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*Installations and Operational Environments (IOE)*

## **Analysis of Vegetation as Terrain: The “How” and “Why” of US Army Doctrine**

W. Gabe Powell, Nathan R. Beane, and  
Matthew D. Blanchard

February 2024

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# **Analysis of Vegetation as Terrain: The “How” and “Why” of US Army Doctrine**

W. Gabe Powell, Nathan R. Beane, and Matthew D. Blanchard

*US Army Engineer Research and Development Center (ERDC)  
Environmental Laboratory (EL)  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199*

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## **Abstract**

There is a significant knowledge gap for Army doctrine concerning civilian research scientists. A relatively small number of soldiers make the transition from warfighter to research and development at the basic and applied levels. That number is even less when considering former warfighters that have applied Army doctrine in an operational or advanced Army schooling environment. This special report is intended to focus solely on the Army's current capabilities and doctrinally defined processes to analyze vegetation as an essential component of the natural terrain. The objective of this report is to review current Army doctrine related to analysis of the vegetated terrain; to explore currently leveraged tactics, techniques, and procedures (TTPs); and identify valuable geospatial resources as they apply to military planning. For ease to readers unfamiliar with US Army doctrine, much of the referenced material is directly presented herein as tables and figures throughout the document and appendices (e.g., data sources, product examples, and glossary).

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## Preface

This study was conducted for the US Army Engineer Research and Development Center–Environmental Lab (ERDC-EL) under Military Direct–Installations and Operational Environments, Funding Work Item Code FF90FK. The technical monitor was Dr. Heather Knotek-Smith, ERDC-EL.

The work was performed by the Wetlands and Coastal Ecology Branch of the Ecosystems Evaluation and Engineering Division for the Military-Direct research program, Intelligent Environmental Battlespace Awareness (IEBA), ERDC-EL. Dr. Nathan Beane was the IEBA Task 5: Vegetation lead. At the time of publication, Ms. Carra Carrillo was acting branch chief; and Mr. Mark D. Farr was division chief. The deputy director of ERDC-EL was Dr. Brandon J. Lafferty, and the director was Dr. Edmond J. Russo Jr.

This report would not be possible without the generous assistance of Soldiers, scientists, and leaders that live in the trenches of terrain analysis in the battle for situational understanding. Special recognition must be given to the National Ground Intelligence Center, US Army Training and Doctrine Command (TRADOC) Proponent Office–Geospatial (TPO-GEO), ERDC’s Geospatial Research Laboratory (GRL), United States Military Academy (USMA), and Army Geospatial Center (AGC).

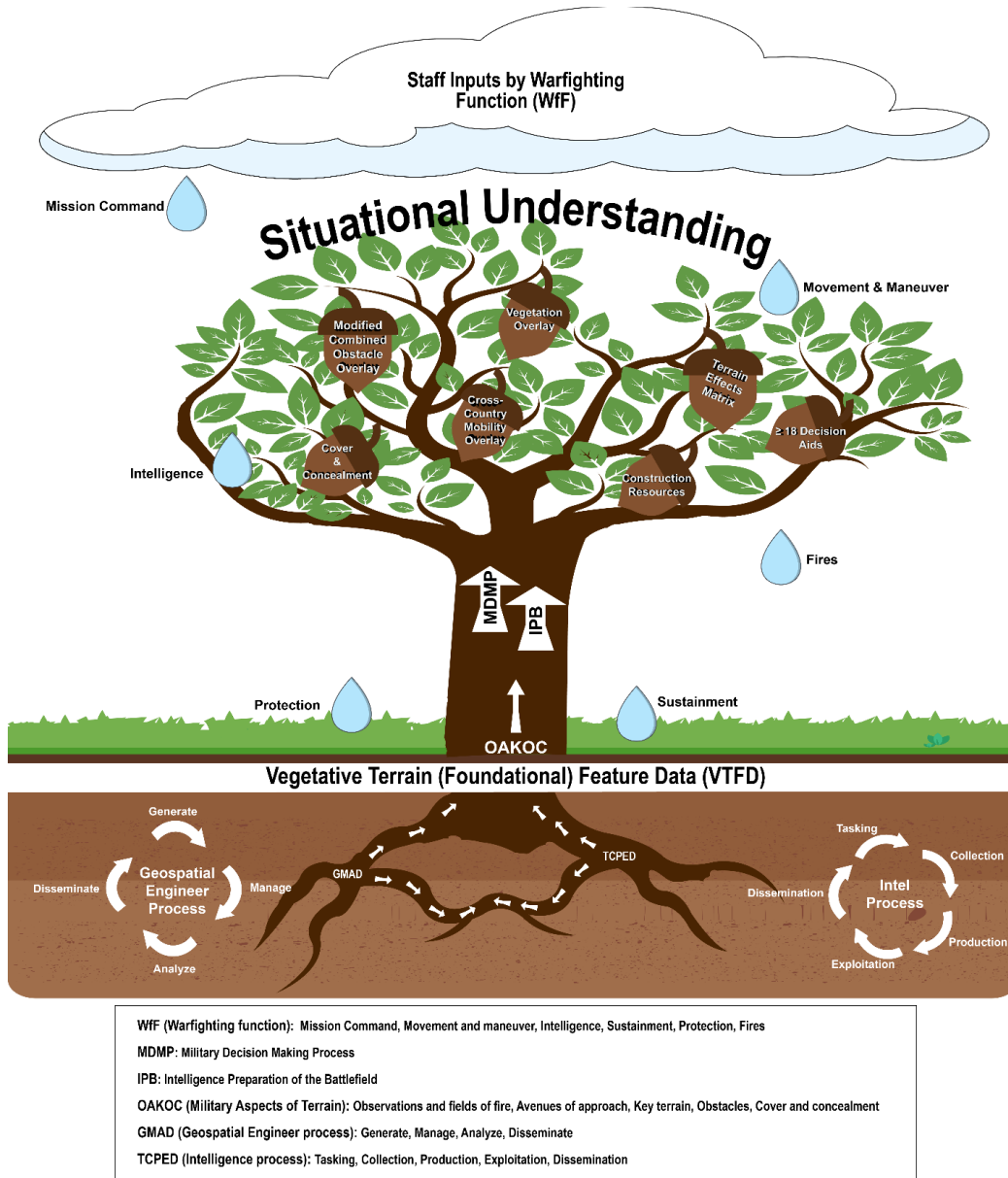
COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

# 1 Introduction

## 1.1 Background

In this report, processes for intelligence preparation of the battlefield (IPB) and the military decision-making process (MDMP) are discussed as they relate to vegetation as terrain. We also explore the roles of intelligence and engineer military occupational specialties (MOSs) for the tasking, collection, generation, and management of vegetative terrain feature data (VTFD). As a significant portion of the overall terrain, VTFD is a crucial part of the foundational landscape on which analysis, decision-making, and current operations management ultimately occur. Figure 1 is a simplified illustration of the personnel, processes, and applications for vegetation as terrain in US Army doctrine. The roots of the tree represent the perpetually present, cyclical, and interdependent processes of the geospatial professionals. They interact with, support, and receive inputs from one another and all other processes throughout the tree. The geospatial engineers create the foundational VTFD with some reliance on intelligence analysts, aided by every staff section (every Soldier is a sensor) for source data and prioritized requirements (ultimately determined by the commander). The trunk finds its strength in two main, concurrent processes: MDMP and IPB. The location and characterization of vegetation in the operational environment (OE) focuses on the military aspects of terrain (i.e., obstacles, avenues of approach, key terrain, observation and fields of fire, and cover and concealment [OAKAC]). The quality of information, analysis, and understanding of VTFD depends heavily on the beneficial inputs (information, intelligence, and refined requirements) from all staff sections across each warfighting function. The warfighting functions (WfF), illustrated in Figure 1, are inputs that strengthen the processes in the VTFD (i.e., the roots and trunk of the tree illustration) and yield tailored products (i.e., tree fruits), such as the modified combined obstacle overlay (MCOO) or one of the almost 20 doctrinally referenced products that rely on VTFD. These processes contribute to the goal of “growing” the most robust and far-reaching situational understanding, for unparalleled mission execution and, ultimately, success.

Figure 1. Army doctrine: Personnel, processes, and deliverables related to vegetation as terrain (sourced from Army Techniques Publication (ATP) 2-01.3 [HQDA 2019a], ATP 3-34.80 [HQDA 2017a], and ATP 2-22.7 [HQDA 2015]).



While MOS roles and responsibilities are well codified in doctrine, there is a glaring absence of doctrinal instructions for the production and standardization of vegetation data. Geospatial professionals at all levels continue to develop unit and area of responsibility (AOR) specific tactics, techniques, and procedures (TTPs) to overcome the lack of standards for the creation of VTFD. Without a doctrinally defined, comprehensive process or a global layer of vegetation attributes that goes beyond land-cover classification, there will continue to be discrepancies in the quality and quantity of VTFD available to individual units. Lower echelons are

especially impacted by this lack of consistency and the resulting loss of efficiency due to increasingly limited resources (e.g., time, personnel, and equipment). US Army Training and Doctrine Command (TRADOC) Proponent Office–Geospatial (TPO-GEO) has placed significant emphasis on developing and improving mechanisms for sharing lessons learned and best practices of geospatial engineers; however, these mechanisms will never be as efficient as having standardized, global VTFD layer(s), along with instructions for its incorporation in multi-domain operations (MDO) processes, readily available for access and application. The good news is that several terrain analysis related efforts are underway at the US Army Engineer Research and Development Center (ERDC) and TPO-GEO to develop and refine processes and doctrine that include the creation of VTFD.<sup>1</sup>

