how he would improve the existing GIS process. The final three new questions were meant to compare the IT implementation model to the actual environment of the GIS unit. These questions included the following:

- How much leadership support do you have for GIS and leeway for implementing changes?
- What are the benefits of GIS and how are they measured?
- What is the best training method for new technology?

Each of these areas (leadership support, benefits of GIS, and training methods) were key elements to a successful IT implementation.

The third set of questions was used after the GeoReach presentation to discuss the possibility of a joint GIS program. The interview group for this set of questions was the same group that had been interviewed individually previously about their current GIS program. The first group of questions was directly about GeoReach and the possibility of adding any of GeoReach's capabilities to the Army GIS program. They included the following:

- What are your initial thoughts of the AF's GeoReach program?
- How do you think the AF's mission differs from the Army's deployable mission?
- Do you think parts of GeoReach could benefit the Army?
- Are there any areas that GIS could be added to for forward deployment planning?

The next group of questions was meant to move the discussion away from directly talking about the Air Force's GeoReach program and to a joint GIS program discussion. The questions used for this discussion were:

- Would a joint GIS program improve any existing capabilities within your organization?
- What capabilities would you want to see in a joint GIS program?
- Do you think your organization would see any new capabilities created by a joint GIS program?
- Could a joint GIS program be created that would aid in joint operations DOD wide?

The remaining questions were meant to steer the discussion towards how to implement a joint GIS program. The questions were formed based on the important components of the Chapter 2 IT implementation model. The following questions were asked:

- What would convince you to switch over to a joint GIS program?
- How difficult do you think the transition to a new GIS program would be?
- What barriers would need to be overcome for the implementation?
- Would the change be better supported by having high-level support or more technician support?
- Who should manage a joint GIS program? Should it be contractor or civilian run, or should it be a joint assignment for active duty military? Should one unified command take lead or joint staff?
- What are the benefits of GIS and how are they measured?
- What is the best training method for new technology?
- Is the existing communication system able to support the exchange of information between the services?
- Is the technical ability sufficient for exchange of GIS information?
- Would upper management be willing to support (financially and politically) a new GIS program?

4.2 Exploration of an Army GIS Unit

The specific GIS unit used for this research was chosen because it is the office responsible for Army topographic support. Also, this unit was responsible for fielding, training, and updating the Army's topographic GIS capability. The office was found through several steps in a referral process, and the unit was very willing to help with this research effort. In order to comply with the human subjects research requirements, only the unit visited will be noted; no names or ranks were taken or used during this case study.

The unit visited for this case study research is a subset of the US Army Corps of Engineers Topographical Engineering Center (TEC). TEC's mission is:

> "to provide the Warfighter with a superior knowledge of the battlefield, and support the Nation's civil and environmental initiatives through research, development, and the application of expertise in the topographic and related sciences" [81].

The unit studied works within the Combat Terrain Information System (CTIS) and is responsible for fielding and technical support of the Digital Topographic Support System (DTSS) and Battlespace Terrain Reasoning and Awareness (BTRA) both of which were discussed in Chapter 2, section 5.1. The unit is a combination of DOD civilians, contractors, and five Army Noncommissioned Officers with varying levels of topographic analysis experience. The DTSS element lead is a retired chief warrant officer with extensive topographical experience. Studying this unit fulfills the first objective for the case study—to further explore GIS uses in forward deployment at a single GIS unit.

The questions designed in Chapter 3 and detailed in Section 4.1 of this chapter were used for the interviews. The interviews were recorded on audio tape for later review and transcription. Appendix E documents relevant parts of the interviews. During the case study travel, the researcher also met and interviewed a Marine Captain who is an instructor at NGA's National Geospatial Intelligence School. The information provided by the Marine Captain has been included in Chapter 2, and he also recommended one of the Marine Corps experts contacted for the Delphi study.

Upon arrival at TEC, the researcher received a unit mission briefing given by the DTSS lead. From this briefing, the researcher learned that this element is responsible for fielding and training Army personnel on the DTSS. The personnel travel to operational units to train new DTSS users and educate existing users on upgrades. The DTSS system is a combination of commercial and military hardware and software that allows the user to create and process terrain information. The digital information in the system can be imported from other agencies or created in-house.

The focus of the terrain analysts is on what the operational commander will need to conduct a land war. As a result, information about type of soil, vegetation, slope, etc. are very important. However, this unit is also responsible for providing topographic support for federal operations within the US such as Federal Emergency Management Agency's (FEMA) operations. For example, if a natural disaster occurs in a major city, this unit or one of the other standby teams will respond and provide topographic support for the recovery operations. For both military and civilian customers, the terrain analysts begin creating a GIS from NGA available data and then add in other sources of information.

Once the in-brief was completed, the researcher began interviewing the five topographic or terrain analysts within the DTSS element. Topographic analysts are used throughout the Army. Their duties include all aspects of cartography and terrain analysis. They also collect and process GIS information. Some of the duties of topographic analysts include the following:

- Extracting terrain data from GIS sources
- Drawing and digitizing cultural, topographic, hydrographic, and other features on overlay or digital formats

- Drawing maps and charts
- Conducting land surveys
- Piecing together aerial photographs to create a larger photomap [82]

All interviewees agreed to have their discussion taped for research purposes. Two of the DTSS software team leaders were also interviewed. Results from all eight of these interviews are in Appendix E. These interviews are used for this case study.

The interviewees were asked what the benefits of GIS were and how they can be measured. The question resulted in two benefits being noted several times. First, the terrain analyst is able to save time using GIS for two reasons. First, the terrain can be analyzed using computers with predetermined algorithms. Second, the terrain analyst no longer has to provide hard copy maps to the operational commanders. Previously, the analyst has to create the map from several flyover images, store the combined image, and then make hard copies for each commander. Now, the commanders view the same digital image through a network. This use of softcopy maps rolls right into the second noted benefit of GIS, which was increased information dissemination. The hardcopy maps took time and limited who could have a copy. Now, the digital map is available to all personnel on the network, and everyone is working off the same, most current map.

Two additional questions were added after the on-site interviews. These two questions, along with five additional questions for the third and fourth objectives, were emailed to the same five participants that were interviewed in person. Three of the five individuals responded. The two additional questions regarding current GIS uses were:

1. What are the drawbacks of using GIS for terrain analysis?
2. What new operational capability has GIS brought to the Army?

In response to the first question, one person said he could not think of any drawbacks to using GIS for terrain analysis. However, the other two responses said that leadership and the terrain analysts become too dependent and trusting of the tool. The second respondent said,

> "People believe that the GIS is perfect with little error. They do not take into account errors in data and resolution. This gives them false trust in the products."

The third response said,

> "Terrain analysis is just that, analysis. For automated GIS applications, many analysts lose site of their job; they become too dependent on software applications to do their jobs and are less prone to employ their analytical skills. In doing so, their skills are apt to degrade. In turn, terrain analysts are doing less analysis and more geo-spatial data dissemination."

All three responses cited new operational capabilities for the Army as a result of GIS. The first responder said that the Maneuver Commander now had the ability to see exactly or very close to what the battlefield will look like prior to leaving the garrison environment. The second responder said that GIS has given the Army quicker response time because data can be manipulated and used at a much faster rate using GIS. The third responder cites the time saved by saying,

> "The greatest asset that GIS has offered is increased speed for product generation. Products that once took months to produce can been created in as little as a few hours—this, however, is not a standard for all products. Some may take longer."

4.3 GIS Unit's Current IT Integration Method

The second case study objective (investigate current IT integration methods being used) was also accomplished during the interview process. Based on the interviews, new technology within the DTSS element is incorporated by downward direction. The change is decided upon by leadership, and the updates are made to the hardware or software. Then, the updates are included in class presentations for new and returning students. The highest priority for updating is the field units with warfighter missions. After the warfighter has the update, then focus changes to updating the chain of command. None of the interviewees said the implementation method followed any planned IT implementation strategy.

When these change implementations are compared to the IT implementation model presented in Chapter 2, the current method is not the ideal implementation method. First, downward directed changes are not supposed to be the most effective method of introducing change. However, the unit's method of introducing the change at the warfighter level and allowing it to diffuse up the change may overcome the resistance caused by downward directed change.

The DTSS members appear and self report as being willing to integrate new updates. This is driven by the fact that the GIS field is continually improving and requires the users to keep current with skills. The best updates and new IT implementation occurred when the technicians were allowed to set up and execute the update. Also, including experts in the change process added credibility during the IT implementation.

These responses to change are included in the IT implementation. The willingness to accept change and the continuous required updates reveals that the prior conditions exist for accepting the new IT. The technicians' preference to set up and execute the change is shown in several areas of the model. First, this is diffusion implementation at its best. Second, the change comes from within the organization. Third, all five of Armenakis' change message questions are answered; the technicians have already seen the reasons and benefits of this change and that is what they are responding to. Experts being included in the change were also noted in the implementation model as helping add legitimacy to the change.

The interviewees' recall of poor IT integration was better than their recall of good occasions. The interviewees cited four specific reasons for difficult IT integrations. First, the requirements for the new applications were determined outside of the integrating organization. Thus, when the organization went to implement the applications, they did not fit the current requirements of the organization. The second reason for difficult integration was that the new IT was introduced right before a training exercise. This timing for the new IT did not allow the unit to learn the new technology and effectively use it during the increased operations tempo during an exercise. The third reason given was that the dedicated funding for the IT implementation diminished as it went through the chain of command. Each step of the chain would take part of the money, and the money that was left for the operational unit was not sufficient to fully implement the new IT. The final reason for difficult implementation noted during the interviews was the difficulty in retaining qualified personnel in the career field and the Army. A comment was made that it is difficult to train somebody on a new technology if they have to work guard duty and change a tire at the motor pool at the same time. The Army is also having the same difficulty as other services at keeping technically qualified people in the service.

All four of these reasons for poor integration were recognized in the Chapter 2 IT implementation model. The first reason, the change originating outside of the organization, shows that external pressure still exists for the unit to change. The interviewees response that the change did not meet the requirements of the organization shows the change agent did not consider the existing conditions prior to suggesting the change. If the change agent had studied the existing conditions accurately, the change would have better met the requirements of the organization.

The second reason for poor change, the timing of the IT implementation, did not comply with Ines and Simpson's five principles for a successful IT implementation. Ines and Simpson said that the IT should be able to be tried in small, reversible trials prior to implementing it across the organization. Some may say that the new IT was tested in small areas of the Army prior to incorporating it into each GIS field unit. However, each field unit still goes through its own IT implementation stages, and the ability to make small trials must be done for each individual organization implementing the new IT.

The third reason for poor IT implementation, lack of dedicated funding, shows two problems. First, it shows a lack of supervisory support. In the original change message, the supervisors needed to show the users that the new IT was going to last. The supervisors show this by a clear expenditure of funds. If funds are funneled off for other projects, the leadership is saying that other requirements are more important. Second, money is required to purchase and maintain the software and hardware required any IT. Without adequate funding, the new IT can not be fully implemented.

The fourth reason for poor IT integration, difficulty in retaining qualified personnel, definitely affects how well an organization can institutionalize a change. If a unit is constantly changing personnel either through moves within the DOD or separations from the DOD, the unit cannot train the personnel on the new IT. The result is the unit is constantly training new personnel and the change cannot be internalized.

4.4 GIS Unit's Receptiveness to a Joint GIS Program

The final section of the case study was intended to test the potential responsiveness to the idea of a joint GIS program. A presentation about the Air Force's GeoReach program was presented to the same topographic analysts as those who were interviewed during the individual interviews. The purpose of the presentation was to show the technicians the current Air Force GIS capability, and use that capability as a starting point for discussion about the possible integration of capabilities into a joint GIS program that the Army would be able to use. A copy of the PowerPoint slides are included in Appendix F.

The GeoReach presentation began with an explanation of the Air Force's overall GeoBase program and then went into to detail about GeoReach. First, the GeoReach concept of operations (fist locate possible sites, image the sites, assess quality of site, map the sits of interest, enable planners, and transition to a FOL) were reviewed. Next, the differences between Garrison GeoBase and GeoReach were exemplified. Then, the presentation showed the add-on capabilities to the ESRI suite that Air Force has pursued for GeoReach. Both GeoBEST and CAPP were presented by quickly stepping through scenarios using screen shots. Then, the presentation turned to the operation successes of GeoReach during Operation Enduring Freedom and Operation Iraqi Freedom. The final slide of the presentation was a meant to start the group discussion with questions for the audience. The time allowed for the presentation and following discussion was constrained by operational requirements immediately following the discussion.

The initial response to GeoReach was very receptive. The DTSS technicians said that the Air Force's GIS capability seems comparable to theirs. They also liked that the basis for the software is ESRI and ERDAS. The technicians would like to see parts of GeoReach capabilities incorporated into their programs. The technicians were particularly interested in GeoBEST and CAPP. However, they also said that a common geodata type is needed improve the exchange of GIS information between the services. They also recommend that one of the Unified Commands take the lead position on a joint GIS program; TRANSCOM was suggested. However, the group debated without resolution whether TRANSCOM would require and maintain the level of detail needed for an operational commander.

Five additional questions were asked via email after the on-site visit:

1. If a joint GIS program is to be developed, should it be based on an existing program (i.e., DTSS, GeoReach) or created from the ground up?
2. Why is your response to number 1 the best way?
3. Would a joint GIS program bring new capabilities to the DOD?
4. If yes to 3, then what capabilities?
5. What scenarios or issues could be better addressed with a joint GIS program?

Of the responses received to the first question, one respondent thought the program should be built on existing systems such as GeoReach or DTSS because it is more efficient to build and improve on existing models. He also said that the model would need to be tailored to suit the needs of all users at the joint level. The other two responses thought the new program should be built from the ground up. One reason was that this approach would allow the new program to take the best parts of each individual program and combine them for the best possible solution. The other reason given was that each service could include their own part because “each service has good ideas for a GIS and they should all have equal inclusion.”

All three respondents rolled their responses to the third, fourth, and fifth questions into a single response. All three thought a joint GIS program would bring new capabilities to the DOD. One response said, “it would make the analysis and process uniform across the services.” Another respondent said it would bring all the services together around the same data with the same technology, which would allow for quicker response times. The third response said the joint system would have to support all the services, and this would expand the scope of each individual service’s GIS capability. The result could be “more efficient ways to produce special products to meet mission needs by changing current operating procedures.”

5.0 Combined Research Results

The Delphi and case studies had different research questions and looked at different levels of organizations within the DOD; however, the results of these methods have shown several areas of similarities. The largest similarities occurred in benefits from GIS. Both the Delphi experts and case study participants noted that the benefits to using GIS are planning/operational capabilities, visualization and mapping abilities, data gathering and sorting, and time savings. It must be remembered that both groups of research participants were already working within the GIS field, and the participants probably would not have remained in the field if they did not think GIS had several benefits.

Similarities were also found in implementation problems experienced. Both groups of research participants noted that leadership support affected the GIS implementation and usefulness. During the case study, one of the reasons for poor IT integration was diminished funding; and while funding was listed as an implementation problem during the Delphi study, the Delphi experts only ranked funding as the fourth biggest problem out of five.

Two areas that the Delphi experts listed as significant problems that were not found in the case study results were education and training, and cultural and individual resistance. This result is rather surprising since the education and training problems should be most felt by the technicians responsible for GIS. The GIS technicians might not experience cultural or individual resistance to the GIS because they are working within an organization that has already implemented it.

The two groups also had similar thoughts about a joint GIS program. Both groups thought that the DOD could benefit from a joint GIS program. Also, both groups said the benefits could be joint training, a more common data standard, and joint operation planning capabilities. These three benefits were listed second, third, and fourth during the Delphi study. However, the case study participants did not list the Delphi experts' most important benefit of a joint GIS program, an organized focus. This difference is probably because the case study participants are GIS technicians while the Delphi experts are GIS managers.

