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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 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 according to the law of war and the rules of engagement. (See FM 27-10.)

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.

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.

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

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

Introduction

The geospatial engineering discipline is one of three engineer disciplines. It plays a major role in supporting combat and general engineering disciplines. This discipline is essential to all lines of engineer 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 earth location 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 terrain 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 decisionmaking.

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 engineer 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 and provide the most effective geospatial support possible to the commander. Although there is a detailed discussion in this manual regarding the topographic company, it will become inactive in fiscal year 2016.

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. This revision also captures the results of the lessons learned and the observations from recent operational experiences in Afghanistan, Iraq, and other locations, to include the challenges of operating in complex terrain. Other changes that have directly affected this manual include the—

- Success of geospatial planning cells (GPCs).
- Adoption of Army modularity on the topographic engineer companies.
- Adoption of the JP 3-34 definition for geospatial engineering.
- Migration of the Digital Topographic Support System (DTSS) into the Distributed Common Ground Systems–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 mission command essential capability that enables a shared basis for representing operational environment complexity and interrelationships.

- Adoption of the term *geospatial data and information* (GD&I) that captures and describes operationally relevant tactical objects and events (spatial and temporal) that are correlated to a geographic location.
- 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.
- Update of the four levels of resolution from strategic, operational, tactical, and urban to global, regional, local, and specialized.
- 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, focuses on defining the Army Geospatial Enterprise (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 decisionmaking.
- Appendix C, Geospatial Data Management, provides information on gathering, storing, and disseminating relevant digital terrain data that supports operations and enables decisionmaking.
- Appendix D, Terrain Characteristics, describes the six characteristics of terrain that geospatial engineers analyze in determining the 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 the near future.

Based on current doctrinal changes, certain terms for which ATP 3-34.80 is the proponent have been added or modified for purposes of this manual. (See introductory table-1, introductory table-2, and introductory table-3.) The glossary contains acronyms and defined terms.

Introductory table-1. New Army terms

Term	Remarks
geospatial data and information	New term and definition

Introductory table-2. Rescinded Army terms

Term	Remarks
geospatial information	Adopted the joint definition
geospatial engineering	Adopted the joint definition

Introductory table-3. Modified Army terms

Term	*Remarks*
complex terrain	Shortened definition.
terrain analysis	Shortened definition.

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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 effectively go outside the engineer 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 the terrain analysis and terrain visualization of the physical environment.

DECISIVE ACTION SUPPORT

1-1. Geospatial engineering is provided to the Army based primarily on the echelon that is supported. 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 is required to support 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.

1-2. Combat and general engineering disciplines rely heavily on geospatial support to conduct tasks efficiently. While conducting offensive tasks, geospatial engineers assist combat engineers in determining the suitability of an area for river-crossing sites and bypasses, and 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 geospatial engineers assist 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 will facilitate the detection of explosive hazards and possible observer locations. Geospatial engineers assist general engineers in providing hydrology analysis to find water sources for wells and key infrastructure locations. There are few unique missions performed by geospatial engineers during the defense support of civil authorities tasks that are not performed during offense, defense, or stability tasks.

1-3. Geospatial engineers are currently embedded in the BCTs, functional brigades, divisions, corps, Army Service component commands (ASCCs), and special operations forces. The GPCs are composed of geospatial engineers with geospatial intelligence imagery analysts. The GPCs coordinate geospatial requirements and efforts to produce geospatial map data to fill operational areas where current data may not exist. Geospatial engineers are a low-density and high-demand discipline across the Army. The geospatial engineering discipline primarily supports the mission command warfighting function; however, the geospatial engineering discipline provides support to the other 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, whether it is to generate and analyze terrain data to assist in the MDMP, to manage the geospatial database within an area of operations, or to produce overlays for situational understanding.

CAPABILITIES

1-4. *Geospatial engineering* is engineering capabilities and activities that contribute to a clear understanding of the physical environment by providing GI&S to commanders and staffs (JP 3-34). FM 3-34 provides additional information on the 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 decisionmaking. 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.

1-5. Within the Engineer Regiment, geospatial engineering is a key enabler for each line of engineer 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 engineer support regardless of opposed or unopposed entry into the theater. These tactical decision aids include three-dimensional terrain mapping and fly-through representations that produce nonstandard, tailored map products (to include cross-country mobility, viewshed, zone of entry, drop zones, and surface and subsurface topographic products).

1-6. Geospatial engineers provide line of sight (LOS) analysis to support the enhance protection line of engineer 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 engineer 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 engineer 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.

1-7. Geospatial engineering is provided to the Army based primarily on the echelon that is supported. It is focused on geospatial data generation, geospatial data analysis, geospatial data management, quality control, and data dissemination at the ASCC and combatant command levels. At echelons above brigade, the majority of the workload is required to support terrain analysis; MDMP; and data generation, management, and dissemination. At the BCT and below levels, geospatial engineering is increasingly focused on MDMP relating to current and future operations; terrain visualization; and database generation, management, and dissemination.

GEOSPATIAL INFORMATION AND SERVICES

1-8. *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, precise 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.

1-9. ***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 support of geospatial information management, analysis, and dissemination.
- Analyze the terrain in support of the MDMP, moreover the intelligence preparation of the battlefield (IPB), and map missions. This enables predictive analysis and provides actionable information for decisionmaking.
- Disseminate geospatial information by publishing and maintaining the geospatial enterprise database server in digital and hardcopy publishing.
- Manage the geospatial database in support of the common operational picture (COP) and current and future operations.

1-10. These major functions required for GI&S are performed by organic geospatial engineer 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.

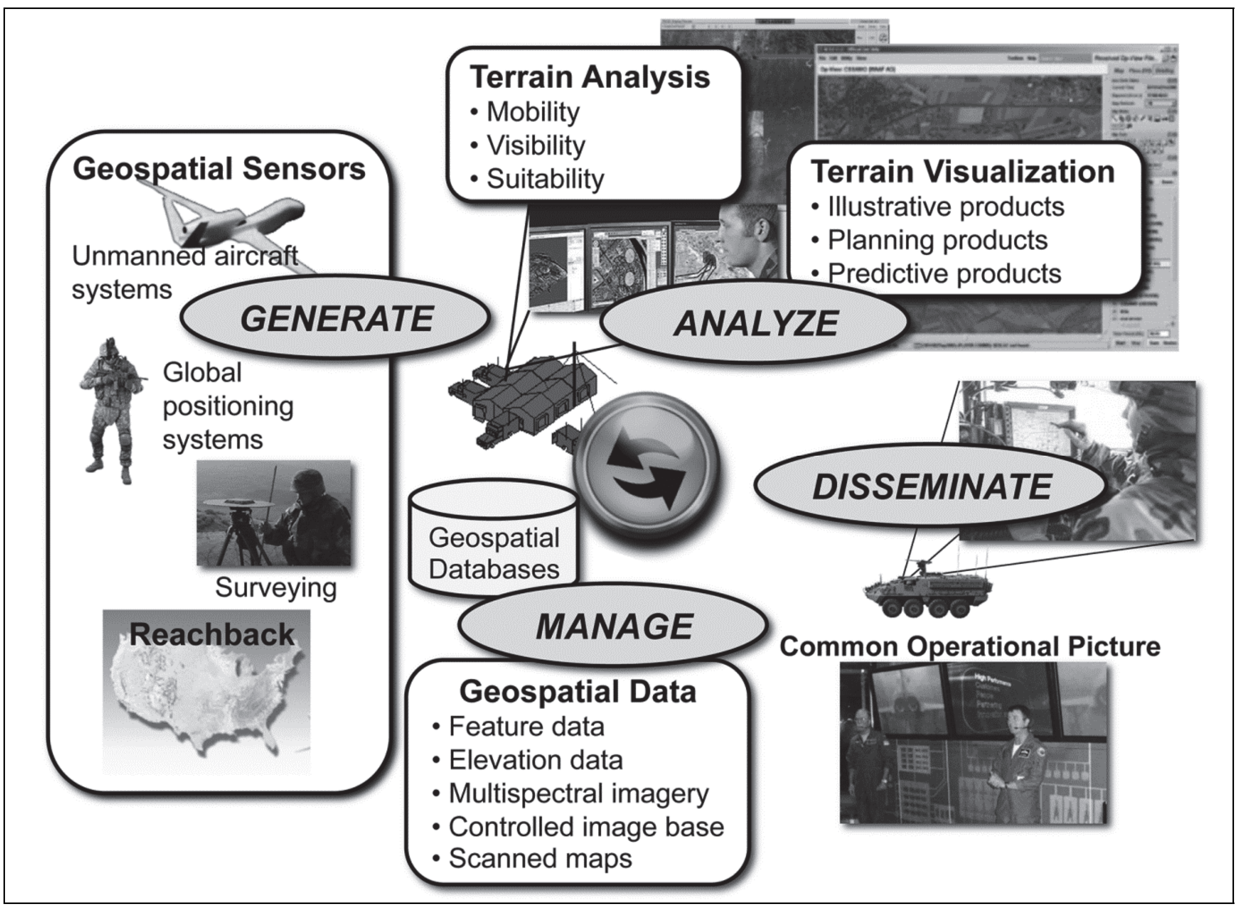


Figure 1-1. Major functions of geospatial engineering

1-11. ***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.

1-12. While terrain analysis is more of a science, terrain visualization is an art. 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 most likely to be used by the threat. It is the subjective evaluation of the terrain physical attributes and the performance capabilities of vehicles, equipment, and personnel that must cross over and occupy the terrain.

Geospatial Information

1-13. *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; in digital simulation and modeling databases; in aerial or satellite imagery form; or in the form of digitized maps and charts. Its effectiveness as an enabler is directly proportional to its currency, accuracy, relevance, and understanding by the user. Although, information assurance restrictions often handicap the enabling abilities of the geographic information system.

Data

1-14. 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 is georeferenced (scanned digital maps, elevation data, imagery, feature data).

Image Map

1-15. Compressed arc digitized raster graphics are digital copies of scanned, unclassified hardcopy maps and charts and are available by stock number from the Defense Logistics Agency on CD 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 better are also available, but will not show all buildings; however, this can be achieved 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 are 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).

1-16. Elevation data has varying 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).

1-17. 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 that the contour lines of a 1:250,000-scale map joint operations graphic does. 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 through the Defense Logistics Agency on CD 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 targets, 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 three-dimensional feature extraction for urban areas and vegetation (shape files).

1-18. 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 useful 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. 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 is a Defense Advanced Research Projects Agency project that collects interferometric radar from a sensor mounted to an airframe. It processes the recorded data into digital elevation models. Interferometric synthetic aperture radar elevation can rapidly generate three-dimensional maps in day, night, or adverse conditions.

1-19. 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.

1-20. Information about the quality, source, date, and other details about the data is 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

1-21. *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) The geospatial intelligence enterprise encompasses all activities that are involved in planning, 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.
- Navigation safety.
- Operational environment awareness.
- Mission planning and mission command.
- Target intelligence.

1-22. The geospatial intelligence spans two branches with two distinct professions: military intelligence (imagery analysis) and the U.S. Army Corps of Engineers (geospatial engineering). Figure 1-2 depicts the alignment of intelligence imagery analyst and geospatial engineers with the three elements of geospatial intelligence.

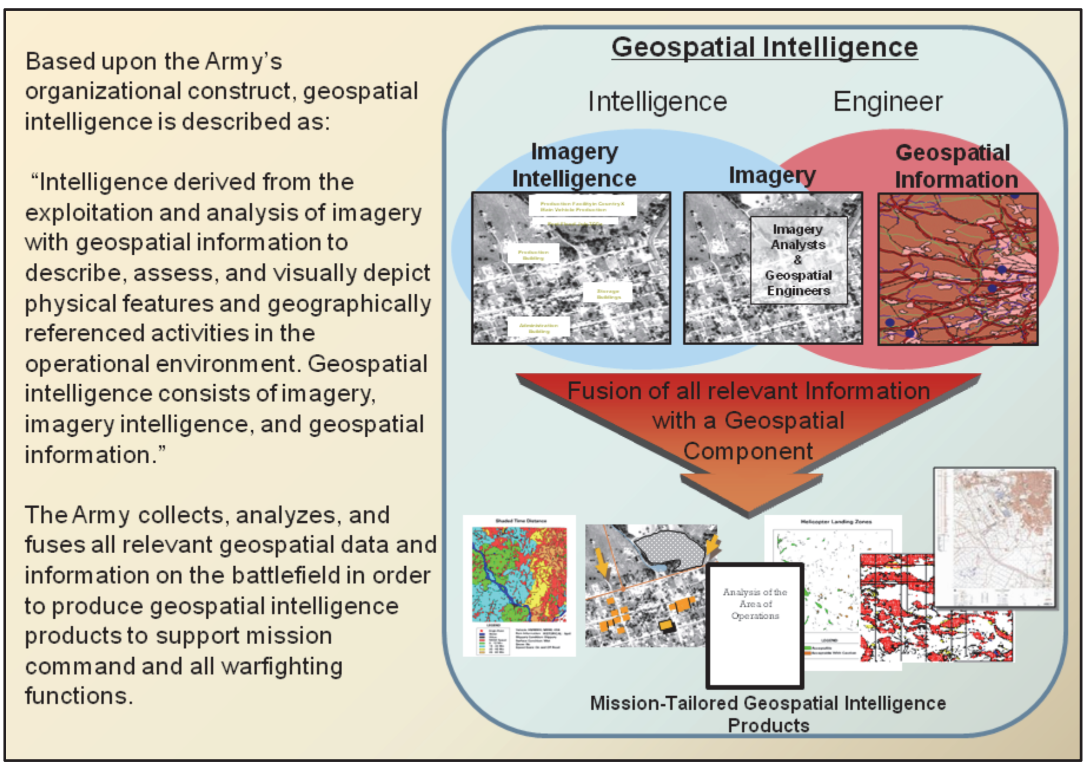


Figure 1-2. Elements of geospatial intelligence

1-23. 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 are compiled from multiple sources (including the NGA, Army Geospatial Center and unified-action partners) and from exploiting 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).

1-24. The National Ground Intelligence Center and the U.S. Army Corps of Engineers Army Geospatial Center are two service centers that support geospatial intelligence. The National Ground Intelligence Center has the mission 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 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 conduct geospatial intelligence readiness assessments of units and provide geospatial intelligence training for unit deployment and sustainment. See the Army Geospatial Center Common Map Background Web site for access to data. The Army Geospatial Center has the mission 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 our mission partners, developing and fielding enterprise-enabled geospatial systems, and providing domain expertise and support to the Army mission command systems and acquisition community.

1-25. 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, to include 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 communications and industrial facilities.
- Determine precise locations and dimensions of objects.
- Conduct physical battle damage assessments.
- Prepare imagery analysis reports and fused geospatial products.

1-26. Geospatial intelligence cells form at echelons above brigade and BCT levels to provide the commander and staff with the most current, accurate geospatial intelligence analysis and products possible. Geospatial intelligence cells are not currently established at the ASCC level; however, the GPC will support geospatial intelligence efforts and initiatives. The GPC provides the geospatial and imagery foundations, but the request for information (RFI) process is conducted by the geospatial intelligence cell. The geospatial intelligence cell manages geospatial and imagery foundations of the COP and 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 TC 2-22.7 for additional information on geospatial intelligence cells.) The geospatial intelligence cell supports joint operations with the following activities:

- Defining requirements.
- Obtaining mission-essential geospatial intelligence.
- Evaluating available data.
- Using and disseminating data.
- Maintaining and evaluating data.

1-27. Geospatial engineers who support echelons above brigade 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 supported force. The organic or augmenting geospatial engineer units that are available to the commander operate within the command geospatial intelligence cell. The geospatial intelligence cell is composed of geospatial intelligence imagery analysts and geospatial engineers that provide geospatial intelligence capabilities. This cell ensures that geospatial intelligence requirements are coordinated through appropriate channels as applicable and facilitates shared access of various domains. 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. The battalion or brigade intelligence staff officer (S-2) and assistant chief of staff, intelligence (G-2) provides guidance and tasking to the geospatial intelligence cell. Cell members are supervised by the geospatial intelligence cell officer in charge but remain under the command of the parent unit to help ensure geospatial engineer capabilities are integrated across staff functions. Based on seniority, the geospatial engineering technician or the imagery intelligence technician will normally serve as the geospatial intelligence cell officer in charge within 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.

NATIONAL SYSTEM FOR GEOSPATIAL INTELLIGENCE

1-28. The National System for Geospatial Intelligence is the combination of technology, policies, capabilities, doctrine, activities, people, data, and communities necessary to produce geospatial intelligence in a variety of environments. The National System for Geospatial Intelligence operates within policies and guidelines established by the Director of National Intelligence. The National System for Geospatial Intelligence community consists of members of the intelligence community, Services, joint staff, combatant commands, and the civilian community. (See JP 2-03 for additional information.)

1-29. 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, to include 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 three-dimensional, 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 Department of Defense level capabilities.)

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.

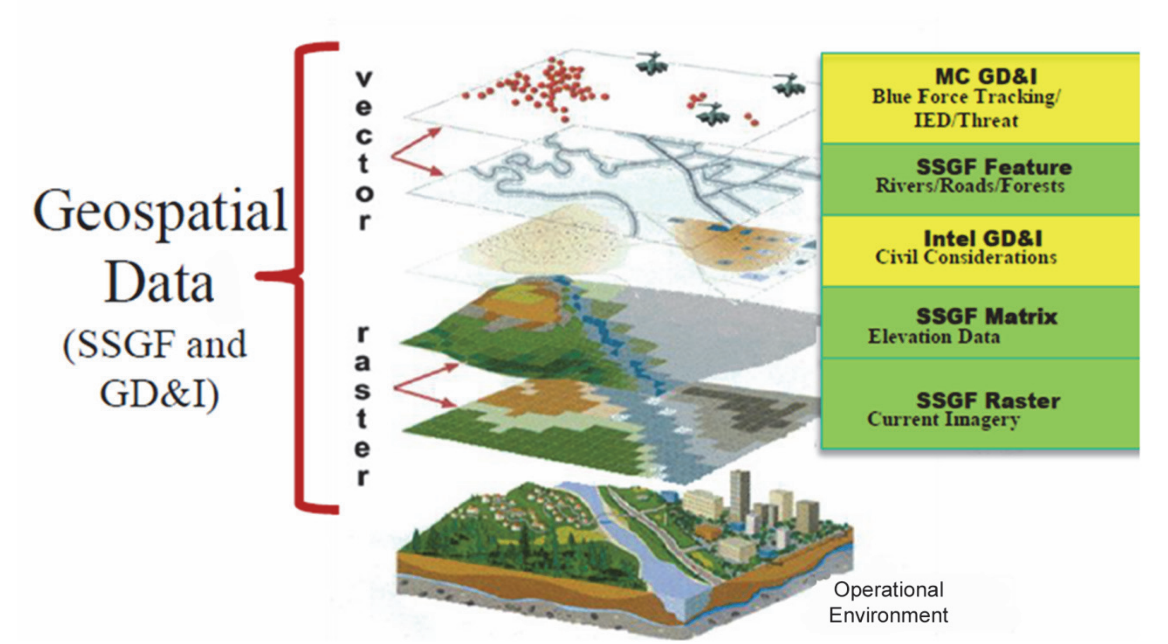
OPERATIONAL USAGE

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. The AGE will allow commanders and staffs the operational adaptability to change situational awareness by having a common geospatial foundation across the operational environment. At its core, the AGE is a set of data stores within a supporting infrastructure based upon 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 community. AGE implementation will enable—

- A consistent, coordinated, and synchronized geospatial foundation for the warfighter COP.
- The geospatial standards that support interoperability and geospatial data exchange between systems and support standard 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 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 (or system of systems) that is developed consistently with the principles of 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 product. 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 has the ability 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 will be 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. Standardized and shareable geospatial foundation leads to a COP. (See figure 2-1.)



Legend:

GD&I	geospatial data and information
IED	improvised explosive device
MC	mission command
SSGF	Standard and Shareable Geospatial Foundation

Figure 2-1. Sample layers in a geographic information system

2-4. The AGE and geographic information system principles that enable AGE are based on the deliberate management of geospatial standards, data, and processes. To maximize the utilization and integrity of geospatial information, it must be timely, accurate, and relevant to make critical decisions, which require attention to how it is collected, processed, exploited, disseminated, and archived. The geospatial information does not evolve and migrate accidentally 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, within the geospatial intelligence cells, are the day-to-day managers of the geospatial foundation data.

2-5. The AGE utilizes the global network enterprise construct concept to leverage the transport, data centers and stores, standards, and common services as a cross-cutting capability to the common operating environment computing environments. An effective AGE is achieved by having trained geospatial engineers at each echelon using DCGS-A to manage and maintain the common geospatial foundation data layer for the assigned area of interest. Figure 2-2 is a notional diagram showing how the geospatial foundation is maintained across the enterprise by geospatial engineer teams.

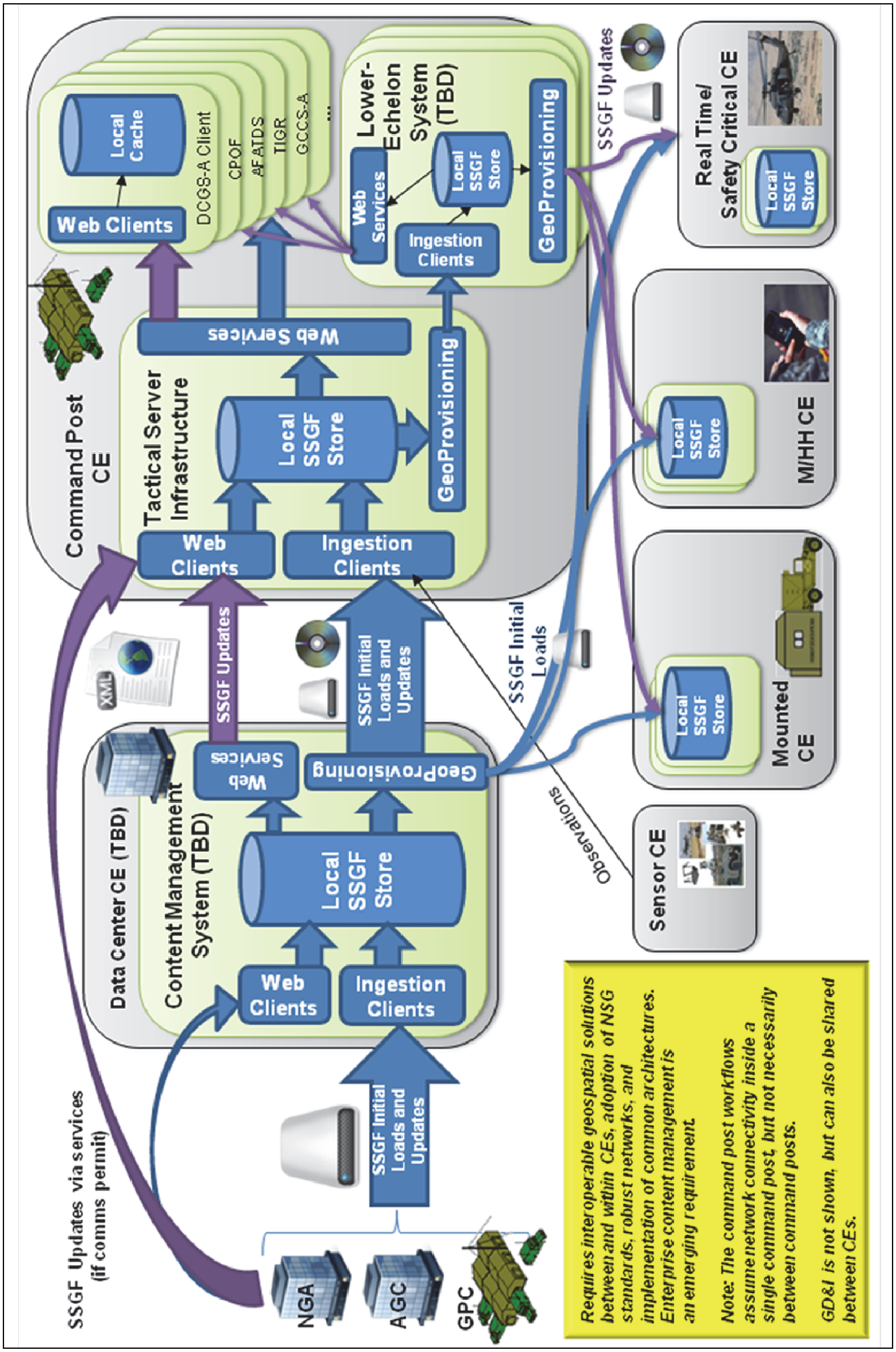


Figure 2-2. AGE/SSGF operational view

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

Figure 2-2. AGE/SSGF operational view (continued)

STANDARD AND SHAREABLE GEOSPATIAL FOUNDATION DATA

2-6. The concept of the AGE is to facilitate the delivery of an SSGF upon which data from all warfighting functions can be used to display the COP on each computing environment. The AGE supports an SSGF to be used by mission command operating force applications. The AGE capabilities are fundamental to enable mission command during decisive action that consists of offensive, defensive, stability, or defense support of civil authorities tasks. The AGE is not a new program or system of record. The AGE defines a set of policies, directions, and standards for implementation by existing and future mission command program of records and commercial off-the-shelf systems, ensuring migration to, and establishment of an SSGF. This AGE is aligned with the AGE policy with linkages to the Army enterprise architecture that is described in AR 25-1.

