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Installation Mapping Enables Many Missions

The Benefits of and Barriers to Sharing Geospatial Data Assets

Beth E. Lachman, Peter Schirmer, David R. Frelinger,
Victoria A. Greenfield, Michael S. Tseng, Tiffany Nichols

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Summary

From the Office of the Secretary of Defense (OSD) to workcenters on military installations, there is widespread use of geospatial information contained in digital databases, specialized software applications, documents, web services, and even hard copy maps for diverse functions and missions. Installations and environment (I&E) geospatial data assets not only support mission areas in DoD's business domain—including emergency response, environmental management, and facility and infrastructure planning—they also support the warfighting and intelligence mission areas.

The widespread use and sharing of I&E geospatial data assets yield many benefits, such as cost and performance efficiencies. Moreover, they can help decisionmakers manage other assets better, enable faster responses for time-sensitive decisions, and improve the communication process across diverse agencies. If data are shared, different organizations can save time and money by not having to develop and maintain the same data; they also avoid problems relating to inconsistencies and quality differences in the data. Using out-of-date or poor-quality data can affect the outcome of a decision or a mission using those data. Many of these effects are very real yet are difficult to quantify or measure.

To encourage the use and sharing of geospatial data assets, DoD and the Office of Management and Budget (OMB) have issued guidance and directives that stress the need for coordinating, sharing, and integrating geospatial data assets across DoD and other federal agencies. In July 2004, within the Deputy Under Secretary of Defense Installation and Environment Business Transformation (DUSD/I&E (Business Transformation)) directorate, a new organization—the Defense Installation Spatial Data Infrastructure (DISDI) Office was created to help facilitate the sharing and integration of I&E assets.

The objective of this RAND study is to assess the net effects of sharing I&E geospatial data assets within the business domain and across the business, warfighting, and intelligence mission areas of DoD's Global Information Grid (GIG) and to recommend how the DISDI Office could maximize the benefits of such sharing. For the study, RAND researchers interviewed over 100 producers and consumers of geospatial data assets, reviewed geospatial and effect assessment literature, and examined sample geospatial data assets to identify the range of missions and effects to them from current and potential future use of these assets. They also developed a methodology for assessing the mission effects of sharing such assets, using it to estimate some effects across DoD. In addition, barriers to sharing were identified and recommendations were made for how DISDI could help overcome such barriers.

What Is Shared, Who Is Sharing It, Why, and How

One of the most common and fundamental geospatial data assets is GIS (geographic information system) datasets. GIS is a class of software for managing, storing, manipulating, analyzing, visualizing, and using digital geospatial data. Geospatial data assets also include other products using geospatial data, such as software applications, documents, hard copy maps, and videos. Geospatial data software applications range from general GIS-based tool sets to simple and sophisticated mission-specific web-based applications.

U.S. military installations across the world are developing, using, and sharing I&E geospatial data assets. Most of the Services' basic digital geospatial data are created, updated, and maintained at the installation or regional level. Historically, the mission functional staff members who needed the data created, maintained, and updated them; for example, Department of Public Works (DPW) staff develop data on building and road infrastructures. Many installations develop and maintain hundreds of GIS data layers, with datasets at different levels of scale and time periods, often maintained because of different needs.

Because of advances in enterprise software capabilities and the growing realization of the benefits of sharing data, installations and the Services are taking a more centralized approach to developing and maintaining basic geospatial data assets. Some fundamental data layers, such as base boundaries, roads, buildings, imagery, and training range areas, are widely used and needed for gaining broad situational awareness across an installation. Therefore, each Service has identified (or is in the process of identifying) basic data layers to be used and shared by organizations across an installation in what is known as a Common Installation Picture (CIP). The idea is to have one map or set of geospatial data shared across each installation.

Service headquarters, functional commands, and regions also develop, maintain, and update geospatial data assets. Other DoD staff, such as DISDI and the National Geospatial-Intelligence Agency (NGA), also exploit I&E geospatial data assets; as an example, DISDI has created the DISDI Portal, a web site where DoD users can view and learn about Service I&E geospatial data. DISDI and other OSD organizations currently focus more on software applications and rely on the installations to supply them with the basic I&E geospatial datasets for those applications. Such organizations may also generate some strategic geospatial datasets, especially ones designed for looking across a region, a nation, or the world, such as a georeferenced point dataset showing installation locations in the world. The NGA develops geospatial data assets for the warfighting and intelligence communities.