Current Army doctrine prescribes the use of mounted forces in open terrain and dismounted forces in complex terrain (ADP 3-90 [HQDA 2019e, chaps. 3 and 4]). However, history shows us that tracked and wheeled vehicles are often forced to navigate restricted terrain and dismounted troops may need to move through more open landscapes. In the analysis of terrain, Army doctrine divides the terrain into two main feature categories, natural and man-made (Army Techniques Publication (ATP) 2-01.3 [HQDA 2019a, p. 3-2, fig. 3-1]). It further divides the natural terrain into a minimum of four mobility factors: vegetation, slope, hydrology, and soils<sup>2</sup> (linear obstacles, such as mountain ranges and rivers, are often included) (ATP 2-01.3 [HQDA 2019a, p. 4-13]; ATP 3-34.80 [HQDA 2017a, p. B-5 and B-6]). Each of these mobility factors are represented by a separate factor overlay that can then be unified to form a combined obstacle overlay (COO) and a MCOO at the completion of IPB, Step 2, Substep 2 (Figure 2) (ATP 2-01.3 [HQDA 2019a, p. 4-2 fig. 4-1]). Each mobility factor can then be assessed in relation to one another and the military aspects of terrain (observations and fields of fire, avenues of approach, key terrain, obstacles, cover and concealment [OAKOC]). The COO is a mobility product, but to fully execute Step 2 of IPB (i.e., evaluate terrain effects on operations), each terrain factor must be assessed by all

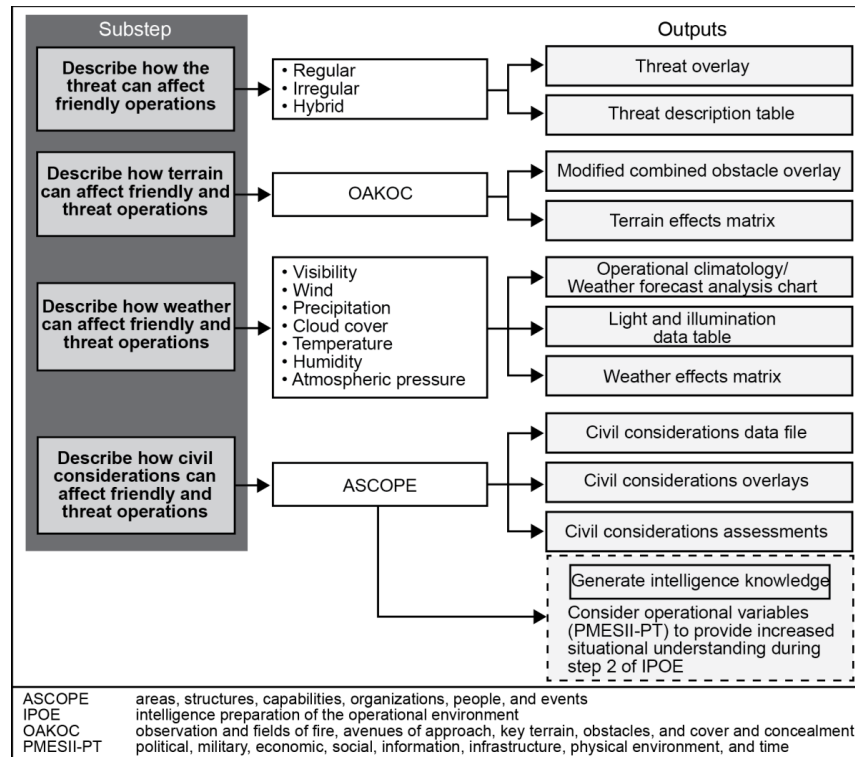
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1. In addition to assisting doctrine revision, ERDC has programs (e.g., Intelligent Environmental Battlespace Awareness and Enhanced Terrain Processing) working to address the lack of standardized VTFD layers and generation processes.

2. The rewrite for ATP 3-34.80 (HQDA 2017a) (currently being prepped for Army Wide Staffing) slightly modifies the mobility factors: surface configuration (slope, surface roughness), hydrology (surface drainage), and surface materials (soils), TPO-GEO correspondence 2 December 2022.

staff elements to address impacts across all six warfighting functions (see Table 1) (ADP 3-0 [HQDA 2019b, p. 4-7]).

**Figure 2. Intelligence preparation of the battlefield (IPB) Step 2 substeps and outputs (sourced from ATP 2-01.3 [HQDA 2019a, fig. 4-1]).**



Regarding Figure 2, note that in the current ATP 3-34.80 (HQDA 2017a), table 4-5 on p. 4-14 incorrectly places “Analyze the factors of the physical environment using OAKOC...” in Step 1 of IPB instead of Step 2, Substep 2. The table has been removed from the upcoming ATP 3-34.80 update and replaced with a statement describing geospatial engineering support to the Intelligence Warfighting Function.<sup>3</sup> Also note that many of the outputs from IPB Step 2, and other tailored geospatial products, are also referred to as tactical decision aids (TDAs) (ATP 3-34.80 [HQDA 2017a, p. 1-2]) with a new term forthcoming, geospatial decision aids (GDAs), which are tailored geospatial products that support Department of Defense (DoD) and Defense Support of Civil Authorities (DSCA) operational planning processes and mission execution by providing decisional authorities with an understanding of advantages and disadvantages of the terrain against critical aspects over a given operational environment and timeframe).<sup>4</sup>

3. TPO-GEO input 2 December 2022

4. TPO-GEO input 2 December 2022

**Table 1. Geospatial product considerations for each of the warfighting functions (sourced from ATP 3-34.80 [HQDA 2017a, table 4-1]).**

Warfighting Function	Geospatial Product Considerations
Mission command	<ul style="list-style-type: none"> <li>• Contribute to situational understanding.</li> <li>• Establish the foundation for the COP.</li> <li>• Determine terrain suitability (including LOS) for positioning mission command nodes and communication systems.</li> </ul>
Movement and maneuver	<ul style="list-style-type: none"> <li>• Identify mobility corridors and determine avenues of approach.</li> <li>• Predict on- and off-road mobility.</li> <li>• Analyze cover and concealment.</li> <li>• Template zones of entry (helicopter landing zones and drop zones).</li> <li>• Provide observation overlays for determining patrol routes, observation posts, and potential ambush or sniper locations.</li> <li>• Locate points of penetration and support-by-fire positions in support of attacks and breaching operations.</li> <li>• Identify and analyze potential engagement areas and obstacle locations based on observation and fields of fire.</li> <li>• Provide updated SSGF.</li> </ul>
Intelligence	<ul style="list-style-type: none"> <li>• Provide terrain analysis products in support of IP8.</li> <li>• Enable intelligence synchronization.</li> <li>• Provide support to targeting (high-payoff target information).</li> </ul>
Fires	<ul style="list-style-type: none"> <li>• Facilitate targeting.</li> <li>• Template observer and firing points based on visibility and suitability.</li> <li>• Analyze mobility to facilitate the positioning of artillery systems.</li> <li>• Provide survey control points for subordinate agencies employing mounted and handheld platforms.</li> </ul>
Sustainment	<ul style="list-style-type: none"> <li>• Display transportation network (road, rail, and air) information for establishing lines of communication and main supply routes.</li> <li>• 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.</li> </ul>
Protection	<ul style="list-style-type: none"> <li>• Identify threat air avenues of approach through elevation and LOS analysis.</li> <li>• Provide observation and fields of fire analysis for implementing counter direct and indirect fire and terrain denial measures.</li> <li>• Provide cover and concealment analysis for assembly areas and forward resupply nodes.</li> <li>• Identify the availability and location of force protection materials.</li> </ul>

Note: COP = common operational figure; LOS = line of sight; and SSGF = standard sharable geospatial foundation.

## 1.2 Objective

The objective of this report is to review current Army doctrine related to analysis of vegetated terrain, to explore currently leveraged TTPs, and identify valuable geospatial resources.

## 1.3 Approach

Domination on the battlefield begins with dominance in understanding the operating environment. To ensure superior situational understanding and develop the COO/MCOO, an improved and codified approach to analyze vegetation as terrain in more detail is imperative. This special report is intended to focus solely on the Army's current capabilities and doctrinally defined processes to analyze vegetation as an essential component of the natural terrain.

## 2 Vegetated Terrain Analysis—Doctrinal Context

Historically, the Army’s terrain analysis methods were prescribed by Field Manual (FM) 5-33 *Terrain Analysis*, published in 1990. This FM was last referenced prior to the Army Doctrine 2015 updates and is no longer current doctrine, particularly due to its focus on Cold War era requirements and aerial photo interpretation techniques. As of 2023, FM 5-33 (to be published as a technical manual [TM]) is undergoing revision with the oversight of TPO-GEO and assistance from ERDC. Pending publication of new terrain analysis doctrine, Warfighters rely largely on three authoritative publications for understanding and executing analysis of the vegetated terrain; ATP 2-01.3 *Intelligence Preparation of the Battlefield* (Unclassified [U]) (HQDA 2019a), ATP 2-22.7 *Geospatial Intelligence* (controlled unclassified information [CUI], previously for official use only [FOUO]) (HQDA 2015), and ATP 3-34.80 *Geospatial Engineering* (U) (HQDA 2017a) (and its associated Training Circular (TC) 3-34.80 [HQDA 2019f]).<sup>5</sup> While these three references are not as comprehensive as the FM 5-33, they do address the purpose, process, and potential outputs of terrain analysis with the intent of increased situational understanding of the OE. ATP 2-01.3 (HQDA 2019a) is written by the Army Intelligence proponent and is intended for application across all staff sections for their, and their commander’s, benefit. ATP 2-22.7 *Geospatial Intelligence* (HQDA 2015), also an Army Intelligence proponent document, is focused on the fundamentals, tasks, and considerations of imagery intelligence. ATP 3-34.80 *Geospatial Engineering* (HQDA 2017a) is written by the Army Engineer proponent with a primary audience of engineer commanders and staff officers who supervise and conduct terrain analysis. All three references are designed to support the operations process and the execution of MDO (FM 3-0 [HQDA 2022e]).