2-7. The AGE and SSGF are fundamental to military operations. The concepts apply to all phases of operations and include personnel, units, systems, platforms, and processes that use, produce, store, manage or disseminate geospatial data that can be shared to support the six warfighting functions. The SSGF consists of maps, imagery, feature data, and elevation data. The SSGF is provisioned as data, products, services, and a three-dimensional globe. Examples of data that is used to overlay on the geospatial foundation include GD&I; geospatial analysis products; operations and intelligence information; maneuver and fires information; significant activities information; traffic control points; civil affairs information; political, military, economic, social, information, infrastructure, physical environment, and time; building interiors information; engineer information; areas, structures, capabilities, organizations, people, and events; and sewage, water, electricity, academics, trash, medical, and security. While this concept deals predominately with the production, management, and exchange of geospatial foundation data, the standards that are required for geospatial interoperability and integration also apply to the geospatial data that will be 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 3900.01C). These knowledge areas are delivered to the COP, where they are fused and presented according to the needs of the commander.

2-8. The current process for handling and managing geospatial data can generally be outlined as—

- **Initial data load and data tailoring.** Before deployment, units (down to the platform and handheld level) receive initial geospatial data loads that are tailored to the AOR directly or indirectly from the NGA; the Central Technical Support Facility, Fort Hood, Texas; or the local geospatial engineer team. Depending on the time available and the availability of geospatial engineer team support (or contracted support), this data may be improved upon or tailored for unit-specific mission requirements before deployment.
- **Data collection and storage.** During operations, new information is collected about the operational environment and then passed to higher and lower echelons through tactical reporting. This information is collected and stored in a variety of disparate systems, spreadsheets, reports, and formats with no commonality between information collected or who, how, what, when, and where it is stored.
- **Data exchange.** Upon mission change, since an updateable map background is not integrated or managed in conjunction with the majority of mission command systems, most collected geospatial data from previous missions is not shared with adjacent/higher units to improve situational understanding. This often results in the loss of the geospatial knowledge base. This inability to easily exchange geographic data is potentially lethal when units rotate into or out of an AOR and the collective geospatial knowledge reverts to the original NGA baseline, which may be outdated or obsolete, forcing the next unit to rediscover the operational environment for themselves.
- **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. Even where coverage is available, standard NGA data holdings require periodic updates to capture changes (urban growth, cultural and environmental changes to geography). It is certain that, at the time of any given contingency operation, data holdings will require updates and augmentation to fully contain the relevant information and spatial resolution for successful tactical ground operations.

2-9. The COP requires the ability to layer various information and data from a variety of data sources over one consistent geospatial foundation. The traditional implementation of the COP in a command post is a board with single or multiple warfighting function functional overlays displayed over a hardcopy map that evolves, through the implementation of service-oriented architecture, into a true enterprise geographic information system. (See figure 2-3, page 2-6.) This capability will enable the fusion of data across different warfighting functions to enhance analysis and situational understanding in support of mission command.

2-10. The COP is an essential capability that displays and shares relevant information and collaboration and executes a running estimate and unified-action partner interoperability with others within the area of operations. Ultimately, the AGE improves planning and execution by enhancing Soldier and leader situational awareness. It also saves time and resources through the efficient reuse of data and eliminates the necessity of collecting, transcribing, and producing multiple data sets and products over the same area of operations.

GEOSPATIAL FOUNDATION

2-11. Initially, the geospatial foundation is composed of baseline authoritative geospatial data from the NGA, Army Geospatial Center, GPCs, unified-action partners, commercial sources, and other mission area data. It is maintained and made shareable to mission command systems and platforms by the geospatial engineer teams using standard AGE infrastructure and procedures defined by Department of Defense business practices between the Army Geospatial Center and the chief information officer or assistant chief of staff, signal. The geospatial foundation layer for the COP is stored, managed, and updated in standardized, authoritative, distributed geospatial data stores.

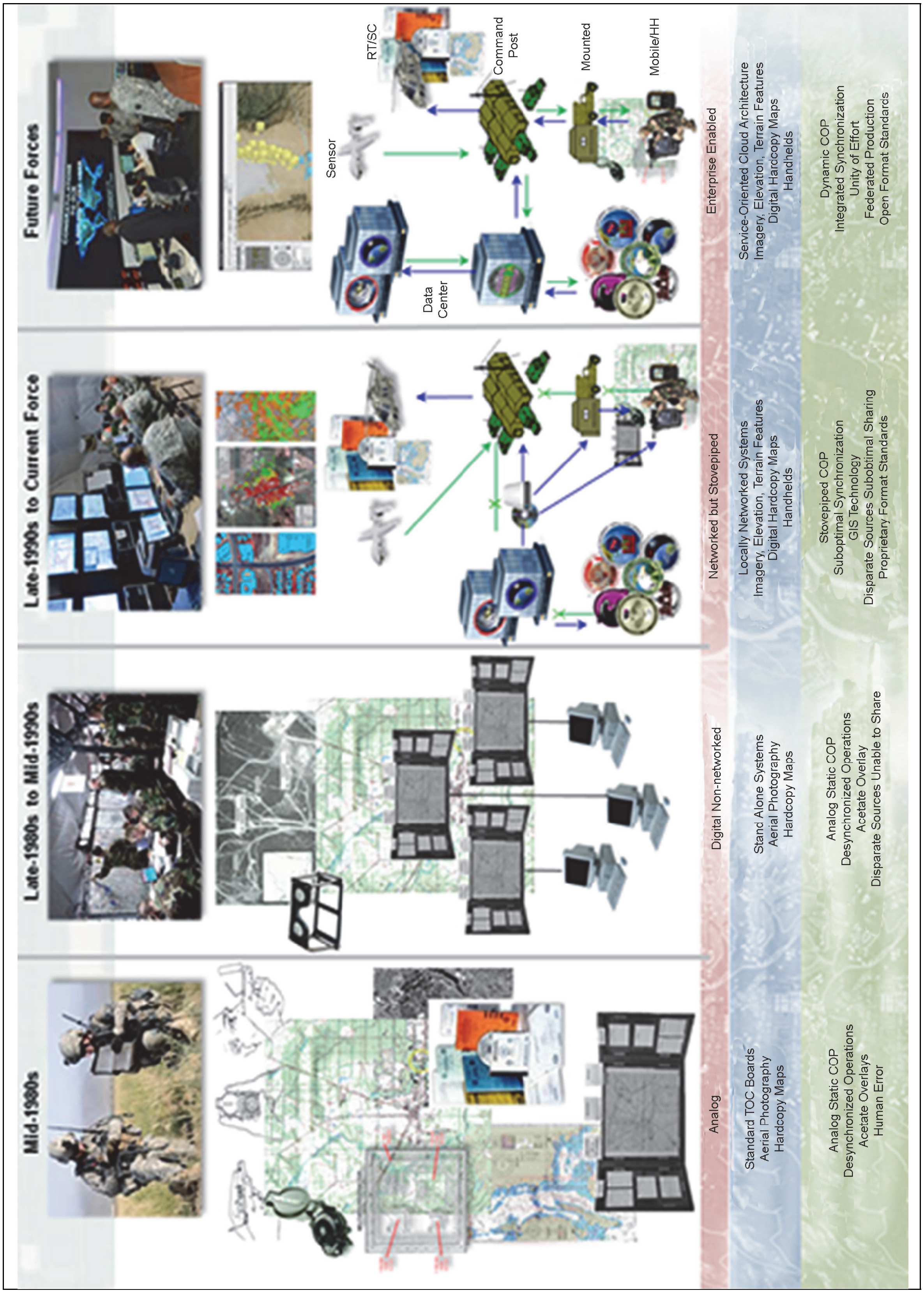


Figure 2-3. Evolution of the COP

Legend:	
COP	common operational picture
GIS	geographical imaging software
HH	handheld
RT	real time
SC	safety critical
TOC	tactical operations center

Figure 2-3. Evolution of the COP (continued)

2-12. The geospatial foundation data will be synchronized from GPCs to echelons above brigade and BCTs to support the building of the COP. The geospatial foundation will be stored at the GPC (or an Army processing center) as a theater geospatial data store. A smaller area of coverage, tailored to the AOR, will be provided to corps as the corps geospatial data store, with a smaller AOR in the division geospatial data store down to the smallest AOR in the BCT and below geospatial data store. Each geospatial data store will contain elevation data, orthorectified base map imagery, vector feature data (in a geospatial data model-compliant data schema), and rasterized finished map products.

2-13. An SSGF is achieved by having common geospatial data and data management processes across the area of operations, which provide the spatial foundation that the warfighting functions can use immediately. The geospatial foundation enables a common and up-to-date map background, which can facilitate the sharing, correlation, and fusing of data from the six warfighting functions to support the COP and the user-defined operational picture. This allows the user to select the information that should be included in or excluded from the data set that defines the user operational picture. The purpose of the user-defined operational picture capability is to create, visualize, and share decision-focused views of the operational environment for decisionmakers to have accurate situational awareness and to make timely decisions in a distributed network centric command and control environment. Warfighting function-geoenabled applications will build data layers upon the geospatial foundation. Data flow across the enterprise will take place whether connected to a Nonsecure Internet Protocol Router or a Secret Internet Protocol Router network, respectively.

2-14. 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.

DATA MODEL

2-15. A standard geospatial data model is the backbone of deliberate data management and 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 will allow 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. Geospatial foundation data can be accessed through Web services or have a local physical instantiation, which is to ensure that the georeferenced data is tied to the geospatial foundation. Configuration management of the geospatial data model ensures that the most accurate, relevant information is available.

GEOSPATIAL DATA STANDARDS

2-16. 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 nonprograms of record will use the relevant geospatial standards adopted by the AGE profile of geospatial standards, a subset of the geospatial intelligence standards documented in the Department of Defense 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 geospatial intelligence standards working group and are designated by the Army Geospatial Center 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 will outline the standards that are supported as part of the geospatial foundation, but will not prescribe products that are created and used as warfighting function data layers. This ensures 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

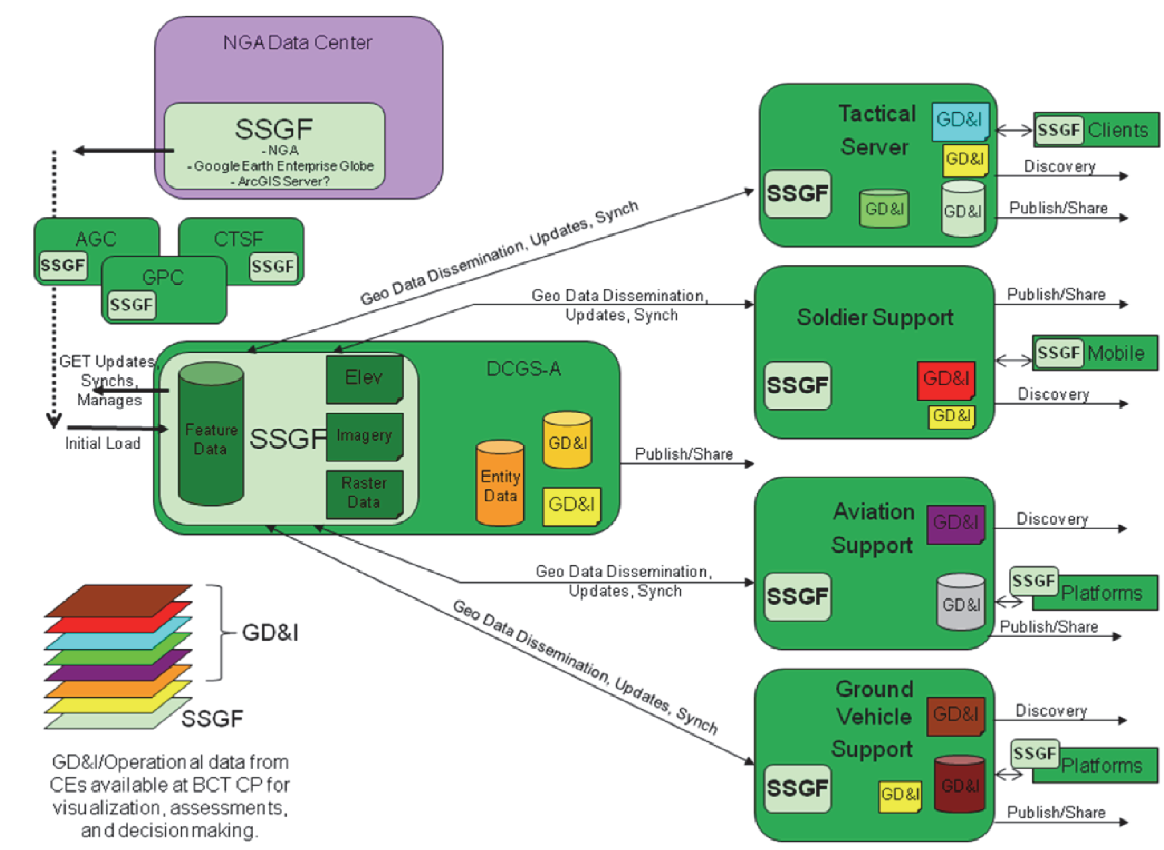
2-17. The AGE makes use of common suites of geospatial software that operate on standards, protocols, specifications, and common engineering principles described above to support the management of geospatial foundation and geoenabled warfighting function data, geospatial analysis, visualization, exploitation, and dissemination. Many currently available viewers render most known data types and formats and adhere to multiple geospatially related standards. Mission command systems require viewers that support common and shareable geospatial data and service standards for interoperability, visualization, analysis, and data update. The DCGS-A is the main tool used by geospatial engineers to manage the geospatial foundation and, as such, will be 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

2-18. The primary manager for the geospatial foundation content for each echelon resides in the respective geospatial engineer team, which serves as the geospatial foundation data manager. This role can be composed of one Soldier or a team of Soldiers. The geospatial foundation data manager is solely responsible for—

- Managing geospatial data within the unit AOR.
- 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.

Note. BCT and below units consuming geospatial foundation data with no organic geospatial engineer team may designate a geospatial data manager (much like a communications security custodian) who can manage data and data loading at their level.



Legend:

AGC	Army Geospatial Center
BCT	brigade combat team
CE	computing environment
CP	command post
CTSF	central technical support facility
DCGS-A	Distributed Common Ground System–Army
elev	elevated
GD&I	geospatial data and information
geo	geospatial
GET	geospatial engineer team
GPC	geospatial planning cell
NGA	National Geospatial-Intelligence Agency
SSGF	Standard and Shareable Geospatial Foundation

Figure 2-4. SSGF data flow

AUTHORITATIVE DATA SOURCES

2-19. Identifying authoritative data sources is part of the Army network centric data strategy. The chief information officer or assistant chief of staff, signal, are responsible for developing a repeatable process to identify authoritative data sources and establish an authoritative data source registry. Authoritative data sources are vetted and approved by data stewards as members of the data board. The geospatial information officer serves as the geospatial data steward. The data board will resolve potentially contradictory sources and coordinate with Department of Defense-wide governance bodies to reconcile and adjudicate authoritative sources. Once a proposed source is certified as authoritative, it becomes registered in the authoritative data sources registry so that other users can determine which (of the many) sources containing the needed information is authoritative and ensure that the most accurate, timely, and trusted data is obtained. NGA and the Army Geospatial Center are examples of authoritative data source producers within the Department of Defense. The theater geospatial data store is an example of authoritative data; however, the GPC data stores or repositories are not. They hold some authoritative data and products (such as common map background), but they also hold much data that is not authoritative (such as crowd-source and open-source data).

WARFIGHTING FUNCTION DATA

2-20. During precombat operations, the mission command system for each warfighting function obtains an initial load (such as elevation, features that are available as vector data and as real-world objects on scanned maps and charts, and controlled imagery) of geospatial data that is available for the AOR that is derived from the geospatial foundation. This enables each mission command system to have the same geospatial data background that is compatible with the geospatial foundation. 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 derived from warfighting function data stores or activities that drive changes in the geospatial foundation layers (such as a bridge being destroyed) are submitted to the geospatial foundation data manager for validation and are synchronized with the geospatial foundation using semiautomated processes.

TWO-WAY DATA FLOW

2-21. Two-way data flow is essential for achieving relevant situational awareness across platforms, command posts, and training and mission rehearsals. As an infrastructure component of the AGE, two-way data flow takes full advantage of the power of a geographic information system. Specifically, the AGE will leverage the geospatial services that will support mission command and, ideally, the ability to readily collect, manage, and share geospatial foundation information between platform, command post, and geospatial data stores across each echelon. Initially, mission command systems will pass applicable geospatial data collected to a geospatial engineer team to validate and insert into the geospatial foundation. The result is geospatial foundation data interoperability and synchronization and a unified geospatial foundation layer in the COP of increased quality and timeliness for a more efficient decision process. This geospatial foundation data interoperability extends beyond the platform and command post and ensures that the relevant and updated geospatial foundation information is available for use in mission rehearsals.

DATA STORES SYNCHRONIZATION

2-22. Synchronization is a geospatial foundation data manager function in the management of the geospatial foundation. When properly integrated, geographic information systems and an array of standards and compliant data management software will provide the capability to update, manage, synchronize, and disseminate changes to the geospatial data encompassed in the geospatial foundation content. This will ensure that the most current and accurate data are available to the geospatial community. Synchronization is a process that propagates changes made in one geospatial data store to one or more other geospatial data stores. Any geospatial data changes must ensure that the pedigree of the data is maintained throughout the community (national, joint, Army) and that synchronization can occur without conflict or loss of data. Geospatial data pedigree retention will be implemented via a geospatial, community-wide, defined governance process. Department of Defense discovery metadata standards allow the identification of the author, publisher, and sources contributing to the data, allowing users and applications to assess the derivation of the data (such as a data pedigree). The source and lineage of the data are its pedigree. The purpose of the pedigree is to enable consumers to determine whether the data is fit for the intended use and to enable them to track the flow of information, its transformations, and modifications. This metadata allows users and applications to select data from known authoritative sources. To minimize synchronization challenges, open geospatial consortium standards (Web map service, Web feature service) will be required to ensure the proper exchange of geospatial data between applications and the geospatial foundation. Within the operational environment, synchronization can be performed during connected and disconnected operations, based on mission, enemy, terrain and weather, troops and support available, time available, and civil considerations. It must be done to the level of sufficiency necessary to ensure the adequate conduct of critical functions where network capability is degraded or constrained. At the last tactical mile, a notification of routine updates will be facilitated by variable message format KO1.1 free text message via combat net radio so that, when received, the update can be scheduled via the publish and subscribe service and data dissemination device. Conversely, large updates will likely require hard media or temporary high-bandwidth direct connections.

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

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Chapter 3
Roles and Responsibilities

Geospatial engineering is one of three engineer 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 AND ABOVE

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 topographic engineer company or GPC to provide geospatial engineering support. GPCs are the only units in the Army force structure with a unique, dedicated geospatial data generation capability. Based on the scope of the data generation mission, GPCs may be augmented with task-organized topographic engineer company support to enhance the data generation capability. The topographic engineer company 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.

Geospatial Planning Cell

3-3. The GPC is the theater geospatial engineering asset that was designed specifically to manage geospatial data in support of operations within a combatant command area of operations. In recent years, the GPC has taken on the arduous task of generating geospatial data in support of operations in a single theater. The data is produced in the form of topographic line maps, image maps, and tactical decision aids while maintaining and updating the theater geospatial database (TGD). A GPC is attached to each theater army for mission command, Uniform Code of Military Justice, and other administrative functions. Although a separate detachment, it is designed to function as a staff section subordinate to the ASCC Engineer. The GPC is usually collocated with the theater military intelligence brigade. This ensures that the GPC has access to the data, intelligence, and connectivity that it needs to perform the specific mission of generating, 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 its ASCC battle staff and major subordinate commands to generate and analyze terrain data; prepare decision graphics, image maps, anaglyphs and three-dimensional 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.

3-4. GPCs collect, manage, and disseminate the TGD for the units operating in the GPC AOR. The GPC enhances existing data, generates new geospatial data, and distributes this data to units operating in the AOR, to include multinational mission partners. The GPC also distributes data to NGA for inclusion in the national geospatial data holdings. The GPC coordinates with geospatial engineer teams across the echelons to ensure that a synchronized geospatial data collection effort is incorporated into the TGD that provides a common database for users.

Topographic Engineer Company

3-5. The topographic engineer company includes a headquarters platoon, a field maintenance team, and three analysis platoons. It is a force pool asset that can be employed throughout the Army based on mission requirements. The topographic engineer company provides task-organized geospatial engineering support to theater army headquarters, GPCs, and deployed units that require augmentation. The company provides modules tailored to support the geographic combatant commander; joint task force headquarters; theater army, corps, and division headquarters; GPCs; modular support and functional brigades without organic geospatial engineer teams; other joint or multinational division- and brigade-size elements; and the Federal Emergency Management Agency regions with analysis, collection, generation, management, finishing, and printing capabilities. Because the topographic engineer company is not controlled by a centralized command structure, its effective employment depends on coordination among the parent engineer brigade commander and staff, the geospatial information officer, the ASCC GI&S officer, the ASCC engineer staff officer or G-2, the GPC officer in charge, and the theater military intelligence brigade commander and staff.

CORPS AND DIVISION

3-6. The modular corps headquarters design, combined with robust communications, gives the corps commander a flexible command post structure to meet necessary requirements. The corps headquarters has two command nodes—the main command post and the tactical command post. The corps command post is organized around the warfighting functions and integrating cells.

3-7. The corps and division geospatial engineer teams are assigned to the main command post and partners with geospatial intelligence imagery analysts to form the geospatial intelligence cell (which supports the G-2 and the assistant chief of staff, operations [G-3], and other staff sections and subordinate units as directed) and fuse intelligence and geospatial information into a common picture for the commander, staff, and subordinate units. The team collects and provides updated geospatial data and products in support of corps and division operations. The team performs the following primary tasks:

- Generate.
  - Identify the gaps in geospatial data, and nominate collection.
  - 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 geospatial engineer teams across the echelons).
  - Provide the appropriate geospatial data sets to the mission command systems that ensure a COP.
- Manage.
  - Manage the geospatial information requirements process.
  - Manage the geospatial content of the three-dimensional 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 Soldiers used as sensors. Incorporate the data into the enterprise geospatial database.
    - Manage RFIs aimed at fulfilling gaps in the geospatial information.
- Analyze.
    - Perform terrain analysis.
    - Validate, extract, analyze, fuse, and produce relevant data and products for decisionmaking or operations.
    - Provide tactical decision aids to support decisionmaking.
- 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.
    - Create map loads for mounted and handheld platforms.

