Building Sustainable Installation Geospatial Information and Services (IGI&S) Programs: A Program Management Framework of Capacity Building Strategies

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Table of Contents

List of Figures

List of Tables

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List of Abbreviations

ADS	Authoritative Data Store
AOR	Area of Responsibility
BRAC	Base Realignment and Closure
CIP	Common Installation Picture
COI	Community of Interest
DISDI	Defense Installation Spatial Data Infrastructure
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
EI&E	Energy, Installations, and Environment
FASCLASS	Fully Automated System for Classification
FDCCI	Federal Data Center Consolidation Initiative
FIAR	Financial Improvement and Audit Readiness
FY	Fiscal Year
GISci	Geographic Information Science
GIS	Geographic Information System
GDM	Geospatial Data Model
GPS	Global Positioning System
GOCO	Government-Owned Contractor-Operated
GOGO	Government-Owned Government-Operated
IDP	Individual Development Plan
IT	Information Technology

IGI&S	Installation Geospatial Information and Services
I&E	Installations and Environment
MCAGCC	Marine Corps Air Ground Combat Center
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCIWEST	Marine Corps Installations West
MCLB	Marine Corps Logistics Base
MCMWTC	Marine Corps Mountain Warfare Training Center
MCRD	Marine Corps Recruit Depot
NGA	National Geospatial-Intelligence Agency
NIMA	National Imagery and Mapping Agency
NSDI	National Spatial Data Infrastructure
NSG	National System for Geospatial Intelligence
OCC	Object Classification Code
OASD	Office of Assistant Secretary of Defense
OMB	Office of Management and Budget
OPM	Office of Personnel Management
PPBE	Planning, Programming, Budgeting, and Execution
PMI	Program Management Institute
PWO	Public Works Officer
RFO	Regional Facilities Officer
REST	Representational State Transfer
ROI	Return on Investment

SLA	Service-Level Agreement
SDSFIE	Spatial Data Structure for Facilities, Infrastructure, and Environment
SWOT	Strengths, Weaknesses, Opportunities, Threats
SME	Subject Matter Expert
TECOM	Training and Education Command
UFC	Unified Facilities Code
URISA	Urban and Regional Information Systems Association
USGIF	United States Geospatial-Intelligence Foundation
WBS	Work Breakdown Structure

Abstract

Prior to Base Realignment and Closure (BRAC) 2005, military installations used Geographic Information Systems (GIS) in an ad-hoc capacity for a variety of installation management issues. BRAC, both a fiscal and political issue, required a common set of digital data and maps to visualize Department of Defense (DoD) installations in a GIS to support the real property–lifecycle process and associated decision-making central to the effort. This integration, however, began to provide business benefits in other installation management areas supported by policies such as the Paperwork Reduction Act of 1995, the Clinger-Cohen Act of 1996, and the E-Government Act of 2002. IGI&S programs have grown to provide geospatial data and tools for a variety of Installations and Environment (I&E) domains, including, but not limited to, planning, management, and operations, emergency response and recovery, environmental management, homeland defense, housing, recreation, and transportation. This research presents capacity building strategies and techniques to assist in both quantifying and qualifying IGI&S programs in the face of competing service- and installation-level priorities that often leads to defunding IGI&S programs. A lack of fiscal discipline in executing service-validated funding priorities such as IGI&S, in favor of local requirements puts life, health, and safety at risk as critical installation functions and services require IGI&S geospatial data to execute their mission. A withdrawal of investment in IGI&S also delays DoD strategic initiatives meant to improve installation functions and services, contributing to the decline of installations as projection platforms of military readiness and power during a time in which joint-force training and interoperability remains critical to US military superiority in the fight against emerging threats.

Chapter 1: Introduction

In “Towards a Theory of GIS Program Management,” Jochen Albrecht articulates that “little attention has been paid to a systematic approach in support of [Geographic Information Systems (GIS)] Program Management,” beyond the occasional critique of “business and organizational aspect[s] of GIS in the 1990s,” (Albrecht 2015, 1). Since then, several institutions and organizations developed, and have continued to expand on, capability and competency frameworks for subdisciplines within Geographic Information Science (GISci) in support of an overall GIS Body of Knowledge. These frameworks primarily focus on best practices and standards for GIS data, analysis, and visualization, and supporting the development of those that utilize GIS to address spatial problems. They do not, however, address the roles, responsibilities, and challenges facing the people that build and maintain the GIS that supports their organizational mission.

The Program Management Institute (PMI) defines program management as, “a group of related projects managed in a coordinated manner to obtain benefits not available from managing them individually. Program management is the application of knowledge, skills, tools and techniques to meet program requirements,” (PMI 2017a, 8). GIS program management serves as the coordinated administration of related GIS projects through the application of GIS knowledge, skills, tools and techniques, to meet organizational objectives and requirements. Only within the last ten years has GIS program management surfaced as a subfield that requires attention. Many problems and challenges exist within the GIS program management domain, and while individual GIS programs are unique, they all require, “GIS Infrastructure (people, hardware,

software, and data) + Ability," (Babinksi 2017, 16). This formula represents GIS capacity, an organization's ability to achieve its mission effectively and to sustain itself over the long-term (Babinski et al. 2017, 15). Capacity building refers to "the process of developing and strengthening the skills, instincts, abilities, processes and resources that organization and communities need to survive, adapt, and thrive in a fast-changing world," (Babinski et al. 2017, 17). When implemented properly, capacity building strategies enable GIS program managers to quantify and qualify their program, showing effectiveness and efficiencies that translate into value. Capacity building strategies that improve an organization's GIS infrastructure and ability can result in optimized GIS Return on Investment (ROI) (Babinski et al. 2017). GIS ROI measures the amount of return an investment in GIS yields, relative to the cost of the investment, both initial and ongoing. GIS capability that results in quantifiable cost avoidance or savings makes an investment in GIS worthwhile.

While existing research discusses capacity building challenges such as GIS program governance, GIS programmatic and data health, approaches to technical architecture, stakeholder engagement, cost/benefit analysis, and so forth, sources only provide generic frameworks meant to appeal to a broad spectrum of domains with GIS applications. Gaps exist in providing actual applied methodologies or guidance documentation tailored to different GIS domain applications. This research investigates Department of Defense (DoD), Office of Assistant Secretary of Defense (OASD) for Energy, Installations, and Environment's (EI&E), Installation Geospatial Information and Services (IGI&S) programs, the programs responsible for installation management–related geospatial data and services. This work will present capacity building strategies

to assist in both quantifying and qualifying IGI&S programs to show program value, optimize resources, and support calculation of ROI.

1.1 IGI&S Program Origins and Mission

Prior to 2005, installations used GIS for a variety of ad-hoc on-installation management issues, such as base planning and operations, environmental compliance and resource conservation, and safety and security. These ad-hoc implementations, however, did not support interoperability among the services through a common data standard or shared geospatial resources. The initial push for interoperability came during Base Realignment and Closure (BRAC) 2005—the congressionally authorized process used to reorganize the DoD's installation structure to more efficiently and effectively support forces and increase operational readiness (Lachman, Schirmer, Frelinger, Greenfield, Tseng, and Nichols 2007). While U.S.C.10 establishes the National Geospatial-Intelligence Agency (NGA) to provide geospatial intelligence services in support of the warfighter worldwide, NGA does not provide the support needed for on-installation mission requirements and activities. BRAC, both a fiscal and political issue, required a common set of digital data and maps to visualize Department of Defense (DoD) installations in a GIS to support the real property–lifecycle process and associated decision-making central to the effort (US Department of Defense 2009). This integration began to provide business benefits in other installation management areas supported by policies such as the Paperwork Reduction Act of 1995, the Clinger-Cohen Act of 1996, and the E-Government Act of 2002 (US Congress 1995, 1996, 2002). Joint Publication 3-34, Joint Engineer Operations, contained the first formal mention of the IGI&S requirement and capability, as part of a broader integration into

engineering operations (US Department of Defense 2007). IGI&S programs have grown to provide geospatial data and tools for a variety of Installations and Environment (I&E) domains, including but not limited to planning, management, and operations, emergency response and recovery, environmental management, homeland defense, housing, recreation, and transportation.

The Office of Assistant Secretary of Defense (OASD), Energy, Installations and Environment (EI&E) created the Defense Installation Spatial Data Infrastructure (DISDI) group to support the requirement, with an aim to close gaps formed by a rapid advance of GIS technology in the installation management mission area that led to ad-hoc data standards and GIS implementations at individual military installations. DISDI develops and establishes standards for installation geospatial data—the Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE). In 2015, DoDI 8130.01 Installation Geospatial Information and Services closed the policy gap by documenting the capability in application to the management of DoD installations and environment to support military readiness in regards to facility construction, sustainment, and modernization (US Department of Defense 2017a). IGI&S programs provide professional GIS data, analysis, and visualization services, create and maintain real property GIS data, serve as subject matter experts (SMEs) on geospatial technology, data standards and compliance, and oversee installations' geospatial authoritative datastore (ADS). IGI&S programs continue to evolve and change in the midst of policy developments, such as the Geospatial Data Act of 2018 and the Open Government Data Act of 2019, new and emerging requirements, and resource constraints (US Congress 2018, 2019).

1.2 Motivation for Framework Development

According to Huxhold and Levinsohn, a “successful GIS implementation…depends upon understanding the real world in which [an] organization operates—how changes to real world features affect the information needed by the organization and how information systems are used to support the functions that deal with such changes,” (Huxhold and Levinsohn 1995). Each military service has a constitutional role codified in US law that comprise training and forward-basing, and strategic-deployment capabilities. The mission of a service and an installation impacts the spatial environment that the GIS must capture, as well as the requirements, priorities, and taskings of its IGI&S program. IGI&S Managers must know the features common across installations, while understanding the unique requirements and complexities of their installation’s landscape. While the built environment possesses similar features across the installation landscape, such as buildings, roads, and utilities, an installation with a training focus will have a different requirement for the amount of range and training area and support infrastructure than a logistics base that will require more repair, maintenance, and storage infrastructure. Installations operate much like municipalities providing important services to the individuals and families that live and work on them.

This research presents capacity building strategies and techniques to assist in both quantifying and qualifying IGI&S programs in the face of competing service- and installation-level priorities that often leads to defunding IGI&S programs. A lack of fiscal discipline in executing service-validated funding priorities such as IGI&S, in favor of local requirements puts life, health, and safety at risk as critical installation functions and

services require IGI&S geospatial data to execute their mission. A withdrawal of investment in IGI&S also delays DoD strategic initiatives meant to improve installation functions and services, such as 21st Century Installations and Airbases, Financial Improvement and Audit Readiness (FIAR) compliance, and Infrastructure Reset, exacerbating the problems at the installation level. This contributes to the decline of installations as projection platforms of military readiness and power during a time in which joint-force training and interoperability remains critical to US military superiority in the fight against emerging threats.

1.2.1 Study Area and Spatial Challenges

Marine Corps Forces engage in land, air, and sea missions, creating a diverse strike-force that can fight a full spectrum of threats and possessing a variety of installations with different purposes to serve their training and readiness requirements. Marine Corps Installations West (MCIWEST) Command presides over installations within its area of responsibility with a variety of mission focuses and diverse locations and landscapes, supporting all I&E functions. MCIWEST comprises five aligned installations: Marine Corps Base (MCB) Camp Pendleton, Marine Corps Air Station (MCAS) Camp Pendleton, MCAS Miramar, MCAS Yuma, and Marine Corps Logistics Base (MCLB) Barstow. MCIWEST also supports three non-aligned Teaching and Education Command (TECOM) installations: Marine Corps Air Ground Combat Center (MCAGCC) Twenty-nine Palms, Marine Corps Mountain Warfare Training Center (MCMWTC) Bridgeport, and Marine Corps Recruit Depot (MCRD) San Diego (US Department of the Navy 2013). While these installations report to TECOM, they engage

in a supported/supporting relationship with MCIWEST and are considered part of MCIWEST's area of responsibility (AOR) for EI&E functions.

The installations that comprise the AOR possess a diversity of mission responsibilities, locations, and landscapes. MCB Camp Pendleton, between San Diego and Orange County, covers a large swath of land from the coast inland allowing for amphibious warfare training along its shores to infantry training in its inland terrain. MCAS Miramar, located in central San Diego County, supports aircraft operations and trains, equips, and deploys air forces for expeditionary missions. MCAS Yuma, located in the Sonoran Desert, possesses open terrain for air-to-ground weapons training and military flight operations, and uniquely shares airfield facilities with Yuma International Airport. MCLB Barstow, located in the Mojave Desert, rebuilds and repairs ground-combat and combat-support equipment and sits in a core transit corridor for both rail and vehicle transport. MCAGCC Twenty-nine Palms, located in the Morongo Basin and Mojave Desert, supports live-fire combined-arms training and readiness of operating forces. MCMWTC Bridgeport, located in the Humboldt-Toiyabe National Forest, exists to prepare Marines for operations in mountainous, high-altitude, and cold-weather environments. MCRD San Diego, located in urban downtown San Diego, supports the initial training of enlisted male recruits and houses both recruiter and drill instructor schools. Figure 1 Installations in the MCIWEST AOR depicts the geographic location of these installations.

Sources: best available geospatial data compiled from Esri, US Department of Defense, and US Geological Survey as of 2019.

Figure 1 Installations in the MCIWEST AOR

These differences in missions and environments results in diverse spatial landscapes, which must be captured in a common data standard to support interoperability among the services. IGI&S programs work to mitigate these landscape challenges when collecting, creating, and maintaining geospatial data by finding commonalities when developing a single authoritative Geospatial Data Model (GDM), data layer standards, and metadata content guides. Additionally, per DoDI 8130.01 IGI&S possesses standards unique to I&E challenges, but must still align to the National Spatial Data Infrastructure (NSDI) (Office of the President of the United States 1994) and the National System for Geospatial Intelligence (NSG) (National Geospatial-Intelligence Agency 2018). Implementing program management practices can support these efforts and improve capacity to execute them.

1.2.2 IGI&S Program Management Challenges

Installations face challenges in the form of GIS implementation, resourcing, professional development, data proponency and stewardship, data creation, maintenance, management and sharing of geospatial data, quality assurance and control, and contracting. As a result, IGI&S Managers must work efficiently and advocate effectively in order to improve the capacity of their program. Unfortunately, IGI&S Managers often lack training, support, guidance, and/or time to create a comprehensive IGI&S program management plan. IGI&S Managers come from a diverse set of backgrounds, disciplines, and experiences, and sometimes receive the role as a collateral duty. For IGI&S program success, IGI&S Managers require a program management framework tailored to their line of business to help address challenges and support capacity building.

Existing GIS program management frameworks provide foundational concepts and recommendations, such as gathering requirements through interviews, focus groups, and working groups, creating a budget for hardware and software, or assessing data for quality (Croswell 2009); however, little research exists on the practical application and outcomes of these techniques in the context of IGI&S programs. IGI&S reports and presentations focus predominately on the movement towards a unified data model, data quality and standards, data sharing and interoperability, and DISDI and service-level policy. Services and their installations occasionally provide insight into projects at major conferences, such as the Esri International User Conference or the Esri Federal Users Conference, but none have provided a comprehensive in-depth analysis of IGI&S program management strategies. An IGI&S program management framework must align to strategic priorities and organizational goals, and must address critical questions, such as:

1) What resources does the IGI&S program require to function effectively and efficiently and why?
2) What value does the IGI&S program provide to an installation?
3) What risk does the installation accept if it chooses to defund IGI&S?
4) How can IGI&S Managers communicate effectively to nontechnical leadership, especially those leaders making critical decisions about the IGI&S program's future, who may lack understanding or consideration for the greater organizational strategic priorities?

