[DA-025] Geospatial Intelligence and National Security

Abstract

GIS&T exists within the national security enterprise as a multidisciplinary field that is now commonly referred to as Geospatial Intelligence (GEOINT). U.S. GEOINT operations are principally managed by the National Geospatial-Intelligence Agency (NGA). GEOINT is one among several types of intelligence produced in support of national security, along with Human Intelligence (HUMINT), Signals Intelligence (SIGINT), Measurement and Signatures Intelligence (MASINT), and Open Source Intelligence (OSINT). Primary technical GEOINT skill areas include remote sensing, GIS, data management, and data visualization. The intelligence tradecraft is historically characterized as a process involving tasking, collection, processing, exploitation, and dissemination (TCPED), and supports decision-making for military, defense, and intelligence operations. The GEOINT enterprise utilizes every type of data collection platform, sensor, and imagery to develop intelligence reports. GEOINT products are used to support situational awareness, safety of navigation, arms control treaty monitoring, natural disaster response, and humanitarian relief operations. Geospatial analysts employed in government positions by NGA or serving in the U.S. armed forces are required to qualify in NGA's GEOINT Professional Certification (GPC) program, and industry contractors have the option of qualifying under the United States Geospatial Intelligence Foundation (USGIF) Certified GEOINT Professional (CGP) program.

Keywords: collection, dissemination, exploitation, GEOINT, Geospatial Intelligence, intelligence tradecraft, processing, remote sensing, tasking, TCPED

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Explanation

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1. Definitions

Geospatial Intelligence was instantiated as a national security enterprise in 2003, when the U.S. National Imagery and Mapping Agency (NIMA) was rebranded as the National Geospatial-Intelligence Agency (NGA), utilizing a hyphen to enable a three-letter acronym on par with other U.S. national security agencies (Murdock and Clark, 2016). Geospatial Intelligence was defined by the U.S. government as “the exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the earth. Geospatial intelligence consists of imagery, imagery intelligence, and geospatial information.” The term “geospatial information” refers specifically to “information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth and includes (A) statistical data and information derived from, among other things, remote sensing, mapping, and surveying technologies; and (B) mapping, charting, geodetic data, and related products” (Title 10 of the United States Code). There have been notable updates to this definition in more recent years, endeavoring to capture the essence of Geospatial Intelligence in practice.

One academically-developed definition describes Geospatial Intelligence as “actionable knowledge, a process and a profession. It is the ability to describe, understand, and interpret so as to anticipate the human impact of an event or action within a spatiotemporal environment. It is also the ability to identify, collect, store, and manipulate data to create geospatial knowledge through critical thinking, geospatial reasoning, and analytical techniques. Finally, it is the ability to present knowledge in a way that is appropriate to the decision-making environment” (Bacastow and Bellafiore, 2009). An industry-based definition indicates that “GEOINT is the professional practice of integrating and interpreting all forms of geospatial data to create historical and anticipatory intelligence products used for planning, or that answer questions posed by decision makers” (Murdock and Clark, 2016). Considered collectively, data capture, visualization, and analysis for decision support are key elements of these definitions. Further, it’s notable that military, defense, and intelligence applications are not explicitly described within these definitions. While it’s clear that the Geospatial Intelligence community focuses primarily on military, defense, and intelligence applications, it should also be recognized that there is often considerable overlap with application areas of interest to the broader academic/professional geospatial field, including examples such as climate change (Crosiar, 2015) and humanitarian crisis mapping (Stack, 2017).

2. Multidisciplinary Meta-Domain

Geographic Information Science and Technology (GIS&T) domains in military, defense and intelligence exist as much more than a geospatial subdomain. GIS&T within this context is a meta-domain where numerous science, technology, engineering, and mathematics (STEM) disciplines intersect to support robust geospatial data collection, curation, visualization, and analysis requirements associated with ongoing military, defense, and intelligence mission and operations.