One additional doctrinal reference is TM 3-34.64, *Military Soils Engineering* (HQDA 2012), used extensively by engineers. This TM states that “every soil deposit develops a characteristic profile because of weathering and the leaching action of water as it moves downward from

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5. The original ATP 3-34.80 *Geospatial Engineering* (July 2010) was created as a combination of three Army publications: FM 3-34.230 *Topographic Operations* (Aug 2000), FM 5-33 *Terrain Analysis* (July 1990), and TC 5-230 *Topographic Drafting* (1940). The combination thus rendered the three pubs inactive from Army Publications Directorate (APD) (TPO-GEO input 30 November 2022).

the surface. The profile developed depends not only on the nature of the deposit but also on factors such as temperature, rainfall amounts, and vegetation type” (TM 3-34.64 [HQDA 2012, p. 4-4]). *Military Soils Engineering* (HQDA 2012) discusses vegetation impacts on soils within three main categories: (1) geomorphology, (2) hydrogeology, and (3) engineering with nature. Examples of geomorphological impacts include terrain feature formation (e.g., sand dunes as impacted by the presence of vegetation) (p. 3-34 and 3-35); tree growth patterns as an indicator of slope stability (p. 10-18); and impacts of trees, mosses, and grasses on permafrost/soil thaw depth (p. 12-8). In the realm of hydrogeology, vegetation type and growth patterns are listed as potential indicators for the presence of groundwater (p. 7-8). TM 3-34.64 (HQDA 2012) also points to ways in which vegetation may be used to improve soil attributes (e.g., planting practices for sand stabilization, p. 9-81), providing clear verbiage that vegetation has an impact on situational understanding: “When provided with adequate geographic and geologic intelligence, commanders are able to exploit the advantages of the terrain and avoid or minimize its unfavorable aspects. Data on soil movement, the presence of hard rock, and the kind and distribution of vegetation is needed when considering concealment and cover, cross-country travel, and field fortifications” TM 3-34.64 (HQDA 2012, p. 2-34).

To understand the applicability of vegetation to situational understanding in Army doctrine, it is necessary to identify where vegetation analysis occurs in the operations process and explore the inputs and outputs identified by doctrine. Figure 3 shows the relationship between the IPB steps and the MDMP. Once a unit receives a mission (MDMP Step 1), Step 1 of IPB begins, in which the operational environment is defined. As part of IPB Step 1, Substep 3, military planners must “identify significant characteristics of the AO [area of operations] and AOI [area of interest]” (Figure 4) that can “influence friendly COAs [course of action] and command decisions” (ATP 2-01.3 [HQDA 2019a, p. 3-2]). This substep coincides with the earliest phases of mission analysis to identify significant characteristics for future analysis. For vegetation, those significant characteristics commonly include forests where various attributes (e.g., species, distribution, size, and foliage density) can impact mobility, cover, concealment, line of sight (LOS) communications, and material available for protection. Similar attributes in areas predominately composed of shrubs or grass can have significant impacts on dismounted forces but are generally less impactful for mechanized units. However, with detailed analysis of vegetative cover, soils, and hydrology, even grassland areas

may be identified with significant impacts to mechanized mobility (Wieder and Shoop 2017; Pauly 2019). Despite the focus of Army vegetation analytics on mechanized mobility, the importance of vegetation in dismounted operations is also critical to the Warfighter. For example, in TC 3-21.76 (*Ranger Handbook*) (HQDA 2017b), trees, shrubs, and vegetation are collectively mentioned 39 times in this very applied doctrinal reference.

Figure 3. IPB and the military decision-making process (MDMP) steps (sourced from ATP 2-01.3 [HQDA 2019a, fig. 2-1]).

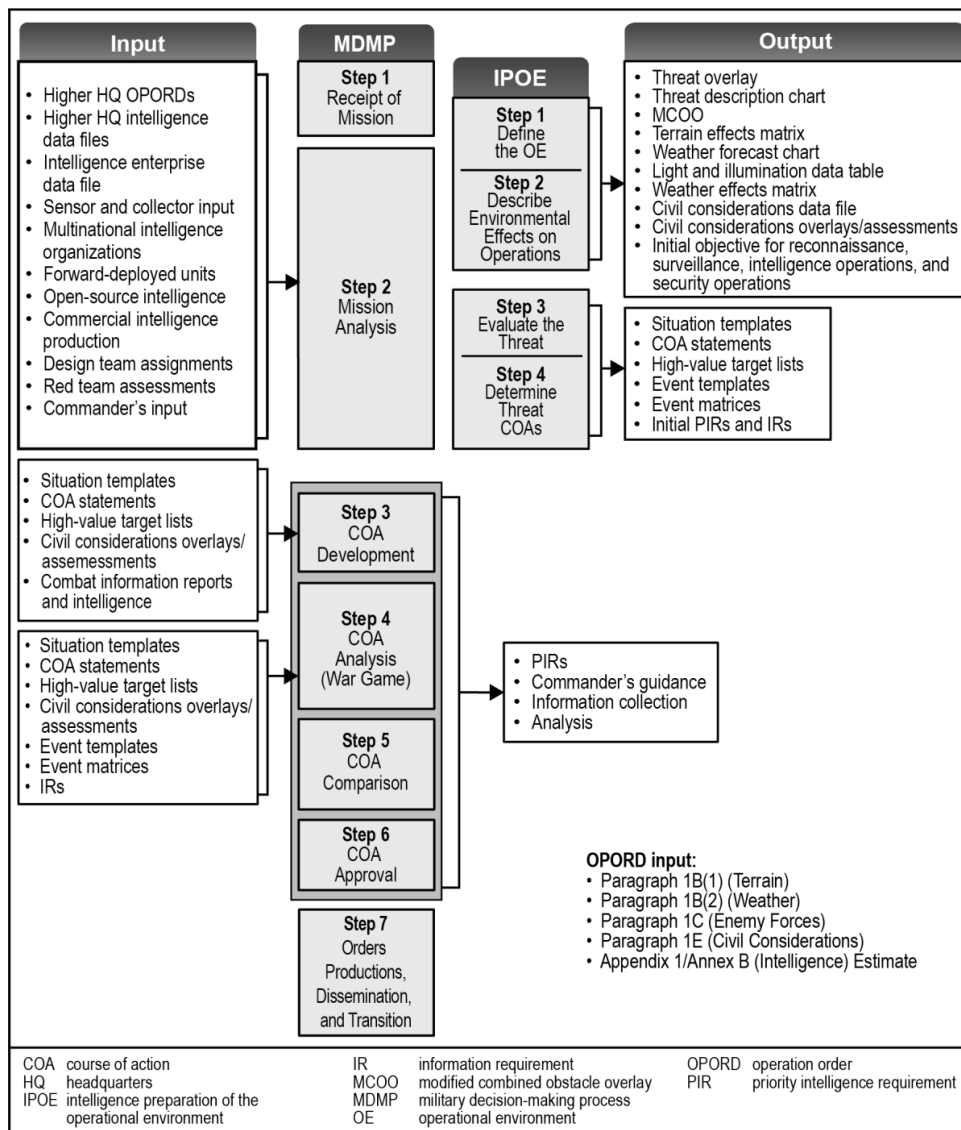
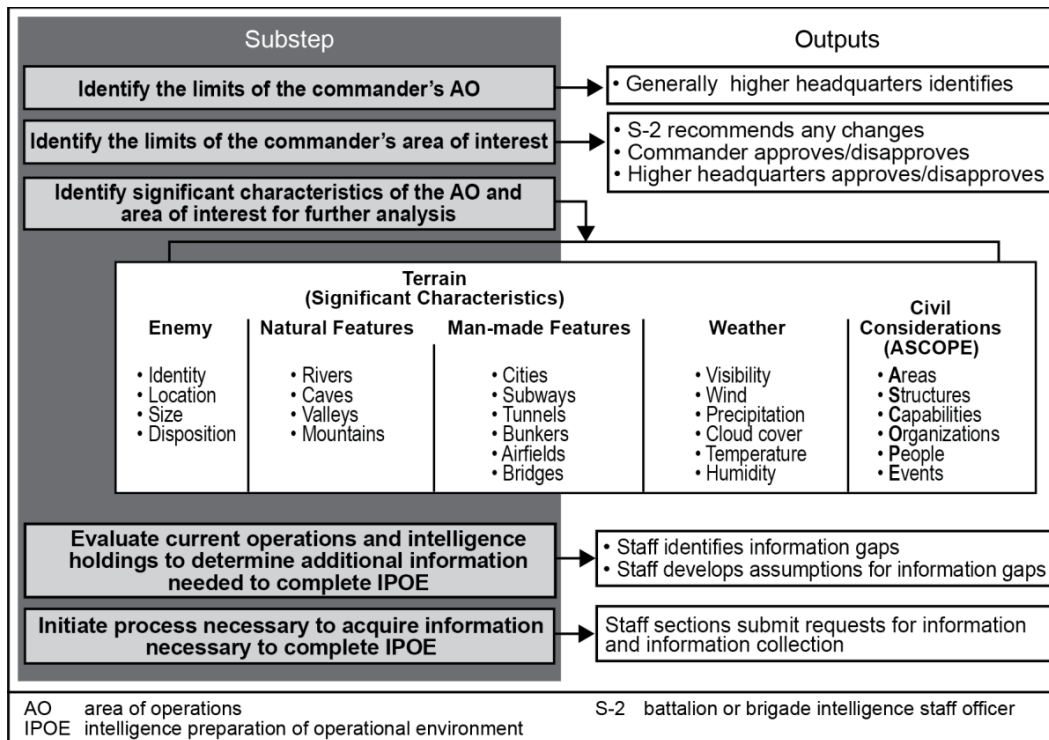


Figure 4. IPB Step 1 substeps and outputs (sourced from ATP 2-01.3 [HQDA 2019a, fig. 3-1]).