But the Services are more than repositories or even managers of geospatial data assets. Each Service has headquarters geospatial organizations to facilitate the development, sharing, and use of geospatial data assets. They facilitate sharing within their respective Services by setting Service I&E geospatial data policies, by being a Service point of contact for geospatial data requests (which they usually forward to the appropriate Service organization), and sponsoring the development of Service-wide geospatial data web viewers so that many military users can access I&E geospatial data assets. Each office also participates with the DISDI Office efforts to establish a DoD-wide I&E geospatial community.

These Service organizations essentially are developing a spatial data infrastructure (SDI) for each of their respective Services. An SDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. Components of an SDI usually include institutional arrangements, policies and standards, data networks, technology, users, data, databases, and metadata.

DISDI serves a similar function for the business functions within DoD. It focuses on the business processes, people, and policies necessary to provide installation visualization and mapping capabilities. DISDI is not in the business of creating information technology (IT) systems; rather, it fosters mechanisms by which geospatial data stewarded by DoD installations can be shared with validated stakeholders to help meet their critical installation visualization and geospatial requirements.

DISDI's first major initiative was developing the Installation Visualization Tool (IVT) for the 2005 Base Realignment and Closure (BRAC) process.[1] The IVT was designed for "situational awareness" in the BRAC process and provided a way to view imagery and geospatial data in a consistent fashion for 354 sites, including training ranges, meeting BRAC 2005 threshold criteria. IVT data were used to support other analyses as part of the BRAC process, but no analysis was performed using the IVT data alone.

Through the efforts of DISDI, the Service headquarters, Major Commands, and the installations themselves, geospatial data assets are widely shared among many organizations. For example, these data assets are shared among regional and headquarters levels within the Services. Geospatial data assets are also shared across different Services and other DoD organizations for such mission functions as joint facil-

[1] Technically the IVT program office started the development of IVT in 2003, then IVT was transformed into a task of the DISDI Office in July 2004.

ity and environmental management, joint training, warfighting, and intelligence.

We found that there is also a large amount of current and potential sharing with other federal agencies outside DoD and with state and local governments that need geospatial information to assist with key governmental functions such as homeland security, environmental management, and disaster preparedness. Further, because of industry outsourcing, public-private partnerships, and other arrangements, I&E geospatial data are also shared with commercial entities to conduct infrastructure management. Finally, we also found that DoD organizations have a need to share with universities, nongovernmental organizations, and allied governments. Sharing, of course, is a two-way street and DoD organizations need to acquire other government agency data and industry data, such as that from utility companies.

I&E Geospatial Data Assets Enable DoD Business Functions and Warfighting and Intelligence Mission Areas

We identified 12 mission areas, based on traditional installation operations, for which I&E geospatial data assets are now being shared or have the potential to be shared:

- base planning, management, and operations
- emergency planning, response, and recovery
- environmental management
- homeland defense, homeland security, and critical infrastructure protection
- military health
- morale, recreation, and welfare: enhancing quality of life
- production of installation maps
- public affairs/outreach
- safety and security
- strategic basing

- training and education
- transportation.

To illustrate how the I&E geospatial data assets enable different business missions within different parts of DoD, we present diverse examples in the text and an even richer set of examples in the appendix. In this summary, we offer three abbreviated examples of mission support for different organizational levels using the asset.

- **Installation level use:** At the installation level, I&E geospatial data assets have been used to help develop, assess, manage, and operate numerous installation assets, from buildings to natural resources to training ranges. For example, at Fort Hood, Texas, the range GIS aerial and topographic data are used in tank and aviation simulators, which help orient the soldier and saves valuable time on the training range. For A-64 Apache helicopter training, it has cut the amount of time that pilots need to spend on the gunnery range by about one-third.
- **Office of the Secretary of Defense application:** Various offices within OSD use I&E geospatial data assets to help in their strategic analysis, planning, management, and operations. Many of these applications are more recent and are taking advantage of IVT data. The OSD Health Affairs TRICARE Management Activity (TMA)/Health Programs Analysis and Evaluation Directorate has been developing a GIS-based "Military Health System Atlas," to help examine and assess military medical capabilities and their populations. This OSD office uses I&E geospatial data assets in this atlas to help with decisions about medical resource allocation.
- **Uses by other parts of DoD and organizations outside DoD:** Other parts of DoD, such as NGA, and organizations outside DoD, such as state and local governments, also use I&E geospatial data assets, especially for emergency response and homeland defense/security missions. With U.S. Geological Survey support, NGA has the federal lead on Project Homeland, a collaborative effort to provide geospatial information to federal, state, and local

government agencies for homeland planning, mitigation, and response so that the U.S. government can more effectively respond to incidents—whether a terrorist attack or a natural disaster.