Given the substantial financial resources made available for military, defense, and intelligence purposes, this domain is a major driver of innovation for development of new technologies and applications. While this domain is highly secretive in operations, much general information is publicly available to describe its geospatial footprint within the

Geospatial Intelligence (aka GEOINT) community of government agencies and industry partners that support United States military, defense and intelligence mission and operations. The United States is a primary driver of GEOINT innovation and implementation, given much greater U.S. emphasis on defense spending compared to other nations (Taylor and Karklis, 2016). The membership directory published by the United States Geospatial Intelligence Foundation (USGIF), a nonprofit organization established in 2004 specifically to support the GEOINT community, provides a comprehensive listing of national security industry partners in conjunction with a few of the government entities prominently involved in GEOINT activities (USGIF Membership Directory, 2017).

3. Intelligence Domains

GEOINT is one among several primary U.S. intelligence domains, and there can be significant overlap between these domains among U.S. national security agencies. Human Intelligence (HUMINT) is commonly associated with Central Intelligence Agency (CIA) operations, and refers to clandestine acquisition of secrets via human sources. Signals Intelligence (SIGINT) is a primary National Security Agency (NSA) function, and is derived from collection and processing of various sources of electronically transmitted data and information. Measurement and Signatures Intelligence (MASINT) is an important Defense Intelligence Agency (DIA) function, and involves detection, location, tracking, identification, and description of fixed and dynamic targets. Open Source Intelligence (OSINT) is ubiquitous and can be gathered by numerous agencies, and is found wherever data and information are distributed via any form of public media. Given the complexity of contemporary national security challenges, there can often be a merging (or fusion) of source data and information from these various intelligence domains for multi-INT analytical operations (Lowenthal and Clark, 2016).

Within the U.S. national security enterprise, GEOINT is produced and managed by a variety of federal government agencies, including but not limited to the Department of Homeland Security, the Department of Energy, the State Department, Treasury Department, and the Federal Bureau of Investigation (FBI). The director of NGA is designated as manager of U.S. Department of Defense (DoD) GEOINT and is formally identified as functional manager for GEOINT in the Intelligence Community (IC). This functional responsibility includes a) tasking imagery, geospatial data, and technical data collection, b) processing of raw geospatial data, and c) analyzing geospatial information and imagery intelligence for decision-making (Murdock and Clark, 2016).

Many nations employ GEOINT capabilities in their military, defense, and intelligence operations. The U.S. has cooperative agreements with their “five-eyes” partners Canada, United Kingdom, Australia, and New Zealand. The Directorate of Geospatial Intelligence (D Geo Int) is responsible for Canadian GEOINT planning and policy. Canada’s RADARSAT constellation provides maritime surveillance (ice, wind, oil pollution, ship monitoring), disaster management (mitigation, warning, response, and recovery) and ecosystem monitoring (forestry, agriculture, wetlands, and coastal change). The Defense Intelligence Joint Environment (DIJE) in the United Kingdom serves as a focal point for bilateral and international arrangements involving the sharing of GEOINT and MASINT. The Defense Industry and Geospatial Organization (DIGO) manages GEOINT in Australia, and operates the Palanterra web-based system for disseminating data and information (Murdock and Clark, 2016).

The North Atlantic Treaty Organization (NATO) likewise uses GEOINT for strategic and tactical operations, operating from the NATO Intelligence Fusion Center at RAF Molesworth in the United Kingdom. Japan's Aerospace Exploration Agency operates satellites for earth observation, and the Geospatial Information Authority is responsible for survey and mapping Japanese territory. The Bundeswehr Geoinformation Service provides GEOINT to the German armed forces, and also serves a geopolitical atlas, satellite data, regional maps, and navigational maps via web portal. The Defence Image Processing and Analysis Center manages India's satellite imagery programs. Israel manages imagery intelligence (IMINT) through a Central IMINT Center that rapidly processes aerial imagery and disseminates reports to combat units in close to real time, and can merge products collected by imaging and SIGINT assets with existing GIS information, combining GEOINT with human demographics and built environment data. China operates a variety of overlapping satellite programs for earth imaging and mapping, for both military and civilian purposes. Russia has been operating satellite systems for military and civilian purposes for roughly the same time frame as the U.S., with similar multispectral, hyper-spectral, and SAR capabilities (Murdock and Clark, 2016).