### 3 Requirements for Success

As mission analysis (MDMP Step 2) begins in earnest, Step 2 of IPB begins to describe the effects of the environment on operations. A key component of this step is the accurate characterization of vegetation present to understand its impacts to (1) observation and fields of fire, (2) avenues of approach and mobility corridors (Table 2), (3) selection of key terrain (generally through its influence on avenues of approach/mobility corridors), (4) obstacles it may pose (mainly for mounted, but also for dismounted, mobility), and (5) cover and concealment. It is important to note that terrain is also described up front in the US Army operations order (OPORD), illustrating the significance of understanding the terrain and vegetation to inform MDMP and IPB (FM 5-0 [HQDA 2022a, p. D-9, paragraph 1b(1)]). In an Army that prioritizes every effort, doing and discussing the most important things first, this is quite a statement. Within the OPORD, vegetated terrain analysis is also presented in the first tab (Tab A, Terrain) of the first appendix (Appendix 1, Intelligence Estimate) of the second annex (Annex B, Intelligence) (ATP 2-01.3 [HQDA 2019a, p. 2-2]) and Appendix 4 (Geospatial Engineering) of annex G (Engineer) (ATP 3-34.80 [HQDA 2017a, p. 4-10]).

The successful execution of vegetated terrain analysis enhances a commander's ability to understand and exploit vegetation characteristics on the battlefield to "best support the mission during decisive, shaping, and sustaining operations" (ATP 2-01.3 [HQDA 2019a, p. 4-1]). Failure to adequately analyze vegetation in a timely manner may yield the upper hand to a threat commander that possesses that knowledge and exploitation capabilities. If a threat commander possesses information about vegetation unidentified by friendly forces, it will significantly inhibit friendly military planners' abilities to develop and evaluate threat COAs. For example, through familiarity of a forest's understory and midstory characteristics, the threat commander may be able to capitalize on mobility corridors made possible by mechanized override of smaller vegetation. Those subcanopy forest characteristics will remain unrecognized by friendly forces identifying mobility corridors through tree canopy analysis, giving the advantage to the threat forces. COA selection criteria can be improved with a greater understanding of vegetation and understory characteristics resulting from an in-depth, quantified analysis of the military aspects of the vegetated terrain.

Table 2. Maximum distances between and typical widths of mobility corridors (sourced from ATP 2-01.3 [HQDA 2019a, table 4-2]).

<i>Maximum Distances between Mobility Corridors</i>		
<i>Avenue of Approach</i>	<i>Cross-Country Mobility Corridor Classification</i>	<i>Approximate Distances Between Terrain Features</i>
Division	Brigade	10 kilometers
Brigade	Battalion	6 kilometers
Battalion	Company	2 kilometers
<i>Typical widths of mobility corridors</i>		
<i>Unit</i>	<i>Width</i>	
Division	6 kilometers	
Brigade	3 kilometers	
Battalion	1.5 kilometers	
Company	500 meters	

## 4 Obstacles to Execution

For the execution of IPB Step 2, the *what*, *how*, and *why* regarding the impacts of vegetation on the ability to conduct MDO are vaguely defined in current doctrine. This is primarily due to the lack of detailed attribution data (particularly stem spacing and diameter) available in contested, nonpermissive environments. It should be noted that geospatial engineers and intelligence analysts are aware of these doctrinal limitations and the need for detailed VTFD. They strive tirelessly to overcome this for every mission. Of note, there are limited doctrinal explanations of the impacts of vegetation to the Warfighter:

1. The terrain effects matrix example (Table 3) mentions that sparse vegetation does not impact observation but does limit concealment (ATP 2-01.3 [HQDA 2019a, p. 4-16, table 4-5]).
2. The vegetation overlay example claims to show its effects, but only depicts land cover (ATP 3-34.80 [HQDA 2017a, p. B-12]).
3. The aerial concealment overlay example is merely a recoded land cover classification delineating forest from shrubland from grassland (ATP 3-34.80 [HQDA 2017a, p. B-16]).
4. Vegetation is somewhat codified as a surrogate for groundwater roughly by vegetation genus (ATP 3-34.80 [HQDA 2017a]).<sup>6</sup>
5. The entire description of geospatial engineering terrain characteristics for vegetation barely exceeds 500 words (ATP 3-34.80 [HQDA 2017a, p. D-7]).
6. Jungle environments are often mapped as featureless entities that require foliage penetration and ground truthing to meet commander's information requirements (ATP 2-22.7 [HQDA 2015, p. 10-2]).
7. ATP 2-22.7 (*Geospatial Intelligence*) (HQDA 2015, tables C-1, D-1, and D-2) acknowledges that there is a relationship between vegetation and sensor type and spatial resolution as related to intelligence collection.
8. In the most authoritative example of a MCOO in Army doctrine, ATP 2-01.3 (HQDA 2019a), the implications of vegetation as an obstacle are not captured in the illustration. Instead, mobility is depicted merely as a derivative of slope (Figure 5).
9. TM 3-34.64 (HQDA 2012, p. 2-34) directly or indirectly associates the distribution of vegetation with impacts on cover, concealment, and cross-country mobility (Table 4).

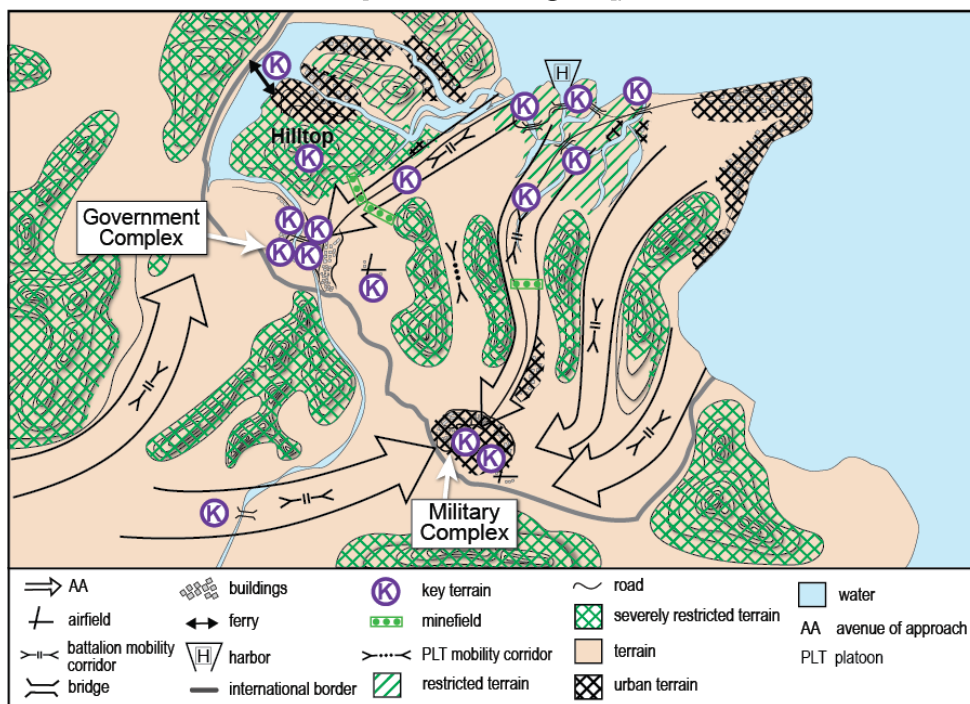
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6. "Palm trees indicate water within 2 or 3 feet, salt grass indicates water within 6 feet, and cottonwood and willow trees indicate water within 10 to 12 feet. The common sage, greasewood, and cactus do not indicate water levels" [ATP 3-34.80 [HQDA 2017a, p. D-2]].

Table 3. Terrain effects matrix (sourced from ATP 2-01.3 [HQDA 2019a, table 4-5, p. 4-16]).

OAKOC Factors (Military Aspects of Terrain)	Terrain Effects
Observation and fields of fire	<ul style="list-style-type: none"> <li>Sparse vegetation on generally flat desert terrain with observation of 3 to 5 kilometers.</li> <li>There are 10 kilometers between intervisibility lines.</li> <li>Limited air support observation due to sparse terrain and the Earth's curvature.</li> <li>Fields of fire for direct fire are 300 to 500 meters for small arms.</li> <li>Intermediate breaks in observation and fields of fire due to runoffs and cuts.</li> <li>Likely engagement area at Julian pass.</li> <li>Likely engagement area 1000 meters north of the major city.</li> </ul>
Avenues of approach (AAs)	<ul style="list-style-type: none"> <li>Primary and secondary road systems for high AAs.</li> <li>Generally flat terrain with brigade-sized mobility corridors between small villages.</li> <li>Railroad in the north running east to west.</li> <li>AA2 is the recommended AA as it enables the placement of organic weapon systems in range before observation from the threat in the defense.</li> </ul>
Key terrain	<ul style="list-style-type: none"> <li>Airfield used as resupply and troop movements.</li> <li>Dam controls water flow on the river and is the primary objective of the threat.</li> </ul>
Obstacles	<ul style="list-style-type: none"> <li>Restrictive runoffs and cuts run throughout the area of operations with an average depth of 5 to 10 feet and an average width of 20 feet that runs 6 to 10 kilometers long.</li> <li>Aboveground oil and transport pipeline (which is severely restrictive terrain) that runs through the central width of the area of operations.</li> </ul>
Cover and concealment	<ul style="list-style-type: none"> <li>Cover by direct fire systems is provided by intervisibility lines.</li> <li>Concealment is limited by the open terrain and sparse vegetation.</li> </ul>

Figure 5. Modified combined obstacle overlay (sourced from ATP 2-01.3 [HQDA 2019a, fig. 4-9]).



**Table 4. Reports for geographic/terrain intelligence (sourced from Technical Manual (TM) 3-34.64 [HQDA 2012, table 2-2]).**

Report Title	Report Application
Terrain study on the state of the ground	Planning movement, maneuver operations Planning ADM activity Planning combat operations (constructing, maintaining, and repairing roads, fjords, landing strips, and fortifications) Planning logistics support
Terrain study on construction suitability	Planning combat operations (constructing fortifications, landing strips, camouflage, obstacles, and a CP's supply installations) Selecting construction supply-point locations
Terrain study on coasts and landing beaches	Planning amphibious operations (preparing and removing obstacles and fortifications) Planning recon activity Planning port construction
Terrain study on cross-country movement	Planning and executing maneuver, movement operations Planning logistics support Planning barrier and denial operations
	Planning engineer combat operations
Terrain study on airborne landing areas	Planning area-clearing support Planning recon activity Planning combat operations (constructing and repairing landing strips) Selecting helicopter landing zones

Note: ADM = area defense management; and CP = command post.