Engineer Brigades

3-8. The engineer brigade is unique due to their geospatial capabilities that allow for the efficient provisioning and collection of geospatial data in theater and the submission of consolidated data back to the GPC for inclusion into the TGD. The engineer brigade commander is designated as the Army geospatial officer in the joint operations area and directly supports a deployed corps headquarters. The geospatial engineer team is part of the geospatial intelligence cell and is responsible for the analysis and production of geospatial products. The geospatial engineer team coordinates in theater geospatial requirements and ensures that units operate off the SSGF. The geospatial engineer team also performs database management for the storage of imagery, maps, digital databases, and collateral source materials.

Functional Brigades

3-9. Geospatial engineer teams provide GI&S support to functional brigades, some of which have unique geospatial needs (aviation and fires). They support the unique needs of these brigades (safety of navigation needs for aviation and targeting databases for fires).

Brigade Combat Team and Below

3-10. The geospatial engineer team is organic to the BCT and the armored cavalry regiment. The team selects functional brigades to perform the analysis, management, and dissemination of geospatial data and products in support of mission requirements. Namely, the combat aviation brigades and maneuver enhancement brigades consume a great deal of geospatial information to accomplish the mission, although both have different mission sets. The geospatial engineer team maintains the brigade enterprise geospatial database on the geospatial server and provides updates to the brigade AOR within the TGD. It validates information for inclusion in the enterprise geospatial database that is obtained or received from subordinate elements as a result of information collection operations. The team partners with geospatial intelligence imagery analysts (organic to or augmenting the brigade) 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 geospatial engineer teams perform similar geospatial engineering missions as the corps and division teams, but with major emphasis on the following capabilities:

- Generate and analyze geospatial data.
- Provide terrain products, and produce tactical decision aids (terrain analysis) to facilitate decisionmaking.
- Produce image maps.
- Manage the enterprise geospatial database.

3-11. Understanding that geospatial engineering provides commanders with terrain analysis and visualization improves situational understanding and enhances decisionmaking during planning, preparation, execution, and assessment. The geospatial engineer team must have a clear understanding of the mission and the commander's intent to ensure a proactive geospatial engineering effort throughout the operations process that is aimed at providing the right information at the right time to facilitate decisionmaking. 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 identification of avenues of approach, mobility corridors, and chokepoints.
- Enhancing rehearsals and reconnaissance missions with the use of three-dimensional fly-throughs, three-dimensional anaglyphs, or simulations.
- Facilitating the positioning and routing of ground and aerial surveillance assets through LOS analysis.

UNIT AND STAFF RESPONSIBILITIES

3-12. 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 engineer 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 standing 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.

TOPOGRAPHIC ENGINEER COMPANY COMMANDER

3-13. The topographic engineer company commander coordinates through the parent engineer brigade with the geospatial information office, GPCs, theater military intelligence brigade, 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 company commander performs the following tasks:

- Coordinates with GPCs, the ASCC G-2, or engineer staff officer to ensure—
  - Two-way synchronization and updates for each TGD.
  - Synchronized data generation efforts in support of each TGD.
  - Deployable modules (augmentation) that are tailored to meet the ASCC requirements.
- Coordinates with the corps, division, and brigade to ensure that—
  - Deployable modules (augmentation) 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 engineer teams and GPCs.
  - Procedures are established for effectively transferring updated SSGF data on mounted and handheld platforms.

TOPOGRAPHIC ENGINEER COMPANY OPERATIONS OFFICER

3-14. The topographic engineer company operations officer coordinates for the deployment of geospatial engineering modules in support of Army requirements. The operations officer also coordinates for rear detachment operations in support of deployed modules.

Analysis Platoon Leader

3-15. The analysis platoon leader is responsible for leading the analysis platoon and for providing effective geospatial engineering support. The platoon leader works with the platoon geospatial engineering technician to ensure the training and readiness of the platoon.

Analysis Platoon Geospatial Engineering Technician

3-16. The analysis platoon geospatial engineering technician trains and supervises the platoon in conducting geospatial engineering operations. The technician works with other geospatial engineering technicians in the GPC, and echelons-above-brigade and BCT geospatial engineer teams to ensure the synchronized transfer of geospatial data among these organizations. The geospatial engineering technician also performs the following tasks:

- Supervises database management operations and data exchange between the 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

3-17. 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 Army Geospatial Center 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 gain foreign disclosure to maintain the enterprise.

Geospatial Planning Cell Operations Officer

3-18. 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 in order to support ASCC missions and planning operations. The GPC operations officer also coordinates with subordinate and Regionally Aligned Forces to provide geospatial data, products and services (to include the SSGF) from the GPC for those units conducting plans and/or operations in support of theater operations.

Engineer Staff Officer

3-19. 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 their section of assignment, the engineer staff officer ensures the synchronization of the overall engineer effort.

3-20. Although the officer in charge is responsible for the organic geospatial engineer team and geospatial intelligence cell operations, the engineer staff officer remains responsible for the integration of geospatial engineering throughout the operations process and does so by performing the following tasks:

- Generate.
  - Coordinate with the S-2/G-2, S-3/G-3, other staff elements, and the geospatial engineering technician for terrain products that will help describe the physical environment to the commander and staff, facilitate a better understanding of the operational environment, and enable decisionmaking.
  - 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 engineering 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 engineering technician in concert with the 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 recommendations on the priorities of geospatial engineering to the S-2/G-2 that coincide with the geospatial engineer team and geospatial intelligence cell.
    - Establish procedures for effectively transferring updated SSGF data on mounted and handheld platforms.

GEOSPATIAL ENGINEER

3-21. 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 provide the commander with a common view of the terrain, through terrain visualization, that enables him to understand and describe his intent.

3-22. 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, topographic survey, site survey, data mining, and satellite imagery.
    - Submit requests for geospatial information from the NGA, Army Geospatial Center, 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 area of operations, 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 geospatial data, digital and hardcopy, in an enterprise environment.
    - Update the geospatial engineer 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 ENGINEERING TECHNICIAN

3-23. Geospatial engineering 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. This enables a proactive geospatial engineering effort aimed at providing the right information at the right time to facilitate decisionmaking. The geospatial engineering technician serves as the officer in charge at the BCT level. At echelons above brigade, the geospatial engineering technician may serve as the officer in charge of the geospatial intelligence cell and collaborate with geospatial intelligence imagery analysts to produce geospatial intelligence. However, intelligence oversight is still the responsibility of the senior geospatial intelligence imagery analyst. Although the geospatial intelligence cell is located within the sensitive, compartmented information facility, geospatial engineering 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 engineering 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 geospatial engineer team.
- Manage.
    - Supervise the geospatial engineer team 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 geospatial engineer team quality control of geospatial data stored in the enterprise geospatial database.
  - Work with the S-2/G-2 in establishing the priorities for the geospatial engineer team 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 intelligence 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, facilitates a better understanding of the operational environment, and enables decisionmaking.
  - Establish and maintain communications with geospatial engineer elements at all echelons within the area of interest to foster the lateral and horizontal collaboration for operations and foster 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

3-24. Although the engineer staff officer has overall responsibility for the integration of geospatial engineering, the S-2/G-2 are responsible for the geospatial engineer team and performs the following tasks:

- Plan.
  - Provide overwatch to the engineer staff officer and geospatial engineering technician who integrate 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 decisionmaking.
  - Work with the S-3, G-3, and geospatial engineering technician to establish priorities for the geospatial engineer team.
- 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 engineering 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, the staff, and subordinate units.
    - Monitor the provision of geospatial information and tactical decision aids in each staff section running estimate.

BRIGADE OPERATIONS STAFF OFFICER

3-25. The S-3 works with the S-2 in synchronizing the geospatial engineer team 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

3-26. 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 will use geospatial information and other tactical decision aids in planning main and alternate supply routes.

BRIGADE PLANS STAFF OFFICER

3-27. The battalion or brigade plans staff officer is responsible for providing the geospatial engineering technician with guidance that will facilitate future planning or the formulation of branches, sequels, change 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 will best depict those aspects of the terrain that are most important to the commander at a given point in the planning phase or that will facilitate future planning or the formulation of branches and sequels.

OTHER STAFF SECTION AND CELL LEADERS

3-28. All staff section and cell leaders are ultimately responsible for integrating geospatial information and tactical decision aids within the respective areas. Critical to this role is ensuring that geospatial information requirements are relevant and mission-essential. This prevents overloading the geospatial engineer team and helps focus their efforts. Staff section and cell leaders must clearly communicate the requirements and expectations to ensure that generated geospatial products meet the intent on 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 will help manage the geospatial engineer 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 centers 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, the operations process, and as a part of the integrating processes.

COMMON OPERATING ENVIRONMENT

4-1. As geospatial technologies enhance situational understanding, information superiority for commanders and battle staffs at all levels is established. It does this by improving the commander's ability to visualize the running staff estimates, MDMP, rapid decisionmaking, and synchronization process through the use of one COP. Furthermore, the functional process that the AGE brings aids in the proposed collaboration efforts that form the interdisciplinary abilities inherent to the operational and intelligence fields as they converge. It will do this by using the SSGF to distribute data to all computing environments, not just the command post computing environment, but data enterprise/data cloud, real-time/safety critical, mobile/handheld, and mounted computing environments.

4-2. At its core, the AGE is a distributed SSGF database and a 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 and generating forces. The SSGF includes map backgrounds, imagery, elevation, and feature data. The SSGF is provisioned as raw data, open geospatial consortium Web services, and three-dimensional globes. The initial geospatial data, services, and globes contain the same version of the SSGF for operational use. 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 in maintaining the initiative and achieving decisive results. As described in ADRP 2-0, support to situational understanding is 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 primarily through IPB. (See figure 4-1, page 4-2.)

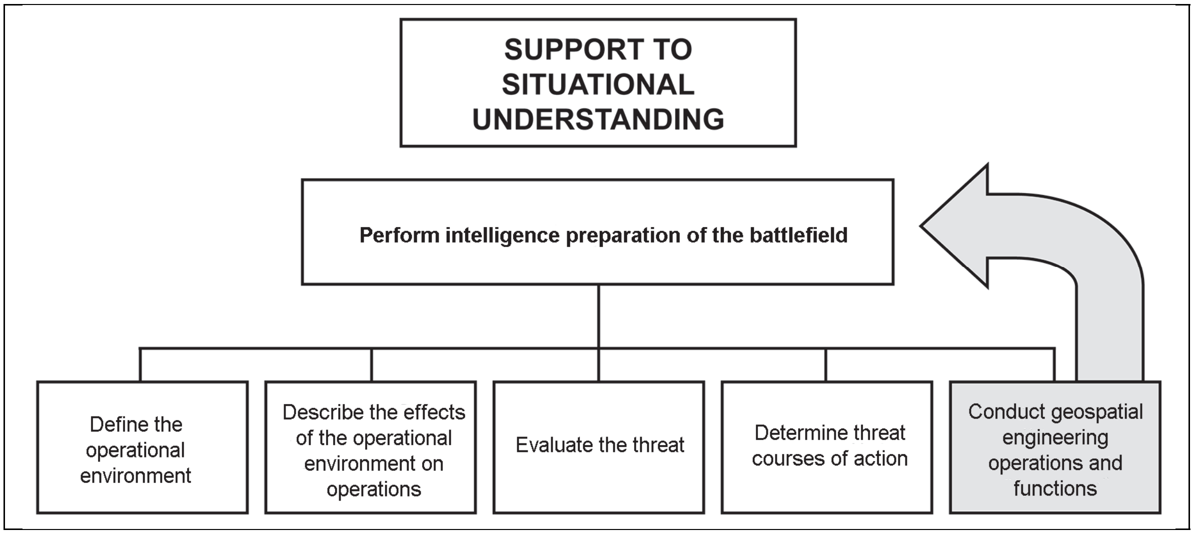


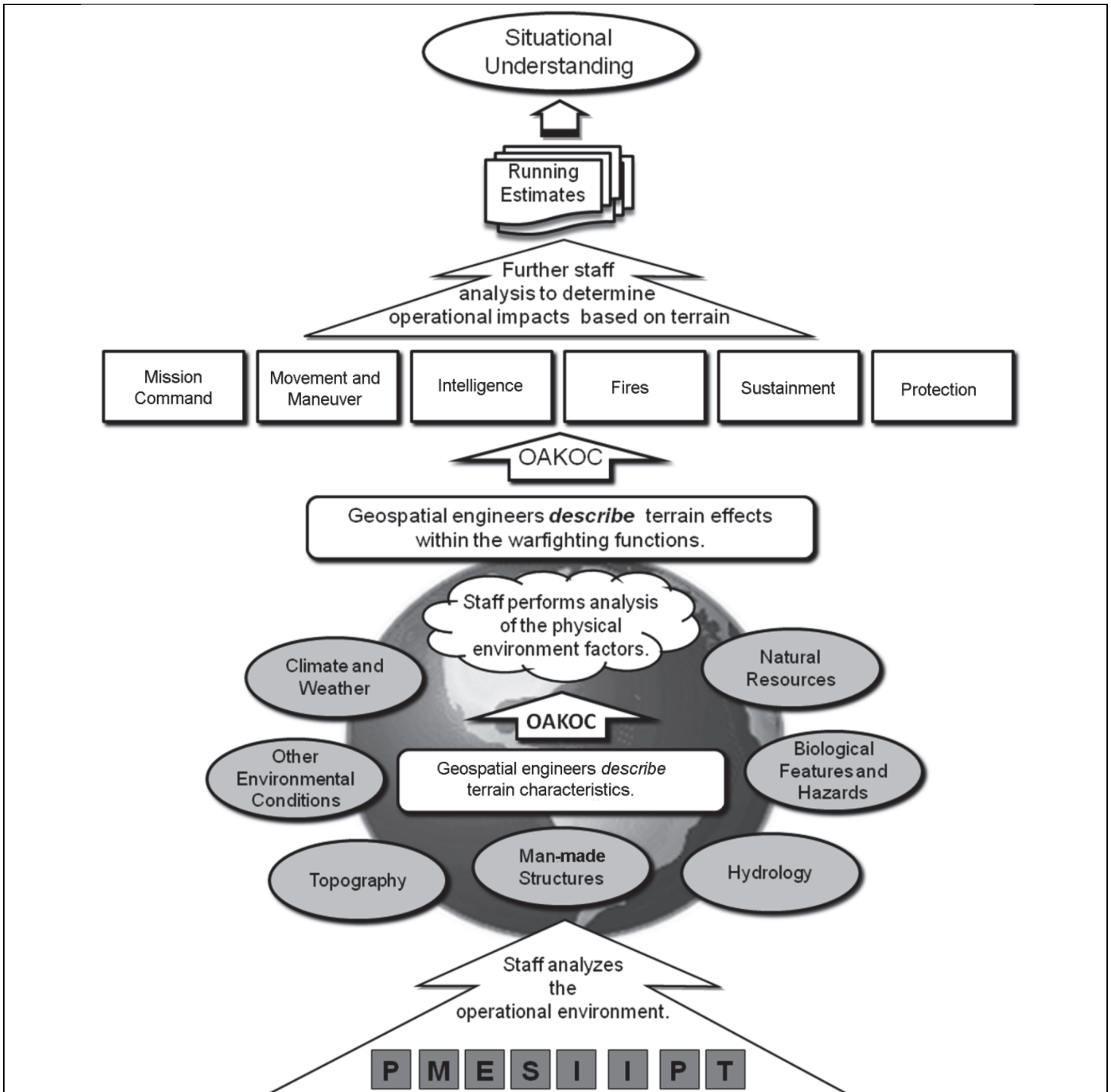
Figure 4-1. Geospatial engineering in support of situational understanding

4-5. Situational understanding aligns with the concept that commanders need to understand and visualize the operating environment to direct, lead, 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 an urban environment or another type of complex terrain by virtue of an asymmetrical threat attempting to offset U.S. advantages. ***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.** Restrictive terrain or environmental conditions include, but are not limited to, slope, high altitude, forestation, severe weather, and urbanization. Commanders will 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. Each staff section shares a role in providing expertise from their perspective and adding depth and breadth to the overall understanding of the operational environment. They seek to identify potential challenges and opportunities associated with political, military, economic, social, information, infrastructure, physical environment, and time factors and use running estimates to provide relevant information that commanders can use to frame operational problems.

4-8. Geospatial engineering contributes to the collaborative analysis of the operational environment by helping the staff better understand and visualize the impacts of the terrain in the areas of expertise. The two primary aspects of the geospatial engineering mission that enable the staff analysis of the operational environment and the commander's situational understanding based on the conditions of the physical environment are terrain analysis and terrain visualization. Geospatial engineering provides the geospatial foundation on which other geospatial information about the physical environment and other operational variables is based. Geospatial engineers facilitate the staff analysis of the operational and mission variables by describing the physical environment. (See figure 4-2.)



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. The concept of describing the physical environment is initiated by geospatial engineers and staff specialists in a collaborative analysis of the factors that affect the physical environment. (See ADP 3-0.) 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 that will enable a more thorough analysis of the physical environment. As the staff analyzes political, military, economic, social, information, infrastructure, physical environment, and time factors, geospatial engineers steadily improve their knowledge of the terrain, based on newly generated or acquired geospatial data that enables a more detailed analysis of terrain characteristics. As planning progresses, geospatial engineers shape the analysis, based on the refinement of the commander's intent and added clarity on likely missions. As it is acquired, additional information on the terrain effects is disseminated by geospatial engineers to the staff in a combination of written and visual form that correspond to the warfighting functions. (See table 4-1.) In turn, the staff assimilates that information into running estimates to assess friendly and threat capabilities (based on the effects of the terrain) in the areas of expertise and determines the operational impacts from individual perspectives. 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 common operational picture. • 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 the targeting process. • Template observer and firing points based on visibility and suitability. • Analyze mobility to facilitate the positioning of artillery systems.
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: IPB intelligence preparation of the battlefield LOS line of sight SSGF Standard and Shareable Geospatial Foundation	

4-10. The geospatial information that is presented (described) to the staff is tailored (formatted) to meet each staff section needs. Geospatial products can 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 can be determined based on staff training exercises and operational experiences. Standardizing these staff requirements, especially those routinely needed in certain steps of the MDMP, can help leaders realize the geospatial workload and allow the geospatial effort to be prioritized and sequenced accordingly. This also allows base products to be built ahead of time, maximizing the time available for planning. These products can be periodically reviewed and updated as new information and time becomes available. Capturing these requirements and activities in standing operating procedures will improve staff efficiency and facilitate 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 favor 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 and the employment of forces, 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 affects operations. In contrast to climate (the prevailing pattern of temperature, wind velocity, and precipitation in a specific area measured over a period of years), 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 cycle 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 line-of-sight 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 line of sight 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.

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 may be briefed in any 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 desired condition depends on the effective collection, management, and dissemination of geospatial data at every echelon from combatant command to deployed BCT.

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 (line of sight) 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.
Avenue 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: OAKOC observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment	

TERRAIN VISUALIZATION

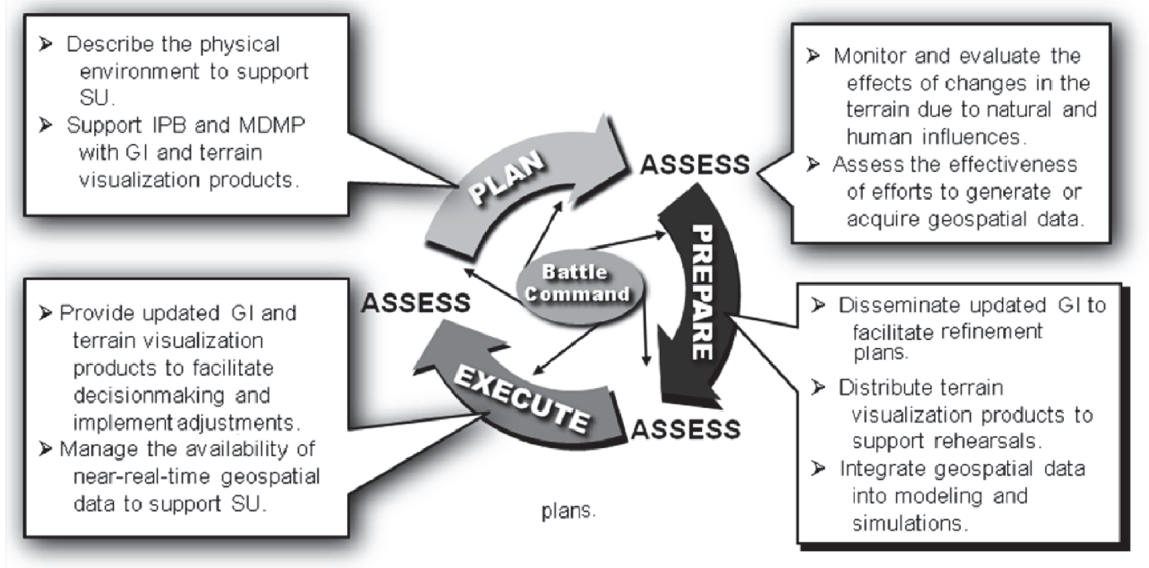
4-15. Engineers at every echelon are considered terrain experts. As such, they present terrain-related relevant information to commanders and staffs to help them conceptualize important aspects of the physical environment and to support decisionmaking. To do so, they first must be able to identify challenges 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 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 help others 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 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. The cyclic activities are usually not discrete; they overlap and recur as circumstances demand. Throughout the process, the four major functions of geospatial engineering (generate, 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 decisionmaking. The engineer staff officer is the primary staff integrator for the geospatial engineer tasks and works together with the general engineering 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 decisionmaking process
SU	situational understanding

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

Plan

4-19. After collecting requisite SSGF data, planning begins with the analysis and assessment of conditions in the operational environment. In a continuation of the ongoing analysis of political, military, economic, social, information, infrastructure, physical environment, and time 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 will be needed during execution. The MDMP also synchronizes several processes (IPB, targeting, risk management) that are 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), as further discussed in paragraph 4-44. 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. The generation of geospatial data centers on fulfilling the geospatial information requirements established during IPB and those resulting from the staff analysis of the operational environment as the running estimates are prepared. Other geospatial data requirements in the form of RFIs will also be 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 area of operations.
	  ▪ 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 area of operations 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 area of operations 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	• Provide 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 engineer capabilities, and critical infrastructure. Recommend CCIR 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 will aid planners in positioning friendly capabilities.
COA analysis	• Integrate terrain products that will 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 perspective.
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 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:

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 decisionmaking 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 on the military aspects of the mission across the warfighting functions. Geospatial information enables the overall staff planning effort conducted during the MDMP and planning refinement that continues through preparation.

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 also disseminated to subordinates in conjunction with the issuance of warning orders to facilitate parallel planning. Geospatial information distributed to subordinates should be referenced in orders and relevant to the other mission information provided. This avoids overloading users with information and deterring independent analysis. Geospatial engineers also ensure the proper dissemination of new maps and 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 and other attachments. Marked improvements in geospatial software and bandwidth capacity have eased the ability to electronically disseminate geospatial products in digital formats (such as geospatial portable document format files). 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 additional information on the general format for orders and attachments.)

4-25. While corps and BCT and below units normally conduct tactical planning, Army forces frequently participate in or conduct joint operations planning. For example, 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 engineer 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. A key preparation activity is 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 information 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 will be generated as a result of subordinate planning. The staff will also continue 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 three-dimensional fly-throughs and perspective views from projected friendly unit positions resulting from predicted outcomes. 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 to-scale and echelon-appropriate, high-resolution geospatial data.

4-29. Based on the success of geospatial engineering efforts initiated during planning, the acquisition of new geospatial data and updated geospatial information should facilitate planning refinement and enable the staff assessment of the current situation using mission variables.

Manage

4-30. 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

4-31. 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.

Disseminate

4-32. 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

4-33. Execution is putting the plan into action. It involves monitoring the situation, assessing the operation, and adjusting the order as needed. Commanders continuously assess the operation 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 decisionmaking, and promoting responsiveness in implementing adjustments.