4. Intelligence Tasking and Collection

The intelligence gathering "tradecraft" has historically been characterized by a conventionally linear cycle referred to as Tasking, Collection, Processing, Exploitation, and Dissemination (TCPED), where analytical requirements are established by client need (military operations, for example) and the analytical team must collect, process, analyze, and report findings that can be used for decision-making purposes. More recently, the national security community has recognized that the threat environment has become much more complex than it was during the Cold War era, with multiple feedback loops now evident throughout the contemporary intelligence development process (Figure 1). Regardless, Tasking, Collection, Analysis and Reporting remain important elements of all intelligence efforts (Maxwell and Tucker, 2014).

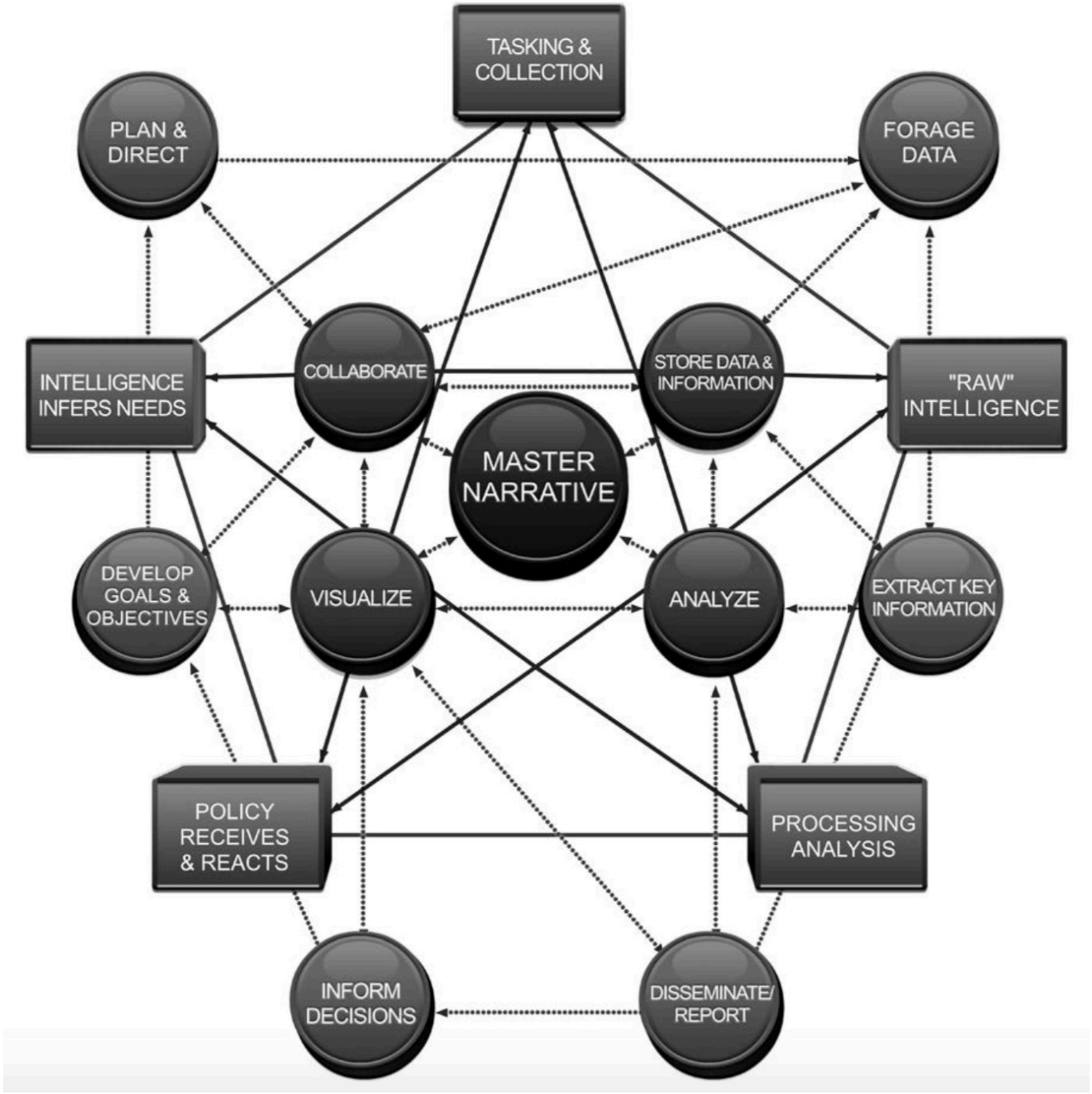


Figure 1. The U.S. Intelligence Community (IC) is evolving operations away from a linear TCPED approach, to more effectively account for iterative complexities of contemporary national security challenges (Maxwell and Tucker, 2014).

Numerous organizations within the U.S. national security enterprise manage GEOINT analysis requirements, in addition to tasking and collection of imagery and geospatial information. Collection management is performed by a variety of National System for Geospatial-Intelligence (NSG) organizations. National level imaging assets are tasked by NGA. Management of National Technical Means (NTM) satellite sensors is handled by the National Reconnaissance Office (NRO). The Defense Intelligence Agency (DIA) coordinates requirements management and tasking collection assets for combat commands. For U.S.

science-related and international GEOINT, the U.S. Geological Survey (USGS) is Landsat mission manager handling requirements and tasking (Murdock and Clark, 2016).

5. GEOINT Collection Platforms

GEOINT collection platforms include satellites and aircraft (manned and unmanned). There are two principal categories of satellite collection with the U.S. military, defense, and intelligence community: National Technical Means (NTM) and commercial satellites. Information about NTM sensors and platforms is classified and not available for public dissemination (Clark, 