The IGI&S Program Management Framework uses foundational concepts from PMI's *Project Management Body of Knowledge* and *Standard for Program Management*, Peter Croswell's *GIS Project Management,* and Urban and Regional Information Systems Association's (URISA) GIS Leadership Academy. Chapters covering methods draw from professional and scholarly articles, theses, dissertations, conference proceedings and interviews with IGI&S community members and GIS Program Management experts. Analysis and significance of the proposed methods using IGI&S programs in the MCIWEST AOR will provide demonstrative use cases where capacity building strategies have been applied to reinforce recommendations.

1.3 The IGI&S Program Management Framework

The IGI&S Program Management Framework serves as a model for IGI&S programs within the DoD in need of a program management framework to build GIS program capacity. The framework possesses four key principles: 1) understand your business, know your requirements; 2) develop a holistic GIS infrastructure lifecycle management plan; 3) perform-to-budget and budget-to-perform; and 4) empowering people and communities of interest. Each principle contains several methods for executing the concept. Figure 2 The IGI&S Program Management Framework depicts the principles in a cycle and their corresponding methods.

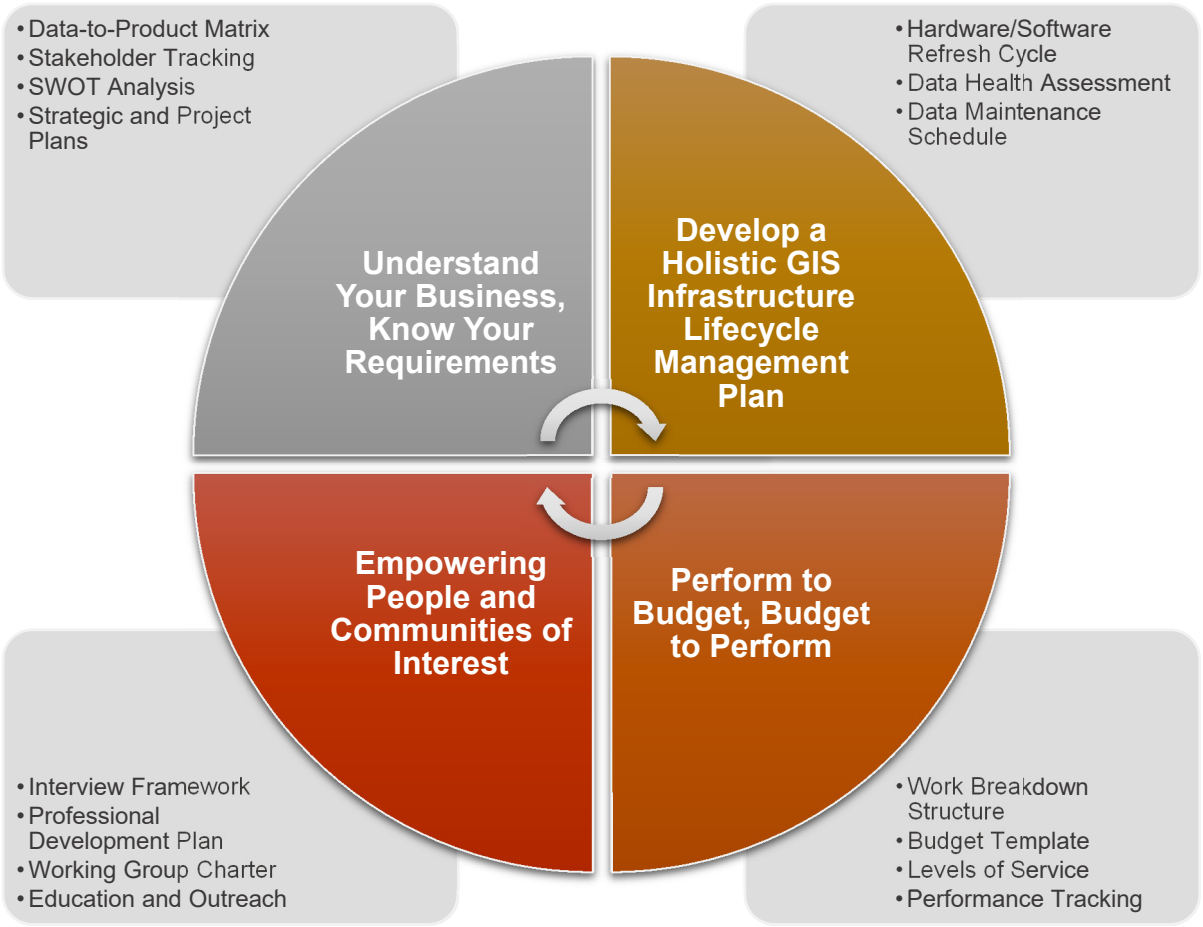

Figure 2 The IGI&S Program Management Framework

Each chapter begins by defining a framework principle and meaning, then conveys key GIS program and project management background concepts for the principle, identifying gaps within as it relates to IGI&S. Each chapter then proceeds with providing the methodology and example implementations of the concept. Each chapter closes with an analysis of the significance of the principle and outcomes. Chapter 2, Understand Your Business, Know Your Requirements, explores several methods for requirements gathering and provides examples to help form a comprehensive view of the state of an IGI&S program. Chapter 3, Develop a Holistic GIS Infrastructure Lifecycle Management Plan, addresses how to use requirements to formulate a plan to

acquire and maintain vital equipment (hardware and software), as well as data, through its lifecycle. Chapter 4, Perform to Budget and Budget to Perform, investigates methods for determining performance metrics and collecting information to drive metrics, as well as formulating sustainable budgets aligned to levels of risk. Chapter 5, Empowering People and Communities of Interest, examines professional development of core IGI&S staff and modes of outreach and education to leadership, stakeholders, and the user community at large. Finally, Chapter 6 concludes the discussion tying together the outcomes and their meanings.

Chapter 2: Understand Your Business, Know Your Requirements

According to Huxhold and Levinsohn, a "successful GIS implementation…depends upon understanding the real world in which [an] organization operates—how changes to real world features affect the information needed by the organization and how information systems are used to support the functions that deal with such changes," (Huxhold and Levinsohn 1995). Each military service has a constitutional role codified in US law that comprises training and forward-basing, and strategic-deployment capabilities. The mission of a service and an installation impacts the spatial environment that the GIS must capture, as well as the requirements, priorities, and taskings of its IGI&S program. "Understand your business, know your requirements," encourages IGI&S Managers to discover the mission of the service and installation, and the needs and requirements it generates for geospatial data.

2.1 Foundational Background and Gap Identification

Croswell provides a foundational overview of GIS program development, and advocates for the examination of organizational mission and business processes in order to ensure GIS program alignment to organizational requirements (Croswell 2009). As PMI notes, programs "operate within the constraints imposed by the organization through their structure and governance…managers need to understand where responsibility, accountability, and authority reside in the organization," (PMI 2017b, 44) and utilize this information to help in the requirements gathering process. IGI&S Managers must understand where their program sits within the organizational construct of an installation in order to have awareness as to how that impacts their program's development, including funding streams, stakeholder alignment, and priorities.

Installation Commands do not always follow the organizational structure of their higher headquarters, nor do they consistently align across services, regions, and installations. The IGI&S mission, however, stems from supporting real property accountability, outlined in DoD Instruction (DoDI) 4165.14 Real Property Inventory and Forecasting, a core function of facilities management (US Department of Defense 2017a). As a result, most IGI&S programs at an installation reside within directorates that manage facilities, usually as part of a public works department. While business-unit based, IGI&S programs support a variety of other on-installation management issues outside of facilities, which can complicate matters, and concerns do exist at various echelon levels as to the appropriate organizational place for IGI&S with its ever-expanding role.

Croswell recommends aligning GIS data and services to business processes within the organization, since “GIS programs succeed when they are aligned with an organization’s mission and business,” (Croswell 2009, 10). Often GIS programs focus on and advocate for the technology, its functionality, and the broad uses of the capability. This focus, however, can inhibit an IGI&S program’s success if it does not tie these elements to business processes within facilities and the broader organization. GIS should not be thought of as merely an IT function, but rather a system that supports business processes and applications within an organizational context, and allows for data fusion across disparate and stove-piped business systems with a geo-locational aspect. Aligning IGI&S to organizational business drivers—a requirement, program, service-area, opportunity, or challenge—forms a strategic foundation for IGI&S program success. IGI&S Managers should look at business processes, including those outside of the facilities management domain, to understand how the data, products, and services

IGI&S provides impacts their organization both programmatically and operationally, and yields dependencies on the program. IGI&S Managers must follow a method to learn about the different business processes and capture the requirements for geospatial information and services.

PMI recommends development of a requirements management plan that captures how requirements will be gathered, assessed, documented, and managed (PMI 2017b). PMI formally defines several data gathering techniques—brainstorming, interviews, focus groups, questionnaires, and surveys—that assist program and project managers in gathering critical requirements data. Such documentation should catalog the requirement's description, business needs, opportunities, goals and objectives, proponents and stakeholders, and deliverables or outcomes—constructed in a way that makes them measurable, testable, traceable, complete, consistent and acceptable to stakeholders. This approach, however, neither takes stock of the current IGI&S program capacity or data health, and whether or not the GIS program can support these needs, nor assesses the current status of the programs that IGI&S supports. Croswell recommends conducting a formal "GIS Situation Assessment"—an appraisal of the current capacity of the GIS implementation including hardware, software, data, personnel, funding, and other required capital—and a "GIS Requirements Evaluation"—a needs assessment that identifies gaps within the GIS program's implementation and execution in order to advocate for means to close those gaps (Croswell 2009). Croswell then recommends writing the findings in a report and provides readers a multi-page template. All of these approaches, however, would benefit from systematically piecing parts of them together to form a holistic evaluation of requirements alignment to

business processes in the context of the current GIS program. IGI&S Managers must approach this with caution, however, as creating lengthy, detailed technical reports may become more of a burden to leadership and potentially go unread. IGI&S Managers must effectively communicate the core requirements, interdependencies with critical business processes, and the risks faced when minimally resourced or utilized, and several strategies exist that can help IGI&S Managers conduct requirements gathering, business process alignment, and stakeholder and user tracking.

2.2 Principle Methods and Examples

2.2.1 Data-to-Product Matrix

In order to support business requirements and processes within an organization, IGI&S Managers must have a good understanding of requirement drivers supported by the geospatial data and the resulting product outputs. IGI&S programs, for example, create and maintain core real property data required to build a basic map of an installation and track real property assets on an installation. DoDI 4165.14 states that DoD systems that relate people or property to any real property attribute, including geospatial location, must associate the appropriate real property–related unique identifier to that information based on policy established in OMB Circular A-16 (US Department of Defense 2017b). Many of the features within the Common Installation Picture (CIP) data, a minimum set of features and imagery required to make a basic map of an installation, are real property features that form the foundation of which most other installation geospatial data depends. Each CIP feature is justified by three to seven different DoD policies (Turner 2016), and IGI&S programs must prioritize CIP data completeness and data maintenance as this data supports a variety of domains,

including, but not limited to, planning, construction, operations, emergency response and recovery, environmental management and natural resource preservation, homeland defense, housing, recreation, and transportation. Table 1 Policy Drivers for IGI&S lists business policies that require geospatial data to be visible, accessible, understandable, trusted, and interoperable to support its function. Many of these policies have been updated to specifically identify “GIS,” as opposed to previously referring to “mapping.”

Table 1 Policy Drivers for IGI&S

Real Property	Master Planning	Environmental, Natural, Cultural Resources	Ranges and Training	Other
DoDI 4165.14 Real Property Inventory Forecasting, 2014 DoDI 4165.70 Real Property Management, 2005	UFC 2-100-01 Installation Master Planning, 2012 DoDI 3030.3 Joint Land Use Study Program (JLUS), 2004	DoDI 4715.03 Natural Resources Conservation Program, 2011 DoDI 4715.16 Cultural Resource Management, 2008 DoDD 4715.11 Environmental and Explosives Safety Management on Operational Ranges Within the United States, 2004 DoDD 4715.12 Environmental and Explosives Safety Management on Operational Ranges Outside the United States, 2004 DoD Manual 4715.20 Defense Environmental Restoration Program (DERP) Manual, 2012	DoDD 3200.15 Sustaining Access to the Live Training and Test Domain, 2013 DoDI 4715.14 Operational Range Assessments, 2005 DoDD 4715.11 Environmental and Explosives Safety Management on Operational Ranges Within the United States, 2004 DoDD 4715.12 Environmental and Explosives Safety Management on Operational Ranges Outside the United States, 2004	DoDI 4165.57 Air Installations Compatible Use Zones (AICUZ), 2011 DoDI 6055.17 DoD Installation Emergency Management Program (IEM), 2009 DoDI 6055.07 Mishap Notification, Investigation, Reporting, and Record Keeping, 2011

IGI&S Managers should create a data-to-product matrix as a means of tracking and displaying their data and the services, functions, or products their data supports (Joffe 2015). The IGI&S Manager clearly displays and defines the interdependencies between data requirements, data proponency, and data quality. A data-to-product matrix should capture the dataset, feature type, an indicator of the feature type's quality, whether or not the feature type is part of the CIP, the data proponent, and all products the data supports, from enterprise-level business systems to mobile and web GIS applications. Capturing the proponent organization can guide an IGI&S Manager to the group of people that own a feature's content. Proponency links data to the responsible party or parties, and more specifically, to a funding stream or streams. Denoting the quality of the data in a simple red, yellow, green color code can help data proponents understand where they need to target their geospatial collection efforts, or make it clear to other stakeholders and users where data they have a dependency on needs investment. Sometimes pressure from other units on a data proponent can drive investment by that proponent. Table 2 Data-to-Product Matrix provides a truncated example of a data-to-product matrix.

Table 2 Data-to-Product Matrix

Feature Dataset	Feature Type	Quality[1]	CIP	Proponent	Military Installation Map	Cantonment Atlas
Cultural Resources	ArchaeologicalSite	●	No	Natural Resources		
Real Property	Building	●	Yes	Public Works	X	X
Environmental	EnviRemeSite	●	Yes	Environmental Compliance		
Natural Resources	ForestCompartment	●	No	Natural Resources		X
Military Operations	MilitaryRange	●	Yes	Range Operations	X	X
Emergency Services	RoadCenterline	●	No	Security Services	X	X
Real Property	Structure	●	Yes	Public Works	X	X
Real Property	Wall	●	Yes	Public Works	X	X
Natural Resources	Wetland	●	Yes	Natural Resources	X	X

Ownership, dependencies, and quality become clearer within the data-to-product context. To enhance the value of the data-to-product matrix further, IGI&S Managers can include columns to denote the entity count in a feature, a utility score based on the number of products the feature type supports, or the number of hours required for data creation and maintenance of the feature. Binding this information together creates an optimal picture for the IGI&S team, leaders, stakeholders, and users as to the investment and integration of the geospatial data and services provided by the IGI&S program. The example in Table 2 Data-to-Product Matrix may not align directly to any one particular service or installation's requirements, but it shows how an IGI&S

[1] Where data fidelity and completeness are either high (●), medium (●), or low (●).

Manager can begin to quantify and qualify the data in the installation's geospatial ADS they oversee, linking data proponency to organizations and highlighting interdependencies among data and products in support of business needs.

2.2.2 Stakeholder Tracker

Effective requirements gathering requires IGI&S Managers to make an effort to research and track their stakeholders and user communities. Stakeholders—an individual, group, or organization that may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project, program, or portfolio (PMI 2017b)—often drive requirements and business processes within an organization. They support a function other than GIS, such as facilities maintenance, range training and maintenance, range safety, environmental compliance, or natural resource management and preservation. All individuals that directly or indirectly use the IGI&S program should be considered stakeholders—they have a stake in the program in order to meet a need. Understanding the dynamics of the personnel in an organization can contribute to unraveling methods to identify and align IGI&S capabilities to business functions. A stakeholder tracker allows the IGI&S Manager to identify and track all of the individuals and functional communities involved in the process of data collection, creation, and maintenance—the content providers—as some features belong to more than one functional area. For example, while utilities data may seem to fall directly to the utilities and energy functional areas, utilities also have a real property component to them as they are tracked in the real property ADS.

