ATP 3-34.80

GEOSPATIAL ENGINEERING

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Geospatial Engineering

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Preface

ATP 3-34.80 provides doctrine for geospatial engineering operations at all echelons. It is an extension of FM 3-34 and is linked to joint and other Army doctrine to ensure its usefulness for operational level commanders and staff. This manual serves as a guide for the integration of geospatial engineering in support of unified land operations at all echelons, with added focus on describing geospatial engineering within divisions and brigades.

The principal audience for ATP 3-34.80 is engineer commanders and staff officers, but all Army leaders, Soldiers, and Army civilians will benefit from reading it. Trainers, combat developers, and educators throughout the Army will also use this manual. This manual will help other Army branch schools in teaching the integration of geospatial engineering capabilities into Army operations.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States (U.S.), international and, in some cases, host-nation laws and regulations. Commanders at all levels ensure that Soldiers operate in accordance with to the law of war and the rules of engagement. (See FM 27-10.)

ATP 3-34.80 applies to Active Army, Army National Guard/Army National Guard of the United States, and United States Army Reserve unless otherwise stated.

ATP 3-34.80 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 3-34.80 is the proponent publication (the authority) are italicized in the text and are marked with an asterisk (*) in the glossary. Terms and definitions for which ATP 3-34.80 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

The proponent of ATP 3-34.80 is the United States Army Engineer School. The preparing agency is the Maneuver Support Center of Excellence (MSCoE) Capabilities Development and Integration Directorate (CDID); Concepts, Organizations, and Doctrine Development Division (CODDD); Doctrine Branch. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, MSCoE, ATTN: ATZT-CDC, 14000 MSCoE Loop, Suite 270, Fort Leonard Wood, MO 65473-8929; e-mail to <usarmy.leonardwood.mscoe.mbx.cdidcodddengdoc@mail.mil>; or submit an electronic DA Form 2028.

Introduction

The geospatial engineering discipline is one of three engineering disciplines. It plays a major role in supporting the combat and general engineering disciplines. This discipline is essential to all lines of engineering support (assure mobility, enhance protection, enable force projection and logistics, and build partner capacity and develop infrastructure). Geospatial engineering is an art and a science that pertains to the generation, management, analysis, and dissemination of geospatial information that is accurately referenced to a precise location on the earth and is used in offense, defense, stability, or defense support of civil authorities tasks. These tasks provide mission-tailored data, tactical decision aids, and visualization products that enable the commander and staff to visualize the operational environment.

Geospatial engineers aid in the analysis of physical and cultural mapping and other activities that significantly contribute to anticipating, estimating, and warning of possible future events. Providing geospatial information that is timely, accurate, and relevant is a critical enabler throughout the operations process for developing shared situational awareness, improving the understanding of capabilities and limitations for friendly forces and the adversary, and highlighting other conditions of the operational environment that are required for mission command. Today, geospatial engineering leverages finer temporal, spatial, and spectral resolutions from additional sensors and platforms that allow increased volumes and more complex data. New methods and technologies provide additional utility and capability and the ability to work effectively and efficiently within a broad pool of partners and allies.

In addition to mastering their respective areas of expertise, engineer staff officers and other staff members must possess a thorough understanding of geospatial engineering to tailor geospatial information to support the mission command warfighting function. Advancements in technology and access to an abundance of information can quickly lead to information overload. Planners must be able to analyze the situation through the mission and operational variables, grasp the military significance of the challenges and opportunities presented, and manage information to enable situational understanding to support decision making.

This manual describes the application of geospatial engineering in support of Army forces conducting unified land operations. It also acknowledges that Army doctrine remains dynamic—balancing current capabilities and situations with projected requirements for future operations. As geospatial engineering capabilities continue to improve through organizational changes, technological advancements, and emerging best practices, leaders and planners at all levels will be charged to leverage those improvements and adapt the processes and procedures that are described in this manual to meet the demands of, and provide the most effective geospatial support possible to, the commander.

ATP 3-34.80 is built directly on new or revised joint and Army doctrine, notably Army capstone doctrine that is found in ADP 3-0 and FM 3-34. Other changes that have directly affected this manual include the—

- Loss of topographic companies.
- Adoption of the JP 3-34 definition for geospatial engineering.
- Migration of the Digital Topographic Support System (DTSS) into the Distributed Common Ground System–Army (DCGS-A) family of systems and the establishment of other peripheral systems and software to the geospatial realm.
- Establishment of the Standard and Shareable Geospatial Foundation (SSGF), a set of geospatial data that provides a common framework for visualizing an area of interest (AOI) to enable mission command and the planning and execution of operational goals. It consists of four data types (elevation, map background, georeferenced imagery, and geographic feature data) presented in standard digital and paper formats.
- Internalization of the memorandum of agreement between the U.S. Army Engineer School and the U.S. Army Intelligence Center of Excellence as a collaboration effort to further the interdisciplinary abilities of geospatial intelligence.

- Evolution of the geospatial intelligence concept, consisting of imagery, imagery intelligence, and geospatial information.
- Revision of the American, British, Canadian, and Australian Armies Program definition for geospatial intelligence.

ATP 3-34.80 is organized into four chapters, with supporting appendixes that sequentially describe geospatial engineering, the roles and responsibilities for integrating geospatial support at the various echelons, and the integration of geospatial engineering within the Army operations process. A brief description of the chapters and appendixes follows:

- Chapter 1, Support to Unified Land Operations, describes the role of geospatial engineering in supporting unified land operations. It also describes the critical roles that geospatial engineering units and staffs have in providing geospatial engineering in support of Army operations.
- Chapter 2, Army Geospatial Enterprise (AGE), focuses on defining the AGE and SSGF.
- Chapter 3, Roles and Responsibilities, discusses the geospatial engineering capabilities that reside within the echelons above brigade down to the brigade combat team (BCT).
- Chapter 4, Geospatial Support Integration, focuses on how to integrate geospatial engineering capabilities into the Army operations process.
- Appendix A provides a metric conversion chart.
- Appendix B, Geospatial Products, provides examples of geospatial products that aid in terrain visualization and support decision making.
- Appendix C, Geospatial Data Management, provides information on gathering, storing, and disseminating relevant digital terrain data that supports operations and enables decision making.
- Appendix D, Terrain Characteristics, describes the six characteristics of terrain that geospatial engineers analyze in determining terrain effects on operations.
- Appendix E, Systems and Software, describes the DTSS family of systems and the DCGS-A that is used to support mission requirements. The DTSS has been absorbed under the DCGS-A program of record, but it is still in use across the geospatial force. The DTSS will be replaced in all components by fiscal year 2019.

Unless stated otherwise, masculine nouns or pronouns do not refer exclusively to men.

Appendix A contains a metric conversion chart for measurements used in this manual. For a complete listing of preferred metric units for general use, see Federal Standard 376B.

Chapter 1

Support to Unified Land Operations

Army forces typically operate as part of a joint force in support of unified land operations. This environment offers various sources of geospatial engineering, geospatial information and services (GI&S), and geospatial intelligence capabilities. The characterization of effective geospatial engineering lies in the ability to understand these available capabilities and to go outside the engineering community and work effectively with other staff sections, organizations, and unified-action partners. As such, coordination across functional areas that is focused on supporting various missions becomes critical. This coordination includes the ability to fully define requirements; discover and obtain the necessary geospatial data; put this data into a usable form; and use, share, and maintain the data with unified-action partners. This chapter describes geospatial engineering capabilities and their role in enabling commanders and staffs to better understand the operational environment through terrain analysis and terrain visualization of the physical environment.

DECISIVE-ACTION SUPPORT

1-1. Geospatial engineering activities are knowledge and information management activities that enable mission command. *Knowledge management* is the process of enabling knowledge flow to enhance shared understanding, learning, and decisionmaking. (ADRP 6-0) *Information management* is the science of using procedures and information systems to collect, process, store, display, disseminate, and protect data, information, and knowledge products. (ADRP 6-0) Geospatial engineers conduct both activities by actively managing the SSGF and generating tailored terrain visualization products to support commanders and staffs in their analysis. This includes providing the foundation for the common operational picture (COP) and conducting analyses to support staff running estimates and the intelligence preparation of the battlefield (IPB). In this role, geospatial engineering supports all warfighting functions.

1-2. Geospatial engineering provided to the Army is based primarily on the supported echelon. Army and combatant commands focus on geospatial data generation, geospatial data analysis, geospatial data management, quality control, and data dissemination. At echelons above brigade, the majority of the workload supports terrain analysis; the military decisionmaking process (MDMP); and data generation, management, and dissemination. At the BCT and below, geospatial engineering is increasingly focused on the MDMP that relates to current and future operations; terrain visualization; and database generation, management, and dissemination, including products tailored for vehicle-mounted and handheld systems.

1-3. Combat and general engineering disciplines rely heavily on geospatial support to efficiently conduct tasks. While conducting offensive tasks, geospatial engineers assist combat engineers in determining the suitability of terrain for maneuver by identifying suitable river-crossing sites and bypasses. Geospatial engineers assist general engineers in the evaluation of road networks, ports, and airfields for initial-entry forces. While conducting defensive tasks, geospatial engineers assist combat engineers in the location of defensible terrain and obstacle emplacement and general engineers in the identification of surface materials that are readily available to harden facilities and improve fighting and protective positions. While conducting stability tasks, geospatial engineers assist combat engineers in route and area clearance by identifying vulnerable points and firing points that facilitate the detection of explosive hazards and possible observer locations. Geospatial engineers assist general engineers in providing hydrology analyses to find water sources for wells and key infrastructure locations. There are additional missions performed by geospatial engineers during the defense support of civil authorities tasks that are not typically performed during offense, defense, or stability tasks.

1-4. Geospatial engineers are currently embedded in the BCTs, functional and multifunctional brigades, divisions, and corps and are assigned to civil affairs battalions, brigades, and civil affairs commands. At Army Service Component Commands (ASCCs), geospatial engineering support is provided by geospatial planning cell (GPC) engineering detachments. These detachments are composed of geospatial engineer Soldiers and warrant officers and an engineer officer who serves as the detachment officer in charge (OIC) and the ASCC GI&S officer. Geospatial engineers make up a low-density, high-demand discipline across the Army.

1-5. Geospatial engineering activities primarily support the mission command warfighting function; however, they also provide relevant and integral support to all warfighting functions and special operations forces. In the conduct of offense, defense, stability, or defense support of civil authorities tasks, some type of geospatial engineering support is required. This includes, but is not limited to, providing the foundation for the COP, generating and analyzing terrain data to assist in the MDMP, managing the geospatial database within an area of operations (AO), and producing overlays for situational understanding.

CAPABILITIES

1-6. *Geospatial engineering* is those engineering capabilities and activities that contribute to a clear understanding of the physical environment by providing geospatial information and services to commanders and staffs. (JP 3-34) FM 3-34 provides additional information on engineer disciplines and their role in support of unified land operations. Geospatial engineering is the art and science of applying geospatial information to enable an understanding of the physical environment for military operations. The art is the ability to understand mission, enemy, terrain and weather, troops and support available, time available, civil considerations, and geographic information available (including the intent of use and limitations); to explain the military significance of the terrain to the commander and staff; and to create geospatial products for decision making. The science is the ability to exploit geographic information to produce spatially and temporally accurate products and services for mapping, visualization, analysis, and modeling within an Army enterprise construct to meet the mission needs of the commander and staff.

1-7. Within the Engineer Regiment, geospatial engineering is a key enabler for each line of engineering support (assure mobility, enhance protection, enable force projection and logistics, and build partner capacity and develop infrastructure). In addition to providing terrain analysis, geospatial engineers provide tactical decision aids that enable general and combat engineers to efficiently support the assure mobility line of engineering support regardless of opposed or unopposed entry into the theater. These tactical decision aids include 3D terrain mapping and fly-through representations that produce nonstandard, tailored map products (including cross-country mobility, viewshed, zone of entry, drop zones, and surface and subsurface topographic products).

1-8. Geospatial engineers provide line of sight (LOS) analysis to support the enhance protection line of engineering support. LOS analysis assists in base or base camp selection and protection of emplacement of protective obstacles, which identify standoff distances of threat weapons. For the enable force projection and logistics line of engineering support, geospatial engineers can identify and provide assessments on key infrastructure (ports, airfields, roads) for the supportability of personnel and equipment for follow-on forces. Geospatial engineers support the build partner capacity and develop infrastructure line of engineering support by providing information on man-made features (such as industrial areas that are used for the extraction, processing, and production of products or raw materials; residential areas; and governmental, institutional, and military facilities) to assist in the analysis of local infrastructure and to assist the local government in developing capabilities.

GEOSPATIAL INFORMATION AND SERVICES

1-9. *Geospatial information and services* is the collection, information extraction, storage, dissemination, and exploitation of geodetic, geomagnetic, imagery, gravimetric, aeronautical, topographic, hydrographic, littoral, cultural, and toponymic data accurately referenced to a precise location on the Earth's surface (JP 2-03). Geospatial services include tools that enable users to access and manipulate data. Geospatial services also include instruction, training, laboratory support, and guidance for geospatial data use. The availability of commercial off-the-shelf geospatial data software applications enables a wide variety of military and civilian users to apply GI&S to an assortment of situations. Common military applications of

GI&S include support to planning, training, and operations (navigation, mission planning, mission rehearsal, modeling, simulation, and targeting). Automated geospatial applications can enhance map features (such as elevation) that may not be discernible on a map to enable a more detailed analysis. The GI&S is tactically employed by geospatial engineers to provide the geospatial foundation for developing shared situational awareness and to improve the understanding of the effects of terrain on friendly and threat courses of action (COAs) and other conditions of the operating environment.

1-10. ***Geospatial data and information*** **is the geographic-referenced and tactical objects and events that support the unit mission, task, and purpose.** These may be derived from, among other things, patrols, reconnaissance, situation reports, mission variables, and operational variables—sources from which the geospatial engineers may incorporate into the data that updates the SSGF. To enable the understanding of the physical environment, geospatial engineers perform the following major functions:

- Generate data to fill the gaps in the theater geospatial database (TGD) and SSGF.
- Analyze the terrain in support of the MDMP of the IPB, enabling predictive analysis and the provision of actionable information.
- Disseminate geospatial information and products via Web services of the geospatial enterprise database and hardcopy publishing.
- Manage the geospatial database to support the COP with current and future operational data and products.

1-11. These major functions required for GI&S are performed by organic geospatial engineering elements at the theater, corps, division, and brigade levels (see figure 1-1). The roles and responsibilities for performing geospatial engineering within each of the echelons are further discussed in chapter 3.

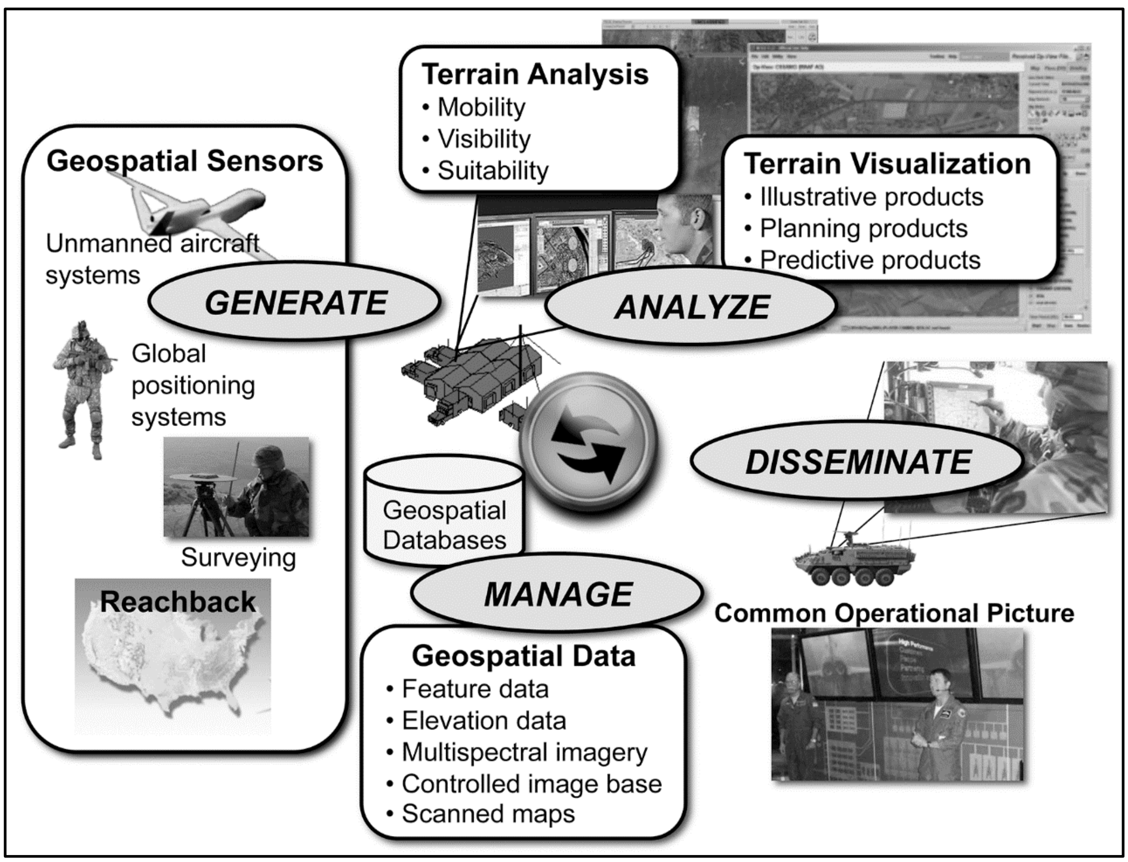


Figure 1-1. Major functions of geospatial engineering

1-12. ***Terrain analysis* is the study of the terrain's properties and how they change over time, with use, and under varying weather conditions.** Terrain analysis starts with the collection, verification, processing, revision, and creation of source data. When conducting terrain analysis, personnel must take into account the effects of climatology (current and forecasted weather conditions), natural and man-made features, and friendly and threat vehicle performance metrics. Terrain analysis is a highly technical and complex process that requires the expertise of geospatial engineering technicians and geospatial engineers. Terrain analysis evaluates the characteristics of natural and man-made terrain that are grouped within the following areas:

- Hydrology.
- Surface configuration.
- Surface materials.
- Vegetation.
- Obstacles.
- Man-made features.

1-13. Terrain analysis and visualization is a combination of art and science. It is a fundamental leadership skill and involves seeing the terrain and understanding the impact on the situation, including the effects on friendly and threat capabilities. It is the identification and understanding of terrain aspects that can be exploited to gain advantage over the threat and those terrain aspects most likely to be used by the threat. It is the subjective evaluation of the physical attributes of the terrain and the performance capabilities of vehicles, equipment, and personnel that must cross over and occupy the terrain.

Geospatial Information

1-14. *Geospatial information* is information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth, including statistical data and information derived from, among other things, remote sensing, mapping, and surveying technologies; and mapping, charting, geodetic data and related products. (JP 2-03) It is the foundation on which all other information about the physical environment is referenced to form the COP. Geospatial information provides the basic framework for visualizing the operational environment. This information is derived from multiple sources to common interoperable data standards. It may be presented in the form of printed maps, charts, digital files, and publications; digital simulation and modeling databases; aerial or satellite imagery; or digitized maps and charts. Its effectiveness as an enabler is directly proportional to its currency, accuracy, relevance, and understanding by the user; however, information assurance restrictions often handicap the enabling abilities of the geographic information system.

Data

1-15. Collecting geospatial data from multiple sources and making it readily available to multiple entities enables a more sophisticated visualization of the COP. Geospatial data includes information that provides geospatial understanding and is georeferenced, such as scanned digital maps, elevation data, imagery, and feature data.

Image Map

1-16. Compressed arc-digitized raster graphics are digital copies of scanned, unclassified, hardcopy maps and charts and are available on CD by stock number from the Defense Logistics Agency or can be downloaded from the National Geospatial-Intelligence Agency (NGA) Web site. All compressed arc-digitized raster graphics and enhanced compressed raster graphics data use the World Geodetic System-84 datum, regardless of the datum used during the creation of the original paper map or chart. The data is published in the NGA raster product format, which can be read by the mission command systems that incorporate the commercial joint mapping toolkit and other GI&S programs. Compressed arc-digitized raster graphics at 1:50,000 and 1:100,000 scales are most widely used for tactical operations. Enhanced compressed raster graphics are a general-purpose product, comprising computer-readable digital map and chart images with appropriate attribution. Their data is derived directly from digital sources through filtering, compression, and reformatting to the enhanced compressed raster graphics specification. Enhanced compressed raster graphic files are physically formatted within a National Imagery Transmission Format 2.1 file. City maps at a 1:12,500 scale or larger are also available, but they do not show all buildings. However, this capability can be acquired using georeferenced imagery. Unlike imagery, compressed arc-digitized raster graphics and enhanced compressed raster graphics digital maps do not provide more detail when viewed at a larger scale. Furthermore, the positional accuracy of compressed arc-digitized raster graphics and enhanced compressed raster graphics is no better than the accuracy of the source map or chart (plus or minus 50 meters horizontal accuracy for 1:50,000 scale topographic line maps and plus or minus 100 meters for 1:100,000 scale topographic line maps).

1-17. Elevation data varies in the following levels of detail:

- Digital terrain elevation data (DTED) Level 1 (roughly 90-meter post spacing, bare earth).
- DTED Level 2 (30-meter post spacing, bare earth).
- Shuttle radar topography mission 2 (30-meter post spacing, reflective surface or treetop data).
- High-resolution elevation data derived from sources (such as interferometric synthetic aperture radar elevation and light detection and ranging).

1-18. DTED Level 1 is intended for strategic- and operational-level terrain analysis of the operational environment and is not appropriate for tactical-level planning that requires higher-resolution viewing. DTED Level 1 provides approximately the same level of detail as the contour lines of a 1:250,000-scale map joint operations graphic. DTED Level 2 and shuttle radar topography mission data may be used for tactical-level LOS and viewshed analysis when higher-resolution elevation (inverse synthetic-aperture radar/light detection and ranging) data are not available. The use of DTED Level 1 with 1:50,000-scale compressed arc-digitized raster graphics is discouraged due to inaccuracies in lower-resolution elevation data. DTED Level 1 and Level 2 data can be ordered on CD through the Defense Logistics Agency or downloaded from the NGA Web site. Most government and commercial software applications that read raster product format will also read DTED data. Light detection and ranging is an optical remote-sensing technology that measures absolute properties of scattered light, including the range, from which the elevation data is derived. Light detection and ranging uses ultraviolet, visible, or near-infrared light to image objects and can be used with a wide range of objects, including nonmetallic objects, rocks, rain, chemical compounds, aerosols, clouds, single molecules, and even subterranean displacements. A narrow laser beam can be used to map physical features with very high resolution. This technology is useful in deriving a 1-meter-gridded, bare-earth digital elevation model (32-bit geographic tagged image file format) and a 3D feature extraction for urban areas and vegetation (shape files).

1-19. Georeferenced imagery may consist of controlled image base 5 (5-meter resolution), controlled image base 1 (1-meter resolution), BuckEye (4-inch resolution), and commercial aerial and satellite imagery. Controlled image base imagery is used for image map backgrounds and to display features that are not represented on digital map backgrounds. However, the image maps are not a replacement for standard topographic line maps. Controlled image base 1 may be used to create image city maps, but higher spatial, spectral, and temporal resolution imagery may exist and should be used in lieu of controlled image base. BuckEye data is collected using geospatial sensors employed on aircraft to collect unclassified/for official use only color image maps with 5- to 10-centimeter resolution and 1-meter elevation data. BuckEye data is especially useful for urban and complex terrain. ***Complex terrain*** **is a geographical area consisting of an urban center larger than a village and/or of two or more types of restrictive terrain or environmental conditions occupying the same space.** Applications for this data include precision mapping, change detection, surveillance, and reconnaissance. Spatial accuracy is extremely good (approximately 1-meter absolute accuracy). Interferometric synthetic aperture radar elevation data is a Defense Advanced Research Projects Agency project that collects interferometric radar data from a sensor mounted to an airframe. It processes the recorded data into digital elevation models. Interferometric synthetic aperture radar elevation can rapidly generate 3D maps in daytime, nighttime, or adverse conditions.

1-20. Feature data (buildings, roads, lakes), also referred to as vector data, is represented digitally as points, curves (lines), and surfaces (polygons). Each feature can include embedded information (attributes) (body-of-water bank heights, road surface type, road width, bridge load-bearing capacity [such as military load classification]). Fully attributed feature data can be used to perform automated terrain analysis. However, the accuracy and fidelity of the attribution directly affects the analysis quality.

1-21. Information about the quality, source, and date and other details about the data are captured in the metadata. Metadata for spatial data may describe and document the subject matter; the how, when, where, and by whom the data was collected; the availability and distribution information for the projection, scale, resolution, and accuracy; and data reliability with regard to some standard. Metadata consists of properties and documentation. Properties are derived from the data source, while documentation is entered by an analyst. Analysts must evaluate the metadata to understand the validity of the products produced from the data.

INTELLIGENCE

1-22. *Geospatial intelligence* is 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. (JP 2-03) Geospatial intelligence, as an Army discipline, consists of any combination of geospatial information and another element of geospatial intelligence. The geospatial intelligence enterprise encompasses all activities that are involved in creating a collection plan, such as collecting, processing, analyzing, exploiting, and disseminating spatial information to gain intelligence about the operational environment. Geospatial intelligence visually depicts this knowledge and fuses the acquired knowledge with other information through the analysis and visualization processes. Geospatial intelligence products help in describing the operational environment effects on friendly and threat capabilities and broad COAs for each. The use of geospatial intelligence can be categorized in the following general areas (see JP 2-03 for additional information):

- General military intelligence, indications, and warnings.
- Operational environment awareness.
- Mission planning and mission command.
- Target intelligence.

1-23. Geospatial intelligence spans two branches with two distinct professional Army disciplines: military intelligence (imagery analysis) and the U.S. Army Corps of Engineers (geospatial engineering). Figure 1-2 depicts the alignment of geospatial intelligence imagery analysts and geospatial engineers with the three elements of geospatial intelligence.

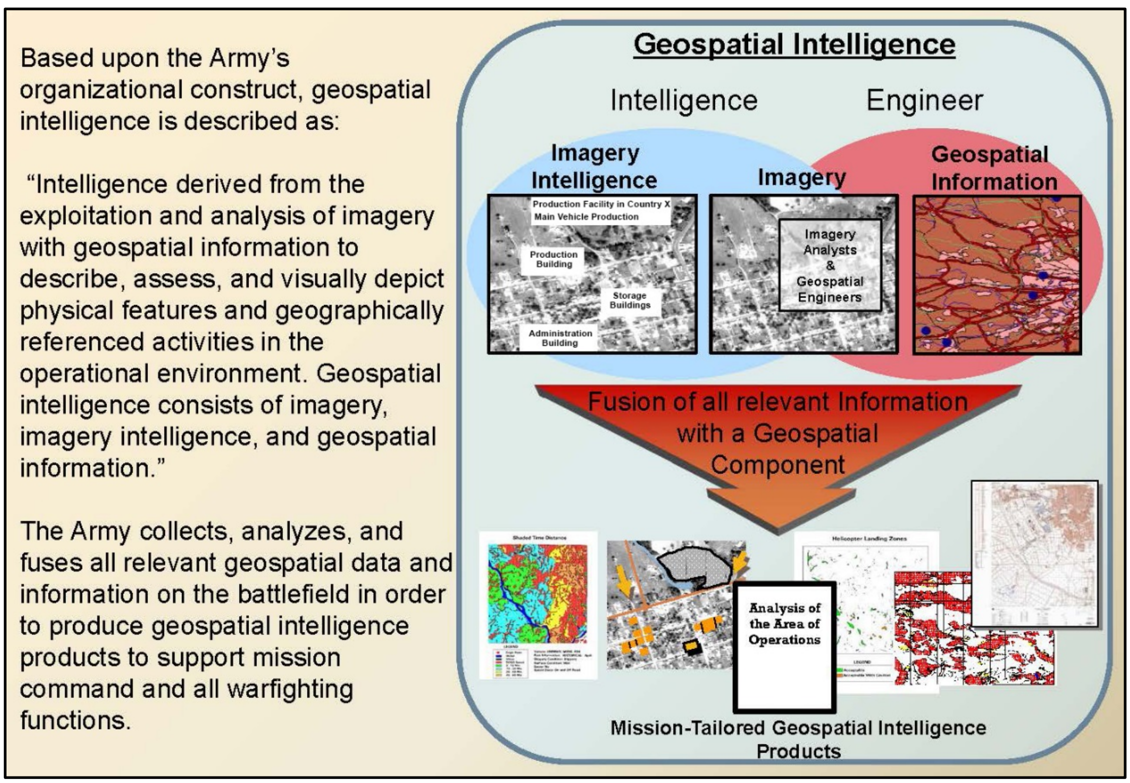


Figure 1-2. Elements of geospatial intelligence

1-24. The geospatial engineering contribution to geospatial intelligence includes the standards, processes, personnel, and equipment required to generate, manage, analyze, and disseminate the geospatial information necessary to enable an understanding of the physical environment. Geospatial engineers manage an enterprise geospatial database that contributes geospatial data to the three elements of geospatial intelligence. Geospatial data is compiled from multiple sources (including the NGA, Army Geospatial Center [AGC] and unified-action partners) and from the exploitation of new collection and production from deployed Soldiers and sensors. Geospatial engineering provides geospatial information that is not intelligence-related (navigation map safety; installation maps; GI&S support to master planning; real estate; range management; geospatial data for training, modeling, and simulations).

NATIONAL SYSTEM FOR GEOSPATIAL INTELLIGENCE

1-25. Many ongoing operations and activities across the Department of Defense (DOD) involve geospatial intelligence. The National System for Geospatial Intelligence (NSG), managed by the NGA, manages operations through guidance, policies, programs, and organizations. The NSG is designed to be a mutually supportive enterprise that fosters collaboration between echelons, the Services, U.S. government departments and agencies, and multinational partners to provide decision makers, commanders, intelligence users and producers, and civil authorities a better understanding of geospatial intelligence to effectively execute assigned missions. When developing intelligence architectures, intelligence staffs develop communications protocols and professional relationships with each relevant component of the NSG. When conducting information collection planning, intelligence staffs leverage the support each of these components can provide. See ATP 2-22.7 for additional information.

1-26. The NGA is the primary source for geospatial intelligence analysis and products at the national level. The NGA produces numerous analytical hardcopy and electronic products and provides standard digital products, including scanned digital maps, elevation data, imagery, and feature data. Units obtain data through networks such as the Nonsecure Internet Protocol Router, Secret Internet Protocol Router, Joint World-Wide Intelligence Communications System, or the NGA (via the Defense Logistics Agency). The Defense Logistics Agency distributes hardcopy and electronic maps to units. Geospatial engineers can request imagery (tactical, commercial, or national) that can be leveraged for terrain analysis purposes to meet operational requirements. Imagery is also used to enhance perspective views and 3D, fly-through applications. Additionally, the NGA provides an NGA support team in direct support to each combatant command joint intelligence operations center. The NGA support team has full connectivity with NGA to ensure reachback capability into NGA continental U.S. resources. NGA geospatial analysts may also be attached to units, normally at the division level and above, to supplement the organic geospatial engineers and staffs. JP 2-03 provides additional information on other national and DOD-level capabilities.

1-27. The National Ground Intelligence Center and the U.S. Army Corps of Engineers AGC are two service centers that support geospatial intelligence. One of the National Ground Intelligence Center missions is to produce and disseminate all source-integrated intelligence on foreign ground forces and related military technologies. A major component of the National Ground Intelligence Center is the Army Geospatial-Intelligence Battalion. Its mission is to produce and disseminate imagery intelligence, geospatial intelligence, and geospatial information products to unified-action partners in support of operational requirements and to conduct geospatial intelligence readiness assessments of units and provide geospatial intelligence training for unit deployment and sustainment. An AGC mission is to provide timely, accurate, and relevant geospatial information, capabilities, and domain expertise for AGE implementation in support of unified land operations. This includes providing geospatial support, training, and products to the Army and mission partners; developing and fielding enterprise-enabled geospatial systems; and providing domain expertise and support to the Army mission command systems and acquisition community. See the U.S. Army Geospatial Center, Common Map Background Web site for access to geospatial data.

GEOSPATIAL INTELLIGENCE WITHIN THE ARMY

1-28. At the ASCC, geospatial intelligence support is provided through the military intelligence brigade–theater, with GI&S provided by the GPC. Geospatial intelligence cells form at BCTs and echelons above brigade to provide the commander and staff with the most current, accurate geospatial intelligence analysis and products possible. The geospatial intelligence cell manages geospatial data and imagery databases, forming the foundation of the COP that enables the commander to visualize the operational area. Advances in technology enable the ability to combine the three elements of geospatial intelligence into a single product that results in a more comprehensive, tailored intelligence product for a wider scope of problems and customers. Geospatial intelligence cells partner the capabilities of geospatial intelligence imagery analysts and geospatial engineers and manage the interface to develop geospatial intelligence products. See ATP 2-22.7 for additional information on geospatial intelligence cells. The geospatial intelligence cell supports joint operations with the following activities:

- Defining geospatial and imagery requirements.
- Evaluating available data.
- Obtaining mission-essential geospatial intelligence information.
- Developing geospatial intelligence and products.
- Disseminating products.
- Maintaining and evaluating geospatial data and services.

1-29. The brigade intelligence staff officer (S-2) or assistant chief of staff, intelligence (G-2) provides guidance and taskings to the geospatial intelligence cell. Cell members are supervised by the geospatial intelligence cell OIC. The geospatial engineering technician serves as the geospatial intelligence cell OIC in the BCT. The key to successful geospatial intelligence processes and support is collaboration across the functional areas within the staff and with echelons above and below. The composition of this cell varies based on the echelon and the availability of geospatial engineers and geospatial intelligence imagery analysts. The geospatial intelligence cell is located in the Top Secret Sensitive Compartmental Information Facility.

1-30. The geospatial intelligence imagery analyst exploits imagery and geospatial data from satellite and airborne systems in support of military operations. The duties, responsibilities, and activities of the geospatial intelligence imagery analyst are to—

- Plan and recommend the use of imaging sensors for reconnaissance and surveillance missions.
- Produce intelligence by studying and exploiting imagery, including visible, infrared, and radar; fixed- and moving-target indicators; and geospatial data.
- Identify conventional and unconventional military installations, facilities, weapon systems, orders of battle, military equipment, and defenses.
- Identify lines of communication and industrial facilities.
- Determine precise locations and dimensions of objects.
- Conduct physical battle damage assessments.
- Prepare imagery analysis reports and fused geospatial products.

1-31. Geospatial engineers provide terrain analysis, terrain visualization, tactical decision aids, geospatial database management, data dissemination, and support to the integration of other geospatial information requirements within the organization. They create content to support geospatially enabled equipment (Spiders, aviation cockpit displays, vehicle-mounted and handheld mission command tools) outside the command post. They also enable staff sections and subordinate units to maintain accurate running estimates and provide the underlying foundation for the COP.

Chapter 2
Army Geospatial Enterprise

The AGE is an integrated system of technologies and processes that provides the geospatial foundation for the COP. The COP results from storing operationally relevant spatial and temporal data in a standardized, distributed geodatabase that enables the sharing and fusing of data from the six warfighting functions across the Army. This chapter focuses on how the AGE and SSGF are applied by the geospatial engineer.

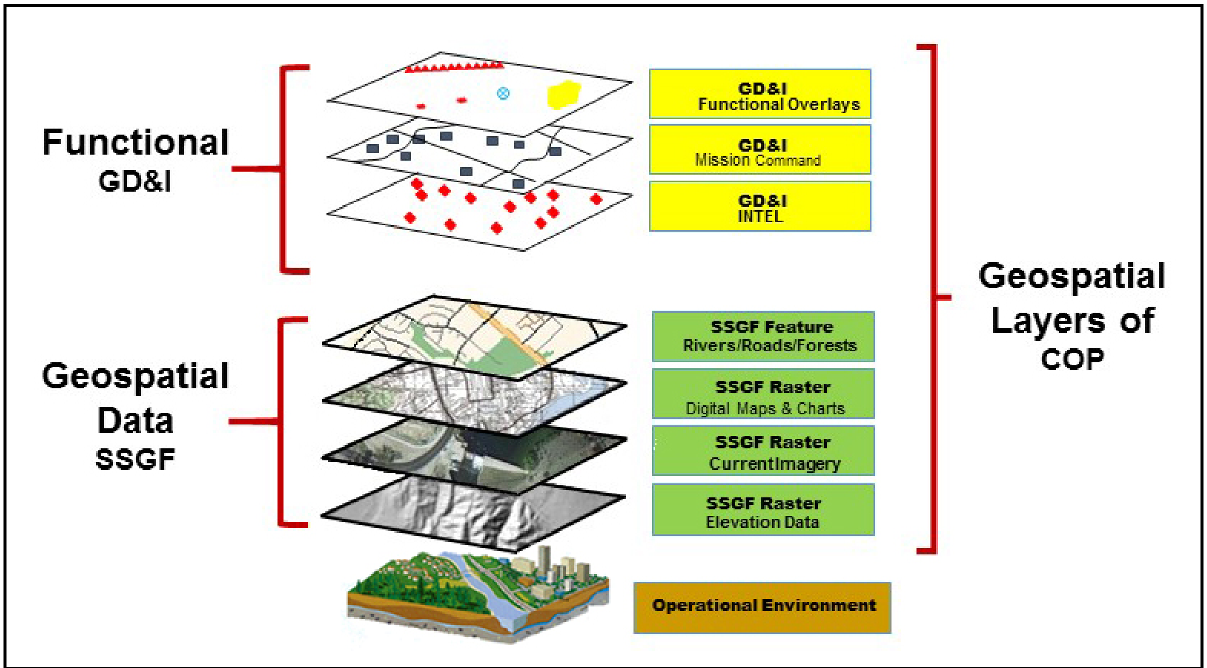
OPERATIONAL USAGE

2-1. The AGE is a comprehensive framework for systematically exploiting and sharing GI&S (including associated spatial and temporal data) to enable decisive action. At its core, the AGE is a set of data stores within a supporting infrastructure based on a common suite of interoperable software, open standards, data formats, and data models. The AGE allows the efficient collection, generation, storage, management, analysis, visualization, and dissemination of geospatially referenced information from peer to peer, echelon to echelon, Army to joint, Army to coalition, and Army to intelligence communities. The AGE enables—

- A consistent, coordinated, and synchronized geospatial foundation for the warfighter COP.
- The geospatial standards that support interoperability and geospatial data exchange between systems. These standards also support the collection, management, analysis, visualization, and dissemination of geospatial information.
- The correlation and fusion of independently collected data at different levels of fidelity and resolution into a common, interoperable geospatial data set.
- The continuity of operations and training between unit transfers, relief-in-place, and transfers of authority—for example, the ability to transfer geospatial data sets or the geospatial foundation between units as one assumes the area of responsibility (AOR) of the outgoing unit.
- The ground force synchronization and training between the Army, Marine Corps, special operations forces, and multinational forces.
- The architecture framework that can be leveraged for current and future activities.