2011). DigitalGlobe and GeoEye were commercial satellite operations supporting U.S. intelligence missions through Next View and Enhanced View contracts, with DigitalGlobe acquiring GeoEye when the U.S. government changed the funding model in 2013. DigitalGlobe was subsequently acquired by MacDonald, Dettwiler and Associates, Ltd (MDA) and rebranded as Maxar Technologies (Chuang, 2017). Airborne imagery is increasingly acquired using Unmanned Aircraft Systems (UAS). The U.S. military operates numerous Unmanned Aerial Vehicles (UAV) for data collection, with sensors mounted to Predators (General Atomics), Global Hawks (Northrop Grumman) for variety of surveillance requirements (Clark, 2011). The recent emergence of SmallSats is providing lower costs and greater deployment agility for highly specialized applications. Sometimes referred to as CubeSats, these smaller satellite collection platforms can range from smaller than 10 kilograms up to 600 kilograms, remarkably modest in size when compared to much larger conventional satellite systems (State of GEOINT Report, 2016).

6. GEOINT Data Capture

Historically, the interpretation of image data captured from different bands of the electromagnetic spectrum for mission-critical operations has been a core GEOINT capability. The GEOINT mission demands utilization of geospatial data and information as close to real-time as possible. Image data collection and analysis is often the fastest way to get this information in front of decision makers. Military, defense, and intelligence applications utilize the full range of available sensors including active (radar and LiDAR) and passive (visible, panchromatic, near-infrared, mid-infrared, and thermal infrared) with multi- and hyper-spectral systems playing significant roles. For electro-optical (EO) imagery, analysts identify objects of interest, verify positions, establish baseline activities, and determine changes between images across time. Additionally, the collection of airborne video imagery (motion imagery, full motion video) has become increasingly valuable for monitoring real-time activity. The concept of persistent surveillance has arisen with the use of motion imagery, enabling near-constant situational awareness and facilitating more efficient response (Murdock and Clark, 2016).