Installations possess many Subject Matter Experts (SMEs) working within a single functional area. SMEs possess knowledge about the functional area, but may not

have the experience required to capture and implement relevant geospatial information about their subject. Two types of SMEs exist—Functional Area SMEs and Data SMEs. Functional Area SMEs approve access and release of data under their functional supervision, communicate and coordinate with Data SMEs, and advocate for resourcing for the collection and maintenance of required content. Data SMEs specify data needs, accuracy levels, attribution and metadata content, and validate data deliverables. Overlap can exist between Functional SMEs and Data SMEs—sometimes they may be the same person, other times they may be different individuals—but usually they exist within the same organizational unit. Data Editors edit and maintain the feature types applicable to the functional area, ensuring compliance with SDSFIE and service-level GDM requirements and standards. Data Editors could be a Functional SME, a Data SME, an IGI&S staff member, or staff member of the unit. Figure 3 Subject Matter Expert Construct provides a visual representation of the SME paradigm in the IGI&S community. As shown, User 1 overlaps as both a Functional SME and a Data SME, while User 2 overlaps as both a Data SME and a Data Editor. Users 1, 2, and 3, are also data consumers.

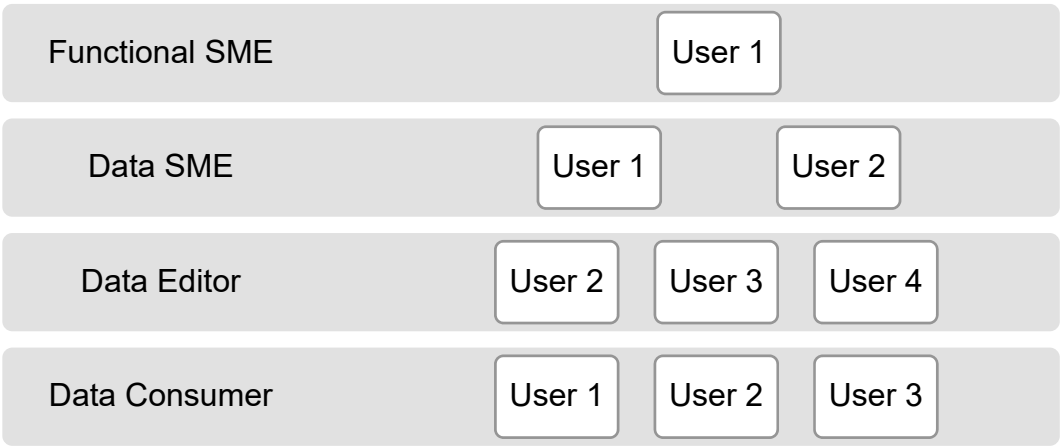

Figure 3 Subject Matter Expert Construct

As a result of the paradigm, IGI&S Managers should track this Community of Interest (COI) in some form. Large installations will struggle as there tends to be a larger quantity of SMEs, and turnover of these individuals can happen quite regularly. An annual review and revision of the product should occur for this reason. Table 3 Stakeholder Tracker by Feature Dataset provides a truncated model for this effort. IGI&S Managers may also want to include information such as contact information, last meeting, or any other pertinent data that may help them administer their community.

Table 3 Stakeholder Tracker by Feature Dataset

Feature Dataset	Feature Type	Proponent	Functional Area SME	Data SME	Data Editor
Cultural Resources	ArchaeologicalSite	Natural Resources	User 1	User 1	User 1
	CulturalResourcePotentialArea	Natural Resources	User 1	User 2	User 2
	CulturalRestrictedAccess	Natural Resources	User 1	User 2	User 3
	CulturalSurveyArea	Natural Resources	User 1	User 2	User 2

When combined with the Data-to-Product Matrix, these two items produce a holistic picture of the organizations and individuals with a stake in the IGI&S program for meeting their mission requirements. Additionally, IGI&S Managers can begin to see data deficiencies and call upon those responsible for content to participate in data modeling efforts and improve their data quality in the interest of data sharing and interoperability within the service and the greater DoD.

2.2.3 Strengths, Weaknesses, Opportunities, and Threats Analysis

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix serves as a concise means of presenting program health information. A SWOT analysis identifies the internal strengths and weaknesses of the program, and the external opportunities

and threats or challenges to the program. Both PMI and Croswell advocate for the use of SWOT matrices in different ways. PMI recommends them as a risk identification data analysis tool (PMI 2017b), while Croswell recommends them as part of the planning process for the creation of an overall greater strategic plan (Croswell 2009). IGI&S Managers, however, should think of them in the context of providing a means for documenting and communicating their overall program health to leadership. Program health captures the holistic health of the elements necessary for GIS capacity: GIS infrastructure, data, people, and ability. Program health information should capture current data priorities, data status, system capabilities, human and non-human capital, and financial resources. The SWOT analysis can also highlight opportunities to support the mission of the command and the business processes of stakeholders, and stress the risks to these efforts without integration. The SWOT analysis should take into account the perspectives of the IGI&S team, but also the greater IGI&S COI, including leadership, stakeholders, and users. Table 4 SWOT Analysis Topics provides suggested topics for consideration when creating a SWOT analysis matrix that an IGI&S Manager should continually build upon.

Table 4 SWOT Analysis Topics

Strengths	Weaknesses
What are the IGI&S program's current strengths when it comes to overall program health?	What are the IGI&S program's current weaknesses when it comes to overall program health?
• GIS capacity • Data quality • Data completeness • Data compliance to standards • Data sharing • Level of service • Staff capabilities • GIS infrastructure • Capital • Program management • Resourcing • Coordination • SME participation and accountability • User community involvement	• GIS capacity • Data quality • Data completeness • Data compliance to standards • Data sharing • Level of service • Staff capabilities • GIS infrastructure • Capital • Program management • Resourcing • Coordination • SME participation and accountability • User community involvement
Opportunities	**Threats**
What opportunities exist that can improve the overall program health and subsequently benefit the business of the organization?	What threats exist that can impair overall program health and subsequently hinder the business of the organization?
• Policy development and implementation • Business line integration • Cost sharing partnerships • Measurable improvements in efficiency • Cost avoidance • Financial (real property) accountability • Advances in technology	• Lack of policy implementation and adherence • Lack of funding and resources • Lack of retention of personnel throughout the organizations and units • Slowness of government adaptability to advances in technology • Deployment of GIS capabilities, personnel, and systems outside of IGI&S • Risk in relation to organizational strategies heavily dependent on quality data

SWOT analyses make a clear, concise, and quick means to identify internal and external challenges to IGI&S mission objectives.

2.2.4 Strategic and Project Plans

Strategic plans should provide a foundation and direction for IGI&S program development and operations that address an organization's mission and business needs. The strategic plan should describe the current situation and organizational

context, mission, vision, and values statements, a description of program objectives and action items, and constraints, feasibility, and approach. Strategic plans often focus on a three- to five-year timeframe, but IGI&S Managers should consider breaking items down into near-, short-, and long-term objectives. Presenting sign posts every one, three, and five years can serve as a means to measure progress and monitor the plan as an internal control, checking off items when completed and realigning items to new timeframes if objectives require more time. Many methodologies and templates exist to create strategic plans, but the content remains most critical to the plan.

Project plans provide a micro-level look at how IGI&S teams will implement projects in support of the strategic plan. These projects usually possess a greater level of effort than the routine day-to-day tasks. Project plans should include the purpose of the project, how it supports the IGI&S strategic plan, the project deliverables, the plan of action and milestones of project execution, any special needs or costs associated with project execution, and the risks to project completion and mitigation efforts for identified risks. Examples of projects could include a feature dataset update or revision effort, a large-scale data collection effort, the creation of a web mapping application, the creation of a hard-copy atlas, or standardizing metadata for global DoD–wide enterprise discovery and web publishing. Taken together, strategic plans and project plans help guide an IGI&S Manager and team to execute the mission in alignment with business drivers.

2.3 Analysis and Significance

Huxhold and Levinsohn note that effective use of information technology depends on several factors: alignment of business, technology, and organizational

strategies; organizational commitment, stakeholder support, and ownership; competence in design, implementation, and mastery of the technology (Huxhold and Levinsohn 1995). Understanding the organization, the individuals, and the business processes, allows IGI&S Managers to begin to form effective program management strategies to increase GIS capacity. Requirements gathering and business needs alignment remains critical to the success of any GIS program. By utilizing the methods proposed, IGI&S Managers can begin work on optimizing their priorities and resources.

The data-to-product matrix prioritizes data requirements based on use and provides a means for determining data value. MCB Camp Pendleton possesses a large amount of data because of the size of land it inhabits and the number of features that exist on its land. The installation produces many products in support of the installation management mission because of the diversity of activities occurring on its land. As a result, quantifying and qualifying the volume and the requirement for the data and products to leadership posed a challenge. By instituting a data-to-product matrix, leadership became aware of the utility of the CIP data and the need to prioritize it as critical for update and improvement, resulting in a shift of existing resources to align to this effort before others (Harris 2018). Furthermore, the data-to-product matrix allows an IGI&S Manager to target datasets by contract holder. An IGI&S Manager can put out a data call to identify potential GIS deliverables in contracts, using this information to work backwards to figure out what datasets feed the products contracted for development. Often Functional SMEs will accept soft- or hard-copy map products instead of the actual digital geospatial data itself, allowing the contractor to reduce overhead costs. This prevents the newly created or updated data from returning to the enterprise. IGI&S

Managers can work with the contract holders to improve the scoped language ensuring GIS data in the right format, model, and schema make it into the enterprise. The GEO*Fidelis* Program Office intervened in the Infrastructure Reset contract development process ensuring geospatial data as a deliverable of the effort and not just maps in support of planning.

Stakeholder identification and tracking, leads to engagement with the COI and frames dialog in the context of how IGI&S supports their mission, requirements, and business needs. This often results in discussions on integration between SMEs and the IGI&S team in attempt to remove barriers and stove-pipes that impact data utility, sharing, and interoperability. Interdependencies among business processes, geospatial data, and SMEs becomes visible. With emphasis on data ownership and accountability for content, IGI&S Managers can broach the topic of IGI&S investment. MCLB Barstow's Public Works Department that oversees the IGI&S program joined with the environmental and natural resources functional office to support a joint investment in an on-site support contract. The IGI&S Manager oversaw the on-site support within his branch, creating an ongoing dialog with the environmental and natural resources SMEs, while ensuring proper project prioritization, planning, and quality of geospatial data. The dig permitting business processes that involved both offices became streamlined as a result of the integration, as the IGI&S team compiled digital data and maps for dig permit approval through a consolidated office, even building an automated solution for validation and approval through SharePoint. The effort resulted in greater GIS capacity than in previous years. RAND Corporation's independent analysis estimates more than $20 million USMC–wide cost avoidance in monetized labor savings by using digital and

analytical processes for dig permitting (Lachman, Schirmer, Frelinger, Greenfield, Tseng, and Nichols 2007).

By summarizing the strengths, weaknesses, opportunities, and threats of their program, IGI&S Managers can better understand and explain the health of their program. Such an effort can help shape the development of strategic plans and project plans. The Marine Corps GEO*Fidelis* program utilizes Portal for ArcGIS as a means to provide geospatial data and services in a secure, user-friendly environment. The movement to Portal for ArcGIS became a strategic initiative in an effort to reduces costs incurred by custom-coded web mapping solutions, eliminate the reliance on expensive ArcGIS licenses for mere data viewing, enhance access to geospatial data via web publishing, and spur SME investment in data and web mapping applications. The MCIWEST IGI&S Regional Program Manager worked with the Office of Government and External Affairs to develop a project plan for several web mapping applications for deployment in Portal, supporting the overall GEO*Fidelis* strategic initiative and the business requirements of the Office of Government and External Affairs. The project plan details an effort to develop web-mapping applications using third-party geospatial data from governmental and non-governmental sources to provide an operational picture of activities in the region beyond installation fence lines. Such a picture provides assistance when evaluating locations Marines may conduct training activities, specifically other Federal lands, evaluating public resources available to Marines and their families in nearby communities, or determining areas for partnership for environmental protection or infrastructure development. By sourcing third-party geospatial data from authoritative sources through publishing third-party

Representational State Transfer (REST) endpoints in the Portal environment, data currency improves for the end-user, and secondary data management and storage costs decline for the IGI&S program. MCIWEST improved SME coordination and aligned efforts to the overall GEO*Fidelis* strategic vision.

Understanding the organization, the individuals, and the business processes, allows IGI&S Managers to begin to form effective program management strategies and relationships that can translate into increased GIS capacity. Requirements gathering and business needs alignment remains critical to the success of any GIS program. Utilizing these techniques will help IGI&S Managers understand their business and know their requirements.

Chapter 3: Develop a Holistic GIS Infrastructure Lifecycle

A holistic GIS infrastructure lifecycle functions as a “cradle-to-grave” strategy for GIS infrastructure: hardware, software, and data (the people component of GIS infrastructure discussed in Chapter 5). GIS infrastructure lifecycle management plans capture current hardware, software, and data that support the IGI&S program’s mission, and should include plans for initial purchase, maintenance, and future replacement or renewal. IGI&S Managers may not feel the desire to create a plan because of the centralized management of hardware and software that so commonly defines DoD IT infrastructures today; however, GIS infrastructure lifecycle management planning prepares IGI&S Managers and their programs for a future when assets under the IGI&S Manager’s purview become outdated or even end-of-life. Local hardware, software, and data will require replacement, renewal, updates, or maintenance that the IGI&S Manager should track as part of his or her planning and programming process. By not including it, the IGI&S Manager places his or her program’s ability to function and meet mission requirements at risk. Furthermore, IGI&S Managers must understand the risks that come with system cyber vulnerabilities and interdependencies of application lifecycles, when looking to implement new technologies. For example, Global Positioning System (GPS) hardware running on a mobile operating system, linked to differential correction software that requires a web connection and operates on a desktop operating system, creates vulnerabilities to the whole network if any one component possesses vulnerabilities. Quantifying and qualifying the risk if not executed upon can help leadership understand why the program requires such investment, and

without these resources GIS capacity becomes severely constrained to the point of mission failure.

3.1 Foundational Background and Gap Identification

According to the DoD Chief Information Officer, “Historically, DoD’s information technology (IT) investments have been made to meet the needs of individual projects, programs, organizations, and facilities. This decentralized approach has resulted in…a patchwork of capabilities…” (US Department of Defense 2011, 2). This patchwork approach replicates itself throughout each military service and their commands when it comes to roles and responsibilities for different aspects of IT: acquisitions, physical infrastructure, implementation, network and cyber security, end-user support, and so forth. The outcome often leads to a multitude of entities having an impact on IT decisions that often impact IGI&S. Croswell articulates that GIS programs must have a strong working relationship with IT, or that the GIS program itself must control the IT infrastructure used to support the GIS (Croswell 2009); however, IGI&S control of IT is rarely the case.

According to the Federal Chief Information Officer in 2010, “the Office of Management and Budget (OMB) launched the Federal Data Center Consolidation Initiative (FDCCI) to promote the use of green IT by reducing the overall energy and real estate footprint of government data centers; reduce the cost of data center hardware, software, and operations; increase the overall IT security posture of the Federal Government; and shift IT investments to more efficient computing platforms and technologies,” (Scott 2016, 1). As a result, many IGI&S programs operate from consolidated data centers, many of which are either Government-Owned, Contractor-

Operated (GOCO) or Government-Owned Government-Operated (GOGO) and contractor-supported, which specifically support the facilities mission and business lines. These data centers, however, often lack integration within the broader service-level IT construct creating challenges.