Appendix B of ATP 2-01.3 (HQDA 2019a) is one of the few attempts in current Army doctrine to quantify the impacts of vegetation characteristics on operations. In Table 5, the relationships between trunk diameter and spacing and mechanized mobility are depicted. Table 6 and Table 7 quantify the relationship between canopy closure as related to cover and concealment. The categories in the tables are coarse and largely inadequate for the needs of today's warfighter. The introduction even states "When conducting IPB, analysts should strive to collect the most accurate and current information on the OE. However, this requires extensive research and analysis. If the data is unavailable, tables [5, 6, and 7] should provide analysts a firm starting point for creating an IPB product. Note. These tables are provided as a last resort and are recommended to only be referenced when better data is unavailable" (ATP 2-01.3 [HQDA 2019a, Appendix B]).

**Table 5. Terrain types for mechanized armor forces (sourced from ATP 2-01.3 [HQDA 2019a, table B-2]).**

<i>Terrain type</i>	<i>Slope (%)</i>	<i>Streams</i>			<i>Vegetation</i>			<i>Typical speeds (unopposed) (km/hour)</i>
		<i>Depth (feet)</i>	<i>Current (feet/sec)</i>	<i>Width (feet)</i>	<i>Spacing (feet)</i>	<i>Trunk diameter (inches)</i>	<i>Roads/ Trails (per km)</i>	
Unrestricted	< 30	< 2	–	< 5	> 20	< 2	2/4	24
Restricted	30 to 45	2 to 4	< 5	< AVLB length	< 20	2 to 6	1/2	16 (8 at night)
Severely restricted	> 45	> 4	> 5	> AVLB length	< 20	> 6	0/<2	1 (.4 at night)

AVLB = armored vehicle-launched bridge; km = kilometer; and sec = second.

**Table 6. Cover from flat trajectory weapons (sourced from ATP 2-01.3 [HQDA 2019a, table B-3]).**

<i>Parameter</i>	<i>Factor</i>	<i>Criteria (percent)</i>
Good	Slope	> 30
	Canopy closure	> 50*
	Roof coverage	> 40
Fair	Slope	10 to 30
	Canopy closure	< 50
	Roof coverage**	20 to 40
Poor	Slope	< 10
	Nonforested	
	Roof coverage**	< 20

\* Or stem spacing 5 meters

\*\* If evaluated

**Table 7. Concealment from aerial detection and percentage of (canopy) roof coverage (sourced from ATP 2-01.3 [HQDA 2019a, table B-4]).**

<i>Roof Coverage (Percentage)</i>	<i>Category</i>	<i>Concealment</i>
75 to 100	Congested	Excellent
50 to 75	Dense	Good
25 to 50	Moderate	Fair
5 to 25	Sparse	Poor
0 to 5	Open	None

## 5 An Adaptive Force

Many units have developed unit specific TTPs for more in-depth analysis of vegetation at relatively large map scales (i.e., small area of coverage). The Army has developed a few, at times underleveraged, mechanisms for sharing such TTPs and for disseminating advances in spatial analytics made in the civilian sector. The US Army Combined Arms Center has a dedicated Center for Army Lessons Learned with the mission statement that reads “deliver timely and relevant information to resolve gaps, enhance readiness, and inform modernization” (US Army, n.d.). Additionally, TPO-GEO hosts All Things Geospatial monthly meetings to garner feedback from the force for TTPs, lessons learned, etc. TPO-GEO also hosts the Geospatial Engineering Working Group annually to facilitate doctrinal inclusion of the TTPs.<sup>7</sup>

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7. TPO-GEO 2 December 2022

## 6 Engineer + Intelligence + Digital Infrastructure: The VTFD Equation

With the completion of the vegetation overlay and its inclusion in the COO and MCOO, the most significant effort(s) to analyze the vegetated terrain are captured in the products of IPB and mission analysis. However, vegetation continues to influence MDMP all the way through the end of the mission. The outcome of initial MDMP and IPB efforts is an OPORD that begins with a description of the terrain and ends with annexes that address its impacts. It is important to realize that vegetation analysis does not end with the completion of the OPORD. Staff sections, across all warfighting functions, collect and assess new information to maintain their running estimates and make recommendations to the commander (ADP 5-0 [HQDA 2019c, p. 5-5]). When collections before, during, and after operations provide new inputs regarding vegetation (e.g., information/intelligence collection from sensors and soldiers), geospatial engineers must update their analysis and all relevant geospatial products.

While geospatial engineers and intelligence analysts share much of the same production capabilities (i.e., they rely on systems that share much of the same underlying software architecture), recent doctrine clearly delineates their production responsibilities. *The Soldier's Manual and Trainer's Guide for MOS 35F Intelligence Analyst Skill Levels 1/2/3/4* charges analysts with identifying the necessary terrain analysis products (see Table 8) and requesting them (via the geospatial intelligence [GEOINT] cell) from geospatial engineers (Soldier Training Publication (STP) 34-35F14-SM-TG [HQDA 2023]). Geospatial engineers complete the requested products, in addition to developing/refining the underlying foundational terrain feature data. Once the products are completed by geospatial engineers, the intelligence section uses those products to create/update the COO and MCOO (STP 34-35F14-SM-TG [HQDA 2023, p. 3-10 to 3-15]). It is important to note that while this is a collaborative process, geospatial intelligence imagery analysts (MOS 35G) do not have specified tasks for generation of foundational vegetation data (STP 34-35G14-SM-TG [HQDA 2021b]).

In the most basic terms, the role of GEOINT and geospatial products are to support MDO, the Army's warfighting doctrine. The processes of MDMP and IPB are nested in that warfighting doctrine and the most prescriptive processes in which geospatial capabilities are applied. As defined in ATP

2-22.7 (HQDA 2015, Glossary-3), GEOINT exploits information with a spatial component (i.e., location) to describe, assess, and visualize physical attributes and activities. Joint Publication (JP) 2-0 (CJCS 2022a) Joint Intelligence (May 2022) further clarifies that imagery, imagery intelligence, or geospatial information may be considered GEOINT. ATP 3-34.80 (HQDA 2017a, p. 1-2) defines geospatial engineering as “those engineering capabilities and activities that contribute to a clear understanding of the physical environment by providing geospatial information and services to commanders and staffs.” The soon to be published update to ATP 3-34.80 incorporates the use of geographic information systems (GIS) to the definition.<sup>8</sup> Geospatial engineers (and GEOINT analysts) create geospatial products to accurately (both in space and time) map, visualize, analyze, and/or model to enable decision making of the commander and staff (ATP 3-34.80 [HQDA 2017a, p. 1-2]).

“The geospatial engineering contribution to GEOINT includes the standards, processes, personnel, and equipment required to generate, manage, analyze, and disseminate [GMAD] the geospatial information necessary to enable an understanding of the physical environment” (ATP 3-34.80 [HQDA 2017a, p. 1-7]). From an MDO perspective, application of VTFD occurs in two main settings: support to planning and operations (as previously discussed in relation to IPB and MDMP) and support to the common operational picture (COP). The COP is a shared display of relevant information for situational awareness across all commands in an operation (ATP 2-22.7 [HQDA 2015, p. 1-2]). The universal situational awareness provided by the COP enables both mission planning and execution across echelons (ATP 2-22.7 [HQDA 2015, p. 1-2]). VTFD supports the COP by providing a portion of the foundational feature data, the vegetation attributes (Figure 6). Ideally, VTFD is incorporated into the standardized terrain data that, along with other foundational layers, comprises the canvas on which current events (e.g., unit positions and significant activities) are painted. Unfortunately, the lack of consistently attributed VTFD often results in the background imagery for the COP providing the only awareness of vegetation in the AO. In nonurban (i.e., natural terrain) environments, the accurate portrait of current operations cannot not be achieved without VTFD’s contribution to the foundational feature canvas on which the COP is painted. Since situational awareness provided by the

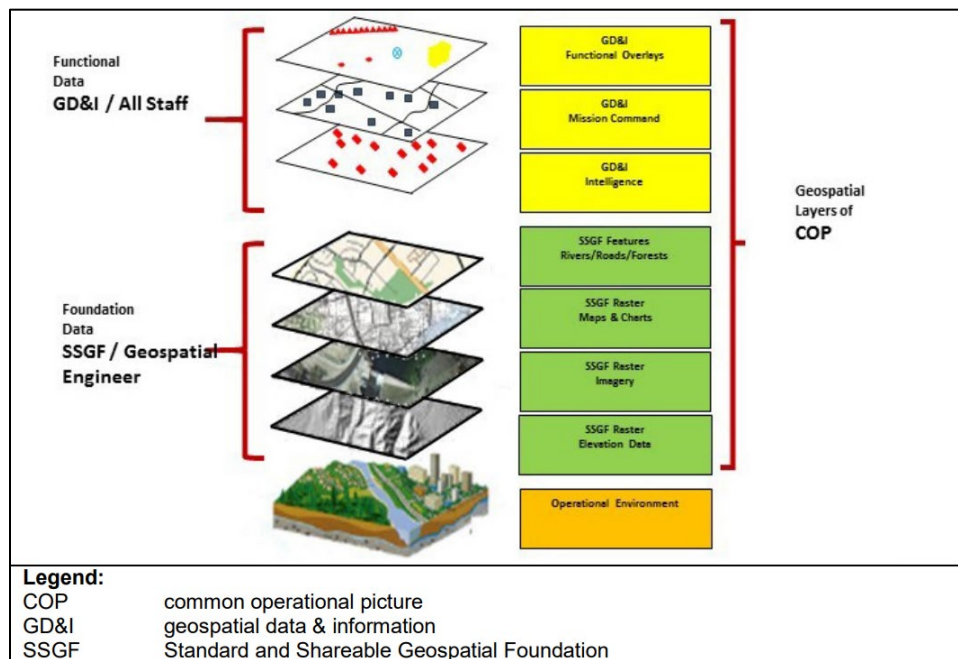
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COP also feeds back into the operations process for planning of future operations, the lack of VTFD also detracts from mission planning.