From an exploitation and analysis perspective, the GEOINT community often employs anomaly detection methods, using different sensor bands to reveal anything that might be out of place. This can include vehicles or structures hidden in forests or chemical spills in otherwise uncontaminated areas. GEOINT analysts also perform threat identification methods, looking at spectral signatures for traces of materials used for production of weapons of mass destruction (WMD). Multispectral, hyperspectral, and ultraspectral sensors are particularly useful for such analyses (Clark, 2011).

Active sensors offer obvious advantages for mission-critical requirements of military, defense, and intelligence operations, with their ability to penetrate environmental

interference such as cloud cover and vegetation canopy. RAdio Detection And Range (RADAR) sensor capabilities have been sharpened with development of Synthetic Aperture RADAR (SAR) systems, resulting in highly detailed change detection capabilities that reveal very small changes in elevation. Very small changes in height are determined by time delay, usually via interferometry. SAR change detection capabilities have proven highly useful for detecting roadside improvised explosive devices (IED) planted along roadsides in conflict zones (Clark, 2011). Pulses from Light Detection And Ranging (LiDAR) systems can provide multiple returns from tree cover, built environment, and landform elevations.These highly detailed LiDAR point clouds are useful for more immersive environment analytical needs (State of GEOINT Report, 2016).

There are other sources of GEOINT data and information, in addition to imagery. Open Source data and information are increasingly useful, particularly with the explosive growth of social media. Volunteered geographic information (VGI) from sources such as OpenStreetMap have been particularly valuable for humanitarian response to natural disasters like earthquakes, tsunami, and typhoons (Committee on the Future U.S. Workforce for Geospatial Intelligence, 2013).

The rapid growth of location-aware data associated with social media, the internet of things (IotT), and other digitally accessible sources has brought increasing emphasis on data science to GEOINT analysis operations. Artificial Intelligence (AI) and machine learning capabilities are becoming increasingly important and represent a significant shift for the GEOINT data capture mission, complementing imagery intelligence with robust insights into the spatial dimensions of national security threats not otherwise visible to sensors mounted on aircraft or satellites (The State and Future of GEOINT, 2017).

7. GEOINT Products

The GEOINT community produces a variety of conceptual products that support situational awareness. For military and defense purposes, there are battlespace awareness products that monitor the activity of friendly and hostile forces with areas of responsibility, typically involving a combination of imagery, radar, and electronic intelligence. For ensuring port security and enforcing national sovereignty there is maritime domain awareness, with shipboard transponders providing identification information for satellite and radar tracking. Safety of Navigation is managed using two types of geospatial information: a) the location of fixed hazards such as submerged objects for shipping and b) high-terrain features and towers for aircraft. Activity-based intelligence (ABI) is a form of situational awareness that focuses on activity and transactions associated with entities, population, or areas of interests, with particular attention paid to interactions over time and anomalies varying from common routines. Response to natural disasters remains an important part of the GEOINT mission, as the Department of Homeland Security (DHS) and NGA support disaster response and mitigation activities with timely, accurate, and relevant GEOINT data and analyses (Murdock and Clark, 2016).

Numerous physical products are created in support of the GEOINT mission, including both specialized and standard products. Specialized products come in numerous classified forms, existing beyond the scope of this summary. Standard products are disseminated to a wide ranging customer set, across broad range of national security and civilian agencies, and include a) aeronautical charts and flight information publications, b) nautical and hydrographic charts and notices, c) topographical and terrestrial maps, charts, and

databases, d) geodesy and geophysical data, and e) GEOINT analytic reporting such as intelligence briefs, highlight cables, and imagery reports (Murdock and Clark, 2016).