2-2. The AGE enables the geospatial interoperability of a mission command enterprise by providing a geographic information system. A geographic information system is a system of hardware, software, and procedures that is used to facilitate the generation, management, manipulation, analysis, modeling, and display of georeferenced data to solve complex problems (terrain reasoning, geospatial intelligence, modeling and simulation, testing). It is a commercially and technically proven solution that is capable of automating the hardcopy map and overlay products. In the strictest sense, a geographic information system is an information system that integrates, stores, edits, analyzes, shares, and displays geographic information. In a more generic sense, geographic information system applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit geospatial referenced data, and present the results of these operations. Further, a geographic information system is able to represent data as layers. Geospatial data layers are coregistered within the operational environment. The coordinates of a given location can be derived accurately within the stated precision of each particular layer. The implementation of geographic information system principles across the mission command system of systems assures geospatial data interoperability between mission command systems.

2-3. Information is more efficiently collected, stored, and fused for analysis and display on mission command systems after they are spatially enabled with open, standards-based, and reusable components. AGE standards for geospatial foundation data interoperability enable mission command systems to discover, access, share, and portray authoritative geospatial foundation data. The SSGF leads to a COP. See figure 2-1, page 2-2.



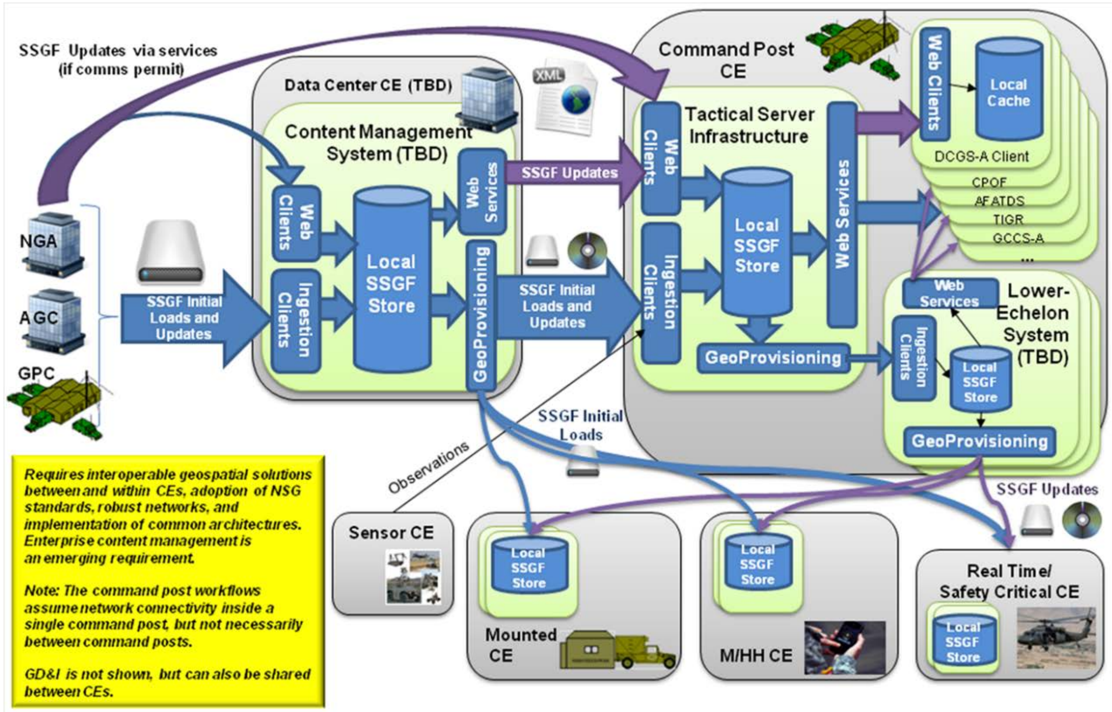
Legend:

COP	common operational picture
GD&I	geospatial data and information
INTEL	intelligence
SSGF	Standard and Shareable Geospatial Foundation

Figure 2-1. Geospatial data of the COP

2-4. The geographic information system principles that enable the AGE are based on the deliberate management of geospatial standards, data, and processes. To maximize the use and integrity of geospatial information, it must be timely, accurate, and relevant. This requires attention to how it is collected, processed, exploited, disseminated, and archived. The geospatial information does not accidentally evolve and migrate from sources to desired destinations. Its collection, discovery, storage, and flow must be ensured by deliberate technical design and deliberate human actions. Geospatial engineer teams (GETs) within the geospatial intelligence cells are the day-to-day managers of the geospatial foundation data.

2-5. The AGE uses home station and tactical networks to store, manage, and disseminate the SSGF and decision-making aides. An effective AGE requires trained geospatial engineers at each echelon using the DCGS-A to manage and maintain the common geospatial foundation data layer for the assigned AOI. Figure 2-2 is a notional diagram showing how the geospatial foundation is maintained across the enterprise by GETs.



Legend:			
AFATDS	Advanced Field Artillery Tactical Data System	GPC	geospatial planning cell
AGC	Army Geospatial Center	M/HH	mobile handheld
CE	computing environment	NGA	National Geospatial-Intelligence Agency
comms	communications	NSG	National System for Geospatial Intelligence
CPOF	command post of the future	SSGF	Standard and Shareable Geospatial Foundation
DCGS-A	Distributed Common Ground System–Army	TBD	to be determined
GCCS-A	Global Command and Control System–Army	TIGR	Tactical Ground Reporting System
GD&I	geospatial data and information		

Figure 2-2. AGE/SSGF operational view

STANDARD AND SHAREABLE GEOSPATIAL FOUNDATION DATA

2-6. The AGE delivers the SSGF upon which data from all warfighting functions is displayed on the COP in each computing environment. The SSGF forms the base on which units build the COP. Use of the SSGF puts current operations, planning efforts, and running estimates in the context of space and time, which supports mission command.

2-7. Because it is the basis of the COP, the SSGF is relevant to all phases of operations and includes personnel, units, systems, platforms, and processes that use, produce, store, manage, or disseminate geospatial data that can be shared within and between the six warfighting functions. The SSGF consists of maps, imagery, feature data, hydrology, vegetation, and elevation data. The SSGF is managed as a data store and provided as a map service on which staffs can overlay other information. Data overlaid on the geospatial foundation includes geospatial data and information (GD&I); analysis products and decision aides; operational and planning graphics from all war-fighting functions and special staff; current operations data; demographic, cultural, economic, industrial and infrastructure data; and staff running estimate information that ties to a specific location. The common operating environment standards required for geospatial interoperability and integration also apply to the geospatial data displayed on the COP (display symbology, data exchange formats, the format of the point location [military grid reference system, latitude, and longitude], the precision required per CJCSI 3900.01D).

2-8. Initially, the geospatial foundation is composed of baseline authoritative geospatial data from the NGA, AGC, GPCs, unified-action partners, commercial sources, and other area-of-operation data. GETs maintain the geospatial foundation and provide it to mission command systems and platforms. The geospatial foundation layer for the COP is stored, managed, and updated in standardized, authoritative, distributed geospatial data stores.

2-9. GPCs and GETs from corps to brigade synchronize the geospatial foundation to support the building of the COP. The geospatial foundation is stored at the GPC (or an Army processing center) as a theater geospatial data store. GPCs provide a tailored TGD and SSGF to the GETs of deploying units. Each geospatial data store contains (at a minimum) elevation data, orthorectified base map imagery, vector feature data (in a geospatial data model-compliant data schema), and rasterized finished map products.

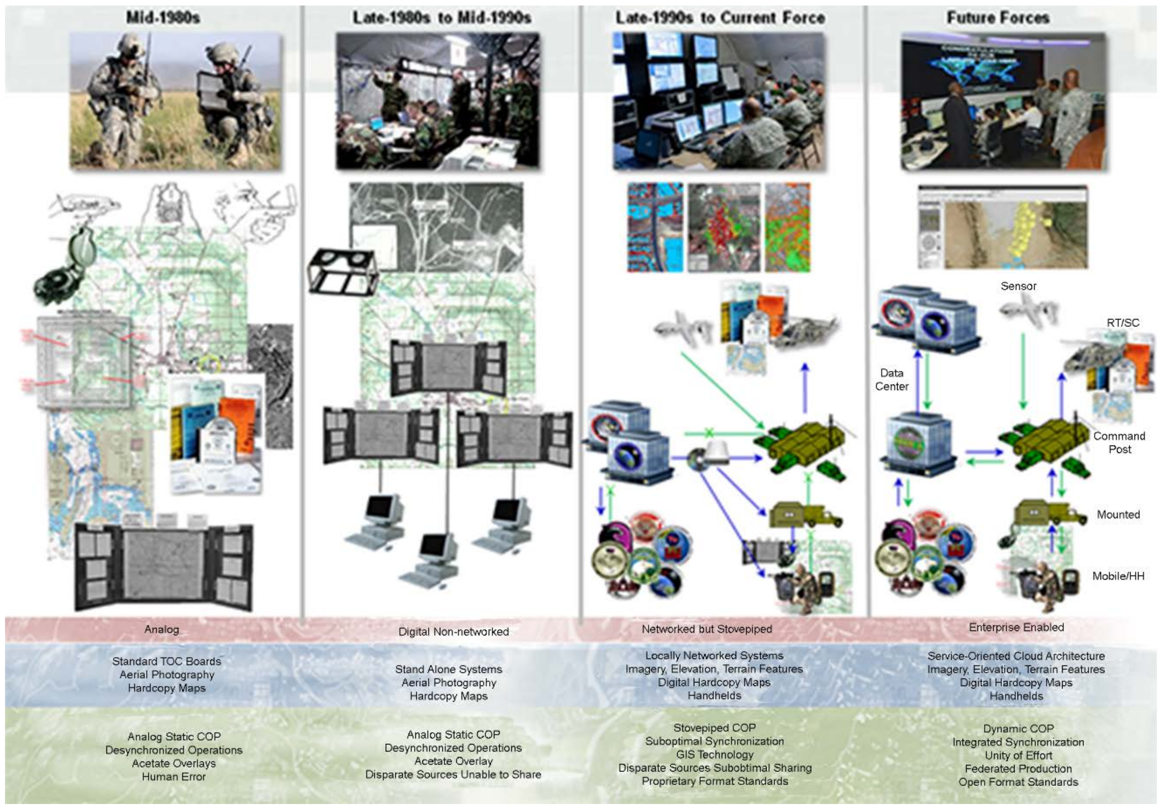
2-10. The geospatial foundation takes advantage of the following AGE infrastructure components:

- The ground warfighter geospatial data model.
- Standards for digital maps, geospatial features, imagery, and elevation data.
- Geospatial system applications (such as a geographic translator) and services (such as the DCGS-A geospatial portal).
- Two-way data flow for geospatial engineers to update, enhance, and disseminate the geospatial foundation via synchronization.

2-11. The process for handling and managing geospatial data is generally outlined as—

- **Data coverage and currency.** Standard NGA topographic line maps and database coverage are available for only a small percentage of the surface of the earth. Data holdings require periodic updates to capture changes, such as urban growth and cultural and environmental geography changes.
- **Initial data load and data tailoring.** At the time of any given contingency operation, planners, GETs, and GPCs coordinate with the AGC and NGA for tailored, authoritative content. They also request additional content to fill gaps in coverage. This becomes the GET TGD that includes the authoritative COP foundation data of the SSGF.
- **Data collection and storage.** During operations, the GET constantly enhances the coverage and quality of geospatial information in the TGD by all available means, including collection requests for high-resolution and wide-area mapping sensors. Information gained from reconnaissance, surveys, sensors, and other data sets becomes authoritative for the Army once it is vetted by a GET. The newly collected information about the operational environment is incorporated into the TGD. It is updated to the SSGF by the GET and synchronized across echelons up to the supporting GPC TGD. All GET geospatial data is stored and managed on the unit tactical server.
- **Data exchange.** GETs coordinate with unit network administrators to distribute the SSGF and updates. The SSGF is provided in the appropriate formats for systems across all computing environments. GETs use the digital network and Web services to provide the SSGF and updates to ingesting systems. GETs use the most efficient method or combination of methods available to provision the SSGF to headquarters and subordinate units.

2-12. As stated previously, the SSGF is the base on which units build their COP. The mission command systems that present the COP require the ability to layer information from a variety of sources over one consistent geospatial foundation. This enables the fusion of mission-essential information. Units tailor this information to meet the needs of the commander. Once built, units share the COP across echelons and, when needed, with interagency and multinational partners. This facilitates the transfer of information and the unity of effort. Figure 2-3 shows the evolution of the COP.



Legend:

COP	common operational picture
GIS	geographic information system
HH	handheld
RT	real time
SC	safety-critical
TOC	tactical operations center

Figure 2-3. Evolution of the COP

DATA MODEL

2-13. A standard geospatial data model is the backbone of deliberate data management and is a key component of the AGE architecture. The geospatial data model documents the geospatial concepts that relate to the operational environment and defines the content of the geospatial data foundation that supports mission command and nonmission command uses. This contributes to mission command system interoperability in operational and nonoperational applications because it enables systems to speak the same language from the same data dictionary. A geospatial data model contains a standard set of geospatial feature types and defines the relationships to other feature types and attributes associated with each feature and its allowable values. The geospatial data model consists of a geospatial logical data model and reference implementations in common geospatial data storage and management technologies used by mission command and other communities supported by the AGE. It is important to note that the geospatial data model content is selectable through the associations described above. This selectivity allows operational and nonoperational activities to draw from the same geospatial foundation without bearing the burden of manipulating, storing, and disseminating the data that is not used by a particular function. Additionally, the relationships between the geospatial data model logical layers provide for the update of information from various sources. Specifically, the physical instantiation of the geospatial data model is a geospatial data store that provides the vector feature data component of the theater geospatial data store. Configuration management of the geospatial data model ensures that the most accurate, relevant information is available.

GEOSPATIAL DATA STANDARDS

2-14. The AGE depends on a core set of standard geospatial intelligence data types and formats that cover the spectrum of geospatial features, imagery, and elevation data. Programs of record and non-programs of record use the relevant geospatial standards adopted by the AGE profile of geospatial standards, a subset of the geospatial intelligence standards documented in the DOD Information Technology Standards Registry to make data usable, accessible, and understandable to other geospatial information producers and consumers. These geospatial intelligence standards are also documented through the open geospatial consortium and NGA National System for the geospatial intelligence standards working group and are designated by the AGC Geospatial Acquisition Support Directorate as required for interoperability. Applicable standards include, but are not limited to, geospatial data and product metadata necessary for cataloging, sharing, and updating the geospatial foundation. The AGE outlines the standards supported as part of the geospatial foundation, but it does not prescribe products that are created and used as warfighting function data layers. This ensures that warfighting function products can be geospatially enabled for accurate and consistent display on the COP and can be exchanged for display and analysis on systems throughout the enterprise.

SYSTEM APPLICATIONS AND SERVICES

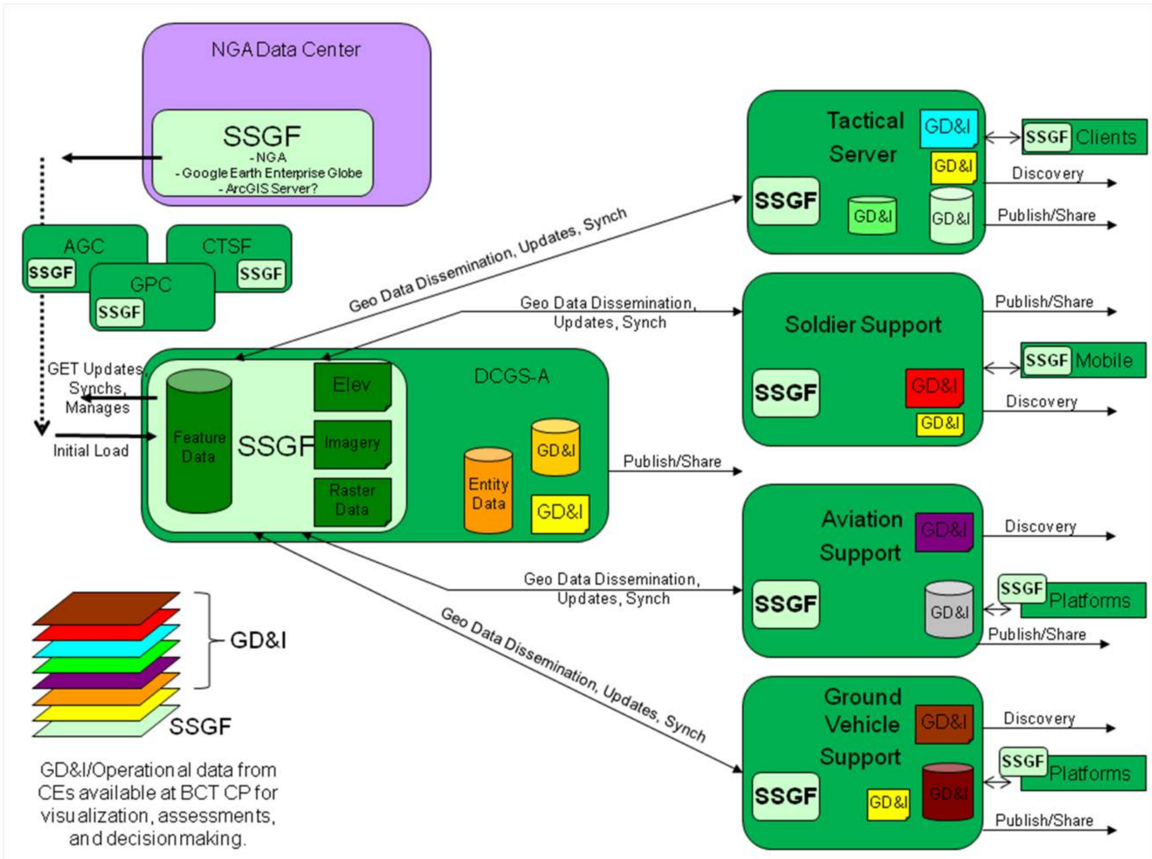
2-15. The AGE makes use of common suites of geospatial software that operate on standards, protocols, specifications, and common engineering principles described above to support the management of geospatial foundation and geo-enabled warfighting function data, geospatial analysis, visualization, exploitation, and dissemination. The DCGS-A is the main tool used by geospatial engineers to manage the geospatial foundation and make it discoverable and accessible. Systems exploiting the AGE must also be able to tie in with applicable geospatial services within the global network enterprise construct and mission command environments.

GEOSPATIAL DATA MANAGEMENT

2-16. The primary manager for the geospatial foundation content for each echelon resides in the respective GET, which serves as the geospatial foundation data manager. This role can be held by one Soldier or a team of Soldiers. The geospatial foundation data manager is solely responsible for—

- Managing geospatial data within the unit AO.
- Supporting warfighting functions with geospatial expertise.
- Creating, maintaining, updating, managing, and disseminating geospatial foundation data.
- Verifying and validating recommended changes to the geospatial foundation before updating the geospatial foundation data store. See figure 2-4 for additional information.

Note. Units consuming geospatial foundation data with no organic GET may designate a geospatial data manager (much like a communications security custodian) who can manage data and data loading at his or her level.



Legend:

AGC	Army Geospatial Center	GET	geospatial engineer team
BCT	brigade combat team	GIS	geographic information system
CE	computing environment	GPC	geospatial planning cell
CP	command post	NGA	National Geospatial-Intelligence Agency
CTSF	central technical support facility	SSGF	Standard and Shareable Geospatial Foundation
GD&I	geospatial data and information		
geo	geospatial		

Figure 2-4. SSGF data flow

AUTHORITATIVE DATA SOURCES

2-17. Army data stewards assess and approve authoritative data sources. They coordinate with DOD-wide governance bodies to reconcile and adjudicate authoritative sources. Once a proposed source is certified as authoritative, it is registered in the authoritative data sources registry. The NGA and the AGC are examples of authoritative data source producers within the DOD. The GPC TGD holds both authoritative data and products (such as common map background SSGF) and nonauthoritative data (such as crowd source and open-source data) that has not been vetted to national standards.

Warfighting Function Data

2-18. During initial fielding and predeployment operations, units receive an initial load of geospatial data (derived from authoritative sources) for the AO. Each warfighting function and staff element manages functional data during operations. As reports, events, or observations occur that generate or update spatially relevant data, these changes are represented on warfighting function overlays. Information that drives changes in the geospatial foundation layers (such as a bridge being destroyed) is submitted to the GET for validation and is synchronized with the geospatial foundation using semiautomated processes.

Two-Way Data Flow

2-19. Two-way data flow is essential for achieving relevant situational awareness across platforms and command posts. As an integral component of the AGE, two-way data flow takes full advantage of the power of a geographic information system. Mission command systems pass collected applicable geospatial data to a GET to validate the data and insert it into the geospatial foundation. The GET disseminates the information across echelons and platforms as an update to the SSGF. This two-way data flow ensures a common view of the AO.

Data Stores Synchronization

2-20. Synchronization is a process that propagates changes made in one geospatial data store to one or more other geospatial data stores. All geospatial data changes must maintain the pedigree of the data and allow synchronization without conflict or loss of data. The source and lineage of the data are its pedigree. This information is stored as metadata that allows users and applications to select data from known authoritative sources. To minimize synchronization challenges, open geospatial consortium standards (Web map services, Web feature services) ensure the proper exchange of geospatial data between applications and the geospatial foundation. Within the operational environment, synchronization is performed during connected and disconnected operations, based on mission requirements. Engineer leaders ensure that unit standard operating procedures address methods to notify users of updates and methods to conduct the updates.

Note. Managers can also use this technology to update the warfighting function data store.

Chapter 3
Roles and Responsibilities

Geospatial engineering is one of three engineering disciplines, and its full potential is only realized through a concerted effort of various organizational activities and individual actions at each echelon. This chapter, in a continuation of the discussion presented in FM 3-34, describes the key roles and responsibilities for effectively incorporating geospatial engineering in support of Army operations. See JP 2-03 and JP 3-34 for specific information on geospatial capabilities in support of joint force operations.

ECHELONS

3-1. Theater, corps, and division headquarters are modular entities designed to employ forces that are tailored to meet the requirements of specified joint operations. All stand-alone headquarters are unconstrained by a fixed formation of subordinate forces. Each is capable of serving as an Army force headquarters. Theater army headquarters serve as the ASCC with administrative control over Army forces and some theater-wide planning and controlling support to joint forces. Divisions and corps are the senior tactical warfighting headquarters, capable of directing BCTs in major operations. Divisions are optimized for the tactical control of brigades during land operations. The corps provides a headquarters that specializes in operations as a joint task force, a joint force land component command headquarters, or an intermediate Army headquarters.

THEATER ARMY

3-2. The theater army headquarters relies on a task-organized engineer brigade GET and/or the GPC deployable team to provide geospatial engineering support. GPCs are the only units in the Army force structure with a unique, dedicated geospatial data generation capability. The engineer brigade geospatial team and the GPC require access to the Global Information Grid, classified tactical local area network, and Secret Internet Protocol Router Network to update and disseminate geospatial information and products.

3-3. The GPC is the theater geospatial engineering asset designed specifically to manage geospatial data in support of operations within a combatant command AO. The GPC has the task of generating geospatial data in support of operations in a single theater. The GPCs coordinate geospatial requirements and efforts to produce geospatial map data for operational areas where current data may not exist. The data is produced in the form of topographic line maps, image maps, tactical decision aids, and the digital TGD. A GPC is attached to each theater army for mission command, Uniform Code of Military Justice, and other administrative functions. Although the GPC is a separate detachment, it is designed to function as a staff section subordinate to the ASCC engineer. The GPC is dependent on the military intelligence brigade–theater for access to the data servers, intelligence, and connectivity it needs to perform the specific mission of generating, updating, managing, analyzing, and disseminating geospatial data, information, and products in support of the theater army headquarters and geographic combatant commander. The GPC consists of an operations section, geospatial enterprise section, and a plans and analysis section. The GPC coordinates with NGA, host and allied nation topographic support activities, higher headquarters, and ASCC battle staff and major subordinate commands to generate and analyze terrain data; prepare decision graphics, image maps, anaglyphs, and 3D terrain perspective views; and manage the TGD, map updates, tactical decision aids, and intelligence preparation of the operating environment. It also coordinates with unified-action partners, host nation geospatial support activities, and higher headquarters to create and maintain the enterprise geospatial database. GPCs can deploy a forward element with, and in support of, an ASCC contingency command post or equivalent forward element.

3-4. The GPC validates and enhances the geospatial data gathered by the engineer brigade geospatial team for integration into the TGD and eventual update of the SSGF. GPCs collect, manage, and disseminate the TGD for units operating in the GPC AO. The GPC enhances existing data, generates new geospatial data, and distributes this data to units operating in the AO, to include multinational mission partners. The GPC hosts an NGA coproduction team that provides theater-generated data to the NGA for inclusion in the national geospatial data holdings. The GPC coordinates with GETs across the echelons to ensure that a synchronized geospatial data collection effort is incorporated into the TGD that provides a common database for users.

CORPS AND DIVISION

3-5. The modular corps and division headquarters designs, combined with robust communications, give commanders a flexible command post structure to meet necessary requirements. Both headquarters have two command nodes—the main command post and the tactical command post. They are organized around the warfighting functions and integrating cells.

3-6. The corps and division GETs are assigned to the main command post and partner with geospatial intelligence imagery analysts within the G-2 to form the geospatial intelligence cell. The geospatial intelligence cell operates within the G-2 Analysis and Control Element, which provides geospatial intelligence support for all phases of intelligence operations within the G-2. The geospatial intelligence cell fuses intelligence and geospatial information into a common picture for the commander, staff, and subordinate units. Geospatial engineer Soldiers within the geospatial intelligence cell perform content and knowledge management of the unit TGD. Geospatial engineer Soldiers provide geospatial engineering support for mission command to the commander; the assistant chief of staff, operations (G-3); other staff sections; and subordinate units as directed. Geospatial engineer Soldiers within the geospatial intelligence cell perform the following primary tasks:

- Generate.
  - Follow the direction of the staff engineer section to identify geospatial data gaps and nominate collection or reconnaissance.
  - Follow the direction of the staff engineer section to identify the geospatial product (type and scale) used as the standard planning foundation throughout the staff.
  - Acquire the geospatial data from multiple sources (such as the NGA, other national agencies, other countries, and other GETs across the echelons).
  - Provide the appropriate geospatial data sets to the mission command systems to ensure a COP.
- Manage.
  - Manage the geospatial information requirements process.
  - Manage the geospatial content of the 3D globe.
  - Manage the enterprise geospatial database that provides the foundation for the COP.
  - Manage the map backgrounds used in the mission command systems to provide the most up-to-date, accurate, and relevant COP.
  - Monitor collection efforts, and verify the field-collected data from information collection assets and Soldier sensor missions. Incorporate the data into the enterprise geospatial database.
  - Manage requests for information (RFIs) aimed at fulfilling gaps in the geospatial information.

- Analyze.
  - Perform terrain analysis.
  - Validate, extract, analyze, fuse, and produce relevant data and products for decision making or operations.
  - Provide tactical decision aids to support decision making.
- Disseminate.
  - Publish and maintain the unit geospatial enterprise database server.
  - Input field-collected and partner-added geospatial data.
  - Integrate and synchronize with the other staff sections and subordinates as requested.

ENGINEER BRIGADES

3-7. The engineer brigade is unique due to its role as a functional brigade and the potential for the commander to be the theater engineer. When tasked as the theater engineer, the commander assumes the responsibilities of the theater geospatial officer. This includes prioritizing and coordinating geospatial data collection with the GPC in theater. Regardless of additional responsibilities, the brigade serves as the epicenter for collecting, managing, and validating theater geospatial data and synchronizes all engineering operations in the AO. The brigade provides the in-country interface with the GPC. Due to the overlapping responsibilities, ASCC commanders and engineer leaders should explicitly delineate the roles and responsibilities of the ASCC engineer staff, the GPC, and the engineer brigade commander and his brigade. The brigade GET analyzes and produces geospatial products; performs database management for the storage of imagery, maps, digital databases, and collateral source materials; and creates tailored products for vehicle-mounted and handheld systems. Additional detail is provided below under the BCT entry. The GET is not inherently part of a geospatial intelligence cell, but it retains the capability to perform geospatial intelligence support tasks in addition to its mission command and geospatial engineering tasks.

FUNCTIONAL AND MULTI-FUNCTIONAL BRIGADES

3-8. GETs provide GI&S support to functional brigades, some of which have unique geospatial needs (aviation, fires, and maneuver enhancement brigades). They support the unique needs of these brigades (such as navigation safety and targeting) with tailored geospatial content. The brigade GET is responsible for the analysis and production of geospatial products; performs database management for the storage of imagery, maps, digital databases, and collateral source materials; and creates tailored products for vehicle-mounted and handheld systems. Additional detail is provided below under the BCT entry. The GET is not inherently part of a geospatial intelligence cell, but it retains the capability to perform geospatial intelligence support tasks in addition to its mission command and geospatial engineering tasks.

BRIGADE COMBAT TEAM AND BELOW

3-9. The GET is organic to the BCT. The GET supports the engineer staff officer by providing terrain analysis and products, maintaining the brigade geospatial database on the brigade server, and providing updates to the brigade AO within the TGD. The team captures and validates field-collected information from subordinate units for inclusion in the geospatial database and partners with geospatial intelligence imagery analysts to form the geospatial intelligence cell. The geospatial intelligence cell supports the S-2, the battalion or brigade operations staff officer (S-3), and other staff sections and subordinate units, as directed, to fuse intelligence and geospatial information into a common picture for the commander. The GETs perform similar geospatial engineering missions as the corps and division teams, but with major emphasis on the following capabilities:

- Generate and analyze geospatial data.
- Follow the direction of the staff engineer officer to provide terrain products and produce tactical decision aids (terrain analysis) to facilitate decision making.
- Produce image maps.
- Manage the enterprise geospatial database.

3-10. Geospatial engineering provides commanders with terrain analysis and visualization; improves situational understanding; and enhances decision making during planning, preparation, execution, and assessment. The staff engineer officer ensures that the GET has a clear understanding of the mission and the commander's intent to enable a proactive geospatial engineering effort throughout the operations process. Together, they provide the right information at the right time to facilitate decision making. Applications of tactical decision aids include—

- Promoting the timely development of the modified combined obstacle overlay during IPB to assist in the development of threat COAs and the identification of avenues of approach, mobility corridors, and choke points.
- Enhancing rehearsals and reconnaissance missions with the use of 3D fly-throughs, 3D anaglyphs, or simulations.
- Facilitating the positioning and routing of ground and aerial surveillance assets through LOS analysis.

UNIT AND STAFF RESPONSIBILITIES

3-11. Geospatial engineering capabilities are task-organized based on the mission and political, military, economic, social, information, infrastructure, physical environment, and time factors. The engineer staff officer is responsible for understanding the full array of engineering capabilities (combat, general, and geospatial engineering) available to the force and for synchronizing them to best meet the needs of the maneuver commander. The engineer staff officer and the geospatial engineer are responsible for establishing the single standard geospatial product and scale to be used in staff planning per joint staff, operations; G-3; or S-3 guidance or the standard operating procedure. As previously mentioned, the section of assignment and grouping of engineer staff varies among echelons and unit types. The organization of the assigned staff to meet the unique requirements of the headquarters and situation is ultimately determined by the theater army, corps, or division commander. Army staff responsibilities are described in ADP 6-0.

3-12. Regardless of the organization, all engineer Soldiers and leaders are expected to understand eight geospatial functions. They carry out these functions while fulfilling their duties, as described in the following bullets:

- **Database management.** Geospatial engineers actively manage the family of databases that comprise the SSGF and TGD. They look for gaps in data and take steps to close those gaps. The SSGF and TGD provide the underlying geospatial data and imagery used to provision the Web map service. This forms the foundation for support to mission command, the COP, and all other geospatial functions.
- **Data collection.** Geospatial engineers coordinate within and between staffs and with other agencies to collect data to fill gaps in the SSGF and TGD. Soldiers can send information requests up the chain of command. Depending on the type of data requested, requests could go through a GPC to the AGC or NGA. These agencies use national assets to collect data and provide processed data back to the requester. This typically yields high-resolution imagery and DTED data and can include several other data types. Unit staff processes synchronize internal and subordinate unit collection efforts. This results in orders to subordinate units to conduct reconnaissance operations. This typically yields feature data that the GET then processes for inclusion into the SSGF and TGD.
- **Geodetic survey.** A geodetic survey is a specialized form of reconnaissance to collect data to a known level of accuracy. Geodetic surveys are conducted by trained survey teams. Survey teams establish precise locations of geographic features within a specified margin of error. They then determine the spatial relationships between features to a known level of accuracy. This, in turn, provides the necessary information to produce accurate maps.

- **Data generation.** Geospatial engineers process the data collected from a variety of sources to extract relevant information and conflate it into the SSGF. This can be as simple as receiving an update from the GPC or as complicated as building SSGF-compliant data files from a route reconnaissance form. The result is a current, accurate geospatial foundation.
- **Data manipulation and exploitation.** This is the process of organizing the family of databases into tools that enable terrain visualization. Geospatial engineers manipulate the TGD to create the SSGF. The SSGF is the foundation for the Web map service that underlies the COP for all computing environments and provides spatial context for running estimates. The analysis and exploitation of TGD data feeds the leaders' geospatial understanding.
- **Terrain analysis.** Engineers evaluate the military aspects of the terrain and local infrastructure and determine how the projected weather interacts to impact operations. The details of this evaluation are discussed in chapters 1 and 4 and appendix D of this ATP. Engineers express the results of the analysis in clear terms to describe the impacts of the terrain and weather on operations. Geospatial engineers create tactical decision aids and other products that enable a commander to visualize and understand the operational environment. They also put staff running estimates into spatial context.
- **Cartographic production.** Geospatial engineers create a variety of standard and nonstandard products to support terrain visualization and navigation. This includes tailored map products for headquarters and subordinate units. Geospatial engineers disseminate these products digitally and in hard copy within technical and logistic limits. The large-scale printing of standard maps and unit-created products requires external support.
- **Geospatial management.** Engineers at all echelons can describe the roles and responsibilities of geospatial engineers, warrant officers, and officers in staff and command positions in the context of geospatial engineering. This includes coordinating geospatial engineering activities, reconnaissance, and staff work to support commanders. This also includes advising the staff on the geospatial resources available to support running estimates and mission command.

GEOSPATIAL PLANNING CELL OFFICER IN CHARGE

3-13. The GPC OIC coordinates through the ASCC Deputy Chief of Staff Engineer and G-2, military intelligence brigade–theater, Army and national agencies, engineer staff officers, and G-2s at echelons above brigade to plan and synchronize geospatial engineering augmentation in support of Army requirements. In doing so, the GPC OIC performs the following tasks:

- Coordinates with the engineer brigade, the ASCC G-2, or the engineer staff officer to ensure—
  - Two-way synchronization and updates for each TGD.
  - Synchronized data generation efforts in support of each TGD.
- Coordinates with the corps, division, and brigade to ensure that—
  - Organic geospatial intelligence cells and GETs include the necessary database management, analysis, and print capabilities to meet requirements.
  - Procedures are established for effectively transferring field-collected data between corps, division, and brigade geospatial intelligence cells and GETs; the engineer brigade GET; and the GPC.

GEOSPATIAL PLANNING CELL OPERATIONS OFFICER

3-14. The GPC operations officer coordinates for the deployment GPC deployed team that supports the ASCC. The operations officer also coordinates for rear detachment operations in support of deployed modules. As a member of the ASCC Deputy Chief of Staff, Engineer staff, the GPC operations officer coordinates and directs geospatial production and analysis activities within the GPC to support ASCC missions and planning operations. The GPC operations officer also coordinates with subordinate and regionally aligned forces to provide GPC geospatial data, products, and services (to include the SSGF) for those units conducting plans and/or operations in support of theater operations.