Dave Peters' work on System Architecture Design Strategies teaches principles for determining GIS system architecture requirements, yet the author assumes that those making these decisions have control, or work closely with those with control, of IT systems, including server configurations and network throughput. System changes can override settings and software, or hinder network communications, required to conduct day-to-day GIS operations and often happen without prior notification or coordination before they take effect. IGI&S programs may suffer as a result of the system architecture design, network traffic routing, throttling, and other latency inducing processes, or physical network architecture, such as switches, routers, hubs, and even cable types that can impact the quality and efficacy of network transmission. Viewing and editing large sets of geospatial data transmitted through a thin-client architecture not adequately developed to handle such processes can make working in the GIS unbearable or even impossible.

The lack of integration also creates challenges when attempting to provide end-user support. A number of different help desk implementations may exist—a service may have one or more for general hardware, software, or network issues, and separate ones for different business-line specific systems, such as GIS. When a problem intersects these different help desk areas of responsibility, a user faces the challenge of potentially bouncing back and forth for a resolution. While Service-Level Agreements

(SLAs) can codify functions and performance expectations between an IGI&S program and a respective help desk, SLA implementation rarely occurs, likely because of concerns to consistently deliver on agreed upon service and the desire to claim lower operating costs. Therefore, ROI calculation needs to address workforce productivity, not exclusive “cost reduction,” but rather monetized labor costs in lost efficiencies.

Procuring and maintaining vital equipment also poses challenges. Changes in IT acquisition place additional burdens on the Government. The decision to use congressionally ear-marked procurement funds for IT acquisitions in an effort to curb cyber vulnerabilities, and the proliferation of IT hardware assets, incurs additional challenges and obstacles to deploying hardware requirements, and reduces agility in adopting emerging technologies. This increases workforce costs from lost productivity to save relatively minor costs in hardware, and setting back acquisition efforts by years in order to gain approval for a more appropriate congressionally appropriated fund type. Obtaining equipment such as GPS units, plotters, or large-format scanners can take months or years for approval to purchase because of convoluted IT procurement processes and requirements for authorization of purchase. Additional hurdles exist in gaining approval for use on the network. By the time the approval occurs, the vendor may no longer support or service the hardware. Workarounds become a normalized business practice. Many IGI&S programs rely on off-network hardware and software for data collection and post-processing. Sometimes on-site support contractors provide this equipment when required by contract, but may take such equipment back when the contract ends unless explicitly stated for turnover to the Government.

While the hardware and software portion of GIS infrastructure possesses process and coordination complexities, data creation and maintenance present different challenges to IGI&S capacity and sustainability. Data origins contribute to a shaky data quality foundation. As mentioned, GIS started becoming formalized during BRAC 2005, when geospatial data used for disparate projects came together in a collective system. Most real property data at the time came from the digitization of as-built drawings. Contractors provide as-built drawings as a means to document the finished condition of a project as constructed, including all directed changes, as accepted by the client. Most contractors, however, provide mediocre as-built drawings at best for reasons such as time, budget, personnel resources, or coordination with sub-contractors (Pettee 2005). This initially produced low quality foundational real property geospatial data: imprecise geometry, missing attribution, and incomplete feature type–level and record-level metadata. Even recently the requirement for “digital data” may be understood as merely a digital picture, and not the actual geospatial data itself.

Since then, IGI&S programs continue to work on improving data quality and completeness, using new and less cost prohibitive geospatial technologies and workflows to document the ever-changing installation spatial environment. Real property features compose a majority of OASD’s CIP dataset and this foundational data must meet OASD’s quality and completeness standards. Completeness means all minimum required attribution populated and in the correct format, completed metadata elements, no glaring geometric errors (data duplications, features outside of installation boundaries, etc.; excludes topology rules), and all entities within a feature correspond to a real property record (either one-to-one, or many-to-one). Many installations, however,

struggle to attain the standard. A variety of reasons contribute to this failure, such as rapid changes to the environment or resource fluctuations. Additionally, changing data structures and emerging SDSFIE standards for metadata, quality, and portrayal, outpace the resources required to implement them. These standards, however, provide a mechanism to quantify data quality in terms of a DoD and industry maturity model, allowing for the identification of impacts to strategic initiatives relying on quality geospatial data. Geospatial data missing critical elements in attribution, for example, that align it to data in other business systems, prevents data fusion and aggregation, a core GIS competency.

During the past five years, DoD services have made one major version transition from SDSFIE version 2.0 to 3.0, with some making minor sub-version level transitions (e.g. 3.1 to 3.2; 3.0.0.1 to 3.0.0.2) as well. Several services have begun to develop their next version of the SDSFIE 4.0 data model with timelines ranging for implementation in the coming few years. Each transition to a new model puts pressure on IGI&S Managers and their teams, requiring significant time to crosswalk and migrate data into the new database structure, in addition to daily duties. Furthermore, with each version change, IGI&S programs can introduce new, or propagate existing, errors into their databases when data, for example, cannot be accommodated in the new schema. IGI&S Managers and teams may look for alternate places within the database to store data, creating field type errors, domain violations, or merely incorrect entries, and highlighting the need for data governance and standards as well as oversight and quality control. At worse, data elements, such as metadata, can be dropped entirely from a database. Continued data model changes impact the quality of data that may

already have been deemed questionable. While IGI&S Managers work to mitigate these technical implementation issues, they may also face interpersonal challenges associated with data management as well.

The lack of collaborative partnerships with SMEs through these changes can negatively impact data content. Installation SMEs may struggle with implications of data model changes as they may not understand the purpose for the transition, their responsibility in the transition, and the effects of such a transition on their content, such as potential data loss. Formalized education and outreach strategies (discussed in Chapter 5) can help bring awareness to these issues and foster partnerships to ease the pain of such transitions. While IGI&S programs serve as gatekeepers and overseers of an installation's geospatial ADS, misconceptions between IGI&S program responsibilities and SME responsibilities can lead SME communities to push the responsibility to maintain and track non-real property data onto an IGI&S team. IGI&S and SME turnover can lead to loss of corporate knowledge about data, which can be especially devastating if the data lacks documentation. While IGI&S Managers cannot resolve every problem identified herein, implementing a GIS infrastructure lifecycle strategy can help mitigate some of the impacts of these challenges. Collaborating with SMEs and formalizing roles and responsibilities with SME buy-in can foster a constructive partnership, while formalizing site assist visits and workforce exchanges to share best practices can help diffuse corporate knowledge.

3.2 Principle Methods and Examples

3.2.1 Hardware and Software Inventory and Refresh Schedule

Although IGI&S programs tend to utilize centralized data centers that manage hardware and software for the storage and processing of geospatial data, IGI&S programs still require on-site hardware and software to successfully meet their mission. An IGI&S Manager should inventory all hardware and software, as well as any devices or media used for storing project-related data. On-site hardware may include, for example, base stations, GPS, GPS accessories, cameras, hard drives, large format plotters and/or scanners, and off-network “standalone” computers. The IGI&S Manager should document the make, model, serial number, date of purchase, warranty length, date of last maintenance, and the date for replacement. The inventory should also contain any specifications unique to the device, whether the device is on- or off-network, and the purpose of the device. IGI&S Managers should document software in a similar fashion. An inventory should also be created for devices, media, or bulk supplies, documenting their date and content, or plotter ink and cartridges noting the type, number of items, and expiration date. Tracking this information allows an IGI&S Manager to manage equipment and supplies that can quickly become inoperable or insufficient to keep operations running, anticipating needs for ordering and aligning procurements and purchasing to the funding cycle or phasing plan. Installations can then use these inventories to coordinate and engage in temporary loans of supplies or equipment from other installations in order to keep operations running until a time at which they can reimburse the loan or return the items. Keeping track of this information

also remains essential for purposes of base property tracking and oversight of equipment use, and represents good business practice.

While creating inventories helps IGI&S Managers stay organized and on top of their capital, they also can provide other benefits to the program at large. If IGI&S Managers construct these inventories, their higher headquarters can analyze them for overlapping requirements and streamline procurement and network approval for hardware and software. Gathering the information from IGI&S programs across a service's enterprise can allow for the development of hardware standards. Ensuring all installations have the same baseline equipment can help when putting maintenance and servicing contracts into place to keep devices running, and supports interoperability among installations in case a need to loan equipment arises. Additionally, commonalities in requirements for software can also lead to consolidated efforts for network approval, bulk license purchase and management, and streamlined training requirements.

3.2.2 Data Health Assessment and Data Maintenance Schedule

IGI&S Managers must have a good understanding of the data within their installation's geospatial ADS—the quality and completeness of the data. A comprehensive data health assessment can provide a useful report to describe the "well-being" of the data within the installation's geospatial ADS, assessing schema compliance to the service's adaptation of SDSFIE, content compliance, geometric validity, and metadata presence. The IGI&S Manager should begin by introducing health assessments to evaluate CIP data, utilizing the results as a guide for CIP data quality improvement. Health assessments can then be conducted for other feature

datasets within the geospatial ADS to provide guidance to SMEs as to where their data content needs improvement, and for developing Performance Work Statements or project plans to address the gaps.

In order to conduct a CIP health assessment, IGI&S Managers must identify mandatory CIP feature types for evaluation at their installation. For example, the CIP feature type Historic District may only occur on specific installations with such a designated area, and therefore would not be a requirement for evaluation at an installation where it does not exist. Scores should reflect the number of mandatory feature types an installation identifies, not whether or not the feature type exists in the most current data model. Table 5 Data Health Assessment Evaluation Factors introduces example evaluation factors when conducting a data health assessment.

Table 5 Data Health Assessment Evaluation Factors

Factor	Description
Feature Type	The feature type evaluated
Feature Count	The number features or entities in a feature type
Feature Minimum Attribution	All non-nullable attributes within the approved GDM are populated
Feature Completeness	Accurate presence of the feature type in comparison with the most accurate imagery available from an accepted source
Feature Metadata	Correctly populated metadata in SDSFIE-M style
Feature Score	Percentage of completeness based on the identified factors

Data health assessments should identify the number of entities in a feature type to get an overall sense of the amount of data the installation's geospatial ADS stores and therefore the amount the installation must manage. The assessment should review attribution to ensure minimum attribution required by the GDM contains valid values using the correct data type and domain if applicable. The assessment also uses samples of vector features and compares them to the latest imagery. An IGI&S team can use a combination of both manual review and geoprocessing tools and techniques

to conduct such a review on data. Table 6 Sample Data Health Assessment presents a truncated example of how a data health assessment might look, while Table 7 Sample Attribution Review looks at whether or not required attribution contains null values indicating a lack of content in the field.

Table 6 Sample Data Health Assessment

Feature Type	Entity Count	Minimum Attribution	Data Completeness	Metadata	Feature Score
Access Control Point	270	Fail	Pass	Fail	33%
Bridge	N/A	N/A	N/A	N/A	N/A
Building	825	Fail	Pass	Fail	33%
Docks and Wharfs	25	Pass	Pass	Fail	67%
Fence	1,110	Fail	Pass	Fail	33%
Impact Area	37	Fail	Pass	Fail	33%
Land Parcel	115	Fail	Pass	Fail	33%
Military Range	35	Fail	Pass	Fail	33%
Pavement Section Roadway	1,120	Fail	Fail	Fail	0%
Total		1/8 feature types pass	7/8 feature types pass	0/8 feature types pass	33.125%

Table 7 Sample Attribution Review

Feature Type	Mandatory Attribute	Number of Nulls/ Total Fields	Percent Null
Building	sdsID	0/825	0%
	InstallationCode	0/825	0%
	buildingIDPK	825/825	100%
	isCUI	0/825	0%
	hasEnvironmentalConcern	825/825	100%
	operationalStatus	0/825	0%
	realPropertyUniqueIdentifier	10/825	1.2%
	facilityIDFK	0/825	0%

More sophisticated review techniques can generate reports that identify the specific errors in field columns, giving the IGI&S Manager information to target correcting the error. For example, if an installation utilizes the values “1, 2, 3, 4,” as a numbering convention for primary keys in their database, the values will pass a check that merely reviews whether fields contain values. As data roll-ups occur from an installation-level

geospatial ADS to a service-level geospatial ADS, however, the entry may no longer be “primary” or unique in nature if other installations happen to utilize the same numbering scheme. IGI&S teams can customize tasks to review for specific content and content-types to appear in a field.

For real property features, an additional step of reconciliation between the real property ADS and the geospatial ADS must occur in order for real property geospatial data to garner a high completeness score. Each real property record in the real property ADS should correspond with at least one real property feature in the geospatial ADS; however, multiple real property features in the geospatial ADS can correspond with a single real property record in the real property ADS as well. IGI&S Managers can tailor reports to identify where issues exist between records by joining tables from systems together on a common attribute—usually the facility asset number. A close working relationship with real property accountability teams remains critical to ensure the recording of transactions in both systems of record.

Once an IGI&S Manager completes a data health assessment, he or she can then start planning the process for update. A step in the update process should include the creation of a Data Maintenance Schedule. Some data in the installation’s geospatial ADS requires more frequent updates and validation than others. Updates to data should ideally happen as changes occur to the environment; however, resource constraints can make this challenging. While a Data Maintenance Schedule will not prevent the need to update data as activities occur on base, it will provide the IGI&S Manager with a schedule used to anticipate upcoming periods during which, at a minimum, data validation should occur. These schedules can help IGI&S Managers to anticipate when

they might require shifts in priorities or resources to support data updates. They can also provide leadership with an understanding of the requirement for continued or on-going data maintenance as some may not recognize the constant changes that occur to the spatial environment. A schedule can prepare SMEs for their involvement in, and time commitment to, the update process. Feature type specifications include a section on temporal representations, which identify the minimum frequency for validation, typically quarterly or annually depending on the feature type. An IGI&S Manager should review these existing specifications and use them to build their schedule.

Table 8 Sample Data Maintenance Schedule provides an example of a schedule, which can be used and merged with the SME tracker, if desired, to provide a holistic reference guide.

Table 8 Sample Data Maintenance Schedule

Feature Type	Validation Frequency	Last SME Validation	Last Update	Next SME Validation	Next Update
Access Control Point	Annually	7/30/2018	Unknown	7/30/2019	8/1/2019
Bridge	Annually	10/15/2018	10/22/2018	1/15/2019	1/22/2019
Building	Quarterly	10/15/2018	10/22/2018	1/15/2019	1/22/2019
Docks and Wharfs	Annually	10/15/2018	10/22/2018	1/15/2019	1/22/2019
Fence	Annually	10/15/2018	Unknown	1/15/2019	2/15/2019
Impact Area	Annually	4/2/2018	5/31/2018	4/2/2019	5/31/2019
Land Parcel	Annually	10/15/2018	10/22/2018	1/15/2019	1/22/2019
Military Range	Annually	4/2/2018	5/31/2018	4/2/2019	5/31/2019
Pavement Section Roadway	Annually	Unknown	Unknown	10/15/2019	11/15/019
Aerial Imagery (3 inch)	Four Years	N/A	2016	N/A	2020

The IGI&S Manager should only update the schedule with each refresh cycle. Creating a schedule supports data maintenance by outlining expectations for refresh activities for both the IGI&S team, leadership, and SMEs.

3.3 Analysis and Significance

GIS infrastructure (hardware, software, and data) remain critical for an IGI&S program to succeed. Taking an inventory of hardware, software, and data requirements gives IGI&S Managers a holistic view of major components of GIS capacity. Hardware and software inventories help installations determine requirements. MCIWEST, for example, conducted an inventory of all large format plotters to determine commonalities when searching for a maintenance provider, and managed to facilitate servicing from the same vendor for installations in the AOR despite their different locations. Furthermore, MCIWEST worked to provide two standards for GPS equipment for purchase across the region as replacements for outdated equipment—one mapping grade, and one survey grade—to accommodate different requirements for data accuracy. Such efforts have led to streamlining efforts for procurement when one installation already completed the IT procurement process. An IGI&S Manager should know what their team currently possesses, and what they will need in the future in order to sustain operations without disruptions to service.