Generate

4-34. As the situation develops throughout execution, geospatial engineers must be prepared to respond to new geospatial information requirements generating from ongoing integrating processes, continuing activities, adjustments in the commander's critical information requirements, or modifications to the concept of operations.

Manage

4-35. Geospatial engineers continue to maintain geospatial databases and incorporate, as appropriate, new or updated GD&I into the SSGF resulting from information collection, reachback, or unit operations to maintain situational understanding, to update the geospatial engineer running staff estimate, and to provide special support to developing situations.

Analyze

4-36. 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 corrective actions (adjustments) based on an assessment of the effects of those variances, the geospatial effort gears toward facilitating the repositioning of capabilities based on an appreciation of the terrain.

Disseminate

4-37. Geospatial engineers ensure the availability of near-real-time geospatial information through common access databases, Web mapping services, and shared content. This allows friendly forces to execute operations at a tempo that the threat cannot match and to act or react faster than the threat can adapt.

Assess

4-38. 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, which provide information from the perspective of each staff section, 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

4-39. Throughout the operations process, the geospatial engineering effort is managed to generate the geospatial information that the staff needs to accurately assess the situation and make adjustments as necessary. Multiple geospatial information requirements will be generated simultaneously 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

4-40. 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

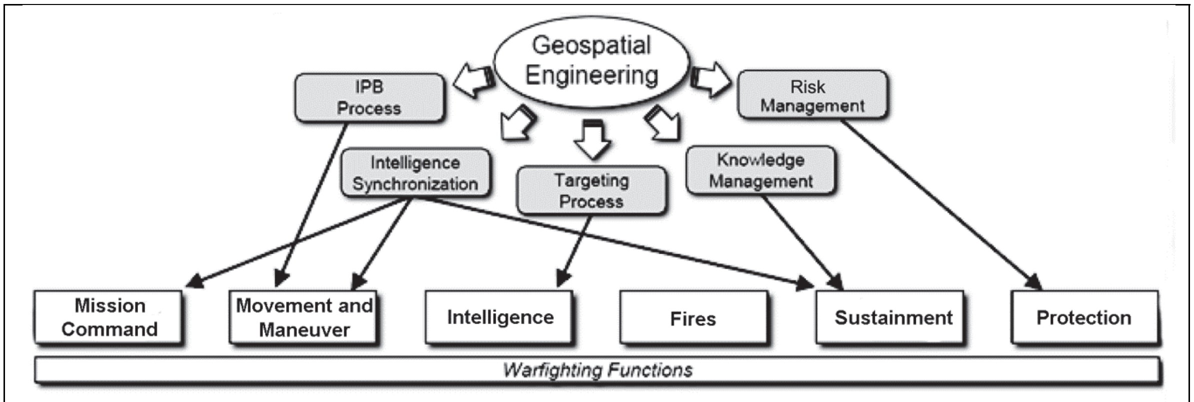
4-41. During assessment, geospatial engineering focuses on helping staffs maintain running estimates through terrain analysis that highlights the impact of changes in the terrain due to natural and human influences. For example, sudden changes in weather (such as heavy precipitation) may require that 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). Reduced visibility due to fog or dust can impact LOS-based surveillance assets. When adjustments are necessary, geospatial engineering facilitates the repositioning of friendly capabilities with LOS analyses and 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.

Disseminate

4-42. 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 new maps and updates to maintain the integrity of the map foundation and allocation for the units. Geospatial engineers maintain, update, and publish common map background data and information in support of the COP.

Integration

4-43. 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, page 4-14.)



Legend:
IPB intelligence preparation of the battlefield

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

INTELLIGENCE PREPARATION OF THE BATTLEFIELD

4-44. IPB is an integrating process and occurs during all operations process activities. As described in FM 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. The analysis includes enemy, terrain, weather, and civil considerations.

4-45. 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 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 area of operations and the area of interest. 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 in respect to critical aspects of possible COA.

Legend:
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

4-46. 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, based on the identification of the area of interest and area of operations, geospatial engineers identify gaps in the coverage and availability of geospatial data and geospatial information for the area of operations and area of interest. 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.

4-47. Geospatial engineers analyze the factors of the physical environment using OAKOC in consideration of 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

4-48. Describing the operational environment effects involves evaluating the aspects of the operational environment that both sides must contend with and the description always includes an examination of terrain, weather, and civil considerations. This step consists of two parts: analyzing the environment and describing its effects on threat and friendly capabilities. Geospatial engineering supports this step by describing to the staff the results of the analysis initiated during the first step. Describing the terrain effects on threat and friendly capabilities enables the staff a further analysis of the operational environment to determine the operational impacts from their perspective.

Evaluate the Threat

4-49. Threat capabilities are evaluated based on threat missions and objectives. For geospatial engineers, this step is a continuation and refinement of the ongoing terrain analysis initiated in earlier steps that remains aimed at helping each staff section better understand the terrain effects on the threat capabilities within the respective areas of expertise. Geospatial engineers concentrate the analysis and evaluation of terrain effects based on geospatial information requirements generated by the staff as it collectively furthers its understanding of threat capabilities. Geospatial engineers incorporate the results of information collection operations, RFIs, and reachback into their analysis and disseminate geospatial information to further the staff analysis. In a 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

4-50. 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 support this step by providing geospatial information and terrain products that help minimize the number of considered COAs based on the effects of intervening terrain. Terrain suitability products are used to 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, such as the terrain effects on mobility or rates of march based on threat vehicle capabilities. Geospatial products that visually highlight those advantages and disadvantages of the terrain for each of the COA evaluation criteria can enable decisionmaking, such as cross-country mobility and movement rates.

INFORMATION COLLECTION

4-51. Information collection contributes significantly to the commander's visualization and decisionmaking. Through information collection, 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. Synchronization is one of the four tasks of surveillance and reconnaissance. *Synchronization* is the arrangement of military actions in time, space, and purpose to produce maximum relative combat power at a decisive place and time. (JP 2-0) Information collection is continuous and is used to assess information collection reporting. (See ADRP 2-0, ATTP 2-01, FM 3-55, and JP 2-03 for more on information collection.)

4-52. Terrain analysis helps the intelligence staff employ collection assets that allow maximum effectiveness without exposing those assets to unacceptable risks. Terrain can mask a target from direct observation or restrict mobility of the information collection asset. 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.

4-53. The staff collectively determines information requirements during the IPB that will focus information collection in generating intelligence 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, Army Geospatial Center).

TARGETING

4-54. Targeting is an integral part of Army operations that determines what targets to attack to achieve the maneuver commander's desired effects and how, where, and when to attack. The targeting working group uses the targeting process to synchronize the effects of fires and maneuver and inform and influence activities with the effects of other warfighting functions. Geospatial engineering supports targeting with high-precision, high-resolution GD&I (for example, 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 to target packets that are otherwise absent from other staff activities. They possess the means to not only allow the commander and staff to visualize the target, but also to understand the complexity of mobility, suitability, and visibility aspects that also impact the decide, detect, deliver, and assess process.

TARGETING PROCESS

4-55. The targeting process is based on four functions—

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

4-56. Like other integrating processes, the targeting process is cyclical and occurs continuously throughout an operation. Its steps mirror those of the operations process—plan, prepare, execute, and assess. Targeting occurs in the 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 geospatial engineering considerations within them. (See ADP 5-0 and FM 3-60 for additional information on the targeting process.)

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 fire support and inform and influence activity-related HVTs. • Provide fire support and inform and influence activity-related input to targeting guidance and targeting objectives. • Designate potential HPTs. • Deconflict and coordinate potential HPTs. • Develop the HPTL. • Establish target selection standards. • 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	• Execute attacks according to the AGM. • Execute inform and influence activity-related tasks.	• 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 attacked with inform and influence-related activities.	• Work with geospatial intelligence imagery analyst (in the geospatial intelligence cell) in performing change detection to assess the effects of targeting operations on buildings, facilities, and other structures.

Legend:

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

Decide

4-57. The decide function is primarily performed during the MDMP. 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 targeting team collaborate and conduct target value analysis for each threat COA to identify potential high-value targets associated with critical threat functions that could interfere with the friendly COA or that are essential to threat success. The completed threat model identifies high-value targets, and the situation template predicts the location. Geospatial engineering helps identify high-value targets by combining 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 threat mission and objectives and the effects of terrain. Geospatial engineers ensure that the S-2/G-2 assesses the importance of those threat capabilities (assets) based on the effects of the terrain and predict where they will be employed in the operational environment. 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

4-58. The detect function involves locating high-payoff targets accurately enough to engage them and is dependent on the results of the information collection effort. Characteristics and signatures of the relevant targets are determined and then compared to potential attack system requirements to establish specific sensor requirements. Information needed for target detection is expressed as a priority intelligence requirement or information requirement to support the attack of high-payoff target and associated essential tasks for fire support. As target acquisition 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. (See paragraph A-17.)

Deliver

4-59. The deliver function occurs primarily during execution, although some inform and influence activities-related targets may be engaged while the unit is preparing for the overall operation. Geospatial engineers have access to high-precision, high-resolution imagery; therefore, the targeting team is not constrained by the accuracy of the common map background used on the firing system. Geospatial engineers assist the targeting team in integrating the results of terrain analysis to determine the types of munitions and delivery means.

Assess

4-60. 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. Geospatial engineers work with geospatial intelligence imagery analysts in the geospatial intelligence cell to perform change detection, which can be used to assess effects on facilities and structures.

Targeting Meetings

4-61. During execution, the targeting working group continually assesses the current situation, tracks decision points, prepares update briefs for the commander, and looks toward the future. The targeting meeting provides a forum for extending the fire support planning that was 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 meeting is an important event in the command post battle rhythm. It focuses and synchronizes the unit combat power and resources toward finding, tracking, attacking, and assessing high-payoff targets. The integration of geospatial engineering in targeting meetings 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 of 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.

4-62. The keys to successful targeting meetings are preparation and focus. Each representative must come to the meeting prepared to discuss available assets, capabilities, and limitations related to their staff area. Much of this preparation will require time-consuming, detailed planning and coordination with other staff sections well in advance. Before the targeting meeting, the engineer staff officer, the general engineering 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 scatterable mines 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, sensitive-site list.

OTHER INTEGRATING PROCESSES

4-63. Geospatial engineers provide support to other integrating processes. Their knowledge of GI&S allows them to use hardware, software, and data to acquire, manage, analyze, visualize, and disseminate tactical decision aids of geographically referenced phenomena. With respect to knowledge and risk management, geospatial engineers have the ability to view, interpret, and display data as a product, service, or three-dimensional globe to determine patterns, relationships, and trends to support mission requirements.

Knowledge Management

4-64. Given the complexity and dynamic nature of operational environments, information must become knowledge that permeates throughout the Army to enable timely decisionmaking. Knowledge management is the art of gaining and applying information using people, processes, and technology. It generates knowledge products and services by and among commanders and staffs. It supports collaboration and the conduct of operations while improving organizational performance. (See FM 6-01.1 for additional information on knowledge management, the knowledge management process, and the roles of the knowledge management section.)

4-65. Geospatial engineers apply knowledge management to effectively transfer knowledge of the physical environment gained through terrain analysis. They work with the knowledge management section, specifically content managers, to implement effective means to apply geospatial information and share knowledge of the terrain to further the staff analysis of the operational environment and enable the commander's situational understanding. Geospatial engineers break down geospatial stovepipes and provide multiple users with rapid accessibility and retrieval of relevant tactical objects and events that are enabled through the effective management of geospatial databases and the map foundation of the COP. They facilitate a near-real-time, collaborative, information-sharing environment by exploiting information systems, knowledge networks, and tactical Web portals.

Risk Management

4-66. Risk management is an integrating process and occurs during operations process activities. Risk management is the process of identifying, assessing, and controlling hazards (risks) that arise from operational factors and balancing that risk 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 cells or working groups throughout the rest of the operations process. Table 4-7 shows geospatial 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*
Identify hazards.	Analyze and describe to the staff those hazards associated with the physical environment.
Assess hazards to determine risks.	Assign risk to each hazard in terms of probability and severity.
Develop controls and make risk decisions.	Determine how terrain (cover and concealment) can be used effectively to enhance survivability.
Implement controls.	Provide appropriate input into mission orders, briefings, running estimates, and standing operating procedures as necessary.
Supervise and evaluate.	Assess the effectiveness of geospatial engineering applied throughout the risk management process, and provide feedback to leaders.

4-67. During mission analysis, the focus is on performing the first two steps, which concern assessment. 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. Geospatial engineers consider the factors that affect the physical environment. Risk is then assigned to each hazard in terms of probability and severity.

4-68. 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, mission briefings, running estimates, and standing 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.

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 decisionmaking. 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 Army Geospatial Center 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.

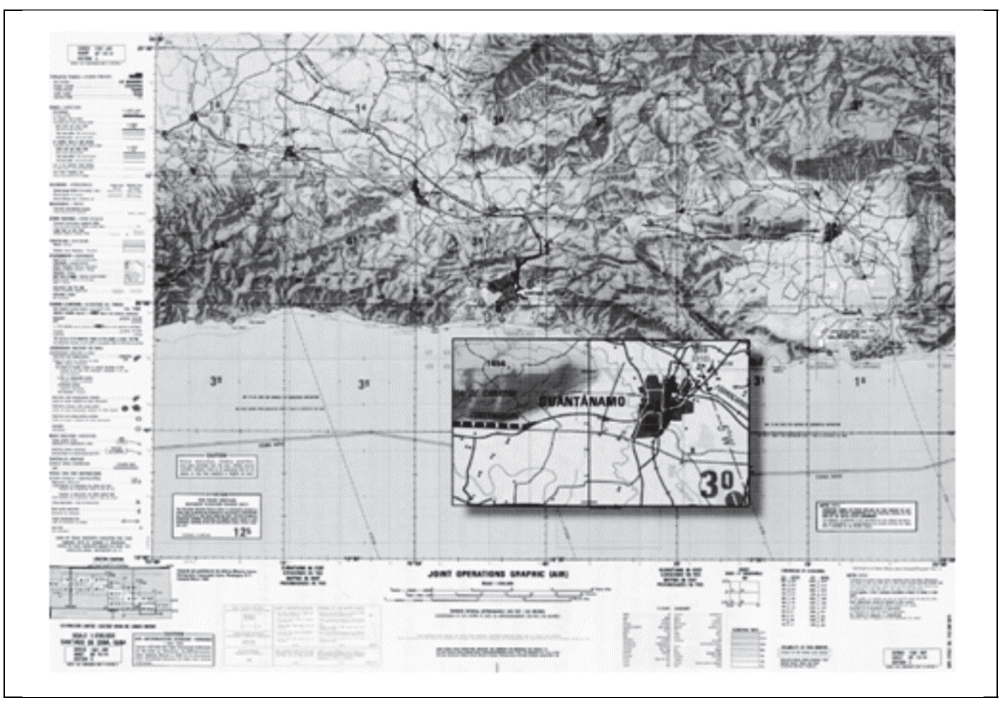


Figure B-1. Example of a joint operational graphic (air) map (1:250,000)

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.

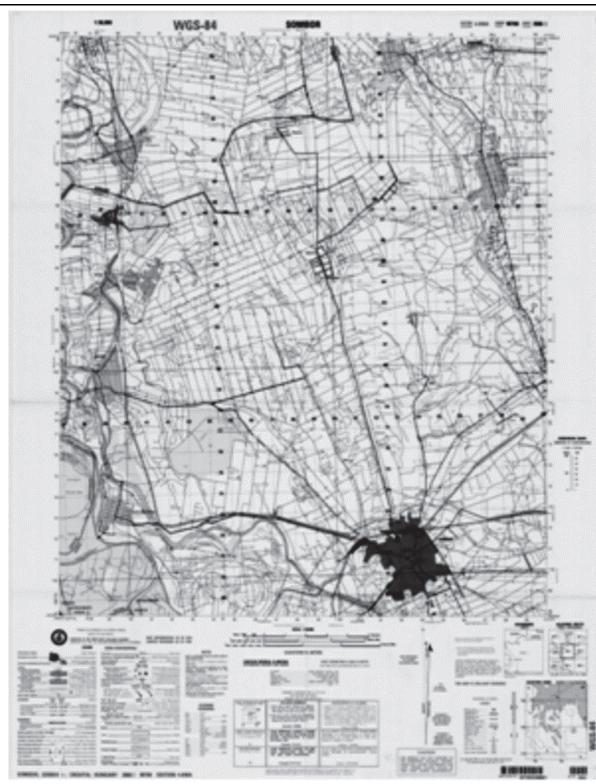


Figure B-2. Example of a topographic line map (1:50,000)

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, map, or elevation background with various layers overlaid on top. These digital layers 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

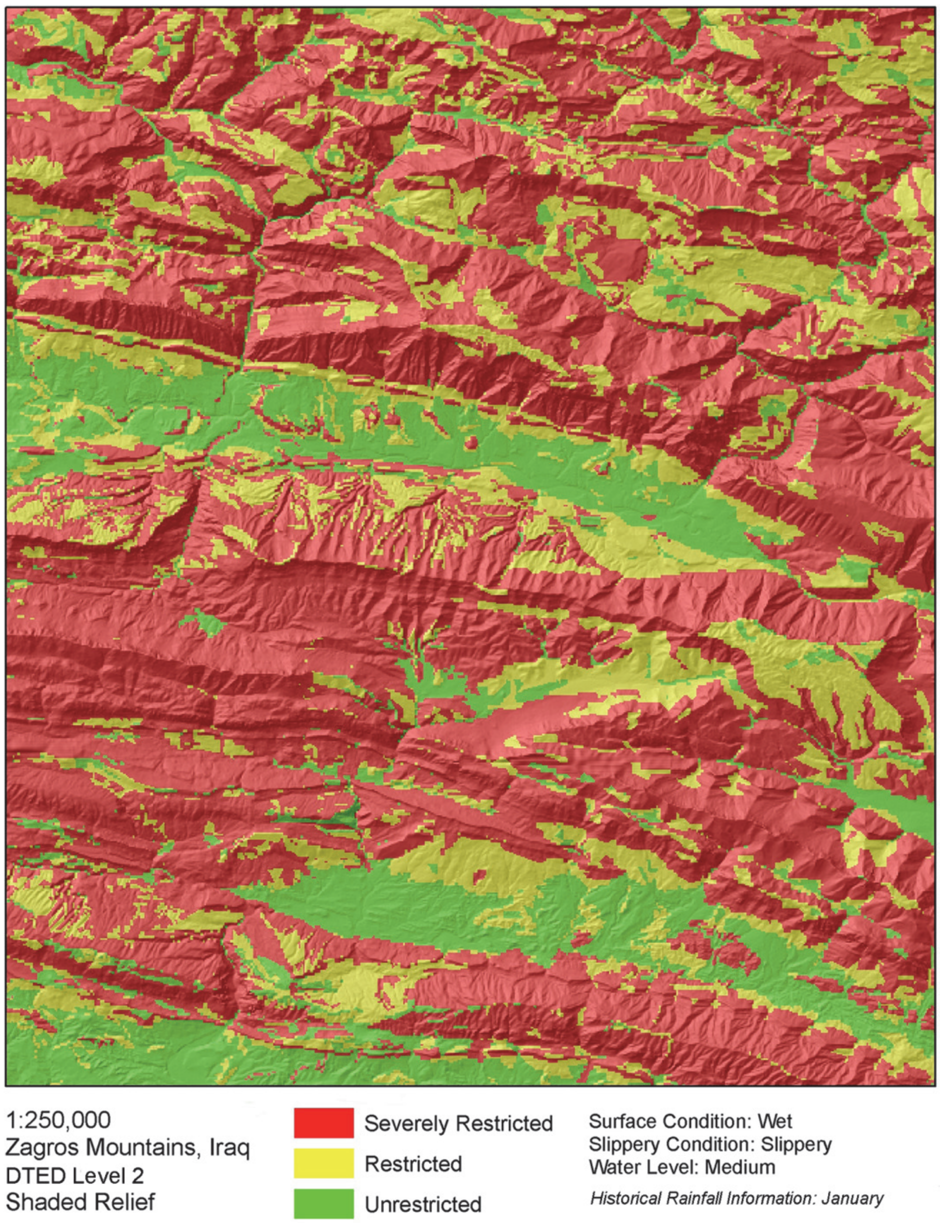
Geospatial Product	*Primary Uses*
Cross-country mobility	Identifies mobility corridors and friendly and threat AAs and EAs.
Linear obstacle	Portrays linear obstacles that impede mobility.
	Combines with cross-country mobility to create a combined obstacle overlay.
Combined obstacle	Identifies mobility 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 area of operations.
Hydrology analysis	Shows the operational impacts of water features in an operational area or area of operations.
Drop zones	Locates possible drop zones in an operational area or area of operations to support airborne operations.
Helicopter landing zones	Locates possible landing zones in an operational area or area of operations 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 area of operations.
Soil trafficability	Shows the effects of soil on trafficability.
Field of fire	Locates defensible terrain in an operational area or area of operations.
	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 area of operations.
Viewshed analysis	Shows areas of direct observation from a given point that can help position LOS-based systems.
Perspective view	Provides three-dimensional terrain visualization from an observer's point of view.
Fly-through	Provides three-dimensional terrain visualization of an area that could be seen from an aircraft.
Urban Tactical Planner™	Displays key aspects of urban terrain to facilitate operating in an urban environment.
BuckEye	Downloadable unclassified high resolution two-dimensional and three-dimensional imagery.

Legend:

AA	avenue of approach
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.) The cross-country mobility is used to help identify avenues of approach and engagement areas.

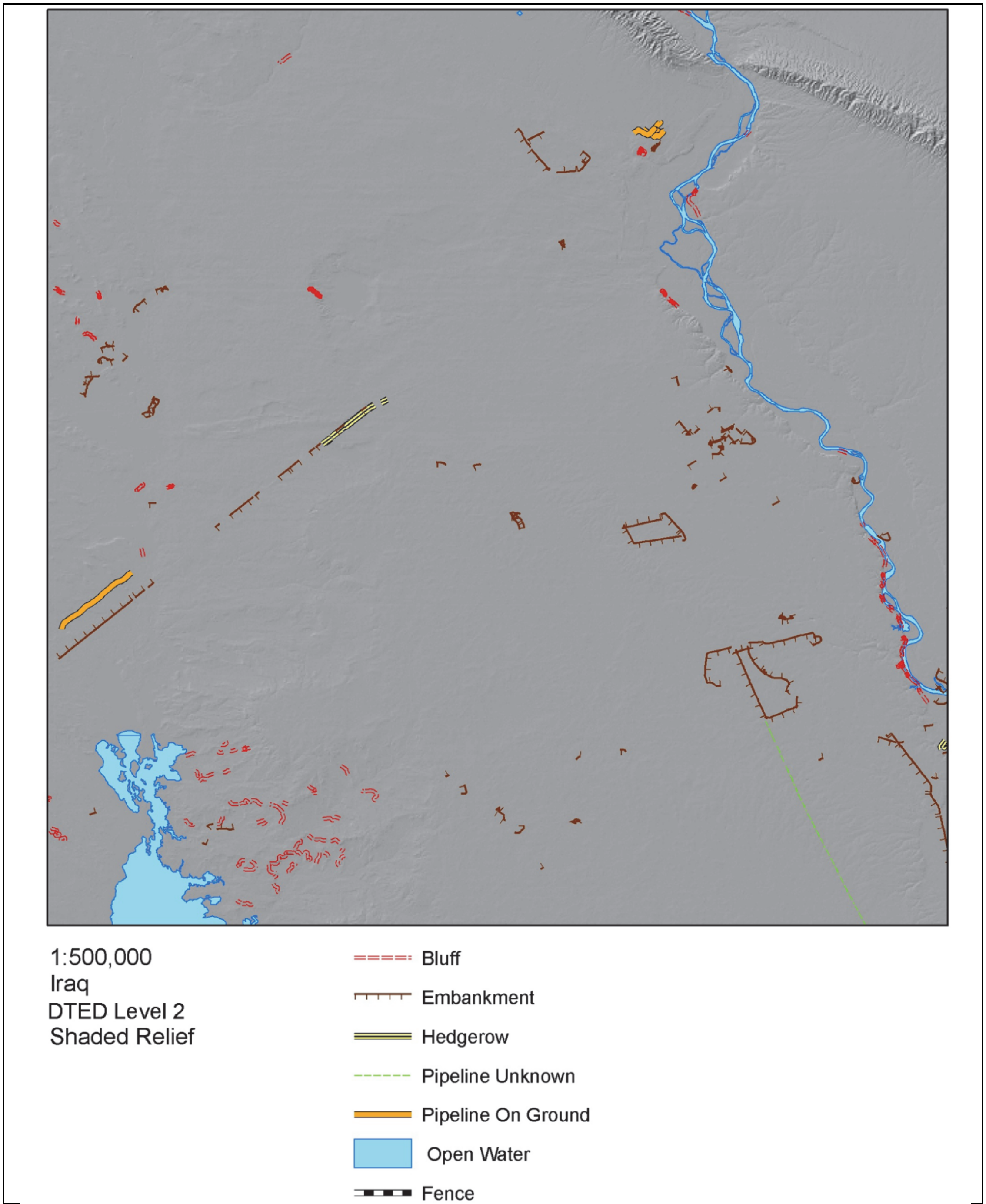


Legend:
DTED digital terrain elevation data

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 as obstacles. (See figure B-4.) This information can be combined with a cross-country mobility product to create a combined obstacle overlay.