GEOSPATIAL PLANNING CELL PRODUCTION OFFICER

3-15. The GPC production officer (usually a geospatial engineer technician) trains and supervises GPC Soldiers in conducting geospatial engineering operations. The production officer works with other geospatial engineer technicians in the GPC and the engineer brigade GET to ensure the synchronized transfer of theater-collected geospatial data to the GPC. The geospatial engineer technician also performs the following tasks:

- Supervises database management operations and data exchange between the engineer brigade GET, GPCs, and deployed modules.
- Manages the deployed unit enterprise geospatial database and ensures that supported unit mission command system operators are using common map backgrounds.
- Supervises terrain analysis performed in support of deployed modules.
- Supervises print operations in support of deployed modules.
- Establishes procedures for effectively transferring updated SSGF data on mounted and handheld platforms.

GEOSPATIAL INFORMATION AND SERVICES OFFICER

3-16. As a member of the ASCC staff, the GI&S officer is the program manager and proponent for the theater geospatial enterprise (programs, policy, and governance). The GI&S officer oversees enterprise contracts for materiel and services and coordinates the validation and prioritization of GI&S requirements. The validated requirements are submitted to the GPC and AGC for production. The GI&S officer coordinates closely with the NGA and the GPC to establish budget programs, revise data standards, verify production assurance, and coordinate with the supporting and supported foreign disclosure officers to provide disclosure guidance for geospatial products to maintain the enterprise.

ENGINEER STAFF OFFICER

3-17. The engineer staff officer (usually the senior engineer officer on the staff) is responsible for coordinating engineer assets and operations for the command. Regardless of the distribution of the engineer staff or its section of assignment, the engineer staff officer ensures the synchronization of the overall engineer effort.

3-18. The engineer staff officer is responsible for the integration of geospatial engineering throughout the operations process. On behalf of the chief of staff, he provides direction to the GET. The OIC of the GET and geospatial intelligence cell is responsible for daily operations. The engineer staff officer performs the following tasks to support the GET:

- Generate.
  - Coordinate with the S-2/G-2, S-3/G-3, other staff elements, and the geospatial engineer technician for terrain products that help describe the physical environment to the commander and staff, facilitate a better understanding of the operational environment, and enable decision making.
  - Coordinate with the S-2/G-2 for the production and distribution of maps and terrain products based on established priorities.
  - Coordinate for terrain models and products to facilitate rehearsals.
- Manage.
  - Establish and maintain a continuous, open link between engineer cells and supporting engineer command posts to assess the effectiveness of geospatial engineering operations.
  - Work with the S-2/G-2 and geospatial engineer technician in assessing the effectiveness of terrain products based on feedback from the commander, the staff, and subordinate units.

- Analyze.
  - Recommend adjustments to the priorities for the geospatial engineer technician in concert with the S-2/G-2.
  - Work with the S-2/G-2 to integrate updated estimates, tactical decision aids, and geospatial products into the orders process.
- Disseminate.
  - Provide the S-2/G-2 with recommendations on the priorities of geospatial engineering that coincide with the GET and geospatial intelligence cell.
  - Establish procedures for effectively transferring updated SSGF data on mounted and handheld platforms.

GEOSPATIAL ENGINEER

3-19. Geospatial engineers, in combination with other engineers and other staff members, provide mission-tailored data, tactical decision aids, and visualization products that define the character of the operational environment for the maneuver commander. They also provide the commander with a common view of the terrain, through terrain visualization, that enables him to understand and describe his intent.

3-20. Geospatial engineers use terrain analysis and visualization capabilities to integrate people, processes, and tools, using multiple information sources and collaborative analysis to build a shared knowledge of the physical environment in support of the unit mission and the commander's intent. Geospatial engineers perform the following tasks:

- Generate.
  - Coordinate the collection of classified and open-source geospatial information through information collection from topographic surveys, site surveys, data mining, reconnaissance assets, and satellite imagery.
  - Submit requests for geospatial information from the NGA, AGC, and GPCs immediately after mission requirements are determined.
  - Partner with the intelligence staff to exploit imagery, information collection reports, and other collected all-source data to supplement the enterprise geospatial database.
  - Coordinate with the Air Force weather detachment or staff weather officer to predict the combined effects of weather and terrain on operations.
  - Respond to new geospatial information requirements generated from updated running estimates, decision points, adjustments in the commander's critical information requirements, or modifications to the concept of operations.
  - Administer and maintain geospatial databases.
  - Distribute geospatial information and terrain products in support of the MDMP and IPB.
  - Establish procedures for effectively transferring updated SSGF data on mounted and handheld platforms.
- Manage.
  - Produce and distribute maps and terrain visualization products based on established priorities to facilitate staff synchronizations and subordinate unit planning timelines.
  - Establish unit level geospatial policies and procedures.
  - Establish a geospatial product storage and distribution capability that is synchronized with other staff elements.
  - Monitor and integrate the geospatial information being generated through information collection, RFIs, and reachback.
  - Facilitate the lateral and horizontal transfer of geospatial information in support of the AGE.

- Analyze.
  - Perform terrain analysis and provide terrain visualization products in support of the MDMP and the IPB.
  - Evaluate the availability of standard and specialized maps and imagery products for the operational area or the specific AO and coordinate any shortfalls through appropriate channels.
  - Maintain geospatial data standards and perform quality assurance and quality control on geospatial information.
  - Process raw data (imagery, elevation, vector, textual) into geospatial information and products to populate the enterprise geospatial database.
  - Perform suitability, mobility, and visibility analysis in support of repositioning capabilities.
- Disseminate.
  - Provide the common map background for the COP.
  - Produce and disseminate updated terrain analysis products for the staff and subordinate units.
  - Publish and disseminate digital and hardcopy geospatial data in an enterprise environment.
  - Update the geospatial engineering running estimate. Advise the commander on geospatial engineering capabilities, limitations, and constraints.
  - Help the staff to identify and assess variances between the current situation and forecasted outcomes resulting from changes in the terrain due to natural or human influence.
  - Establish procedures for effectively transferring updated SSGF data on mounted and handheld platforms.

Geospatial Engineer Technician

3-21. Geospatial engineer technicians are the Army terrain analysis and GI&S experts. The technicians assimilate and integrate geospatial information to aid the commander and staff in understanding the impacts of the terrain on friendly and threat operations. As an integral part of the planning staff, the technicians participate in each step of the MDMP to ensure an understanding of the mission and the commander's intent. They ensure a proactive geospatial engineering effort aimed at providing the right information at the right time to facilitate decision making. The geospatial engineer technician serves as the OIC at the BCT level. At echelons above brigade, the geospatial engineer technician may serve as the OIC of the geospatial intelligence cell and collaborate with geospatial intelligence imagery analysts to produce geospatial intelligence. The geospatial intelligence cell OIC is responsible for intelligence oversight. Although the geospatial intelligence cell is located within the sensitive, compartmented information facility, geospatial engineer technicians spend much of their time outside the facility, interacting with planners and staff members from each staff section to ensure that the geospatial information requirements are being met. Geospatial engineer technicians perform the following tasks:

- Generate.
  - Identify gaps in geospatial information for those aspects of the terrain deemed critical during the MDMP and focus the data generation effort to fulfill those requirements.
  - Coordinate RFIs and nominate information collection tasks through the collection manager to acquire geospatial data (imagery, elevation, full-motion video).
  - Ensure the quality of the terrain analysis being performed by the GET.
- Manage.
  - Supervise the GET in generating data and performing feature extraction from various sources (imagery, elevation data, vector data, full-motion video, text-based data, reports).
  - Manage the production and distribution of maps and terrain products based on established priorities.
  - Supervise the GET quality control of geospatial data stored in the enterprise geospatial database.
  - Work with the S-2/G-2 in establishing the priorities for the GET throughout the operations process.

    - Manage geospatial resources and request resupply through appropriate channels.
    - Coordinate with the S-3, G-3, or operations directorate of a joint staff to issue fragmentary orders to adjacent and major subordinate staff elements to provide raw geospatial information to generate geodatabases for staff consumption.
- Analyze.
    - Integrate geospatial engineering into the MDMP and IPB to describe the physical environment to the commander and staff, facilitate a better understanding of the operational environment, and enable decision making.
    - Establish and maintain communications with geospatial engineering elements at all echelons within the AOI to foster the lateral and horizontal collaboration for operations and to cultivate effective geospatial engineering operations.
    - Ensure that geospatial data collected from the field and other sources is evaluated, compared with the existing database, and incorporated into the new database to provide the foundation for the COP and terrain analysis.
    - Continuously assess the effectiveness of geospatial information based on feedback from the commander and staff.
- Disseminate.
    - Provide updated geospatial information and terrain visualization products in support of updated running estimates and decision points, as necessary.
    - Ensure that the enterprise geospatial database is maintained to ensure that mission command system users have a common map background.
    - Provide geospatial information updates and tactical decision aids in support of each staff section running estimate to facilitate the understanding of the terrain effects on the current situation.
    - Provide terrain visualization products to facilitate rehearsals and reconnaissance.
    - Direct the dissemination of tactical decision aids and other geospatial information using Web mapping services, collaborative software, database server connections, and hardcopy production.
    - Brief the terrain analysis portion of the IPB to the commander and staff during the MDMP phases.
    - Establish procedures for effectively transferring updated SSGF data on mounted and handheld platforms.

INTELLIGENCE STAFF OFFICER

3-22. Although the engineer staff officer has overall responsibility for the integration of geospatial engineering, the S-2/G-2 are responsible for the GET and perform the following tasks:

- Plan.
    - Provide overwatch to the geospatial engineer technician who integrates geospatial products into the MDMP and IPB to describe the physical environment to the commander and staff, facilitate a better understanding of the operational environment, and enable decision making.
    - Work with the S-3, G-3, engineer staff officer, and geospatial engineer technician to establish priorities for the GET.
- Prepare.
    - Monitor the production and distribution of maps and terrain products based on established priorities.
    - Monitor and integrate the geospatial information being generated through information collection, RFIs, and reachback.

- Execute.
  - Adjust the priorities for the geospatial intelligence cell based on the situation.
  - Work with the engineer staff officer and geospatial engineer technician to integrate updated geospatial information and geospatial products into integrating processes and continuing activities as necessary.
- Assess.
  - Support the collection and management effort of geospatial information.
  - Continuously assess the effectiveness of geospatial products based on feedback from the commander, staff, and subordinate units.
  - Monitor the provision of geospatial information and tactical decision aids in each staff section running estimate.

BRIGADE OPERATIONS STAFF OFFICER

3-23. The S-3 works with the engineer staff officer and S-2 in synchronizing the GET priorities of support and levels of participation in the various functional and integrating cells and working groups in the command post based on mission requirements and the commander's intent. The S-3 provides quality control of the orders process and approves the appropriateness of geospatial engineering-related tasks and coordinating instructions provided in plans, orders, and attachments.

BRIGADE LOGISTICS STAFF OFFICER

3-24. The battalion or brigade logistics staff officer is responsible for ensuring the resupply of materials needed for the printing and reproduction of maps and other geospatial products through the appropriate channels. The battalion or brigade logistics staff officer often uses geospatial information and other tactical decision aids in planning main and alternate supply routes.

BRIGADE PLANS STAFF OFFICER

3-25. The battalion or brigade plans staff officer coordinates with the engineer staff officer to provide the geospatial engineer technician with guidance that facilitates future planning or the formulation of branches, sequels, changes of mission, and out-of-sector missions that require as much lead time as possible. Throughout the MDMP, the battalion or brigade plans staff officer and assistant chief of staff, plans, provide guidance on the quality and nature of terrain products that best depict those aspects of the terrain that are most important to the commander.

OTHER STAFF SECTION AND CELL LEADERS

3-26. All staff section and cell leaders are ultimately responsible for integrating geospatial information and tactical decision aids within respective areas. Critical to this role is ensuring that geospatial information requirements are relevant and mission-essential. This prevents overloading the GET and helps focus its efforts. Staff section and cell leaders must clearly communicate requirements and expectations to ensure that generated geospatial products meet the intent with the first attempt. Staff section and cell leaders seek the expertise of geospatial engineers in tailoring products that are practical and suitable to their needs. Recognizing recurring geospatial information requirements and standardizing terrain products that are typically needed during the MDMP help manage the geospatial engineering workload and allow base products to be built ahead of time when time is available. These requirements should be captured in the internal staff section or cell standing operating procedures to help train new members and improve staff efficiency.

Chapter 4
Geospatial Support Integration

The successful integration of geospatial support provides the right geospatial information to the right person at the right time. Successful integration requires a thorough understanding of the depth of geospatial resources available, inherent capabilities, and the ability to recognize opportunities during the conduct of combined arms operations to exploit those capabilities. Geospatial engineering efforts require a thorough understanding of the systems used, the differing types of information involved, and the methods used to exploit these factors into relevant information and tactical decision aids. This chapter focuses on how geospatial engineering is applied to the common operating environment and the operations process and on how it is part of the integrating process.

COMMON OPERATING ENVIRONMENT

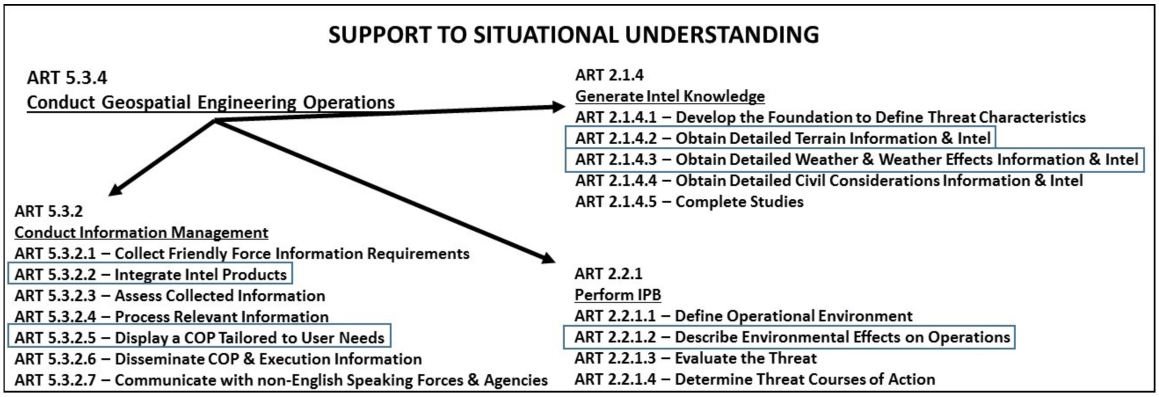
4-1. Geospatial technologies enhance situational understanding by enabling the commander's ability to visualize running staff estimates, decision making tools, and synchronization tools through the use of one COP. The COP uses the SSGF as the basis for fusing information from across the staff. Units share the COP across echelons and platforms to enhance situational awareness.

4-2. At its core, the AGE is a distributed SSGF database and supporting infrastructure that is based on a common suite of interoperable software. This allows geospatial information and, ultimately, geospatial intelligence to be collected, stored, fused, analyzed, and disseminated from peer to peer, from echelon to echelon and, subsequently, into the MDMP and down to the individual Soldier.

4-3. The integrated technologies and the actions of collecting, generating, managing, analyzing, visualizing, and disseminating from peer to peer and from echelon to echelon will, subsequently, provide information to the individual Soldier. This extends from Army to joint, Army to coalition, Army to intelligence community, and operating to generating forces. The SSGF is provisioned as raw data, open geospatial consortium Web services, and 3D globes. Updated SSGF are fused into globes and databases. GD&I operational data is overlaid on top of the SSGF for mission relevance, forming the COP.

GEOSPATIAL ENGINEERING FOR PLANNING AND OPERATIONS

4-4. Commanders use experience, applied judgment, and various analytic tools to gain the situational understanding necessary to make timely decisions to maintain the initiative and achieve decisive results. As described in ADRP 2-0, providing support to situational understanding refers to the task of providing information and intelligence to commanders to assist them in achieving a clear understanding of the current state of the force with relation to the threat and other relevant aspects of the operational environment. Geospatial engineering adds to the commander's situational understanding by improving the understanding of the physical environment, which is integrated through the IPB and staff running estimates. See figure 4-1, page 4-2.



Legend:

ART	Army tactical task
COP	common operational picture
Intel	intelligence
IPB	intelligence preparation of the battlefield

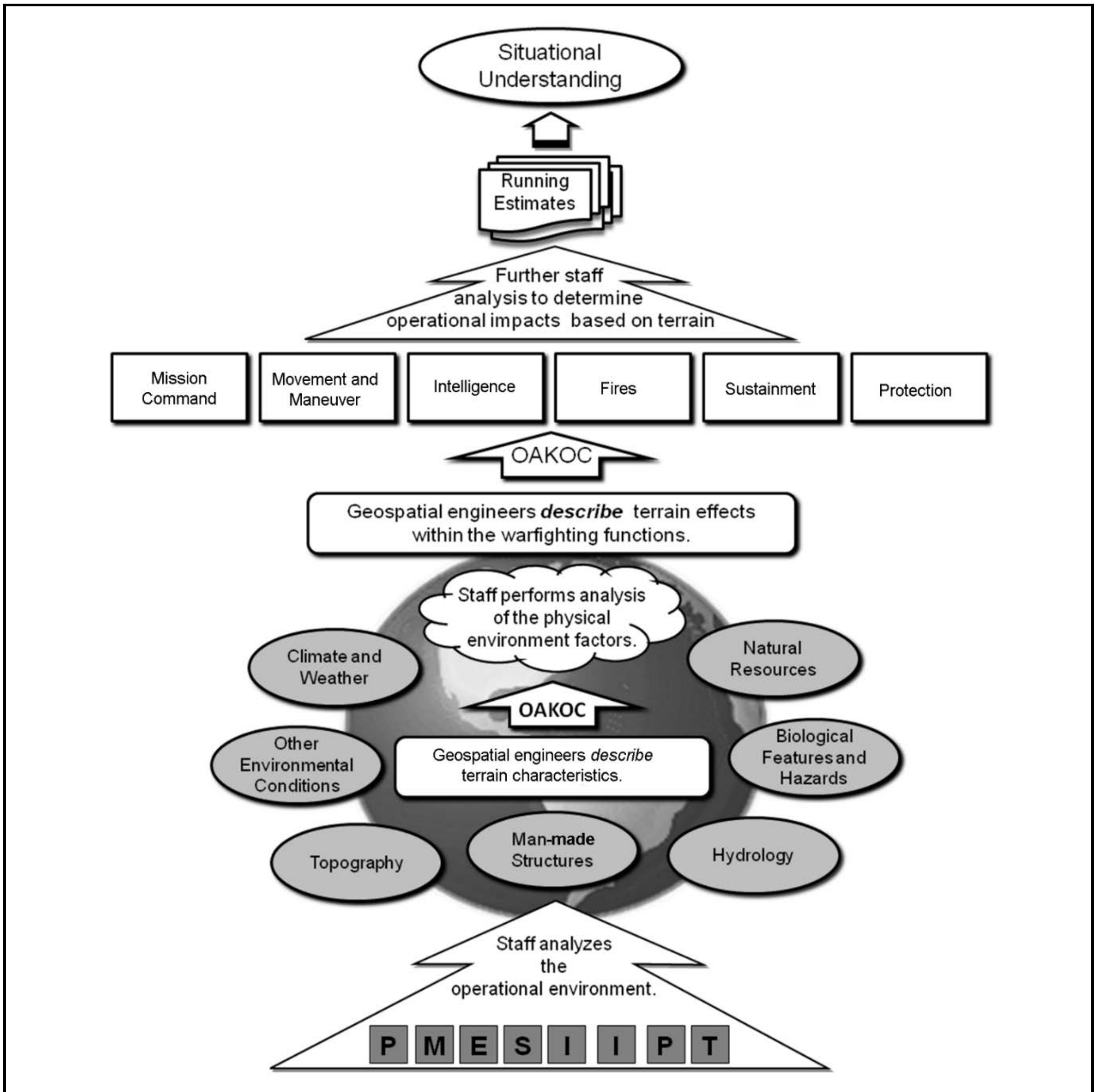
Figure 4-1. Geospatial engineering in support of situational understanding

4-5. Situational understanding aligns with the concept that commanders need to understand and visualize the operating environment to describe, direct, and assess operations. Engineer staff officers and geospatial engineers—in cooperation with their counterparts in higher, adjacent, and subordinate units—use analysis and visualization capabilities to integrate people, processes, and tools, employing multiple information sources and collaborative analysis to build a shared knowledge of the physical environment.

4-6. The more commanders understand the operational environment, the more effectively they can employ forces. As described in ADP 3-0, operational environments will likely be set in complex terrain with an asymmetrical threat attempting to offset U.S. advantages. Commanders depend on several sources of knowledge and relevant information to understand the complexity of the operational environment.

4-7. Army doctrine describes an operational environment in terms of eight operational variables—political, military, economic, social, information, infrastructure, physical environment, and time (PMESII-PT). Each staff section shares a role in providing expertise from its perspective and in adding depth and breadth to the overall understanding of the operational environment. It seeks to identify potential challenges and opportunities associated with these variables and to use running estimates to provide relevant information that commanders can use to frame operational problems.

4-8. Geospatial engineers facilitate the staff analysis of the operational and mission variables by describing the physical environment (see figure 4-2). The two primary aspects of the geospatial engineering mission that enable staff analysis are terrain analysis and terrain visualization. Geospatial engineering provides the foundation on which other information and the operational variables are based.



Legend:

OAKOC	observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment
PMESII-PT	political, military, economic, social, information, infrastructure, physical environment, and time

Figure 4-2. Description of the physical environment

4-9. Geospatial engineers focus on describing the broad characteristics of the terrain (hydrological, surface configuration, surface materials, vegetation, obstacles, and man-made features), using the framework of the five military aspects of terrain. The staff analyzes the operational variables, incorporating the terrain analysis as appropriate. As planning progresses, geospatial engineers tailor the analysis based on the refinement of the commander's intent and added clarity on likely missions. Geospatial engineers disseminate additional information in a combination of written and visual products as it is acquired. These products correspond to the warfighting functions. See table 4-1, page 4-4. In turn, the staff assimilates that information into its running estimates and determines the operational impacts from its perspective. The resulting relevant information is shared within and across echelons to refine the COP and enable situational understanding.

Table 4-1. Geospatial product considerations within the warfighting functions

Warfighting Function	***Geospatial Product Considerations***
Mission command	• Contribute to situational understanding. • Establish the foundation for the COP. • Determine terrain suitability (including LOS) for positioning mission command nodes and communication systems.
Movement and maneuver	• Identify mobility corridors and determine avenues of approach. • Predict on- and off-road mobility. • Analyze cover and concealment. • Template zones of entry (helicopter landing zones and drop zones). • Provide observation overlays for determining patrol routes, observation posts, and potential ambush or sniper locations. • Locate points of penetration and support-by-fire positions in support of attacks and breaching operations. • Identify and analyze potential engagement areas and obstacle locations based on observation and fields of fire. • Provide updated SSGF.
Intelligence	• Provide terrain analysis products in support of IPB. • Enable intelligence synchronization. • Provide support to targeting (high-payoff target information).
Fires	• Facilitate targeting. • Template observer and firing points based on visibility and suitability. • Analyze mobility to facilitate the positioning of artillery systems. • Provide survey control points for subordinate agencies employing mounted and handheld platforms.
Sustainment	• Display transportation network (road, rail, and air) information for establishing lines of communication and main supply routes. • Determine terrain suitability for positioning sustainment capabilities and establishing base camps based on hydrological analysis and assessment of other environmental conditions, such as hazards associated with industrial areas and underground utility lines.
Protection	• Identify threat air avenues of approach through elevation and LOS analysis. • Provide observation and fields of fire analysis for implementing counter direct and indirect fire and terrain denial measures. • Provide cover and concealment analysis for assembly areas and forward resupply nodes. • Identify the availability and location of force protection materials.
Legend:	
COP	common operational picture
IPB	intelligence preparation of the battlefield
LOS	line of sight
SSGF	Standard and Shareable Geospatial Foundation

4-10. The geospatial information presented to the staff is tailored to meet the needs of each staff section. Geospatial products help the staff visually communicate relevant information to support collaborative planning with higher, adjacent, and lower units and to update the commander throughout the operations process. Advances in technology allow terrain visualization products to be formatted into smaller, more exportable, geospatially aware digital files (such as a geospatial portable document format that can be electronically disseminated to a larger audience).

4-11. Recurring staff requirements for geospatial information and staff preferences for customized geospatial products are determined based on staff training exercises and operational experiences. Standardizing staff requirements routinely needed in each step of the MDMP helps leaders understand the geospatial workload and allows efficient prioritization and synchronization of the geospatial effort. Capturing these requirements and activities in standard operating procedures improves staff efficiency and facilitates the training and integration of new staff members.

TERRAIN ANALYSIS

4-12. Terrain and weather are natural conditions that profoundly influence operations. They are neutral and favoring neither side unless one side is more familiar with, or better prepared to operate in, the resulting conditions. Terrain includes natural features (rivers, mountains) and man-made features (urban areas, airfields, bridges). Terrain directly affects the selection of objectives; the employment of forces; and the equipment, location, and movement and maneuver of forces. It also influences protective measures and the effectiveness of lethal and nonlethal weapons and other systems. The effective use of terrain reduces the effects of threat fires, increases the effects of friendly fires, and facilitates surprise.

4-13. Weather describes the conditions of temperature, wind velocity, precipitation, and visibility at a specific place and time. Climate is typically used in strategic and operational planning that covers a large, geographically diverse area, whereas weather is generally more applicable to tactical planning where its effect on operations is limited in scale and duration. Climate and weather present opportunities and challenges in every operation. They affect the conditions of the physical environment and the capabilities and performance of Soldiers, equipment, and weapon systems. Table 4-2 shows some of the weather conditions to be considered when analyzing the terrain.

Table 4-2. Weather considerations within terrain analysis

Weather Condition	***Considerations When Performing Terrain Analysis***
Temperature	• Freezing temperatures can amplify the effects of precipitation on man-made structures (roads, bridges) and affect trafficability. • Extremely high temperatures affect contrasting in thermal imagery.
Humidity	• Humidity can affect materials (soil, concrete) used in constructing airfields, roads, and combat trails. • Humidity can affect work-and-rest cycles of Soldiers. • Humidity can expedite erosion of terrain or corrosion of materials.
Precipitation	• Rain and snowfall affect trafficability on and off roads. • Heavy rainfall can render low-lying areas unusable.
Visibility	• Dust, fog, and day and night conditions affect the effective distances used in LOS analysis and displays. • Rain, snow, extreme heat, and haze may restrict visibility and the effective employment of weapon systems and equipment.
High winds (>35 knots)	• High winds reduce visibility by blowing sand, dust, and other battlefield debris, which can affect movement rates. • Wind can improve trafficability by causing soil to dry faster. • Wind can amplify the effects of temperatures below 40°F (wind chill).
Cloud cover	• Reduced ceilings impact the LOS of friendly and threat aerial attacks and reconnaissance platforms. • Cloud cover impairs aerial and satellite imagery, reduces the effectiveness of certain types of remote-sensing platforms, and restricts the employment of certain aircraft.
Legend: LOS line of sight	

4-14. For tactical operations, terrain is analyzed using the five military aspects of terrain: observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment (OAKOC). While OAKOC is an easily remembered acronym to use for analysis, the results are briefed in an order based on local guidance. Table 4-3 shows terrain analysis considerations in relation to the military aspects of terrain. The effectiveness of terrain analysis in support of mission planning and operational requirements is directly proportional to the availability of current, accurate, high-resolution geospatial data. This depends on the effective collection, management, and dissemination of geospatial data at every echelon from ASCC to deployed BCT. Engineer staff officers are responsible for this effort.

Table 4-3. Terrain analysis considerations with OAKOC

Military Aspects of Terrain (OAKOC)	*Terrain Analysis Considerations*

Observation and fields of fire	• Analyze terrain factors that impact observation capabilities for electronic (LOS) surveillance systems and unaided visual observation.
	• Determine terrain effects on the trajectory of munitions (direct and indirect fire) and tube elevation.
	• Evaluate the potential engagement area, including the—
	  ▪ Defensibility of the area (for friendly and threat forces) based on terrain impacts on specific equipment or equipment positions.
	  ▪ Vulnerability of friendly forces based on threat observation and fields of fire.

Avenues of approach	• Identify mobility corridors based on equipment and preferred doctrinal formations. • Categorize mobility corridors by size or type of force accommodated. • Evaluate avenues of approach by comparing mobility (such as speed based on vegetation, slope, obstacles, and soil conditions), observation, sustainability, and accessibility.

Key terrain	• Display nominations for key terrain based on the mission, concept of the operation, threat, and environment.
	• Evaluate the following key terrain based on the environment:
	  ▪ Urban environment—tall structures, choke points, intersections, bridges, and industrial complexes.
	  ▪ Open environment—terrain features that dominate an area with good observations and fields of fire, choke points, and bridges.

Obstacles	• Evaluate the effects of natural and man-made obstacles based on—
	  ▪ Current and projected weather conditions.
	  ▪ Type of movement (foot, wheeled, tracked, or air).
	  ▪ Capabilities of vehicles and equipment.
	• Analyze water features (and surface drainage) to include width, depth, velocity, and bank slope for potential river- or gap-crossing sites.
	• Identify and evaluate impacts of potential dam breaches.
	• Analyze on- and off-road surface conditions, including—
	  ▪ Slope.
	  ▪ Vegetation.
	  ▪ Complex terrain.
	  ▪ Road characteristics (curves, slope, width, clearance, and load bearing [bridge classification]).
	• Analyze air movement obstructions, including—
	  ▪ Elevation that exceeds aircraft service ceilings.
	  ▪ Restrictions to flying the nap of the earth or vertical obstructions that impact flight profiles (buildings, power lines, communication towers).
	• Create the cross-country mobility to reflect severely restricted, restricted, and unrestricted terrain on the combined obstacle overlay and modified combined obstacle overlay.

Table 4-3. Terrain analysis considerations with OAKOC (continued)

Military Aspects of Terrain (OAKOC)	*Terrain Analysis Considerations*
Cover and concealment	• Analyze aspects of the terrain that offer protection from bullets, exploding rounds, and explosive hazards (cover). • Analyze aspects of the terrain that offer protection from observation (from aerial and ground detection), such as vegetation and surface configuration (concealment).
Legend:	
LOS	line of sight
OAKOC	observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment

TERRAIN VISUALIZATION

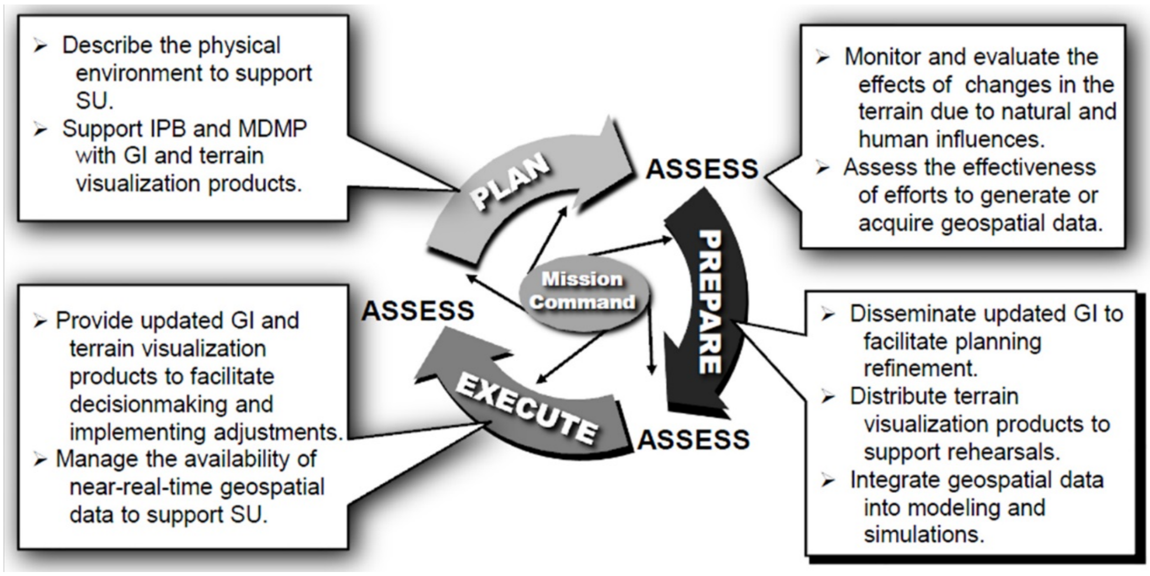
4-15. Engineers at every echelon are considered terrain experts. As such, they present relevant terrain-related information to commanders and staffs to help them conceptualize important aspects of the physical environment and to support decision making. To do so, they first must be able to identify challenges to the commander's ability to move and maneuver, protect the force, and sustain the operation. Likewise, they must also look for opportunities to directly impact the adversary's freedom of action.

4-16. Advanced technology provides the capability to analyze and display geospatial data in different ways to create interactive, dynamic, and customized terrain visualization products. For example, terrain visualization products can integrate threat and other man-made obstacles with natural restrictions of the terrain to help determine and show the best avenues of approach toward a given objective. Additionally, terrain visualization supports geospatial intelligence because geospatial products can now leverage a wider variety of data, including those from other intelligence sources (such as signals intelligence and human intelligence through collaborative processes) to provide more accurate, comprehensive, and relevant products. A good example of this is the ability to add more dimensions to standard geospatial products. The third dimension provides the capability to visualize in depth, while the fourth dimension integrates the elements of time and movement.

4-17. Staff officers must work with geospatial engineers to fully visualize the terrain more effectively. Geospatial engineers evaluate the available geospatial content for suitability in performing analysis and in providing needed visualization products. Geospatial engineers constantly collect, create, and manage geospatial data to determine its analytical quality and terrain visualization potential. Geospatial engineers apply filters to screen irrelevant content that could slow analysis or clutter displays. They also check the integrity of the content to ensure its completeness and logical consistency and then perform analysis to generate tactical decision aids. Terrain visualization products contain standardized symbols and colors to ensure quality and understandability. When possible, operational graphics should be included in visualization products to provide an extended military purpose to the map. This is especially useful when products, in conjunction with the running estimates, are used to update a maneuver commander.

OPERATIONS PROCESS

4-18. As described in ADP 5-0, the operations process consists of the major mission command activities performed during operations (planning, preparing, executing, and continuously assessing the operation) and is driven by commanders (see figure 4-3, page 4-8). The cyclic activities of the operations process may be sequential or simultaneous and are usually not discrete; they overlap and recur as circumstances demand. Throughout the process, the four major functions of geospatial engineering (plan, manage, analyze, and disseminate) are continuously performed to describe the physical environment and the operational significance of the terrain, to facilitate the further analysis of the operational environment, to support situational understanding, and to enable decision making. The engineer staff officer is the primary staff integrator for the geospatial engineer tasks and works together with the general engineer technician and the S-2/G-2 in advising the commander to realize the full potential of geospatial engineering.



Legend:

GI	geospatial information
IPB	intelligence preparation of the battlefield
MDMP	military decision-making process
SU	situational understanding

Figure 4-3. Geospatial engineering applied throughout the operations process

Plan

4-19. After collecting requisite geospatial data, planning begins with the analysis and assessment of conditions in the operational environment. In a continuation of the ongoing analysis of the PMESII-PT factors, staffs analyze the current situation using mission variables while preparing running estimates. Commanders and staffs use the MDMP, described in ADP 5-0, to develop the necessary detailed information that is needed during execution. The MDMP also synchronizes several processes (IPB, targeting, risk management) discussed later in this chapter. Most of the geospatial engineering effort is integrated into the MDMP, primarily through the IPB process (a mission analysis task). Table 4-4 shows geospatial engineering considerations in relation to the seven steps of the MDMP.

4-20. The generation of geospatial data initiated during planning responds to the gaps in geospatial data coverage identified during mission receipt. This centers on fulfilling the geospatial information requirements established during IPB and those resulting from the staff analysis of the operational environment. Other geospatial data requirements in the form of RFIs are also generated as a result of subordinate unit planning in parallel, especially from units at battalion and below that lack organic geospatial engineering capabilities.