Creating a data health report can help IGI&S Managers begin to improve their data. MCIWEST installations received CIP data report cards at the end of Fiscal Year (FY) 2018 that rated their data against OASD standards. Many installations received scores lower than 50% completeness, but since that time have begun to make improvements to their data in attempt to improve scores. The reports showed a variety of different issues, from missing mandatory attribution to a complete lack of metadata. The report cards provided installations with the ability to target issues within their CIP data. MCB Camp Pendleton, MCAS Yuma, MCLB Barstow, and MCAS Miramar have

all taken steps to make modest improvements in their scores in the six months since the report card release. MCB Camp Pendleton has actively been revalidating their CIP data working on core real property features and reconciling them with the real property inventory, while also updating required attribution to improve their score. MCAS Miramar began instituting office hours specifically for revising the CIP data, closing the office to limit disruptions while working on data editing. Leadership bought into this idea understanding that without these features, no other data or products could be produced with reliability. MCLB Barstow and MCAS Yuma drafted metadata as a way to improve scores dramatically. Without a report card, IGI&S Managers and their teams cannot prioritize data development and work to make improvements. Additionally, they cannot effectively communicate to leadership the required data development work. The MCIWEST report cards showed leadership the need for data improvement to support the business requirements including critical emergency services, range training and safety, and other decision-making support activities. Tying the reports to the OASD standards gives legitimacy to the performance reporting and linking risks to health, life, and safety, to service-level financial risk with congressional interest, garners the attention of those in at the highest-level of the DoD.

Creating the GIS infrastructure lifecycle plans helps IGI&S Managers take account of aspects of their program's operational requirements. Using these tools as a means to advocate for the required resources poses the next critical step in capacity building.

Chapter 4: Budget-to-Perform and Perform-to-Budget

The amount of funds provided to an IGI&S program can influence or determine the level at which the program performs, and the performance of an IGI&S program can influence or determine the budget it receives. Therefore, developing a sound budget and measurable performance indicators serve critical roles as capacity building strategies for sustainable IGI&S programs because they provide justification for the investment and expenditure, provide transparency and accountability, and help the organization understand risks.

Croswell notes that, “Traditionally, budgets allocate funds without directly analyzing their impact on services, focusing on organizational units and historical patterns of funding,” (Croswell 2009, 119). Budget offices in the Federal Government often look to previous years’ allocations to make determinations as to the amount a program receives. Performance based budgeting, a type of budgeting that directly links money to measurable results, has become more relevant in recent decades in the Federal Government as budgets become tighter and agencies must do more with less (Obermeyer 2005). Therefore, IGI&S programs must participate in the budgeting process to prevent stagnate funding numbers and to provide an understanding of budget requirements, expected levels of service or performance based on funding, and risks when funding does not come through, especially as requirements and dependencies on installation geospatial data increase. An IGI&S program that can articulate these costs combined with justification and risk stands a better chance of “not only get[ting] what they want, but…[preempting] internal threats that could diminish future…opportunities,” (Kloos 2016a, 28).

4.1 Foundational Background and Gap Identification

PMI defines budgets as the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline; the process determines the cost baseline against which performance can be monitored and controlled (PMI 2017b). PMI recommends the basis for cost estimates—quantitative assessments of the probable costs required to complete work and contingency amounts—include documentation of the basis of the estimate, including assumptions, constraints, potential fluctuations, confidence level of the estimate, and activities that may influence the estimate. PMI identifies a hierarchical overview of components to include in a work breakdown structure, however, examples of a collection of methods and processes to capture and present GIS program projects or tasks and their costs, including business justifications and risks, levels of services, and performance metrics should be considered as well.

Croswell articulates the need for GIS managers to be involved in the budget and funds allocation processes, discusses common development and operational costs for GIS programs and projects, and suggests funding sources and financing strategies in the public sector; however, the author's funding and financial strategies possess limitations for IGI&S programs (Croswell 2009). While the author's list of typical cost elements for GIS development and operations accounts for many activities, the list does not directly align to Office of Management and Budget Object Classification Codes (OCCs), "a uniform classification for identifying the transactions of the Federal Government by the nature of the goods or services purchased," (US Department of Defense 2016). Per the DoD Comptroller, "every obligation recorded by the Department

of Defense must be coded with an object class. These obligations by object class must be accumulated and reported to the Treasury on a quarterly basis," (US Department of Defense 2016). IGI&S programs must align all budgetary formulations to OCCs and have limits on funding sources and strategies identified because of the use of taxpayer dollars to fund operations.

While Croswell emphasizes the use of GIS project management strategies and risk management (Croswell 2009), and Joffe suggests breaking down application costs, scheduling costs, data costs, data maintenance costs, startup costs, and ongoing operating costs (Joffe 2015) in budgetary formulations, most authors tend to focus heavily on the philosophy and calculation of ROI rather than on the processes or procedures to gather information necessary to calculate it. Obermeyer focuses on explaining the difference between tangible and intangible benefits, the difficulties associated with conducting a value assessment, and considerations and refinements to the cost-benefit analysis approach (Obermeyer 2005). Kloos' article focuses on the importance of getting GIS managers to develop an ROI mindset—thinking in the context of growing themselves and their programs by putting the effort into measuring their results (Kloos 2016a). As Kloos articulates, "…you will find yourself needing to justify a GIS project or a request for funding or respond to a threat to your existing resources…" (Kloos 2016, 28). Both Croswell and Kloos provide methods or formulas for actually calculating GIS project ROI, yet skip explaining the formalization of budgeting and cost estimating processes and examples. Joffe provides a more in-depth analysis of cost determination; however, the author articulates that discussions with stakeholders can determine cost factors for data maintenance and metadata creation and maintenance.

IGI&S stakeholders, however, often rely on the IGI&S program to provide cost estimate because of the lack of project management techniques in the programs that own the requirements. Unfortunately, this results in the IGI&S programs having to substantiate the value of GIS to the very programs that own the requirements.

Communicating the program's performance in relation to the funding it receives allows leadership to understand what they get and what they do not get as a result of allocated resourcing, and can form the basis for future budget decisions. Only a few authors have touched on the importance of key performance indicators, but none of them have sufficiently addressed the process of determining them and by what means those could be validated or tracked. PMI describes performance as an integrated scope-schedule-cost plan for the project work against which project execution is compared to measure and manage performance; however, PMI does not advise on methods or techniques to measure or track performance, other than collecting reporting documentation (PMI 2017b). Huxhold and Levinsohn articulate the need for recording project information using a standard methodology, and recommend a project definition form to capture information (Huxhold and Levinsohn 1995). Joffe proposes, however, that, "experienced managers generally know how much time and cost their staff should expend to conduct a task, and how much time and cost they actually do expend," (Joffe 2015, 15); yet this should not preclude GIS managers from tracking project information. For IGI&S programs, time and cost expended can vary depending on whether installations must solely execute tasks or if they have reach back–support from a regional- or program-level team for assistance. A variety of methods can support conducting a true cost analysis and budget formulation process.

4.2 Principle Methods and Examples

4.2.1 Work Breakdown Structure (WBS)

Defining the tasks for execution helps define and manage the resource requirements to conduct the work. A WBS outlines the list of tasks or deliverables executed by the team in a hierarchical manner (PMI 2017b). After the requirements gathering phase, IGI&S Managers should develop a program objective list, a list that identifies major objectives of the installation and overall service's IGI&S program. After identifying the objectives, an IGI&S Manager should identify the proponent of the objective, the entity with the requirement, the priority and the progress. IGI&S Managers should begin to estimate the personnel hours required to execute the tasks initially, and any personnel hours required for continued and on-going work associated with the objective in the future. IGI&S Managers should quantify time in hours, and should refer to historical records, interviews with team members, and professional experience to determine the initial estimates. The estimate does not require precision at its creation, but must come close to reflecting reality in order to garner confidence and legitimacy from leadership and stakeholders. As an IGI&S program develops its metrics capture process the IGI&S Manager can then refine existing estimates to better reflect the actual time. Table 9 Yearly Program Objective Work Breakdown Structure provides an example.

Table 9 Yearly Program Objective Work Breakdown Structure

Program Objectives	Proponent	Priority	Current Status	Initial Hours	Maintenance Hours
Program Management					
1.0 Programmatic Documentation	IGI&S	Medium	50%	80	40
1.1 Work Breakdown Structure	IGI&S	Medium			
1.2 Budget Template	IGI&S	Medium			
1.3 Levels of Service	IGI&S	Medium			
1.4 Performance Tracking	IGI&S	Medium			
2.0 Official Taskers	IGI&S	High	On-going		40
3.0 Procurement Packages	IGI&S	Low	0%	40	20
3.1 On-site Support Contract	IGI&S	Medium			
3.2 Equipment/Supplies	IGI&S	Low			
4.0 Strategic and Project Plans	IGI&S	Low	25%	160	80
4.1 Working Group Meetings	IGI&S	Low			
4.2 Community Outreach/Training	IGI&S	Low			
5.0 Standard Operating Procedures	IGI&S	Medium	0%	160	80
Real Property Data Creation and Maintenance					
6.0 Planimetric Data Review	IGI&S	High	20%	200	
7.0 Asset Validation	IGI&S	High	20%	2,000	1,000
8.0 Real Property Data Quality Assurance	IGI&S	High	0%		
8.1 Geometry Check	IGI&S	High			
8.2 Attribution Check	IGI&S	High			
8.3 Metadata Check	IGI&S	High			
9.0 Data Updates	IGI&S	High	10%	2,000	1,000
10.0 Real Property Reconciliation	RPAO	Medium	0%	800	400
Manage Installation Geospatial Data					
11.0 SDSFIE Requirements	IGI&S	Medium	10%	1,000	500
12.0 Non-Real Property Data Quality Assurance	Varies	Medium	0%	1,000	1,000
12.1 Geometry Check	Varies	Medium			
12.2 Attribution Check	Varies	Medium			
12.3 Metadata Check	Varies	Medium			
13.0 Reports to Functional SME	Varies	Low	0%	80	80
Data, Analysis, and Visualization Services					
14.0 Data Requests	Varies	Medium	On-going		160
15.0 Standard Map Products	Varies	Low	50%	300	80
GIS Platform Technical Support and Administration					
16.0 End-user Technical Support	IGI&S	High	On-going		160
17.0 System Management	IGI&S	High	On-going		80

The WBS remains crucial throughout the IGI&S program lifecycle as it provides a roadmap for IGI&S Managers and their teams, as well as their leadership that may not understand what the program or team does on a day-to-day basis. Additionally, it serves as a tool to communicate to leaders the business lines that rely on the IGI&S program and the components required for task completion. Leaders can use this information to reprioritize program objectives, and look to proponents to provide resource support. Most importantly, the WBS provides an understanding of the amount of labor resources required to execute tasks and conduct maintenance. DoD leaders often think that once an IGI&S program completes installation geospatial data creation, the geospatial data can be considered finished; however, installations experience regular changes to the spatial environment, such as construction, demolition, natural disasters, environmental hazards, and natural resource fluctuations. The WBS documents the expected requirement for maintenance on geospatial data and other program objectives that possess a lifecycle, allowing DoD leadership and IGI&S Managers the ability to make better planning and decision-making with regard to program objective labor requirements and costs through time.

4.2.2 Budget Development

IGI&S Managers must articulate the requirements for their program to function in order to advocate for resources. A budget template for IGI&S programs should present more information than merely a list of items for purchase and their cost as often described in GIS program management literature (Croswell 2009; Joffe 2015). A budget template for IGI&S programs should include OCCs to categorize and organize the ledger in alignment with Federal budgetary categories that define how the program

spends funds. Table 10 Common OCCs for IGI&S provides overarching descriptions of commonly used OCCs for IGI&S and examples.

Table 10 Common OCCs for IGI&S

OCC	Definition and Example
21 Travel and Transportation of Persons	Obligations for transportation of Government employees or others, their per diem allowances while in an authorized travel status, and other expenses incident to travel that are to be paid by the Government either directly or by reimbursing the traveler. *Example: travel to a training course.*
22 Transportation of Things	Contractual obligations for the transportation of things, for the care of such things while in process of being transported, and for other services incident to the transportation of things. *Example: shipping geospatial data on hard drives*.
24 Printing and reproduction	Obligations for contractual printing and reproduction (including photocomposition, photography, blueprinting, photostating, and microfilming), and the related composition and binding operations performed by the Government Printing Office, other agencies or other units of the same agency (on a reimbursable basis), and commercial printers or photographers. Includes all common processes of duplicating obtained on a contractual or reimbursable basis. *Example: printing and binding of official atlases.*
25 Other Services	Obligations for contractual services not otherwise classified. Supplies and materials furnished by the contractor in connection with such services are included even though they may be separately itemized on the voucher. *Examples: tuition for training courses; on-site support contract.*
26 Supplies and Materials	Obligations for commodities whether acquired by formal contract or other form of purchase that are: ordinarily consumed or expended within one year after they are put to use; converted in the process of construction or manufacture; or used to form a minor part of equipment or fixed property. Also includes charges for off-the-shelf software purchases of $25,000 or less. Also includes charges for off-the-shelf software with a useful life of under 2 years. Other property of little monetary value that does not meet any of these 3 criteria listed above may also be classified as "Supplies and materials" at the option of the agency. *Examples: general office supplies; printer paper; printer toner; binding supplies; mounting supplies.*
31 Equipment	Obligations for the purchase of personal property of a durable nature; that is, property that normally may be expected to have a period of service of a year or more after being put into use without material impairment of its physical condition. Includes obligations for service in connection with the initial installation of equipment when performed under contract. Excludes off-the-shelf software valued at $25,000 or less, and supplies and materials classified under object class 26.0. Also excludes fixed equipment that is classified under object class 32.0. This object class may consist of both equipment that is not capitalized (not set up in property accounts) and equipment that is capitalized. In determining subclasses for administrative use, agencies may appropriately maintain such a distinction. *Examples: GPS field equipment; large format plotter and scanner.*

Source: adapted from US Office of Management and Budget 2018 and US Department of Defense 2016.

The budget template should include the OCC category, the program functions the item supports, the cost and description of the item, and the risk associated with not funding. Table 11 Truncated Budget Ledger Template provides a sample from a larger budget ledger.

Table 11 Truncated Budget Ledger Template

OCC	Item/Supporting Functions	Cost	Description	Risk
21: Travel and Transportation of Persons	Esri International Users Conference Travel			
	Manage Installation Geospatial Data Data, Analysis, and Visualization Services Data creation and maintenance	$8,000	Travel and transportation of two (2) Government employees to the conference across four (4) days. Includes plane, rental car, hotel, and meals/ incidentals.	Installation will not participate in annual Esri International User Conference missing important event to receive Esri ArcGIS training, opportunities for engagement with Esri experts, and networking interactions with other IGI&S programs. Creates knowledge gap and limits sharing of best practices within IGI&S community.
	URISA Leadership Academy Travel			
	Program Management	$2,000	Travel and transportation of one (1) Government employees to the training across five (5) days. Includes plane, rental car, hotel, and meals/ incidentals.	Installation Manager will not receive proper GIS leadership and management training. Weakens IGI&S program oversight at the installation. Does not support employee investment or support achieving developmental goals.
	Annual Asset Management Meeting			
	Program Management Manage Installation Geospatial Data Data creation and maintenance	$500	Travel and transportation of four (4) Government employees to the meeting across three (3) days. Includes reimbursement for POV.	Installation will not participate in Asset Management Meeting. Coordination efforts between higher headquarters and installation in the asset management functional area will be limited. Creates knowledge gap on organizational goals, tools techniques, and processes only available through this event.