Even the lowest ranking member of a fire team is aware that in every situation for the Army there is someone in charge. The GMAD process for creating the VTFD canvas, as well as the tasking, collection, production, and dissemination (TCPED) of the intelligence painted on it are no different. The National Geospatial-Intelligence Agency (NGA) is the proponent for the National System for Geospatial Intelligence (NSG) and serves as the primary source of national level data and standards in support of MDO (ATP 3-34.80 [HQDA 2017a, p. 1-7]; ATP 2-22.7 [HQDA 2015, p. 1-6]). Many agencies and centers support the NSG, see Appendix F of ATP 2-22.7 (HQDA 2015). The two main Army entities that support the NSG are the National Ground Intelligence Center (NGIC) and the US Army Corps of Engineers (USACE) Army Geospatial Center (AGC). Formal support to the NSG continues down through the Army echelons all the way to the Brigade Combat Team (BCT). Table 9 depicts the personnel structure of support to GMAD for VTFD at Corps, Divisions, and BCTs.

Figure 6. Geospatial layers of the COP (sourced from Training Circular (TC) 3-34.80 [HQDA 2019f, fig. 3-1]).



**Table 8. Tailored geospatial products dependent on vegetation characterization (modified from ATP 3-34.80 [HQDA 2017a, Appendix B]; ATP 2-22.7 [HQDA 2015, table 7-2]; and ATP 2-01.3 [HQDA 2019a, table 4-5]).**

Geospatial Product	Primary Use	Description	Unmet Need	Vegetation Characteristics Required*
Aerial Concealment	Shows areas or routes that offer concealment from overhead detection	Identifies the most suitable areas to conceal a force from overhead detection based on the analysis of woods, underbrush, tall grass, and cultivated vegetation. It is particularly useful in templating areas where threat forces may be operating. It can also help friendly forces identify concealed movement routes and staging areas.	Will benefit from accurate canopy closure and understory characterization assessments	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Canopy/Foliage density and seasonality</li> </ul>
Combined Obstacle Overlay (COO)	Identifies mobility corridors and friendly and threat avenues of approach (AAs) and engagement areas (EAs)	Includes data about obstacles, surface configuration, surface material, vegetation, hydrology, and some information about lines of communications. Unlike the cross-country mobility overlay, the combined obstacle overlay integrates obstacles to vehicular movement (built-up areas, slope, soils, vegetation, hydrology) into one overlay. The overlay depicts areas that impede movement (severely restricted and restricted areas) and areas where friendly and threat forces can move unimpeded (unrestricted areas).	Requires more in-depth vegetation analysis. See "Vegetation Analysis."	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Concealment/Cover	Shows a visualization of the vegetation and terrain that may allow for concealment/ cover of vehicles, personnel, and facilities	Includes aspects of the terrain that offer protection from bullets, exploding rounds, and explosive hazards (cover) and aspects of the terrain that offer protection from observation, such as vegetation and surface configuration (concealment). May determine how cover and concealment can be used to effectively enhance survivability.	Will benefit from under and mid story characterization (concealment) and from accurate tree density, diameter, and abundance measurements (cover)	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Cross-Country Mobility	Annotates the mobility that meets the mission objective	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. Cross-country mobility is used to help identify avenues of approach and engagement areas.	Requires more in-depth vegetation analysis. See "Vegetation Analysis."	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>

**Table 8 (cont.). Tailored geospatial products dependent on vegetation characterization (modified from ATP 3-34.80 [HQDA 2017a, Appendix B]; ATP 2-22.7 [HQDA 2015, table 7-2]; and ATP 2-01.3 [HQDA 2019a, table 4-5]).**

Geospatial Product	Primary Use	Description	Unmet Need	Vegetation Characteristics Required*
Construction Resources	Shows areas that contain certain types of materials to support construction planning	Shows the natural resources of an area. This product can help engineers plan major construction projects (roads, base camps) that are benefited by having close access to certain types of construction materials that can be made readily available through quarrying. May include timber resources.	Will benefit from accurate tree species, height, and diameter	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem abundance, diameter, and height</li> </ul>
Drop Zone	Locates possible drop zones to support airborne operations	Helps planners quickly template possible drop zones in support of airborne operations. Uses 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.	Often, only includes slope and basic landcover in analysis, will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Field of Fire	Locates defensible terrain in an area of operations and identifies possible EAs and positions fighting systems	Shows the area that can be effectively covered from a specific position based on LOS and weapon capabilities. Used to locate defensible terrain, identify potential engagement areas, and position fighting systems to allow mutually supporting fires. May also reveal where maneuvering forces are more vulnerable to ambush.	Will benefit from understory characterization and from accurate tree density and abundance measurements	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Helicopter Landing Zone	Locates possible landing zones in an operational area or AO to support air assault operations	Depicts suitable open areas (free of vertical and linear obstacles) that have less than a 15 percent slope. Soil conditions should also be evaluated to avoid areas that may contribute to brown-out conditions for pilots.	Often, only includes slope and basic landcover in analysis, will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>

**Table 8 (cont.). Tailored geospatial products dependent on vegetation characterization**  
 (modified from ATP 3-34.80 [HQDA 2017a, Appendix B]; ATP 2-22.7 [HQDA 2015, table 7-2];  
 and ATP 2-01.3 [HQDA 2019a, table 4-5]).

Geospatial Product	Primary Use	Description	Unmet Need	Vegetation Characteristics Required*
Hydrology analysis	Shows the operational impacts of water features in an area of operations	Identifies drainage features by size and location. 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). Can also provide a flood analysis simulation of tidal fluctuations (dam collapse) over a given time period. Used to evaluate friendly and threat COAs and highlight conditions that can impose a major operational or logistical concern.	Often, only includes basic landcover for vegetation in analysis, will benefit from in-depth vegetation characterization to aid in modeling of overland flow	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Mobility Corridors	Shows mobility corridors by combining cross-country mobility, transportation, and linear obstacle overlays	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. Used to identify avenues of approach, plan the size/echelon that support movements, and develop engagement areas.	Requires more in-depth vegetation analysis. See “Cross-Country Mobility” and “Vegetation Analysis.”	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Modified Combined Obstacle Overlay (MCOO)	Combined Obstacle Overlay that includes threat template	Combined Obstacle Overlay that includes threat template. Joint intelligence preparation of the operational environment (OE) product used to portray the militarily significant aspects of the OE (e.g., obstacles restricting military movement, key geography, and military objectives). Tailored to the mission and is a collaborative effort involving input from the entire staff. The staff uses its warfighting function expertise to determine how the terrain will impact that function.	Requires more in-depth vegetation analysis. See “Combined Obstacle Overlay” and “Vegetation Analysis.”	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>

**Table 8 (cont.). Tailored geospatial products dependent on vegetation characterization (modified from ATP 3-34.80 [HQDA 2017a, Appendix B]; ATP 2-22.7 [HQDA 2015, table 7-2]; and ATP 2-01.3 [HQDA 2019a, table 4-5]).**

Geospatial Product	Primary Use	Description	Unmet Need	Vegetation Characteristics Required*
Perspective View	Provides 3D terrain visualization from an observer's point of view	3D point of view terrain depiction produced by combining imagery layers with elevation data. May include roads, rivers, operational graphics, text to enhance the terrain visualization, and anything typically displayed on a two-dimensional map.	Often, only includes slope and basic landcover in analysis, will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Soil Trafficability	Shows the effects of soil on trafficability	Usually based on the type of soil and its moisture content to depict effects of soil on trafficability. Fine-grained soil and highly organic soils are currently listed as severely restrictive to movement, while dry and compact soils are more trafficable.	Does not incorporate interaction of vegetation with soil (e.g., root systems' impacts to soil strength). Will benefit from any level of vegetation characterization.	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Terrain Effects Matrix	Describes OAKOC factors' effects on friendly and threat operations	Tabular product in which analysts relate the evaluation of terrain effects on the COAs available to friendly and threat forces. Should include a detailed discussion of the military aspects of terrain (OAKOC). To evaluate terrain effects on COAs, analysts use four basic techniques: concentric ring, belt, avenue in depth, and box.	Requires more in-depth vegetation analysis. See "Modified Combined Obstacle Overlay" and "Vegetation Analysis."	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Three-Dimensional Visualization/Fly-through	A full motion video type depiction of an AO or approach as seen from the point of view of a pilot, vehicle driver, or dismounted soldier to aid in terrain visualization	A computer-generated view of an area along a specified line of travel at a specified altitude and angle as viewed from inside a vehicle or by dismounted soldiers. May include roads, rivers, operational graphics, and text to enhance the terrain visualization.	Often, only includes slope and basic landcover in analysis, will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>

**Table 8 (cont.). Tailored geospatial products dependent on vegetation characterization (modified from ATP 3-34.80 [HQDA 2017a, Appendix B]; ATP 2-22.7 [HQDA 2015, table 7-2]; and ATP 2-01.3 [HQDA 2019a, table 4-5]).**

Geospatial Product	Primary Use	Description	Unmet Need	Vegetation Characteristics Required*
Vegetation Analysis	Determines the suitability of an area based on the operational effects of vegetation in an AO.	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. It also reflects information about cultivated areas (crop types, wet or dry conditions) and whether the area is terraced or not. This product is used to create more complex products such as cross-country mobility, combined obstacle overlay, and zone of entry (i.e., HLZ and DZ) products. Helps planners to determine the suitability of an area based primarily on the availability of cover and concealment and restrictions to mobility, but also applies across all warfighting functions.	Often, only includes basic landcover (down to tree type) and potentially some canopy information in analysis, will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Landcover class (grassland, shrubland, or mixed, coniferous, or deciduous forest)</li> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Viewshed Analysis	Shows areas of direct observation from a given point that can help position LOS-based systems	Shows an area of observation that is possible from a 360° perspective based on elevation. Used in templating threat positions, positioning friendly capabilities (such as LOS-based communications and observation platforms), and developing engagement areas. Accuracy of this analysis is [currently] directly proportional to the level of resolution of existing elevation data. This is not to be confused with direct observation, another form of LOS analysis, which is the visibility from one single point to another single point.	Usually only utilizes a bare earth digital elevation model. Will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>
Direct Observation Visibility Product	Shows visibility of a given position by another position	Shows the visibility from one single point to another single point	Usually only utilizes a bare earth digital elevation model. Will benefit from in-depth vegetation characterization	<ul style="list-style-type: none"> <li>• Dominant/codominant species</li> <li>• Stem density/spacing, diameter, and height</li> <li>• Foliage density and seasonality</li> </ul>

\*Landcover assessments are required for all products to some degree, especially for rapid analysis of large areas. However, it rapidly loses influence as the analysis becomes more in-depth. Vegetation species, size, and density attributes provide substantially more quantitative analytical value than coarse landcover assessments.