Table 4-4. Geospatial engineering considerations in relation to the MDMP

Steps of the MDMP	*Geospatial Engineering Considerations*
Receipt of mission	• Determine the initial geospatial information requirements, based on the— ▪ Geospatial information aspects of EEFI, such as prominent features of the AO. ▪ Mission. ▪ Type of operations likely to be conducted. • Assess the availability of existing geospatial data, geospatial information aspects of EEFI, and terrain products for the AO by— ▪ Identifying gaps in knowledge of the terrain that existing maps or data cannot satisfy. ▪ Generating geospatial data from organic sources (reconnaissance, imagery, reports) to fill gaps in geospatial information. ▪ Requesting geospatial data (geological, climatic, cultural) and geospatial information from higher headquarters, national activities, and agencies through RFIs and reachback. ▪ Disseminating available maps, tactical decision aids, geospatial data, and geospatial information of the AO to the staff to enable the updating of running estimates. ▪ Ensuring that correct COP or common map background versions are used in the mission command systems to establish the map foundation of the COP.
Mission analysis	• Disseminate geospatial information and tactical decision aids throughout the staff in support of IPB and the development of running estimates. • Evaluate terrain, weather, and threat capabilities to determine the potential impact on friendly and threat operations. • Identify available feature data and geospatial information on critical infrastructure (roads, bridges, airfields). • Provide geospatial information and terrain products to help the staff evaluate LOCs, aerial ports of debarkation, and seaports of debarkation requirements. • Assess the availability of geospatial engineering capabilities, to include national, joint, multinational, and host nation assets. • Review existing geospatial data and geospatial information (including environmental and biological hazards) on potential lodgment areas, reinforced with on-site reconnaissance and infrastructure assessments when possible. • Analyze the mobility restrictions of terrain, to include the effects based on obstacle intelligence, threat engineering capabilities, and critical infrastructure. Recommend CCIRs as appropriate. • Integrate gaps in geospatial data and geospatial information into the information collection and generation effort.
COA development	• Integrate tactical decision aids across the warfighting functions that aid planners in positioning friendly capabilities.
COA analysis	• Integrate terrain products that help evaluate the COAs based on evaluation criteria. • Insert possible changes in terrain conditions (scenarios) into war games based on weather effects, such as the loss of a movement route due to surface drainage. • Help planners realize time-distance factors based on movement rates associated with on- and off-road mobility predictions.
COA comparison	• Use terrain products to help staff sections highlight the advantages and disadvantages of the COAs from their perspectives.
COA approval	• Provide an update on terrain impacts as part of the current IPB presented during the COA decision brief to the commander. • Determine geospatial information requirements based on the new CCIR to support execution.

Table 4-4. Geospatial engineering considerations in relation to the MDMP (continued)

Steps of the MDMP	*Geospatial Engineering Considerations*
Orders production	• Provide geospatial information and terrain products to support the staff development of attachments to operation plans and orders. • Facilitate the production of tab A (Terrain) to appendix 1 (Intelligence Estimate) to annex B (Intelligence) and appendix 4 (Geospatial Engineering) to annex G (Engineer). • Disseminate geospatial information and tactical decision aids to subordinate units in support of mission planning and execution.

Legend:

AO	area of operations
CCIR	commander's critical information requirement
COA	course of action
COP	common operational picture
EEFI	essential elements of friendly information
IPB	intelligence preparation of the battlefield
LOC	line of communication
MDMP	military decision-making process
RFI	request for information

Manage

4-21. Geospatial databases are established and managed at the onset of planning and are continuously updated and maintained through execution to provide users at all levels with access to timely, accurate geospatial data. Geospatial engineers manage the COP used in mission command systems to minimize inconsistencies. Geospatial engineers ensure that correct map editions are being used and that updates are incorporated into the mission command system so that all users are operating from a common map background. The volume of generated geospatial data increases proportionately with the duration of the operation. Incomplete, inaccurate, or antiquated geospatial information residing in shared folders contributes to information overload and can be misleading. Geospatial data must be managed to ensure its effectiveness.

Analyze

4-22. Geospatial engineers analyze the physical environment to help the staff further its analysis of the operational environment and for commanders to visualize the terrain for better mission planning. This broad view of the operational environment is narrowed upon mission receipt through the analysis of the mission variables. Geospatial engineers focus on the characteristics of terrain and its effects across the warfighting functions. Geospatial information enables the MDMP.

Disseminate

4-23. Geospatial information is systematically disseminated through the mission command system and tactical networks to enable staff planning and the development of running estimates. Geospatial information is disseminated to subordinates to facilitate parallel planning. Geospatial information distributed to subordinates should be referenced in orders and relevant to the other mission information provided. Geospatial engineers also ensure the proper dissemination of map updates to ensure that mission command system users are operating from a common map background.

4-24. During the last step of the MDMP, the staff prepares the order or plan by turning the selected COA into a clear, concise concept of operations with the required supporting information that subordinates need for execution. Geospatial information and tactical decision aids are distributed to the staff to help prepare the annexes. Geospatial information and other information necessary for coordinating and synchronizing the geospatial engineering effort are placed into the appropriate paragraphs in the base order and attachments. See FM 6-0 for information on the general format for orders and attachments.

4-25. While units at corps level and below normally conduct tactical planning, Army forces frequently participate in or conduct joint operations planning. ASCCs routinely participate in joint operation planning, to include developing plans as the joint force land component. Corps and divisions perform joint operations planning when serving as a joint task force or Army force headquarters. Corps, divisions, and BCTs that are directly subordinate to a joint task force participate in joint operations planning and receive joint formatted orders. It is important that leaders serving in BCTs and echelons above brigade understand the joint planning process and are familiar with the joint format for plans and orders. For a detailed explanation of joint operation planning, refer to JP 5-0 and JP 3-33. The primary joint doctrinal publication for planning engineering operations is JP 3-34. JP 2-03 provides the format for annex M (GI&S) to joint orders.

Prepare

4-26. Mission success depends as much on preparation as it does on planning. Preparation creates the conditions that improve friendly force opportunities for success. Key preparation activities are planning refinement based on IPB updates and answering information requirements that result from information collection, RFIs, and reachback. The commander and staff continuously review IPB products against the current situation and redirect collection assets to focus on the most important intelligence and information gaps remaining, while emphasizing the commander's critical information requirements.

Generate

4-27. After issuing plans and orders, new geospatial information requirements in the form of RFIs are generated as a result of subordinate planning. The staff also continues to identify new geospatial information requirements based on its own planning refinement.

4-28. Geospatial engineering supports mission rehearsals with terrain visualization products, such as 3D fly-throughs and perspective views from projected friendly unit positions. Geospatial data is used in modeling and simulation applications in the Army Battle Command System and in stand-alone simulation systems to allow commanders to replicate realistic scenarios and facilitate mission rehearsal. To be effective, these applications must represent a realistic physical environment using echelon-appropriate, high-resolution geospatial data that is presented to scale.

Manage

4-29. Geospatial engineers monitor and integrate selected GD&I being generated through information collection efforts, RFIs, and reachback and continue to update geospatial databases to support planning refinement in preparation for execution. Geospatial engineers maintain, update, and publish SSGF data and information in support of the COP.

Analyze

4-30. Geospatial engineers analyze newly acquired GD&I collected through information collection, RFIs, and reachback and implement changes to previous terrain assessments used during planning and issued to subordinates in mission orders.

Distribute

4-31. Geospatial engineers disseminate new or updated geospatial information and tactical decision aids to enable subordinate unit mission planning, planning refinement, and execution. Geospatial engineers maintain, update, and publish common map background data and information in support of the COP.

Execution

4-32. Execution refers to putting the plan into action. It involves monitoring the situation, assessing the operation, and adjusting the order as needed. Commanders continuously assess progress based on information from the COP, running estimates, and assessments from subordinate commanders. During execution, geospatial engineering focuses on maintaining situational understanding, facilitating assessment, enabling decision making, and promoting responsiveness in implementing adjustments.

Generate

4-33. As the situation develops throughout execution, geospatial engineers respond to new geospatial information requirements generated from ongoing integrating processes, continuing activities, adjustments in the commander's critical information requirements, or modifications to the concept of operations.

Manage

4-34. Geospatial engineers continue to maintain geospatial databases and incorporate, as appropriate, new or updated GD&I resulting from information collection, reachback, or unit operations into the SSGF to maintain situational understanding, to update the geospatial engineering running staff estimate, and to provide special support to developing situations.

Analyze

4-35. During execution, the priority for geospatial engineering is typically on the decisive operation; however, developing situations may dictate a shift in focus. Geospatial engineering helps the staff identify and assess variances between the current situation and forecasted outcomes resulting from changes in the terrain due to natural or human influence. When commanders direct adjustments based on an assessment of the effects of those variances, the geospatial effort shifts appropriately.

Disseminate

4-36. Geospatial engineers ensure the availability of near-real-time geospatial information through common access databases, Web mapping services, and shared content.

Assess

4-37. During assessment, commanders, staff, and subordinate commanders continuously monitor and evaluate the current situation and the progress of the operation. They compare the current situation with the concept of operations, mission, and commander's intent. The COP and running estimates are primary tools for assessing the operation. Running estimates aim to refine the COP with information not readily displayed. The development and continuous maintenance of running estimates drives the coordination among staff sections and facilitates the development of plans, orders, and the supporting attachments. During planning, assessment focuses on understanding the current conditions in the operational environment and developing relevant COAs. During preparation and execution, assessment emphasizes evaluating progress toward the desired end state, determining variances from expectations, and determining the significance (challenge or opportunity) of those variances.

Generate

4-38. Throughout the operations process, the geospatial engineering effort is managed to generate the geospatial information that the staff needs to accurately assess the situation. Multiple geospatial information requirements are generated as a result of the ongoing staff synchronizations, requiring prioritization of effort for geospatial engineering tasks. In support of simulations and modeling, geospatial data is generated to reflect realistic scenarios and conditions based on the physical environment, which enables future planning and allows for branch and sequel design.

Manage

4-39. In support of assessment, geospatial engineers continue to maintain and update geospatial databases. They also manage the content, packaging, and provisioning of the SSGF.

Analyze

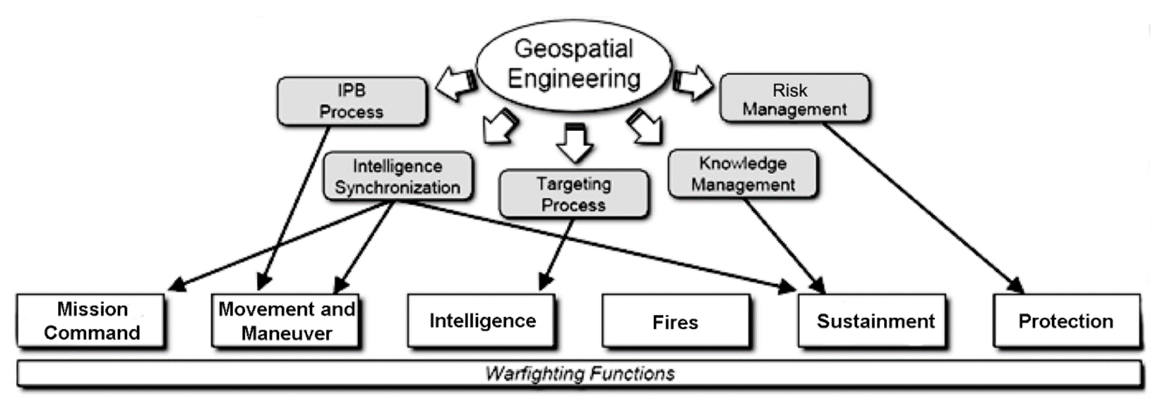
4-40. During assessment, geospatial engineering focuses on helping staffs maintain running estimates through terrain analysis that highlights the impact of changes in the terrain due to natural and human influences. For example, sudden changes in weather (such as heavy precipitation) may require that geospatial information be rendered in certain low-lying areas that are vulnerable to flooding (such as wadis, low-water crossing areas, and other severely restricted terrain). When adjustments are necessary, geospatial engineering facilitates the repositioning of friendly capabilities with terrain visualization products. Change detection can be used to assess the progress or effects of events or activities that alter the terrain (friendly and threat activity, natural disaster, civil-military construction projects, water level adjustments in reservoirs, agricultural activities). This is particularly useful in areas where the security or political situation restricts a physical presence by friendly forces.

Distribute

4-41. Geospatial engineers disseminate mission-relevant GD&I and visualization products to staff sections, functional cells, subordinate units, and working groups to help the staff evaluate the current situation and the progress of the operation. Geospatial engineers ensure the distribution of updates to maintain the integrity of products to the units. Geospatial engineers maintain, update, and publish common map background data and information in support of the COP.

Integration

4-42. As described in ADP 3-0, commanders use the warfighting functions to help exercise mission command. Commanders also use integrating processes to synchronize operations throughout the operations process. Geospatial engineering is applied across the warfighting functions through various integrating processes as described in the following paragraphs. See figure 4-4.



Legend:
IPB intelligence preparation of the battlefield

Figure 4-4. Integration of geospatial engineering across the warfighting functions

INTELLIGENCE PREPARATION OF THE BATTLEFIELD

4-43. IPB is an integrating process and occurs during all operations process activities. As described in ATP 2-01.3, IPB is a systematic, continuous process of analyzing and visualizing the operational environment in a specific geographic area for a specific mission or in anticipation of a specific mission.

4-44. Although the S-2 or G-2 leads the IPB, it involves the entire staff and incorporates information from each section area of expertise. The integration of geospatial engineering into the IPB requires a concerted effort between the engineer and intelligence staffs and coordination and synchronization with higher, lower, and adjacent units. Table 4-5, page 4-14, shows geospatial considerations in relation to the steps of the IPB process.

Table 4-5. Geospatial engineering considerations in relation to the IPB steps

IPB Steps	*Geospatial Engineering Considerations*
Define the operational environment.	Identify gaps in the coverage and availability of geospatial data and geospatial information for the AO and the AOI. Analyze the factors of the physical environment using OAKOC in consideration of each warfighting function.
Describe the operational environment effects.	Describe the terrain effects on threat and friendly capabilities.
Evaluate the threat.	Describe and show the terrain effects on threat capabilities based on the threat mission or objectives.
Determine the threat COAs.	Incorporate geospatial information and tactical decision aids to eliminate improbable COAs. Describe the effects of terrain on the military aspects of threat COAs. Create tactical decision aids that depict OAKOC advantages with respect to critical aspects of possible COAs.

Legend:

AO	area of operations
COA	course of action
IPB	intelligence preparation of the battlefield
OAKOC	observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment

Define the Operational Environment

4-45. Defining the operational environment centers on identifying for further analysis those specific features of the environment or the activities in the environment that may influence the available COAs or the commander's decisions. During this step, geospatial engineers identify gaps in the coverage and availability of geospatial data and geospatial information for the AO and AOI. The geospatial intelligence cell and staff work closely together to fill these gaps, to include—

- Providing input to the information collection plan.
- Submitting RFIs to higher headquarters.
- Using reachback to GPCs, national agencies, and other sources.

4-46. Geospatial engineers analyze the factors of the physical environment using OAKOC in consideration with each of the warfighting functions. The results of this analysis are then described to the staff as part of the next step.

Describe the Operational Environment Effects

4-47. This step involves analyzing the environment and describing its effects on threat and friendly capabilities. Geospatial engineers evaluate the effects of terrain and weather on operations and then brief the staff on the conclusions. The staff incorporates the results into its running estimates.

Evaluate the Threat

4-48. Threat capabilities are evaluated based on threat missions and objectives. For geospatial engineers, this is a continuation and refinement of the ongoing terrain analysis aimed at helping the staff understand terrain effects on threat capabilities. Geospatial engineers incorporate the results of information collection operations, RFIs, and reachback into their analysis and disseminate geospatial information to further staff analysis. In cyclic fashion, as the staff furthers its analysis, the level of detail required to fulfill the staff additional geospatial information requirements increases as IPB progresses. Geospatial engineers continue to use information collection operations, RFIs, and reachback to augment their analysis. As geospatial information accumulates within the staffs at each echelon, the management of geospatial information and knowledge about the terrain becomes increasingly important.

Determine the Threat Courses of Action

4-49. The intelligence staff, helped by the rest of the staff, determines threat COAs based on the analysis performed during the previous steps. COAs are prioritized based on the likelihood of occurrence. Geospatial engineers provide geospatial information and terrain products that help minimize the number of considered COAs based on the effects of intervening terrain. Terrain suitability products help visualize the mobility, suitability, and visibility aspects of terrain, which can quickly render COAs unfeasible. In prioritizing the threat COAs, geospatial engineers determine if the terrain will support the COAs by assessing the terrain effects against the COA evaluation criteria—for example, examining the terrain effects on the mobility and rates of march for threat vehicles. Geospatial products that visually highlight those advantages and disadvantages of the terrain for each COA enable decision making.

Information Collection

4-50. Information collection contributes to the commander's visualization and decision making. Commanders continuously plan, task, and employ collection assets and forces. These assets and forces collect, process, and disseminate timely and accurate information and intelligence to satisfy the commander's critical information requirements and other intelligence requirements. Information collection is continuous and is used to improve situational awareness. See ADRP 2-0, ATP 2-01, FM 3-55, and JP 2-03 for more on information collection.

4-51. Terrain analysis helps the intelligence staff employ collection assets for maximum effectiveness without exposing those assets to unacceptable risks. Viewshed analysis can help in positioning LOS-based information collection assets. Evaluating the cover and concealment provided by natural and man-made terrain can help in determining which routes offer the best survivability based on the protection needs of the information collection asset.

4-52. The staff collectively determines information requirements during the IPB to focus information collection to support the mission. In a cooperative effort between the intelligence and engineer staffs, information requirements are analyzed to determine which ones can be fulfilled through geospatial engineering, to include reachback through appropriate channels to GPCs and national level assets (NGA, AGC).

Targeting

4-53. Targeting is an integral part of Army operations in which targets are selected and prioritized and, while considering operational capabilities to achieve the commander's desired effects, appropriate responses are matched. The targeting working group uses targeting to synchronize the effects of fires, including information-related capabilities, with the capabilities of other warfighting functions. Geospatial engineering supports targeting with high-precision, high-resolution GD&I (such as the Digital Point Positioning Database). The full potential of geospatial engineering in support of targeting is best realized through the integration of geospatial engineers within geospatial intelligence cells. Geospatial engineers have the ability to bring precision terrain analysis support that is otherwise absent from other staff activities to electronic target folders. The electronic target folders provide the means to visualize the target and understand the complexity of mobility, suitability, and visibility aspects that also impact targeting.

4-54. Army tactical targeting methodology is based on the following four functions:

- Decide.
- Detect.
- Deliver.
- Assess.

4-55. Like other integrating processes, targeting is cyclical and occurs continuously throughout an operation. Its steps mirror those of the operations process—plan, prepare, execute, and assess. Targeting occurs throughout the operations process and MDMP and continues after the order is published, validating previous decide, detect, deliver, and assess decisions while planning for future decisions. Table 4-6 shows the four targeting functions, the associated targeting tasks, and the geospatial engineering considerations within them. See ADRP 5-0 and ATP 3-60 for additional information on targeting.

Table 4-6. Geospatial engineering considerations in relation to the targeting functions

Targeting Process Function	***Targeting Task***	***Geospatial Engineering Considerations***
Decide	• Perform a target value analysis to develop HVTs. • Provide fire support and input to targeting guidance and targeting objectives. • Designate potential HPTs. • Deconflict and coordinate potential HPTs. • Develop the HPTL. • Develop the AGM. • Determine the measure of performance and measure of effectiveness for BDA requirements. • Submit IRs and RFIs to the S-2 or G-2.	• Integrate mobility, suitability, and visibility products to help template targets and identify potential EAs. • Calculate movement rates in support of establishing decision points, timelines, and triggers. • Assist in determining building and structure composition and location and defining characteristics and the surrounding area. Identify sensitive areas and locations (schools, key infrastructure, culturally significant sites, religious institutions, hospitals) to avoid collateral damage and subsequent host nation backlash.
Detect	• Execute the information collection plan. • Update PIRs and IRs as they are answered. • Update the HPTL and AGM.	• Perform LOS/viewshed analysis to help position LOS-based target acquisition assets. • Help update the HPTL based on new geospatial information or assessments of changes in the terrain due to natural or human influence.
Deliver	• Integrate capabilities across all warfighting functions matching the appropriate response.	• Ensure that the latest and current version of the SSGF is being used, and support the fires cell with appropriate GD&I (Digital Point Positioning Database) to meet target execution.
Assess	• Assess task accomplishment (as determined by the measure of performance). • Assess effects (as determined by the measure of effectiveness). • Monitor targets engaged with information-related activities.	• Work with a geospatial intelligence imagery analyst (in the geospatial intelligence cell) in performing change detection to assess the effects achieved by attacks on buildings, facilities, and other structures.

Legend:

AGM	attack guidance matrix	HVT	high-value target
BDA	battle damage assessment	IR	information requirement
EA	engagement area	LOS	line of sight
G-2	assistant chief of staff, intelligence	PIR	priority intelligence requirement
GD&I	geospatial data and information	RFI	request for information
HPT	high-payoff target	S-2	intelligence staff officer
HPTL	high-payoff target list	SSGF	Standard and Shareable Geospatial Foundation

Decide

4-56. The decide function is cyclic and occurs throughout the operations process based on the unit battle rhythm. As part of IPB, the S-2/G-2 adjusts threat models based on the effects of terrain and weather to create situational templates that portray possible threat COAs. The S-2/G-2, S-3/G-3, fire support coordinator, and other members of the staff collaborate and conduct target value analysis for each threat COA to identify potential high-value targets. The completed threat model identifies high-payoff targets, and the situation template predicts the location. Geospatial engineering combines the terrain analysis conducted during IPB with the staff analysis of the critical threat functions in each COA and the required capabilities (assets) associated with each function. The staff determines which assets are likely to be of value based on the threat mission and objectives and the effects of terrain. For example, in a threat-offensive COA, the prominence of linear obstacles in an operational environment could indicate value in threat obstacle-breaching and gap-crossing assets. The further analysis of gap characteristics (width, bank height) can reveal possible crossing sites and, when considered in the overall threat COA, can help the S-2/G-2 template the employment location of threat gap-crossing assets.

Detect

4-57. The detect function involves locating high-payoff targets accurately enough to engage them and depends on the results of the information collection effort. Characteristics and signatures of the relevant targets are determined and compared to potential engagement system requirements to establish specific sensor requirements. Information needed for target detection is expressed as a priority intelligence requirement. As collection assets gather information, the findings are reported to the commander. Detection plans, priorities, and allocations change during execution based on the mission variables. The terrain analysis conducted during the decide function is applied within the detect function to help template the location of high-payoff targets and predict the location of employment (based on terrain) to help focus target acquisition assets. For example, artillery slope tint products can help template threat artillery positions based on slope restrictions.

Deliver

4-58. The deliver function is the execution of capabilities against targets. Geospatial engineers have access to high-precision, high-resolution imagery, adding more capabilities to increase the location accuracy of targets. Geospatial engineers integrate the results of terrain analysis to aid in the selection of the appropriate response to targets.

Assess

4-59. The assess function occurs throughout the operations process, but it is most intense during execution. Battle damage assessment is the timely and accurate estimate of damage resulting from attacks on targets. As part of the geospatial intelligence cell, geospatial engineers support the change detection used to assess effects on facilities and structures.

TARGETING WORKING GROUP

4-60. During execution, the targeting working group continually assesses the current situation, prepares update briefings for the commander, and looks toward the future. The working group provides a forum for extending the planning conducted during the MDMP throughout the operation, allowing the targeting working group to reconsider decisions made and modify or initiate actions to implement those decisions. The targeting working group is an important event in the battle rhythm. It recommends the use of unit combat power and resources toward detecting, engaging, and assessing high-payoff targets. The integration of geospatial engineering in targeting working groups can help to—

- Update the high-payoff-target list based on new geospatial information or an assessment of changes in the terrain due to natural or human influence.
- Position or shift LOS-based target acquisition assets based on terrain restrictions.

- Determine the suitability of lethal and nonlethal delivery systems based on the natural and man-made terrain.
- Determine effects and battle damage assessment based on change detection of imagery.

4-61. The keys to successful targeting working groups are preparation and focus. Each representative must come to the meeting prepared to discuss available assets, capabilities, and limitations related to his or her staff area. Much of this preparation requires time-consuming, detailed planning and coordination with other staff sections well in advance. Before the targeting working group, the engineer staff officer, the geospatial engineer technician, and the S-2/G-2 work to—

- Gather available geospatial information pertaining to potential high-payoff-target nominations and employment location, based on the terrain.
- Provide geospatial information that could impact the means of delivery, munitions used, or placement of systems to reinforce existing natural and man-made obstacles.
- Make recommendations for air tasking order nominations (normally based on a 72-hour cycle) for the employment of fixed-wing imagery assets.
- Provide updates on the terrain effects based on changes in the terrain due to natural or human influence or the acquisition of new geospatial information resulting from refined terrain analysis, surveillance and reconnaissance collection, RFIs, and reachback.
- Provide geospatial information and geospatial products pertaining to the restricted target, no-strike, and sensitive-site list.

OTHER INTEGRATING PROCESSES

4-62. Geospatial engineers provide support to other integrating processes. They provide the foundation to put staff running estimates into context in terms of location, and they develop and disseminate tactical decision aids based on geographically referenced phenomena. With respect to risk management, geospatial engineers possess the ability to view, interpret, and display data as a product, service, or 3D globe to determine patterns, relationships, and trends to support mission requirements.

4-63. Risk management is an integrating process that occurs throughout the operations process. Risk management is the process of identifying, assessing, and controlling hazards (risks) that arise from operational factors and then balancing those risks with mission benefits (see ATP 5-19). Risk management helps to preserve the force and is integrated primarily through the MDMP during planning and through protection working groups throughout the rest of the operations process. Table 4-7 shows geospatial engineering considerations for each step of the risk management process.

Table 4-7. Geospatial engineering considerations in relation to the risk management steps

Risk Management Steps	*Geospatial Engineering Considerations*
1. Identify hazards.	Analyze and describe to the staff those hazards associated with the physical environment.
2. Assess hazards to determine risks.	Assign risk to each hazard in terms of probability and severity.
3. Develop controls and make risk decisions.	Determine how cover and concealment can be used to effectively enhance survivability.
4. Implement controls.	Provide appropriate input into mission orders, briefings, running estimates, and standard operating procedures as necessary.
5. Supervise and evaluate.	Assess the effectiveness of geospatial engineering applied throughout the risk management process and provide feedback to leaders.

4-64. During mission analysis, the focus is on performing the first two steps. Hazards are identified using mission variables as a standard format. Geospatial engineering focuses on helping the staff to visualize and assess those hazards associated with the physical environment. Risk is assigned to each hazard in terms of probability and severity.

4-65. The develop controls and make risk decisions step is accomplished during COA development, analysis, comparison, and approval. Geospatial engineering can aid planners in determining the effectiveness of cover and concealment provided by natural and man-made features along movement routes and in static positions. Controls are implemented through mission orders and standard operating procedures. Geospatial engineers can create special-purpose maps and visualization products (such as image maps with annotations) to help leaders communicate their instructions. The supervise and evaluate step is conducted continuously throughout the operations process.

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Appendix A

Metric Conversion Chart

This appendix complies with AR 25-30, which states that weights, distances, quantities, and measurements contained in Army publications will be expressed in both U.S. standard and metric units. Table A-1 is a metric conversion chart for the measurements used in this manual. For a complete list of preferred metric units for general use, see Federal Standard 376B.

Table A-1. Metric conversion chart

U.S. Units	***Multiplied By***	***Equals Metric Units***
Feet	0.3048	Meters
Inches	0.0254	Meters
Metric Units	***Multiplied By***	***Equals U.S. Units***
Meters	3.2808	Feet
Meters	39.3700	Inches
Legend: U.S. United States		

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Appendix B

Geospatial Products

Geospatial products are visual representations of relevant information pertaining to the terrain effects derived from terrain analysis. Geospatial products contain information about the physical environment that can be easily understood by commanders to help them better understand the operational environment and enable decision making. This appendix provides an overview of the standard geospatial products provided by national agencies and the tailored products generated by geospatial engineers.

STANDARD GEOSPATIAL PRODUCTS

B-1. The production of standard products (paper and digital maps) is overseen or completed by the NGA and the U.S. Geological Survey. Scanned maps are paper maps that have been scanned into a computer file and georectified. Two types of scanned maps are produced by NGA: arc-digitized raster graphics and compressed arc-digitized raster graphics. The AGC also publishes NGA maps in geospatial portable document format.

JOINT OPERATIONAL GRAPHIC (AIR)

B-2. Joint operational graphic (air) charts are medium-scale maps designed for aeronautical use (see figure B-1). The joint operational graphic (air) displays topographic data (relief, drainage, vegetation, populated areas) and includes an aeronautical overprint depicting vertical obstructions, aerodromes, special-use airspace, navigational aids, and related data. Joint operational graphic (air) maps support tactical and other air activities, including low-altitude visual navigation.

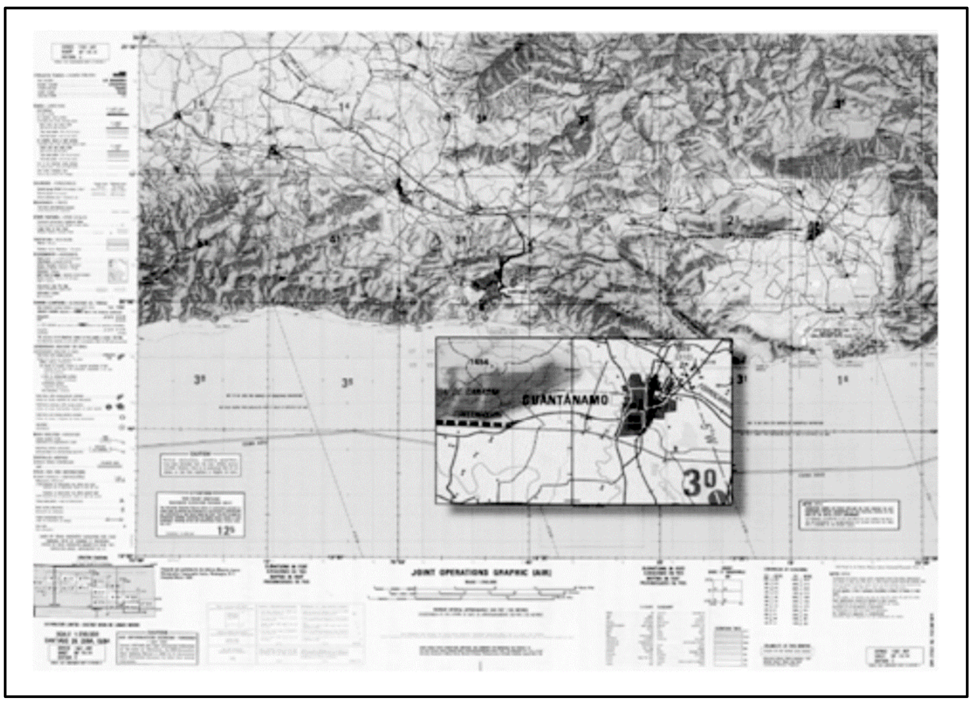


Figure B-1. Example of a joint operational graphic (air) map (1:250,000)

TOPOGRAPHIC LINE MAP

B-3. Topographic line map coverage is not currently available for the entire world. Requirements for the NGA production of topographic line maps are based on theater commander requirements.

B-4. A 1:50,000-scale topographic line map is the standard map used for dismounted tactical planning and operations (see figure B-2). A 1:100,000-scale map is more commonly used for mounted planning and operations and is better suited in areas with less significant terrain features and when movement can be conducted rapidly across the area.

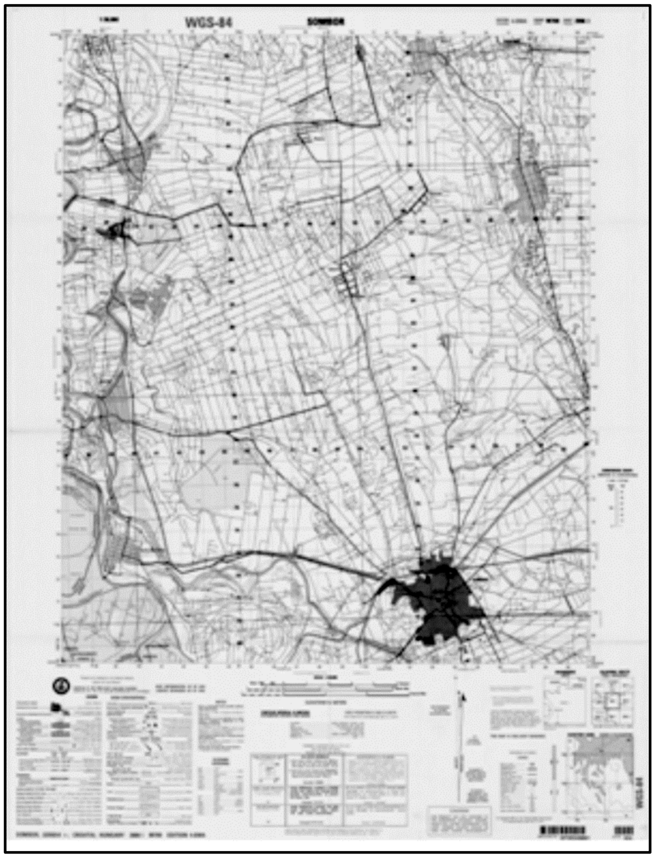


Figure B-2. Example of a topographic line map (1:50,000)

CITY GRAPHIC MAP

B-5. The scales of city graphic maps generally range from 1:10,000 to 1:35,000, depending on the size of the city. This large-scale product is used for planning and conducting ground combat operations in urban areas. It depicts street names; traffic networks; port facilities; airfields; individual buildings; military, industrial, and governmental complexes; hospitals; schools; places of worship; and other key features.

TAILORED PRODUCTS

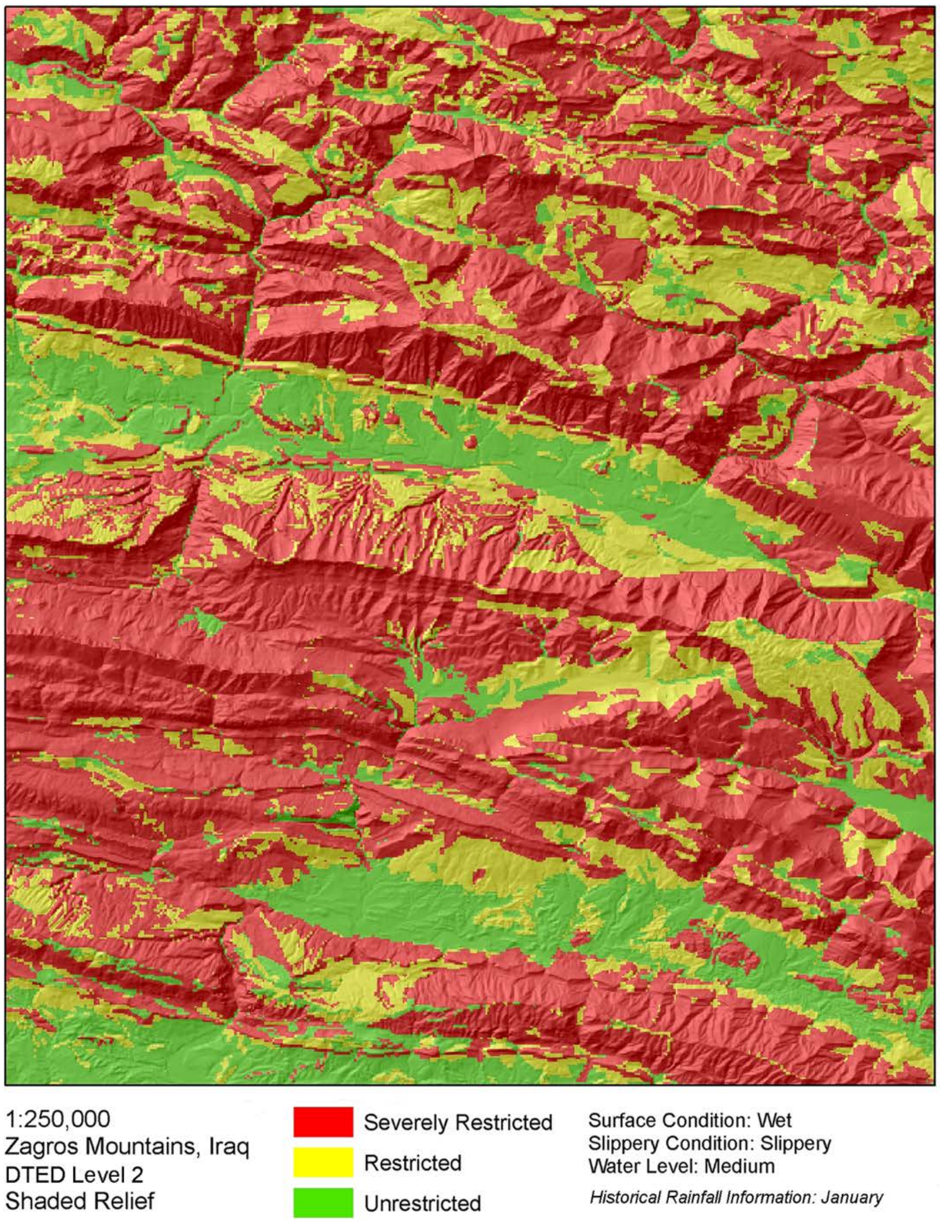
B-6. Geospatial engineers create tailored products that combine or integrate raster, vector, and text information (see table B-1). The following are examples of products that geospatial engineers can tailor to support mission planning, preparation, execution, and assessment. These products are generated digitally and consist of base imagery or a map or elevation background with various layers placed on top. These digital overlays have database tables associated with each component that allows them to be queried, analyzed, and displayed to create the desired end product. Because they are digital overlay files, they can be displayed in any number of mission command systems.