25 (25.1): Other Contractual Services/ Advisory Assistance Services (Training)	ArcGIS 4: Sharing Contents on the Web			
	Manage Installation Geospatial Data Data, Analysis, and Visualization Services Data creation and maintenance GIS Platform Technical Support and Administration	$3,700	Provides training for two (2) Government employees to assist with the implementation of Portal for ArcGIS in support of the enterprise transition.	Higher headquarters incorporating Portal for ArcGIS into GIS platform. Required for IGI&S personnel to become trained on the system. If not trained, personnel will not be able to provide system support to the wider installation community using Portal for creation of web maps or use of web mapping apps in support of FIAR, Infrastructure Reset, planning and construction projects, utility and energy saving projects.
	Explosive Safety Siting (ESS) Training			
	Data, Analysis, and Visualization Services Data creation and maintenance	$2,100	Provide training for one (1) Government employee to utilize ESS software.	Explosive Safety Siting software creates Explosive Safety Quantity Distance Arcs utilized in the community planning, engineering, utility, and general construction activities to ensure safe distance from explosions. Without data, installations are at risk for safety violations when conducting these activities.
	GIS Leadership Academy Registration Fee			
	Program Management	$1,800	Provides training for one (1) Government employee, the IGI&S Manager, to learn GIS management and leadership skills.	Installation Manager will not receive proper GIS leadership and management training. Weakens IGI&S program oversight at the installation. Does not support employee investment or support achieving developmental goals.
OCC 25.2 Other Contractual Services/ Other Services from Non-Federal Sources	On-site GPS Surveying Crew			
	Data, Analysis, and Visualization Services Data creation and maintenance	$360,000	Provides one (1) year of on-site GPS surveying support. On-site survey crew will conduct survey and mapping grade field collection in support of Common	OASD requirement for installation CIP data to be at 95% completeness. Installation requires a field survey crew to survey CIP data that could not be extracted from imagery. Without resourcing, IGI&S will fail to be in compliance with mandatory OASD requirements, will be unable

		Installation Picture (CIP) data completeness. Includes vehicles and equipment.	to reconcile real property data in support of FIAR, and will not be able to create and maintain other datasets in the geospatial ADS such as utility data, range and training data, or environmental data that relies on CIP foundational data. Impacts to other programs such as E-911 and Critical Infrastructure Protection that rely on this data for their mission success.
On-site GIS Analysts			
Manage Installation Geospatial Data Data, Analysis, and Visualization Services Data creation and maintenance GIS Platform Technical Support and Administration	$330,000	Provides one (1) year of on-site GIS analyst support. On-site GIS analysts will conduct data creation and maintenance of CIP data to assist in improving completeness and property record reconciliation in support of FIAR.	OASD requirement for installation CIP data to be at 95% completeness. Installation requires GIS analysts to feature extract data from imagery, update attribution and metadata. Without resourcing, IGI&S will fail to be in compliance with mandatory OASD requirements, will be unable to reconcile real property data in support of FIAR, and will not be able to create and maintain other datasets in the geospatial ADS, such as utility data, range and training data, or environmental data that relies on CIP foundational data. Impacts to other programs such as E-911 and Critical Infrastructure Protection that rely on this data for their mission success.

	On-site GIS Project Manager			
	Program Management Data Management Data, Analysis, and Visualization Services Data creation and maintenance GIS Platform Technical Support and Administration	$180,000	Provides one (1) year of GIS Project Management Support. On-site project manager will support and oversee work of on-site GPS field survey crew and GIS analysts. Will create project plan, conduct quality assurance, and ensure best practices and efficient processes and procedures are in place to maintain scope, schedule, and cost.	OASD requirement for installation CIP data to be at 95% completeness. Installation requires a GIS Project Manager to manage and oversee CIP data clean-up project. Without resourcing this requirement, IGI&S will fail to be in compliance with mandatory OASD requirements, will be unable to reconcile real property data in support of FIAR, and will not be able to create and maintain other datasets in the geospatial ADS, such as utility data, range and training data, or environmental data that relies on CIP foundational data. Impacts to other programs such as E-911 and Critical Infrastructure Protection that rely on this data for their mission success.

Military leaders' preference for risk and their perception of risk are central to decision-making (Knighton 2004). Capturing these elements can help military leaders make better decisions about how they choose to resource the IGI&S program. Such an example demonstrates ownership and responsibility for the program, fosters transparency about funding needs and expenditures, and communicates threats to other mission areas from a lack of funding the identified requirement.

4.2.3 Identifying Levels of Service or Performance

Utilizing the project list identified in the WBS, IGI&S Managers can further quantify and qualify risk by assessing their levels of service or performance in relation to their resourcing. An identification of the expected level of service or performance, based on the resourcing provided, can show decision-makers the losses they will incur from

funding cuts. Table 12 Levels of Service: Real Property Data Creation and Maintenance provides a sample assessment of the levels of service for one IGI&S function when only a percentage of the full requirement is funded.

Table 12 Levels of Service: Real Property Data Creation and Maintenance

Program Objectives	Service Level	Risk
90-100% of the Requirement		
6.0 Planimetric Data Review	Standard	Assumes low risk
7.0 Asset Validation	Standard	Assumes low risk
8.0 Real Property Data Quality Assurance	Standard	Assumes low risk
8.1 Geometry Check	Standard	Assumes low risk
8.2 Attribution Check	Standard	Assumes low risk
8.3 Metadata Check	Standard	Assumes low risk
9.0 Data Updates	Standard	Assumes low risk
10.0 Real Property Reconciliation	Standard	Assumes low risk
80-90% of the Requirement		
6.0 Planimetric Data Review	Standard	Assumes low risk
7.0 Asset Validation	Standard	Assumes low risk
8.0 Real Property Data Quality Assurance	Standard	Assumes low risk
8.1 Geometry Check	Standard	Assumes low risk
8.2 Attribution Check	Standard	Assumes low risk
8.3 Metadata Check	Standard	Assumes low risk
9.0 Data Updates	Limited	Risk increase as data updates take longer to get into the ADS; makes data less reliable for projects and decision-making, impedes project performance
10.0 Real Property Reconciliation	Limited	Risk increase as reconciliation with Real Property database of record does not occur in a timely manner, lowering service's financial audit score/results
70-80% of the Requirement		
6.0 Planimetric Data Review	Standard	Assumes low risk
7.0 Asset Validation	Limited	Risk increase as data updates take longer to get into the ADS; makes data less reliable for projects and decision-making, impedes project performance
8.0 Real Property Data Quality Assurance	Standard	Assumes low risk
8.1 Geometry Check	Standard	Assumes low risk
8.2 Attribution Check	Standard	Assumes low risk
8.3 Metadata Check	Standard	Assumes low risk

Program Objectives	Service Level	Risk
9.0 Data Updates	Limited	Risk increase as data updates take longer to get into the ADS; makes data less reliable for projects and decision-making, impedes project performance
10.0 Real Property Reconciliation	None	Assumes high level of risk as reconciliation with Real Property database of record does not occur, severely lowering service's financial audit score/results

The items in the table can be truncated to cover primary tasks, eliminating the subtasks, and can be built out further with additional cuts to funding of the requirement. Levels of service identifies what a leader will lose and the resulting impacts when cutting funding to a requirement. Military leaders' preference for risk and their perception of risk are central to decision-making (Knighton 2004). By clearly identifying the program objectives that cannot be met when leaders cut resources, IGI&S Managers can potentially preempt threats to their program (Kloos 2016a).

4.2.4 Establishing Metrics and Tracking Performance

Metrics, measures of an identified quality or characteristic of a system or process, supply information to IGI&S Managers, their team, and leaders, about how a program performs. Since IGI&S programs provide a variety of services—professional data, analysis, and visualization services, creation and maintenance of real property geospatial data, oversight of the technical GIS platform, support to end-users, and program management—IGI&S Managers should track a variety of metrics that capture information about program performance. IGI&S programs should track the type of work, the customers generating the requests, and the level of effort required for internal and external projects at a minimum. Knowing the program's customers, and the time their projects require, paints a tangible picture for leadership to understand how the IGI&S

program serves their installation community. For examples of metric parameters and their descriptions, refer to Table 13 Recommended Parameters for Tracking. No matter the method of tracking, a common set of metric parameters will provide meaningful data for analysis and these metric parameters should serve the service's IGI&S enterprise, not just a specific installation.

Table 13 Recommended Parameters for Tracking

Parameters	Description
Unique Project Identification Number	Unique identification number for the project; recommend using this number to link electronic project records and project deliverables to the service request
Project Title	Descriptive project title
Project Status	An indicator of the status of the request
Customer Information	Customer name and contact information
Customer Organization	Organization a customer supports
Government Sponsor Information	Government Sponsor's name and contact information
Government Sponsor Organization	Organization of the Government Sponsor
Type of Request	Service category of the request
Project Description	Description of the project
Contract/Project Number	Associated contract or project number
Assigned To	Name of staff member(s) assigned to project
Due Date	Date of requested completion
Date Opened	Date of initial request
Date Complete	Date of actual completion
FY and Quarter	FY and quarter
Hours	Number of labor hours
Project Comments	Comments as project progresses

Several authors identify methods to track performance—from the hard-copy project definition form advocated by Huxhold and Levinsohn (1995) to the spreadsheet ledger or project management software recommended by Croswell (2009). If not already provided by the service, IGI&S programs should look for an out-of-the-box solution for work tracking with nominal costs, and should avoid creating a system that becomes inflexible to changing requirements, obsolete, or exponentially expensive. The best

approach will depend on the IGI&S program's needs and the ease of implementation and use.

4.3 Analysis and Significance

Cost-benefit evaluation and ROI remain central to the discussion of GIS program management because of the need for GIS managers to show the value in investment of GIS programs. Utilizing the strategies discussed above supports IGI&S Managers' ability to identify the costs of their program and the benefits it provides, as well as conducting project-based ROI calculations. These methods support the capture of ROI by establishing the baseline costs for various activities that can then be used to measure against the return from the activities' outcomes; for example, found real property that translates into plant replacement value (PPV) and results in an increase in sustainment dollars for an installation. This allows IGI&S Managers to effectively determine their program's contribution based on real evidence.

Most installations in the MCIWEST AOR created WBS to identify major tasks, hours associated with those tasks, and the cost of conducting those tasks. Several MCIWEST installations received significant increases in programmed funding during the Planning, Programming, Budgeting, and Execution (PPBE) process, a process that produces plans from Services and Defense Agencies for the Office of Secretary of Defense detailing the allocation of funds to programs. MCB Camp Pendleton received a 75% increase in FY19 programmed funding over the FY14 amount. Other installations in the MCIWEST AOR saw modest improvements in their programmed figures as well. MCAGCC Twentynine Palms did not use this methodology prior to 2017, and as a result grossly underestimated their requirement (Goering 2017); but, once the IGI&S Manager

adopted the methodology, their program received an increase in local funding. By identifying the work in a WBS and using the information to generate a budget ledger template, the GEO*Fidelis* Program Manager used the information to form justifications for increased funding during the PPBE process. Furthermore, linking funding requests to strategic goals of the organization built on substantiated and defendable amounts also supported increased funding during the process, as the PPBE process tests program managers to defend their funding requests. The WBS and historic information increases the confidence of members of the PPBE; failure to adequately defend the numbers encourages increased scrutiny and risk-taking in budgeting decisions.

MCB Camp Pendleton created a work tracking site using Microsoft SharePoint out-of-the-box, a Marine Corps enterprise-provided tool for knowledge management and collaboration. The IGI&S Manager created a list of metric parameters, their definitions, and built a collaborative site for his team to track their work. The IGI&S Manager then utilized SharePoint to generate metrics reports, including pivot tables and graphs, to display important information about his program each FY. The IGI&S Manager showed that between 2009 and 2012, MCB Camp Pendleton discovered $80 million worth of sustainment dollars not accounted for by the installation through the use of geospatial data development and analysis techniques, with the IGI&S program costing a mere fraction of the missing sustainment dollars uncovered (Harris 2018). The IGI&S Manager utilized the results in a variety of presentations on his program that led to gains in funding locally shortly after its implementation, as well as through the enterprise-level performance and funding processes several years later (Harris 2018). Furthermore, the IGI&S Manager could then also determine a per feature data

maintenance cost. The GEO*Fidelis* Program Office utilized this data to calculate ROI for cost avoidance in data sharing across multiple systems that consume the GIS data, extrapolated against the number of adds and deletes in year-to-year CIP submissions as part of internal controls reporting.

The Marine Corps GEO*Fidelis* Program Office went on to adopt a version of his methodology creating a centralized SharePoint site for all installations to log their work, allowing for performance tracking at the service-level by enabling enterprise-wide pulls of performance metrics. The change resulted in the ability for the GEO*Fidelis* Program Office to get consistent information across the enterprise for reporting at the highest leadership levels, improving the quality of the program defense and justification for increases in funding during the PPBE process. Articulating clear funding requirements, and the various expected levels of service, give leaders options during times of healthy and unhealthy funding levels.

Creating visual representations showing performance help communicate the achievements and deficiencies, and allow for prioritization of effort and streamlining of business operations to optimize performance. The MCLB Barstow IGI&S Manager struggled to effectively communicate to his leadership his need for on-site support contractors, the work they produced, and the level of funding required to support their efforts (Wiley 2018). By providing his Public Works Officer (PWO) a WBS in conjunction with a level of service and budget breakout, he could effectively articulate his requirement. MCLB Barstow's IGI&S Manager reflected "I wish I had these documents a year ago when my PWO asked me to explain my program and my requirements," (Wiley

2018). The IGI&S Manager felt well prepared to defend his requirements, and promoted confidence and trust with his leadership as a result.

IGI&S Managers still, however, face challenges when using the proposed methods. For example, leadership disinterest, organizational mismanagement, and extreme budget limitations, can all impact the effectiveness of the recommended strategies. IGI&S Managers, however, should not let these factors impede their efforts to develop and maintain these tools for their program. IGI&S Managers must continue to devise and document the work breakdown and the costs and personnel required to execute it because it impacts the IGI&S program credibility during the PPBE process. Funding levels, leadership, and organizational structure change as a result of changes to an administration, economy booms and busts, and defense posture from emerging threats. By having these methods in place prior to these types of changes, IGI&S Managers can make the case to sustain and grow their programs in light of change, while showing competency, responsibility, and leadership. Investments that show good stewardship of taxpayer dollars and foster transparency with the public matter. IGI&S Managers can then work to form effective relationships with leaders and stakeholders using the documented outcomes from these methods.

Chapter 5: Empowering People and Communities of Interest

DiMarco and Lister note, “The major problems of our work are not so much technical as sociological in nature. Most managers are willing to concede the idea they’ve got more people worries than technical worries,” (Croswell 2009, 98). Whether GIS professionals, practitioners, or end-users, people play a role throughout the entire IGI&S program lifecycle, whether directly or indirectly, actively or passively. IGI&S Managers must engage with their internal team, enforcing standards, ensuring professional tradecraft, and providing performance leadership and guidance, while also outreaching to business units, stakeholders, and end-users to ensure effective diffusion of the GIS capability and advocation for capacity.

Depending on funding ability, IGI&S Managers may find themselves as a team of one or a team of many. Some IGI&S teams consist of Federal Government civilian staff, whereas others rely on project-oriented contracted support. Larger, more dynamic installations, may use both sources to meet program objectives and tasks. Different command structures may encourage reach back to a higher-level echelon, such as a regional- or program-level office. No matter the circumstances, IGI&S Managers should become versed in team creation and building, professional development strategies, and performance management; hiring, developing, maintaining, and retaining talent serves as an investment in the program and the program’s ability to meet its mission. An investment in people, a critical factor in the GIS capacity equation, supports strong IGI&S program health and capacity building.

The IGI&S Manager plays a vital role as a leader and influencer internally in his or her business unit and also externally to stakeholders and end-users as well. The

ability to communicate and form strong relationships will impact the diffusion of the IGI&S program throughout the organization. The greater the investment of individuals into the use of the IGI&S capability, coupled with positive outcomes, the more likely those individuals will feel empowered to advocate for program sustainability. Individuals and their organizational units, however, can weaken IGI&S program support if the opposite occurs. Such experiences can result in damage to the program as extreme as the development of “cottage GIS” implementations, when organizational units attempt to develop their own GIS capabilities to avoid using the IGI&S enterprise system (Harris 2018). Such actions lead to organizational inefficiencies, such as duplication of effort, cost, time, system technology, data, and maintenance, as well as potential security risks (Reeve and Petch 1999). IGI&S Managers must therefore actively work to create the right professional environment for their program to thrive through individual engagement and organizational outreach to support the program’s diffusion.