8. Categories of GEOINT Utility

For military, defense, and intelligence purposes, GEOINT is commonly used to identify features of tactical or strategic interest, provide information about where these features are located, and describe the physical condition of these features. There are three general categories that describe the intelligence value of GEOINT: a) GEOINT as primary source, b) GEOINT as major contributor, and c) GEOINT as an ancillary source. The fundamental elements of those three categories include:

- GEOINT as primary source
  - Situational awareness supporting political, military, and law enforcement operations
  - Arms control and treaty monitoring to verify assets and deployments
  - Environment and natural resource monitoring of climate change and pollution
  - Humanitarian disaster and relief operations support regarding current conditions
- GEOINT as major contributor
  - Military and civilian infrastructure
  - Agriculture and food security supporting crop forecasts
  - Terrorism location and movements
  - Transnational organized crime related to piracy and illicit weapons shipments
  - Demographics, migration, and population movements related to refugee populations
  - Chemical warfare development and proliferation
  - Missile development and proliferation
  - Nuclear weapons development and proliferation related to manufacture, movement and storage of nuclear materials
  - Foreign military combat capabilities, operations, and intentions associated with military exercises and force movements
  - Human rights and war crimes
  - Energy security threat monitoring
  - Advanced conventional weapons development and proliferation monitoring
- GEOINT as ancillary source
  - Counterintelligence identify imagery denial and deception efforts
  - Cyber threats by geolocating sources
  - Political stability supporting demographic analyses
  - Infectious diseases and health mapping disease origins and diffusion
  - Biological warfare development and proliferation

GEOINT does not provide access to human thinking processes, and therefore does not add value for those intelligence missions that rely on human intent (Murdock and Clark, 2016).

9. GEOINT Workforce Professionalization

Insights into GIS&T applications in military, defense and intelligence can be gained by reviewing public materials associated with GEOINT workforce development and professionalization efforts. In 2011, Dr. Michael Vickers (then Undersecretary of Defense for Intelligence) issued a mandate requiring the National Geospatial-Intelligence Agency (NGA)

to develop a professional certification program for the GEOINT analyst workforce (GEOINT Essential Body of Knowledge, 2015). In response, NGA developed the multi-tiered and multi-threaded GEOINT Professional Certification (GPC) credential for government personnel within NGA and the broader DoD enterprise (Osborn, 2017). In parallel, the United States Geospatial Intelligence Foundation (USGIF) developed the Certified GEOINT Professional (CGP) and Universal GEOINT Professional (UGP) credentials for geospatial professionals supporting the GEOINT enterprise from industry and academic positions (Foerch, 2017). Additionally, both NGA and USGIF support workforce development through engagement with institutions of higher learning. USGIF accreditation of collegiate Geospatial Intelligence programs was launched in 2008 and is currently integrating elements of the new CGP certifications into the accreditation guidelines (Mitchell, 2017). NGA launched the Centers of Academic Excellence in Geospatial Sciences program in 2015 to support more effective engagement with U.S. colleges and universities (Cohen-Levy, 2015). Collectively, the requirements associated with each of these workforce development efforts reveal significant information regarding scope and framework of GIS&T application areas within the broader military, defense, and intelligence context.

The NGA's GEOINT Professional Certification (GPC) program requires all government analysts to qualify at a Fundamentals level (GPC-F) before proceeding to qualifications in professional specializations. There are ten areas of GPC specialization, including:

- GEOINT Collection (GPC-GC-II),
- Imagery Analysis (GPC-IA-II),
- Geospatial Analysis (GPC-GA-II),
- Imagery Science (GPC-IS-II),
- Aeronautical (GPC-AA-II),
- Human Geography (GPC-HG-II),
- Applied Science (GPC-AS-II),
- Cartography (GPC-CA-II),
- Maritime (GPC-MA-II), and
- Geospatial Data Management (GPC-GDM-II).

Assessments for these specializations are developed with input from technical and subject matter experts prior to administration for each certification (GEOINT Professional Certification Program Handbook, 2016).

USGIF's Universal GEOINT Certification program is designed for geospatial analysts working in non-government positions supporting the GEOINT mission as industry contractors or in academic research and education roles. Certified GEOINT Professionals (CGP) can pursue certification specializations in: GIS and Analysis Tools (CGP-G), Remote Sensing and Imagery Analysis (CGP-R), or Geospatial Data Management (CGP-D), and must pass all three assessments and hold five years of professional experience to qualify for the comprehensive Universal GEOINT Professional (UGP) credential (Universal GEOINT Certification Program Candidate Handbook, 2016). Prior to establishing the Universal GEOINT Certification Program, USGIF developed and published the GEOINT Essential Body of Knowledge, providing contextual parameters for professional GEOINT certification.