Table B-1. Examples of tailored geospatial products

Geospatial Product	*Primary Uses*
Cross-country mobility	Identifies mobility corridors and friendly and threat AAs and EAs.
Linear obstacle	Portrays linear obstacles that impede mobility.
	Combines with cross-country mobility to create a combined obstacle overlay.
Combined obstacle overlay	Identifies mobility corridors and friendly and threat AAs and EAs.
Mobility corridors	Shows mobility corridors by combining cross-country mobility, transportation, and linear obstacle overlays.
LOC	Identifies available road and transportation networks in an operational area or AO.
Hydrology analysis	Shows the operational impacts of water features in an operational area or AO.
Drop zones	Locates possible drop zones in an operational area or AO to support airborne operations.
Helicopter landing zones	Locates possible landing zones in an operational area or AO to support air assault operations.
Vegetation analysis	Determines the suitability of an area (cover and concealment, mobility restrictions) based on the effects of the vegetation in an operational area or AO.
Soil trafficability	Shows the effects of soil on trafficability.
Field of fire	Locates defensible terrain in an operational area or AO.
	Identifies possible EAs and position fighting systems.
Artillery slope tint	Templates threat artillery assets based on slope restrictions.
Aerial concealment	Shows areas or routes that offer concealment from overhead detection.
Surface material	Depicts areas based on types of soil that constitute its surface.
	Provides information on trafficability, construction projects, and survivability (dig/slow-dig overlays).
Construction resources	Shows areas that contain certain types of materials to support construction planning.
Shaded relief	Highlights variations in elevation and slope in an operational area or AO.
Viewshed analysis	Shows areas of direct observation from a given point that can help position LOS-based systems.
Perspective view	Provides 3D terrain visualization from an observer's point of view.
Fly-through	Provides 3D terrain visualization of an area as seen from the point of view of a pilot, vehicle driver, or dismounted Soldier.
Urban Tactical Planner™	Displays key aspects of urban terrain to facilitate operating in an urban environment.
BuckEye	Downloadable, unclassified, high-resolution, two-dimensional and 3D imagery.
Legend: AA avenue of approach AO area of operations EA engagement area	LOC line of communication LOS line of sight

CROSS-COUNTRY MOBILITY

B-7. The cross-country mobility product demonstrates the off-road speed for a vehicle as determined by the terrain (soil, slope, and vegetation) and vehicle performance capabilities; however, it does not consider the effects of roads and obstacles (see figure B-3). Cross-country mobility is used to help identify avenues of approach and engagement areas.



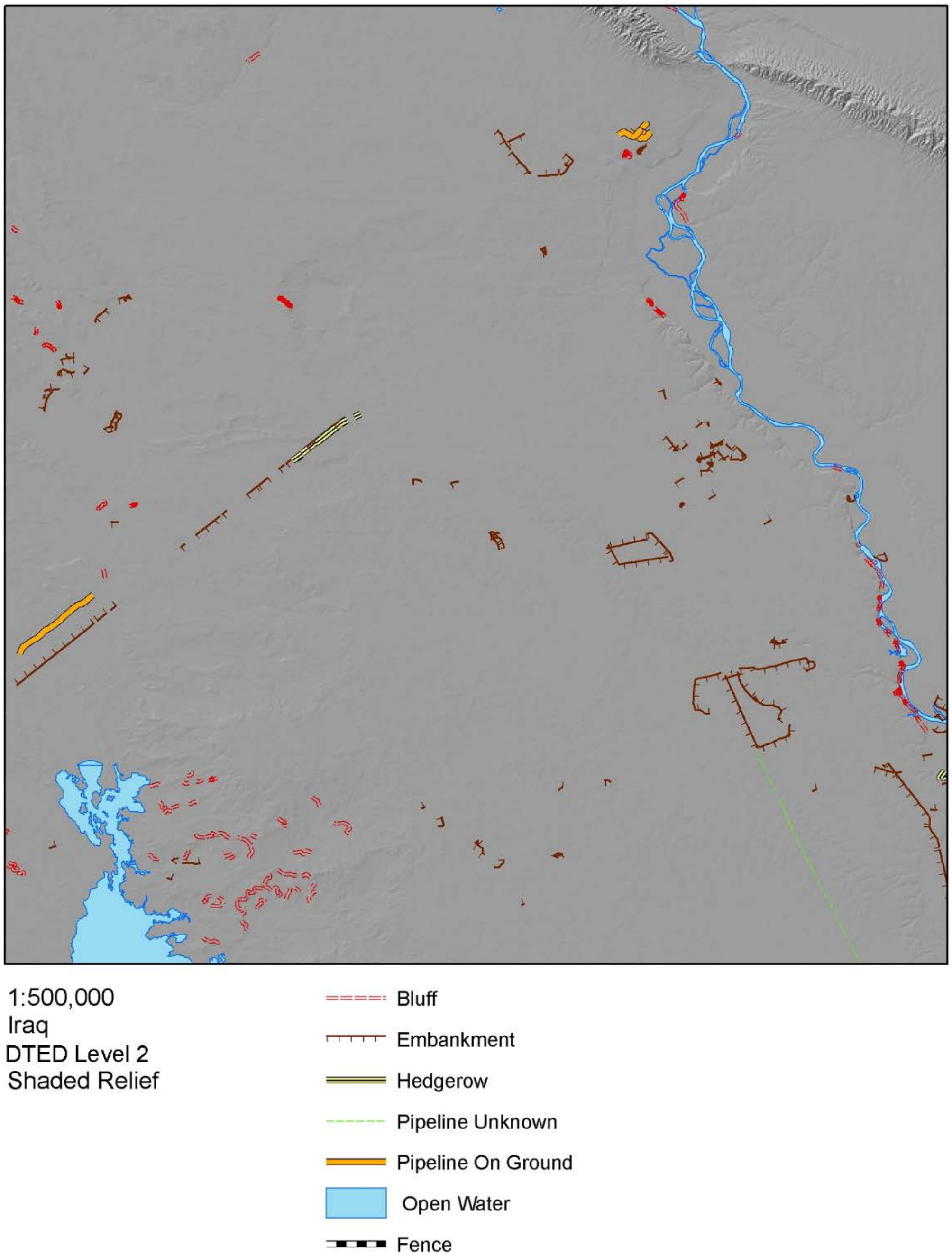
Legend:

DTED digital terrain elevation data

Figure B-3. Example of a product showing cross-country mobility

LINEAR OBSTACLE

B-8. The linear obstacle overlay portrays linear natural or man-made terrain features (escarpments, embankments, road cuts and fills, depressions, fences, walls, hedgerows, pipelines, bluffs, moats) that pose obstacles (see figure B-4). This information can be combined with a cross-country mobility product to create a combined obstacle overlay.



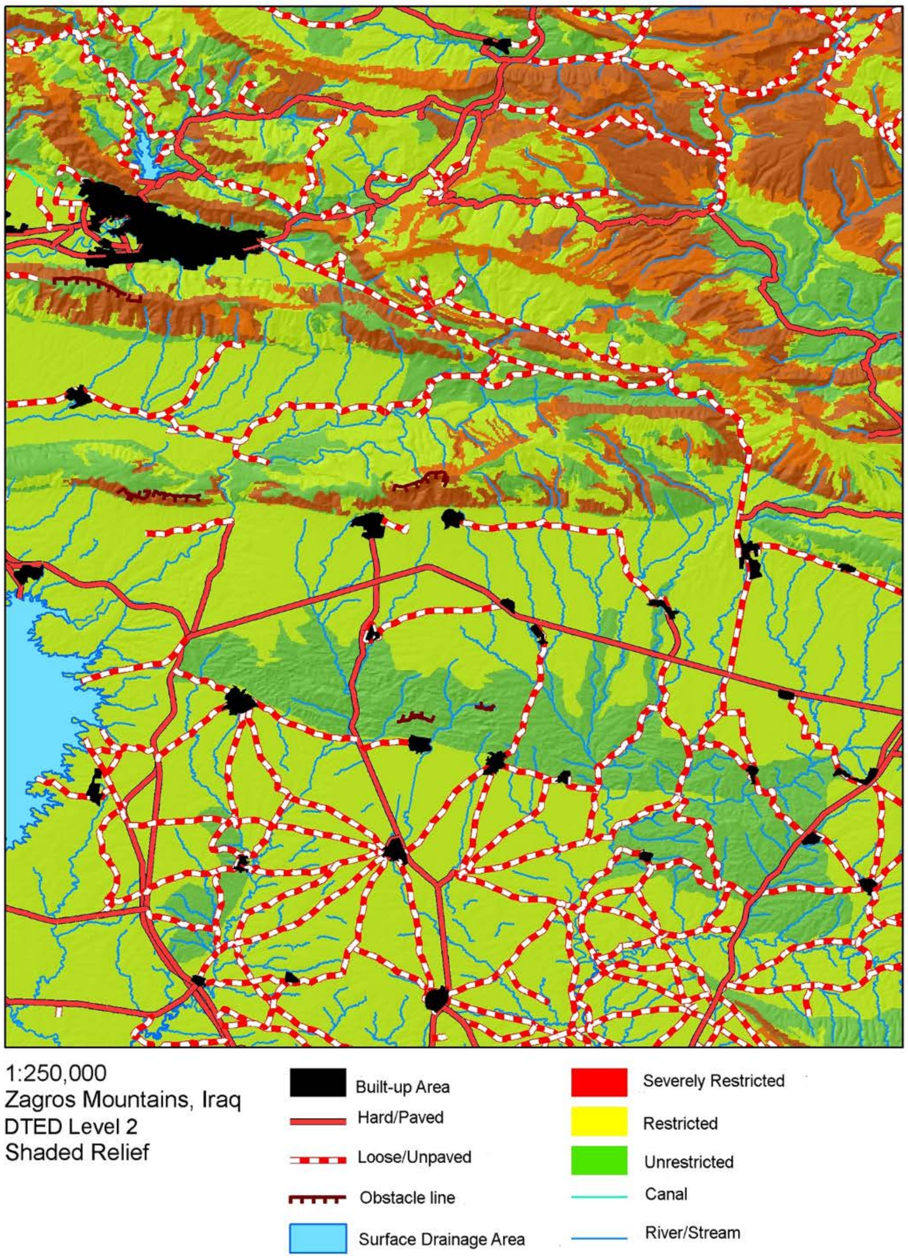
Legend:

DTED digital terrain elevation data

Figure B-4. Example of a product showing linear obstacles

COMBINED OBSTACLE OVERLAY

B-9. The combined obstacle overlay provides a basis for identifying ground avenues of approach and mobility corridors (see figure B-5). Unlike the cross-country mobility overlay, the combined obstacle overlay integrates obstacles to vehicular movement (built-up areas, slope, soils, vegetation, hydrology) into one overlay. The overlay depicts areas that impede movement (severely restricted and restricted areas) and areas where friendly and threat forces can move unimpeded (unrestricted areas).



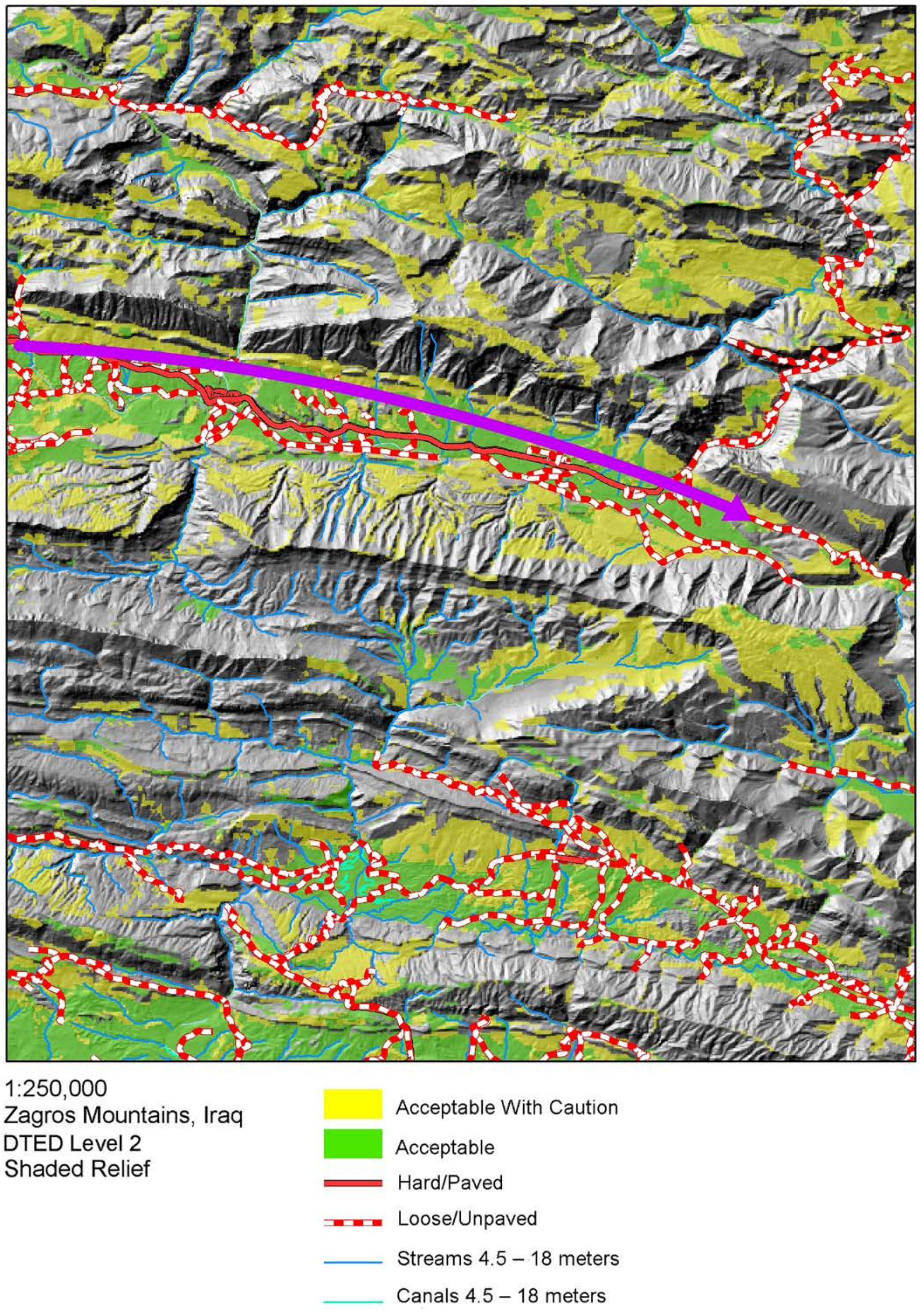
Legend:

DTED digital terrain elevation data

Figure B-5. Example of combined obstacle overlay linear obstacles

MOBILITY CORRIDORS

B-10. The mobility corridor product is a combination of cross-country mobility, transportation, and linear obstacle overlays to show mobility corridors that are based on the restrictiveness of the terrain, vehicle capabilities, and preferred movement formations (see figure B-6). This product is used to identify avenues of approach, plan the size/echelon that support movements, and develop engagement areas.



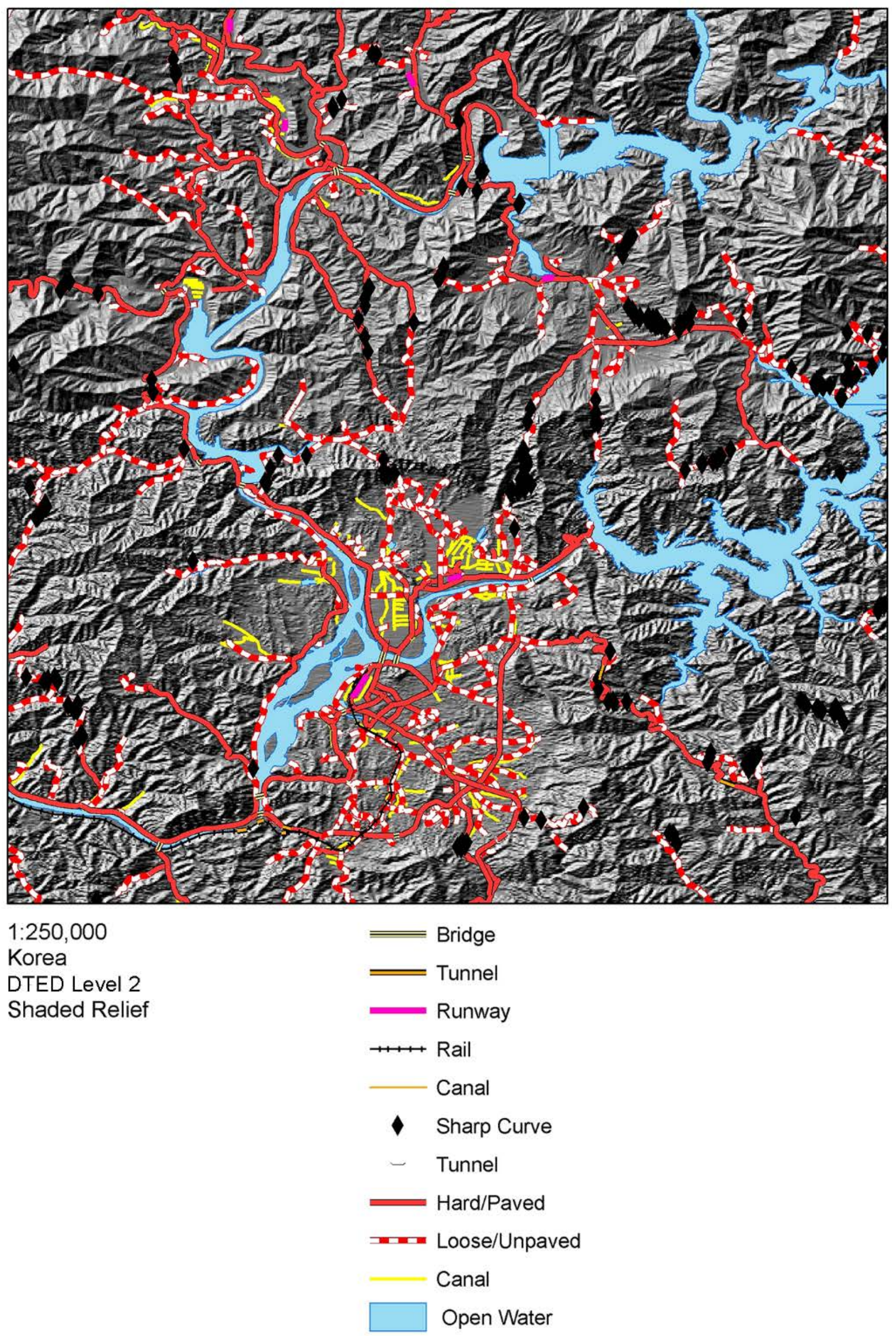
Legend:

DTED digital terrain elevation data

Figure B-6. Example of a product showing mobility corridors

Lines of Communication

B-11. The lines-of-communication overlay shows routes into an operational area, to include dual highways, all-weather hard and loose surface roads, footpaths, airfields, railroads, bridges, ferries, docks, and other man-made features that are used for transporting people, goods, and equipment. See figure B-7.



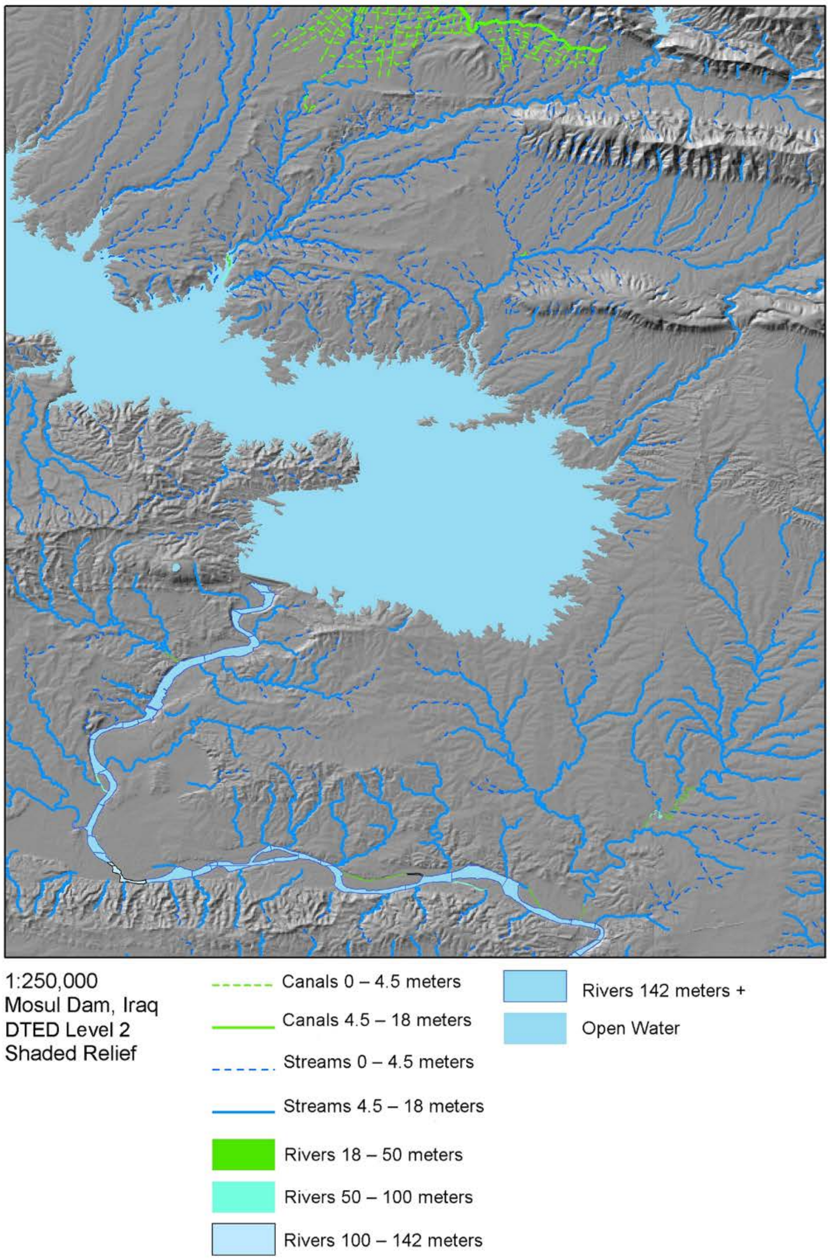
Legend:

DTED digital terrain elevation data

Figure B-7. Example of a product showing lines of communication

HYDROLOGY ANALYSIS

B-12. Hydrology overlays identify drainage features by size and location (see figure B-8). Where interim terrain data and vector interim terrain data (or other detailed vector data) exist, geospatial engineers can provide a wide variety of detail about drainage features (widths, depths, water velocity, bank heights, vegetation along banks, bottom materials). The data can also provide a flood analysis simulation of tidal fluctuations (dam collapse) over a given time period. These overlays may be used to evaluate friendly and threat COAs and highlight conditions that can impose a major operational or logistical concern.



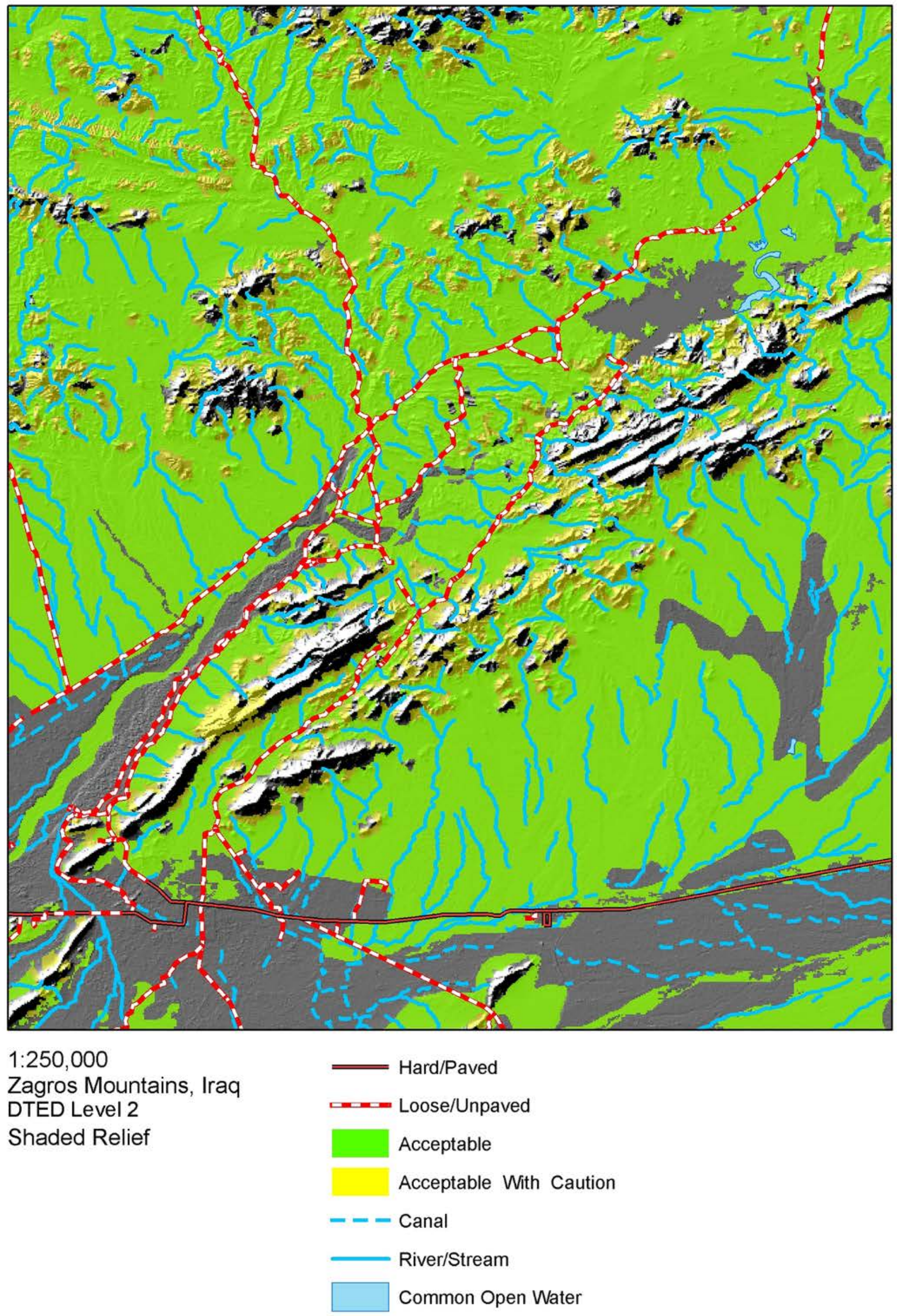
Legend:

DTED digital terrain elevation data

Figure B-8. Example of a hydrology overlay

DROP ZONES

B-13. This drop zone product helps planners quickly template possible drop zones in support of airborne operations (see figure B-9). Drop zone overlays use slope (less than 10 percent slope for personnel and less than 30 percent slope for equipment) as the limiting factor. In addition to slope, cover and concealment, accessibility (entry and exit routes), and vertical and linear obstacles must also be considered.



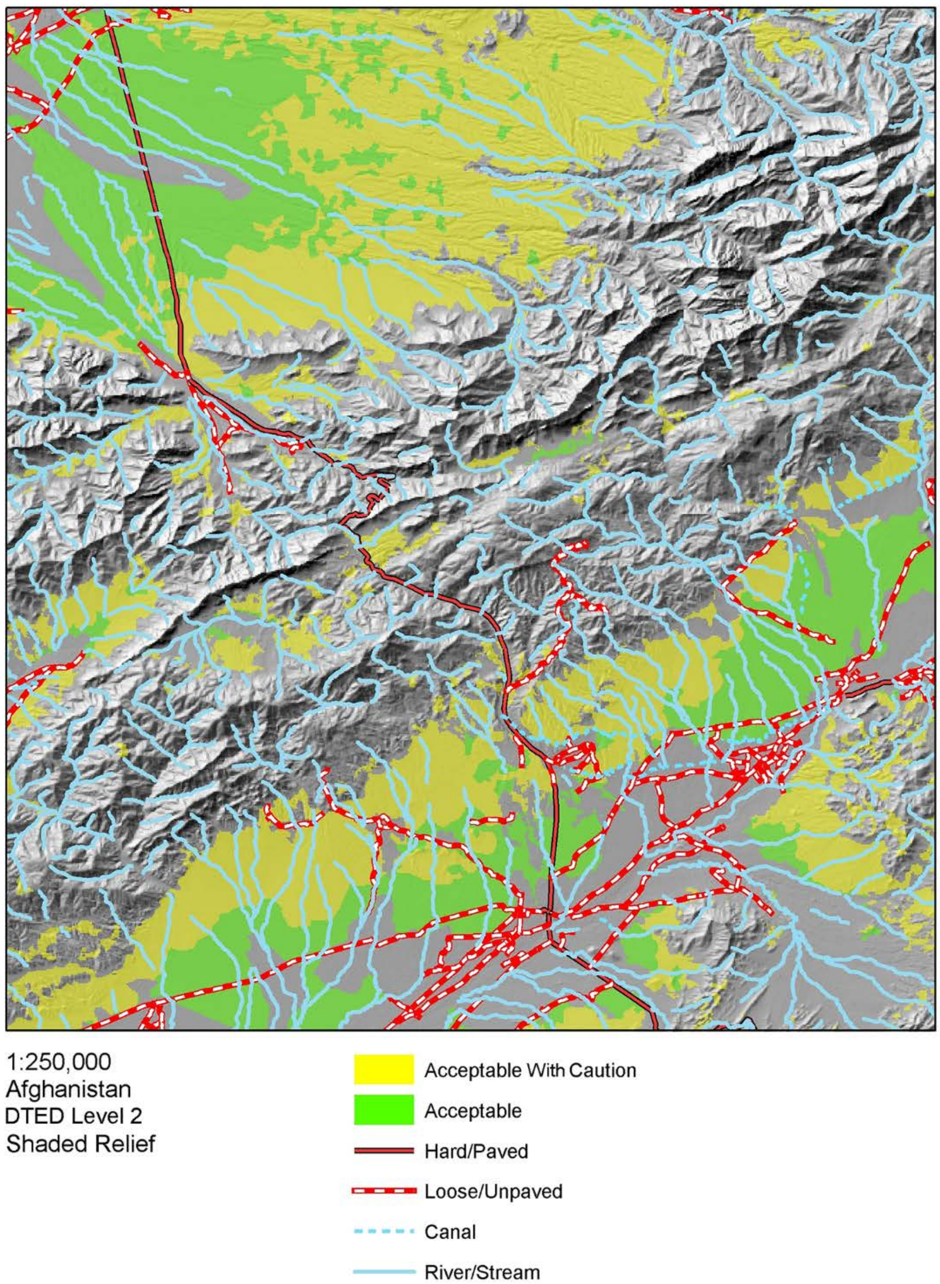
Legend:

DTED digital terrain elevation data

Figure B-9. Example of a product showing potential drop zones

HELICOPTER LANDING ZONES

B-14. The helicopter landing zone product helps planners quickly template possible landing zones in support of air assault operations. Helicopter landing zone overlays depict suitable open areas (free of vertical and linear obstacles) that have less than a 15 percent slope (see figure B-10). Soil conditions should also be evaluated to avoid areas that may contribute to brown-out conditions for pilots.



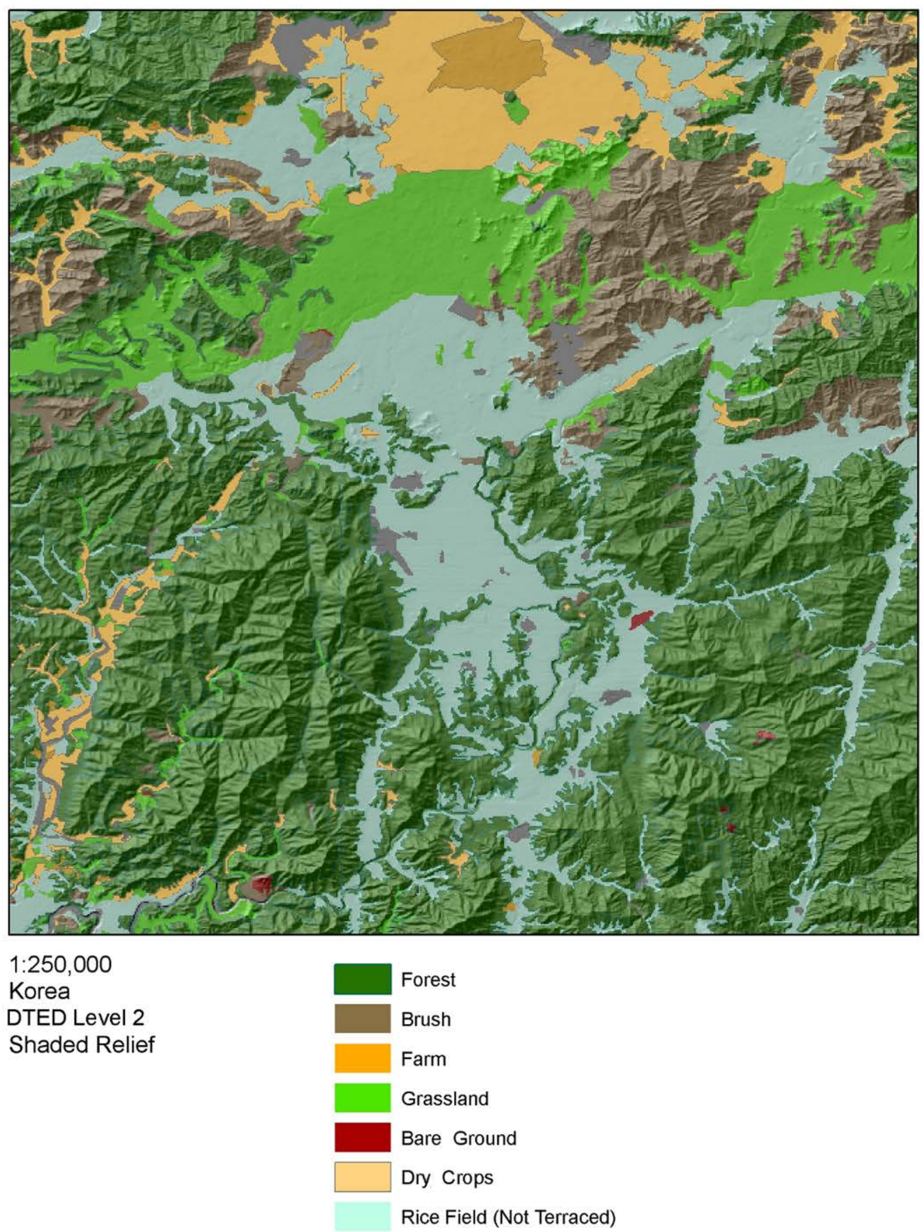
Legend:

DTED	digital terrain elevation data

Figure B-10. Example of a helicopter landing zone product

VEGETATION ANALYSIS

B-15. The vegetation analysis product shows the effects of vegetation in an operational area based on the tree types (coniferous, deciduous, or mixed), tree heights, stem diameter, stem spacing, and canopy closures (see figure B-11). It also reflects information about cultivated areas (crop types, wet or dry conditions) and whether the area is terraced or not. This product is used to create more complex products such as cross-country mobility, combined obstacle overlay, and zone of entry products. It helps planners to determine the suitability of an area based primarily on the availability of cover and concealment and restrictions to mobility.



Legend:

DTED digital terrain elevation data

Figure B-11. Example of a product showing the effects of vegetation

SOIL TRAFFICABILITY

B-16. This product shows the effects of soil on trafficability, usually based on the type of soil and its moisture content (see figure B-12). Fine-grained soil (such as silt and clay) and highly organic soils (referred to as peat) severely restrict or prohibit movement, while dry and compact soils are more trafficable.