5.1 Foundational Background and Gap Identification

People, a key parameter of the GIS capacity equation, remain critical to the sustainability and growth of IGI&S programs. Building program capacity involves hiring, training, and maintaining personnel with the knowledge, skills, and abilities to carry out mission requirements; yet, unique challenges exist when it comes to Federal human resource’s processes, procedures, and standards as it relates to IGI&S programs. The Office of Personnel Management (OPM) sets categories and standards for occupational series, a job classification for Federal Government civilian employees that identifies basic knowledge, skills, abilities, and qualifications within the identified field. For example, the 1300 Physical Sciences category, maintains job classification standards

for positions such as the 1315 Hydrology series, 1320 Chemistry series, and 1370 Cartography series. Each individual agency maintains a position description that provides details regarding the specific job duties and qualifications as they align to the series and the agency's requirements. IGI&S personnel do not have a standardized job series because of the lack of an OPM occupational series from which to draw standards. While the Bureau of Labor Statistics identifies GIS occupations, as do many other professional organizations such as Urban Regional Information Systems Association (URISA) and the United States Geospatial Intelligence Foundation (USGIF), OPM does not identify a GIS occupational series (Goering 2017). GIS, with an emphasis on remote sensing and digital cartography, blends several OPM occupational series, and only came into existence as an independent occupation in the Federal Government approximately 15 years ago as exemplified by the creation of NGA in 2003 from the National Imagery and Mapping Agency (NIMA) (Goering 2017). Most commonly agencies classify GIS positions as 0150 Geographer, 1370 Cartographer, or 1371 Cartographer Technician; however, agencies also use the 0802 Engineering Technician series, 2210 IT Specialist series, or even the catch-all 0343 Management and Program Analysis series. The general job descriptions and qualifications requirements for each of these series can impact the knowledge, skills, and abilities that individuals bring to the IGI&S program. An IGI&S Manager should become familiar with any position descriptions for civilian personnel on their team, including his or her own, and should actively encourage the review, and if necessary, the rewriting and reclassification of positions to align to current requirements. A lack of resources exists to draw from for the creation or update of position descriptions. The US Army Fully

Automated System for Classification (FASCLASS) Library represents the best available library for existing position descriptions that an IGI&S Manager can use for reference. Creating and classifying generic position descriptions for an IGI&S Manager and an IGI&S Analyst for use by installations would benefit the enterprise. Position descriptions not only serve an important role in the hiring of personnel, but also in setting performance standards and objectives.

Position descriptions drive performance objectives and can help with the framing of Professional Development Plans, also known as Individual Performance Plans (IDPs). IGI&S personnel may report to non-GIS professionals, however, that may lack knowledge to help develop performance objectives for them that align position requirements, program requirements, and grade-level expectations. Additionally, non-GIS professionals in supervisory positions may lack the time or consideration for familiarizing themselves with these criteria, or worse, not enforcing accountability against performance objectives and standards at all. Similarly, these issues can impact professional development planning as GIS combines knowledge from multiple competencies, such as information technology, cartography, photogrammetry, and geodesy that many non-GIS professionals may find abstract. IGI&S Managers may need to take an active role in educating non-GIS supervisory personnel and participating in the development and implementation of performance criteria. A standard set of performance objectives and sample IDPs for both IGI&S Managers and team members could assist those with such challenges.

In addition to the formalities of position descriptions, performance objectives, and IDPs, IGI&S Managers must also monitor team dynamics and morale. GIS program

success has been characterized by long-term continuity of staff supported by clearly defined career paths and management opportunities, staff autonomy in regards to user relations and task completion, involvement with current technologies that provide challenges, and clearly defined roles within the unit and the organization as a whole (Huxhold and Levinsohn 1995). Croswell maintains that “GIS managers must understand the preferences and motivations of their staff…with which they interact and must adapt their practices to respond to these motivations,” (Croswell 2009, 103). Individuals who become supervisors, managers, or team leads often do not receive education or training in soft-skills, such as communication, conflict resolution, difficult conversations, and feedback, and must develop and hone them on the job. Additionally, creating positive energy can seem incredibly challenging if the work environment becomes toxic, hostile, or subject to negative organizational politics or a floundering program.

Stakeholders and end-users also play an important role as their acceptance of the technology, the data, and the program paradigm can impact the success of the program. As Budic articulates, “individual perceptions, experiences, attitudes and communication behaviors take precedence over organizational and technical factors in decisions about whether to use or not to use GIS technology,” (Budic 1993, 55). This can also impact whether or not stakeholders or end-users accept their responsibilities in the IGI&S paradigm when it comes to funding the creation and maintenance of content in their functional area. When grouped together as part of a business unit, such perceptions can fuel organizational politics, the processes and behaviors of human interactions relating to power and authority. People inherently partake in organizational

politics and navigating such situations demands exceptional savvy. Burks and Convery both articulate in their research respectively that creating a GIS “champion” serves as an important steering agent to a program’s success and such an individual can play an important role in navigating these issues (Burks 2009; Convery 2008). To mitigate and overcome these challenges, IGI&S Managers must develop skills and implement methods that empower people in a positive and constructive way.

5.2 Principle Methods and Examples

5.2.1 Support the Development of a Competent and Motivated Workforce

5.2.1.1 Position Descriptions

Creating a team with the knowledge, skills, and abilities necessary to meet IGI&S program requirements involves research, and navigating the human resources documentation can seem daunting because of the number of standards and regulations imposed by OPM. The IGI&S Manager should make every effort to work with his or her leadership to review the position descriptions for appropriate series classification and assigned duties for all IGI&S Federal Government civilian personnel. Hiring authorities should classify positions for IGI&S personnel as either 1370 or 1371 series, or alternatively the 0150 series. Table 14 Occupational Series Comparison compares the 0150 and 1370 series. OPM considers both series “professional” series, which require “knowledge in a field of science or learning characteristically acquired through education or training equivalent to a bachelor’s or higher degree with major study pertinent to the specialized field,” and “the exercise of discretion, judgement, and personal responsibility for the application of an organized body of knowledge that is constantly studied to make

new discoveries and interpretations, and to improve data, materials, and methods," (US Office of Personnel Management 2009, 9).

Table 14 Occupational Series Comparison

Source	GS-0150 Geographer	GS-1370 Cartographer
OPM Handbook of Occupational Groups and Families	This series covers positions the duties of which involve professional work in the field of geography, including the compilation, synthesis, analysis, interpretation, and presentation of information regarding the location, distribution, and interrelationships of, and processes of, change affecting such natural and human phenomena as the physical features of the earth, climate, plant and animal life, and human settlements and institutions.	The series includes positions requiring the application of professional knowledge and skills in mapping and related sciences, and relevant mathematics and statistics to plan, design, research, develop, construct, evaluate and modify mapping and charting systems, products, and technology.
OPM [Job Family] Position Classification Standard for Professional Work	Taxonomic and descriptive work involves the assembly and presentation of information concerning the location, nomenclature, and distribution of phenomena, including the differences that exist among things that seem to be alike. This information is used for geographic categorization and designation, for producing maps, charts, and gazetteers, for standardizing geographic nomenclature, and for determining and comparing the distribution of phenomena. Analytic and interpretive work goes beyond scientific observation, collation and reporting of facts. It attempts to understand the relationships existing among various phenomena, to ascertain the significance of the location and distribution of things, and to understand and determine the reasons for geographic change.	Develops and monitor the production of geographic information systems and hardcopy map generation for a staff unit. Works on inter- and intra-agency committees to develop and/or revise geospatial data. Revises agency cartographic standards and specifications. Provides staff advisory, consulting, and reviewing services. Applies standard cartographic practices to new situations and solves novel or obscure problems. Exercises initiative and originality in the solution of cartographic problems. Serves as a technical authority on all aspects of cartography.
Sample Duties	Collect and analyze spatial data, plan and develop geographic information and projects to facilitate scientific analysis, and enhance communications of results through reports and maps. Performing data reconciliation between GIS (systems) and organizational or other data storage systems. Performing geospatial analysis to identify inconsistent information.	Design and produce maps using geographic information systems, incorporating satellite data, aerial reconnaissance, and field surveys to produce datasets used by both scientists and everyday people. Use of Computer Aided Design and Drafting (CAD) and Geographic Information Systems (GIS) software in developing maps. Review engineering documents and drawings, such as design

Source	GS-0150 Geographer	GS-1370 Cartographer
		memoranda, construction plans and specs, determine real restate and location requirements for projects. Perform boundary determination, real estate mapping procedures and land area calculations. Serve as a technical point of contact for cartographic and GIS interests.

Source: adapted from US Office of Personnel Management 1963, 1997, 2009, 2018.

Professional series differ from “technical” or technician series, where work “involves extensive practical knowledge, gained through experience and/or specific training less than that represented by college graduation,” and “technical employees carry out tasks, methods, procedures, and/or computations that are laid out either in published or oral instructions and covered by established precedents or guidelines.” (US Office of Personnel Management 2009, 10). These distinctions, for example, differentiate the 1370 Cartographer and 1371 Cartographic Technician series.

By ensuring the position description accurately reflects the roles and responsibilities of the position, the supervisor creates clarity for the employee regarding the employee’s duties and fosters trust and transparency regarding the expectations of the person in the position. Furthermore, having an accurate position description can help supervisors ensure they hire the right person for the job, and can easily use the descriptions to assist in formulating performance objectives when the time comes.

5.2.1.2 Resumés and Interviews

Resumés should discuss experience through work history and education, while noting technical proficiencies in software and hardware, professional memberships, and recent awards. Potential interviewees should include a short introductory paragraph summarizing themselves and/or objectives in prose, and use bullet notation for all other

sections. Resumés should be free of typos and grammatical errors, well-organized, and consistently formatted. Acceptable resumés for civilian positions can span multiple pages, but should stick to outlining the responsibilities and activities of the current and previous positions, the impacts of the individual during the position tenure, such as his or her achievements not merely his or her duties, and the relevant educational accomplishments and applicable coursework. Additionally, IGI&S Managers should ensure no gaps exist in the timeline of the resumé, and if so, seek clarification. IGI&S Managers should also assess other relevant documentation including cover letters and transcripts, but a resumé outlining activities and accomplishments in a challenge-context-action-result method should hold the most weight in a decision for an interview. Prior to an interview, consider requesting the interviewees provide a portfolio, map sample, and/or writing sample for the interview.

Interview panels should possess at least three individuals: the supervisor, an IGI&S SME, and any other additional leadership and/or human resources team member. Encouraging an IGI&S Manager or team member to assist in or observe during the panel also serves as a good experience for him or her to see how interviews work as part of a developmental experience. All interviews should include an introduction of the personnel on the panel, a description of the position, job duties, and performance expectations, followed by an opportunity for the interviewee to ask any initial questions. The panel should ask a series of pre-determined questions with each panel member taking a turn. Interview questions should possess a mix of questions on technical competencies and interpersonal skills tailored to the requirements of the position. Table 15 Sample Interview Questions provides some example interview

questions and the objectives of the question. Panel members should have a consensus as to the types of answers they expect for each question.

Table 15 Sample Interview Questions

Question	Objective
You are given two projects at the same time. Each project individually takes two hours to complete; however, both projects are due three hours from the time they were received. What do you do?	Tests an individual's ability for problem-solving, delegation and/or teamwork, communication, and time management.
You missed an important deadline and a customer is unhappy. How do you rectify the situation?	Tests an individual's ability for communication and customer service.
GIS technology evolves quickly. How do you maintain your GIS proficiency?	Tests an individual's ability for professional development and self-activation.
What are some strategies you employ when you run into a problem in GIS that you do not know how to resolve?	Tests an individual's ability for problem-solving.
Describe a recent GIS project. What types of data, analysis, and/or visualization tools and techniques did you use?	Tests an individual's proficiency.
You're asked to create a map, but the data does not exist or possesses severe deficiencies. What do you do?	Tests an individual's ability for problem-solving, research, SME interaction, communication, and customer service.
Describe some of the different projects and the geoprocessing tools you've used in them.	Tests an individual's proficiency.
Describe a positive team experience and a negative team experience. Why was one positive and the other negative? Looking back what would you do to improve the negative situation given what you know now?	Tests an individual's ability to work with others, communication, ownership, self-reflection, and identification of lessons learned.

All interviewees will be given the same interview introduction and questions, and the panel should not ask any additional questions outside of those agreed upon. Panel members should make notes during the interviews for reference during the selection process, as a means to document qualifications and qualities displayed by interviewees' answers for selection justification, and for protection in case of accusations of unfair selection.

5.2.1.3 Career Road Maps and Professional Development Plans

Developing a career road map can assist IGI&S Managers and IGI&S Analysts see a pathway to maintaining professional competencies and advancing in their career either internal or external to the organization. A career road map can include competencies expected at different GIS proficiency levels, such as novice, developmental, or full performance, as well as competency-based training opportunities for different proficiency levels. Additionally, the career road map may identify descriptions of, and qualifications required for the progression through, an occupational series' different grade levels. Table 16 Core Competencies highlights aptitudes for IGI&S personnel. These criteria form the foundational competencies required by personnel working in IGI&S and should serve as a guideline for developing position descriptions, performance standards and objectives, and IDPs.

Table 16 Core Competencies for IGI&S Personnel

Competencies	Description
Conceptual Geospatial Foundations	Understands and applies principles of geography and spatial thinking to solve real world problems and phenomena.
Geospatial Data Management and Manipulation	Ability to model the earth with basic understanding and use of geoids, ellipsoids, and spheres, coordinate systems, map projections, and datums. Create, maintain, and render data through multiple means, and use the appropriate geospatial representation of geographic features and documentation through metadata. Understanding of differences between raster and vector representations, and accuracy, precision, and resolution.
Data and Database Design	Understanding of relational database modeling systems (RDBMS) and principles, including normalization and query. Ability to conduct database modeling, both logical and physical.
Analytical Methods	Use of simple and complex geoprocessing tools. Ability to document analysis processes and methodologies, and provide confidence level based on data quality.
Cartography and Visualization	Understanding of basic cartographic principles in relation to projections, scale, generalization, aggregation, design, layout, color theory, typography, symbology, and labeling principles.
Organizational Awareness	Understands organizational mission and vision, and the role of the program in the organization. Knowledge of different business lines and their geospatial requirements.

Competencies	Description
Communication	Provides concise, accurate, relevant, and timely information to others orally and in writing. Demonstrates active listening skills.
Project Management	Plans and manages discrete, technical projects, including budget, controls, risk, and time, in alignment with project management principles.
Program Management	Plans and manages strategic aspects of a program, such as budget, personnel, and contracting, using program management principles and techniques. Monitors and evaluates program initiatives.
Leadership	Demonstrates a high level of initiative, effort, and commitment towards achieving results. Coaches, mentors, and guides others to maximize potential of skills. Promotes team morale, productivity, and goals. Effectively influences individuals at all levels.
Self-Management and Planning	Works with minimal supervision, is motivated to achieve, and demonstrates responsible behavior. Organizes work and manages priorities efficiently.
Problem Solving	Identifies issues, proposes courses of action, and supports or demonstrates decision-making authority.
Teamwork	Facilitates cooperation and trust to foster a positive team dynamic.
Coalition Building	Promotes cross-organizational integration through outreach and education. Leverages opportunities for collaboration, consensus building, and productive negotiation. Effectively influences individuals at all levels.

Source: adapted from US Department of Defense 2014.

Identifying competencies and competency-based training at the novice, developmental, and full performance skill levels helps guide employees to training opportunities, solidify requirements for career advancement, and documents expectations of qualifications and performance within that skill level. The career road map also supports the creation of performance objectives and standards, as well as IDPs.