The GEOINT Essential Body of Knowledge was developed in partnership with the Global Skills Exchange Corporation (GSX), a professional services firm supporting psychometric development of a variety of professional certifications mandated by the Undersecretary of

Defense for Intelligence (USDI) roughly concurrent with GEOINT professional certification. Over the course of one and a half years, a series of analytical steps were undertaken towards distilling essential GEOINT analyst requirements. These steps included a) thought leader interviews, b) legacy document review, c) development of a draft essential body of knowledge with input from subject matter experts, d) validation of the draft essential body of knowledge with input from subject matter experts, and e) finalization of the essential body of knowledge document (GEOINT Essential Body of Knowledge, 2015). In addition to Remote Sensing, GIS, Data Management domains, results of this psychometric development process included Data Visualization as a professional capability spanning the three core specializations, and further recognized the importance of three softer skills: Synthesis, Collaboration, and Reporting (Figure 2).

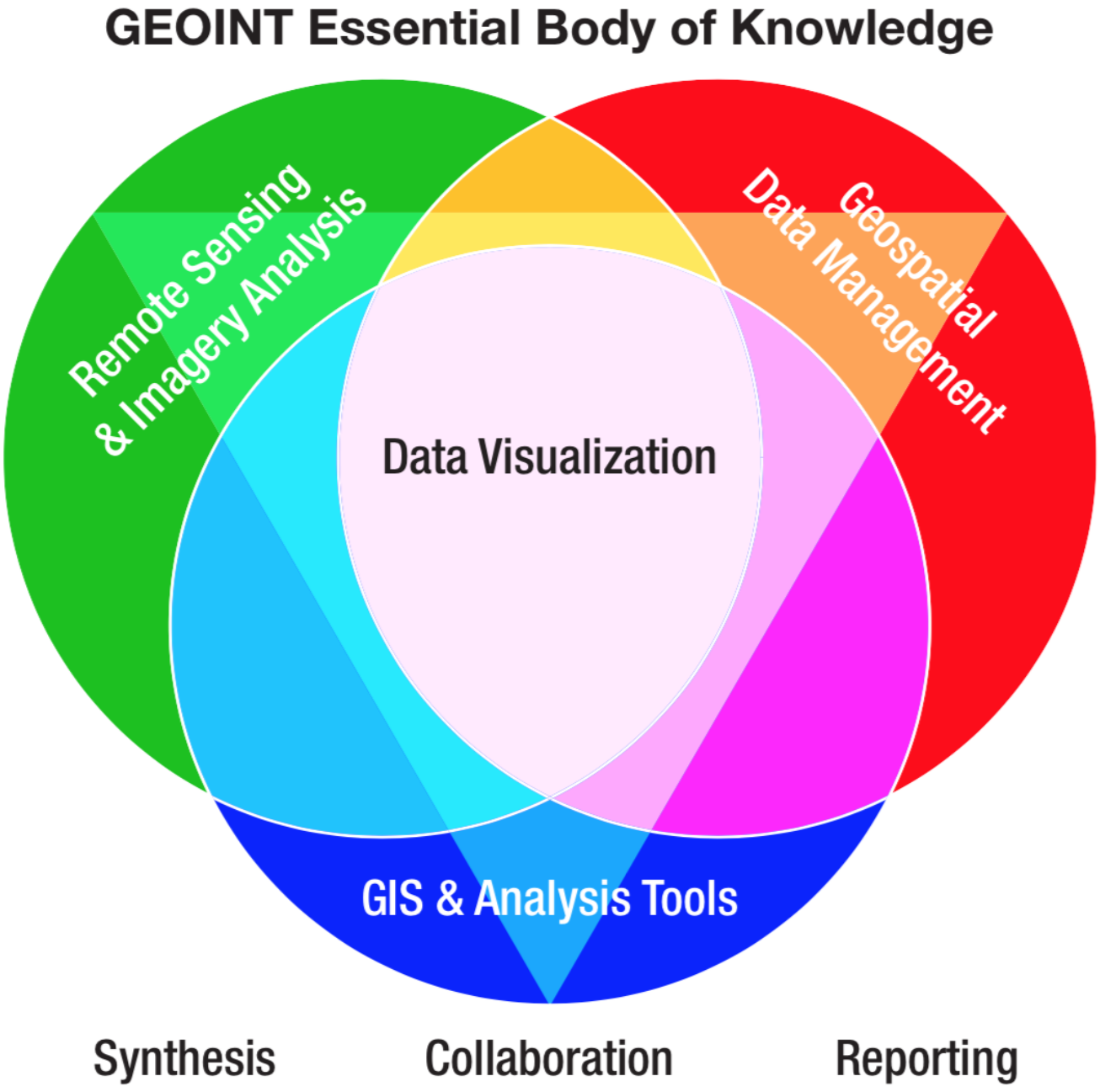


Figure 2: Primary GEOINT skill areas are represented by this modified Venn diagram, with overlapping circles of GIS, remote sensing, and data management domains further linked

with a data visualization domain represented by a triangle to indicate deeper reach of visualization across the breadth of GEOINT professional capabilities, and three important softer skills: Synthesis, Collaboration, and Reporting (GEOINT Essential Body of Knowledge, 2015).

While the USGIF certification reveals that Remote Sensing, GIS, Data Management, and Visualization are primary skill areas, the NGA certification program makes clear that data collection, human geography, aeronautical, and maritime requirements are also important application areas for the military, defense, and intelligence domain. Within active daily operational context, there is considerable emphasis on data collection due to real-time urgencies associated with mission response requirements, resulting in heavy focus on variety of sensor types mounted on array of collection platforms (GEOINT Professional Certification Program Handbook, 2016).

10. GEOINT Trends