Table 9. GEOINT cell military occupational specialties (sourced from ATP 2-22.7 [HQDA 2015, table 2-1]).

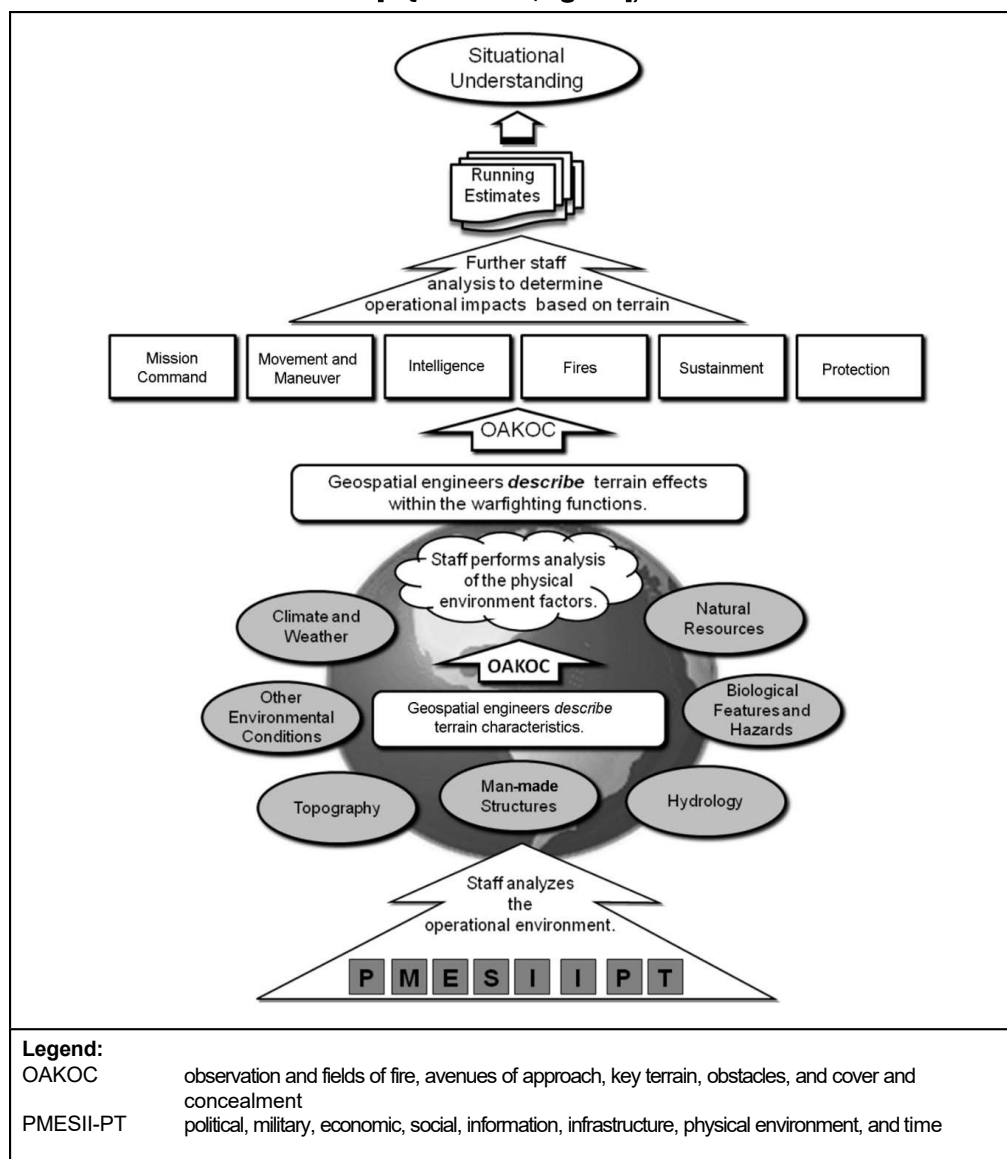
<b>CORPS</b>				
<i>Imagery Section</i>				
Code	Military Occupational Specialty	Number per Section		
350G	Imagery intelligence technician	2		
35G	Geospatial intelligence imagery analyst	22		
<i>Geospatial Engineer Team</i>				
Code	Military Occupational Specialty	Number per Team		
125D	Geospatial engineering technician	1		
12Y	Geospatial engineer	8		
Total		33		
<b>DIVISION</b>				
<i>Imagery Section</i>				
Code	Military Occupational Specialty	Number per Section		
350G	Imagery intelligence technician	0		
35G	Geospatial intelligence imagery analyst	15		
<i>Geospatial Engineer Team</i>				
Code	Military Occupational Specialty	Number per Team		
125D	Geospatial engineering technician	1		
12Y	Geospatial engineer	8		
Total		24		
<b>BRIGADE COMBAT TEAM (Task-organized)</b>				
<i>Imagery Section</i>				
Code	Military Occupational Specialty	Number per Section		
		Infantry	Armored	Stryker
350G	Imagery intelligence technician	0	0	0
35G	Geospatial intelligence imagery analyst	2	2	2
Note. (U) There are six geospatial intelligence imagery analysts located at the military intelligence company-tactical intelligence ground station.				
<i>Geospatial Engineer Team</i>				
Code	Military Occupational Specialty	Number per Team		
		Infantry	Armored	Stryker
125D	Geospatial engineering technician	1	1	1
12Y	Geospatial engineer	4	4	4
Total		13	13	13
<b>ARMY SERVICE COMPONENT COMMAND</b>				
Note. The Army Service component command does not have a geospatial intelligence cell. The imagery intelligence capability (350Gs and 35Gs) remains in military intelligence brigades (theater). Geospatial planning cells support Army Service component command geospatial engineering requirements.				
UNCLASSIFIED				

As echelons increase from BCT to the top of the NSG, resources also increase, with computing power, personnel, and bandwidth more readily available. However, the fundamental processes to produce VTFD are the same. This interoperability is ensured by the Army Geospatial Enterprise (AGE) and its components: the Standard Shareable Geospatial Foundation (SSGF) data, the Ground-Warfighter Geospatial Data Model (GGDM), and the DoD's Distributed Common Ground System–Army (DCGS-A).

AGE is a technological system of systems designed to ingest, analyze, and distribute data within and between warfighting functions to develop and maintain situational awareness and enable decisive action by providing the geospatial foundation for the COP (ATP 2-22.7 [HQDA 2015, p. 3-1]; ATP 3-34.80 [HQDA 2017a, p. 2-1]). For the AGE to function, it relies on three main categories of components: (1) foundational data, (2) logic and definitions for that foundational data, and (3) the infrastructure (an expansive system of hardware and software). As the name might suggest, SSGF is a key component of the AGE. New to the 2017 revision of ATP 3-34.80 (HQDA 2017a, p. v), the SSGF provides a common framework for visualizing an AOI to enable mission command and the planning and execution of operational goals. It consists of four data types (elevation, map background, georeferenced imagery, and geographic feature data). The SSGF relies on a logical and physical data model and a data dictionary known as the GGDM. The GGDM is nested in the data standards ultimately curated by the NGA as the standard bearer for all geospatial data with the Department of Defense. The GGDM “is designated for collecting, maintaining, and disseminating vector data (including rivers, roads, buildings, vegetation, and bridges) with identifying attributes related to features (such as function, height, type, physical condition, operational status, and metadata) describing the accuracy, content, origin, and classification level” (ATP 2-22.7 [HQDA 2015, p. 5-7]). While based in NGA standards, the Army's Geospatial Planning Cells (GPCs) are generally responsible for GGDM data generation and maintenance within the AGE (ATP 2-22.7 [HQDA 2015, p. 5-7]). The DCGS-A, residing at the Joint Task Force and below, is the primary tool of geospatial engineers to maintain a geospatial foundation and enabling interoperability and connectivity across numerous mission command systems. DCGS-A is the Army's portion of a DoD and Service wide “net-centric joint force intelligence processing and dissemination system” (ATP 2-22.7 [HQDA 2015, p. 2-11]; ATP 3-34.80 [HQDA 2017a, p. 2-6]). See Appendix A in ATP 2-22.7 (HQDA 2015) for more information on DCGS-A.

From the tactical users’ perspective, VTFD products are created and distributed on workstations that are part of the DCGS-A. Those products rely on the definitions and physical/logical models of the GGDM that are rooted in the SSGF to support the greater AGE’s contribution to situational understanding. This process, when nested with the operations process, can be visualized through Figure 7 if all graphics represented by ovals surrounding OAKOC are understood to be inputs analyzed at a geospatial workstation as part of the AGE for support to MDO.

Figure 7. Description of the physical environment (sourced from ATP 3-34.80 [HQDA 2017a, fig. 4-2]).



The underlying software enabling VTFD generation in DCGS-A workstations is based on commercially available products. Two of the most

used software applications for creating VTFD are Environmental Systems Research Institute (Esri) and Environment for Visualizing Images (ENVI). For a partial list of geospatial software and application tools, see Appendix D.

## 7 Unmet Needs of the Force

Despite the professional mechanisms for collaboration, there is evidence of the unmet requirement for consistent and attributable global vegetation data identified through over 100 conversations conducted with Army intelligence and engineer professionals, industry experts, and the US Department of Agriculture–Forest Service (USDA–FS). Given that each organization has access to varying degrees of attributed vegetation data, each has adopted varied approaches for conducting vegetative terrain analysis. Given heterogenous vegetation attribution across units, we noted instances in which a single leader with geospatial expertise was diligently identifying, or creating, and executing problem and AOR specific solutions to gain situational understanding.