I&E geospatial data assets also support different warfighting missions across DoD, including:

- command, control, communications, and computer (C4) systems
- logistics
- warfighting operations
- strategic planning, policy, and assessments.

Here we provide only one example for the warfighting mission that is related to deployed operations but many more are provided in the main document. I&E geospatial data models and techniques are used at forward bases and sites to help build, manage, and operate these sites, such as helping address force protection, critical infrastructure, and other safety concerns. Sharing geospatial expertise help saves money and time and improves safety and planning to help save lives. For example, the Assessment System for Hazardous Surveys (ASHS) program, a GIS-based application software tool to assess capacities for explosive safety hazard reduction, has been used to help plan and manage explosives safety at deployed host nation bases supporting operations in Afghanistan and Iraq.

Assessing Mission Effects

Not only do I&E geospatial data assets aid in a wide range of mission areas, they also generate many different types of mission effects. As we will show, these effects are seen at all levels within DoD—from an individual office on an installation to the Office of the Secretary of Defense. Our definition of effects is broad and includes the attainment of desired outcomes by the individual organization developing, using, or sharing the assets and any other outcomes to any organization from that asset development, use, and sharing. We identified four categories of effects from using and sharing geospatial data assets:

- changes in efficiency
- changes in effectiveness
- process changes
- other mission effects.

At least implicitly, we are suggesting that the goal of use and sharing is to improve the efficiency and effectiveness of organizations' efforts to attain mission objectives, although in some instances, it may have an even more direct and immediate bearing on mission attainments. Organizations often invest in geospatial data assets with the expectation of efficiency effects, in the form of time savings or cost avoidance, and effectiveness effects, in the form of new or improved outputs and outcomes, such as improved operations and decisionmaking. Table S.1 provides some examples of effectiveness effects for different mission areas.

However, organizations often underestimate the extent of those gains. For example, once the data and related systems are in place, organizations often identify additional uses that improve efficiency even more, or they find that the intended use of the geospatial data assets generates benefits that were never anticipated, such as improved communications between two offices or automating a formally manual process.

We were asked to help the DISDI Office identify a methodology for assessing the net mission effects of developing, using, and sharing geospatial data assets across the GIG. We recommend applying a methodology that consists of three elements:

1. Construct an information flow model to understand the range of organizations using and sharing an I&E geospatial data asset.
2. Apply a set of logic models to map how the inputs, activities, and outputs of an organization's data development, use, and sharing lead to outcomes for different customers.

Table S.1
Sample Effectiveness Effects from Using I&E Geospatial Data Assets, by Mission Area

Mission Area	Sample Effectiveness Effects
Base planning, management, and operations	Better placement and siting of new facilities, such as buildings Improved infrastructure and facility construction, management, and oversight Better use of construction and maintenance resources
Emergency planning and response and homeland defense and security [a]	Improved planning and response decisionmaking by having more accurate and common situational awareness of potential and actual incidents Faster response times Better coordinated response with other federal, state, and local agencies Better pre-placement and use of resources
Environmental management	Improved environmental quality, such as reducing erosion and improving water quality Protecting habitat, species, and cultural resources while maintaining installation operational flexibility Reduction in noise complaints More effective working collaborations with community and other stakeholders to address environmental issues
Training	Improved siting of a training range or testing facility by minimizing safety and environmental effects Increased operational flexibility at a training range Increasing the number of hours that a training range or testing facility can be used Cutting by one-third the time on a training range Being able to use more of the installation for training
Warfighting operations	Improved management and operations of base camps and other forward operating sites (FOSs) Improved force protection and safety at base camps and other FOSs More rapid deployment and better use of resources in deployments Faster and more accurate assessments of adversary operations, such as insurgency attacks in Iraq Improving postconflict reconstruction by providing tools for infrastructure reconstruction and management