Looking again at the implementation stage of the Chapter 2 IT model, implementation can be broken down differently based on the Delphi and case study results. Now, the implementation stage can be broken into reasons for more difficult implementations and reasons for smooth implementation as shown in Figure 33. This research identified several reasons why the technology implementation was difficult. The main reasons included limited education of the changing organization, organizational costs, lack of committed leadership and resulting lack of funding, technical problems, incorrect timing, and difficulty in retaining qualified people. A few reasons for smooth implementation were also identified. The three main reasons identified by the participants were subject matter experts inclusion in the change, the organization already continually updates, and the organization was allowed to set up and execute the change itself. As shown in the figure, just having a reason for difficult or smooth implementation will not guarantee a successful implementation. The research participants noted that even though the reasons for difficult implementation did result in a more difficult implementation the technology was still implemented. Similarly, having one of the reasons for a smooth implementation does not mean the implementation will be successful. Other factors, such as the requirement for the new capability is removed, may make the implementation unsuccessful. Finally, only a successful change continues in the model to confirmation. An unsuccessful change can not be confirmed.

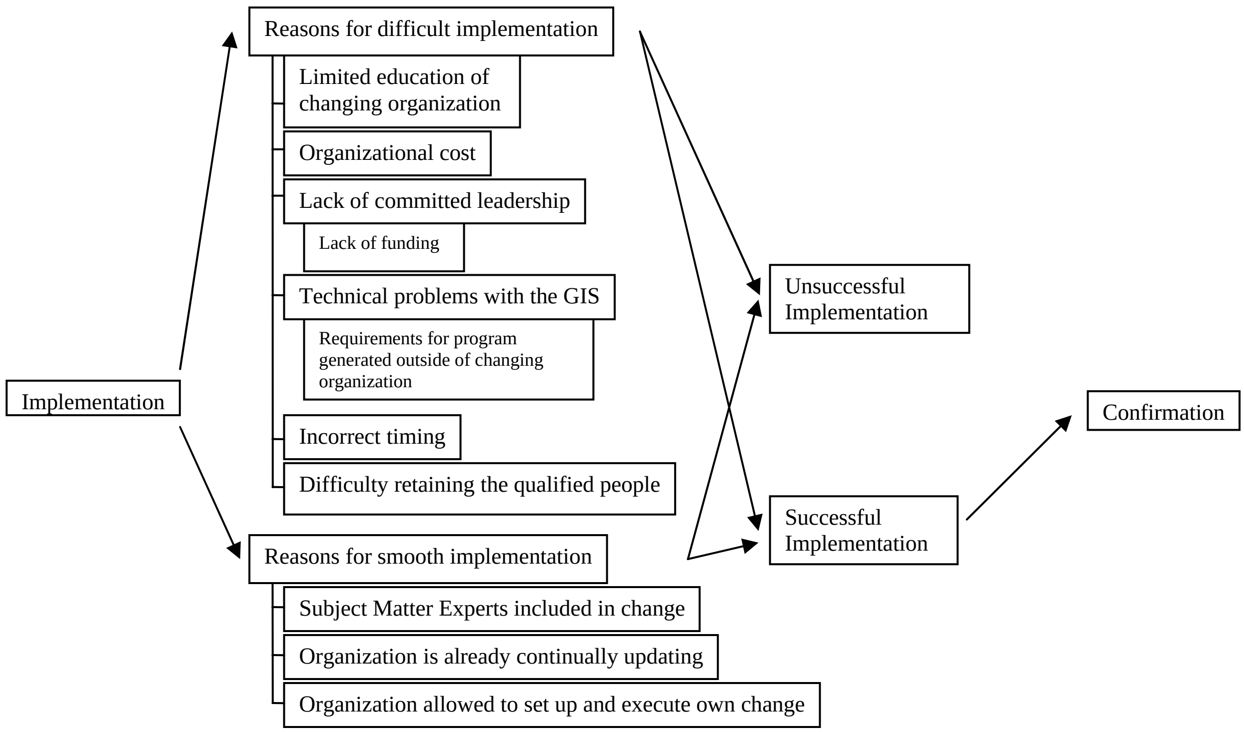


Figure 33. Revised Implementation Stage based on Research

6.0 Summary

In this chapter, the development of the questions for both the Delphi and case study was summarized. Then, the execution of the Delphi study and case study was stepped though. Next, the information gathered from each part of the methodology was analyzed. Finally, the results from both methodologies were compared, and several similarities were found. The conclusions and recommendations are presented in the next chapter.

V. Conclusion

1.0 Summary of Research

This research had two research objectives. The first was to investigate how GIS is currently used in the armed services, highlighting any redundancies or shortfalls. This objective was accomplished during Chapter 2 with the culmination of the summary comparison in Table 5.

The armed services have each chosen to pursue GIS for forward deployment planning and execution in various ways. The Army has DTSS; the Marines have GLIDE; the Navy uses digital nautical charts; and the Air Force has GeoBase. DTSS is focused on the terrain that the soldier on the ground has to cross. Thus, the program looks at large areas of land for maneuverability and the best possible path across it. The program enables a mission commander to know the terrain before setting foot on the battlefield. GLIDE is used to get the Marine on the ground the quickest with the most up-to-date map possible. The program does not include any layers, and is not intended to sort through any data past picking the most current, accurate map. The Navy is using digital nautical charts to navigate ships. This use is unique to the Navy within the armed services; however, it is common among civilian mariners. The Air Force has the most detailed GIS planning method for forward deployment. GeoBase, and more specifically GeoReach, enables the planners to visualize and geospatially plan a new FOL without having to send personnel to the location. Even though each system has a slightly different focus, all a common goal—to consolidate and organize information about possible forward operating locations to improve decision making accuracy.

The second research objective was to investigate the possible desire for, and potential capability improvements from, a joint GIS program. This objective was also accomplished. The Delphi study was used to ask DOD GIS experts their opinions about the current state of GIS in their respective service, GIS information flow within the services and DOD, and then the possibility of a joint GIS program. In combination, the case study was used to investigate a unit currently using GIS for forward deployment operations to determine possible implementation techniques.

The Delphi expert panel consisted of eight GIS experts from across the DOD. The Delphi method used two rounds of electronic questionnaires to investigate how the services are currently using GIS, planned GIS uses, and the potential demand for a joint GIS program. Between the two rounds, the researcher combined the first round responses and added questions based on the inputs of the expert panel. Then, during the second round questionnaire, the experts were able to comment on all the other experts' responses and answer the additional questions.

The Delphi study showed that the services have found GIS useful and cited several benefits including planning/operational capability improvements, visualization and mapping abilities, and data gathering, sorting and flexibility. The panel cited four specific problems with GIS: culture and individual resistance, lack of training and understanding, technological/development problems, and funding. The difficulty of implementing GIS ranged from very easy to very difficult. According to the expert panel, there may be a problem with the cross-flow of information between the services. The expert panel did come to a consensus that a joint GIS program could benefit the

DOD. The panel said that a joint program should have an organized focus, common data standard, joint operation planning and training capabilities.

The case study looked at an individual Army GIS unit. The unit selected was responsible for fielding, training, and updating the DTSS. The unit is part of the Combat Terrain Information System at the US Corps of Engineers Topographic Engineering Center. Five enlisted terrain analysts, the civilian team lead, and two software developers were interviewed for this research.

Based on interviews of personnel from this unit, the Air Force and Army have similar GIS capabilities. However the focus of the GIS differs; the Army is focused on the ground warfighter, and the Air Force is focused on planning for a stationary site for the air warfighter to launch from. As a result, the Army has more overlay programs to the GIS software that look at the terrain. The unit uses a downward-directed method for updates; however, the warfighter gets the update first, and then, the update is diffused back up the chain of command. The participants cited several reasons for good and bad IT implementations. The group was receptive to the idea of a joint GIS program. They said it would need a common geo data format and thought a unified command should manage the joint program.

2.0 Recommendations and Conclusions

From this research, it is clear that each service now uses GIS; however, the level and capability of each service's GIS varies greatly. For example, the Air Force and Army have similar capabilities, both use ESRI software, but have separate add-ons to work over the ESRI suite. However, the exchange of information between the two programs is extremely limited.

The DOD is operating more often in a joint environment. The reason for this increased joint environment is well stated in Joint Vision 2020:

> "The joint force, because of its flexibility and responsiveness, will remain the key to operational success in the future…To build the most effective force for 2020, we must be fully joint: intellectually, operationally, organizationally, doctrinally, and technically" [12].

It is suggested that the planning and execution of the deployments must also become joint. For the services to plan a joint deployment, all the participants should be working from the same knowledge about the location and more specifically the same map of the location. The improved decision making allows for quicker information updates since only one map has to be updated. The view of the entire operation will also be more accurate because every unit's information will be on the same map. As seen during the problems in Operation Allied Force, the services must work together to plan for a joint deployment; otherwise, valuable time could be lost and decisions could be made without the correct knowledge. The Air Force Geo-Integration Office's vision for GIS is to have all participants work from a common map. It is suggested that GIS could also be used to create a common map that all the services could use for a forward deployment operation.

If a joint GIS program was developed, the DOD could use the new capability to improve the speed and accuracy of planning a joint operation and many of the problems seen in Operation Allied Force would be avoided. The NGA would still provide the initial imagery obtained from remote sensing. Then, the joint GIS office would maintain a GIS library that the Unified Commands could access for their individual AORs. Each Unified Command would add additional information to the GIS based on inputs. Then, when a requirement is generated for a new FOL in the AOR, the planners can retrieve information about possible FOLs from the library and access all the information on the given location. This will provide the most complete picture possible to the planners without forcing them to request information from each individual service.

Once the initial list of possible operating locations is created, the joint level planners could use programs such as CAPP, GeoBEST, and BTRA to access the possible joint missions that the FOL could support. Here, FOL expands past a simple airfield. The FOL could be a port to supply forward operations including the terrain crossed from the port to the forward operation. The next step, if possible, is to send individual teams to each location to gather additional information. Since the program is built around joint requirements, only one team would need to be sent to each location to gather all the services' requirements, rather than one team from each service. This efficiency will reduce the number of teams required and decrease the time to compile the information. Then, with a joint GIS program, the information obtained from each site survey team can be organized and reviewed by the planners and senior leadership. Any updates made to the information by one segment of the planning process would then be seen by all the other planning participants in real time. With this rapid information flow, the planners can narrow down the possible FOLs and make recommendations to leadership.

After the joint leadership review and select the FOL based on mission requirements, the planners could begin to plan the specific operations at each location. As seen during this research, GIS would be able to decrease the time required for this detailed planning. However, the joint program would provide an additional benefit in that all the services would be planning on the same map. The individual service requirements would be laid out on a common GIS map that is continually updated. This map would highlight any redundancies and/or space conflicts. For example, the Air Force and the Marine Corps planners could not place an aircraft in the same location on the aircraft parking ramp. With the aid of the GIS and the SIPRNET, the individual participants in the proposed operation can plan and prepare for the operation from their geographically separated locations. The joint program would also aid in establishing a TPFDD for the entire operation based on all the mission needs.

Once the execute order is given, the geographically separated units would deploy forward to the same location. This operational map created from the GIS will show the units exactly where to begin build up operations upon arrival at the location. The individual units will not have to determine the space requirements in the first few days after arrival. Then, the original GIS can be almost continuously updated at the location to create an accurate base map showing base utilities and facilities for future construction or return to the host nation. This forward deployed GIS could be used in combination with BTRA and force protection software to develop a comprehensive base defense plan. This plan would highlight patrol routes and positions key for base defense.

In this research, the Delphi GIS experts and case study's terrain analysts both showed that the desire exists for a more joint GIS program and listed many of these possible benefits from joint a program. The case study showed that GIS units are currently integrating IT changes. However, if the implementation of a joint program was easy, it would have already been accomplished. Each service has a different part of the combat mission, and as a result, the GIS technology has followed that mission, which has resulted in isolated capabilities. For example, BTRA is specifically focused on crossing terrain the quickest. The Army is very concerned about this for combat operations; however, the Air Force is concerned about a specific location for the potential FOL.

For a joint GIS system to be successful, a methodical process must be used to implement the change. The IT implementation model presented in Chapter 2 could provide the framework for just a process. The method used would need a requirements list developed by all the DOD users. As shown by the Delphi responses, the most important requirement of a joint GIS is an organized focus. This does not mean that the same company should be used DOD wide; however, one office should be responsible for coordinating GIS applications. This single point of contact can be a central point of GIS ability and knowledge throughout the DOD. The office would also be able to set data standards for all the DOD. This central office would provide central management of information and data standards. Who funds and controls this office requires further and higher level discussions, but that will be left for future investigation.

For now, each service needs to clearly identify one office that is responsible for GIS applications within its service. The Air Force has already accomplished with its Geo-Integration Office (GIO). The office is responsible for all GIS applications within the Air Force, and members within the Air Force know the GIO is the focal point for new applications. The other services need to follow the Air Force's lead and establish a similar office. Once these offices have been established, the offices can talk between each other for information cross flow. The members of the offices would be able to build stronger interpersonal bonds during GIS conferences and workshops. These offices could then talk at the same level between the services. These service's POC offices could also work to increase the knowledge of other services' capabilities through publications and meetings/conferences. This office would be able to fix one of the current problems found during the case study and Delphi study, a standardized geodata standard. This problem must be corrected if the DOD is going to invest large amounts of money and time into creating a GIS process/program that is going to be relied upon for combat planning.

The potential benefit of increased information flow between the services can not be predicted. However, based on the Delphi experts responses, the case study responses, and the Air Force's success of having all the Air Force participants using the same map in a base beddown during Operation Enduring Freedom and Operation Iraqi Freedom, the benefits to the DOD could be immeasurable.

3.0 Limitations

This research has several limitations. First, this research effort used social science research methodologies, which are not an exact science. Second, the case study was conducted using only one GIS unit. There are numerous GIS units across the DOD and even within the Army, and this one unit was selected to sample those many GIS units. The Delphi study also used a small group. However, the panel members were the GIS experts for their respective services; and therefore, the sample size was sufficient per the Delphi methodology. Third, the participants in both methodologies were GIS users, managers, or technicians; the research did not include joint operational planners or logisticians. However, the Delphi panel members from Headquarters Air Force, EUCOM, and NGA did provide a joint perspective to potential GIS uses. Fourth, the two research methodologies were only used to look at the capabilities of each service; this was not a technical comparison of each service's GIS. Technical problems would have to be identified and worked through for a joint GIS program. Finally, this research did not focus on any one specific level of the deployment planning and execution, which could have identified similar problems between the services at the same operational level. The case study looked at an operational level GIS, not at theater planning or operational execution. The Delphi study included GIS experts at all levels of GIS use. The members included a EUCOM and Joint Staff member and many GIS offices.

4.0 Areas for Future Research

There are several suggested areas of follow-up or related research. First, the services place more importance on joint ability to target and attack locations. This may allow for an interesting comparison between cross-service sharing of joint intelligence/targeting information and how deployment planning and execution information is shared.

Follow-on research could technically compare each service's GIS capabilities. This comparison would require the researcher to have an extensive understanding of GIS applications and software packages. However, this research would better identify areas of redundancy and possible operational benefits among the services.

Other follow-on research could take a logistician and planner look at the same issue of the possible benefits of a joint GIS program. This research looked at the question from a GIS expert and GIS user perspective, not the planners and logisticians. Planners and logisticians would provide a different perspective about the possible use of a joint GIS program and how it should be implemented.

Another area of research would be to look at how to implement a joint GIS program. This research identified that a joint GIS program could benefit the DOD; however, the exact implementation method has not been described. The questions remain who would control and fund the program, and who would set the requirements of the program. This line of research would require an in-depth understanding of the Joint Staff and its operations. There is a possibility that a single joint GIS program is not the answer; but rather, the requirement is best met by a few joint GIS programs that are accessed by each service as required by mission type and location.

During the Delphi study, an expert said that she had excellent support and funding to implement a new GIS program while other experts implementing GIS several years earlier said it was very difficult. This begs the question, is GIS implementation becoming easier? Are commanders understanding the importance and benefits of using GIS and are becoming willing to support GIS implementation?

Finally, it is suggested that anyone wanting to do research about GIS, specifically cross-service GIS uses, should attend the ESRI national conference. The researcher attended the GeoBase conference, which was very informative and provided an opportunity to meet GIS experts who were later used in this research. However, the GeoBase conference did not provide many opportunities to meet other services' GIS experts. Since ESRI software is used by several different services, the conference would provide a chance to meet GIS managers and users from several different services.