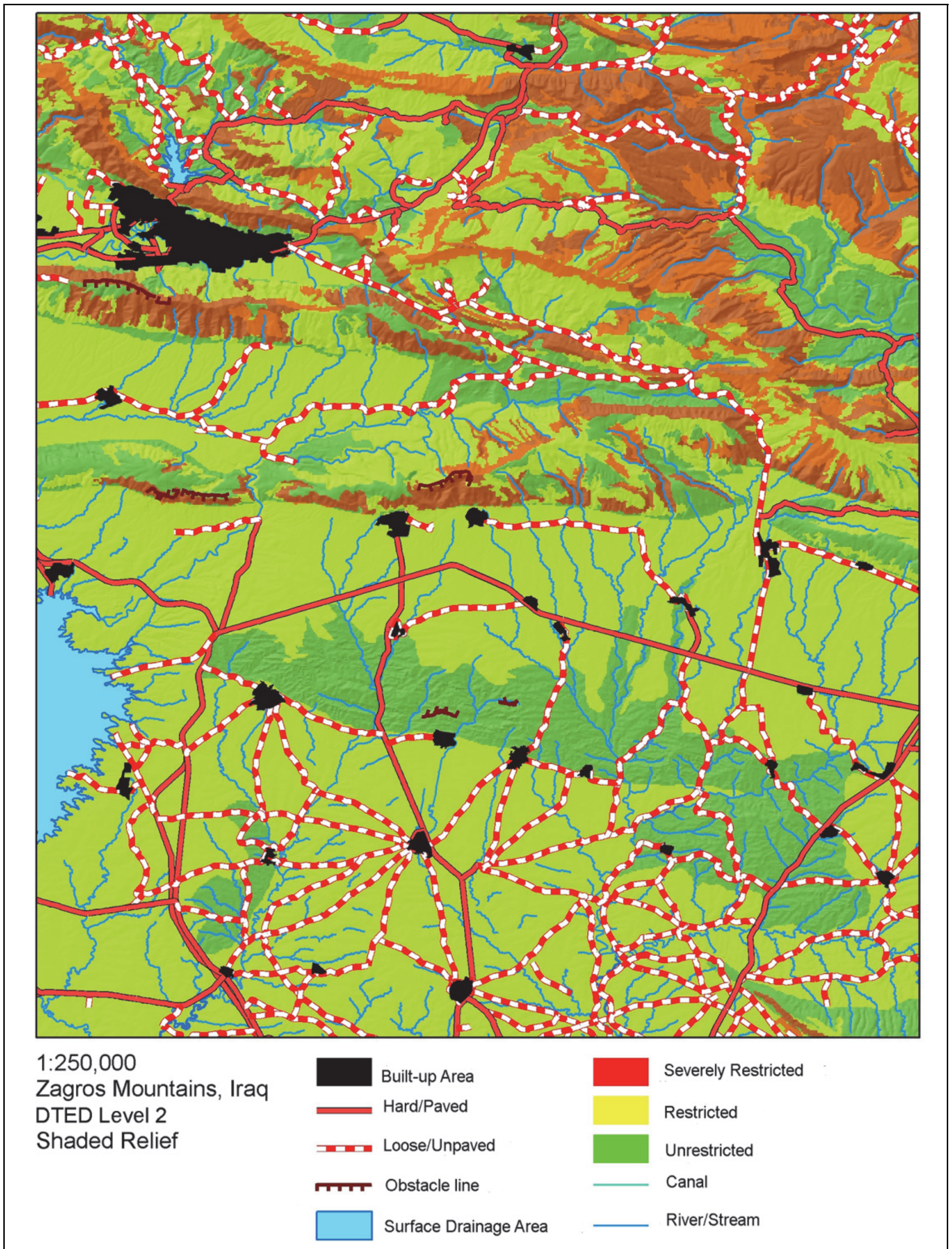
Legend:

DTED	digital terrain elevation data

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

COMBINED OBSTACLE

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, 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).



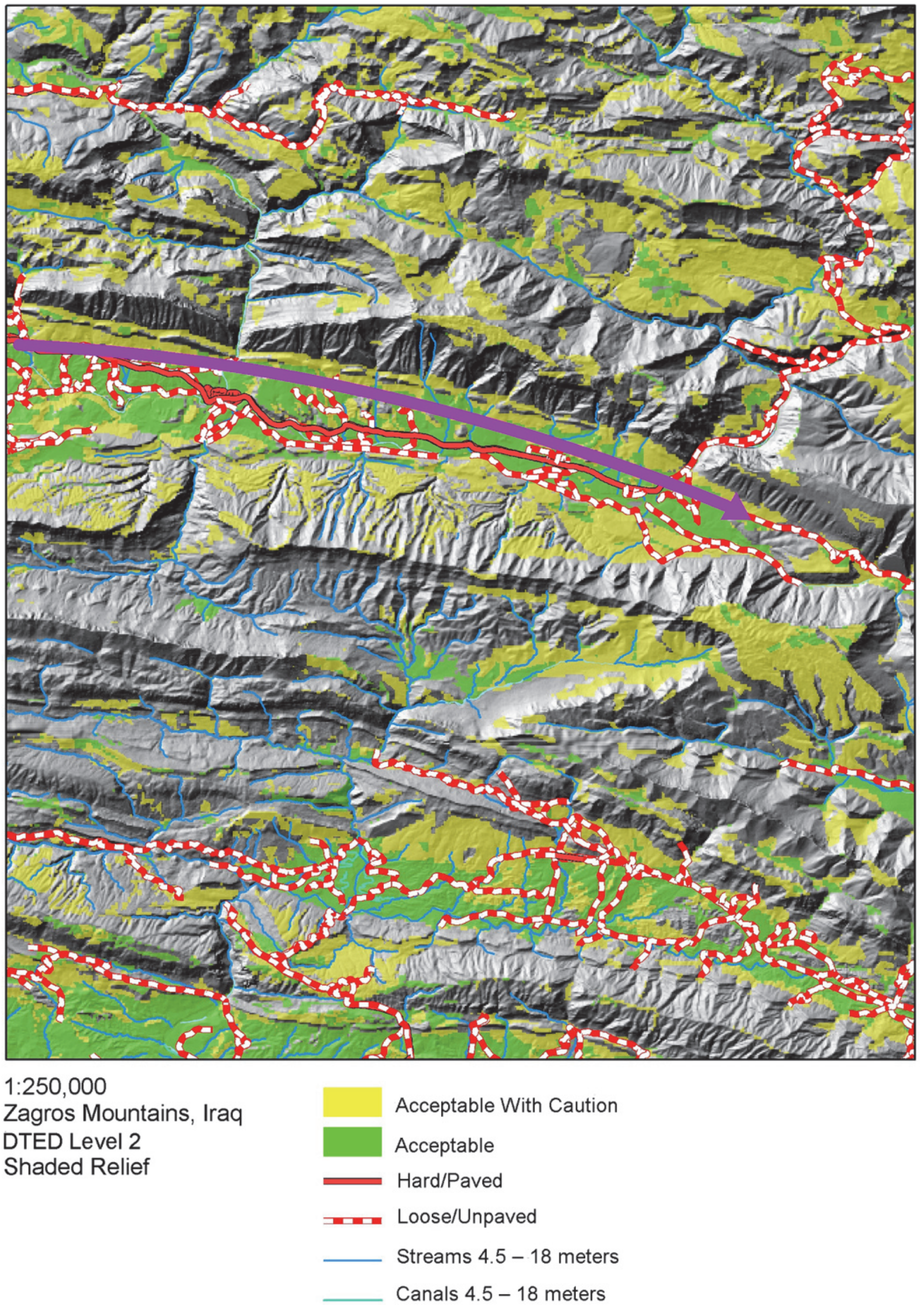
Legend:

DTED digital terrain elevation data

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

MOBILITY CORRIDORS

B-10. The mobility coordinator 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 size/echelon that will support movements, and develop engagement areas.



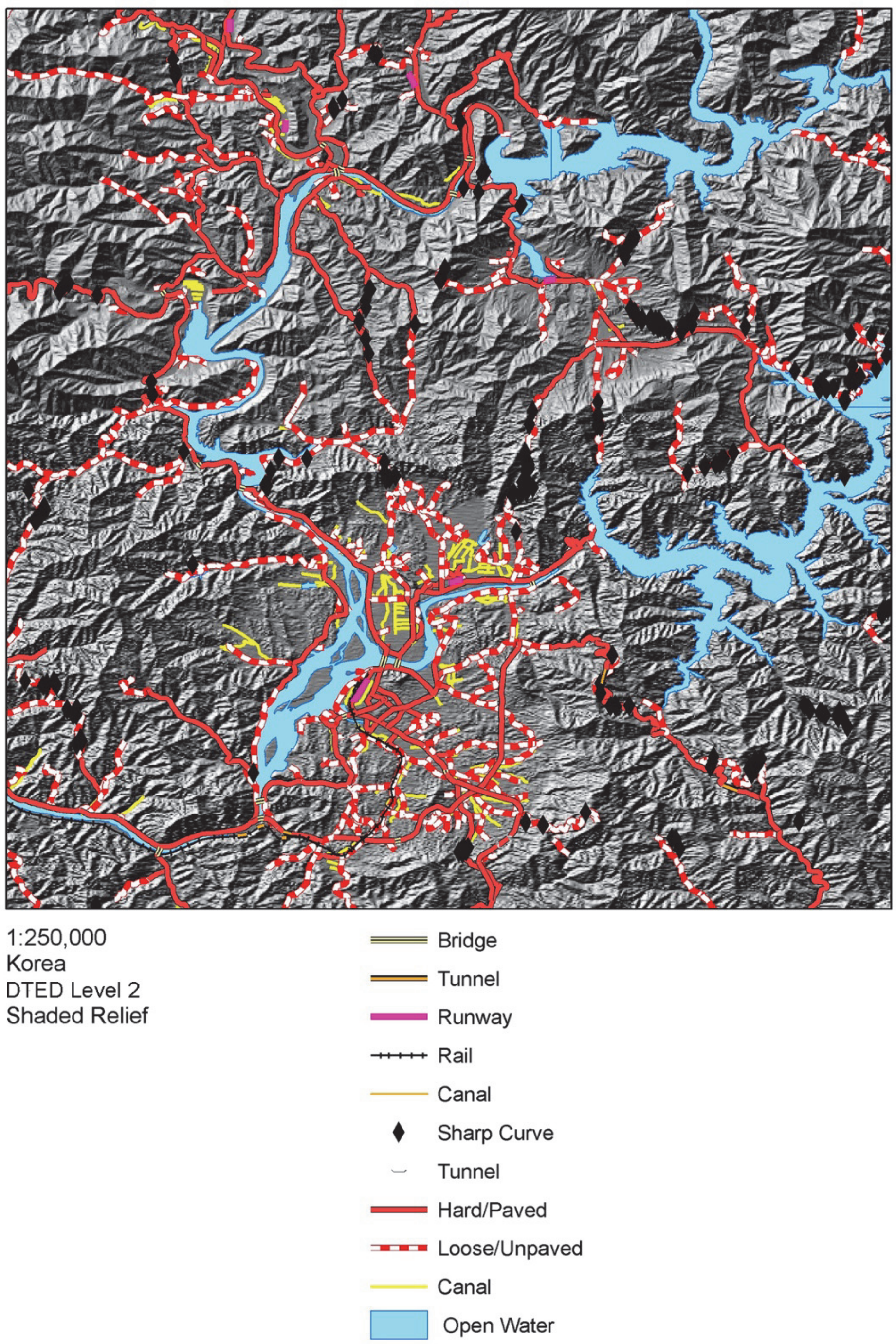
Legend:

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.)



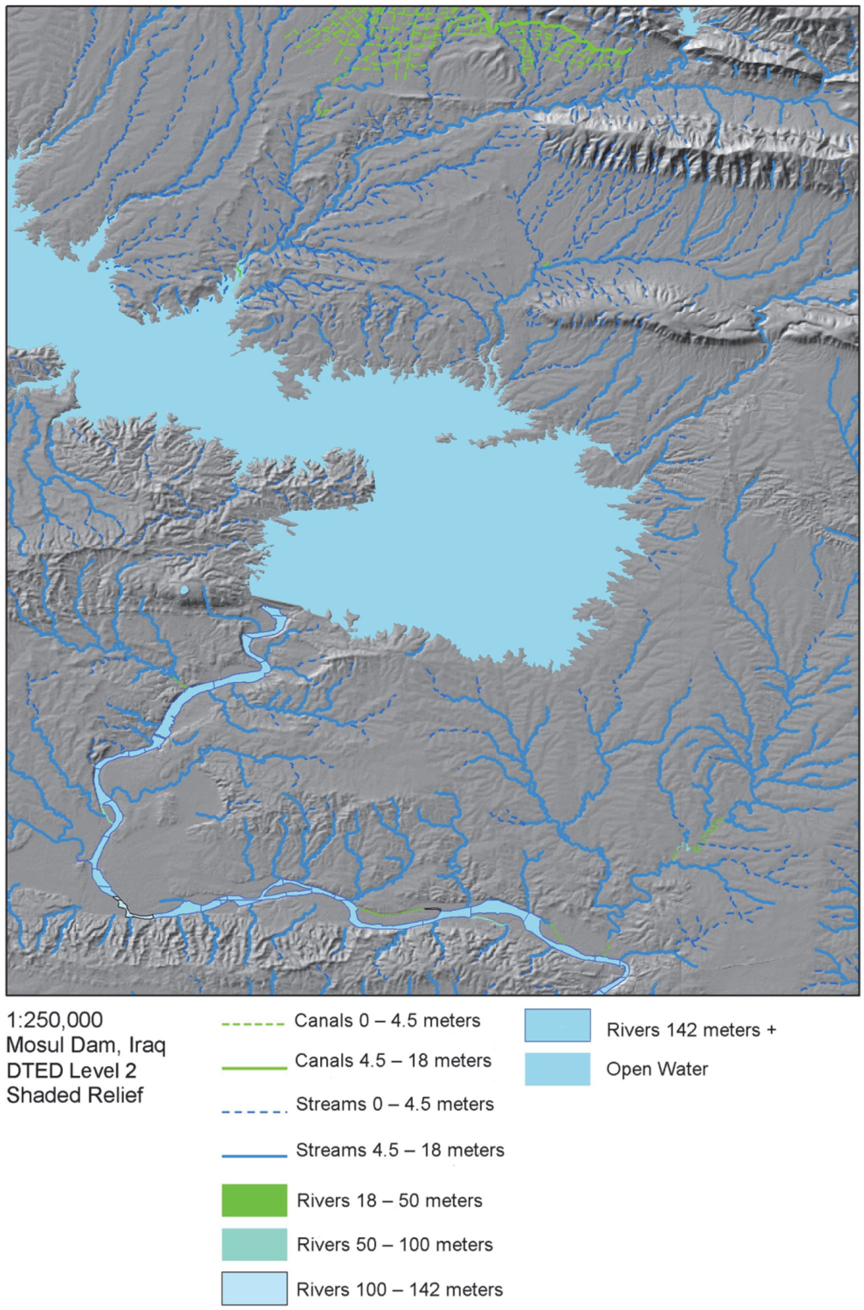
Legend:

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.



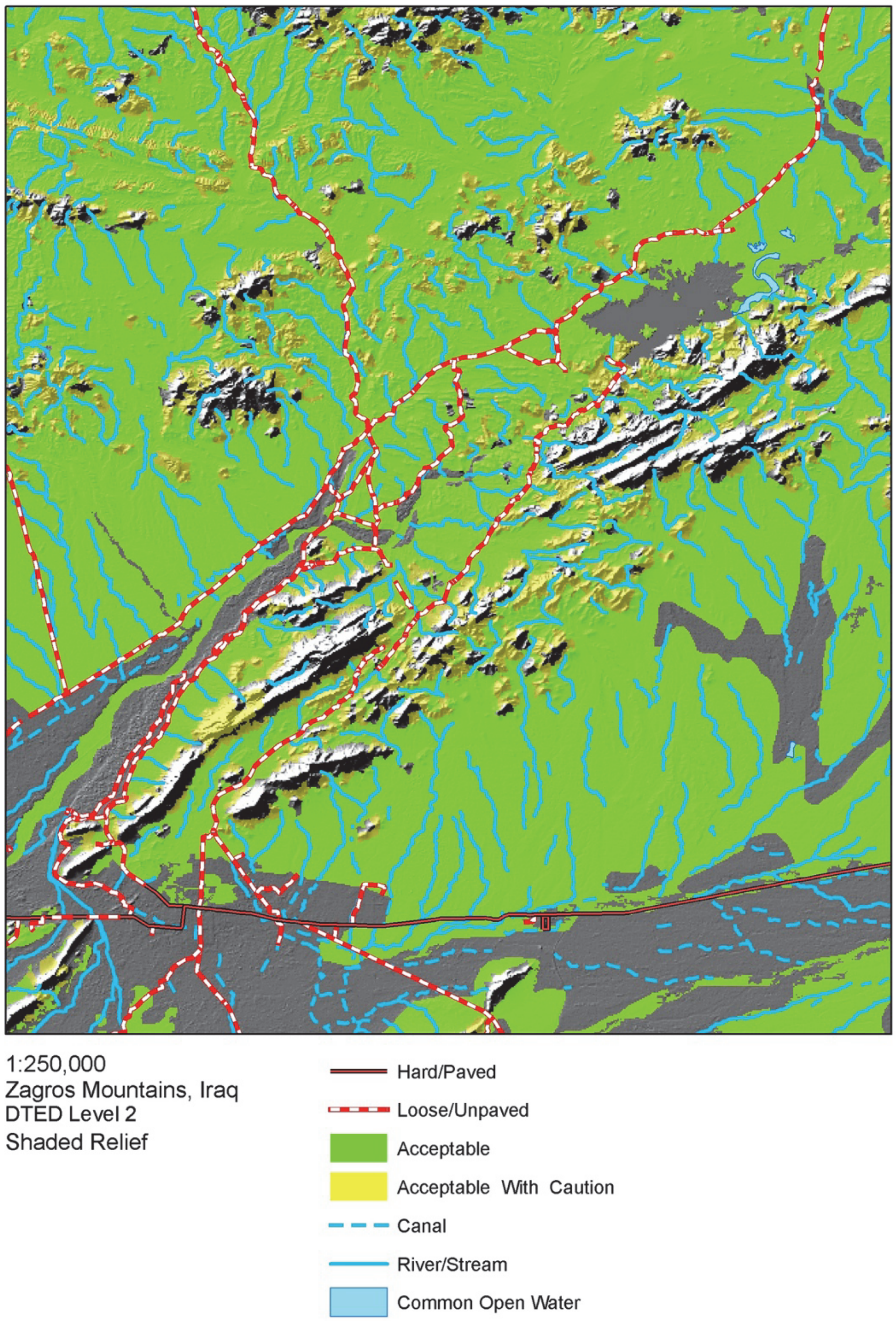
Legend:

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.



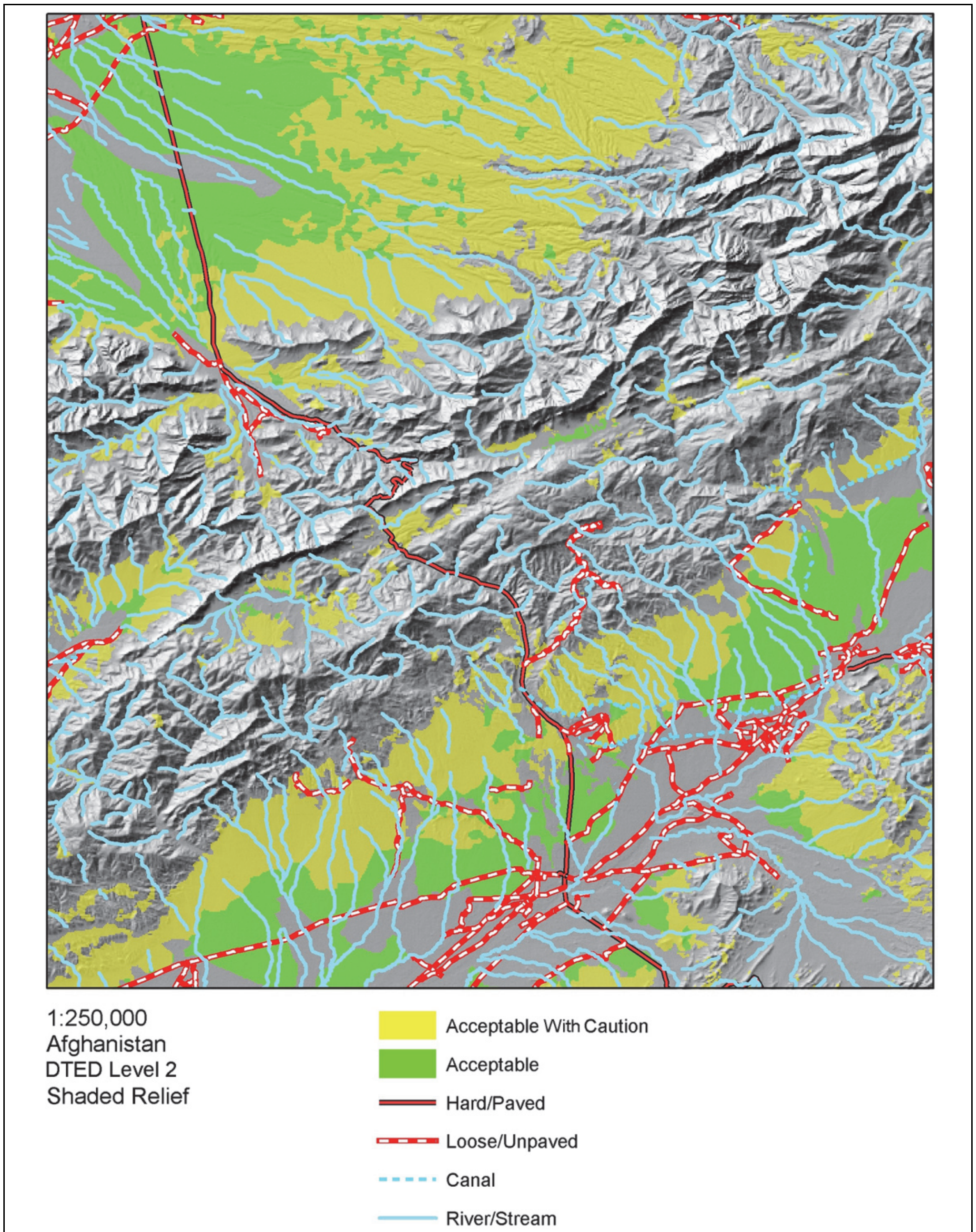
Legend:

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.