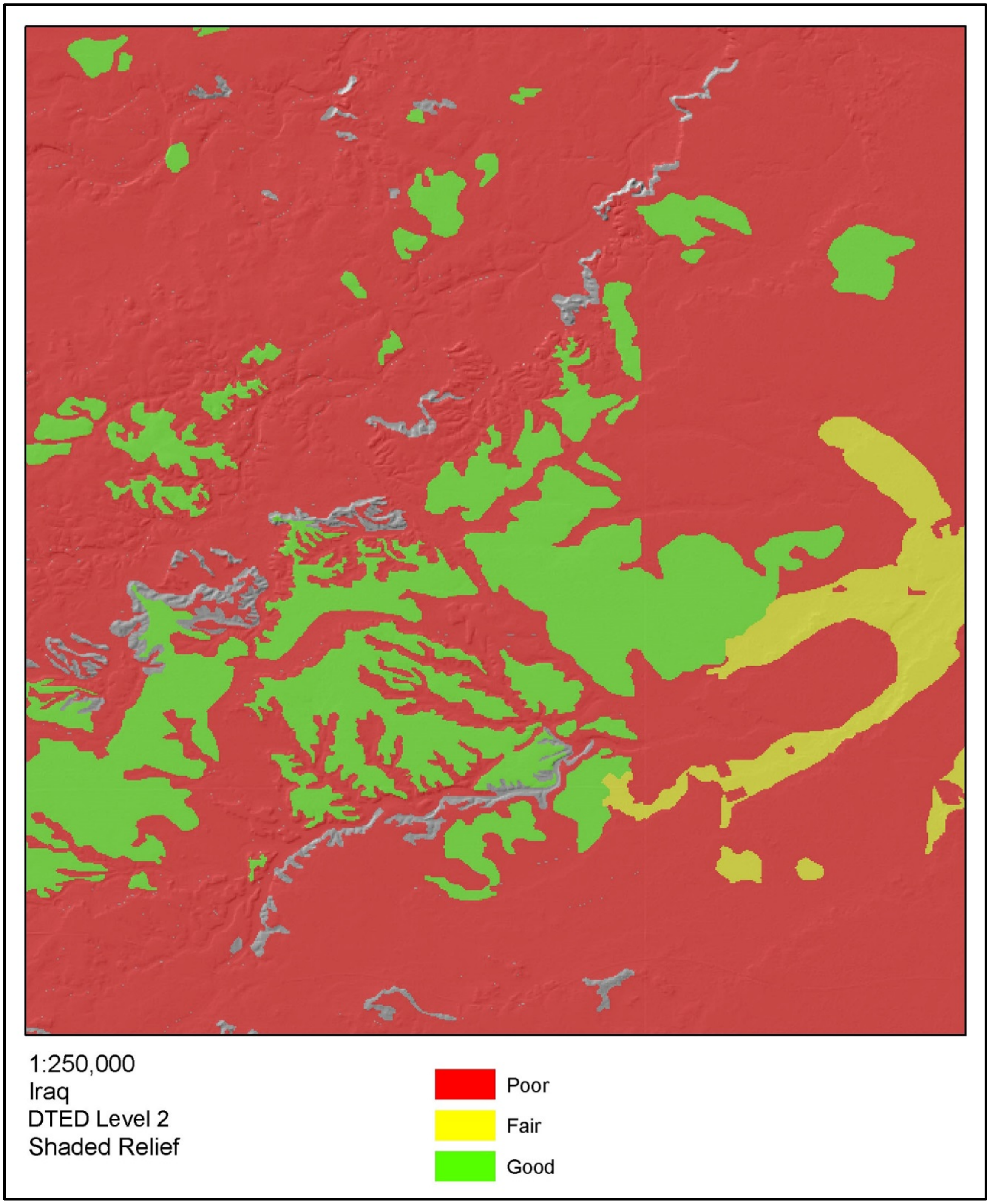
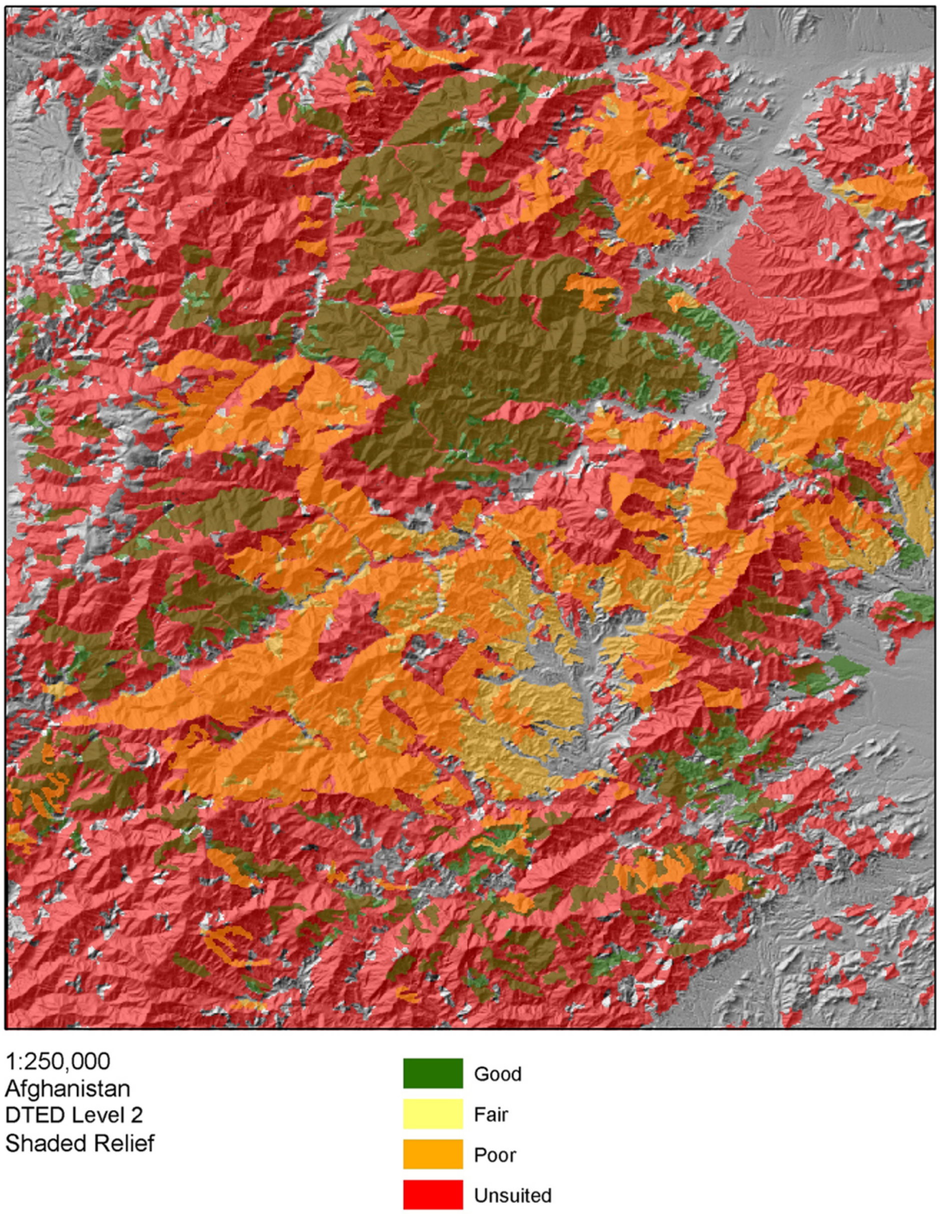


Figure B-12. Example of a product showing the effects of soil on trafficability

Field of Fire

B-17. A field-of-fire product shows the area that can be effectively covered from a specific position based on LOS and weapon capabilities (see figure B-13). This product is used to locate defensible terrain, identify potential engagement areas, and position fighting systems to allow mutually supporting fires. It can also reveal where maneuvering forces are more vulnerable to ambush.



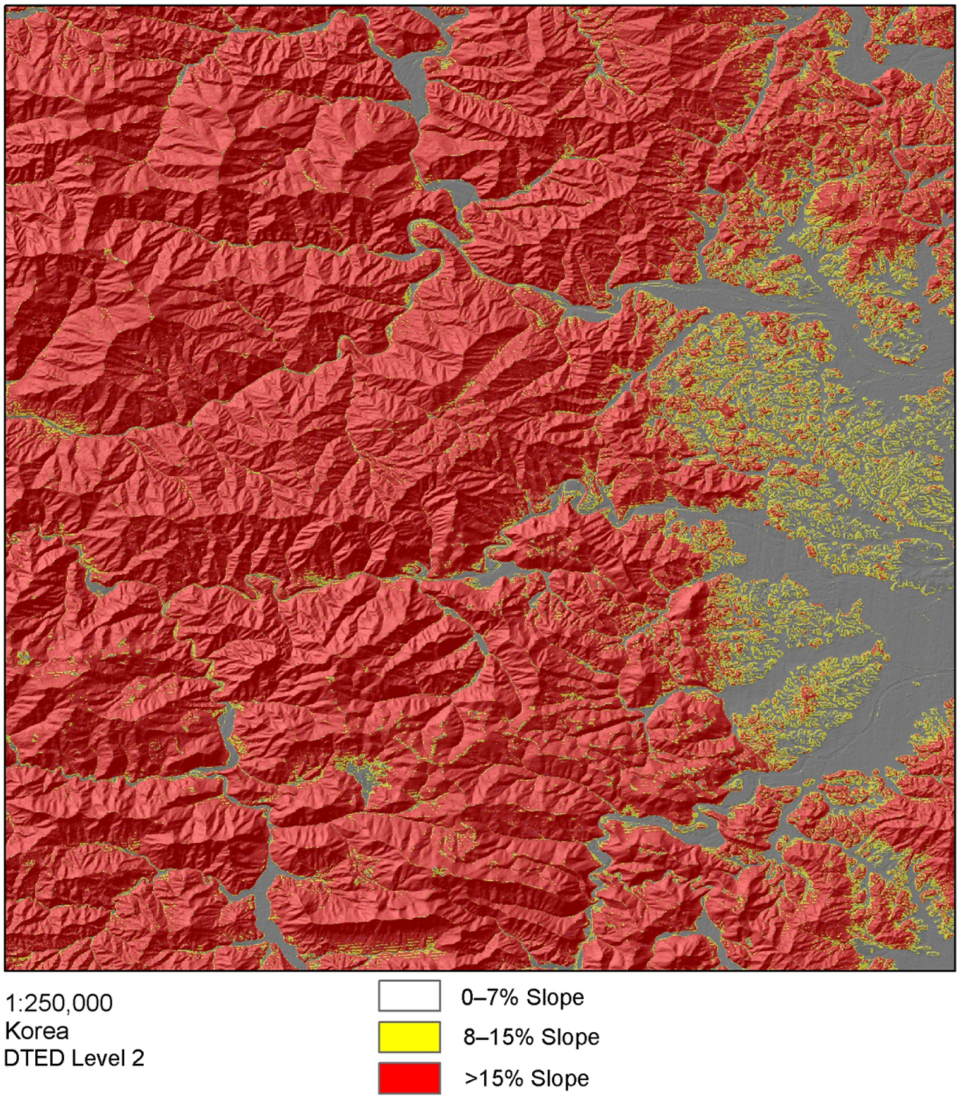
Legend:

DTED digital terrain elevation data

Figure B-13. Example of a product showing fields of fire

ARTILLERY SLOPE TINT

B-18. The artillery slope tint product depicts areas of interest for artillery assets where slope is the primary limiting factor (see figure B-14). Areas with a slope from 0 to 7 percent are considered suitable for artillery firing positions, while a slope of 8 to 12 percent is considered marginal. This product helps template threat artillery assets by narrowing the likely areas for firing positions based on slope restrictions.

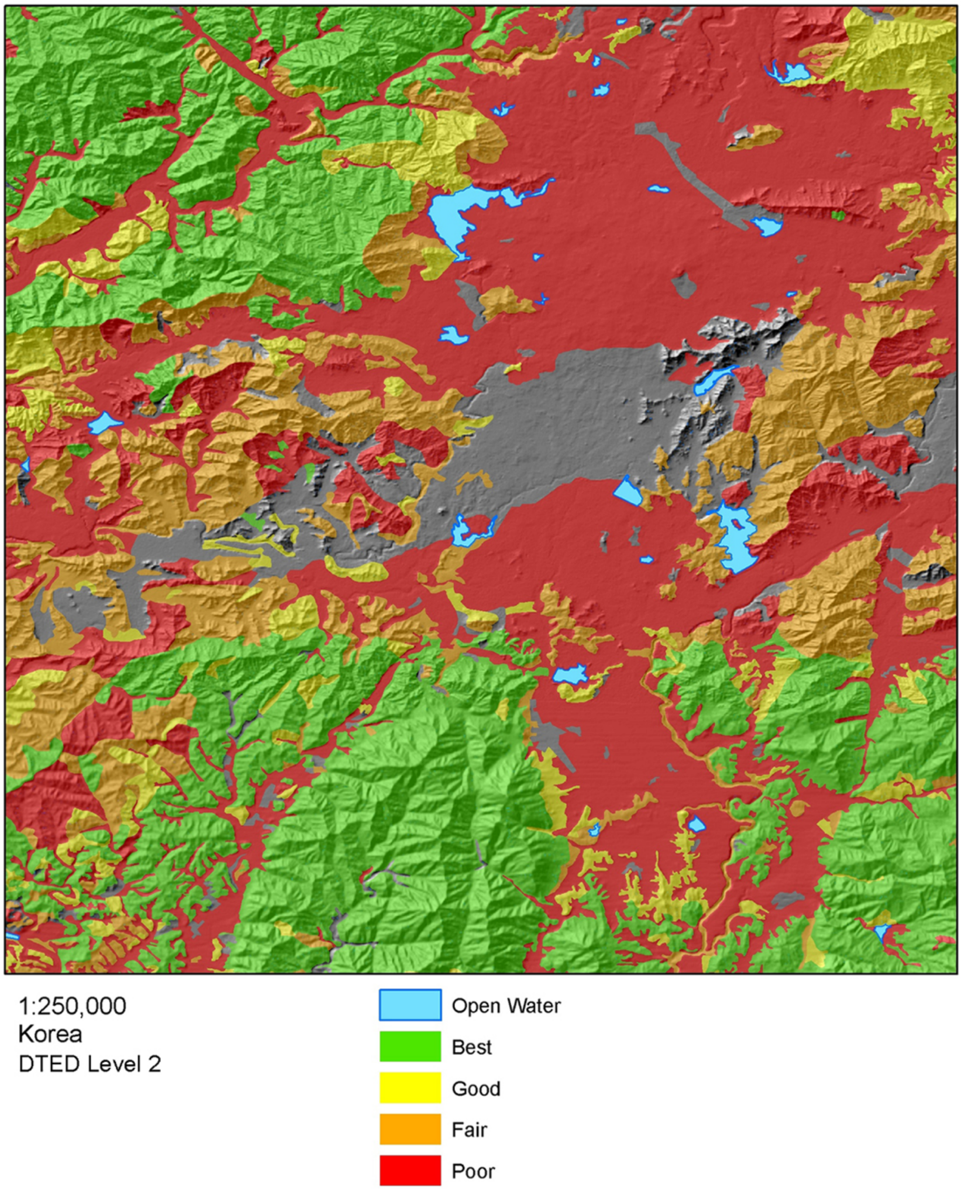


Legend:
DTED — digital terrain elevation data

Figure B-14. Example of a product showing artillery slope tint

Aerial Concealment

B-19. The aerial concealment overlay shows the most suitable areas to conceal a force from overhead detection based on the analysis of woods, underbrush, tall grass, and cultivated vegetation (see figure B-15). This product is predicated on canopy closure information within the vegetation layer. It is particularly useful in templating areas where threat forces may be operating. It can also help friendly forces identify concealed movement routes and staging areas.



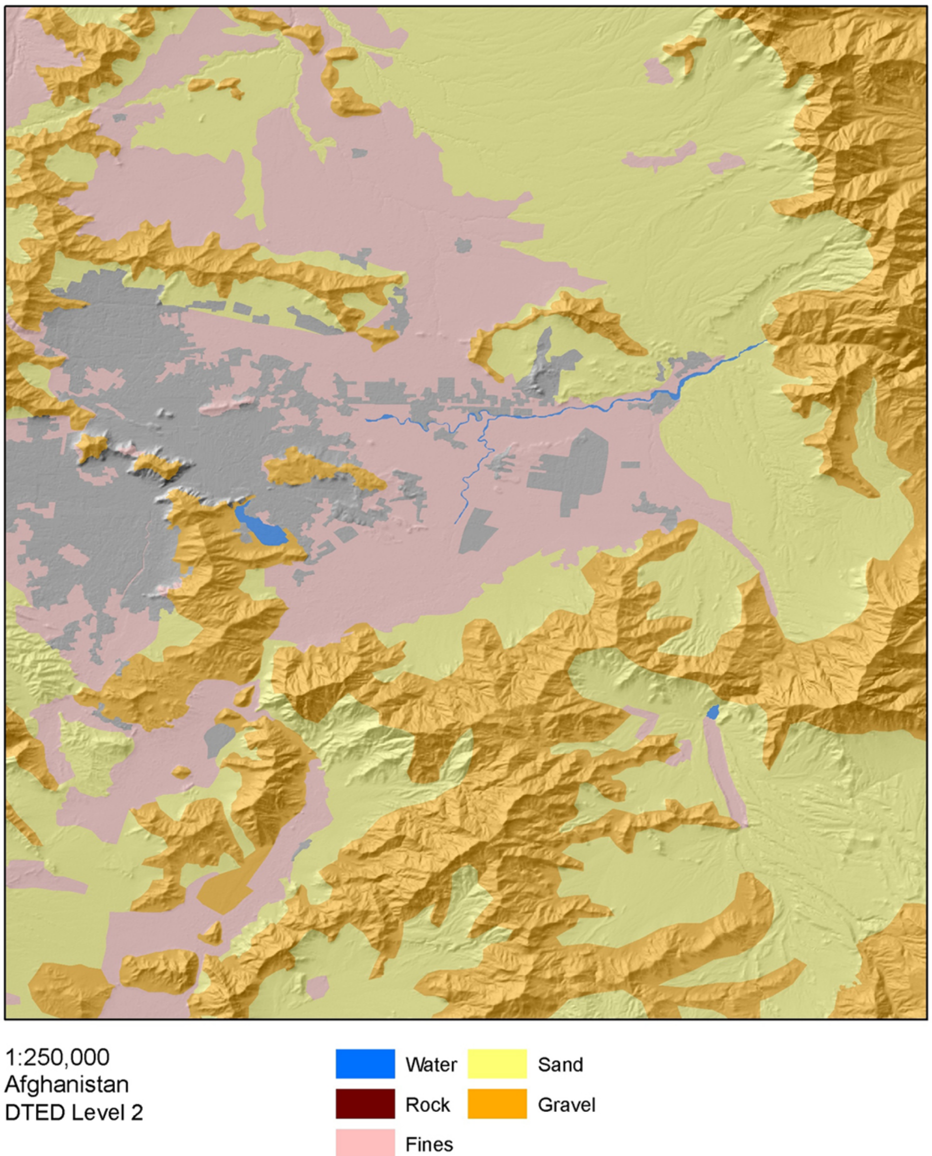
Legend:

DTED	digital terrain elevation data

Figure B-15. Example of a product showing aerial concealment

SURFACE MATERIAL

B-20. The surface material overlay shows a contrast based on the predominant type of soil that constitutes the surface area (see figure B-16). This information is useful in determining the trafficability of an area, assessing the ease of excavating fighting positions, and planning construction projects that are better suited on certain types of soil.



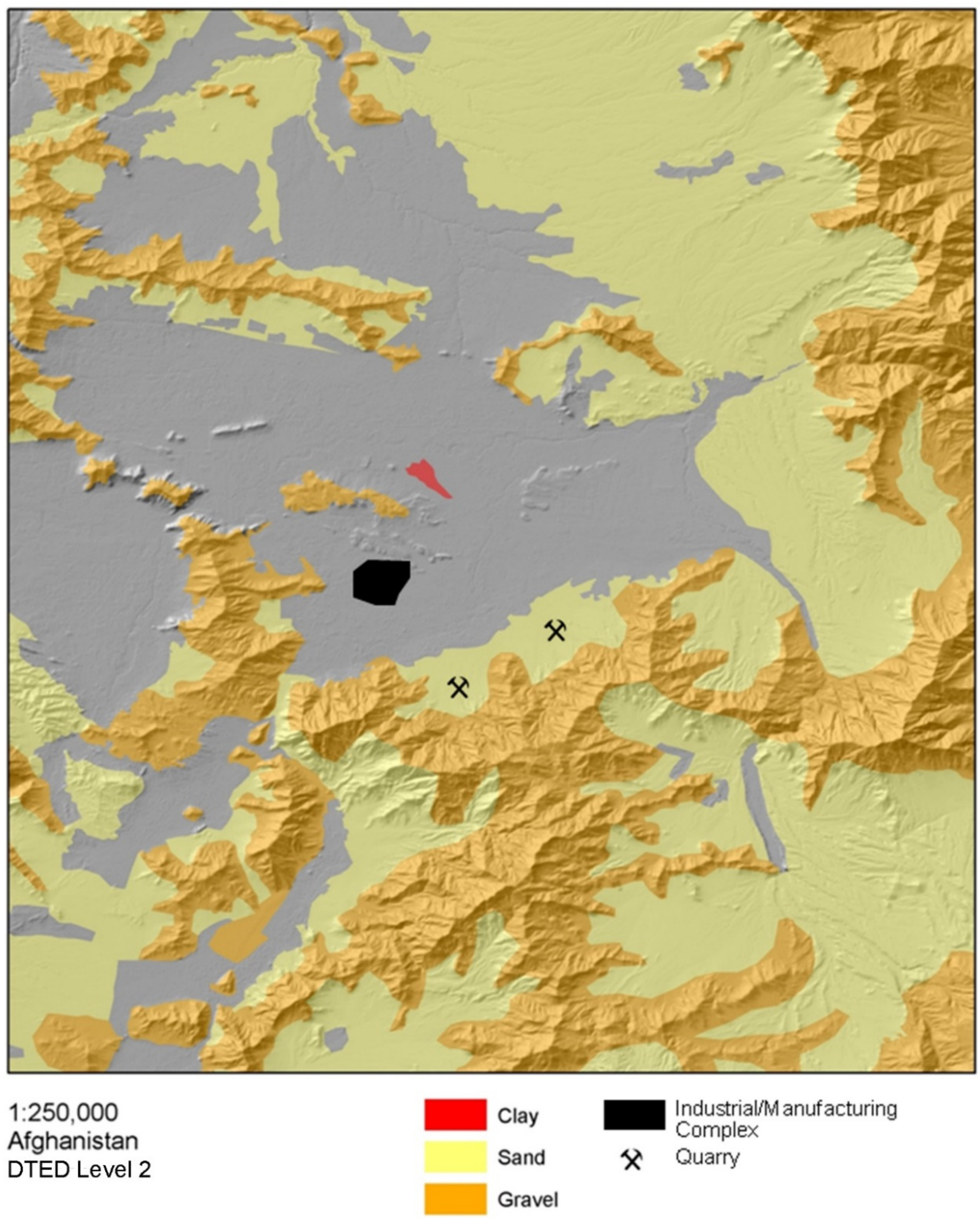
Legend:

DTED   digital terrain elevation data

Figure B-16. Example of a surface material overlay

Construction Resources

B-21. The construction resources product shows the natural resources of an area (see figure B-17). This product can help engineers plan major construction projects (roads, base camps) that are benefited by having close access to certain types of construction materials that can be made readily available through quarrying.



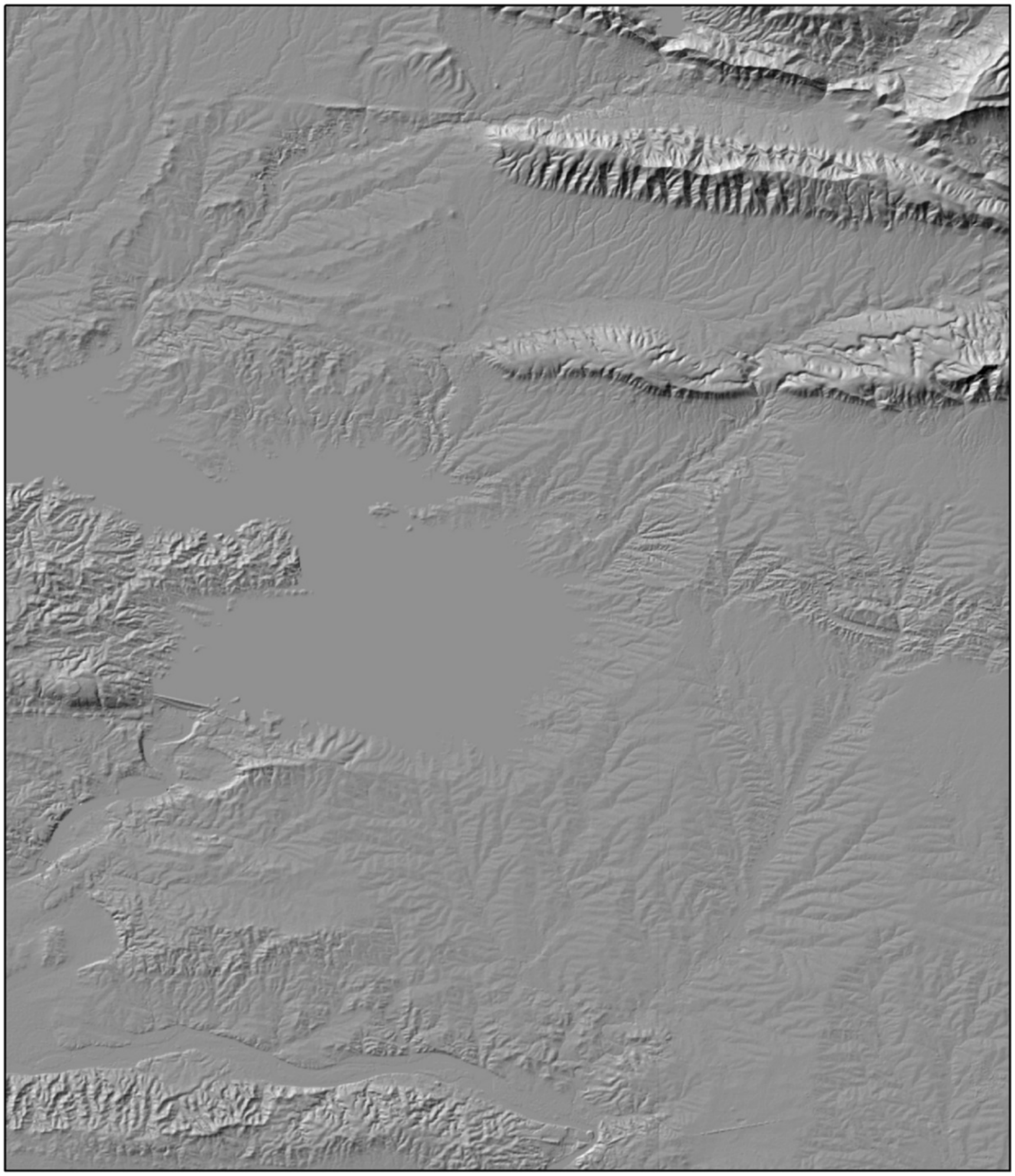
Legend:

DTED	digital terrain elevation data

Figure B-17. Example of a product showing construction resources

SHADED RELIEF

B-22. A shaded-relief image depicts relief of an area by mimicking shadows of the sun to highlight variations in elevation and slope (see figure B-18). This product can be depicted in grayscale or a single/multicolor ramp or used as the foundation for other products to enhance appearance.



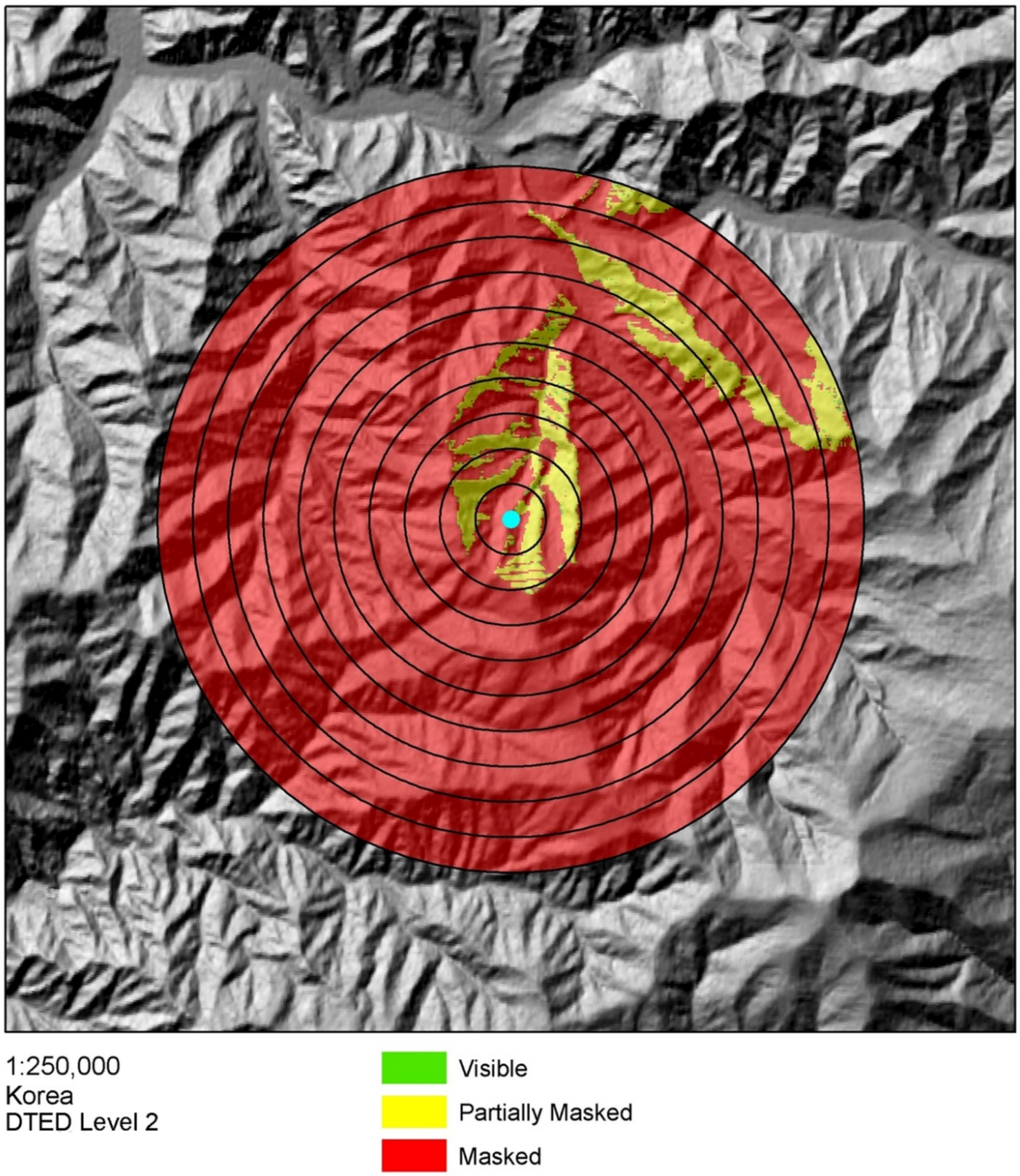
1:250,000
Mosul Dam, Iraq
DTED Level 2

Legend:
DTED digital terrain elevation data

Figure B-18. Example of a shaded-relief image

VIEWSHED ANALYSIS

B-23. A viewshed analysis, often misnamed LOS profiles, shows an area of observation that is possible from a 360° perspective based on elevation (see figure B-19). Viewshed or LOS analysis is used in templating threat positions, positioning friendly capabilities (such as LOS-based communications and observation platforms), and developing engagement areas. The accuracy of this analysis is directly proportional to the level of resolution of existing elevation data. This is not to be confused with direct observation, another form of LOS analysis, which is the visibility from one single point to another single point.



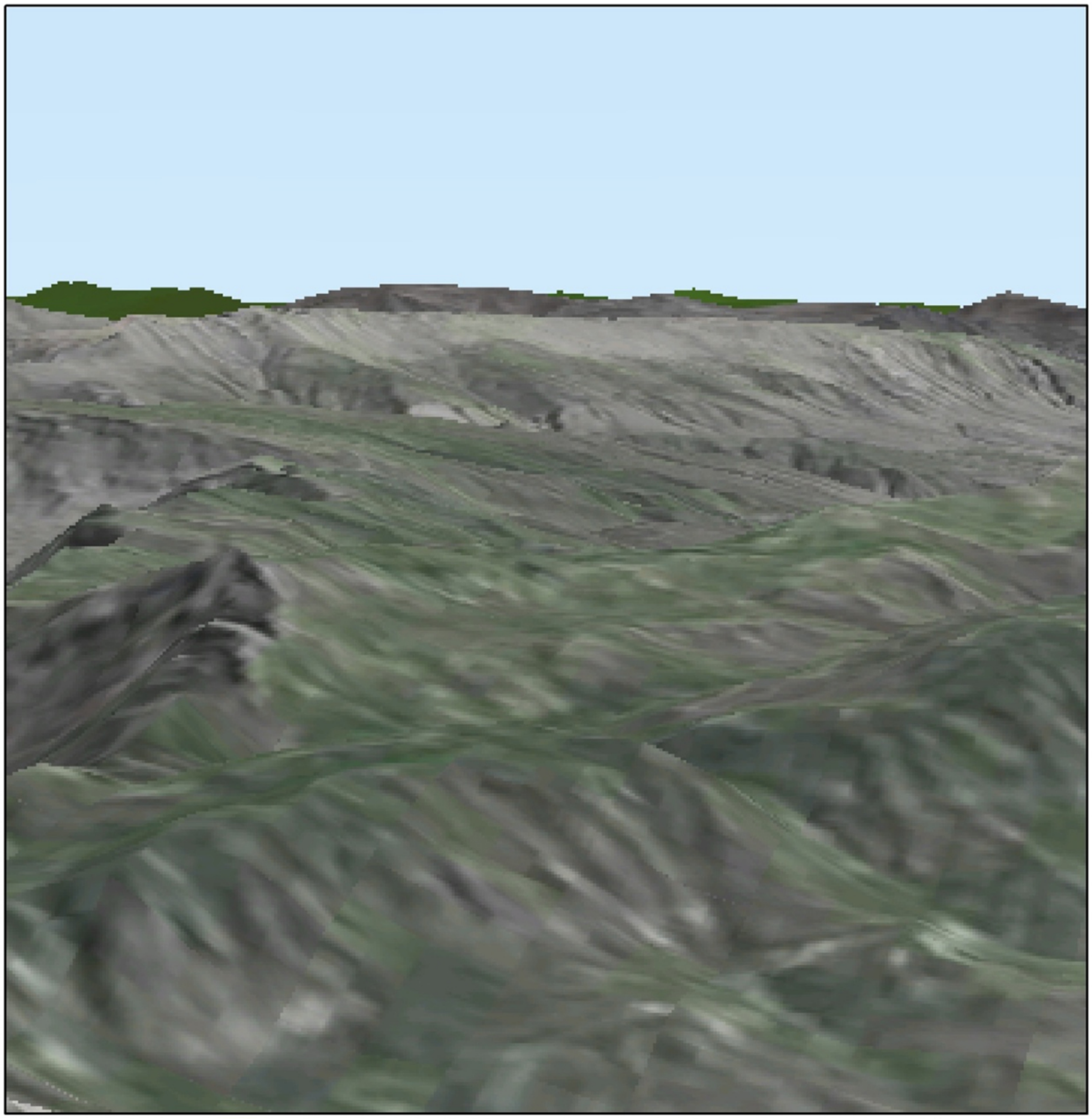
Legend:

DTED digital terrain elevation data

Figure B-19. Example of a viewshed analysis

PERSPECTIVE VIEW

B-24. The perspective view product is a 3D depiction of an area from an observer point of view that is produced by combining imagery layers with elevation data (see figure B-20). The display can include roads, rivers, operational graphics, text to enhance the terrain visualization, and anything typically displayed on a two-dimensional map.



Zagros Mountains, Iraq
DTED Level 2

Legend:
DTED digital terrain elevation data

Figure B-20. Example of a perspective view

FLY-THROUGH

B-25. The fly-through product is a computer-generated view of an area along a specified line of travel at a specified altitude and angle as viewed from inside a vehicle or by dismounted Soldiers (see figure B-21). The display can include roads, rivers, operational graphics, and text to enhance the terrain visualization.

Figure B-21. Example of a fly-through

URBAN TACTICAL PLANNER

B-26. The Urban Tactical Planner is a data set that can be viewed as two- or three-dimensional (see figure B-22). It consists of imagery, maps, elevation data, and urban vector overlays. It displays key aspects of the urban area in thematic layers that are overlain on high-resolution imagery or maps. The Urban Tactical Planner provides an overview of the urban terrain in the form of maps, imagery, elevation data, perspective views, handheld photography, video clips, and building information. The Urban Tactical Planner is produced by the AGC; however, GETs have the capability of incorporating new data and imagery into the Urban Tactical Planner, and it can be exported to CD for use by nongeospatial engineers.

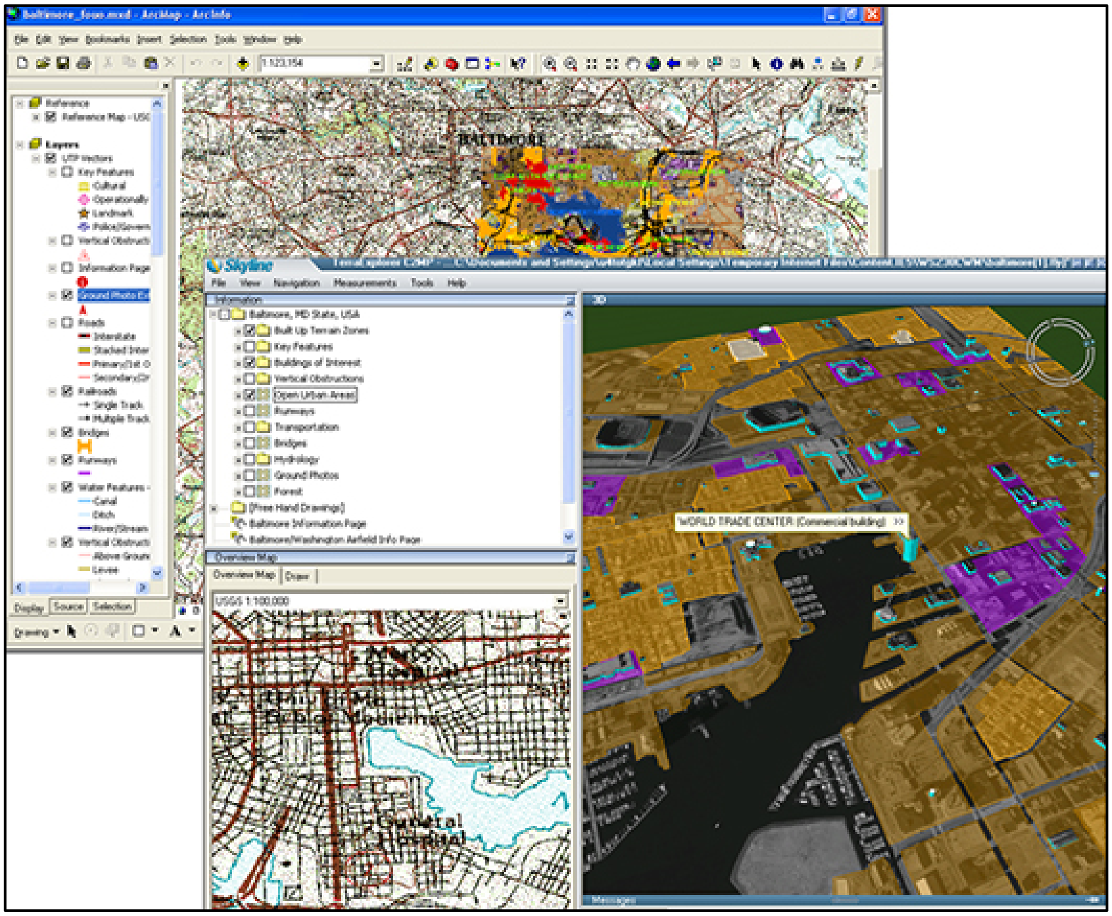


Figure B-22. Example of an Urban Tactical Planner product

BUCKEYE

B-27. The BuckEye capability uses aerial geospatial sensors to collect unclassified, geospatially accurate color imagery and high-resolution elevation data to support the ground warfighter. Light detection and ranging sensors provide 1-meter post spacing elevation data, and mapping cameras provide 5- to 10-centimeter resolution color imagery. Color imagery collected from the mapping camera undergoes radiometric balancing and is orthorectified using BuckEye elevation data to build contiguous image maps across areas of interest (see figure B-23). Under the Wide Area Mapping Initiative, this will evolve into a program of record by 2020.