Appendix A – Delphi Expert Panel

The members of the Delphi Expert panel that agreed to have their information included in this document are:

SMSgt Pat Abbott, USAF
HQ AFCESA/ CEOF (Force Development)

Maj Wesley D. Baker, NGA (USAF)
National Geospatial Intelligence School
NGA/ TDGH

CDR Brian K. Baldauf, USN
HQ USEUCOM/ ECJ25-PG

Larry C. Baucom, USN
Naval Facilities Engineering Command (NAVFAC HQ)
Director GeoSpatial Systems Integration

Dick Bilden, USN
CADD/GIS Policy Coordinator
NAVFAC HQ
Contributing Editor, Information Systems
The MILITARY ENGINEER magazine

Capt John Kays, USAF
HQ USAF/ ILEX

David P. Knox, USA
Directorate of Simulation, Terrain Simulations, 7th Army Training

Frederick N. Pessaro, Jr., USA
Corps of Engineers, Topographic Engineering Center
CEERD-TS-B

Tobi Sellekaerts, USAF (Contractor)
Geo Integration Offices at RAFs Alconbury, Croughton, and Fairford
422&423&422ABS/CECD

Appendix B – Round One Questionnaire for Delphi Panel

This questionnaire is for an Air Force Institute of Technology graduate thesis research. The questions asked in this questionnaire are for research purposes only and responses are entirely voluntary. Please read the following instructions before filling out this questionnaire electronically.

SURVEY INSTRUCTIONS

1. This questionnaire consists of scaled and open-ended questions.

2. The rating system for the scaled questions ranges from a low of 1 to a high of 5. Please type the selection you feel best reflects your opinion in the space provided. If you would like to provide additional comments, just type them below the question.

3. Each of the open-ended questions has space provided for your reply. If there is insufficient room, continue typing; the space will expand to fit your full response.

4. At the end of the questionnaire, you are given an opportunity to provide additional comments or suggest questions that should be included in the next questionnaire.

5. Participants' specific responses will be treated anonymously. However, each participant's name, organization, and contact information will be included in a list of contributors unless he/she desires to be excluded. **Please identify below if you do not wish to be included**.
   I_ _ __**(do/do not)** wish to be included on the list of contributors.

6. If you would like to be included in the list of participants, please fill out the optional "Participant Information" section below.

7. Please save the completed questionnaire as an MS Word document and e-mail it back to me at Matthew.Beverly@AFIT.edu by _____. If you have any questions, please contact me at my AFIT email account or at home at 937-431-1478. Since I am a student, I do not have a dedicated phone; however, if you email me, I can call you back via DSN.

PARTICIPANT INFORMATION (**OPTIONAL**)

Participant Name ____
Participant Organization_________________________
Office Symbol_________________________
Service_________________________
Phone Number: DSN__________ Commercial ______________

Background Information
1. How many years have you been using GIS? -
2. What other organizations have you worked with, i.e., military organizations, contractor, or civilian? -
3. What is the highest level of education you have achieved (i.e., BS, MS, PhD) and identify your area(s) of study? -
Organizational GIS Implementation and Use
4. How useful has GIS been in your service for forward deployment planning and execution (1 - not useful, 5 - very useful)? -
5. How long has your organization and service been using GIS? - Service: - Organization:
6. How long has your service been using GIS for forward deployment planning? -
7. How difficult has the implementation of GIS technology been in your service (1 - very easy, 5 - very difficult)? -
8. How does your service use GIS for forward deployment (basic map capabilities, planning, etc)? -
9. What are the three most beneficial results you have seen from using GIS? a. b. c.
10. What are the three greatest problems you have seen with GIS in your area? a. b. c.
11. What new applications does your organization have planned for GIS? -

Possible Future Joint Uses for GIS
12. How would you rank the cross-flow of GIS information between the services (1 - very poor, 5 - very good)? -
13. What type of problems have you encountered with cross-flow of information between the services? -
14. How useful do you think a joint GIS would be (1 - not very useful, 5 - very useful)? -
15. What capabilities would you require from a joint GIS program? -
16. What new capabilities do you think a joint GIS program would bring to the DOD? -
Comments and/or questions that should be asked in the next questionnaire:

Appendix C – Round Two Questionnaire with Responses

This is the second of two questionnaires for an Air Force Institute of Technology graduate thesis research. This questionnaire includes the responses from round 1 (the previous questionnaire), follow-up questions, and entirely new questions. All questions asked in this questionnaire are for research purposes only and responses are entirely voluntary. This research has been declared exempt from human subject research requirements by AFRL/HEH.

SURVEY INSTRUCTIONS

1. The following questionnaire includes the combined round 1 responses, eight new questions, three rank order questions, and one rating question.

2. Please review the round 1 responses for correctness, completeness, and for any additional information that should be included. As before, a comment area is provided with each question and at the end of the questionnaire. Any and all comments will be appreciated.

3. For rank order questions (questions 10b, 11b, and 17b), you are given a list of broad categories from the round 1 responses to the question. In the space provided to the left of the categories, place the order number that you think best represents the categories importance. Please do not rank each individual response in the category. You may make specific comments and/or additions to the individual responses in the comment section.

4. For question 15b, you are asked to rate each category based on how often you have experienced each problem. For this question use the 1 to 5 rating system.

5. Each of the open-ended questions has space provided for your reply. If there is insufficient room, continue typing; the space will expand to fit your full response.

6. At the end of the questionnaire, you are given an opportunity to provide additional comments or suggest questions that should be included in the next questionnaire.

As with the round 1 questionnaire, please save the completed questionnaire as an MS Word document and e-mail it back to me at Matthew.Beverly@AFIT.edu by 12 Dec. If you have any questions, please contact me at my AFIT email account or at home at 937-431-1478. Since I am a student, I do not have a dedicated phone; however, if you email me, I can call you back via DSN.

After I have all the round 2 responses, I will compile them into one document. I will send the final responses back to you with a list of research participants who have agreed to have their names included in the research. **If you would like an electronic copy of the final thesis, please let me know.**

Background Information

1. Round 1 Question: How many years have you been using GIS?

2-15 years. [This is GIS use only. Responses did not include time spent in the surveying field or other areas related to GIS]

2. Round 1 Question: What other organizations have you worked with, i.e., military organizations, contractor, or civilian?

Round 1 Responses:
The combined responses cover all the armed services and include Joint level coordination efforts. The government agencies mentioned by name were: HAFCIO, HAFGIO, USACE, USGS, DHS, USCG, NOAA, HQ PACAF, US Army Topographic Engineer (26 years), Directorate of Simulations (Terrain Simulations, 7th Army Training Command), AFC2ISR Center, ACC/CEX, Checkmate, OEF CFACC Staff, AF/ILEX

Also, the responses covered several contractors. The contractors mentioned by name were:
ESRI
Trimble
AutoDesk
Intergraph
Booz Allen Hamilton
Cubic Technical Services
Logicon Technical Services
Northrop Grumman Technical Services

Round 2 Comments:
Other contractors I've worked with include Titan Corporation, CH2MHill, Montgomery Watson Howza (UK company). Military include AFCESA. Recommend adding NIMA (with the signing of the FY2004 Defense Authorization Bill, NIMA officially became the National Geospatial-Intelligence Agency (NGA)

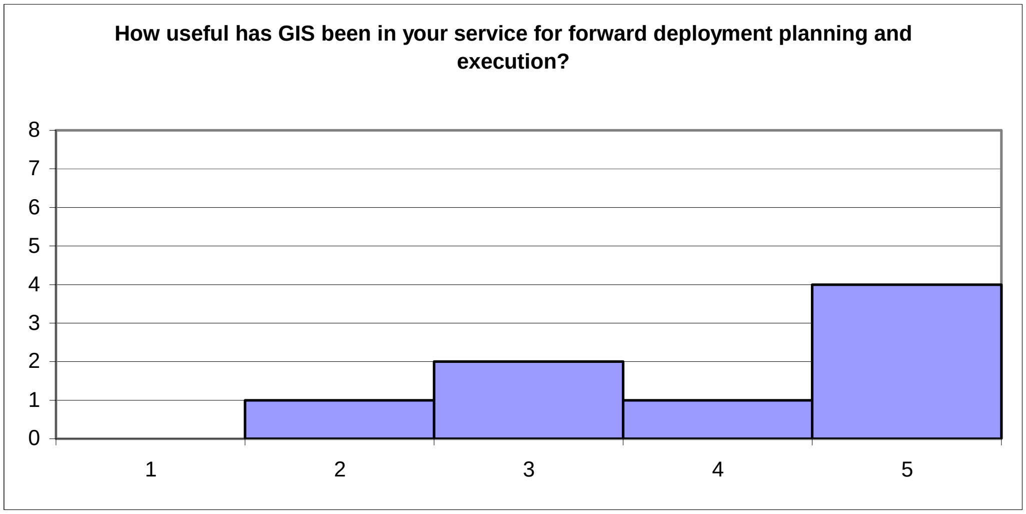
3. Round 1 Question: What is the highest level of education you have achieved (i.e., BS, MS, PhD) and identify your area(s) of study?

Round 1 Responses:
The responses included an engineering associates degree, a BA working towards an MA, three BSs , and three MSs

Organizational GIS Implementation and Use

4a. Round 1 question: How useful has GIS been in your service for forward deployment planning and execution (1 - not useful, 5 - very useful)?

Round 1 Responses:
The following chart shows the combined responses to this question. The x-axis represents the possible responses (1-not useful, 5- very useful), and the y-axis is the count of responses. For example with this question, four people responded saying GIS has been very useful within their service for forward deployment planning. This same graphical layout is used to show responses to later questions.



Round 1 Comments:
- Needs wider use beyond headquarters
- 5 when data is available

Analysis: From these responses, it appears that GIS has been useful/very useful in many parts of the DOD. However, this high usefulness is not across the entire DOD.

4b. NEW QUESTION for Round 2: Why has GIS use not had the same level of usefulness across the DOD?

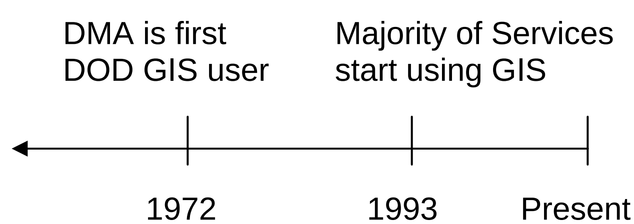
Round 2 Responses

- Have you evaluated the background of your responders? Just because a CE dude says GIS hasn't been useful to the Army doesn't mean it hasn't been useful for an infantry troop… To different specialties it may have been useful in varying degrees across the DoD
- The level of usefulness is directly proportional to the level of data availability!
- Can be costly and some folks don't want to pay for the additional capability it provides. 2. GIS has come a long way in the last few years; some aversion to GIS from past users because it was more difficult to use 5-10 years ago
- Differing levels of acceptance and funding
- Education, Lack of Exposure, Lack of Understanding. If more people were informed and educated on the power of GIS then I think you would find the level of usefulness increasing exponentially across the DOD
- Different mission focus. Navy doesn't beddown aircraft. We bring our own airport.
- Lack of Executive Level education as to its utility. 2. Looked upon as a techie thing vice a knowledge management – command and control tool

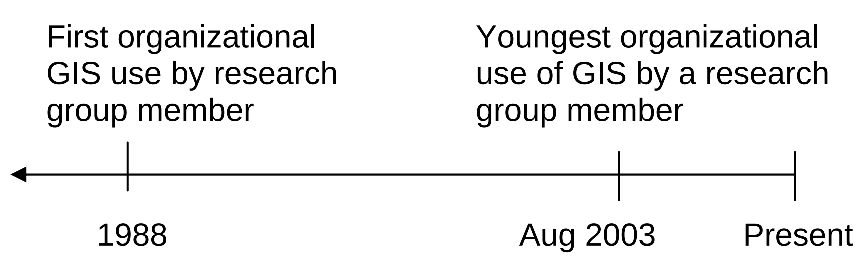
5. Round 1 question: How long has your organization and service been using GIS?

Round 1 Responses Combined:

Service GIS use:



Organization use:



6. Round 1 Question: How long has your service been using GIS for forward deployment planning?

Round 1 Responses:

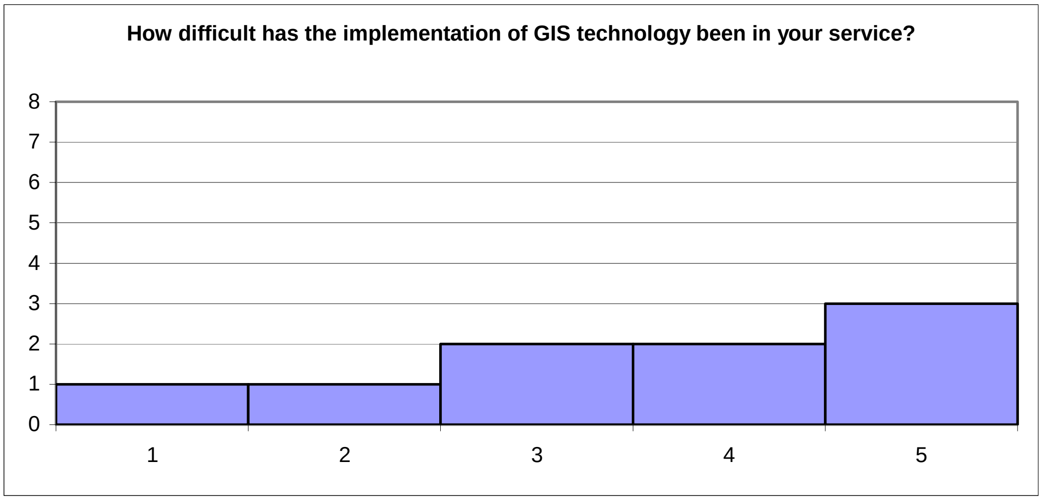
- Here the responses varied greatly. DMA started accomplishing GIS studies in the 1980's. The Army started around the time of Desert Shield/ Storm (1991). The other services seem to have only begun using GIS for forward deployment planning in the last 4 or 5 years.

Round 2 Comments:

- We used GIS at the USAF Ballistic Missile Office in the mid 80s for ICBM basing decisions, and would have used it for operations of Peacekeeper Rail Garrison program, had it not been cancelled.
- Not necessarily so – see Navy Facilities chronology

7a. Round 1 Question: How difficult has the implementation of GIS technology been in your service (1 - very easy, 5 - very difficult)?

The chart below shows the responses.



Round 1 Comment:
- 1 (well supported with both dollars and equipment by HQ, lots of support at all of my installations)

Round 1 Analysis: The responses show that difficulty in implementing GIS differs in the DOD. The "1" responder is also the responder who is starting up the GIS capability for the past 3 months.

7b. NEW QUESTION for Round 2: Why could some organizations be finding GIS implementation easier than others?

Round 2 Responses:

- Education
- The services do not do a very good job with GIS training. Leaders often assume vendors will do the training on commercial data even though commercial data does not resemble military data sets. Also, new GIS organizations do not know that NGA provides GIS training.
- Executive education and support.
- Organizational Costs
- Funding
- Manning
- Service priorities for funding (need to have vs. nice to have)
- Return on investment—need to produce results
- Leadership
- commander emphasis and vision
- Different Leadership—those that see the technology helping them meet capabilities tend to embrace it.
- High level support is needed to ease implementation
- Goes back to Executive Level Education and “what’s in it for me?”
- Data availability! Forwardly deployed units do not have time to create their own data!

8. Round 1 Question: How does your service use GIS for forward deployment (basic map capabilities, planning, etc)?

Round 1 Responses:

- Planning at HQ level
- USAF now uses GIS as part of its Expeditionary GeoBase process to select deployment sites, implement deployment ops, and transition to operational status. NIMA uses GIS for Geospatial Intelligence analysis over potential hotspots globally.
- Firewire drives, web based support, custom products, standard and non-standard NIMA products, foreign produced products and maps
- Battlespace management and navigation (digital nautical charts)
- GIS allows for web-enabled map sharing for collaborative planning. Additionally, GIS facilitates visualization--fuses imagery, mapping, and data.
- Planning graphics, basic map capabilities, relief and shaded elevation, line of sight, the full range of Tactical Decision Aids. In the pure sense the greater Army does not use the full range of GIS capabilities, there is a lack of understanding and a lack of clear course of action to fully implement GIS across the service.
- all functions or facets of Army operations

Round 1 Analysis: Of particular interest are the last two responses, which are underlined, because there seems to be some disagreement about how much the Army has integrated GIS across the service.