The GEOINT community of government, industry, and academic partners is closely tracking broader geospatial science and technology trends. USGIF convenes annual meetings of GEOINT thought leaders from government, industry, and academia to review current Geospatial Intelligence trends. Recent hot topics have included:

- Deep Learning,
- Geodata Analytics-as-a Service,
- Data Science teams for GEOINT analysis,
- managing the “Big Hot Data Mess,”
- management of increasing commercialization in government-industry partnerships,
- adaptability and professional agility in the GEOINT workforce,
- core professional competencies for next generation GEOINT analysts,
- evolving the GEOINT analytic tradecraft,
- understanding patterns of life revealed using Activity-Based Intelligence (ABI),
- strengthening GEOINT Human Geography capabilities,
- transforming Internet of Things (IoT) into a GEOINT of Things (GoT),
- exploiting a growing Small Satellites industry for more tightly focused applications, and
- deploying rapidly increasing numbers of Unmanned Aerial Systems for monitoring national security challenges.

There is growing interest in location intelligence and data science, particularly as applied to the explosion of crowdsourced data associated with social media and mobile technologies. GEOINT community interest in Human Geography has accelerated in recent years, in association with challenges of terrorist organizations and increasingly individualized threats. Increasing agility of SmallSat and UAS data collection platforms is enabling improved monitoring of a wide array of threats to humankind, from environmental to national security. The Internet of Things is providing data useful for intelligence exploitation. Machine learning and Artificial Intelligence algorithms are being developed to improve GEOINT mission response efficiencies. Quality assurance in GEOINT professional development is moving the workforce away from stove-piped career roles and requiring ongoing skills maintenance and updates. Geospatial science and technology is rapidly advancing, and GEOINT community resources are pacing both innovation and adoption of new geospatial data capture and analysis capabilities (The State and Future of GEOINT,

2017). It's clear that many of the same trends prominent on the civilian side of GIS&T are likewise prominent within the GEOINT national security enterprise.

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