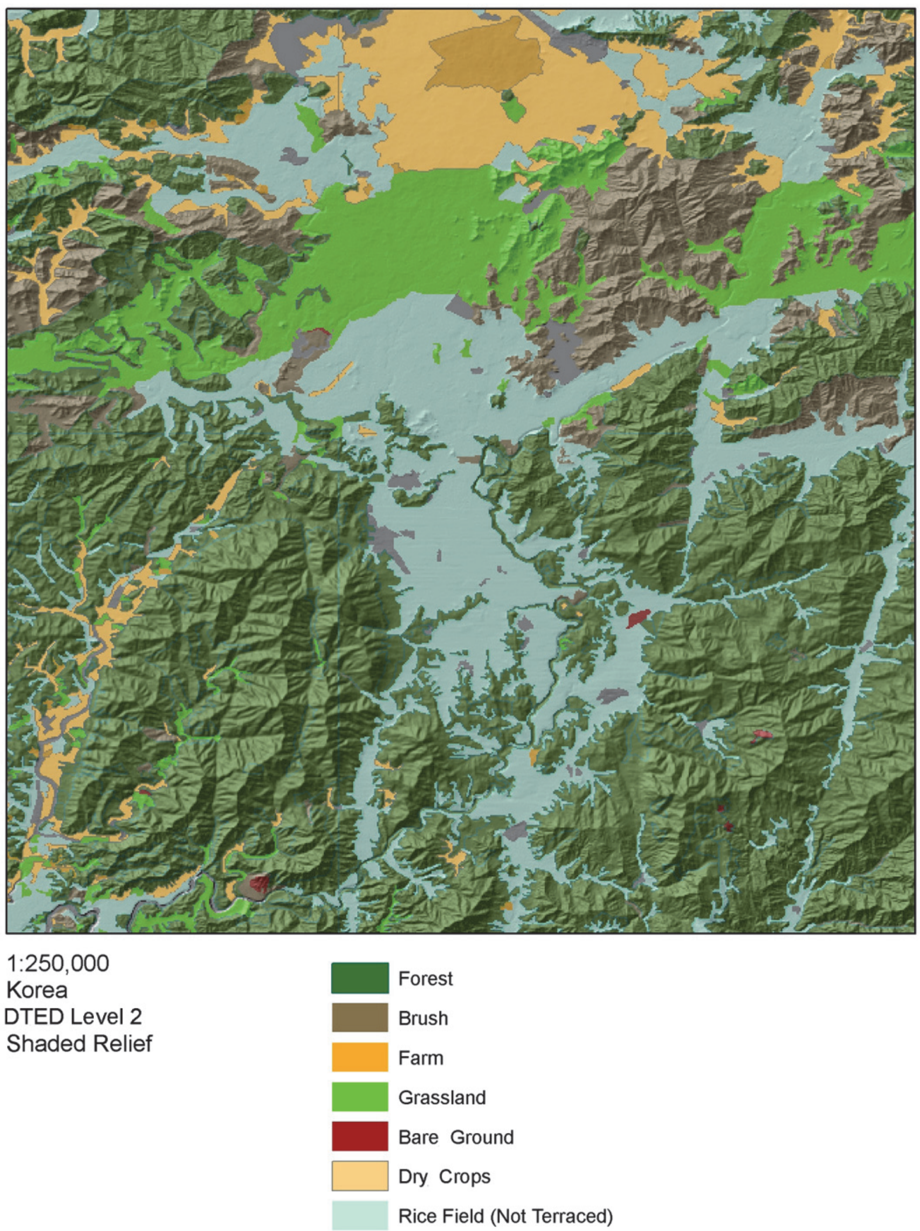
Legend:

DTED	digital terrain elevation data

Figure B-10. Example of a product showing potential helicopter landing zones

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) 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. 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

FIELD OF FIRE

B-16. 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-12.) 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.

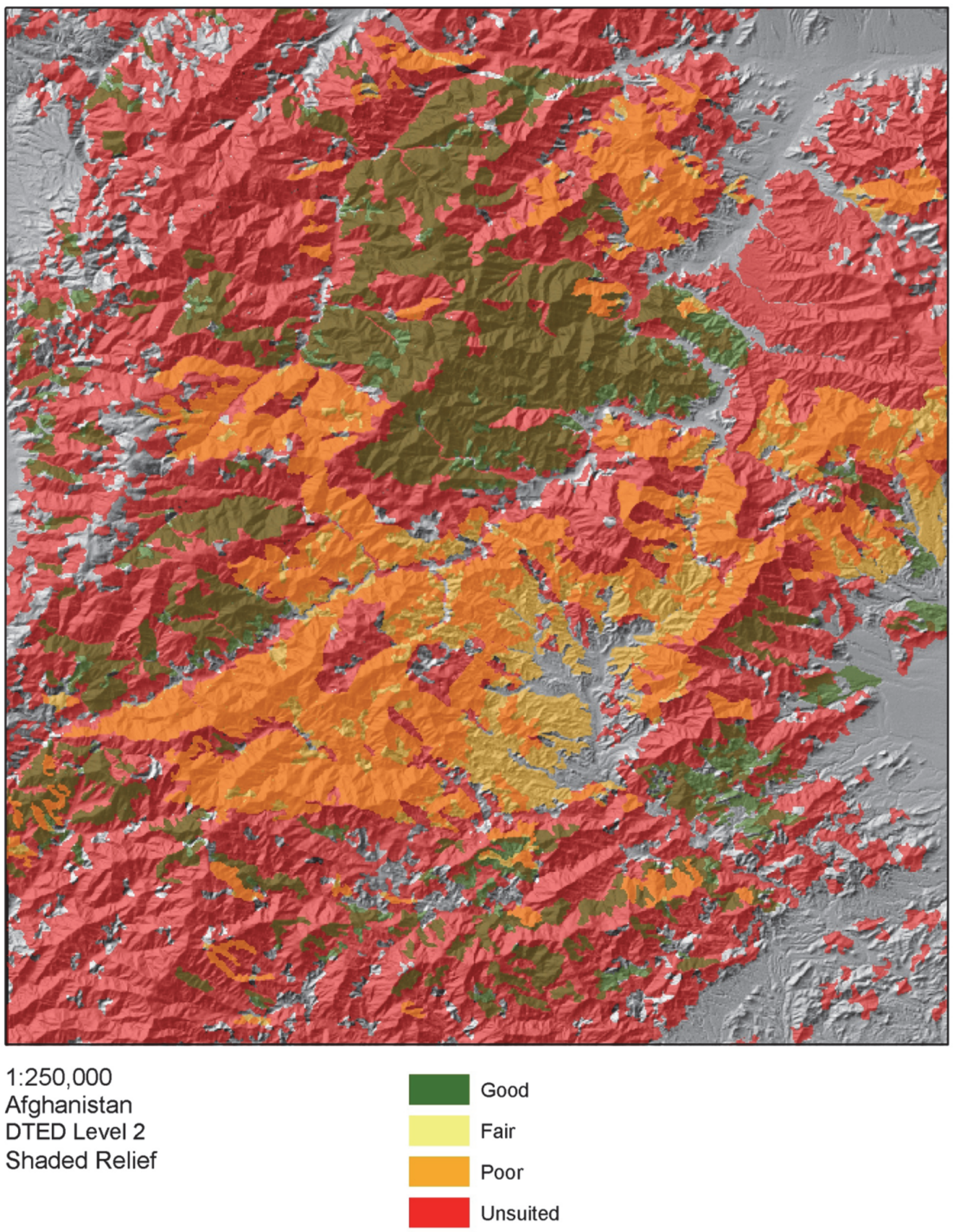
Legend:

DTED digital terrain elevation data

Figure B-12. Example of a product showing fields of fire

ARTILLERY SLOPE TINT

B-17. The artillery slope tint product depicts areas of interest for artillery assets where slope is the primary limiting factor. (See figure B-13.) 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 down the likely areas for firing positions based on slope restrictions.

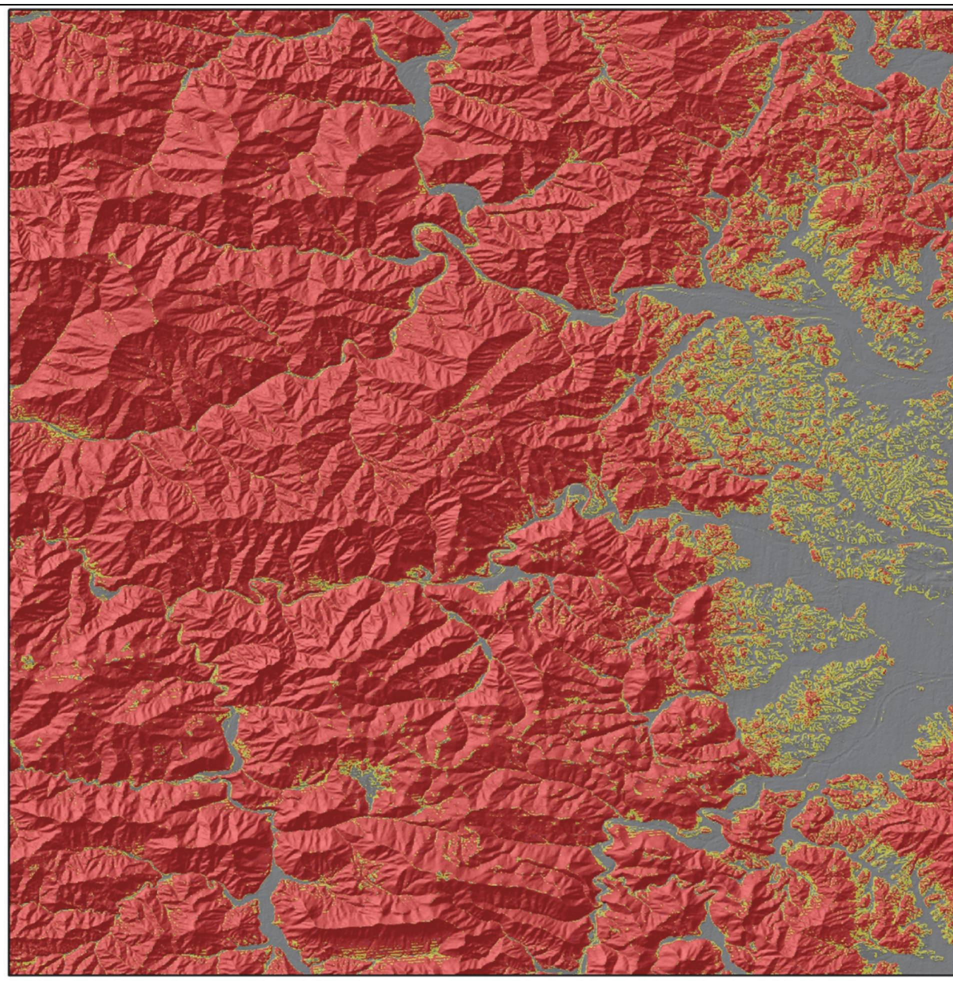


Legend:
DTED digital terrain elevation data

Figure B-13. Example of a product showing artillery slope tint

AERIAL CONCEALMENT

B-18. 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-14.) This product is predicated on canopy closure information within the vegetation layer. This overlay 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.



1:250,000
Korea
DTED Level 2

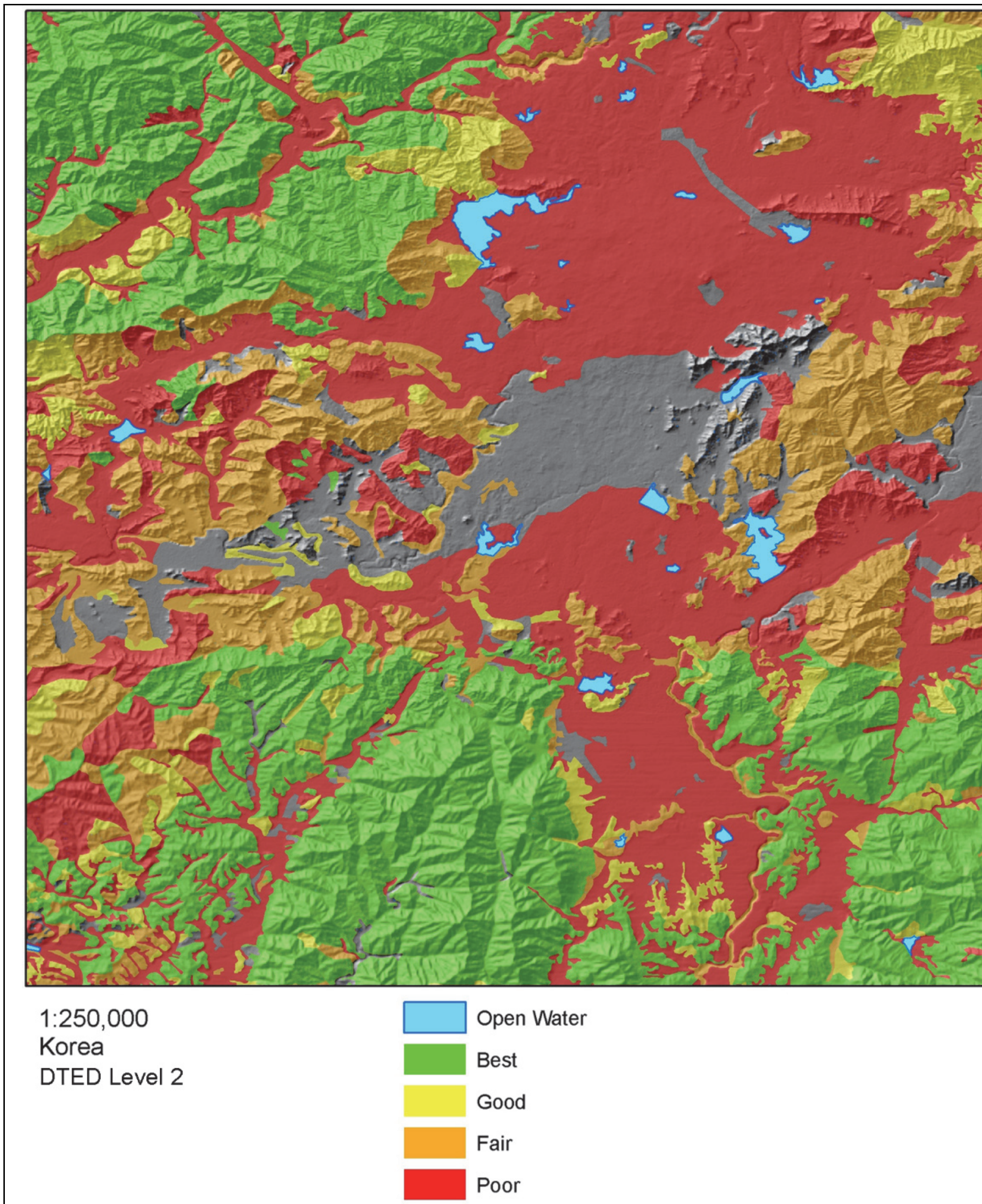
0–7% Slope
8–15% Slope
>15% Slope

Legend:
DTED digital terrain elevation data

Figure B-14. Example of a product showing aerial concealment

SURFACE MATERIAL

B-19. The surface material overlay shows a contrast based on the predominant type of soil that constitutes the surface area. (See figure B-15.) 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.



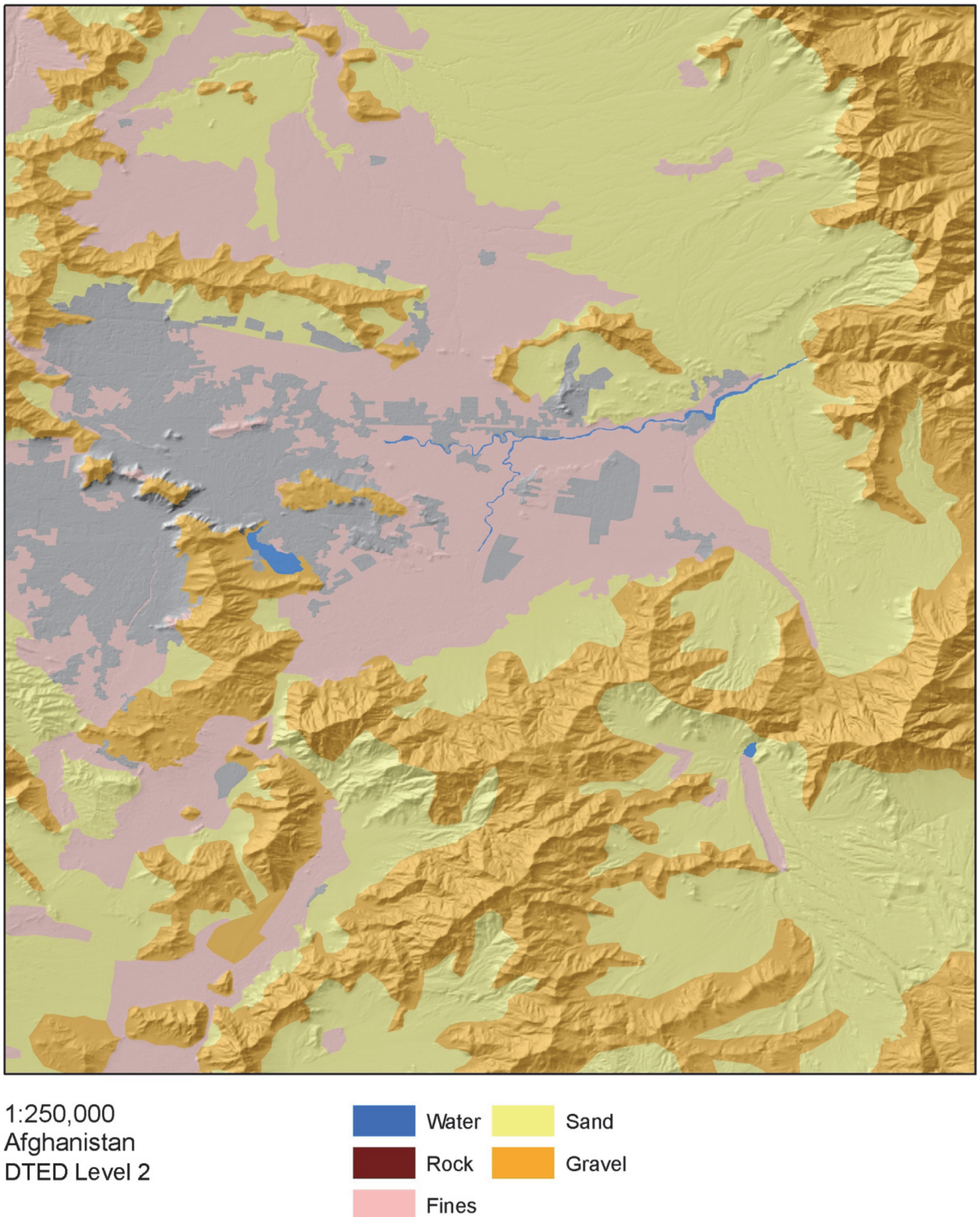
Legend:

DTED digital terrain elevation data

Figure B-15. Example of a surface material overlay

CONSTRUCTION RESOURCES

B-20. The construction resources product shows the natural resources of an area. (See figure B-16.) This product can help engineers plan major construction projects (roads, base camps) that are benefitted by having close access to certain types of construction materials that can be made readily available through quarrying.



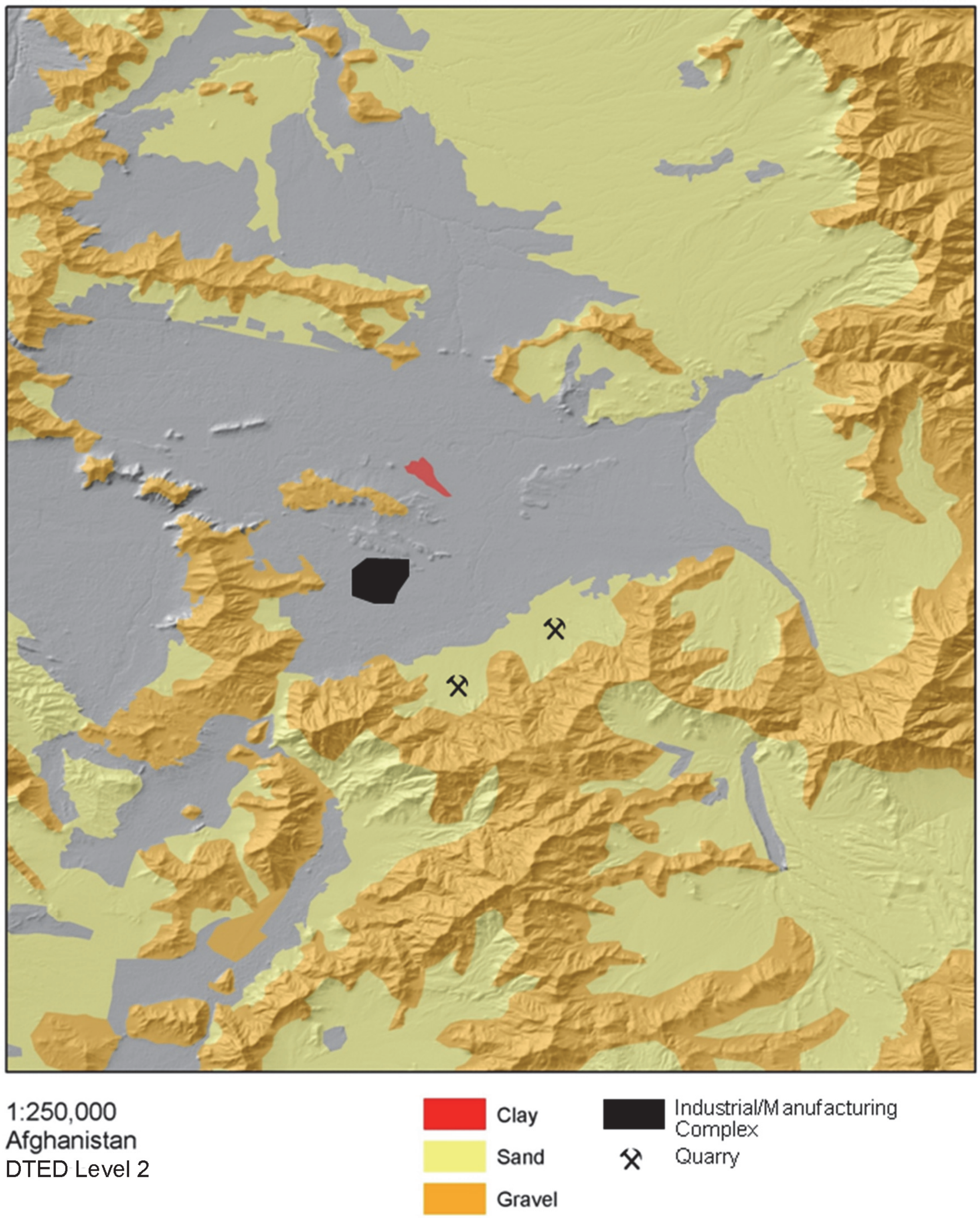
Legend:

DTED digital terrain elevation data

Figure B-16. Example of a product showing construction resources

Shaded Relief

B-21. 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-17.) This product can be depicted in grayscale or a single/multicolor ramp or used as the foundation for other products to enhance appearance.