Round 2 Comment:
The last two comments don't necessarily disagree. Yes, to SOME extent GIS is used across 'all functions or facets of Army operations'. However, 'the Army does not use the full range of GIS capabilities' in that the GIS that IS used is very outdated, newer technologies are not being used across the service. Some facets of Army GIS use (modeling & simulation) are far more advanced than others. This is somewhat true in the USAF as well; the GeoBase program is really using very simple GIS as far as current research is concerned. GeoBase is doing easy things, but doing them very well and with much top level support.

9. NEW QUESTION for Round 2: If your service has used GIS for forward deployment planning or operating, please provide an operational example.

Round 2 Responses:

- All I have are classified. Sorry.
- I can write a book here. Most recent example--CSAF's briefing team requested graphics showing the "lay of the land" at deployed Iraqi sites. Appears stemming from CSAF's days as the CENTAF/CC and the Khobar Towers bombing. ACC/CE provided graphics showing the locations of AF industrial and housing areas for CSAF. Posted to the web. Can be done with imagery and CAD data as well, but GIS currently allows picture and drill-down capability on web
- GeoReach at HQ PACAF: supported OEF extensively. A. As 2001 was still early in the evolvement of GeoReach, so there was only one GeoReach server online (SIPRNET) on Sept. 11th, carrying the full weight of all forward operating airfield data for approx. 2 months. Data from server used for forward planning by HAF, ACC, and PACAF staffs. B. Forward deployed engineers gathered geospatial data over airfields and sent that information back to HQ for posting on the GeoReach server.
- GeoReach data used to plan airfield use for potential non-combatant evacuation operations.
- Talk to the USAF GeoBase program folks. They've used GeoBase for go/no-go basing decisions for OEF and OIF.
- Service – GeoReach and Intel; AFCESA ROC – Deployment planning and support with a visualization of the forward locations.
- JTF Liberia : Actually here at EUCOM we use GIS for all operational planning. We provide direct support to the warfighters via our web based map services that was developed here at EUCOM.

Navy contingency (SEABEE) planners now talking with GeoBase / GeoReach

10a. Round 1 Question: What are the three most beneficial results you have seen from using GIS? Your responses have been combined into the 8 broad categories below.

Round 1 Responses are under the categorized headings

10b. Round 2 Question: RANK ROUND 1 RESPONSE CATEGORIES: Rank order the following categorized list of benefits by placing the number 1 through 8 in each of the boxes to the left of each category, with 1 being most important and 8 being least important. Please only rank the categories, not the bulleted responses. (1-most important benefit, 8-least important).

	Planning/ Operational Capabilities - GIS allows for web-enabled map sharing for collaborative planning - Increased acceptance of Civil Engineer's role in bed down - Wider use of predeployment information – STEP, GeoReach and BSP - Analysis based on fact, rather than conjecture or ancient maps and charts, word of mouth, etc. Decision makers respond instinctively to GIS produced analyses as being more credible than traditional manual planning processes. - You can use GIS to get a good understanding of denied areas, through data collected by remote sensing and other sources. - Battlespace situational awareness *1,1, 2 ,1, 2, 2, 1, 1 (These are the rank ordered responses from Round 2 which are graphed at the end of this question)*
	Visualization and mapping abilities - GIS facilitates visualization--fuses imagery, mapping, and data. - Custom product development from digital data (specific products are now tailored to meet specific warfighter needs) - Digital nautical charts - Enabling better installation visualization by enabling access to the CIP. *3,2, 3 ,2, 4, 1, 4, 2*
	Software Applications - GIS is COTS--Industry leads development - ARC GIS software applications - Ease of use *7,4, 1, 3, 7, 5, 6, 6*
	Data gathering, sorting, and flexibility - GIS allows you to work with almost any kind of data in a new spatial framework. Now you can marry up huge collections of raw facts about features with accurate spatial reference. - Compatibility with civilian generated data - Ability to generate your own data if necessary - Digital data *2, 5, 5, 3, 3, 5, 4*

	Time Savings - Reduction of time spent by engineer assistants career field on tasks such as map production and copying – users are able to access the CIP via the intranet and fulfill their requirements from there. *6, 6, 4, 1, 4, 2, 5*
	Employment Opportunities - Jobs for starving recent Geography graduates. *8, 8, 8, 8, 6, 8, 8*
	Range management/ facilities management *4,7, 7, 5, 7, 3, 3*
	Better access to GPS *5, 3, 6, 6, 8, 7, 7*

Round 2 Comments:

"Jobs for starving…" was a joke but legitimately you are giving real-world GIS skills to active duty soldiers who need skills for jobs once they separate or retire.
Above is a mix of apples and oranges – shows that many of your respondents are still approaching GIS from a techie point of view vice an operational perspective

Greatest Benefit of GIS (Rank Order)

Category	1	2	3	* 4	5	6	7	8	Total # of Responses	Mean	Median	Mode	SD	Range
Planning/ Operational Capabilities	1	1	2	1	2	2	1	1	8	1.38	1	1	0.52	1
Visualization and Mapping Abilities	3	2	3	2	4	1	4	2	8	2.63	2.5	2	1.06	3
Software Applications	7	4	1	3	7	5	6	6	8	4.88	5.5	7	2.10	6
Data Gathering, Sorting, and Flexibility	2	5	5		3	3	5	4	7	3.86	4	5	1.21	3
Time Savings	6	6	4		1	4	2	5	7	4.00	4	6	1.91	5
Employment Opportunities	8	8	8		8	6	8	8	7	7.71	8	8	0.76	2
Range Management/ Facilities Management	4	7	7		5	7	3	3	7	5.14	5	7	1.86	4
Better Access to GPS	5	3	6		6	8	7	7	7	6.00	6	6	1.63	5

* This expert only ranked the top three benefits

11a. Round 1 question: "What are the three greatest problems you have seen with GIS in your area?" Again, I have combined your responses into five categories. Round 1 Responses are under the categorized headings **11b. Round 2 Question: RANK ROUND 1 RESPONSE CATEGORIES: Rank order the following categorized list of problems by placing the number 1 through 5 in each of the boxes to the left of each category, with 1 being the greatest problem and 5 being the smallest problem.** (1- greatest problem, 5- smallest problem).	
	Education and training (listed by five panel members) - GIS is hard. Too many supervisors think you can buy a copy of ArcView, send a guy to a two-week class, and be fully GIS proficient. - non user friendly - "use it or loose it" software skills - Lack of understanding of what GIS it's capabilities. - You need to be GIS-smart to manipulate the data (e.g. add points, lines, and polygons, or imbed information) *2, 3, 2, 1, 4, 2, 4, 1 (Round 2 Responses)*
	Culture and Individual Resistance - Acceptance from field - lack of executive support - To many rice bowls, everybody is doing their own thing, no standardization in terms of products or programs. - Resistance from contractors doing work on the installation to provide as-builts (at all, or in any kind of geospatial format). - Resistance from CIP users who are accustomed to having engineering assistants do map production and copying for them as we attempt to transition the users to partial or full self-sufficiency. - Attitude of Civil Engineers who feel that GeoBase is not their 'deal' or responsibility; also seeing GIS as a 'free' gift from HQ that they do not need to invest in (with financial and/or human resources). *1, 1, 3, 2, 1, 3, 1, 2*
	Funding (listed by three panel members): NIMA, DIA, [Unified] Commands don't want to fund GI&S hardware/software applications and web based development Can get relatively expensive with software upgrades and having to hire contractor support. 4, 5, 4, 2, 1, 3, 4
	Technological/ Development problems: - Lack of data (listed twice): GIS is sometimes oversold by people who have no idea how much work is required to build high-resolution data sets. - slow map refresh - complexity of the software - Managing GI&S data. So much is produced and it's difficult to keep track of everything that is out there

	- Developing systems that are acceptable in a Combined environment, sharing data on systems with coalition partners in a warfighting environment (i.e. LOCE, system used in USFK (forgot the name??)) *5, 2, 1, 3, 3, 4, 2, 5*
	Other Problems: - Bad analysis is not always obvious. People can make a great looking product out of worthless data, and unsuspecting decision makers will fall for it. - Lack of a definitive approach for implementation of GIS across the service and within DoD. *3, 4, 5, 5, 5, 5, 3*

Round 2 Comments:

- I would rename "Technological/ Development problems" to 'Lack of quality data'. There aren't many technological / development problems, but there ARE many misunderstandings about lack of quality data.
- Education vice Training issue. You need to educate the managers. All else follows.

Greatest Problems with GIS (Rank Order)

Category	1	2	3	* 4	5	6	7	8	Total # of Responses	Mean	Median	Mode	SD	Range
Education and training	2	3	2	1	4	2	4	1	8	2.38	2	2	1.19	3
Culture and Individual Resistance	1	1	3	2	1	3	1	2	8	1.75	1.5	1	0.89	2
Funding	4	5	4		2	1	3	4	7	3.29	4	4	1.38	4
Technological/ Development Problems	5	2	1	3	3	4	2	5	8	3.13	3	5	1.46	4
Other	3	4	5		5	5	5	2	7	4.14	5	5	1.21	3

* This expert only ranked the top three benefits

12a. Round 1 question: What new applications does your organization have planned for GIS?
Round 1 Responses:
Army:

- My organization builds and maintains large terrain databases used in support of the Army simulations community. We are moving to web based map server and making a significant investment in database technology to support our future growth.
- Creation of Army standard products.

Navy: Strategic repository/ portal to spatial data….. a Navy Spatial Data Inventory
Air Force:

- Integrated Pavements Eval tool
- Very young program; right now just trying to get off the ground. No new apps are currently planned by my installations. We are currently using applications to track vertical obstructions (AIROBS), and calculate QD Arcs (ASHS). NOTE: However, HQ USAFE is developing a tank tracking application (i.e. utility tanks), asbestos data tracking & viewing application, and electronic Base General Plan.)
- Looking to use GIS for Expeditionary Site Planning (includes GeoReach)

EUCOM: I have procured (with Unfunded Requirements) 4 servers, 4 TB SAN and ARC GIS software applications and ARC SDE. We are building a theater wide web based mapping capability. *http://maps.eucom.smil.mil*

Joint Staff developing Joint Engineer Planning and Execution System which will likely include GIS for airfield and port visualization

NIMA is working with civil authorities to develop a common GIS for homeland security

Homeland Defense is looking to use GIS for among other things, mapping air bases for Force Protection

12b. NEW QUESTION for Round 2: Could any of the applications being developed by another organization benefit your service?
Round 2 Responses:

- In the facilities management arena, there is already a good joint development program for GIS apps, such as GEOBEST.
- Map server and inventory
- AF Installation database (for planning), USMC/NAVY Beach and hydro info
- Yes. NGA's work with airfields in GIS, Intel Community's work for Red Order items.
- C2 programs should be standardized across all the services; in a joint environment the various services could 'plug-in' their component to the overall C2 system.
- Yes. I'm sure there are lots of applications being developed that could be integrated into our architecture. I find that now as we are gaining more exposure other organizations are calling on us to integrate our geospatial data

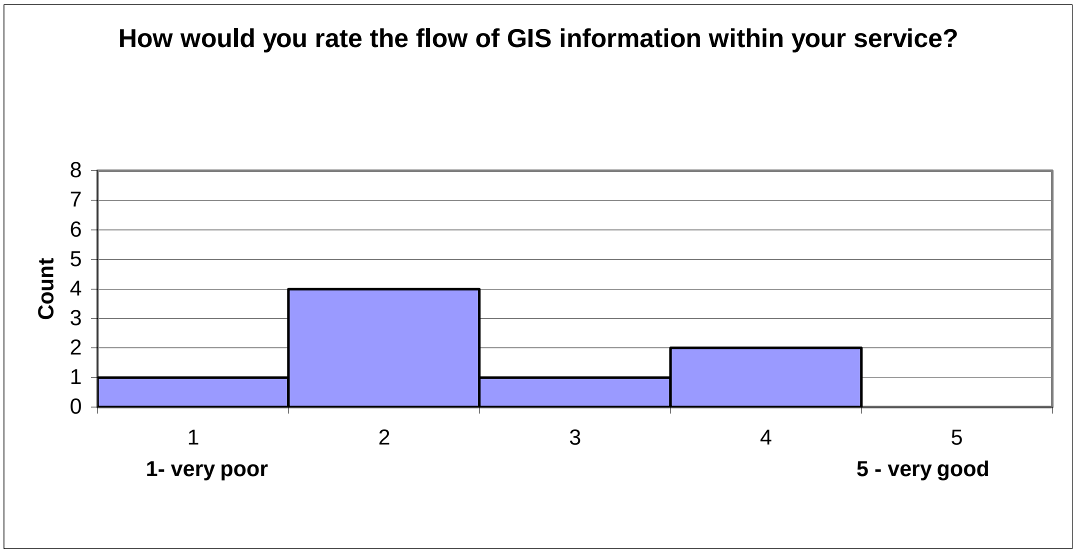
into their applications.
- Certainly. Coordination/collaboration a must
- Not so much a question of applications in the software sense, but one of policy and joint program coordination. There has been considerable progress in this direction for Homeland Security "applications" and the OSD IVT which is being driven by BRAC 2005

Possible Future Joint Uses for GIS

13. NEW QUESTION for Round 2: How would you rate the flow of GIS information within your service (1- very poor, 5 - very good)? This question has been added to help distinguish if GIS information flow is just a problem between services or is also a problem within each service.

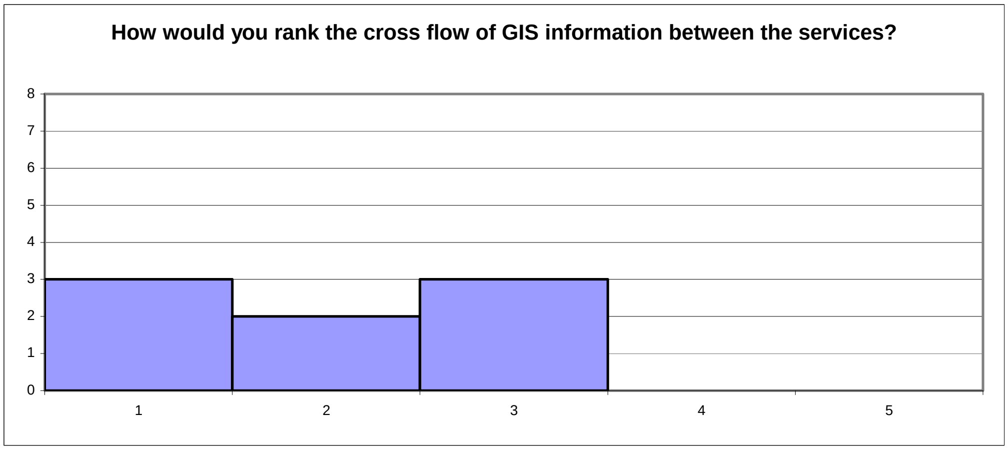
Round 2 Responses:

- Comments: I'd say the USAF is doing a pretty good job of flowing GIS data around to the proper organizations within the GeoBase world. On the intelligence side, I think the USAF is doing pretty well too.
- 1, functionally we are not sharing information very well. i.e., XO, CE, CS
- poor
- Getting better with more intro to GeoX in classes.
- 2 within the USAF; 4 within Civil Engineering
- 2
- 2, Just getting started on enterprise network. Not yet mature
- A year ago – 2; today 4



14. Round 1 Question: How would you rank the cross flow of GIS information between the services (1 - very poor, 5 - very good)?

Round 1 Responses are summarized in the table.



Round 1 Analysis: The responses seem to indicate there is a problem with the cross flow of information between the services.

Round 2 Comment: Common among a non-Purple world.