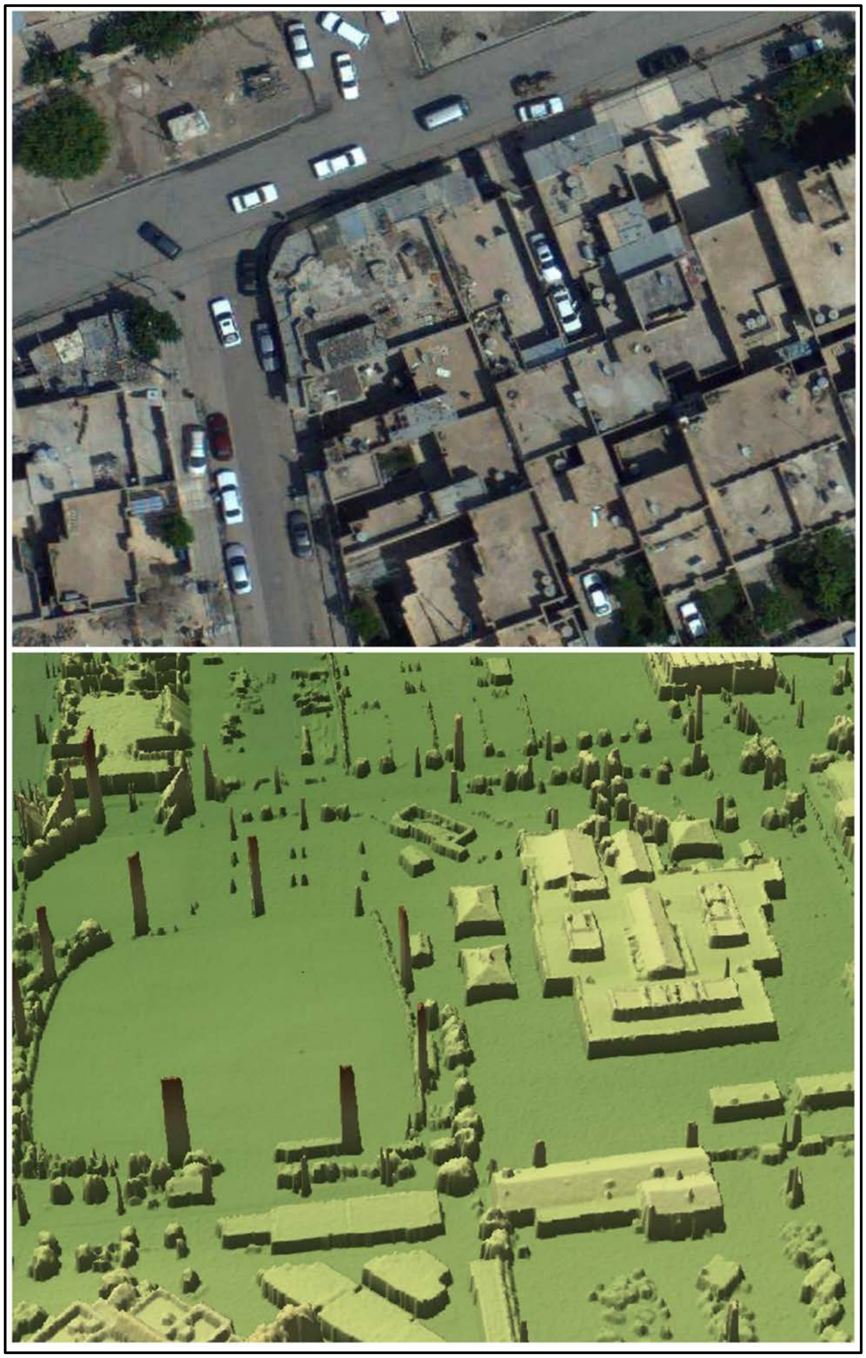


Figure B-23. BuckEye

Appendix C
Geospatial Data Management

The Army capitalizes on the information-sharing capabilities enabled by mission command systems to facilitate decision making. To be effective, mission command systems rely on access to current, accurate, and common geospatial data that resides in shared, distributed geospatial databases to form the foundation of the COP. The unique nature of geospatial data—the size and diversity—presents management challenges. Geospatial data differs from other data in that it contains structured data (location, shape, and orientation) about objects in relation to the surface of the earth—making the data extremely large and cumbersome. Geospatial data also originates from various sensors, national resources, intelligence assets, host nation resources, and reconnaissance forces in a variety of formats that increase the potential for inconsistencies. Geospatial engineers are charged with managing this data through an enterprise geospatial database that aims to allow multiple applications to simultaneously use the same geospatial data for different purposes at different echelons. This appendix discusses those requirements and provides considerations for effectively managing geospatial databases in support of unified land operations.

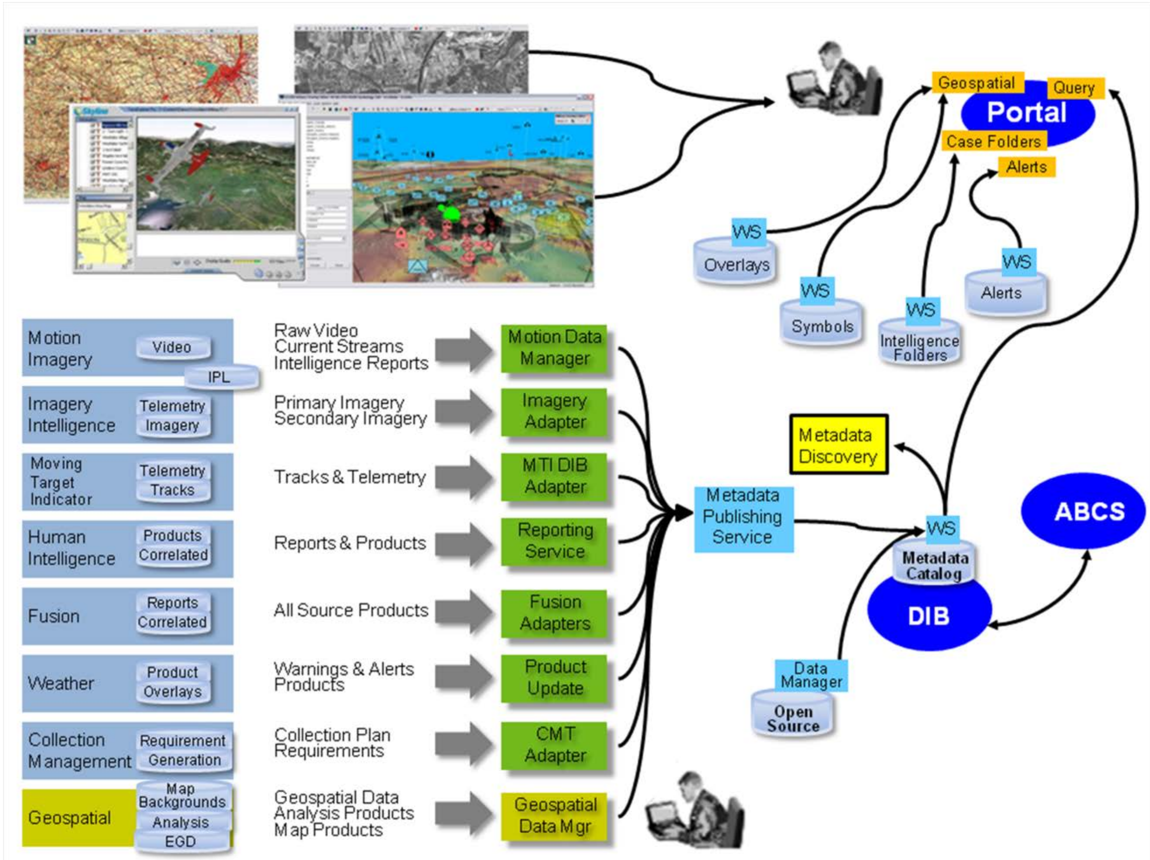
DIGITAL GEOSPATIAL DATA

C-1. Geospatial data is disseminated to the computing environment as rapidly as possible, while security is ensured and integrity is retained. Figure C-1, page C-2, shows how geospatial engineers integrate within the DCGS-A architecture based on the migration of DTSS into DCGS-A.

C-2. The two types of services (product and discovery) are enabled through metadata (data about data) that resides on a metadata catalog. This requires data or products that are posted on a server to be accompanied by appropriate metadata, which allows users to search for products or data and obtain services. Metadata allows discovery services in two ways. The first is a simple search feature that allows users to search key phrases, dates, areas of interest, names, and product and data types. The second allows geospatial engineers and other analysts to set an alert that is triggered when a product or data that meets the predefined query is posted on the network. This allows data, once posted, to find the analyst.

C-3. These product and discovery services provide the staff with faster access to geospatial products. Some of the more common geospatial products (LOS, cross-country mobility, helicopter landing zones) can be provided through Web services in which a customer accesses the Web using a thin-client approach to submit product requests. With certain situations, customers create their products by entering a few key parameters.

C-4. Orchestrating this effort begins with an understanding of the desired end state based on user requirements. This includes requirements for geospatial data storage, manipulation (the ability to process updates), and multidimensional displays. Geospatial engineers determine what data sets are being developed by national agencies and how they will be distributed to users, including the dissemination of geospatial information generated by theater level geospatial capabilities and the reverse flow of enhanced geospatial data that will update Army databases.



Legend:			
ABCS	Army Battle Command System	IPL	imagery product library
CMT	collection management	mgr	manager
DIB	distributed, integrated backbone	MTI	moving-target indicator
EGD	enterprise geospatial database	WS	workstation

Figure C-1. Geospatial data flow and fusion in Distributed Common Ground System–Army

C-5. The digital terrain data framework will be implemented in stages, varying in resolution and area coverage. The framework consists of—

- NGA data.
- TGD.
- Field-collected and -generated data.

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY DATA

C-6. The NGA provides the data that forms the foundation terrain data sets initially used by all units before deployment. Based on preexisting data prepared from national sources for dissemination to all military users, the data consists of elevation, feature, and imagery data and is typically incomplete, out of date or, in many cases, nonexistent. NGA provides the data electronically through the Nonsecure Internet Protocol Router Network, Secret Internet Protocol Router Network, and Joint Worldwide Intelligence Communications System gateways and in hardcopy through the Defense Logistics Agency and the Army supply system.

THEATER GEOSPATIAL DATABASE

C-7. NGA data forms the foundation of the TGD that each GPC manages for its assigned theater of operations. As the central authority for geospatial data in the theater, the GPC ensures the distribution of geospatial data to geospatial units at each echelon. The GPC also collects enriched data from those units; evaluates, corrects, updates, and incorporates it into the TGD; and provides updated data to the NGA for inclusion in its national geospatial databases.

FIELD-COLLECTED AND -GENERATED DATA

C-8. Field-collected and -generated data updates the geospatial databases residing at the Army level down to the BCT. The generation of enriched data relies on top-down and bottom-up feeds. While top-down feeds can result from multiple sources, bottom-up feeds primarily rely on the result of information collection activities. An information collection capability is any human or automated sensor, asset, or processing, exploitation, and dissemination system directed to collect information that enables better decision making, expands the understanding of the operational environment, and supports warfighting functions in decisive action.

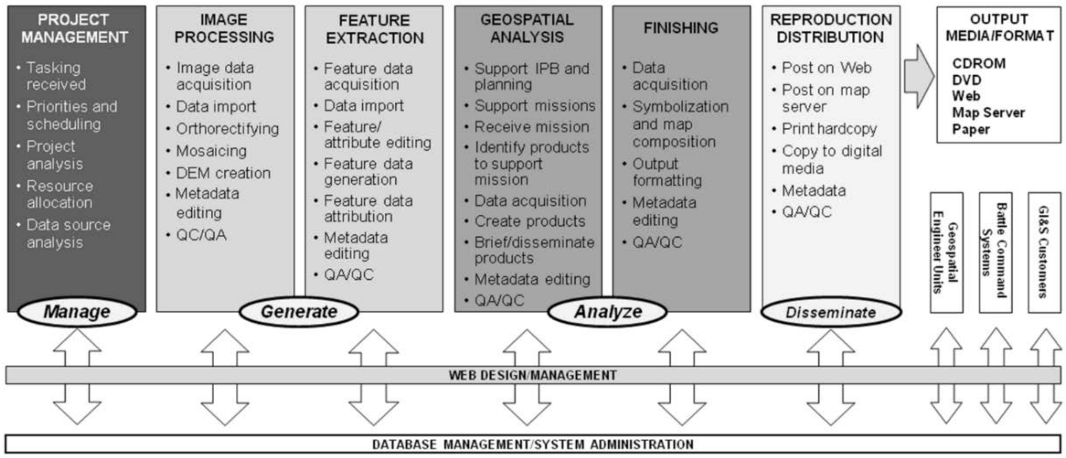
C-9. Data that is retrieved from tactical units is normally provided to the tactical operations center through digital and voice reports or imagery. Issues regarding the validity of the data are normally addressed by the senior geospatial engineer, while concerns about the quality of the data rest with the intelligence staff. After issues pertaining to data validity or quality are resolved, the database manager updates the unit master database according to the established operating procedures and passes the updated data to the GET at higher headquarters for further incorporation and dissemination to other units. The enrichment data provided by subordinate units is consolidated and organized to enable an enterprise geospatial database at that echelon. For example, reports from the BCT to the division showing individual minefields are consolidated with terrain data. The information is then presented on a combined obstacle overlay that shows a more comprehensive picture of the mobility restrictions in the division AO.

ENTERPRISE GEOSPATIAL DATABASE DEVELOPMENT

C-10. Geospatial database development and maintenance is a continuous process and a shared responsibility by geospatial engineers at each echelon down to the BCT. The data management sections in the GPCs are responsible for the development and maintenance of the TGD and help geospatial intelligence cells and GETs acquire data and build the respective databases. Figure C-2, page C-4, shows the primary functions and supporting tasks that are performed by the GPC in managing the TGD in relation to the major functions of geospatial engineering.

C-11. Most geospatial database development occurs in anticipation of future operations. In cooperation with higher headquarters, geospatial engineers monitor the status of geospatial data covering the AO. This data is normally provided to the GPC by the NGA, the AGC, and other national sources. Geospatial engineers use the available geospatial data to develop initial databases that serve as basic references for geospatial information production in support of the operational commander’s planning requirements. In preparation for deployment, geospatial engineer units acquire and load geospatial data provided by the GPC into primary and secondary servers that contain the master databases. Once deployed, the GET manages the map file server and maintains the supported unit geospatial data and terrain products. This includes the digital maps and Web map services used by the unit mission command system, which enable mission command system operators to evaluate the terrain using the embedded mapping toolkit. Deployed geospatial engineer units maintain configuration management control over the digital geospatial data.

C-12. Following deployment, field-collected and -generated data is gathered using the means available to facilitate the creation of geospatial products in support of IPB and other integrating processes. Close coordination and working interfaces with the intelligence staff ensure the acquisition of imagery data through national imagery and other intelligence data sources early in the operation.



Legend:

CDROM	compact disc read-only memory
DEM	digital elevation model
DVD	digital video disc
GI&S	geospatial intelligence and services
IPB	intelligence preparation of the battlefield
QA	quality assurance
QC	quality control

Figure C-2. Primary functions of the GPC in managing the TGD

C-13. Distributing in-theater updates and data feeds to echelons below BCT is a challenging aspect of geospatial data dissemination. This involves moving data between dispersed and possibly engaged forces and the nearest geospatial engineer element. The GET that is organic to the BCT establishes and manages the enterprise geospatial database. Updates to this initial database are disseminated through established tactical networks or removable media devices as prescribed in mission orders or standard operating procedures. These updates typically require less memory than the full enterprise geospatial database since the mission command system is normally provided with an initial load before deployment. Tactical updates and feedback resulting from operations at the lower tactical levels are submitted to higher headquarters using the method specified for disseminating products, but in reverse. The provision of tactical updates and feedback is critical in establishing the most accurate geospatial data for other users.

C-14. The geospatial engineer elements at each echelon, in cooperation with the respective S-2/G-2, work to develop and rehearse procedures for producing and disseminating geospatial information. Enabling this interoperability down to the lowest tactical level helps ensure that terrain products and analytical data are rapidly disseminated to the appropriate data users.

C-15. The engineer staff officer, S-2/G-2, S-3/G-3, geospatial engineers, and geospatial intelligence imagery analysts in the geospatial intelligence cell work during the planning phase to fulfill geospatial information requirements through information collection, RFIs, and reachback, as appropriate. The GET identifies geospatial data requirements and develops geospatial databases using the requirements cited by the operational commander and subordinate commanders, which are prioritized by the senior geospatial engineer in coordination with the S-2/G-2. These databases may also contain other information as deemed appropriate by the senior geospatial engineer.

C-16. The enterprise geospatial database requirements are established at the highest deployed echelon or the GPC to ensure database integrity. The mission command systems use a mapping toolkit and Web mapping service. Based on digital terrain data, Soldiers can evaluate the operational area or a specific AO, develop a limited set of tactical decision aids, and provide an accurate digital display of the digital terrain data.

C-17. Geospatial data is exchanged among the GPCs, geospatial intelligence cells, and geospatial engineering teams at the various echelons using communication networks. The senior geospatial engineer at each echelon is responsible for establishing and standardizing the procedures for populating the database at that echelon. Newly generated or obtained geospatial data is checked, validated, and cataloged using uniform naming conventions to facilitate the use of the database. This provides other users with efficient access to the geospatial database residing on the unit servers.

C-18. When operating in a multinational environment, the geospatial engineer team must work closely with the engineer staff officer and S-2/G-2 to develop procedures for disseminating geospatial information updates to those mission partners without access to digital systems to ensure data integrity throughout the command.

C-19. A database management system controls the organization, storage, and retrieval of data. The database management system embedded in the DTSS and DCGS-A helps the geospatial engineer manage geospatial data. The database management system automatically correlates data from various sources, enabling the analyst to manipulate the data to create and disseminate new or updated geospatial products. The database management system also facilitates the exchange or addition of new categories of data (digital maps, overlays) without major disruptions to ongoing work.

C-20. The GPC is a critical node in the overall geospatial enterprise architecture. Each GPC is responsible for data generation and quality control of data in its operational area. This provides a single point of responsibility, increases the confidence level of geospatial data within a theater, and prevents the duplication of effort that can result in multiple, conflicting data sets. The desired end state is to have every GPC TGD mirrored at a central location (such as the AGC) for Army-wide access and to have that data accepted and included in the NGA national database.

C-21. GPCs must coordinate with each other and develop coproduction agreements to reduce the duplication of effort and facilitate the management of geospatial data generation and collection activities in their respective operational areas. Each GPC usually maintains only data that is required for its operational area; a TGD does not need to mirror every other TGD. In special situations where a GPC may need to access data residing in another GPC operational area, it can subscribe to updates based on metadata. If a GPC enters into a coproduction agreement with another TGD, the validation and acceptance of data belongs with the TGD responsible for that theater.

C-22. The GPC may be augmented with NGA geospatial analysts, cartographic analysts, and data stewards to enhance its ability to manage the TGD and ensure the quality of data generated by the GPC and subordinates in meeting national mapping accuracy standards for subsequent inclusion and redistribution in the NGA national and regional databases.

C-23. The geospatial data within an area must be cross-referenced to ensure accuracy and to ensure that the geospatial data provides the same terrain information through varying levels of scale. Geospatial engineers compare scales and metadata associated with the data to identify inconsistencies and modify the appropriate levels as needed. Any changes to verified NGA data (vector map, feature foundation data) are reported to NGA and to the other GPCs to ensure database consistency.

C-24. TGD features are stored in a geospatial database and organized by the four levels of resolution or scales (see figure C-3, page C-6). The following four levels can be utilized by any echelon of command:

- **Global level.** Generally equivalent to the 1:1,000,000 scale and has features that are associated with standard NGA maps at this scale (such as NGA vector map Level 0).
- **Regional level.** Generally equivalent to the 1:250,000–1:500,000 scale. Newly extracted data must adhere to NGA cartographic standards at this map scale (such as an NGA vector map Level 1, feature foundation data, and planning interim terrain data).
- **Local level.** Generally equivalent to the 1:50,000 scale, but can range from the 1:100,000 scale (such as NGA vector map Level 2, vector interim terrain data, and interim terrain data).
- **Specialized level.** Any special products that are 1:10,000 or larger (such as an NGA urban vector map or AGC Urban Tactical Planning data).

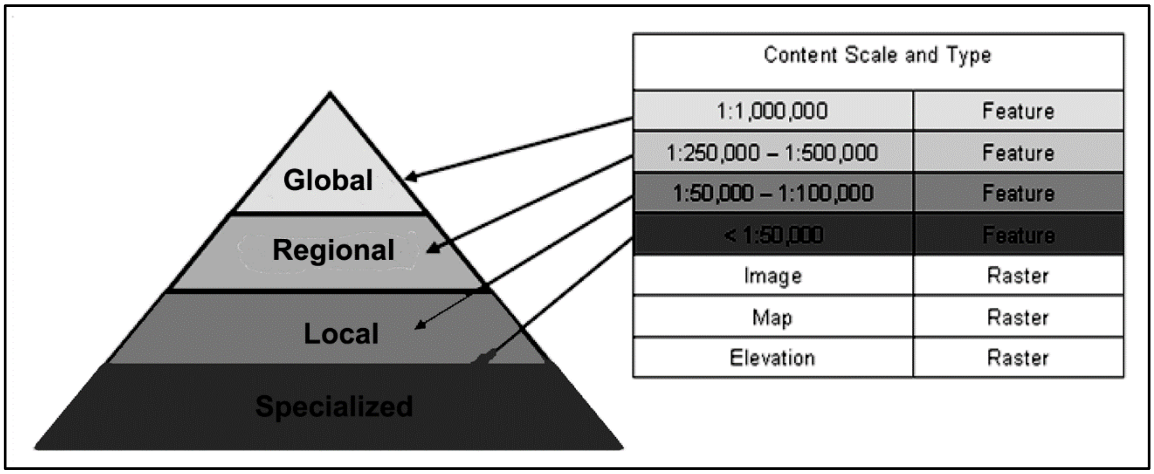


Figure C-3. TGD data model

Appendix D
Terrain Characteristics

Terrain analysis is conducted to study the natural and man-made features in an area and evaluate the effects on military operations. This appendix describes the six characteristics of terrain (hydrology, surface configuration, soil composition, vegetation, obstacles, and man-made features) that geospatial engineers address during terrain analysis. These characteristics serve as the framework for describing the terrain in an operational area or a specific AO.

HYDROLOGY

D-1. Water is an essential commodity and is always an important factor in planning. It is necessary for drinking, sanitation, food preparation, construction, and decontamination. Support activities (helicopter maintenance, operation of medical facilities) consume large volumes of water. When untreated or stagnant, water can present health hazards. Drainage features (streams, rivers) can affect mobility and shape COAs. Engineers play an important role in providing water to Army forces and are responsible for finding subsurface water; drilling wells; and constructing, repairing, or maintaining water facilities. Geospatial engineers generate, manage, and analyze hydrologic data and work with ground survey teams and well-drilling teams to locate water sources. Geospatial engineers also produce geospatial information to help commanders and staffs understand the effects of surface drainage on operations.

WATER SOURCES

D-2. Water availability and consumption requirements vary based on the climate and topography of a region and the type and scope of operations. Through terrain analysis, geospatial engineers can help planners determine probable sources of water that can exist on and below the surface.

Surface Water

D-3. Surface water is commonly selected for use in the field because it is the most accessible; however, it tends to be more contaminated than groundwater. Surface water resources are generally more accessible and adequate in plains and plateaus than in mountains. Large amounts of good-quality water can normally be obtained in coastal areas, valleys, or alluvial and glacial plains. Although large quantities are available in delta plains, the water may be brackish or salty. Water supplies are scarce on lacustrine, loess, volcanic, and karst plains. Large springs are the best sources of water in karst plains and plateaus. In the plains of arid regions, water usually cannot be obtained in quantities required by modern armies; and when it is, it is usually highly mineralized. In the plains and plateaus of humid, tropical regions, surface water is abundant but is generally polluted and requires treatment. Perennial surface water supplies are difficult to obtain in arctic regions; in summer they are abundant, but often polluted.

Groundwater

D-4. Groundwater is usually less contaminated than surface water and, therefore, is typically a more desirable water source. In arid environments, exploring and using groundwater can reduce the need to transport water to desired locations. Groundwater is easily obtained from unconsolidated or poorly consolidated materials in alluvial valleys and plains, streams and coastal terraces, glacial outwash plains, and alluvial basins in mountainous regions. Areas of sedimentary and permeable igneous rocks may have fair to excellent aquifers, although they usually do not provide as much groundwater as areas composed of unconsolidated materials. Large amounts of good-quality groundwater may be obtained at shallow depths from the alluvial plains of valleys and coasts and at greater depths in the terrace. Aquifers underlying the surface of inland sedimentary plains and basins also provide adequate amounts of water. Abundant quantities of good-quality water generally can be obtained from shallow to deep wells in glacial plains. In loess plains and plateaus, small amounts of water may be secured from shallow wells but these supplies fluctuate seasonally. Plains and plateaus in arid climates generally yield small, highly mineralized quantities of groundwater. In semiarid climates, following a severe drought, dry streambeds frequently can yield considerable amounts of excellent subsurface water. Groundwater is abundant in the plains of humid, tropical regions, but it is typically polluted. In arctic and subarctic plains, wells and springs fed by groundwater above the permafrost are dependable only in summer; some of the sources freeze in winter, and subterranean channels and outlets may shift in location.

D-5. Wells may yield large quantities of water if they tap into underground streams. Wells that penetrate aquifers within or below the permafrost are good sources of perennial supplies. Adequate supplies of groundwater are hard to obtain in hills and mountains composed of gneiss, granite, and granite-like rocks. They may contain springs and shallow wells that generally yield water in small amounts. Shallow wells in low-lying lava plains normally produce large quantities of groundwater. In lava uplands, water is more difficult to find, wells are harder to develop, and careful prospecting is necessary to obtain adequate supplies. In wells near the seacoast, the excessive withdrawal of freshwater may lower the water table, allowing the infiltration of saltwater that ruins the well and the surrounding aquifer. Springs and wells near the base of volcanic cones may yield fair quantities of water; but elsewhere in volcanic cones, the groundwater is too far below the surface for drilling to be practicable. See NTRP 4-04.2.13/TM 3-34.49/AFMAN 32-1072 for additional information on the ability of rocks and soils to hold and transmit water. See DODD 4705.1E for surface, ground, and existing water facility information.

D-6. Vegetation is a good indicator of groundwater sources. Deciduous trees tend to have far-reaching root systems, indicating that a water table is close to the ground surface, while coniferous trees tend to have deep root systems, indicating that the water table is farther away from the ground surface. Palm trees indicate water within 2 or 3 feet, salt grass indicates water within 6 feet, and cottonwood and willow trees indicate water within 10 to 12 feet. The common sage, greasewood, and cactus do not indicate water levels. Other indicators of potential groundwater include—

- Crop irrigation.
- Karst topography.
- Snowmelt patterns.
- Wetlands.
- Springs.
- Soil moisture.
- Surface water.
- Wells and qanats.
- Urban areas.

SURFACE DRAINAGE

D-7. Surface drainage can significantly impact military operations. It can impede cross-country mobility, restrict movement to roads, and render land areas that are prone to flooding unsuitable for positioning forces or capabilities. Planners must first analyze the flow and channeling characteristics of surface water, which vary based on geographic location and seasonal weather patterns. Drainage features can be perennial (containing water most of the year), intermittent (containing water part of the year), or dry or cyclical (rarely containing water, such as wadis). Planners can then determine the effects of surface water on operations based on the capabilities of personnel, vehicles, and equipment. Geospatial engineers enable this analysis by acquiring or generating surface drainage data that includes such things as width and depth of streams and canals and the velocity and discharge of streams. They also obtain or produce information on dams, levees, and other drainage features and can create geospatial products that show the catastrophic effects if they fail.

D-8. In the absence of geologic maps and data, drainage patterns can be studied to determine rock types and to better understand the area structure and composition. The most common drainage patterns are shown in figure D-1.

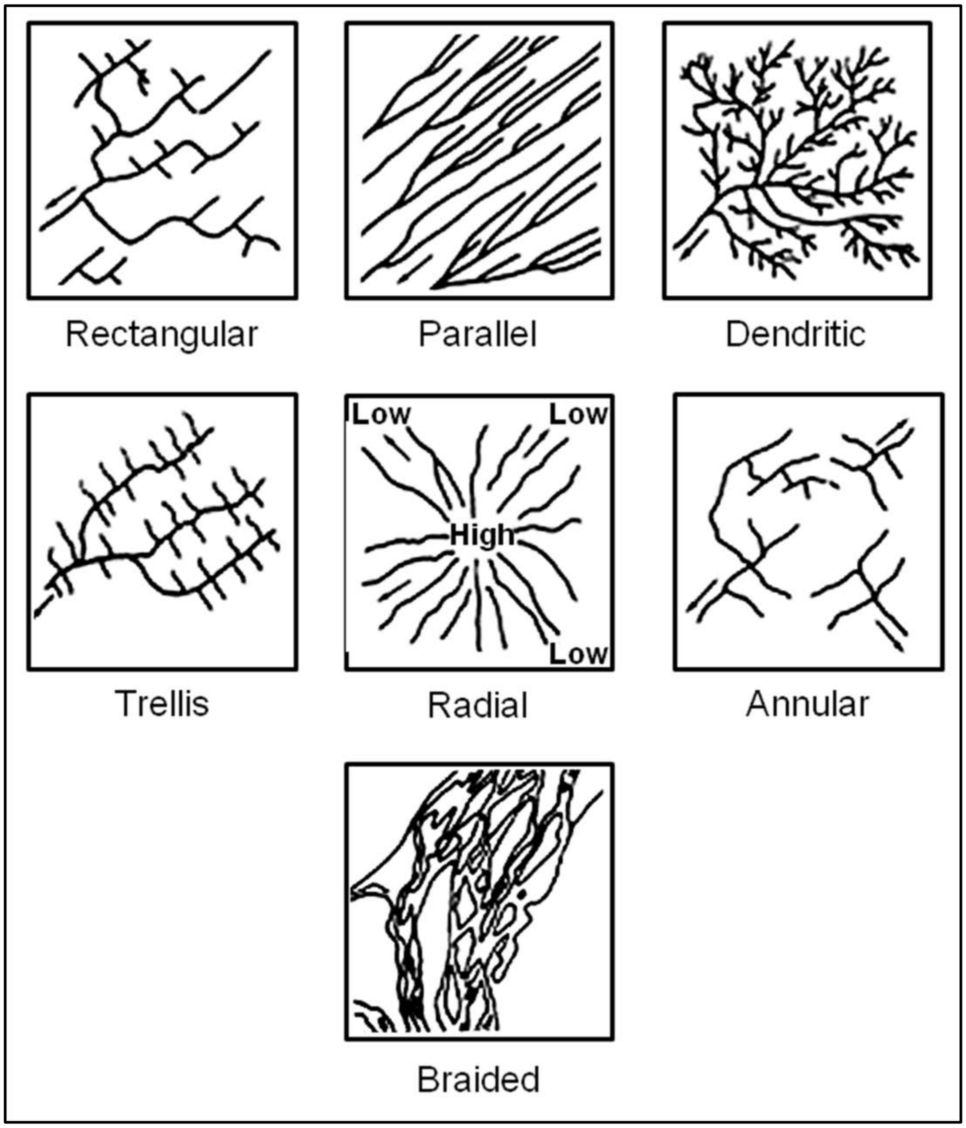


Figure D-1. Common drainage patterns

Rectangular

D-9. The rectangular drainage pattern, characterized by abrupt bends in streams, develops where a treelike drainage pattern prevails over a broad region and is generally associated with massive igneous rock. Metamorphic rock surfaces, particularly those composed of schist and slate, commonly have rectangular drainage. Slate possesses a particularly fine-textured system. The drainage pattern is extremely angular and has easily recognizable short gullies that are locally parallel.

Parallel

D-10. In the parallel pattern, major streams flow side by side in the direction of the regional slope. Parallel streams are indicative of gently dipping beds or uniformly sloping topography. The greater the slope, the more nearly parallel the drainage and the straighter the flow. Local areas of lava flows often have parallel drainage, even though the regional pattern may be radial. Alluvial fans may also exhibit parallel drainage, but the pattern may be locally influenced by faults or jointing. Because of the slope toward the sea, coastal plains develop parallel drainage overboard regions.

Dendritic

D-11. The dendritic drainage pattern is a treelike pattern composed of branching tributaries to a main stream, characteristic of essentially flat-lying and homogeneous rocks. This pattern implies that the area was originally flat and is composed of relatively uniform materials. Dendritic drainage is also typical of glacial till, tidal marshes, and localized areas in sandy coastal plains. The difference in texture or density of a dendritic pattern may help identify surface materials and organic areas.

Trellis

D-12. In a trellis pattern, the main stream runs parallel and small streams flow and join at right angles. This pattern is found in areas where sedimentary or metamorphic rocks have been folded.

Radial

D-13. In a radial pattern, streams flow outward from a high central area. This pattern is found on domes, volcanic cones, and round hills. However, the sides of a dome or volcano might have a radial drainage system while the pattern inside a volcanic cone might be centripetal, converging toward the center of the depression.

Annular

D-14. The annular pattern is a modified form of the radial drainage system and is found where sedimentary rocks are upturned by a dome structure. In this pattern, streams circle around a high central area. The granitic dome drainage channels may follow a circular path around the base of the dome when it is surrounded by tilted beds.

Braided

D-15. A braided stream pattern commonly forms in arid areas during flash flooding. The stream attempts to carry more material than it is capable of handling. Much of the gravel and sand is deposited as bars and islands in the stream bed.

SURFACE CONFIGURATION

D-16. Surface configuration refers to the physical shape of the terrain and includes—

- Elevation.
- Depressions.
- Slope.
- Landform type.
- Surface roughness.

D-17. The elevation of a point on the surface of the earth is the vertical distance it is above or below mean sea level. Relief is the representation of the shapes of hills, valleys, streams, or terrain features on the surface of the earth. Local relief is the difference in elevation between points in a given area. The elevations or irregularities of a land surface are represented on graphics by contours, hypsometric tints, shading, spot elevations, and hachures.

D-18. The rate of rise or fall of a terrain feature is known as its slope. Slope affects the speed at which equipment or personnel can move. Slope can be categorized as gentle, steep, concave, or convex and can be expressed as the slope ratio or gradient, the angle of slope, or the percent of slope (see TC 3-25.26). The slope ratio is a fraction in which the vertical distance (rise) is the numerator and the horizontal distance (run) is the denominator. The angle of slope in degrees is the angular difference that the inclined surface makes with the horizontal plane. The tangent of the slope angle is determined by dividing the vertical distance by the horizontal distance between the highest and lowest elevations of the inclined surface. The actual angle is found by using trigonometric tables. The percent of slope is the number of meters of elevation per 100 meters of horizontal distance. Slope information that is available to the analyst in degrees or in ratio values may be converted to the percent of slope by using a nomogram.

D-19. Landforms are the physical expression of the land surface and are generally categorized into the following groups:

- Plains.
- Plateaus.
- Hills.
- Mountains.

D-20. Within each of these groups are surface features of a smaller size (flat lowlands, valleys). Each type results from the interaction of earth processes in a region with given climate and rock conditions. A complete study of a landform includes a determination of its size, shape, arrangement, surface configuration, and relationship to the surrounding area.

D-21. Subsurface configuration is the physical shape of terrain that is beneath the surface of the earth or body of water and not exposed at ground level. Most common are underground structures that can be natural or man-made. Geospatial engineering can assist in the mapping of possible underground facilities (tunnels, bunkers, sewer, water, and gas networks). See ATP 3-34.81 for additional information on the detection of subsurface structures.