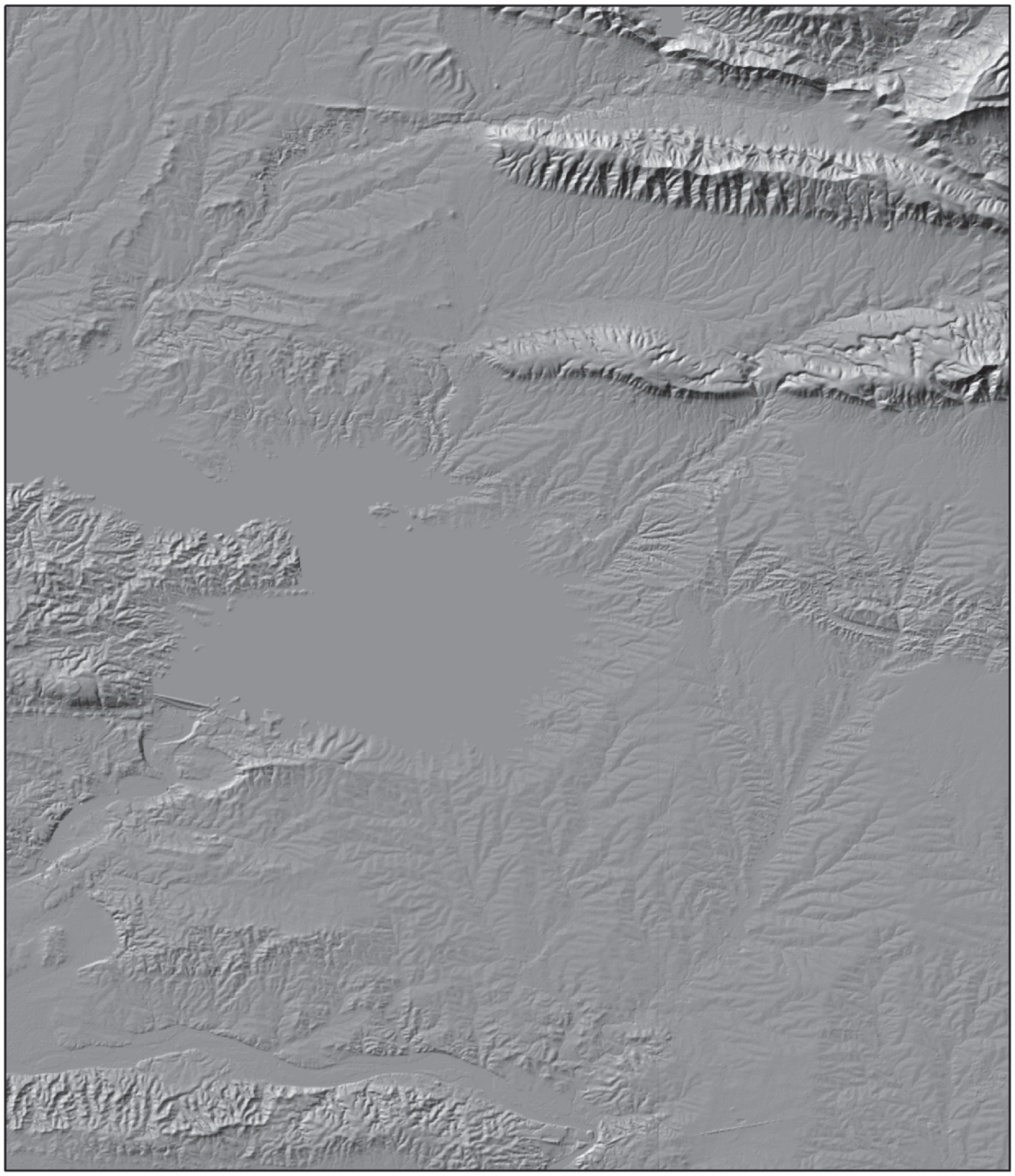
Legend:

DTED digital terrain elevation data

Figure B-17. Example of a shaded-relief image

VIEWSHED ANALYSIS

B-22. A viewshed analysis, often miscoined *LOS profiles*, shows an area of observation that is possible from a 360° prospective based on elevation. (See figure B-18.) 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 another form of LOS analysis that is direct observation, which is the visibility from one single point to another single point.



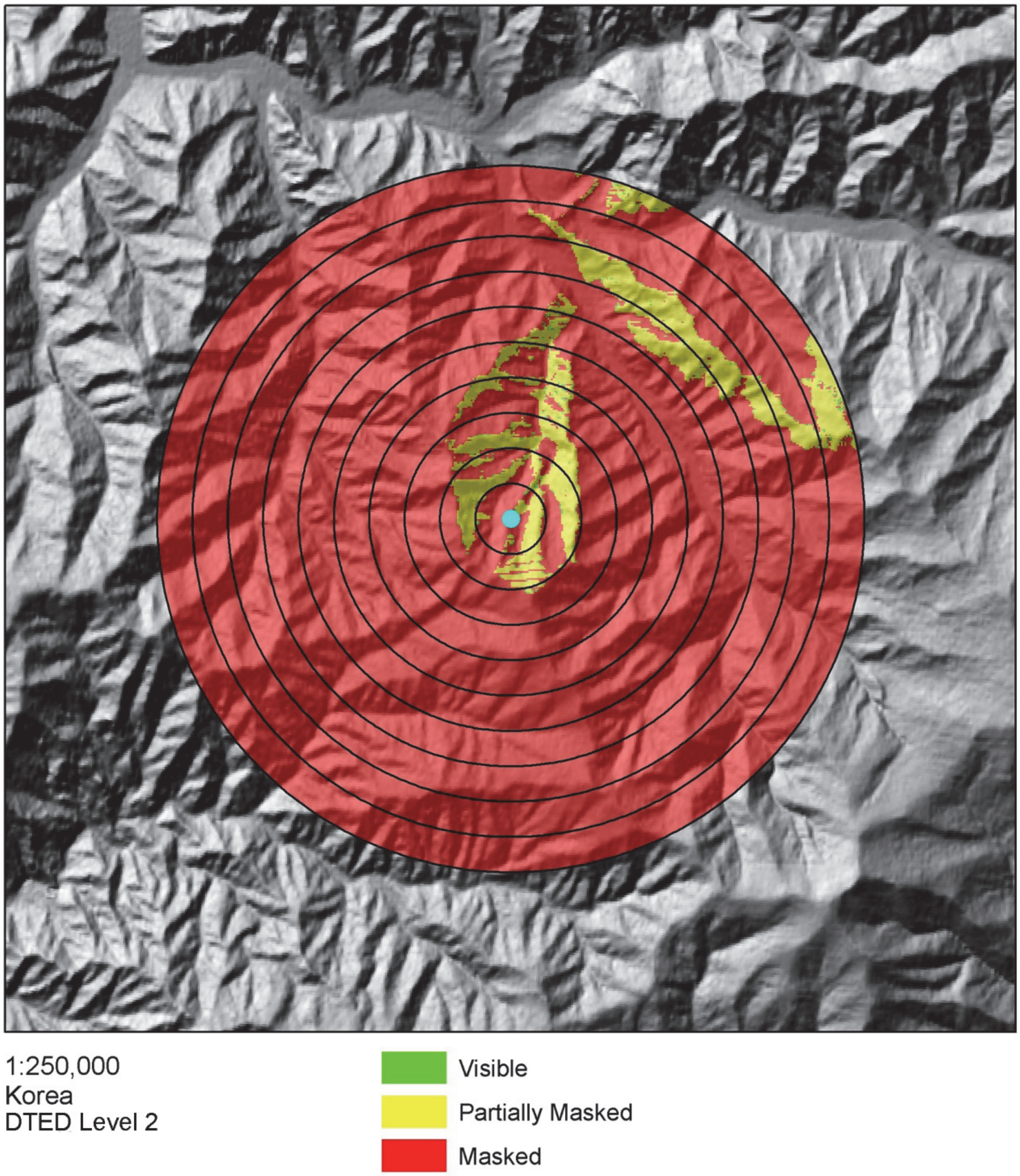
1:250,000
Mosul Dam, Iraq
DTED Level 2

Legend:
DTED digital terrain elevation data

Figure B-18. Example of a Viewshed analysis

Perspective View

B-23. The perspective view product is a three-dimensional depiction of an area from an observer point of view that is produced by combining imagery layers with elevation data. (See figure B-19.) The display can include roads, rivers, operational graphics, text to enhance the terrain visualization, and anything typically displayed on a two-dimensional map.

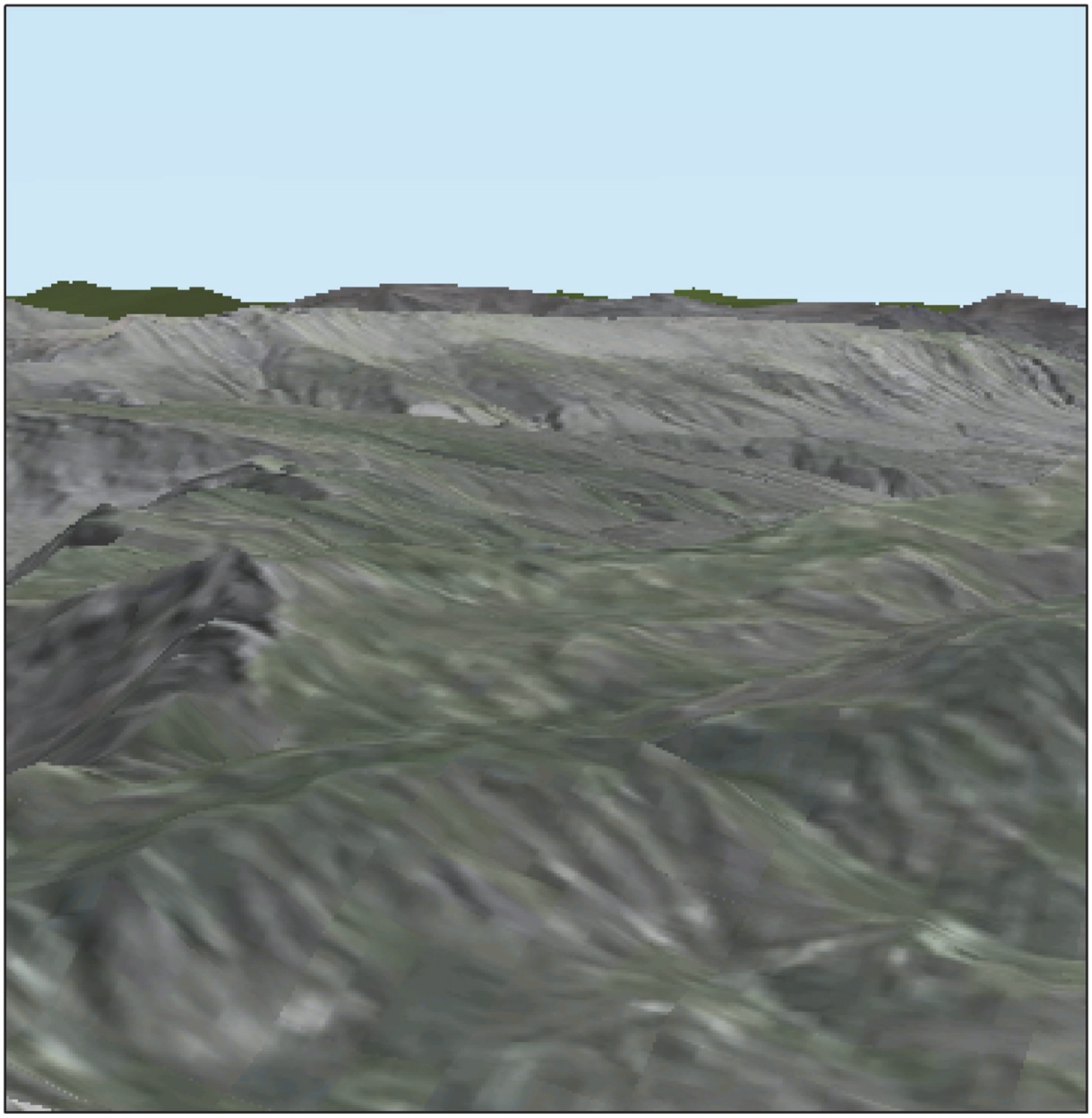


Legend:
DTED digital terrain elevation data

Figure B-19. Example of a perspective view

FLY-THROUGH

B-24. The fly-through product is a computer-generated view of an area along a specified flight line at a specified altitude and angle that is viewed from inside the aircraft. (See figure B-20.) The display can include roads, rivers, operational graphics, and text to enhance the terrain visualization.



Zagros Mountains, Iraq
DTED Level 2

Legend:
DTED digital terrain elevation data

Figure B-20. Example of a fly-through

URBAN TACTICAL PLANNER

B-25. The Urban Tactical Planner is a data set that can be viewed as two- or three-dimensional. (See figure B-21, page 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 overlaid 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 Army geospatial center, but geospatial engineer teams 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.

Legend:

AGL	above ground level
Kbps	kilobytes per second
km/h	kilometers per hour
lat	latitude
long	longitude

Figure B-21. Example of an Urban Tactical Planner product

BuckEye

B-26. 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 postspacing 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-22.)

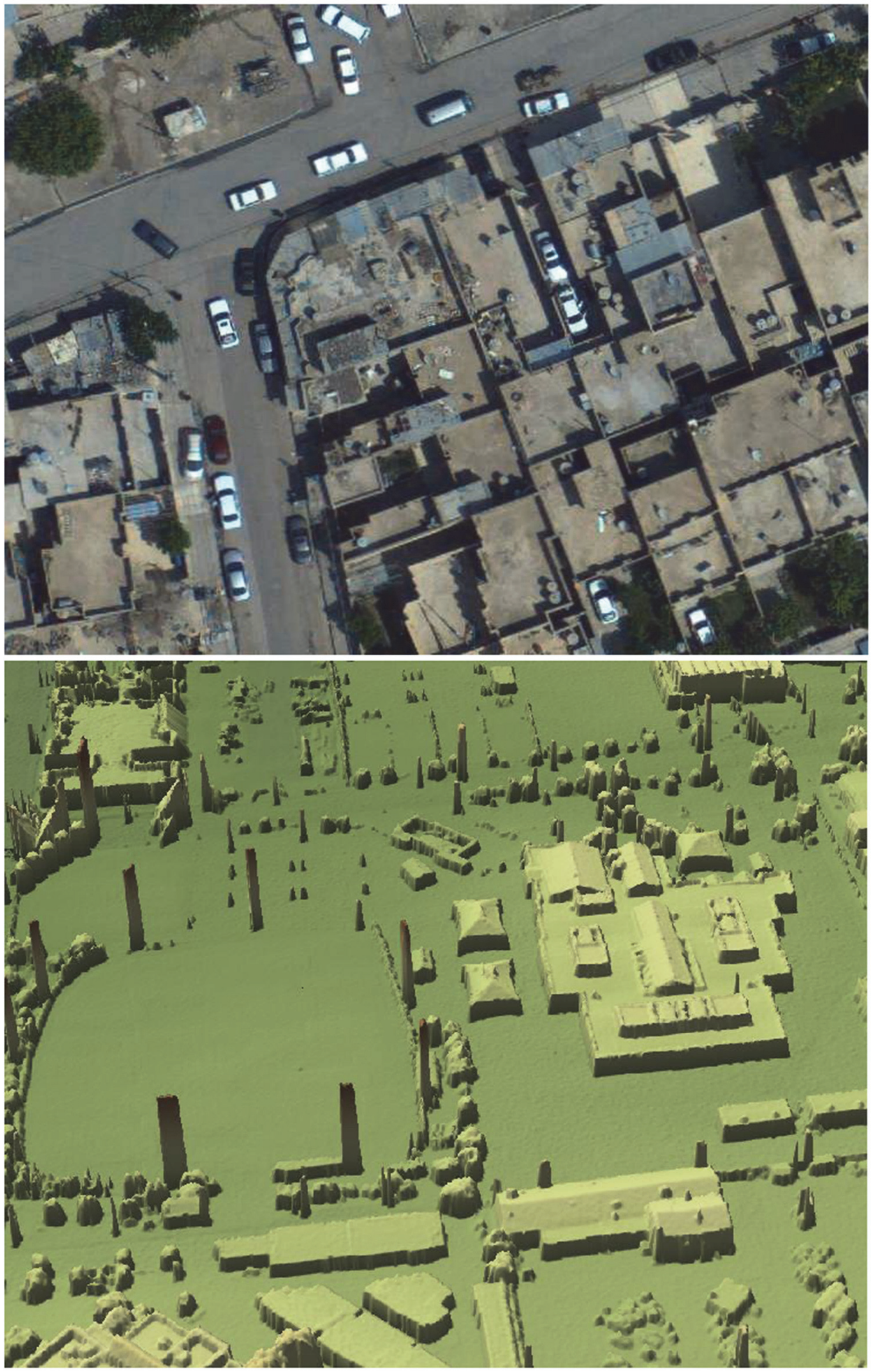


Figure B-22. BuckEye

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Appendix C
Geospatial Data Management

The Army capitalizes on the information-sharing capabilities enabled by the mission command systems to facilitate decisionmaking. 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 these data through an enterprise geospatial database that aims at allowing 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.

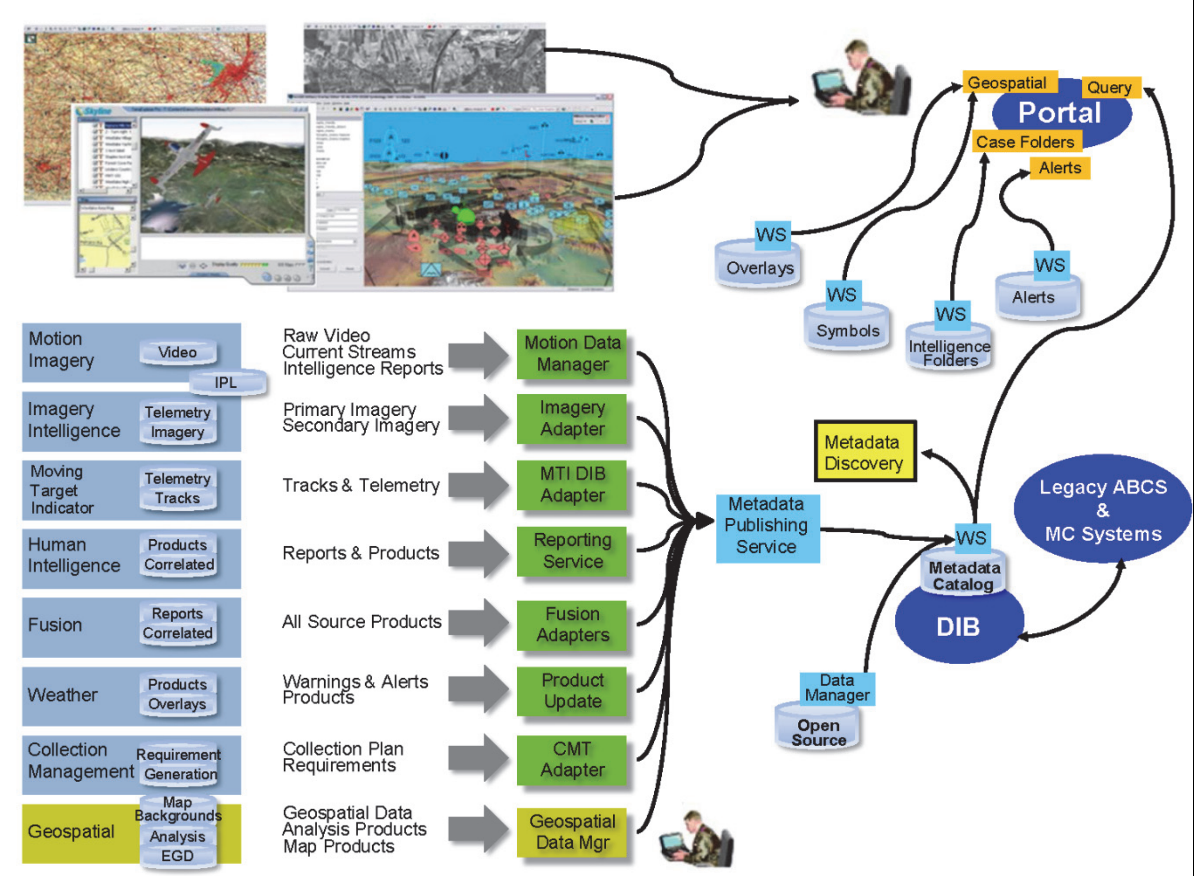
DIGITAL GEOSPATIAL DATA

C-1. Geospatial data must be disseminated to the computing environment as rapidly as possible while ensuring security and retaining integrity. 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. This concept is based on the transition of DTSS to a service-oriented architecture that will allow geospatial engineers to better serve customers and gain access to information stored throughout the battle command network.

C-2. The two types of services (product and discovery) are enabled through metadata (data about data) that will reside on a metadata catalog. This requires data or products posted on a server to be accompanied with appropriate metadata, which will allow 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 instead of the analyst having to continue searching.

C-3. These services (product and discovery) 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 national databases.



Legend:

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

Figure C-1. Geospatial data flow and fusion in distributed common ground system–Army

C-5. Geospatial data users must adhere to the established enterprise geospatial database requirements for using digital geospatial data in the mapping toolkits in the mission command system and GI&S software applications. Based on the digital terrain data, mapping toolkit operators can evaluate the operational area or specific area of operations, develop a limited set of tactical decision aids, and provide an accurate digital display of the digital terrain data.

C-6. 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-7. 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 (such as with Grenada, the Balkans, and Afghanistan). 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-8. 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 and 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

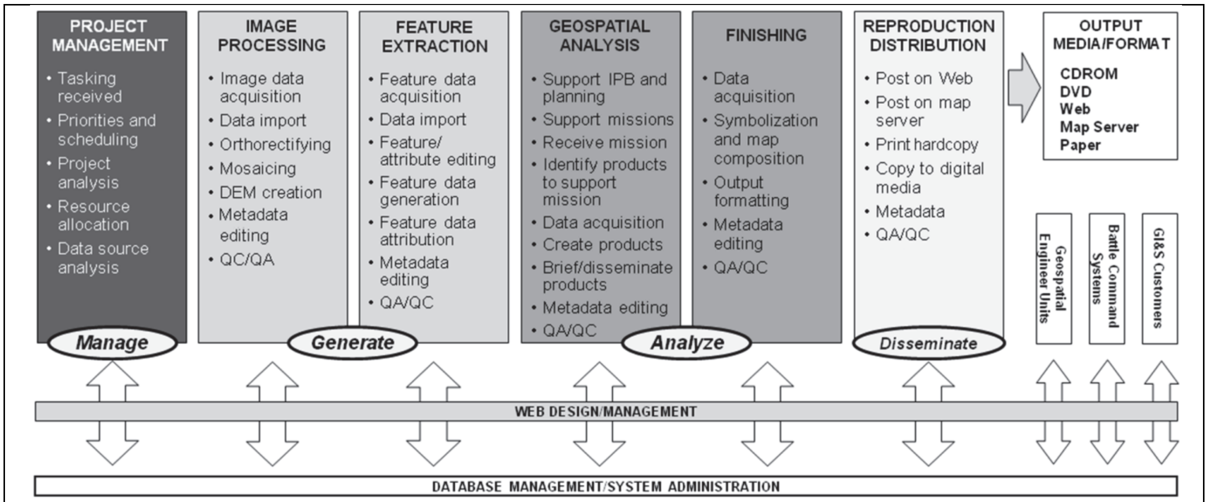
C-9. Field-collected and -generated data updates the geospatial databases residing at the national level down to the BCT. The generation of enriched data relies on top-down and bottom-up feeds. While top-down feeds can result from multiple sources, bottom-up feeds primarily rely on the result of information collection operations at the tactical level using the following:

- Air and ground reconnaissance (including engineer survey teams).
- Unmanned aircraft systems.
- Imagery intelligence or human intelligence sources.

C-10. Data that is retrieved from tactical units is normally provided through digital and voice reports or imagery to the tactical operations center. 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 procedures or standing operating procedures and passes the updated data to the geospatial engineer team at higher headquarters for further incorporation and dissemination to other units within the echelon of command in support of maintaining a current COP. The enrichment data that is provided by subordinate units is then 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 area of operations.

ENTERPRISE GEOSPATIAL DATABASE DEVELOPMENT

C-11. 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 the topographic companies and geospatial engineer teams 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.