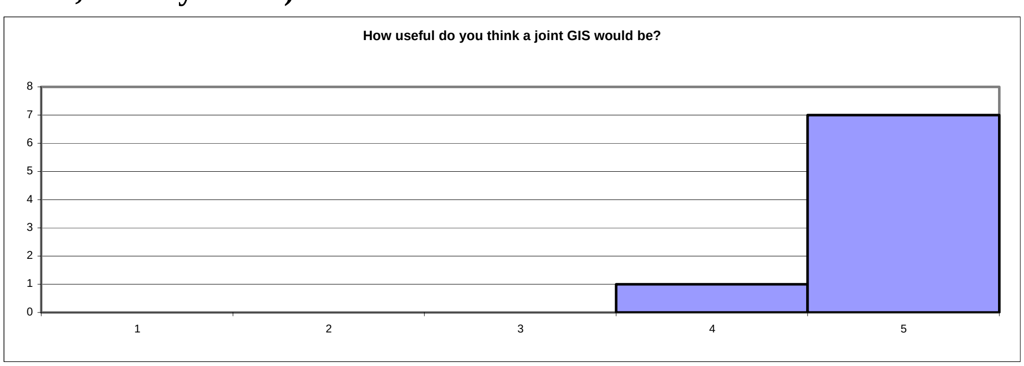
15a. Round 1 Question: "What type of problems have you encountered with cross flow of information between the services?" The responses seemed to fit into 8 general areas. 15b. Round 2 Question: **RATE ROUND 1 RESPONSE CATEGORIES: Rate the following categorized lists of information cross flow problems based on your experiences. Place the number 1 through 5 in each of the boxes to the left of each category, with 1 being the greatest problem and 5 being the smallest problem. (1-very rarely, 5- very frequently).**	
	Knowing who to contact- *5, 5, 2, 5, 3, 5, 4 (Round 2 Responses)*
	No agreed-to standards. The SDS/FIE data model is a good start, but as far as I know, only the USAF really produces data based on it. "do your own thing" with no standards- *3, 3, 1, 2, 2, 4, 5* Round 2 Comment: WRONG – NAVY HAS DEFINED AS POLICY SINCE 1999 AND IMPLEMENTED ACROSS THE BOARD
	Identifying what data and products are available. There is a lot of production going on out there and keeping track of who's produced what is overwhelming. Developing Metadata services is critical in keeping a handle on all that is available. Metadata schema is critical for sharing of data and products and assisting the warfighter in finding the best GI&S data to assist them in mission success- *4, 3, 3, 3, 2, 3, 1*
	Culture- *3, 3, 5, 2, 1, 1*
	Huge differences in mission, data, and GIS product terminology; data classification; 'established' procedures for data use; entrenched established formats for data and products.-*3, 5, 4, 1, 1, 3, 4, 2*
	BIG contractors who manage and develop (and essentially own) software applications remove the (usually) enlisted GIS 'operators' from the underlying technology and knowledge of GIS.- *2, 1, 6, 4, 5, 3*
	These big applications are essentially compartmentalized, preventing cross-service discussion. JMTK is an effort to combat this, but more work needs to be done.-*2, 5, 8, 2, 4, 4, 3, 2*
	Lack of understanding across DoD about the of GIS products available, the reluctance of each of the services to look at the progress being made in the GIS community by the other services and leveraging success. - Somewhat stove-piped. Don't get to always see what the other services are doing.-*5, 4, 7, 3, 3, 2, 4*

Problems with cross flow of information (Frequency Expert Encountered)

Category	1	2	* 3	* 4	* 5	6	7	8	Total # of Responses	Mean	Median	Mode	SD	Range
Knowing who to contact	5	5	2		5	2	5	4	5	4.20	5	5	1.30	3
No agreed to standard	3	3	1		2	2	4	5	5	3.40	3	3	1.14	3
Identifying what data and products are available	4	3	3		3	2	3	1	5	2.60	3	3	1.14	3
Culture	3	3	5			2	1	1	5	2.00	2	3	1.00	2
Huge differences in mission, data, and GIS product terminology	3	5	4	1	1	3	4	2	5	3.40	3	3	1.14	3
Big contractors developing own software	2	1	6			4	5	3	5	3.00	3	-	1.58	4
Compartmentalized applications	2	5	8	2	4	4	3	2	5	3.20	3	2	1.30	3
Lack of understanding across the DOD about GIS products available	5	4	7	3		3	2	4	5	3.60	4	4	1.14	3

* These three experts ranked the categories rather than rate. Thus, their responses were not considered for this question

16. Round 1 Question: How useful do you think a joint GIS would be (1 - not very useful, 5 - very useful)?



Round 1 Analysis: From the responses, it appears that the consensus is that a joint GIS program could be useful to all parts of the DOD.

Round 2 Comments:

- Joint GIS development ought to be NGA's responsibility.
- Much more important now that we are MANADATED to a common C2 venue for National, Federal and Civilian Emergency Response.
- Agree

17a. Round 1 Question: "What capabilities would you require from a joint GIS program?" Again, I have combined the responses into 6 general categories.

17b. Round 2 Question: RANK ROUND 1 RESPONSE CATEGORIES: Rank order the following categorized list of capabilities by placing the number 1 through 6 in each of the boxes to the left of each category, with 1 being the most important capability and 6 being the least important capability.
(1- most important, 6-least important)

	Common Data Standard - Geospatial Data Standard for all DOD organization - Enforce common data standards and develop a common enterprise architecture that will embrace what each service is doing rather than maintain the stovepipe approach. - Standardization of data formats, storage and access and visualization methodology, software (yes, probably would end up as a monopoly by ESRI), products, terminology - Needs to be developed and built on the same software application. All services need to adopt or buy into the ESRI solution. It's the best on the market today. Round 2 Responses: WE ALREADY HAVE A CONTENT STANDARD FOR FACILITIES, INFRASTRUCTURE AND ENVIRIONEMT – THE SDSFIE ; IT'S BEING ENHANCED FOR HOMELAND SECURITY AND THE NIMA HOMELAND SECURITY INFRASTRUCTURE PROJECT (MINIMUM ESSENTIAL DATA SETS FOR THE 133 CITIES INITIATIVE) Again, a techie point of view *3, 1, 1, 2, 1, 6, 6 (Round 2 Responses)*
	Joint Training - Joint training program for all levels of users - A consistent level and delivery method of education to the (usually) enlisted GIS 'operators' across all the services, also standard list of skill sets for those operators. [Pie in the sky dream would be for there to be GIS people in just one of the services who are shared amongst the others, same goes for GPS people.] *2, 5, 3, 3, 4, 2, 4, 3*

	A organized joint focus - Focus. GIS is already applied to everything from combat ops to facility management. The first the joint world needs is a DoD equivalent of the USAF GeoBase program [Not an AF member]. - Define 'who's in charge' - 'Who pays?' *1, 2, 2, 1tie, 1, 3, 2, 2*
	Joint Operation Planning Capability - Integrated planning…all reading off the same sheet of music Joint Beddown, Executive decision support - Mission oriented decision support *5, 3, 4, 1tie, 3, 4, 1, 1*
	A single point of access to the data library that houses quality data! *4, 6, 5, 5, 5, 5, 4*
	Relevant layer query capability *6, 4, 6, 6, 3, 5, 6*

Capabilities Required in a Joint GIS program (Rank Order)

Category	1	2	3	* 4	5	6	7	8	Total # of Responses	Mean	Median	Mode	SD	Range
Common Data Standard	3	1	1		2	1	6	6	7	2.86	2	1	2.27	5
Joint Training	2	5	3	3	4	2	4	3	8	3.25	3	3	1.04	3
A organized focus	1	2	2	1	1	3	2	2	8	1.75	2	2	0.71	2
Joint Operation Planning Capability	5	3	4	1	3	3	2	2	8	2.88	3	3	1.25	4
Single Point of access to the data library that houses quality data	4	6	5		5	5	5	4	7	4.86	5	5	0.69	2
Relevant layer query capability	6	4	6		6	6	3	5	7	5.14	6	6	1.21	3

* This expert only ranked the top three benefits

17c. NEW QUESTION for Round 2: Is it necessary to only use one software company to create a common data standard?

Round 2 Responses:

- Absolutely not. SDS/FIE is a good example: You can use SDS formatted data in practically any GIS or CAD package.
- No – HOWEVER the USAF has fielded ESRI and Autodesk to the Engineering schoolhouse, contingency training venues and the Prime BEEF teams. That is all we can support as a career field.
- No, not if it is a new data standard.
- No, proven by flexibility of SDSFIE which supports AutoCAD, ESRI, Integraph, etc
- not necessarily; NGA needs to build the standard and software companies would then build applications to meet the NGA approved and established standards. NGA is not making any progress in getting the standard established so companies are running in their own direction
- No.
- No. The industry has already solved that problem

18a. Round 1 Question: What new capabilities do you think a joint GIS program would bring to the DoD?

Round 1 Responses:

- Cross flow of info
- Rational decision making, vs. emotional knee-jerk reaction. Especially in the BRAC process
- Better management of GI&S data, better display of data and most importantly it would bring GI&S together and eliminate a lot of the stovepipe activity that is currently going on across the services and commands using GI&S applications and data
- Joint enterprise range management
- Joint facilities management
- Joint asset requirements generation – avoid duplication
- A focus to develop a common operating picture across the DoD based on common terrain data.
- standardization of algorithms
- standardization of data structures/layers
- DOD contract for COTS GIS software
- Time and money savings from the reduction of: a) time spent on training and re-training, b) efforts to convert data into the formats and products required by each service (FFD is an effort to do this but again more work is needed)

18b. NEW QUESTION for Round 2: Do you think a joint GIS program would bring all these benefits to the DOD?

Round 2 Responses:

- No, A GIS will not change human nature
- Not right away. There's a huge diversity of GIS uses, data etc. It will be long time before DoD can get a grip on that.
- Not right away. Would help facilitate the culture shift necessary to achieve these benefits in the long term.
- If done properly, but unlikely to actually occur
- Most benefits
- Yes, given new data standards and standard data manipulation procedures
- YES
- Yes – we're working towards it already with the IVT

19. NEW QUESTION for Round 2: Have you been in situations where a joint GIS program would have improved the mission or enable a new capability? Please provide examples and specifics where possible.

- Base-level Force Protection planning is generally done with paper charts. The USAF GeoBase operating capability is already addressing how that can be improved with GIS. But so many of our facilities are now dual-use, or joint, etc. Some sort of share3d understanding of how to use GIS to manage these for better situational awareness would be a big step forward.
- GeoBEST is a good example of this between the USAF and Army.
- Some USAFE bases are owned / managed by other services; shared installation GIS at those locations would improve the mission at those locations. Also in situations where the USAF is forward deployed to a USN or RAF installation.
- I work in a Joint environment here at EUCOM so joint GIS program makes obvious sense
- Continuous

Additional Comment for Round 1:

- The Air Force has taken a significant step forward with their GeoBase program. It is a model that the other services need to seriously look at! The concern that GeoBase does or does not have the capability to support a deployed ground force needs to be addressed. The Air Force has developed a simple straight structure that each command has to go to for funding, present scheduled program reviews & updates, a set of criteria to work toward etc. This need not be lost but expanded upon by the smart folks in the other services! [comment was not from an AF member]
- 3D Scene Visualization is critical. TOPSCENE is the 3-D visualization package of choice in the EUCOM theater and it is absolutely essential. It needs more attention in the GI&S environment.

Additional Comments for Round 2:

NIMA was renamed to National Geospatial-Intelligence Agency (abbreviated NGA).

Appendix D – Case Study Questions

The different lists of questions were created prior to departure for the case study: observation of each office visited, questions for each individual visited, and responses to a Joint GIS presentation. The questions were in a paper form layout to aid the researcher in asking questions. However, for ease of reading, the questions are listed in numbered format for this document.

Observation of each office visited

1. Office visited:
2. Date:
3. POC:
4. Contact information:
5. What are the responsibilities/mission of your office?
6. How many people are in your office? How is it organized? To whom do you report?
7. What current GIS applications does your office offer the Army?
8. Who are your customers?
9. How often do you have to request information from other services? First on any type of information, second with any type of information.
10. How often do you coordinate with other offices inside/outside the Corps?
11. How are your products accessed?
12. What are the benefits of GIS and how are they measured?
13. What equipment and software is your unit using currently for GIS?
14. What are the capabilities and limitations with the current system in regards to GIS?
15. What are planned future uses for GIS?
16. How is new technology or updates implemented?
17. How was your GIS program implemented throughout the Army?
18. What new changes are being implemented? (ie Reserve components coming on-line)
19. Were there any exceptionally good implementations? Why?
20. Were there any exceptionally bad implementations? Why?
21. How does you office deal with classified information at the deployed location?
22. Do you see any benefit from a single GIS program DoD wide?
23. Additional notes:

Questions for each Individual interviewed:

1. Name:
2. Date:
3. Job Title:
4. Office:
5. Contact Information:
6. Miscellaneous background information.
7. What do you do in your current job?
8. How long have you been working with GIS?
9. Have you worked with other service's GIS units? How? When? Where?
10. How often do you have to request information from other services? (1st any type of information, 2nd GIS information)
11. How would you improve the GIS existing process?
12. Have you seen any really good or really bad implementations of technology, specifically GIS?
13. How was your GIS program implemented throughout the Army?
14. What new changes are being implemented? (ie Reserve components coming on-line)
15. Were there any exceptionally good implementations? Why?
16. Were there any exceptionally bad implementations? Why?
17. What do you think GIS could become? Where is it not being used to its fullest potential?
18. How much leadership support do you have for GIS and leeway for implementing changes?
19. Do you see any benefit from a single GIS program DoD wide?
20. What are the benefits of GIS and how are they measured?
21. What is the best training method for new technology?
22. Additional Notes:

Response to Joint GIS program idea (post GeoReach presentation)

1. Date:
2. Time:
3. Notes about presentation group…
4. What are your initial thoughts of the AF's GeoReach program?
5. How do you think the AF's mission differs from the Army's deployable mission?
6. Do you think parts of GeoReach could benefit the Army?
7. Are there any areas that GIS could be added to for forward deployment planning?
8. What capabilities would you want to see in a joint GIS program?
9. Would a joint GIS program improve any existing capabilities within your organization?
10. Do you think your organization would see any new capabilities created by a joint GIS program?
11. Could a joint GIS program be created that would aid in joint operations DoD wide?
12. What would convince you to switch over to the joint GIS program?
13. How difficult do you think the transition to a new GIS program would be?
14. What barriers would need to be overcome for the implementation?
15. Would the change be better supported by having high-level support or more worker-bee support?
16. Who should manage a joint GIS program? Should it be contractor or civilian run, or should it be a joint assignment for active duty military? Should one unified command take lead or joint staff?
17. What are the benefits of GIS and how are they measured?
18. What is the best training method for new technology?
19. Is the existing communication system able to support the exchange of information between the services?
20. Is the technical ability sufficient for exchange of GIS information?
21. Would upper management be willing to support (including financially and politically) a new GIS program?
22. How do you quickly implement technology within your organization and/or the Army?
23. Additional Notes:

Appendix E – Case Study Discussion Documentation

This appendix includes responses during the study interviews. The interviews are only numbered to show a different interviewee. The number does not imply order interviewed or position of interviewee. This is not a complete transcript of the interview process. Information that was not needed for this research has been omitted.

1.0 DTSS Mission In-Brief

This first section covers the initial DTSS mission in-brief. Because the briefing lasted for over two hours, a complete transcript will not be included. Only the answers to the predetermined questions will be included in this document.

1. **What are the responsibilities/missions of your office?**
   CTIS Mission:
   > "The mission of the Combat Terrain Information Systems (CTIS) Project Management Office is the materiel development and acquisition of topographic support systems to meet the terrain geospatial information requirements of the Army Warfighter" [53].
2. **How many people are in your office? How is it organized? To whom do you report?**
   An element lead, 5 enlisted, an unstated number of civilians, and contractor support
3. **What current GIS applications does your office offer the Army?**
   See Chapter 2 for review of DTSS system
4. **Who are your customers?**
   Army commanders needing tactical decision aids
   Civilian cities and Agencies for disaster response because CTIS can bring groups of different people together around one map for a crisis response
5. **How often do you have to request information from other services? First on any type of information, second with any type of information.**
   Only listed NIMA
6. **How often do you coordinate with other offices inside/outside the Corps?**
   Always requesting data from NIMA
   From cities and counties for disaster relieve in US (per TA#1 interview)
   CTIS can import several different data types and can output in many forms also
7. **How are your products accessed?**
   The DTSS-H, DTSS-L, or DTSS-D. Per TA#1 interview, information can also be stored on DVD if necessary for individual users… accomplished by TAs
8. **What are the benefits of GIS and how are they measured?**
   Not asked.