IDPs serve as a means for helping employees set out their desired professional development goals and aspirations. The IDP differs from performance objectives set in a performance review cycle because the IDP outlines short-, mid-, and long-term professional goals and career activities for the individual, whereas performance objectives stipulate the performance outcomes expected of the individual during a specified rating period. Performance objectives should be “SMART”: specific, measurable, attainable, relevant, and timebound, whereas IDPs may be more

conceptual and flexible. IDPs represent an opportunity to help mentor employees towards their overall developmental and professional goals. IDPs, for example, could include rotational assignments, job shadowing, or on-site assisted training. Formalizing a mentoring program that focuses on highly-motivated, high-performing employees serves as one of the best efforts an IGI&S program can make to generate ROI.

5.2.2 Stakeholder, Leadership, and Customer Engagement

5.2.2.1 Education and Outreach

An IGI&S Manager should make an effort to conduct user education and outreach internal to their directorate and department, as well as to external stakeholders and SMEs. Stakeholder education and outreach promotes the IGI&S capability and works “to obtain maximum participation by multiple business lines, establish data integration, and standards for use, and derive benefits to the mission from use of geospatial information,” (Phillips 2016). Educating users on the data and tools available, and their roles and responsibilities with data content, can lead to stakeholders and SMEs programming for the requirement through their own funding lines and engagement aimed at improving data quality respectively. Utilizing the SME and user tracking methods, discussed earlier, facilitates the outreach effort, while continued engagement by the IGI&S team provides information to keep the documents up-to-date when organizational or personnel changes occur. IGI&S Managers can utilize a variety of methods to educate and outreach to users, and should identify some methods to help them see their vision through. Table 17 Education and Outreach Methods provides suggested methods for education and outreach.

Table 17 Education and Outreach Methods

Education and Outreach Methods	Description
Classroom/One-on-One Training	Provides in-person hands-on training and interaction
E-Learning/Computer-based Training	Provides an alternate method to in-person training in cases where in-person training is not an option
Tri-Folds	Provides relevant facts about IGI&S, capabilities, services, contact information
Fact Sheets	Provides relevant facts about IGI&S, capabilities, or integration with a business line
Public Displays	Provides an opportunity to target potential uses unaware of IGI&S capabilities and services
Brown Bags/Functional Area Roadshows	Provides focused informational and discussion sessions for users and stakeholders
Intranet sites	Provides tools for sharing important information, data, and tools electronically
E-Mail Lists	Provides a means for communicating and interacting with users and stakeholders

Trial and error may be required in order to gauge effectiveness of each method in the local organization. IGI&S Managers should try a blended approach to education and outreach and not overly rely on one particular method. Over use of any one method can cause a saturation effect and lead recipients to ignore or resent the effort, such as an overreliance on e-mail that can lead to individuals deleting the messages without reading them first, especially if the e-mail contains lengthy prose. IGI&S Managers should embrace the use of in-person meetings as necessary—putting a name to a face can help build connections with people and encourage positive rapport.

5.2.2.2 Working Groups

Working Groups serve as a mechanism for in-person, interdisciplinary coordination amongst the various directorates and departments. IGI&S Managers may wish to establish a Working Group to serve executive-level leadership at the executive-level, and/or to create one at the working-level for Functional and Data SMEs. IGI&S Managers should draft a charter that serves as a formal guidance document for the

Working Group. Table 18 Working Group Charter Section Examples provides examples of sections to include in a charter and the objective of the section.

Table 18 Working Group Charter Section Examples

Section	Objective
Purpose	Establishes the purpose of the working group: "…to advise, promote, and sustain the business use of geospatial data, technology, and services in support of an integrated approach to Geographic Information System use in decision-making in support of mission requirements."
Background	Describes the background that led to the formation of the group: "Geospatial information is critical to provide effective Installation management…"
Scope and Function	Identifies the type of work and breadth of the group: "forum for Directorates and departments to identify geospatial information, service requirements and resources, promote fiscal management and resource advocacy, manage and coordinate geospatial data lifecycle requisites…"
Meetings	Captures the meeting facilitator, the frequency of meetings, and the capture and coordination of meeting minutes and documentation, "…will facilitate quarterly meetings...Detailed minutes of each meeting shall be kept and shall contain a record of attendees, a complete and accurate description of matters discussed…"
Roles and Responsibilities	Includes membership, meeting inputs and outputs: "Membership will include…Members of the Working Group are responsible for inputs...coordination with respective Directorate/departmental SMEs…providing data ownership and stewardship over their functional area…and outputs…prioritized projects…formalized and implemented policy...reviewed and validated resource management activities…"
Authority	The authority for establishing the Working Group, "…the Chief of Staff authorizes the establishment of the Working Group…"

Source: adapted from US Department of Defense 2018.

Capturing the members present during a meeting, the directorate or department they represent, and their position within their organization, provides IGI&S Managers with critical information in case they need to follow-up after the discussion. Furthermore, depending on the audience of the working group, whether executive- or working-level, knowing the position of the person present helps determine the amount of authority and influence that individual carries within their organization. The IGI&S Manager should take notes or request a person from their team or department provide notetaking support in order to capture all items discussed and any action items or due-outs for the next meeting and the person or persons responsible for the due-out.

5.3 Analysis and Significance

Empowerment strategies in support of internal IGI&S team dynamics proved fruitful for several installations. MCAS Miramar's longtime IGI&S Manager recently retired creating a vacancy. MCAS Miramar's Public Works Department made an active and engaged effort to form an integrative and collaborative resumé review, interview, and hiring process that included key personnel, such as the PWO, the Asset Management Branch Head that oversees the IGI&S program, and the MCIWEST IGI&S Regional Program Manager. Together the group reviewed resumés against IGI&S core competencies and selected interviewees. The MCIWEST IGI&S Regional Program Manager contributed a variety of technical and supervisory questions, while the PWO and Asset Management Branch Head contributed leadership and values-driven questions. The interview process led the panel to make an offer to an interviewee that displayed an outstanding breadth of technical knowledge and leadership qualities in the IGI&S field. The hiring panel also successfully secured a bonus for the offeree—something unprecedented previously for IGI&S personnel in the region—by taking a collaborative approach to writing the justification document.

Through the evaluation of standardized IGI&S core competencies for performance objectives, MCB Camp Pendleton Public Works Department leadership recognized the position descriptions for IGI&S team members required re-alignment with a more appropriate series. In collaboration with the MCIWEST IGI&S Regional Program Manager, the GIS and Support Branch head rewrote and reclassified position descriptions for IGI&S Analysts and the IGI&S Manager, to align with the Cartographic Technician and Cartographer series respectively, and to better reflect the current job

duties. By realigning series and updating job duties, the supervisor created transparency in the performance objective creation and evaluation process, and defined clear roles and expectations for personnel. Reeves and Petch argue that such empowerment “allow[s] some workers to take fuller, and more independent, control of their working environment,” (Reeves and Petch 1999, 173). The realignment also benefited the personnel, by aligning them to the GEO*Fidelis* Career Road Map providing them with a tool to support the development of their IDP.

A variety of outreach, education, and training efforts supported successes internally to IGI&S teams and externally to other functional areas, and inspired a senior leader to become a GIS champion in the organization and encourage executive-level engagement with the program. The MCIWEST IGI&S Regional Program Manager provides support to IGI&S Managers in the MCIWEST AOR, including professional development. New IGI&S Managers come to MCIWEST-MCB Camp Pendleton for one week of hands-on training with the MCIWEST IGI&S Regional Program Manager to learn program management tools and techniques. Additionally, the MCIWEST IGI&S Regional Program Manager advocates for continued education and training through activities such as attendance at the URISA GIS Leadership Academy and the annual Esri International Users Conference. Participation in asset management team roadshows and events, supervisory training events, and PWO summits facilitates engagement by the MCIWEST IGI&S Regional Program Manager with IGI&S Managers and their leadership. Such engagement leads to understanding a person’s expectations of empowerment, allowing for alignment to those expectations. The efforts established

trust within Facilities leadership throughout the MCIWEST AOR and earned a champion for the IGI&S program in the Regional Facilities Officer (RFO).

The RFO serves as a promoter of the IGI&S capability to executive-level leadership, facilitates coordination across all levels, assists in the implementation of policy to support data quality improvement, and advocates for funding. These efforts led to the founding of the MCIWEST Geospatial Working Group and creation of a formal charter signed by the MCIWEST Chief of Staff. The Working Group supported the development of a regional policy letter signed by the MCIWEST Commanding General regarding installation geospatial data coordination, validation, lifecycle management, and storage. The policy letter directs the housing of SDSFIE–domain installation geospatial data in the installation's geospatial ADS throughout the MCIWEST AOR, a first step in eliminating organizational stove-pipes to data sharing throughout the enterprise. The policy letter also serves as a directive IGI&S Managers and Functional SMEs can turn to when arguing for resources to support the creation and maintenance of data. Such outcomes encourage stakeholders and functional SMEs to invest in their data. The MCB Camp Pendleton IGI&S Manager worked with the Operations, Training and Plans Directorate to improve the fidelity of their military operations features as a method of outreach. The success led to further investment in those features at MCAS Yuma, MCAGCC Twentynine Palms, and MCMWTC Bridgeport.

The strategies outlined herein do not encompass every possible means of facilitating empowerment of people and the organization as a whole. In fact, these strategies may not always yield successful outcomes, especially in the face of challenges such as organizational politics, personal agendas, relationships, and

backdoor deals—these instances happen. IGI&S Managers must strive to set an example of professionalism within their unit, organization, and program, no matter the challenge that working with people presents. Creating a “reputational shield,” through demonstrative performance and customer service can protect an IGI&S Manager against negative situations he or she may encounter. IGI&S Managers have the latitude to get creative and experiment to discover what works best within their particular team, unit, or organization.

Chapter 6: Conclusion

Competing service- and installation-level priorities often lead to defunding IGI&S programs. A lack of fiscal discipline in executing service-validated funding priorities such as IGI&S, in favor of local requirements puts life, health, and safety at risk as critical installation functions and services require IGI&S geospatial data to execute their mission. A withdrawal of investment in IGI&S also delays DoD strategic initiatives meant to improve installation functions and services, such as 21st Century Installations and Airbases, Financial Improvement and Audit Readiness (FIAR) compliance, and Infrastructure Reset, exacerbating the problems at the installation level. This contributes to the decline of installations as projection platforms of military readiness and power during a time in which joint-force training and interoperability remains critical to US military superiority in the fight against emerging threats. Providing a tailored IGI&S program framework that supports sustainability and capacity building can lead to the successful implementation of DoD strategic initiatives reliant on accurate and timely installation geospatial information. The IGI&S Program Management Framework serves as a model for IGI&S programs within the DoD for increasing GIS program sustainability and capacity.

IGI&S Managers must, “understand their business, and know their requirements,” discovering the mission of their service and installation, the needs and requirements it generates for geospatial data, and institutional priorities and requirements the geospatial data supports. The mission of a service and an installation impacts the spatial environment that the GIS must capture, as well as the requirements, priorities, and taskings of its IGI&S program. Requirements gathering and business needs

alignment remains critical to the success of any GIS program. Understanding the organization, the individuals, and the business processes, allows IGI&S Managers to begin to form effective program management strategies and relationships that can translate into increased GIS capacity. To effectively gather and synthesize this information into actionable opportunities, IGI&S Managers should implement a data-to-product matrix to capture how the GIS data translates into products that support different mission functions and a stakeholder tracker to track stakeholders' responsibilities and accountability for geospatial data creation and maintenance in their functional area. Additionally, IGI&S Managers should create a SWOT analysis to evaluate and pinpoint issues that impact strategic and project planning, and use the analysis to help develop effective strategic and project plans that yield impactful results. Once IGI&S Managers develop their knowledge, they can then begin to capture their own requirements in a GIS infrastructure lifecycle management plan in order to execute functional mission needs.

GIS infrastructure lifecycle management plans capture current hardware, software, and data statuses and on-going needs. Local hardware, software, and data will require replacement, renewal, updates, or maintenance through time. The IGI&S Manager should capture hardware and software inventories and create a refresh cycle in order to ensure the program maintains operational capabilities. A data health assessment provides a holistic evaluation of the GIS data, targeting places for improvement, while a data maintenance schedule documents the ongoing lifecycle of data maintenance. Creating GIS infrastructure lifecycle plans helps IGI&S Managers take account of their operational requirements and interdependencies. The IGI&S

Managers place their program at risk by not capturing this information for submission into the planning and programming process that determines the amount of funding a program receives. GIS infrastructure lifecycle plans support the development of budget proposals and the measuring of program performance levels by capturing current capabilities and needs within the IGI&S program.

The amount of funds provided to an IGI&S program impacts the level at which the program performs, and the performance of an IGI&S program can impact the budget it receives. Developing a sound budget and measurable performance indicators serve critical roles as capacity building strategies for sustainable IGI&S programs because they provide justification for the investment and expenditure, provide transparency and accountability of the requirements and costs, and help the organization understand risks to the program and dependent programs if not resourced appropriately. IGI&S programs must participate in the budgeting process to prevent stagnate funding numbers and to provide an understanding of budget requirements to their leadership that often may underestimate the program's needs or value it provides. Through the development of a WBS, IGI&S Managers can effectively show the responsibilities, tasks and projects that consume their time, and can translate that into cost. This supports the capture of ROI by establishing the baseline costs for various activities that can then be used as a measure against revenues generated by outcomes; for example, found real property that results in an increase in sustainment dollars for an installation. Additionally, creating metrics to track the level of performance can help quantify and qualify the requirements and dependencies on IGI&S. Quantifying and qualifying the risk if not executed upon can help leadership understand why the program requires such investment. IGI&S

Managers can use the “budget-to-perform, and perform-to-budget” outcomes to make the case to sustain and grow their programs and can use this information when working to form effective relationships with leaders and stakeholders, and can help drive increased opportunities for personnel development.

The IGI&S Manager plays a vital role as a leader and influencer internally in his or her business unit and also externally to stakeholders and end-users. IGI&S Managers must engage with their internal team to support the development and retention of a competent and motivated workforce by developing appropriate position descriptions, hiring individuals that align to the required core competencies, and support professional development through evaluation and ongoing training. Identifying and engaging the COI through continued education and outreach methods can yield strong relationships that will impact the diffusion of the IGI&S capability throughout the organization. The greater the investment of individuals into the use of the IGI&S capability, coupled with positive outcomes, the more likely those individuals will feel empowered to advocate for program sustainability, and potentially lead to a GIS champion in the organization. IGI&S Managers must therefore actively work to create the right professional environment for their program to thrive through individual engagement and organizational outreach.

The IGI&S Program Management Framework contributed to successes at installations in the MCIWEST AOR despite ongoing programmatic challenges in the region; but the framework’s success ultimately depends on the IGI&S Manager and the IGI&S COI. In summary, IGI&S Managers can 1) encourage the use of GIS as a system that supports business processes and applications with an organizational context that

allows for data fusion across disparate and stove-piped business systems with a geo-locational aspect; 2) tie data quality reports to standards, and link risks to health, life, and safety to service-level financial risk of interest to Congress to garner attention at the highest levels of the DoD; 3) track and document all tasks and projects, and use outcomes to develop budgets with legitimacy—built on substantiated and defendable amounts—that support strategic goals of the greater organization; and 4) encourage formal on-site training exchanges, site assist visits, and mentoring to improve professional development and tradecraft. The ability, commitment, dedication, and resolve of the IGI&S Managers throughout the MCIWEST AOR to own their program and implement these strategies made the framework effective. With diffusion of the framework and its methods, other IGI&S programs can hopefully experience similar successes that ultimately support DoD strategic initiatives, enabling installations to support joint-force training and interoperability, serve as projection platforms of military readiness and power, and sustain US military superiority in the fight against emerging threats.

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