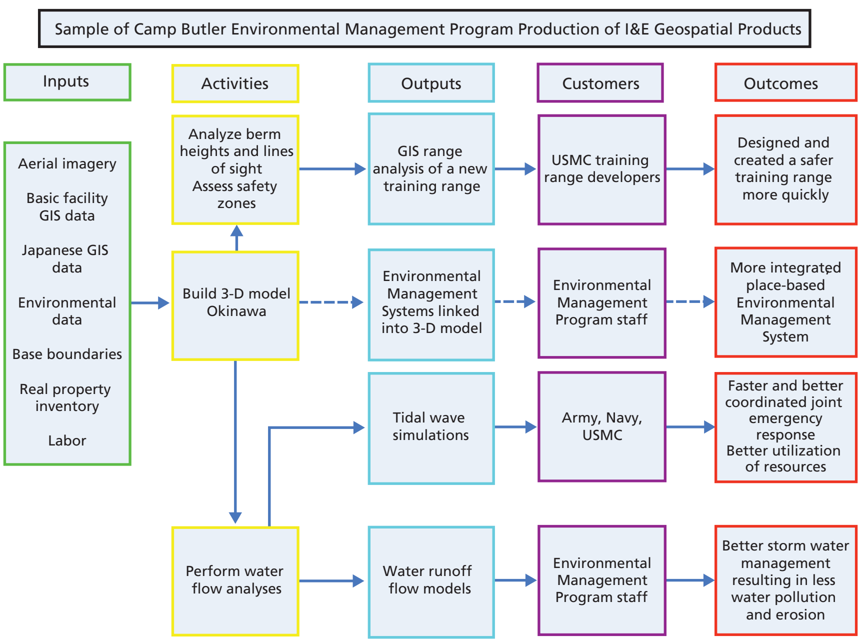
[a] Since these mission areas have some of the same effectiveness effects, they were grouped together here. See details in the appendix for each mission area's application.

3. To the extent possible, when the data are available, employ a variety of methods for quantifying the logic models.

The information flow model diagrams organizations and the geospatial data assets that they share to understand the institutional structure. This is the first step to understanding how geospatial data assets are shared. Along the way, each organization may see one or more effect. The second step is to apply logic models, which illustrate how the inputs and activities of an organization potentially lead to beneficial outcomes—in other words, logic models illustrate the underlying logic of an organization's activities in relation to an intended end state.

Figure S.1 presents a logic model for some of the geospatial activities of the Camp Butler Environmental Management Program in Okinawa. This logic model shows that the program uses geospatial data

Figure S.1
Logic Model for Camp Butler Environmental Management Program



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that are collected and managed on the installation as well as data provided by the local community. One key intermediate activity is the creation and maintenance of a 3-D model of Okinawa, which is used to help support watershed modeling, training range development, and tsunami simulations. The activities and outputs of this program support different customers and mission areas (under the outcomes), including training, emergency response, and environmental management. For example, the tsunami simulations improved joint planning and emergency response training, which results in better joint decisionmaking, coordination, and communication; faster response times; and better use of resources for an emergency incident; whereas the water runoff flow models and analysis helped the environmental staff better manage storm water runoff so that there is less pollution and fewer erosion problems from the runoff, such as by more efficiently placing the technologies to capture and treat oil runoff from parking lots. The dashed line indicates that one output based on the 3-D model is planned but has not yet been implemented.

The third step is to apply methods for quantifying some of the effects using the logic models when data are available. We were able to collect some data directly from personnel we interviewed at different installations. In other cases, more complete data were available because other researchers have conducted a cost-benefit analysis or done related research.

In our interviews with Langley AFB personnel, we found that two construction-related functions—dig permitting and delivery order processing—saved from 450 to 2,600 man-hours annually by using geospatial data assets in place of more labor-intensive manual activities.

Aberdeen Proving Ground and Naval Air Station Patuxent River conducted benefit-cost analyses that provide a more complete picture of the net effect of using and sharing geospatial data assets. In 1992, the DPW at Aberdeen Proving Ground conducted a cost-benefit study for the implementation of a GIS for different mission uses across the installation and estimated a net present value of $3 billion in 1992 dollars over an eight-year period. Most of the benefits were in the form of monetized workload reductions. The Patuxent River study took a much broader view of its IT investments and assets and valued its net benefit at $82.5 million in 2000 dollars. Those mission functions involving geospatial data assets accounted for about $1.4 million in annual gross benefits.