Legend:

DEM	digital elevation model
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-12. Most geospatial database development occurs in anticipation of future operations before deployment. In cooperation with higher headquarters, geospatial engineers monitor the status of geospatial data covering the AORs. This data is normally provided to the GPC by the NGA, the Army Geospatial Center, 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 geospatial engineer team data management element manages the secondary map file server and maintains the supported unit geospatial data and terrain products. This includes the digital maps that are 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 for the supported unit.

C-13. Following deployment, field-collected and -generated data will be 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 should be established with the intelligence staff to ensure access and acquisition of imagery data through national imagery and other intelligence data sources early in the operation.

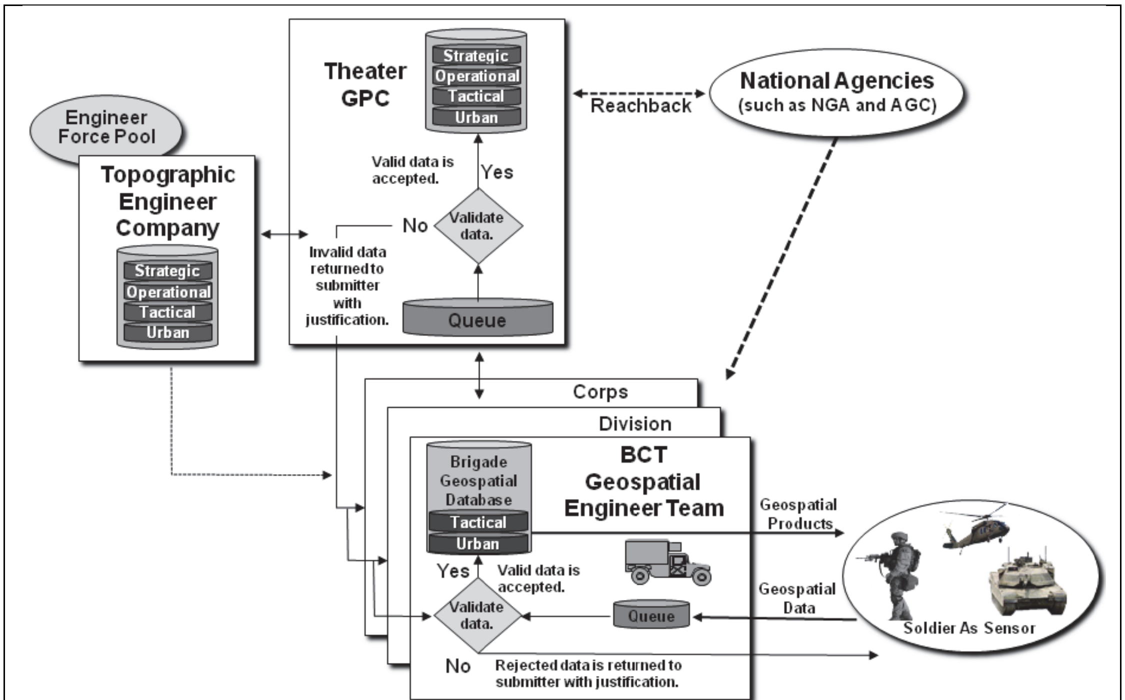
C-14. Distributing in-theater updates and data feeds to echelons below BCT can be the most challenging aspect of geospatial data dissemination. This involves moving data from higher to lower and from dispersed and possibly engaged forces to the nearest geospatial engineer element, which may not have a terrain data file server. The geospatial engineer team 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 standing 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 (and eventually to the NGA) using the method that was used 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-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 geospatial engineer team 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 echelon to ensure database integrity. The mission command system uses a mapping toolkit. Based on the digital terrain data, mapping toolkit operators can evaluate the operational area or a specific area of operations, develop a limited set of tactical decision aids, and provide an accurate digital display of the digital terrain data.

C-17. 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-18. Geospatial data is exchanged among the GPCs, topographic engineer companies, and geospatial engineering teams at the various echelons using communication networks. (See figure C-3.) The senior geospatial engineer at each echelon down to the BCT has the overall responsibility for establishing and standardizing the procedures for populating the database within the respective echelon. Newly generated or obtained geospatial data are checked, validated, and cataloged using uniform naming conventions to facilitate the use of the database. This provides mission command system users with efficient access to the geospatial database residing on the DTSS, DCGS-A, and mission command system servers.



Legend:

AGC	Army Geospatial Center
BCT	brigade combat team
GPC	geospatial planning cell
NGA	National Geospatial-Intelligence Agency

Figure C-3. Enterprise geospatial data flow

C-19. The senior geospatial engineer, in coordination with the S-2/G-2 and the S-3/G-3, oversees the data management element located in the main command post. The noncommissioned officer in charge of the data management element manages the terrain data file server and oversees and directs the terrain analysts in populating, updating, and archiving geospatial databases. The noncommissioned officer in charge helps develop standardized procedures and enforce policies related to filing, formatting, storing, retrieving, and archiving the geospatial data acquired for geospatial engineer elements within the command. The noncommissioned officer in charge also coordinates with the division G-2 to establish dissemination priorities for topographical folders or products based on division and BCT requirements. The senior geospatial engineer at the BCT main command post follows the established procedures in managing the BCT database in coordination with the BCT S-2.

C-20. When operating in a multinational environment, the geospatial engineering team must work closely with the engineer staff officer and S-2/G-2 at various echelons to develop procedures for disseminating geospatial information updates to those mission partners without access to digital battle command systems to ensure data integrity throughout the command.

C-21. A database management system is computer software designed to manage databases that control 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-22. 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 and 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 data mirrored at a central location for Army-wide access (such as the Army Geospatial Center) and to have that data accepted and included in the NGA national database.

C-23. 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 will generally only maintain 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, such as the country code and the operational level of the data (strategic, operational, tactical, or urban). 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-24. The GPC may be augmented with NGA geospatial analysts, cartographic analysts, and data stewards to greatly 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-25. 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) will be reported to NGA and to the other GPCs to ensure database consistency.

C-26. TGD features are stored in a geospatial database and organized by the four levels of resolution or scales. (See figure C-4.) 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 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 NGA urban vector map or the Army Geospatial Center Urban Tactical Planning data).

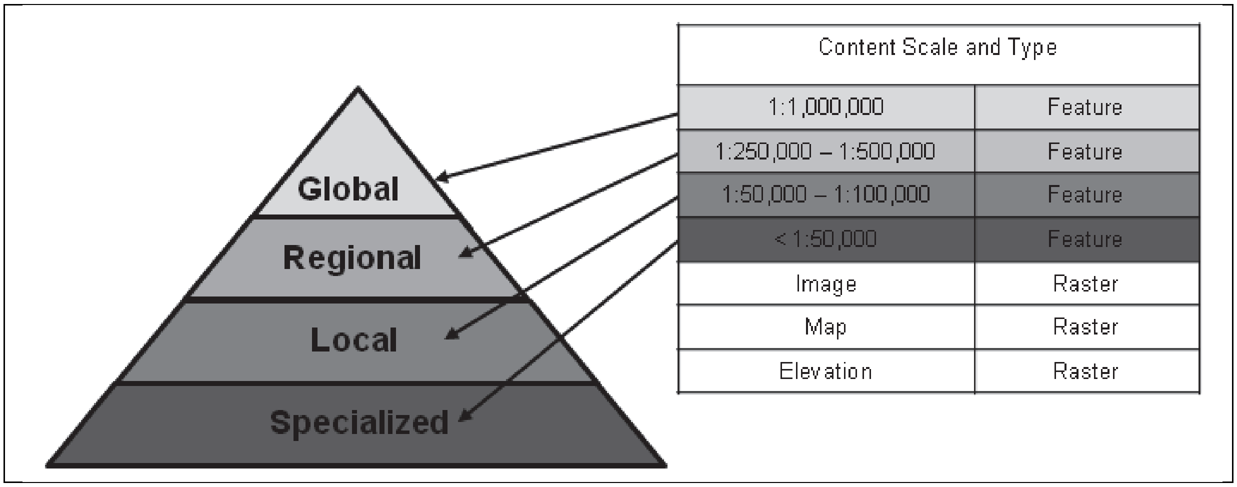


Figure C-4. TGD data model

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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 area of operations.

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 karstic 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 in 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 supply. 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 TM 3-34.49 for additional information on the ability of rocks and soils to hold and transmit water. See DODD 4705.1 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 movements 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 varies 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 (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.

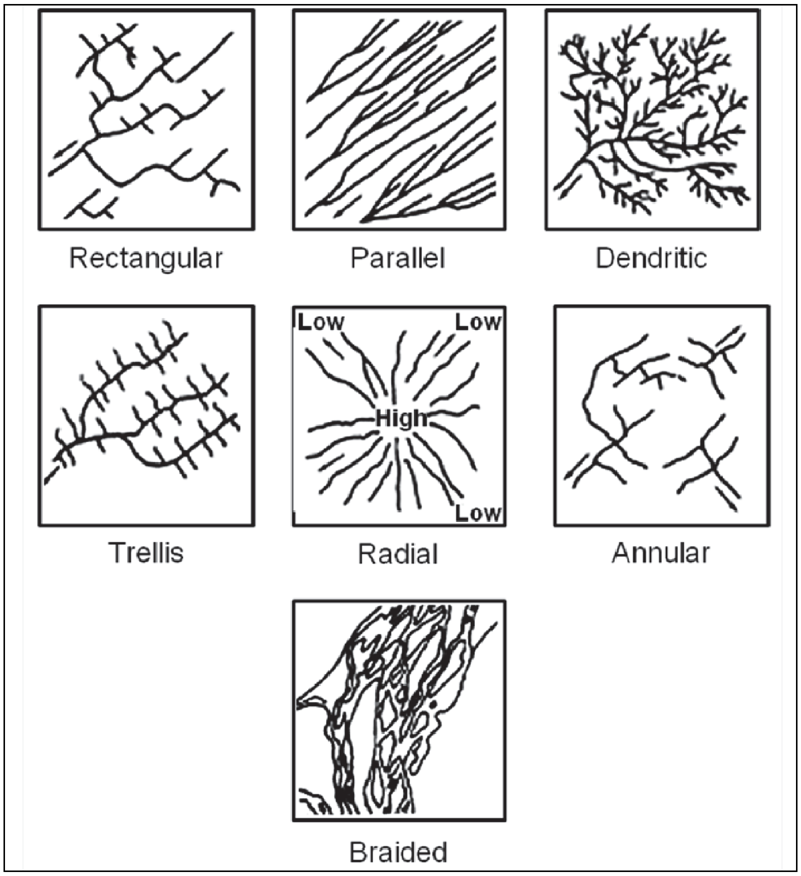

Figure D-1. Common drainage patterns

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 mainstream 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 is 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 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 FM 3-34.170 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 are acquired, geospatial engineers use these in combination with standard geospatial products and imagery to create tailored geospatial products (such as the soil trafficability overlay shown in figure B-12, page B-13) that enables the staff to further its own analysis of the operational area or specific area of operations and 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 categories:

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

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

GRAVEL

D-25. Gravel is 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 and 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 is soil- or rock-derived granular material of a grain size between sand and clay. It lacks plasticity and possesses little or no cohesion when dry. Because of silt instability, water will cause it to become soft or to change to a quick condition (a hydraulic uplift phenomenon where water quickly saturates silted sand). 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, which 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 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 sedimentations. 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.

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 these types of vegetation—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. Trees that are large enough to stop wheeled vehicles are usually too closely spaced to allow passage.

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. Needle leaf trees do not normally lose their leaves 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 that species. Wooded areas that contain less than a 60 percent mixture of either species are classified as a mixed forest. 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. As part 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 in that area can be made based on information about the predominant crop. For example, rice requires fine-textured soils, while other crops generally must have 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 vehicles and some tracked vehicles are unable to cross flooded paddy fields, although they may be negotiated when the fields 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 are 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. 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 FM 90-7 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 or on different types of vehicles (wheeled or tracked). Obstacles to air mobility include mountains; power lines; or 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 three-dimensional nature of the topography (supersurface, surface, and subsurface areas). Advancements in automated geospatial applications, such as the Urban Tactical Planner developed by the Army Geospatial Center, provide more detailed geospatial information and better visualization of the urban environment. An example of an Urban Tactical Planner product is shown in appendix B. (See figure B-22, page B-23.) (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—

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

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 sites 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, but is not limited to, highways, railways, and waterways over which troops or supplies can be moved.

Roads

D-43. FM 3-34.170 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.

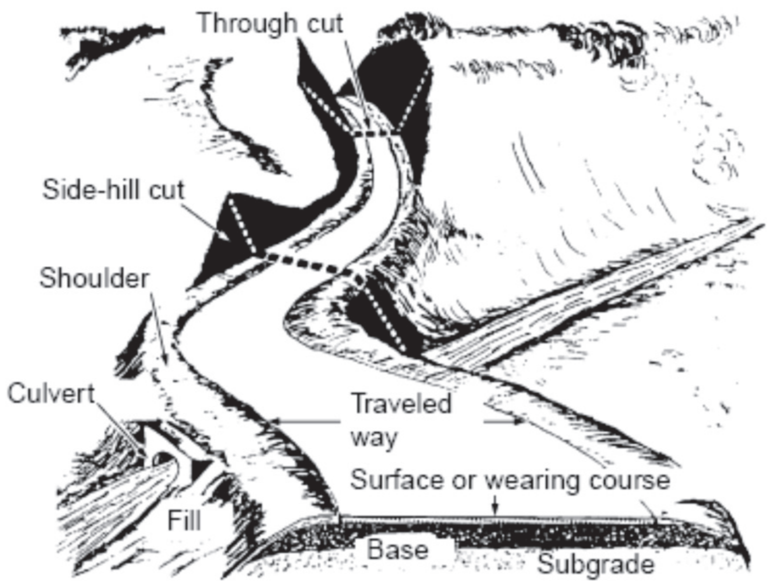

Figure D-2. Road characteristics

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). • Affected by precipitation and temperature changes slightly.
All-weather, hard surface	• Paved with concrete, bituminous surfacing, brick, or paving stone (waterproof surface). • Affected by precipitation and temperature changes slightly.
All-weather, loose surface	• Constructed of crushed rock, gravel, or smoothed earth with an oil coating. • Graded and drained, but not waterproof. • Affected by rain, frost, or thaw considerably. • 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). • Can become quickly impassable in adverse weather.
Cart track	• Traveled pathways, natural (includes caravan routes and winter roads). • Unable to accommodate four-wheeled military vehicles (too narrow).

Railways

D-45. Railways can be a highly desirable adjunct 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. They include 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 United States and the rest of Europe. Narrow gauges are less than the standard gauge. The use of narrow gauges is somewhat limited to, and 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 of the 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 a restricted (one- or two-track) entrance and exit called a *choke point*. 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 the capacity of the roundhouse. 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 transportation and are generally found in small towns or cities where sidings and storage space already exist. Characteristics of a railhead are 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 or organized into convoys or trains); and temporary dwellings (such as tents for housing troops who are guarding and handling supplies).

Bridges and Culverts

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

- 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 FM 3-34.170 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 concrete, but corrugated metal and cast iron are also used. The pipes have different shapes and can range from 12 inches to several feet in diameter. Box culverts are used to a great extent in modern construction; they are rectangular in cross section and usually 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 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 and keyed head to base and may be used for spans of 3 meters or less.

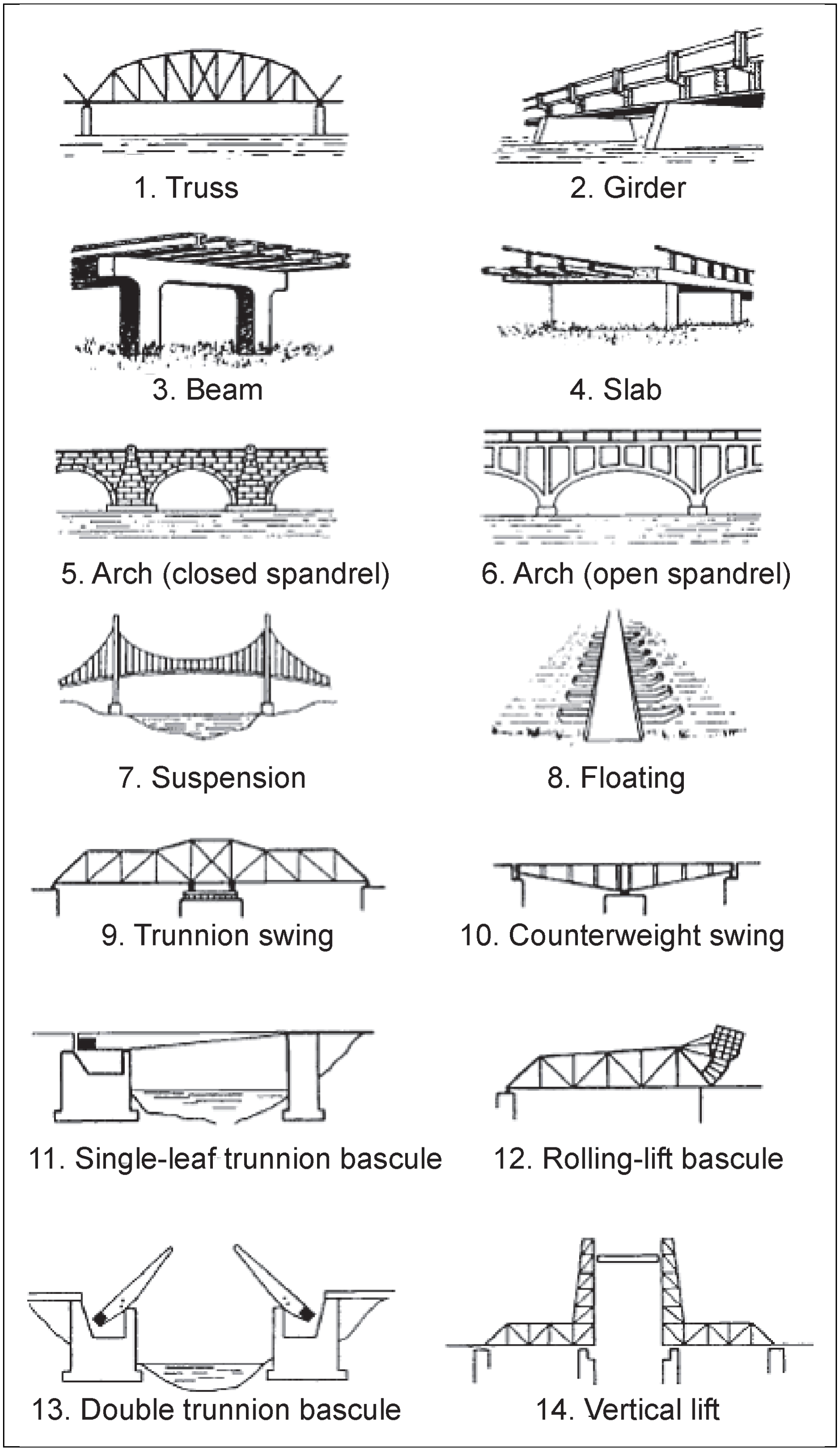

Figure D-3. Common types of bridges

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 FM 3-34.170 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). FM 3-34.170 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. (ATTP 3-90.4) 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. FM 3-34.170 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 transport 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 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. Piers are supported by pilings driven into the harbor bottom, while 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 this protection, 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 establish basic facts of 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 ATTP 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, but 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 area of operations 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, 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 are where civilians live and can be found dispersed throughout an urban area. 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 along with a software suite of geospatial information processing capabilities that supports the Army with GI&S and special map reproduction.

DISTRIBUTED COMMON GROUND SYSTEM−ARMY

E-1. The DCGS−A is the intelligence collection, weather, geospatial engineering, and space operations component of the mission command system and will further enhance the network centric capability of the Army and joint Services to visualize, understand, and act decisively. It must be understood that 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, depending on where units are within the transition from DTSS to DCGS−A.

E-2. 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 (Force XXI Battle Command, Brigade and Below; DCGS-A; Joint Battle Command Platform; Advanced Field Artillery Tactical Data System; Command Post of the Future System; Tactical Ground Reporting System; and commercial off-the-shelf programs [such as the Combined Information Data Network Exchange]) were designed to support mission command; however, 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 complete 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.

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 will interact 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, all 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) and 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, friendly and environmental weather.
- Ability to host, manage, and provide the SSGF to all common operating environments.

E-5. The DCGS–A incorporates the subsystems 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 *Digital Topographic Support System–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 Digital Topographic Support System–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 VARIANTS

E-7. The DTSS is employed in various configurations at all echelons down to the BCT. The three DTSS configurations are—

- DTSS–Light.
- DTSS–Deployable.
- DTSS–Base.

DIGITAL TOPOGRAPHIC SUPPORT SYSTEM–LIGHT

E-8. 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.

DIGITAL TOPOGRAPHIC SUPPORT SYSTEM–DEPLOYABLE

E-9. The DTSS–Deployable is a ruggedized computer system that is capable of receiving, formatting, creating, manipulating, merging, updating, storing, retrieving, and managing digital geospatial data and creating digital and hardcopy geospatial products. It is contained in hardened transit cases to facilitate deployment with tactical forces. It has similar capabilities to the DTSS–Light, except that it is not configured for vehicular mounting, which makes it well-suited for supporting light forces.

E-10. The DTSS–Deployable is designed for a two-person geospatial engineer team. It includes a server and a storage device—created mostly from commercial, off-the-shelf software, which is used to manage geospatial data. The DTSS–Deployable comes equipped with the necessary communications capabilities to operate independently or in conjunction with a DTSS–Light.

DIGITAL TOPOGRAPHIC SUPPORT SYSTEM–BASE

E-11. The DTSS–Base 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 DTSS–Base has increased data production capabilities over the other DTSS configurations and enhanced feature and elevation data extraction tools. It also has increased data storage, management, distribution, and dissemination tools. The DTSS–Base is also augmented with a direct link to commercial and national imagery.

E-12. The DTSS–Base is unique in that it is the only DTSS configuration with six analogous functions or functional slices, which are—

- Imagery slice to ingest and process national technical means imagery, extract three-dimensional features, generate and enhance DTED, process multispectral images, and support IPB.
- Production slice to produce tactical decision aids, value-added data, map products, and three-dimensional visualization products.
- Database slice to store and manage data online with an automated archival capability.
- Map server slice to provide a Web-accessible digital database of products and data.
- Output slice to output hardcopy maps and a limited reproduction of digital products.
- Media replication slice to replicate electronic storage media for dissemination.

GEOSPATIAL-RELATED SOFTWARE

E-13. 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-14. Reachback engineer data integration provides a common database, mapping tool, and robust user interface for managing, tracking, and archiving data and reachback support that is managed through the U.S. Army Corps of Engineers Reachback Operations Center related to the engineer reachback process and the field force engineering program.

E-15. 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 reachback engineering data integration system was designed as a common database for all reachback engineer 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-16. The reachback engineering data integration is developed within Microsoft SharePoint® and thus provides the full suite of standard tools and capabilities. Custom-designed tools and menus are provided within the reachback engineering data integration 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-17. Another powerful feature provided in the reachback engineering data integration is a robust mapping tool that enables any data stored within the reachback engineering data integration to be plotted geospatially. The system also provides the capability for data from external sources to be plotted. The user may choose from a variety of maps and imagery as the background layer 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 chat within the reachback engineering data integration. Access to the reachback engineering data integration is available to any common access card holder, and the reachback engineering data integration is available on the unclassified, Secret Internet Protocol Router Network and on the Combined Enterprise Regional Information Exchange System–Korea network for Korean networks.

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
AGE	Army Geospatial Enterprise
AOR	area of responsibility
AR	Army regulation
ASCC	Army Service component command
ATP	Army techniques publication
attn	attention
ATTP	Army tactics, techniques, and procedures
BCT	brigade combat team
CJCSI	Joint Chiefs of Staff instruction
COA	course of action
COP	common operational picture
DA	Department of the Army
DC	District of Columbia
DCGS-A	Distributed Common Ground System–Army
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
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
OAKOC	observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment
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 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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23 JUNE 2014

By order of the Secretary of the Army:

RAYMOND T. ODIERNO
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