9. **What equipment and software is your unit using currently for GIS?**
   Software: ERDAS, ESRI, ARCMis, DTSS is a drop down menu within ESRI. The DTSS software was created by a contractor other than ESRI

   Hardware: Army standard computer equipment. However, the unit is transitioning to all COTS hardware in the future. One drawback of this transition is that the Army standard computer equipment could be repaired in the field by other organic Army maintenance units. The hardware follows the Army's 5 year update cycle for the hardware.
10. **What are the capabilities and limitations with the current system in regards to GIS?**
   See TA #1 interview
11. **What are planned future uses for GIS?**
   BTRA (See Chapter 2)
12. **How is new technology or updates implemented?**
   Every year they have an update to DTSS
   Constantly updating map data
13. **How was your GIS program implemented throughout the Army?**
   Through this office for the DTSS
   CTIS is at the end of the development and fielding of program
14. **What new changes are being implemented? (i.e. Reserve components coming on-line)**
   Working towards a digital combined combat map
   Next step is BTRA, and developing algorithms which allow an unskilled user use the GIS software and data to determine the best path from point A to point B
15. **Were there any exceptionally good implementations? Why?**
   Not asked (team lead giving briefing is part of Delphi study)
16. **Were there any exceptionally bad implementations? Why?**
   Not asked (team lead giving briefing is part of Delphi study)
17. **How does you office deal with classified information at the deployed location?**
   Everything is put on the SIPRnet because it can have the classified and unclassified. One person is responsible for declaring SIPRnet information unclassified within the unit.
18. **Do you see any benefit from a single GIS program DoD wide?**
   Question not asked because waiting for GeoReach presentation

2.0 Terrain Analyst (TA) #1

Interview Date: 4 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

TA: [TA is showing the researcher examples of DTSS products on a computer] DTSS uses ESRI software which is pretty much the industry leader in terms of GIS. ERDAS is pretty much the industry leader for raster manipulation. These software packages allow the user to take data from multiple sources because everybody uses the industry leader's standards which allows for the exchange of information to be easier. Both can manipulate information from NIMA.

DTSS imports VIT layer (NIMA standard vector data) - includes layers: vegetation, soil type, transportation networks, hydrology, and obstacles (linear and points- cuts and fill), soil type, rail yards, slopes, what the vegetation is broken down into. VITD, vector interim terrain data, [another NIMA data type] contains all the information about the location or cell of the earth. Limitations are most complete data source… harder to come by, takes longer. Each category has its own set of attributes. Rail layers has railroads, what type of rail lines, spur sidings, where you can transfer a line, what gauge of a rail line it is. Just an example of the data that comes along with VITD. Best guess estimate on vehicle speed, traffic ability, to make a judgment on go, slow go, or no go. We don't attempt to tell anyone where they can and can't go. The best decision maker for that is the tank driver. We can give them an estimate on the type data: here are possible chokes points, this section will be muddy during certain times of the year. DTSS allows us to create something, some special tools that we call TDAs. It allows us to query out certain things. So, say I was only interested in four-lane, hard surface areas that were within a certain distance of point A or point B. We can query out all the roads that are within that area, and we can say this is the road that you need to take. This is the road that is the farthest away from that point; this road has the steepest sides making it more dangerous. The goal is to give the commander an idea of what is on the ground before they get there.

This is example of standard NIMA data. We take that vector information and we also have the ability to, with ERDAS mapping, to process standard imagery, CIB (controlled image base), which comes 1:5, 10 meters is black and white picture of the world, but is not great stuff. A video of what is on the ground, the CIB works pretty good. This can be combined with the vector data, laid over each other, and print out on a grided map and give it to the guy on the ground and produce it digitally for the common operating picture (COP). For what we call special purpose products. So, say we needed a highly detailed map of this section. We can actually print this out at any scale, and combine it with whatever information we have, update it with whatever scenario information there is, we can annotate that and reproduce the map. We can take the standard map background that the soldier gets and put it as an image base and overlay any of the information that we choose to. That is an example of standard NIMA data.

Digital terrain elevation data (DTED) contains elevation values. This is the same image information (elevation information) and assigned a shading based on the actual elevation to look like an image of the earth. We have taken all the numbers buried within that image so that you can actually make some assumptions based on this, we can figure out the drainage patterns. You can make some rudimentary estimates of line of sight and field of view. What can I see from here, how far out can I see. If I overlay the roads, if I put a point here, how far away can I see. At what point can they see me, and I can see them. Based on elevation, we can actually import vegetation information. So say that there was, say that I had a vegetation layer, based on the slope of the earth, the height of the earth, the height of the trees, the density of the trees, what can I see. So it makes it, you can also do things like line of sight for communication towers. So say, based on the estimate, the commo guys say this is our best guess on putting up the relay towers. They have to be line of sight to each other. Based on our guess, yes or no. It is not 100%, it is about 80%. There are a lot of variables. So, we answer the mail as best as we can. We take all of this information. This also has the ability to… we can get a hold of any standard map that anybody was used to see in the world, and reproduce here. We can take the added information that we derive and update the map. In all reality, these maps are not as current as we would like. Based on information, that we know from all sorts of sources there's all sorts of building growth out there, we can actually update this imagery, intel, and maps.

We wish we had current maps, but sometimes you have to do it. So you can take and match any scale of from the navigational charts of the earth to 1:25000 city maps you can reproduce them. So, we are talking information from all sorts of sources. Witch also has the ability to include in this is aerial photography. So what we have done, what other people have done with the same equipment, they have actually stitched all those little pieces together and have rectified them to the same place on the ground. Now, this is has the same geo coordinates as a map would, it has an actual place on the earth. Then we can ingest commercial sources of data such as space imagery. Some of the other ones you see like on CNN, through CECIL we are able to get things that have already been purchased, and then able to process that through here and get near real time information.

Then what we are kind of moving towards is taking… what we are trying to move towards is taking 2D image information, 2D vector information, and combine them into a more… Now, we take the 2D vector information and combine it into a 3D environment. So, to make it as real time, and as valuable as possible. The entire goal of all of this is to give the commander an idea of what is there prior to going.

We can make AVI files, but the question becomes what is over there. This package allows us to take all that information, elevation, image vectoring. So, I can access that same attribute table to find out what that building was. We can model buildings based on their actual height.

Example of spraying a toxic over an area… do the plume modeling… based on the weather, the plume would go there. We used HPAC. We put in real weather information, what time of day, and then we were able to make an estimate on the number of people affected. We were able to establish four checkpoints along these exit roads. We took all of the hospital information, and all of the contact information. Basically, then we could update this.   [All attributes are updateable]. This can then be served up to the big screen where the commander was.

The goal is take all that pertinent information, and make a guess as to what, make estimations about the terrain and the affect. Now, we are able to it digitally and 3D.
It all runs off the CPU. One of the other benefits to this package is that it will run with minimal loss of speed off of a DVD. So, one of the advantages, one of the nice things, is that we did—we were going to be working with all sorts of different agencies [listed] and we are supporting them all—we take our assets and what we provide them, and we will find the best package to provide them. What we are able to do with this is burn it to a DVD that comes with a free DVD viewer which has all the capabilities as this one including attribute editing, layer adding, and jump to location, overview maps. We burn them all to the DVD and give it to anybody we want to and have them drop it to their laptop, and it auto installs the same program and boots right into the screen. So, you don't have to be a computer genius to work it. Not only are you able to serve it up on a server, you can also burn it to a DVD and get it to anybody that needs it.

Researcher: Any concerns about the refresh rate on the DVD since you are using a dated map?

TA: Yes, there are. But we thought in terms of most of the things we would be updating, not everybody would need to see. So what we did was, and we can always reburn the DVD is, we….

The nice thing about this is package, unlike many of the ones you see on CNN where you have to view the AVI file that somebody else made you see what they want to see, is you can see what you want to see.

[DTSS has the same capability to fly through with whatever plane selected, the same as GeoReach; example shown] So, you can view objects from any direction.

You adjust approach, look, altitude, angle, speed… you take all that information and do it in terms of mission rehearsal and mission planning, after action. You take all that information and what we provide is how the terrain affects the actual.

Researcher: Do you know of agencies using this capability [3D] in the Army? The Air Force has the capability, but kind of use it for briefings only. We don't actual use it for mission requirements.

TA: This particular package is not yet fielded to the Army. They do have some rudimentary 3D capability such as the movie file. They all have the capability to view that, and they are used quite frequently to review movements. [Example:] what do you see from here to here. It is still AVI.

What we hope to move towards is actual. When ever I have briefed anybody, they always ask, what is to the right? Well, that is to the right.

Researcher: They are trying to show 3D is useful for a pilot's initial flight into a new airfield. Tower over here.

TA: Take all that information and construct it into 3D types
[The TA shows how to take a 2D image of building and add the third dimension information with the correct attributes. A digital photo can be used for the different faces of the building if time allows]

Researcher: Do you guys actual do this level of analysis? Do you do the input or let a contractor do the input. When you start out with data and information from NIMA, do you change the 2D imagery to the 3D in house or contract it out?

TA: We do it in-house. [limited discussion afterward about how easy it is to import a shape file of all the buildings to create a 3D image of a location]

3.0 Terrain Analyst #2

Interview Date: 5 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

Researcher: [provides personal background information on self and research]
Have you worked with other services at all? Where have things worked well, where have things worked bad?

TA: I don't have too many example of it. Which ones are you talking about?

Researcher: You work with the Air Force at all?

TA: No, besides just working with the weather. That is the only people I have worked with side-by-side. Nothing else.

Researcher: Did you have any problem with transferring information back and forth?

TA: No, not at all. Actually, they never asked for anything from us. We just mainly had to brief the General on the whole situation. Other than that, it was like we never had to work with the AF.

Researcher: Have you had to deal with implementing a new technology, a new change, and new idea. How do you teach that to new students?

TA: Like the new software we get here?

Researcher: Yes.

TA: Yah, actually we get the training first. We get it then we go teach it. To deal with new students. We usually don't have that experience because we only teach students that already have a little bit of knowledge with the program.

Researcher: What kind of teaching method do you usually find works the best? Show them how it works.

TA: I usually go through the slides [PowerPoint], and explain what we are going to do, what kind of software, what kind of imagery we are going to use. I go by the slides. I then try to talk with them and make sure they understand everything I talk about on the slides. Then, I then go through a little practical exercise. Then, go back and ask more questions about it. Do they have any questions about what they did. If they have questions, we go back to it and cover it more.

Researcher: Have you ever seen a change come down to you that thought didn't go well?

TA: Many times.

Researcher: Why? They didn't tell you it was coming? Didn't fund it?

TA: Sometimes they make mistakes with what they do. So, they don't have the civilians that work with the software. They come out with software that they see one way, but when it comes to us we see it as a different way. [Different perspectives]

Researcher: Once you enter terrain analysis are you always in terrain analysis? Basically, once you get the experience and knowledge in this field, are you always using it, or do you have to go do another job and then come back and relearn the skills?

TA: If you don't do it, you are going to loose it. Some people go to drill sergeant school, and this MOS changes so much in a few months, that if you are not on the top of it, you are going to loose the experience.

4.0 Terrain Analyst #3

Interview Date: 5 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

Researcher: [Same background information]

TA: The joint world, I have only dealt with one exercise. Pretty much that was a multi-national thing as well. Navy GIS is pretty interesting.

Researcher: How easy was the cross-flow of information to the Navy?

TA: It wasn't that bad. The Navy actually had very little care of what I was doing. It was more the Marine Corps, even though they had their own, they didn't have any of their own topo guys on the exercise. The J-3 had the C2 PC. So, he would request some mobility information and I would throw it to him in the magic format that the C2 PC can read. Look for mobility information, line of communication. We were pretty limited because it was a remote sight. The Navy, maybe I shouldn't even really mention them.

Researcher: Have you seen any good or bad examples of technology integration? Such as new GIS?

TA: There are several times I have seen that. I have been in the whole topographic thing for the past 10 years. I have pretty much seen the progress of GIS.

Researcher: Has the progress been software based or capability based that you said "wow"?

TA: Mostly software based. On my side, it is more the DTSS program because that is what I am familiar with. The wow, great is the ArcGIS how that is advanced and from that command line ArcInfo to what we have now, that is one of the greatest things.

There have been models made such as this NATO Reference mobility model that has been wow in the opposite direction. The first time I saw it was great, it uses different aspects from vegetation slope to surface materials and then has parameters built in for each vehicle and will pretty much give you out a mobility overlay. It looks great and runs perfect, but when once you compare it against it something that is actually correct, it is way off.

Researcher: Was it a programmer problem?

TA: [doesn't really know why] I first saw it in '96. WES created it (Cold Regions Lab). It was made there, I am pretty sure, along with TacDam, it is a dam breaching program. It is another one of those pretty impressive things. Everything is data, TacDAm doesn't work if you don't have the right data. We went through manual extracting data from each of the layers and the actual overlay that we got was so much different. I am not saying we did it correctly, but then we compared it to the NIMA model, and theirs was the same as ours.

NIMA has a heck of a demonstration. [but they don't always work afterwards]

Researcher: Have you dealt with distributing new technology from here? Such as fielding?

TA: Yes.

Researcher: How did you implement the change? Did you start at the top and work down, or the bottom up.

TA: Training?

Researcher: Yes.

TA: Bottom up because they have the highest priority. We usually train Stryker brigades first and then other echelons.

Researcher: When you train them, how do you do it?

TA: Depending on the system, Humvee or deployable. Regardless of what it is, you start with a classroom section with a demo. Then, they do a hands-on task. Depends on the instructor. I actually just show them the program. Saying this button does this, doesn't really help. Everybody learns differently though. The hands-on method is the best way.

Researcher: How much flexibility do you have to change things? Such as how you teach class?

TA: Yes, I do usually change the class around. A lot of the time, we train the next trainer. However, unfortunately, we get several people who have not used DTSS. Here these are mid level NCOs that have no experience and have not even used ArcGIS before, and we are teaching them plug-ins for ArcGIS. We get the people who don't know anything about the software and we are trying to teach the advanced stuff to them, and in those cases, when I know there are a lot of people who don't know much about the software, I will aim it at them. The guys that already know the software have to sit through the explanation. Recently, we had the commander and NCOIC in the class. I could have given the commander a PowerPoint presentation on her desk rather than try to teach her the entire program.

Researcher: How do you measure the benefits of GIS? How do you show upper management the benefits of GIS?

TA: Archiving. I worked before we had GIS, back in Mylar and pens stuff. Mainly you do this massive overlay. So, you have these 4 or 5 drops of overlay that you are working, and the whole place is working on days for days. After it is all done, you roll it up and stick it in a vault. Reproducing that is an issue. The Diazo machine, which was originally created for blueprints, used ammonia and we had it in the back of tractor trailer. Making copies just sucked. You could never get the same product. You could store it and lose it for years, not that you can't lose it on a hard drive. Storage and reproduction has vastly improved with GIS.

Being able to actually visualize the terrain is one of the main benefits as opposed to what it used to be. You couldn't just look at a fly through of an area and see what it looks like. Before you just pretty much looked at contour lines. We are talking denied areas, which would be nice to look into before we go. With the high resolution imagery and modeling, you get a better idea than you used to. We just got into the 3D modeling.

Yah, imagery which is another whole aspect. Remote sensing is amazing. Technically, we have that in our job title, but it is not something that we have really held on to. Yah, they give you a 1.5 week class, and you can become the remote sensing expert after that.

5.0 Terrain Analyst #4

Interview Date: 4 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

Researcher: [same background on research] What kind of a background do you have?

TA: I have been in the field for two years. Before this, I was a scout. I have been in numerous exercises with the Corps staffs.

Researcher: Have you seen any cases where they have implemented new technology?

TA: Yes.

Researcher: What were the pros and cons of it?