Using these quantitative measures and DoD's *2005 Base Structure Report*,[2] we show how a relatively straightforward extrapolation can produce a ballpark order-of-magnitude estimate of the total potential effect across all DoD installations in the United States.[3] We present the results of extrapolations in Table S.2 and provide more detail on the calculations in Chapter Seven. Note that these results are very rough approximations and rely on a very small sample set and the original estimations provided by persons we interviewed and studies reviewed. Thus, we suggest that although these are estimations, they help to convey a sense of how large the potential annual benefits may be, measured narrowly in terms of mostly workload reductions.

Table S.2
Order-of-Magnitude Estimation of Potential Annual Benefits of I&E Geospatial Data Asset Use at DoD U.S. Installations

	Annual Savings at the Installation	Extrapolation to All DoD U.S. Installations
Langley dig permitting and construction order processing	450 to 2,600 hours per year	About 100,000 to 600,000 hours per year, which is equivalent to 50 to 300 full-time personnel[a]
Aberdeen Proving Ground gross benefits	$1.3 million (2005 dollars)	$200 million (2005 dollars)
NAS Patuxent River gross benefits	$1.7 million (2005 dollars)	$360 million (2005 dollars)

[a] Assuming a 2,000 hour work year, the savings equate to between about 50 and 300 full-time personnel.

2 Department of Defense (2005a).

3 We base the extrapolations on the assumption that total plant replacement value (PRV) and total base personnel (both of which are reported in the *2005 Base Structure Report*) are roughly proportional to the amount of savings realized at an installation. If an installation such as Patuxent River accounts for about 0.5 percent of all U.S. PRV and personnel, we assume that its benefits account for about 0.5 percent of all potential U.S. savings from using geospatial data assets. In this estimate, we used only U.S. installations, since operations at installations in other parts of the world may have different procedures.

Benefit-cost, return on investment (ROI), cost-effectiveness, and cost-avoidance analyses can be powerful decisionmaking tools that provide quantitative measures of certain types of effects—mainly efficiency gains, such as time and dollar savings. But because they are computationally complex, time-intensive, and not easily updated, such methods are probably not feasible to use by themselves on an ongoing basis to measure and monitor the full effects of efforts of the DISDI Office and other organizations to promote the use and sharing of geospatial data assets. Our methodology of using together the information flow models, logic models, and such quantifying methods (when feasible) provides a more appropriate tool for assessing effects.

Likely Future Use and Sharing of I&E Geospatial Data Assets

The development, use, and sharing of I&E geospatial data assets continue to grow for many reasons. The data and technology are now easier to use in more user-friendly ways, such as in web-based systems; standards and interoperability conditions are being implemented that help facilitate use and sharing by multiple organizations and individuals; efficiency and effectiveness benefits are being realized, which helps facilitate investment in these resources; sharing is mandated by OMB Circular A-16; and centralized military organizations, such as the Service headquarters offices and DISDI are now facilitating the use and sharing of such assets.

Because of these factors, the use and sharing of I&E geospatial data assets across the GIG will likely continue to increase. We identified some likely future trends in several mission applications. First, there will likely be more use by the warfighting and intelligence communities. The relationship between these communities and the installations will evolve because of the benefits in collaborating to improve the speed and effectiveness of the U.S. military's ability to rapidly deploy and respond where needed around the world to fight the Global War on Terrorism as well as perform other missions, such as providing humanitarian assistance.

The second trend is increased demand and use of I&E geospatial data assets by other parts of OSD and DoD. The demand is driven by the benefits to decisionmaking and management that result from integrating, aggregating, and sharing geospatial information from installations to higher management, in such areas as real property, environmental issues, military health capabilities, and safety. Sharing will also likely increase with NGA because of the need to coordinate all types of geospatial information across all of DoD and the growing use of I&E geospatial data assets to support warfighting and intelligence missions.

A third trend is the increased demand for nonmilitary community geospatial data by DoD agencies and for I&E geospatial data assets by nonmilitary communities. Military installations want and need access to local, state, and federal data to help perform their missions. For some organizations, such as the U.S. Army and Air National Guard, such sharing with state and local governments is critical to their mission. Likewise, other U.S. government agencies need geospatial information to help with key U.S. government functions, such as homeland security, environmental management, disaster preparedness and response, and land-use planning. And at the local level, military installations share their I&E geospatial data assets with adjacent local governments to help with joint infrastructure, utility, safety, and natural resource management and for emergency planning and response.

Finally, a fourth trend is the evolution of geospatial applications toward web-based spatial applications, using more real-time information, and integrating and sharing more detailed information from diverse sources.