SOIL COMPOSITION

D-22. Planners rely heavily on the results of soil analysis since variations in soil composition (soil type, drainage characteristics, and moisture content) can affect trafficability, road and airfield construction, and the ease of digging fighting positions in a specific area. Generating soil data normally requires extensive field sampling and the expertise of soil analysts. Once the data is acquired, geospatial engineers use it in combination with standard geospatial products and imagery to create tailored geospatial products that enable the staff to further its own analysis of the operational area or specific AO and to facilitate planning. The effectiveness of these products is directly related to the quality of available soil data. See TM 3-34.64 for additional information.

D-23. For field identification and classification, soil is grouped into the following five major types:

- Gravel.
- Sand.
- Silt.
- Clay.
- Organic matter.

D-24. These soil types seldom exist separately. They are usually found in mixtures of various proportions, which contributes to their unique characteristics. Some soils may gain strength under traffic (compaction), while others lose it.

GRAVEL

D-25. Gravel consists of angular to rounded, bulky rock particles ranging in size from about 0.6 to 7.6 centimeters (1/4 to 3 inches) in diameter. It is classified as coarse or fine; well or poorly graded; and angular, flat, or rounded. Next to solid bedrock, well-graded and compacted gravel is the most stable natural foundation material. Weather has little or no effect on its trafficability. It offers excellent traction for tracked vehicles; however, if not mixed with other soil, the loose particles may roll under pressure, hampering the movement of wheeled vehicles.

SAND

D-26. Sand consists of angular or rounded rock grains that are 0.6 centimeter (1/4 inch) in diameter and smaller. Sand is classified as coarse, medium, or fine. Well-graded, angular sand is desirable for concrete aggregate and foundation material. It is easy to drain and ordinarily not affected by frost action or moisture. Analysts must be careful in distinguishing fine sand from silt. When sand is wet enough to become compacted or when it is mixed with clay, it provides excellent trafficability. Very dry, loose sand is an obstacle to vehicles, especially on slopes. Under wet conditions, remoldable sands react to traffic, as do fine-grained soils.

SILT

D-27. Silt consists of soil- or rock-derived granular material with a grain size between sand and clay. It lacks plasticity and possesses little or no cohesion when dry. Because of its instability, water causes silt to become soft or to change to a quick condition (a hydraulic uplift phenomenon where water quickly saturates the material and reduces its cohesiveness and strength). When dry, silt provides excellent trafficability, although it is very dusty. However, it absorbs water quickly and turns to a deep, soft mud (a quick condition) that impedes movement. When groundwater or seepage is present, silt exposed to frost action is subject to ice accumulation and consequent heaving.

CLAY

D-28. Clay generally consists of microscopic particles. Its plasticity and adhesiveness are excellent characteristics. Depending on mineral composition and the proportion of coarse grains, clays vary from lean (low plasticity) to fat (high plasticity). Many clays that are brittle or stiff in their undisturbed state become soft and plastic when worked. When thoroughly dry, clay provides a hard surface with excellent trafficability; however, it is seldom dry except in arid climates. It absorbs water very slowly, but takes a long time to dry and is very sticky and slippery. Slopes with a clay surface are difficult to maneuver or are impassable, and deep ruts form rapidly on level ground. A combination of silt and clay makes a particularly poor surface when wet.

ORGANIC MATTER

D-29. Chemically deposited and organic sediments are classified on the basis of mode and source of sedimentation. Chemically deposited sediment affects how soil is characterized. Some soils (such as silt and sand) may have been chemically altered to bond the organic matter together to create a dust-free layer on top of the normal soil composition. The identification of highly organic soil is relatively easy. It contains partially decayed grass, twigs, and leaves and has a characteristic dark brown to black color, a spongy feel, and a fibrous texture.

SOIL CLASSIFICATION

D-30. Geospatial engineers use the two-letter abbreviations established in the Unified Soil Classification System to describe soil. The primary letters identify the predominant soil fraction:

- G—gravel.
- S—sand.
- C—clay (used only with fine-grained soil with 50 percent fines or greater).
- M—silt.
- O—organic.

D-31. The secondary letters further describe the characteristics of the predominant soil fraction. The percent of gravel, sand, and fines provides the information necessary to choose the primary letter. The secondary letters are—

- W—well-graded (used to describe sands containing less than 12 percent fines).
- P—poorly graded.

- M—silty fines (used with sands and gravels containing less than 5 percent but more than or equal to 50 percent fines).
- C—clay-based fines.
- L—low compressibility (used to describe fine-grained soils [silts, clays, organics]).
- H—high compressibility.

VEGETATION

D-32. Geospatial engineers generate and analyze vegetation data and create geospatial products to show the effects of vegetation on vehicular and foot movements, landing zones, drop zones, observation, and cover and concealment.

D-33. The types of vegetation in an area can give an indication of the climatic conditions, soil, drainage, and water supply. Geospatial engineers focus terrain analysis on trees, scrubs, shrubs, grasses, and crops.

D-34. Trees can provide good cover and concealment and can also impede movement and maneuver. Large trees are usually spaced far enough apart to allow the passage of vehicles, but this gap is often filled with smaller trees or brush that must be considered. Small trees are usually spaced closer together and do not offer a gap for vehicles; however, depending on diameter, the trees can be pushed over by large tracked vehicles. Trees that have been pushed over tend to pile up and can block follow-on vehicles.

D-35. Trees are classified as deciduous (broadleaf) or coniferous (evergreen). With the exception of species growing in tropical areas and a few species existing in temperate climates, most broadleaf trees lose their leaves in the fall and become dormant until early spring. Coniferous trees do not normally lose their leaves, or needles, and exhibit only small seasonal changes. Woodlands or forests are classified according to the dominant type of tree in them. A forest is classified as deciduous or coniferous if it contains at least 60 percent of the designated species. Wooded areas that contain less than a 60-percent mixture of either species are classified as mixed forests. Shrubs include a variety of trees whose growth has been stunted due to soil or climatic conditions. Shrubs comprise the undergrowth in open forests, but are the dominant vegetation in arid and semiarid areas. Shrubs are normally not considered an obstacle to movement and provide good concealment from ground observation; however, they may restrict fields of fire. For the purposes of terrain analysis, grass exceeding 1 meter in height is considered tall and may provide concealment for dismounted troops. Grass can improve the trafficability of soils.

D-36. Field crops represent the predominant class of cultivated vegetation. The size of cultivated areas ranges from a paddy field covering a quarter of an acre to vast wheat fields extending for thousands of acres. In a concentrated agricultural area where all arable land is used for the crop producing the highest yield, predictions on the nature of the soil can be made based on information about the predominant crop. For example, rice requires fine-textured soils, while other crops generally depend on firm, well-drained land. An area containing orchards or plantations usually consists of rows of evenly spaced trees, showing evidence of planned planting, which can be distinguished in aerial imagery. These areas are usually free of underbrush and vines. Rice fields are flooded areas surrounded by low dikes or walls. Some crops (such as grain) improve the trafficability of soils, while others (such as vineyards) present a tangled maze of poles and wires and create obstacles to vehicles and dismounted troops. Wheeled and some tracked vehicles are unable to cross flooded paddy fields, although the fields may be negotiated when they are drained and dry or frozen. Sown crops (wheat, barley, oats, rye) are grown on a flat surface and have a different impact on movement and concealment than crops planted in furrows.

OBSTACLES

D-37. Obstacles refer to any physical characteristics of the terrain that impede the mobility of a force. All obstacles are existing or reinforcing. Existing obstacles are inherent aspects of the terrain and can be natural, man-made, or a combination of both. Examples of natural obstacles include rivers, forests, and steep slopes. Examples of man-made obstacles include buildings and structures. Reinforcing obstacles are obstacles specifically constructed, emplaced, or detonated by military forces and are categorized as tactical or protective. See ATP 3-90.8 for additional information on reinforcing obstacles.

D-38. Obstacles can have varying degrees of impact on different types of movement, such as ground (mounted or dismounted) or air movement, or on different types of vehicles (wheeled or tracked). Obstacles to air mobility include mountains; power lines; and tall buildings that exceed an aircraft service ceiling, restrict nap-of-the-earth flight, or force an aircraft to employ a particular flight profile. The obstacle analysis performed by geospatial engineers provides the foundation for further staff analysis of the effects of obstacles and the assessment of the operational impacts based on areas of expertise. As discussed in chapter 1, geospatial engineers describe the terrain to the staff using geospatial products (such as the combined obstacle overlay) that facilitate further staff analysis of the operational environment.

MAN-MADE FEATURES

D-39. Man-made features generally exist in, near, and between urban areas. The level of detail in describing man-made features depends on the mission and the level of planning. In support of urban operations at the lower tactical levels, geospatial engineers provide a greater degree of emphasis on the 3D nature of the topography (supersurface, surface, and subsurface areas). Advancements in automated geospatial applications, such as the Urban Tactical Planner developed by the AGC, provide more detailed geospatial information and better visualization of the urban environment. See FM 3-06 for additional information on analyzing an urban environment.

D-40. Man-made features can be grouped into broad, functional categories to help organize the results of analysis and describe the terrain. These functional areas include the following:

- Industrial areas.
- Transportation areas.
- Commercial and recreational areas.
- Residential areas.
- Communication areas.
- Governmental and institutional areas.
- Military areas.

INDUSTRIAL

D-41. Industrial areas and facilities are used in the extraction, processing, and production of intermediate and finished products or raw materials. Examples include factories, warehouses, power plants, and oil refineries. Manufacturing plants are categorized as heavy or medium to light. Heavy plants contain distinctive structures (such as blast furnaces), while medium and light plants are usually housed in loft buildings from which machinery can be removed. Industrial areas often develop on the outskirts of urban areas where commercial transportation is easiest. These areas may provide ideal locations for sustainment bases and maintenance sites.

TRANSPORTATION

D-42. Transportation areas and facilities are used in moving materiel and people. Geospatial engineers evaluate transportation features (networks and facilities) to determine the effects on likely operations. This includes highways, railways, and waterways over which troops or supplies can be moved.

Roads

D-43. ATP 3-34.81 provides additional information on road classification, road characteristics, and limiting factors considered during route reconnaissance. Road characteristics (see figure D-2) include—

- Minimum traveled-way width.
- Road surface material.
- Obstructions.
  - Bridges and culverts.
  - Overpasses.
  - Cuts and fills.

- Restrictions.
  - Grades.
  - Curves.
  - Load-bearing capacity.

D-44. Roads are categorized within the following (see table D-1):

- All-weather, dual or divided highway.
- All-weather, hard surface.
- All-weather, loose surface.
- Fair-weather, loose surface.
- Car track.

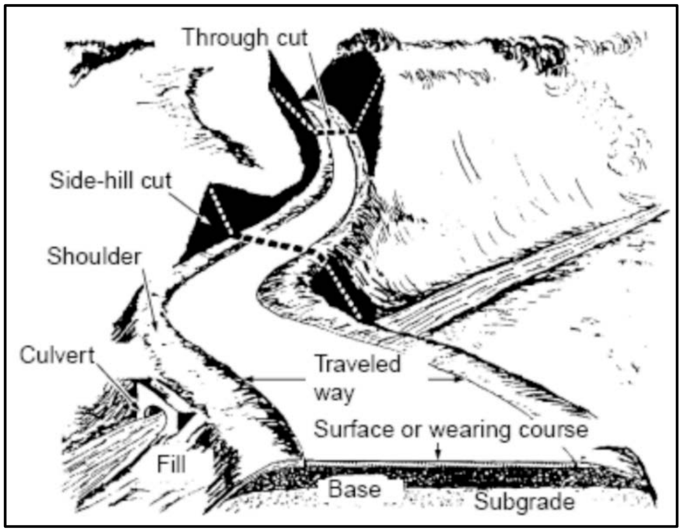


Figure D-2. Road characteristics

Table D-1. Road categories

Road Categories	***Description***
All-weather, dual or divided highway	• Paved with concrete, bituminous surfacing, brick, or paving stone (waterproof surface). • Slightly affected by precipitation and temperature changes.
All-weather, hard surface	• Paved with concrete, bituminous surfacing, brick, or paving stone (waterproof surface). • Slightly affected by precipitation and temperature changes.
All-weather, loose surface	• Constructed of crushed rock, gravel, or smoothed earth with an oil coating. • Graded and drained, but not waterproof. • Considerably affected by rain, frost, or thaw and may collapse completely under heavy use during adverse weather conditions.
Fair-weather, loose surface	• Constructed of natural or stabilized soil, sand, clay, shell, cinders, or disintegrated granite or rock (includes logging roads, abandoned roads, and corduroy roads that can become quickly impassable in adverse weather).
Cart track	• Traveled natural pathways (includes caravan routes and winter roads that may become unable to accommodate four-wheeled military vehicles that are too narrow).

Railways

D-45. Railways can be highly desirable adjuncts to extended military operations. Railroads include all fixed property belonging to a line, such as land, permanent way, and facilities necessary for the movement of traffic and protection of the permanent way. This includes bridges, tunnels, and other structures. Railway analysis covers all physical characteristics and critical features of the existing system and includes components such as roadbed, ballast, track, rails, and horizontal and vertical alignment.

D-46. The gauge of a railroad is the distance between the rails. Railroad gauges are classified as wide, standard, or narrow. Wide gauges are 5 feet or wider and are mostly used by Russian, Finnish, and Spanish lines. Standard gauges are 4 feet, 8 1/2 inches and are used for main and branch lines in the rest of Europe and the United States. Narrow gauges are less than the standard gauge. Narrow gauges, which have somewhat limited use, are usually found in mountainous, industrial, logging, and coastal defense areas; mines; and supply dumps. In South and Central America, a 1-meter gauge is found in many places; however, many countries are now adopting the standard gauge because they import U.S.-made rolling stock.

D-47. Marshaling yards are used to sort freight cars. They are identified by a large group of parallel tracks with restricted (one- or two-track) entrances and exits called choke points. Service yards are normally found in or near marshaling yards and can be identified by the presence of roundhouses, turntables, service facilities, and car repair shops. Roundhouses are used for the light repair and storage of locomotives. The number of roof vents on top of the roundhouse indicates its capacity. Turntables are used for turning the engines around. Service facilities include coal towers, water towers, and coal piles. Car repair shops normally appear as long, low buildings straddling one or more tracks, with cars awaiting repairs on sidings adjacent to the buildings. Freight or loading yards are identified by loading platforms, freight stations, warehouses, and access to other means of transportation. Special loading stations are identified by grain elevators, coal and ore bins, oil storage tanks, and livestock pens with loading ramps.

D-48. Railheads are points of supply transfer from railroads to other forms of transportation and are generally found in small towns or cities where sidings and storage space already exist. Characteristics of a railhead include spurs and sidings from a main line; a road net (including narrow-gauge railroads) leading away from the area; piles of materials stacked near the track trucks, wagons, or both (without order and without organization into convoys or trains); and temporary dwellings (such as tents for housing troops guarding and handling supplies).

Bridges and Culverts

D-49. All bridges present a potential restriction to traffic. Important feature data include—

- Location.
- Type of gap being crossed.
- Overall length.
- Roadway width.
- Horizontal and vertical clearance.
- Military load classification.
- Number and length of spans.
- Type of span construction.
- Bypasses.

D-50. The common types of bridges are shown in figure D-3. See ATP 3-34.81 for information on specific bridge characteristics used in determining bridge classification.

D-51. Culverts are grouped into the following four main categories:

- Pipe (most common).
- Box.
- Arch.
- Rail girder spans.

D-52. Culverts are usually of concrete construction, but corrugated metal and cast iron are also used. The pipes have different shapes and can range from 1 foot to several feet in diameter. Box culverts are used to a great extent in modern construction; they are rectangular in cross section and usually made of concrete. A large box culvert is similar to a slab bridge. Arch culverts were used frequently in the past, but are rarely constructed now; they are made of concrete, masonry, brick, or timber. Rail girder spans are found on lightly built railways or, in an emergency, on any line. The rails are laid side by side, keyed head to base, and may be used for spans of 3 meters or less.

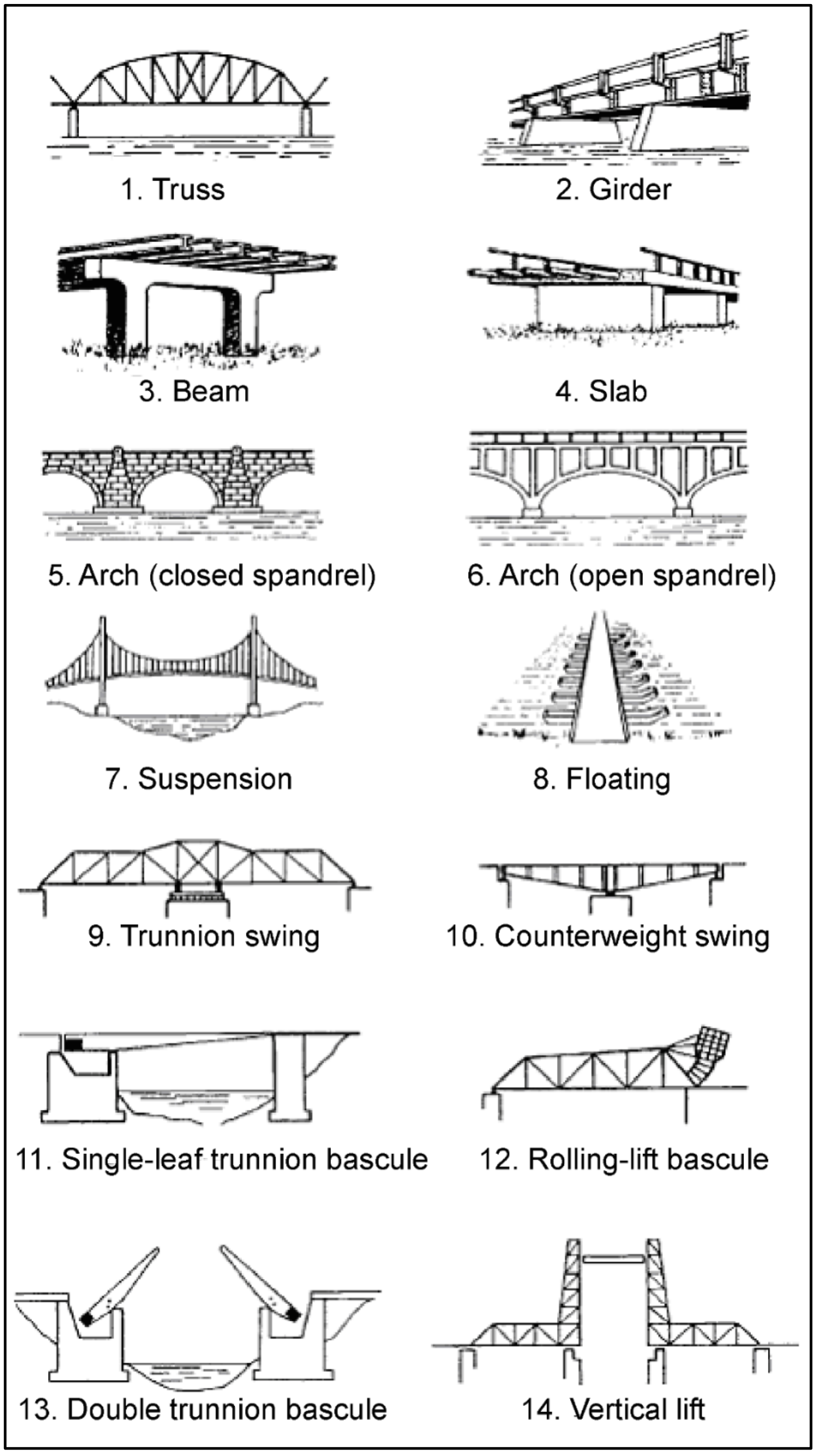


Figure D-3. Common types of bridges

Tunnels

D-53. A tunnel is an artificially covered (such as a covered bridge) or underground section of road along a route. Important characteristics of tunnels include location, type, length, horizontal clearance, overhead clearance, alignment, and gradient. See ATP 3-34.81 for additional information on tunnel types and characteristics.

Ferries

D-54. Ferries convey traffic and cargo across a water feature. These vessels vary widely in physical appearance and capacity depending on the depth, width, and current of the stream and on the characteristics of traffic to be moved. The capacity of a ferry boat is usually expressed in tons and the total number of passengers. The ferry boat is sometimes assigned a military load classification number. Climatic conditions have a marked effect on ferry conditions. Tide fluctuations, fog, ice, floods, and excessive dry spells can reduce the total traffic-moving capacity and increase the hazard of the water route. A ferry site is the place where ferries convey traffic and cargo. Important information about ferry sites includes the width and depth of the water barrier and the conditions of the approaches (such as clearance and load-bearing capacity). ATP 3-34.81 contains information on ferry reconnaissance and reporting.

Fords

D-55. A ford is a shallow part of a body of water or wet gap that can be crossed without bridging, boats, ferries, or rafts. It is a location in a water barrier where the physical characteristics of current, bottom, and approaches permit the passage of personnel, vehicles, and other equipment where the wheels or tracks remain in contact with the bottom at all times. Fords are classified according to the crossing potential or trafficability for foot or wheeled and tracked vehicles. The ford stream bottom composition largely determines its trafficability. In some cases, the natural river bottom of a ford may have been improved to increase load-bearing capacity and to reduce the water depth. Improved fords may have gravel or concrete surfacing, layers of sandbags, metal screening or matting, or timber or wooden planking. The composition and slope of approaches to a ford also affect trafficability. Approaches may be paved with concrete or bituminous surface material, but they are usually unimproved and can be affected by inclement weather and vehicle traffic. Climatic conditions (seasonal floods, excessive dry seasons), the velocity of the current, and the presence of debris are also important factors in assessing stream fordability. ATP 3-34.81 contains information on ford reconnaissance and reporting.

D-56. Low-water bridges consist of two or more intermediate supports with concrete decking and are located entirely in ravines or gullies. During high-water periods, they are easily confused with paved fords because both are completely submerged. It is important to know the difference between this type of bridge and a paved ford because of corresponding military load limitations.

Pipelines

D-57. Pipelines that carry petroleum and natural gas are an important mode of transportation, while rail, water, and road transportation are used extensively for transporting fluids and gases. The overland movement of petroleum and refined products is performed most economically and expeditiously by pipeline. Crude oil pipelines are used only to transport crude oil, while many refined product pipelines carry more than one product. These products are sent through the pipelines in tenders (or batches) to keep the amount of mixing to a minimum. Because of the vital link in the energy supply system of an industrialized country, coal and ore are also carried in pipelines as slurry.

D-58. Pipelines can exist above or below ground and may extend cross-country or follow the alignment of roads and railroads. When a pipeline crosses a stream or river, it is usually run along the stream bottom. Where streams are swift or where beds may shift rapidly, the pipe can be attached to existing bridges or special pipeline suspension bridges. Siphon crossings are used where necessary. When an increase or decrease of pressure is required, regulating features (pumps, compressors) are used. Pumping stations are used for liquid fuels, and compressor stations are used for gas. They are similar in appearance except for the cooling towers present at compressor stations.

D-59. Valves, manifolds, and meters are integral parts of any pipeline system and are located at frequent intervals along the pipeline and at terminals. Valves protruding from the ground are often the only indicators of a pipeline alignment.

Ports and Harbors

D-60. Ports are areas located along seacoasts, navigable rivers, or inland waterways where ships may discharge or receive cargo. Principal port facilities are berthing spaces, storage spaces, cargo-handling equipment, cargo transshipment facilities, and vessel-servicing facilities. Ports may have various structures affording berthing space or may be any place that a vessel can be produced more quickly. These structures include piers, moles, and wharves or quays. Piers project into the water at an angle with the shoreline and are supported by pilings driven into the harbor bottom. Moles are of solid construction. Wharves and quays are parallel with the shoreline, while piers and moles are perpendicular to it. Most landing structures are piers or wharves.

D-61. Harbors are areas where the anchorage and shore are protected from the sea and storms by natural or man-made barriers (seawalls, breakwaters, jetties, moles). Areas that do not have these protections but are still suitable for vessel anchorage are open anchorages or roadsteads. A good harbor consists of deep water, adequate protection from storms, enough space to accommodate a large number of vessels, and a shoreline that can be developed as a port and as a site for industry. Harbors may be situated on the sea, estuaries, or inland lakes and rivers.

D-62. Important factors concerning ports and harbors include water depth, bottom characteristics, tidal fluctuations, discharge volumes and river flow velocity, tidal and river currents, landmark locations, and underwater obstacle locations. Engineers, divers, and other specialists perform surveys to acquire basic information about the shoreline, water depth, bottom character, and existing structures (harbors, wharves). See TM 3-34.73 for additional information.

D-63. Dredging operations require detailed topographic and hydrographic surveys and data on tidal range, tidal prism, flood stages, velocity, and other hydrographic characteristics, including the status of siltation and scour. Other information requirements include data on bridges, breakwaters, jetties, piers, islands, overhead and submarine cables, and vessels (type and size) scheduled to use the waterway. See ATP 4-15 for additional information.

Airfields and Heliports

D-64. Airfields and heliports are classified by the degree of permanence and type of aircraft (fixed or rotary-wing) that they are designed to support. An airfield consists of runways, taxiways, and parking areas that may be permanent, temporary, or natural. A heliport is an area specifically designated and marked for helicopter landings and takeoffs. The surface of the pad may be natural, temporary, or permanent.

D-65. Runways are the most significant feature of an airfield. Detailed information concerning runways, taxiways, and parking areas is essential in properly evaluating airfield capabilities. The length, width, load-bearing capacity, and pavement condition directly influence the type and amount of traffic an airfield can accommodate. Taxiways are access paths to parking aprons, hangar aprons, and handstands or revetments. A parallel taxiway parallels the runway but is usually narrower. Under emergency conditions, it may be used as a runway; however, it should not be reported as a runway. Airfield capacity is described by stating the maximum (aircraft) on the ground, which is the maximum number of aircraft (usually expressed in terms of C-141 aircraft) that can be accommodated on an airfield.

D-66. Geospatial engineers, intelligence analysts, and other specialists provide baseline information on available airfields and heliports in the operational area or specific AO based on a broad view early in the planning phase. As required, more specific information is generated from airfield assessments performed by engineer assessment teams or survey teams or as a result of reconnaissance operations.

Commercial and Recreational

D-67. Commercial and recreational areas and buildings (shopping centers, parking lots, stadiums, sports fields) are where the major business and recreational activities occur in an urban area. Larger open areas (parking lots, sport fields) can serve as landing zones and artillery firing positions. Large, covered areas or areas with some type of containment (stadiums, arenas) can provide locations for displaced civilians, interrogation centers, and enemy prisoner of war holding facilities.

Residential

D-68. Residential areas and associated buildings, which can be found dispersed throughout an urban area, are where civilians live. Large, suburban areas (or sprawl) normally form on the outskirts. Residential areas often consist of row houses or single-family dwellings set in a grid or ringed pattern in a planned development project. Schools are often located throughout residential areas.

Communication

D-69. Communication buildings and structures (such as communication towers) are used to transmit information and data from place to place. They provide the means for operating telephone, radio, television, and computer systems.

Governmental and Institutional

D-70. Governmental and institutional areas and facilities constitute the seat of legal, administrative, and other governmental functions or serve as public service institutions (universities, hospitals) for a country or political subdivision. This wide-ranging category includes embassies, universities, hospitals, police and fire stations, courthouses, and prisons.

Military

D-71. Military areas and facilities are used for controlling, billeting, training, or transporting military forces. Fortifications and military installations may be found in or near urban areas throughout the world.

Appendix E

Systems and Software

The DTSS/DCGS-A is the geospatial engineering component that automates terrain analysis and visualization; database development, updates, and management; and graphics reproduction in support of mission requirements. The DTSS/DCGS-A provides the hardware and software necessary to develop and manage a geospatial database and a software suite of geospatial information-processing capabilities that support the Army by supplying GI&S and special map reproduction.

DISTRIBUTED COMMON GROUND SYSTEM–ARMY

E-1. The DTSS, in all configurations, is a legacy Army computer system that is migrating from the Army Battle Command System to the DCGS-A (geospatial) system. The Geospatial Intelligence Work Station will become the primary tool for geospatial engineers during and after the migration. System replacement is anticipated to continue until the end of fiscal year 2019.

E-2. Current mission command systems do not exchange geospatial foundation data efficiently or in a timely manner within command posts, across units (horizontally), or between echelons (vertically). Mission command programs were designed to support mission command; no two were designed to seamlessly share geospatial foundation data (maps, imagery, feature data) with each other in a standard, efficient, and timely manner without translation or a manual workaround. Some fielded systems require a completely new software load or the preprocessing and conversion of standardized geospatial foundation data to a vendor-specific format at a continental U.S. contractor facility or by vendor contractors in the field to update the geospatial foundation data on the system. Material developers addressing the lack of interoperability will begin fielding new mission command systems in 2019.

E-3. The DCGS-A adds a key system attribute for the ease of use; digital network intelligence capabilities; and a full, on-the-move capability that interacts across common operating environments and command post computing environments. The DCGS-A enables commanders to access information, task organic sensors, and synchronize nonorganic sensor assets with organic assets. These services are shared by commanders, Services and coalition partners across the network-centric enterprise services (using the Distributed Common Ground/Surface System integration backbone, Defense Intelligence Information Enterprise, cloud architecture), the AGE, and the SSGF (using common standards and services). DCGS-A provides a transition to cloud-based advanced analytics to provide users with enhanced processing, exploitation, and geospatial intelligence capabilities.

GEOSPATIAL INTELLIGENCE WORKSTATION

E-4. The core functions of the DCGS-A are the—

- Tasking of sensors.
- Processing of data.
- Exploitation of data.
- Dissemination of intelligence information about the threat, weather, and terrain and operating environments at all echelons through the receipt and processing of select sensor data.
- Control of select sensor systems.
- Intelligence synchronization.
- Information collection planning, and reconnaissance and surveillance integration.
- Fusion of sensor information.

- Direction and distribution of relevant threat, nonaligned, and friendly forces and of environmental weather conditions.
- Ability to host, manage, and provide the SSGF to all common operating environments.

E-5. The DCGS-A incorporates the subsystem tactical ground station, operational ground station, and geospatial intelligence workstation in its full deployment.

E-6. The geospatial intelligence workstation was previously known as the DTSS–Deployable. It is a ruggedized, commercial, off-the-shelf, deployable computer that hosts a core set of geographic information system imagery intelligence applications, software, and map applications that enable warfighter functions (movement and maneuver, intelligence, fires, protection). The geospatial intelligence workstation replaces the DTSS–Light. It combines the capabilities of several legacy Army and quick-reaction capability geospatial and imagery workstations. It is the prime DCGS-A workstation for geographic information system and imagery intelligence processing, exploitation, and dissemination. It provides geospatial engineers and geospatial intelligence imagery analysts within tactical and operational units the ability to process, view, exploit, transmit, and store geospatial and imagery information via area communications to brigades and echelons above brigade. The geospatial intelligence workstation receives and processes initial geospatial data, raw imagery, full-motion video, reports, and information received from multiple geospatial, imagery, and full-motion video intelligence sensors via the network or tactical or operational intelligence ground processing centers. The geospatial intelligence workstation provides geospatial data, analysis products, maps, and updates in support of terrain analysis and visualization.

DIGITAL TOPOGRAPHIC SUPPORT SYSTEM–LIGHT

E-7. The DTSS–Light is employed in various configurations at all echelons down to the BCT. The DTSS–Light is a completely self-contained system that is capable of storing and manipulating imagery, imagery intelligence, and geospatial information. It is housed in a lightweight, multipurpose shelter that is mounted on a high-mobility, multipurpose, wheeled vehicle and includes a tent extension to provide additional workspace. There are current plans to reduce some versions of the DTSS and the current DTSS program. The DTSS–Light can produce a variety of geospatial products that can be exported in various formats for use in the mission command systems that incorporate the commercial joint mapping toolkit and other GI&S programs (such as Falcon View). In addition to creating tailored geospatial products, the DTSS–Light provides access to the full capabilities of the image processing and GI&S software packages.

FIXED MULTIFUNCTION WORKSTATION AND DISTRIBUTED COMMON GROUND SYSTEM–ARMY FIXED SERVER

E-8. The fixed multifunction workstation is a theater level asset that is operated by the GPC from a fixed facility located with or near the ASCC headquarters. It gives geospatial engineers operating at theater the ability to generate and analyze geospatial data and augment existing databases to provide operational commanders with geospatial information and geospatial products in support of mission requirements. The fixed server provides a stable data store for the SSGF and mission command products and services.

GEOSPATIAL-RELATED SOFTWARE

E-9. Generally, these software programs are developed by leaders in the corporate field of geospatial technology and are often developed at the U.S. Army Corps of Engineer sites. The various versions of any particular software are bundled into packages and are the compilation of upgrades and other similar changes to other brands of software. Tables detailing software brands, version sets, reference codes, and system requirements are readily available within the community of interest but are not listed in this text due to the continually emerging package types. Units that purchase commercial, off-the-shelf versions of software are susceptible to compatibility and interoperability issues with the government-provided software. The U.S. Army Training and Doctrine Command Capabilities Manager (geospatial) is the Army user representative to the DCGS-A (geospatial) program of record that is responsible for providing information to the program and feedback from the user perspective.

REACHBACK ENGINEER DATA INTEGRATION

E-10. Reachback engineering data integration (REDi) system provides a common database, mapping tool, and robust user interface for managing, tracking, and archiving data and reachback support related to the engineer reachback process and the field force engineering program through the U.S. Army Corps of Engineers Reachback Operations Center.

E-11. From its origins of fielding RFIs in support of deployed engineers, the U.S. Army Corps of Engineers Reachback Operations Center has evolved to provide a variety of other capabilities under the U.S. Army Corps of Engineers Field Force Engineering Program, including data collection tools, communications equipment, training, and video teleconference support. Historically, multiple databases and portals were required for U.S. Army Corps of Engineers Reachback Operations Center customers to access the various data, tools, and support. To provide a more efficient solution, the REDi system was designed as a common database for all reachback engineering data. It is a single-user interface through which data sources and other services and tools provided by the U.S. Army Corps of Engineers Reachback Operations Center may be accessed and managed.

E-12. The REDi system provides a full suite of standard tools and capabilities. Custom-designed tools and menus are provided within the REDi system for U.S. Army Corps of Engineers Reachback Operations Center customers to—

- Submit a new RFI.
- Search the RFI database for archived information.
- Request training on systems and equipment.
- Request information or acquisition of equipment.
- Connect to the Geospatial Assessment Tool for the Engineer Reachback Database.
- Return equipment for repair or replacement.
- Request video teleconference support.

E-13. Another powerful feature provided in the REDi system is a robust mapping tool that enables data stored within the REDi system to be plotted geospatially. The system also provides the capability of plotting data from external sources. The user may choose a background layer from a variety of maps and imagery on which to overlay these data feeds. A variety of standard SharePoint® tools are also provided for users to store and manage documents, store and organize commonly used internet sources and links, post announcements, or participate in online chats within the REDi system. Access to the REDi system is available to any common-access card holder, and the REDi system is available on the unclassified network, the Secret Internet Protocol Router Network, and on the Combined Enterprise Regional Information Exchange System–Korea network.

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Glossary

The glossary lists acronyms and terms with Army or joint definitions. Terms for which ATP 3-34.80 is the proponent are marked with an asterisk (*).

SECTION I – ACRONYMS AND ABBREVIATIONS

ADP	Army doctrine publication
ADRP	Army doctrine reference publication
AGC	Army Geospatial Center
AGE	Army Geospatial Enterprise
AO	area of operations
AOI	area of interest
AOR	area of responsibility
AR	Army regulation
ASCC	Army Service component command
ATP	Army techniques publication
attn	attention
BCT	brigade combat team
CDID	Capabilities Development and Integration Directorate
CJCSI	Chairman of the Joint Chiefs of Staff instruction
COA	course of action
CODDD	Concepts, Organizations, and Doctrine Development Division
COP	common operational picture
DA	Department of the Army
DC	District of Columbia
DCGS-A	Distributed Common Ground Systems–Army
DOD	Department of Defense
DODD	Department of Defense directive
DTED	digital terrain elevation data
DTSS	Digital Topographic Support System
FM	field manual
G-2	assistant chief of staff, intelligence
G-3	assistant chief of staff, operations
GD&I	geospatial data and information
GET	geospatial engineer team
GI&S	geospatial information and services
GPC	geospatial planning cell
IPB	intelligence preparation of the battlefield
JP	joint publication
LOS	line of sight
MDMP	military decisionmaking process
MO	Missouri

MSCoE	Maneuver Support Center of Excellence
NGA	National Geospatial-Intelligence Agency
No.	number
NSG	National System for Geospatial Intelligence
OAKOC	observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment
OIC	officer in charge
PMESII-PT	Political, military, economic, social, information, infrastructure, physical environment, and time
REDi	reachback engineering data integration
RFI	request for information
S-2	intelligence staff officer
S-3	operations staff officer
SSGF	Standard and Shareable Geospatial Foundation
TC	training circular
TGD	theater geospatial database
TM	technical manual
U.S.	United States

SECTION II – TERMS

***complex terrain**

A geographical area consisting of an urban center larger than a village and/or of two or more types of restrictive terrain or environmental conditions occupying the same space.

***geospatial data and information**

The geographic-referenced and tactical objects and events that support the unit mission, task, and purpose.

***terrain analysis**

The study of the terrain's properties and how they change over time, with use, and under varying weather conditions.

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22 February 2017

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