TA: It really depends on the timing of the implementation. If you do it right before an exercise or operation, it really slows you down. But once you get used to it, it makes it a lot easier. Something we were taking hours to do in the last build, now we can do it in a matter of minutes. So, it is a matter of getting the right mix of timing so that it is not interviewing with their missions while maximizing the benefits.

Researcher: Have you had any trouble with getting funding for the change?

TA: At 3rd Corps, we had trouble funding for the maintenance of the equipment. We were supposed to get x amount of money per system, but once it reached us it was about nine tenths gone.

Researcher: How was the leadership supporting the change? Was it top down or worker bees?

TA: The leadership that I worked with, the worker bees could say that we needed this, and since the leadership rotates through so much, we pull officers from the engineering branch, at most they spend 18 months max in the topo field and then move on. So, they really don't know the systems and what we do is some complex it is really hard to learn. About the time they are leaving, they are starting to figure it out. So, they rely on us to determine what we need.

Researcher: Do you have any dealings with the other services while at the 3rd Corp?

TA: Some, not really face to face. Just staff weather officers.

Researcher: What about information from NIMA?

TA: I have, your level of importance matters. If they have their own mission, they aren't going to drop everything. I have never really had a problem. I have talked with the Marines and the Navy and every time I have talked with them, I have gotten everything I needed.

The last exercise, we actually had some more Air Force personnel in our TOC, the last exercise at the 3rd Corps. We haven't really, for me it is getting a used to thing. I am sure there are things we can provide for them, but it is a matter of them asking for it.

Researcher: As for new technology, what has been the most effective training methods?

TA: The best, in my opinion, some people, we recently brought in a group from a bunch of different posts and we put them in a classroom environment. Some people learn like that. However, other people are more just give it to them and let them go and they can figure it out on their own. You have got to have the classroom, but then still walk them through an exercise. I like to integrate. [One person available per unit being trained to answer questions. Also, have the trainers travel to the unit being trained works sometimes.]

6.0 Terrain Analyst #5

Interview Date: 4 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

TA: Pretty much since my time in the Army, I have seen it evolve from analysis to information dissemination. You take the major types: vector, raster, and matrix data and synthesis the data to something that the customer requests.

Researcher: How long have you been working with GIS?

TA: 5 years.

Researcher: How long has the Army been using GIS?

TA: To my knowledge, the Army started with cartography. It goes way back before… the very beginning.

Researcher: You said you have some knowledge of how the Air Force works.

TA: Just a preliminary knowledge of how the Air Force is starting to use GIS. You guys [AF] would be more interested in a larger scale product. Something with greater detail. The problem with that is that NIMA only has greater detail in certain areas of the world. They prioritize areas based on need.

Researcher: Have you been involved with the implementation of new products, technology?

TA: Yes, within the last five years the Army has implemented has gone from an analytical perspective to more a deployment of information. Now we have systems that are automating a lot of our work.

Researcher: What makes it easier for the user to begin using the new technology?

TA: They follow the criteria based on what they need from the beginning. We synthesize the data based on those requirements.

Researcher: Any cases where you were the receiver of the technology and you questioned why? [researcher explained the change process per Chapter 2 model]

TA: No major problems so far. Recently the Army has gone through a major revolution, such as the Pedicts [unknown program] that must stay on the forefront of technology with new computer systems, faster rates, dual processors. Stay on the forefront of technology. Yes, there is a lot of change, but it falls on the end user, the analyst, to adapt to it. It is not the problem with resources or technology available. It is usually the user who is not up to snuff on the new program. Not ever part of the world has data available.

Researcher: Have you worked with the other services at all?

TA: No. I do know the Marines have some experience with GIS, but no direct knowledge.

Researcher: How did they train you on the new technology in school? How to implement new technology?

TA: Hands on. The instructors are the resident expert. They are versed on the new technology and the new GIS technology. This is a relatively small field, and everybody knows everybody else. Yes, hands on.

7.0 Two GS software design managers (SDM)

Interview Date: 5 Nov 2003
Location: USACE TEC, Fort Belvoir, VA

SDM1: [Two guys very much into the structure and architecture of the GIS software. SDM1 is familiar with GeoReach and GeoBase because GeoBase guys made a presentation a few years prior]

I know a few years ago the Air Force was using TCBMS. They were doing geoprocessing with software created by TEC. It was a joint terrain analysis tool. They were looking at suitability and the ability to plan sorties after a scud was shot off, based on terrain, where could have that launcher gone. That work is actually going on our DTSS. The Air Force has called their system a DTSS clone because their system was built around ArcGIS. The software package is customized for the Air Force needs. There has been some collaboration between the functionalities between the TCBMS and DTSS to provide terrain reasoning to provide intel.

Researcher: The Army seems to be very interested in the forward deployment and operational area, does the Army ever focus directly on the logistical hub requirement?

SDM1: We provide the topographic information with all the packages. Our main goal is import that image data, commercial imagery, or any data, and use that for analysis, or value added on the battle field. To take that information and value add that information. If the Air Force had a need to use NIMA data to analyze and value add if new roads were constructed. We build data models based on NIMA standards. We also do analysis, integrated mobility analysis, point, line, and line of sight. We have a tool called a query wizard which allows you to create your own models based on Boolean "and/or." If the user wants helicopter landings based on well draining and 2 percent slope, we provide a query tool for the user to create the model and present it to people. Suitability models allow users to with Boolean "and/ors." You can actually click features and attributes which... In a dam breach problem given the reservoir size, given you blow it up this percent, how much water is going to flow out? We have some tools that make it easier to make maps. All I have to do is draw with one pencil to create a predetermined map based on tactical needs. We have got a lot of customization about ArcGIS to have data generation and value added. How do you bring NIMA data down to the division or brigade and validate the terrain, and then provide it to all the other command and control units that have terrain requirements. We are part of the Army battle command system. We provide the terrain piece.

SDM2: Cooperate more between… with the Air Force using the standard commercial packager, ERDSA, that is a good step from out point because that is what we use. Those packages that they use, they support our data and NIMA data. A lot of these other systems have not been developed that way.

SDM1: You are looking at the base building technology.

Researcher: Yes.

SDM2: Now the MCS is looking at combining with the C2 to CJMTK or use Atlas commercial package. Everyone has their own unique flythrough database. The first step is standardizing. You can't standardize on one data type because each have their own advantages. But limiting the number, the number of new unique data types.

SDM1: The Air Force got rid of its terrain teams.

SDM2: The theater geodata space is broken down into the land, air, and marines. They will have data even if it is from contractors.

SDM1: Looking at GeoBase and GeoReach, we here can help you data analysis of NIMA data.

Researcher: What is the best of technology integration?

SDM1: A MOA (memorandum of agreement) would be the best way.

Researcher: Start at the top?

SDM1: Yes, as we do software development. What we have done with the Marines, for the software builds, they are invited to come to our documentation review and we can tweak it a little so it is a joint solution. So, software development through a MOA would be the way to start.

Researcher: I am also looking at to implement the change to at the unit level. Do have any experience in that area?

SDM2: You are talking about software builds?

Researcher: A new package, not just data. When you are required to work with people.

SDM1: We have two methods: Defense Mapping School, now National Geospatial Intelligence School; they do our basic and advanced training. When we put out new releases, we have a field support team that goes out and provide the delta training of the DTSS builds. We are putting out the build 8.1 now. Next summer, we are putting out build 9.0. Occasionally, we send out a contract team, but usually the field support team does that. We have a requirement to do embedded training, but when funding is cut, that typically falls off. With the Marines, when we share, we do pretty good lesson plans, training plans, and software user manuals. So when the Marines take our software and they are sharing with other countries, they are using our plans. All the manuals are hyperlinked in the software help menus. The time and money spent on the user manuals is well spent.

SDM2: When we do a new release, we are sending out an updated version. We are not changing the program entirely. So, we concentrate on the changes.

Researcher: Why does it seem the Army is working with Marines so much?

SDM1: They almost have an identical system to ours.

SDM2: We are geared more towards the tactical applications. We are very little focused on the facilities. A couple of people are involved with airfield surveys, but that is a small part. We are interested in the same types of products and analysis as what they are [the Marines]. We are interested in what is going-on on the ground.
[7 minute DTSS capability briefing from PowerPoint]

Researcher: Do you have any examples where you have tried to implement new technology that went poorly?

SDM1: The biggest issue we have had is, my goal is, to keep as much COTS as possible. We are moving towards 95% COTS. Our biggest issue is putting decision aids on the program that are never used because there isn't the data available for it. [The data from NIMA is not detailed enough for some of the tools]. So you have got these high end tools that the user must really have to understand how to use the GIS and image processing so that they are able to create something from what is given them. The dam breach is good example. If you look at a VIT data set, there is typically not much information on the dam. It was a nightmare when the software went out there because the data didn't match up or was incomplete. The future of technology that we haven't dealt with is data conflation—taking data from all sorts of sources and combine it based on metadata. If a road is represented in six different sources, what is the best source to use? There is technology to do it, but it is not that robust yet. We have not tackled it yet. We also keep throwing all this stuff at the soldier, but eventually we reach a saturation point. We have all these packages. Training all the complexity and intricacies for all the different packages has been an issue for us. We provide all this need stuff, but they are expected to know all of our software packages as well as the commercial systems. While still doing PT, guard the gate, and change tires on the trucks. Training, that is one of our biggest problems, and if they do pick up all that stuff, they are gone. They get out and get a better paying job.

Researcher: What kind of problems do you have with retention? Job skill knowledge?

SDM1: I think the ones that stay in use it a lot. There is so much to do with terrain analysis. The only place we have had problems is the National Guard, and the National Guard are the ones that are continually rotating now. If they stay in, they use it a lot.

Also, everybody has their own pet ways of doing it. Somebody may really like ArcMap and every place he goes, they will use ArcMap. We have had two guys that work really slick with Socket Set, and they can do any type of extraction you want, and the next person that comes in doesn't know it, and the system doesn't get used.

There are a lot of things that you [AF] can just have. We just need a MOA. When the Marines started, they took our data and used it as a beta version.

SDM2: The one thing I want to stress gain: there are issues with the systems that don't use the geographic data very much. They are the ones that you have to keep in mind to keep with the standards; otherwise, we will end up creating data they can't use.

SDM1: One of the biggest AAR (after action report) comments from our terrain teams was that there were a lot pseudo analysts. Because you have Falcon View, you all of a sudden think that you know everything about geospatial. The people wouldn't understand datums, projections, and what all, and they were putting out all these products that were wrong. NIMA data might come in incorrectly rectified, and the terrain analysts recognized that and corrected it, but others were just using it as they were given it. Just because you have the software and not the training, you are not an expert. Our terrain teams were doing so much damage control for terrain information that these other people were trying to put out.

SDM2: The senior warrant built up the trust with the leadership. That way when they presented a product that was different from somebody else, the commander trusted the terrain warrant.

Researcher: How do you measure the benefits of GIS?

SDM1: That was one of the things we used to do. Because the terrain teams used to everything by hand, we used to say it took 2 days to do a mobility analysis, now we can do it in 2 minutes. It used to take hours to do a line of site analysis, now it takes minutes.

SDM2: With the ACMT, it used to be if you wanted to print 500 copies of something, you spent so many hours prepping. Now, you can get turn around in 2 or 3 hours.

SDM1: We had some specifics for GIS and value added data. One of the things we have been trying to push is GIS for all the command and control. Rather than just DTSS having the viewers, if you built the technology around GIS so that all the information all the battlefield would be tied to geospatial information.

8.0 Discussion after group GeoReach presentation

Interview Date: 5 Nov 2003
Location: USACE TEC, Fort Belvoir, VA
[The TA number below does not correspond to the previous interviews]

Researcher: [Gave 16:30 minute presentation showing the capabilities and benefits of GeoReach.]

Researcher: Is it technologically possibly to share data among the services?

TA1: We have two theaters that are attempting to standardize database format. As of a matter of fact, ESRI is helping define what that is. So that everybody will be able to use it. We are grappling with that right now.

Researcher: If we were to go to a more joint environment, would you want to keep each service separate and have NIMA set the standards?

TA1: The theater commanders, the unified commanders, set the requirements. ArCent sends requirements to CentComm which then send it to the JCS and NIMA to set the standards. Then, they prioritize the requirements. Now, you have all the unified commands putting in requirements to the JCS. Based on the predictions of the requirements by the JCS, they prioritize it. NIMA looks at the list and funds as many projects as possible on the list. That is how our data requirements are generated.

Researcher: If we decided to go more joint, should that be more management push, or should individual units?

TA1: What about TRANSCOM. Why aren't they heading up this requirement? Why are we reinventing the wheel? What is it that they are doing, that we aren't getting elsewhere?

Researcher: [I do not know]

TA2: TRANSCOM is a joint out fit… yes. I understand their stuff is a little out of date because they have to cover the entire world.

TA1: The resolution of the data that is needed by TRANSCOM is not is what is needed by the brigade commander.

TA2: The information that they track doesn't interest me, so it must interest somebody.

TA1: TRANSCOM is interested in every road that is over 4 m, but at the brigade level they need more detail. There in lies the problem, the requirements are not the same for everybody, and the people at the top of the food chain get to set the requirements.

Researcher: Would it be possible to add altered information back to the central repository?

TA1: The central database should be built to support all the requirements.

TA3: TRANSCOM doesn't need everything we need, but have them collect all the information.

Researcher: It seems like information leaves NIMA, but nobody takes it back to NIMA or a central location.

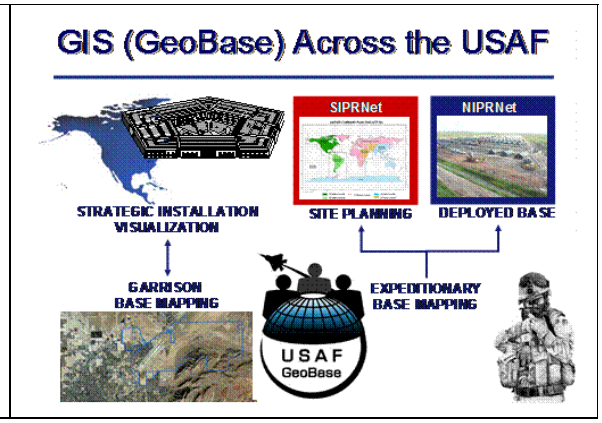
TA1: Oh, they don't want it.

TA4: No, they don't want it.

TA2: Maybe TRANSCOM is answering mail that nobody wants. I don't know what it takes to move an expeditionary Air Force forward, but their system seems very detailed.