Despite these trends, we have identified a number of barriers that continue to impede successful sharing of I&E geospatial data assets. The main ones identified in our study are

- security concerns and other data restrictions
- different IT system, firewalls, and policies
- lack of communication or collaboration between different functional organizations and disciplines

- lack of knowledge about, interest in, or expertise to use I&E geospatial data assets
- lack of data-sharing policy, standards, and contractual agreements
- reluctance of data stewards to share assets, fearing that they will lose control over access to their data
- lack of on-going high-level program support and investments
- risks from sharing undocumented, poor-quality, and out-of-date data.

Such barriers will need to be addressed to realize significant increases in the future use and sharing of I&E geospatial data assets across the GIG. DISDI and the Service geospatial information offices are playing an important role in addressing such barriers.

Recommendations

In April 2006, NGA was formally identified to OMB as the lead office for DoD geospatial information management issues. We offer a number of recommendations for how DISDI, in partnership with NGA, can do even more to help DoD overcome the barriers to I&E geospatial data asset development, use, and sharing. The first set of recommendations relate to policy. The DISDI Office serves an important role in setting OSD policy regarding I&E geospatial data assets. DISDI should collaborate with NGA to provide more official OSD policy guidance about the need to share geospatial data assets, about security concerns, and about how to share assets, such as by providing guidance about developing memoranda of understanding/agreement (MOUs/MOAs) for data sharing.

The DISDI Office also has an important role in coordination and outreach regarding I&E geospatial data asset development and sharing within as well as outside DoD. The DISDI Office has already done a lot to help coordinate and conduct outreach across DoD about the need to share and how to share. DISDI should continue and expand on coordination and outreach efforts inside DoD, assist OSD organizations in their acquisition and use of I&E geospatial data assets, cultivate a close working partnership relationship with NGA, and expand outreach and coordination outside the DoD.

Since standards, contracting, and quality control processes are all key to the sharing of I&E geospatial data assets, DISDI has an important facilitator role in such processes. First, it should help develop and promote I&E geospatial data standards development and adoption. It is also important that DISDI provide OSD policy and standard contracting language for military contracts that involve digital geospatial data and analysis.

The tasks mentioned above represent quite a large workload for the current DISDI staff. DISDI presently has a director and four contracted staff members and some limited funds to allocate for projects. Given such tight resources, it is important that DISDI is managed wisely. We present three recommendations. The first is to examine the benefits and feasibility of temporarily expanding the DISDI staff, perhaps using knowledgeable geospatial staff Intergovernmental Personnel Act (IPA) assignments from other DoD organizations part time at DISDI.

Second, to help assess its success in promoting data sharing, DISDI should apply the methodology we developed for assessing effects, i.e., using together information flow models, logical models, and, when feasible, cost-benefit analysis and other quantifying methods. DISDI can use this approach to help understand, assess, and explain the full range of effects from the development, use, and sharing of I&E geospatial data assets. Such assessments can be used to help DISDI manage its current and future investments.

Last, we recommend that DISDI establish processes for managing future investments by applying the Government Accountability Office (GAO)[4] maturity model. Long-term improvements in processes, policies, and organizational relationships can be planned systematically using the IT Investment Management (ITIM) maturity model developed by the GAO.

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[4] Effective July 7, 2004, this agency's name changed from General Accounting Office to Government Accountability Office.

Conclusions

U.S. military I&E geospatial data assets are being shared with many different organizations in many different ways inside and outside the DoD. The assets support many mission areas—from the installation level to the Office of the Secretary of Defense. The effects from such use and sharing relate to both efficiency, such as cost and manpower savings, and effectiveness, such as improving operations and decision-making. There are also secondary benefits, such as improving communications and working relationships. However, the use of I&E geospatial data assets in many of these areas has just begun and more needs to be done to fully accrue such benefits across the GIG. Data asset use and sharing, and the benefits, will likely increase and reach even more users within DoD. However, barriers exist to such sharing. The DISDI Office and the Service geospatial information offices serve an important role in addressing the barriers to data asset sharing to facilitate more I&E geospatial asset development and sharing across the GIG.

By implementing the methodology suggested here to help show the benefits of geospatial data sharing and the policy recommendations outlined for the DISDI Office, I&E geospatial data asset development and sharing will continue to increase and to accrue significant financial and operational benefits across the GIG helping to improve mission performance and ultimately save lives and dollars.