Appendix F - GeoReach Presentation for Case Study

Slide 1



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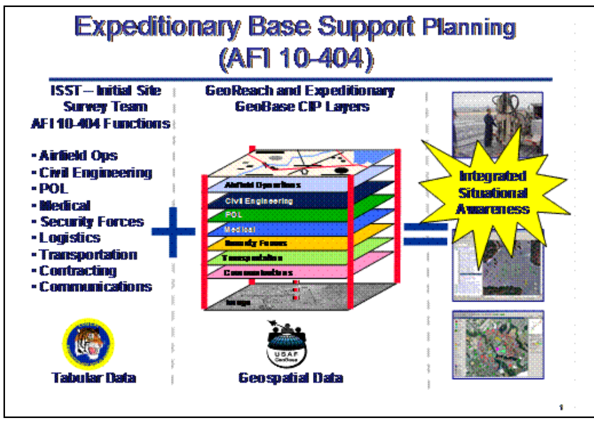

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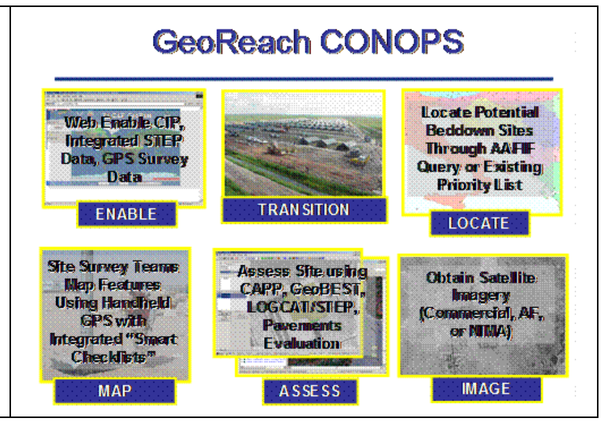
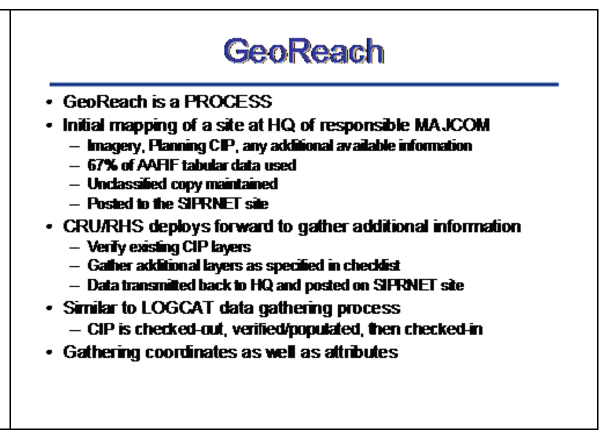


Slide 4

Slide 5



Slide 6

Garrison vs. GeoReach CIPs

- GeoReach CIP is a subset of the Garrison GeoBase CIP
  - 10 layers in GeoReach CIP
  - Approx. 55 layers in Garrison GeoBase CIP
- During sustained forward operations (Expeditionary GeoBase), the GeoReach CIP evolves into a Garrison GeoBase CIP
  - Additional layers of information gathered
  - Data accuracy improved by survey grade equipment

Slide 7

Latest GeoReach Requirements

- Software
  - Windows 2000
  - ArcGIS 8.2
    - Spatial Analyst, 3D Analyst
  - ArcView 3.2
    - Spatial Analyst, 3D Analyst, Image Analysis, Network Analyst, Tracking Analyst
  - ERDAS Imagine 8.5 - Professional
    - OrthoBase Pro, Stereo Analyst, Virtual GIS, Vector, NITF
- Hardware (AFCESA supplied)
  - 1 Dell Optiplex GVX420
  - 2 Dell Precision 330
  - HP1055CM Plotter

Slide 8

RED HORSE/CRU Integration

- Concept: Streamlined/equipped/trained RED HORSE outfits
  - Light/lean…backpack GPS, field computers
- Respond to typical scenarios with CENTAF, SOUTHAF
  - Surprise Humanitarian or Disaster Relief
  - Small Scale Contingency
  - Support of Global Strike Task Force
- Ops Test in controlled scenario with real-world value
  - Full range of agile combat support planning needs
  - Real time updates to common installation picture (CIP)

Slide 9

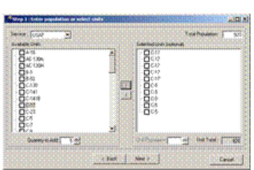
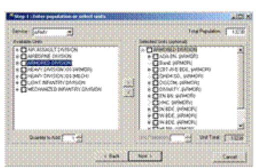
GeoBEST v. 2.0
(Base Engineer Survey Toolkit)

- Force beddown planning software
  - Assists with developing tent city and initial industrial operations at a FOL
    - AFH 10-219, Vol 5: Bare Base Conceptual Planning
    - AFH 10-222, Vol 2: Bare Base Assets
  - Supports USAF, Army, and Joint beddown scenarios
  - Navy interested
- Partly automates development of bare base layout plans
  - Not intended to transform unskilled staff into bare base planners
  - Not a turnkey solution
  - No limitations on making bad placement decisions

Slide 10

Create Scenario

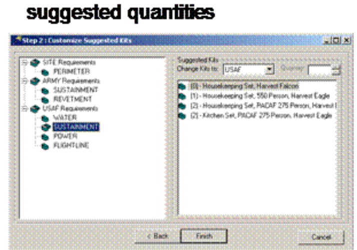
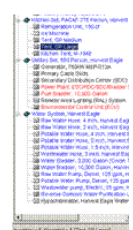
- Use a Planning Wizard to determine suggested assets
- Can add or subtract from the support population calculated from the selected units
- Can place assets for Air Force and/or Army units - allows for multiple Services within one scenario

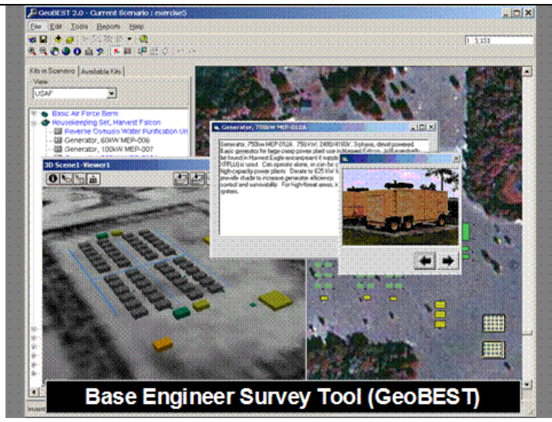
Slide 11

Allocate Components

- Population, aircraft, and unit selections determine component quantities - Can add or subtract from the suggested quantities

Slide 12

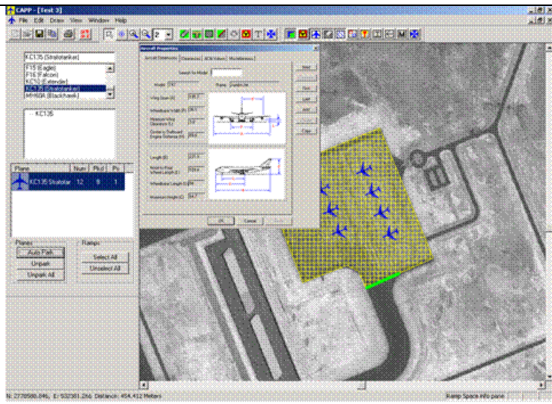


Slide 13

CAPP v. 2.0
(Contingency Aircraft Parking Planner)

- Aircraft Parking Planner software
  - Assists with developing aircraft parking plan and estimated ramp requirements at a FOL
    - AFPAM 10-1403/AFI 11-218/AFM 32-1123
    - AFH 32-1084/AFMAN 32-1008, Volume 1/AFJMAN 32-1013
    - AFMAN 91-201/ETL 1110-3-394/FAR Part 77
    - NATO USAFE Supplement 1 to AFR 55-14
    - AR 385-64
  - Supports USAF, Army, Navy and NATO aircraft
- Provides assessment and delineation of aircraft, ramps, marking lines, and safety factors
  - Not intended to transform unskilled staff into aircraft parking planners
  - No limitations on making bad placement decisions

Slide 14

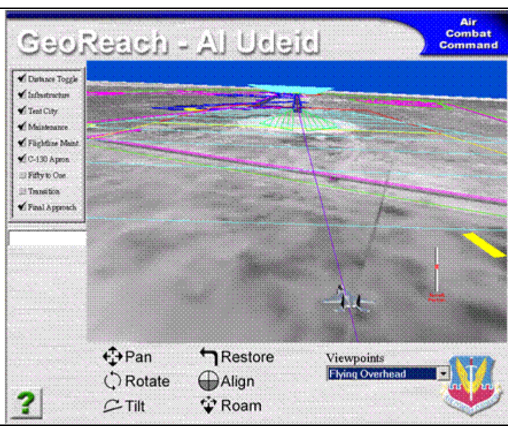


Slide 15

Force Protection Mapping

- Consolidate functional mapping requirements into the integrated Common Installation Picture
- Unit Level TBMCS, RESTOPS already using GeoBase platform
- Software used in GeoBase same as software used in NIMA's Joint Mapping Toolkit (JMTK)
- New GeoBase contractor at AFSFC to assist with efforts

Slide 16



Slide 17

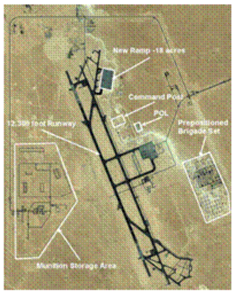
GeoReach Planning in OEF

- AF Operations Group (Checkmate), CENTAF requested support for beddowns
  - Located forward deployment sites for OEF missions
- Team accessed "GeoReach Library"
  - ISR, NIMA, and commercial image products
  - NIMA's Airfield Products
  - AMC's Global Decision Support System (GDSS)
- Team remotely assessed beddowns
  - Used Contingency Aircraft Parking Planner (CAPP), Base Engineer Survey Tool (GeoBEST) to pre-plan beddown and agile combat support needs
- Teams deployed forward to fill in map data sets
- Satellite updates enabled access for all users (e.g. CENTCOM, HAF, ACC, CFACC, CFLCC)

Slide 18

GeoReach Results in OEF

- Deployed personnel as part of
  - Checkmate staff
  - CENTAF A-7 forward deployed staff
- Provided new web-enabled basing visualization tools for Component Staffs and AF CAT situational awareness
- HQ-level library of FOL common installation pictures
  - Used to support "Go/No-Go" basing decisions
  - Allowed tailoring of TPFDD forces and resources
- Ground breaking synergy between CE, IN, LG, SF

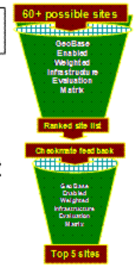


Slide 19

USAFE OIF Decision Analysis

Checkmate tasking: Provide engineering assessment of potential Iraqi forward staging sites

- Developed weighted infrastructure evaluation matrix
- Evaluated and ranked 60+ sites
- Forwarded top 5 recommendations, 2 of 5 have US forces there today
- Tasking took 2 people, 48 hours without boots on the ground

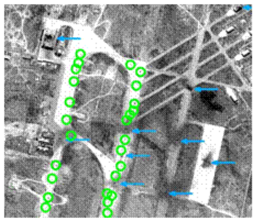


"Outstanding support, you keep hitting them over the fence"
- Checkmate Staff to ACC GeoReach

Slide 20

OIF Airbase Execution

- Provided airbase securing forces (820th & 86th CRGs) with potential seizure site imagery and related feature data
- Provided airbase recovery forces (1 ERHG) with airfield support and obstruction data
- Allowed TPFDD assets to be prioritized maximizing use of limited airlift assets
- Deployed CE commander:
  - *"Amazing detail without having put anyone in harm's way"*
  - *"Outstanding 75% solution, a critical time-saver for my troops"*



Slide 21

Future of GIS?

- Joint Operations are becoming the standard
- How are Service's Functions similar?
  - Army logistical hubs
  - Army forward presence tent cities
- Is the cross-flow of GIS information timely and helpful in Joint Operations? Is it possible?
- How could it be improved?
- Next AF GeoBase conference:

May 04 in San Antonio, Texas

https://www.il.hq.af.mil/geobase/index.cfm

ACC GeoReach Site: accgeo.langley.af.smil.mil

Slide 22

Acronym list

ACBG	Aircraft battle group
ACC	Air Combat Command
AEF	Air Expeditionary Forces
AFCS	Army Facilities Components System
AFPAM	Air Force Pamphlet
AFPC	Air Force Personnel Command
AMOPES	Army Mobilization and Operations Planning and Execution System
APS	Army Prepositioned Stock
ARG	Amphibious ready group
ATF	Amphibious Task Force
BDP	Base Development Plan
BRAC	Base Realignment and Closure
BTRA	Battlespace Terrain Reasoning and Awareness
CAD	Computer Aided Design
CAP	Crisis Action Planning
CAPP	Contingency aircraft parking planner
CATF	Commander Amphibious Task Force
CBMU	Construction Battalion Maintenance Unit
CESP	Civil Engineer Support Plan
CIP	Common Installation Picture
CJCS	Chairman of the Joint Chiefs of Staff
CLF	Commander, Landing Force
COA	Course of Action
CONPLANs	Contingency Plans
CSD	Coastal Scene Description program (Navy)
CTIS	Combat Terrain Information System
DCEM	District contingency engineer manager
DIA	Defense Intelligence Agency
DoD	Department of Defense
DTSS	Digital Topographic Support System
EBO	Effects-Based Operations
FOL	Forward Operating Locations
GAO	United States Government Accounting Office
GeoBEST	Geographic Base Engineering Survey Toolkit
GIS	Geographic Information System
GLIDE	Geographically Linked Information Display Environment

GPS	Global Positioning System
HN	Host Nation
IT	Information technology
JCS	Joints Chiefs of Staff
JFC	Joint Forces Commander
JFC	Joint Forces Commander
JP	Joint Publication
JPEC	Joint Planning and Execution Community
JSCEC	Joint Strategic Capabilities and Execution Community
JSCP	Joint Strategic Capabilities Plan
JTF	Joint Task Force
LF	Landing Force
LiDAR	Light Detection and Ranging
LOGCAP	Army Logistics Civil Augmentation Program
LOGCAT	Logistics Capability Assessment Tool
MAGTAFs	Marine Air-Ground Task Forces
MEB	Marine Expeditionary Brigade
MEF	Marine Expeditionary Forces
MEU	Marine Expeditionary Unit
MOOTW	Military Operations other than War
MPS	Maritime Prepositioning Ship
MPR	Maritime patrol and Reconnaissance
NAVFAC	Naval Facilities Engineering Command
NAVSTAR	Navigation System with Timing and Ranging
NC	Naval Complex
NCF	Naval Construction Force
NCFSU	Naval Construction Force Support Unit
NCA	National Command Authority
NCR	Naval Construction Regiment
NGA	National Geospatial-Intelligence Agency (Formerly known as NIMA, until 2004 Defense Appropriations Bill)
NIMA	National Imagery and Mapping Association, now NGA
NMCB	Naval Mobile Construction Battalion (the Seabees)
NSF	National Science Foundation
OPLANs	Operational Plans
PACAF	Pacific Air Forces
Prime BEEF	Prime Base Engineer Emergency Force
PWC	Public Works Center (Navy)
QDR	Quadrennial Defense Review (1997 or 2001)
RED HORSE	Rapid Engineering Deployable Heavy Operational Repair Squadron

	Engineer
SBCT	Stryker Brigade Combat Team
SIPRNET	SECRET Internet Protocol Router Network
TACAPS	Theater Army Construction Automated Planning System
TDA	Tactical decision aids
TEC	Topographic Engineering Center (USACE)
TPFDD	Time-Phased Force and Deployment Data
UCT	Underwater Construction Team
US	United States
USACE	United States Army Corps of Engineers
USAFE	United States Air Forces Europe
USCENTCOM	US Central Command
USEUCOM	US European Command
USNORTHCOM	US Northern Command
USPACOM	US Pacific Command
USSOUTHCOM	US Southern Command

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Vita

Captain Matthew H. Beverly graduated from Lewis-Palmer High School in Monument, CO. He entered undergraduate studies at the United States Air Force Academy in Colorado Springs, CO, where he graduated with a Bachelor of Science degree in Civil Engineering and was commissioned on 2 June 1999.

His first assignment, beginning in August 1999, was at Seymour Johnson AFB, NC, as an officer in the 4th Civil Engineer Squadron. At Seymour Johnson AFB, he worked as a civil engineer and filled the role as the base pavements engineer. While there, he was deployed as part of the ADVON team to Manas, Kyrgyzstan, to plan and construct a coalition airbase to support Operation Enduring Freedom.

In August 2002, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to the 823rd RED HORSE at Hurlburt, FL.

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14. ABSTRACT
This research investigated the armed services' current uses of GIS, and asked the question whether or not a joint GIS program could benefit the DOD. An information technology implementation model was presented as a framework to implement a joint GIS program.

It was found that all four armed services use GIS for forward deployments. The Army has its Combat Terrain Information System (CTIS). The Navy's digital nautical charts are a GIS. The Marine Corps has created their Geographically Linked Information Display Environment (GLIDE) program, which is similar to a map repository. Finally, the Air Force has its GeoBase program for installation GIS, and GeoReach is the expeditionary deployment base-planning subset.

The research methodology combined a case study and a Delphi study. The case study research examined a single Army GIS unit for current GIS implementation methods and uses. The Delphi study asked eight DOD GIS experts their opinions about current GIS uses and the possibility of a joint GIS program. Through the case study and Delphi research, it was found that information flow between the services is limited and that a joint GIS program may bring improved and new planning and executing capabilities for the DOD.

15. SUBJECT TERMS
Case study; Delphi Study, information technology implementation; geographic information system; geospatial information system; information resource management; GeoReach; Digital Topographic Support System, Geographically Linked Information Display Environment

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