Only in rare instances, does the operational tempo (OPTEMPO) afford leaders the time to codify their unique vegetation analysis TTPs, much less share them across the force. To be clear, there are a few battle rhythm events designed to share TTPs across the force and they do get information to the points of greatest need; however, those events do little to inform nongeospatial experts (e.g., commanders and staffs) regarding the possibilities for a more situationally aware force regarding vegetation.

In training and education, due to the absence of current doctrine detailing TTPs for vegetation analysis, the discrepancies continue with some courses for company and field grade leaders still constructing acetate vegetation overlays based on a “green/not green” assessment of a 1:50,000 military topographic map. All Warfighters conducting vegetation analysis should be capable of creating acetate overlays on paper maps. Based on GEN Mark Milley’s description of future warfare (AUSA 2016, at 1:04:38–1:08:15 and 1:11:48–1:15:58), the capability of operating in an analog and disconnected environment is a must. However, he also stated that technology will help win these wars. The Army lacks an overarching process for conducting vegetation analysis by leveraging the latest technological advances, particularly in the realm of machine learning and artificial intelligence, for any analysis more detailed than basic land cover classification.

The Army’s geospatial professionals have adapted to find or create better decision tools than those options presented in Appendix B of ATP 2-01.3 (HQDA 2019a). Currently, they are acting with minimal doctrinal guidance to create the best available vegetation analysis outputs. Despite the doctrinal gaps, their efforts are focused on creating relevant

vegetation analysis outputs, many of which contribute to the production of the COO. (Note: The COO is the precursor to the MCOO listed in the output section of Figure 2.) Examples of the numerous geospatial products that require vegetation data are described in Table 8 and depicted in Appendix C of this document. Unfortunately, the doctrinal examples, and often terrain analysts, are still focused on increasing the accuracy and spatial resolution of land cover classifications. While terrain and intelligence analysts may brief a broad description of vegetations impacts to operations, detailed analysis and TDAs for vegetation remain the exception, not the norm. This paradigm is driven by gaps in doctrine that still characterize forests as simply deciduous, coniferous, or mixed (ATP 2-01.3 [HQDA 2019a]; ATP 3-34.80 [HQDA 2017a]). It is compounded by the packaged software tools (as program of record) that are severely lacking in assessing or measuring vegetation characteristics necessary for true situational understanding (Table 8 and Table 10). Table 10 depicts the military aspects of terrain, corresponding vegetated terrain analysis considerations, and provides examples of commercially based software processes to address each consideration.

**Table 10. Military aspects of terrain, their corresponding vegetated terrain analysis considerations, and examples of commercially based software processes (modified from table 4-3 in ATP 3-34.80 [HQDA 2017a]).**

Military Aspects of Terrain (OAKOC)	Terrain Analysis Considerations for Vegetation	Vegetation Characteristics	Commercially Available ENVI or Esri Processes
Observations and Fields of Fire	<p>Vegetation impacts to LOS surveillance systems, unaided visual observation, and electromagnetic signal transmission</p> <p>Vegetation impacts on trajectory of munitions (direct and indirect fire) and tube elevations</p> <p>Vegetation impacts (on specific equipment and equipment positions) on the defensibility of the potential engagement area (for friendly and threat forces).</p> <p>Vegetation impacts on vulnerability of friendly forces based on threat observation and fields of fire</p>	<p>1. Land cover class (grassland, shrubland, or forest)</p> <p>2. Dominant/codominant species</p> <p>3. Stem density/spacing, diameter, and height</p> <p>4. Foliage density and seasonality</p>	<p>1. Image classification<sup>a</sup></p> <p>2. Image classification</p> <p>3. Canopy height model = digital surface model – digital elevation model<sup>b</sup></p> <p>4a. Temporal comparison of spectral vegetation indices<sup>c</sup></p> <p>4b. Lidar canopy (point cloud) density<sup>d</sup></p>
Avenues of approach	<p>Identify mobility corridors [from vegetation impacts to mobility] based on equipment and preferred doctrinal formations</p> <p>Evaluate mobility corridors for vegetation impacts to speed of travel, observation, sustainability, and accessibility</p>		
Key Terrain	<p>Vegetations impacts on the other four military aspects of terrain will influence nominations and evaluation of key terrain</p>		
Obstacles	<p>Evaluate vegetation potential for natural or man-made obstacles based on type of movement (foot, wheeled, tracked, or air) and the capabilities of vehicles/equipment</p> <p>Identify and evaluate vegetation impacts to surface hydrology for potential dam breaches and potential river/gap-crossing sites</p> <p>Analyze vegetation impacts to on- and off-road surface conditions</p> <p>Analyze vegetation for restrictions to flying nap of the earth or vertical obstructions that impact flight profiles</p> <p>Classify vegetation impacts to mobility as severely restricted, restricted, and unrestricted as input to the cross-country mobility overlay, COO, and MCOO</p>		
Cover and concealment	<p>Analyze and classify vegetation based on the protection it offers from bullets, exploding rounds, and explosive hazards (i.e., cover)</p> <p>Analyze and classify vegetation based on the protection it provides from aerial and ground observation (i.e., concealment)</p>		

<sup>a</sup><https://pro.arcgis.com/en/pro-app/latest/help/analysis/image-analyst/overview-of-image-classification.htm>;  
<https://www.13harrisgeospatial.com/docs/classification.html>

<sup>b</sup><https://desktop.arcgis.com/en/arcmap/10.3/manage-data/las-dataset/lidar-solutions-estimating-forest-density-and-height.htm>; <https://www.13harrisgeospatial.com/docs/FilterByHeight.html>

<sup>c</sup><https://www.13harrisgeospatial.com/docs/spectralindices.html>; <https://pro.arcgis.com/en/pro-app/latest/help/data/imagery/indices-gallery.htm>

<sup>d</sup><https://desktop.arcgis.com/en/arcmap/10.3/manage-data/las-dataset/lidar-solutions-estimating-forest-density-and-height.htm>

## 8 Conclusion

Since tailored geospatial products are created based on operational need without a prescriptive field manual (i.e., detailed instructions or work-flows), they are often created in an ad hoc manner based on unit TTPs or user preferences.<sup>9</sup> Without a comprehensive process or global layer of vegetation attributes, there will continue to be discrepancies in the quality and quantity of VTFD available to individual units, especially at the lower echelons where resources (e.g., time, personnel, and equipment) become increasingly limited. The solution is difficult to achieve and even more difficult to codify in doctrine. To fight and win wars in increasingly complex environments, against increasingly capable adversaries, Warfighters require the utmost situational understanding across the entire OE. Comprehensive and adaptable processes are required to develop VTFD that fills the current gap in this area. To achieve this goal, we must leverage the fullest extent of our national capabilities.

Many opportunities exist, and many are being addressed, to generate high quality VTFD products and processes. Doctrine revisions that capture ways to leverage the geospatial data and complex analytical processes available today are needed. TPO-GEO's doctrine revision cycle is addressing just this need with ATP 3-34.80 almost fielded and FM 5-33 currently being transformed into a nonequipment technical manual. The Warfighter also requires the development of dynamic process for unit level AOI generation that is compatible across the DCGS-A system of systems. This dynamic process should facilitate the use of the best available data for an AOI to generate quantified and accurate vegetation attributes needed for situational understanding across warfighting functions. Seasonally appropriate static layers (with regular update cycles) of high-resolution vegetation attributes must be created as part of the SSGF to serve as the go-to VTFD when limited time, resources, or information diminish the ability to utilize a dynamic attribution process. Success will require an all-out scientific effort to create a comprehensive, adaptable process for vegetation characterization on global scales with local level detail and a perpetual emphasis on creating and maintaining doctrinal standards and practices that capture current advances in data collection and analytics while allowing for rapid incorporation of future innovations.

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9. Geospatial-intelligence analytic standards are prescriptive per AR 525-95 (HQDA 2022d), but the processes to create the products are not.

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## Appendix A: US Army Geospatial Data Clearing Houses

Table A-1. US Army geospatial data clearing houses.

Name	Data Type	Organization	Release and Update	Access and Cost	Description
Army Geospatial Center (AGC)	Raster and vector	<u>USACE</u> <u>AGC</u>	Not applicable (n/a)	<u>AGC-Ordering</u> CAC+ Free	<ul style="list-style-type: none"> <li>• <u>Common Map Background</u></li> <li>• <u>Ground-Warfighter Geospatial Data Model</u></li> <li>• Geospatial Standards and Foundation: <u>Standard Shareable Geospatial Foundation (SSGF)</u> &amp;</li> <li>• <u>Common Operational Picture (COP) Modeling &amp; Simulation: VBS/2</u></li> <li>• <u>Lidar &amp; Buckeye System</u></li> </ul>
Joint Engineer Common Operating Picture (JECOP)	Raster and vector	<u>USACE</u> <u>UROC</u>	n/a	CAC+ Free	<u>JECOP</u> is a collaborative knowledge management tool that depicts network information on a map for end-users to quickly gather and analyze location.
National Geospatial-Intelligence Agency (NGA)	Raster and vector	NGA	n/a	CAC+ Free	<ul style="list-style-type: none"> <li>• <u>Imagery</u></li> <li>• <u>GEOINT Links</u></li> <li>• <u>Geosciences</u></li> <li>• <u>Elevation</u>: Geospatial Repository and Data Management System (<u>GRID</u>) w/ 3D and 2D data &amp; TanDEM-X</li> <li>• <u>Map of the World</u></li> </ul>
Reachback Engineer Data Integration (REDi)	Raster and vector	<u>USACE</u> <u>UROC</u>	n/a	CAC+ Free	REDi provides a common database, robust user interface and fully integrated mapping tools
World View Multispectral Imagery (MSI)	1.25 m cell raster	<u>Maxar</u> (DigitalGlobe)	A: <1 day R: Daily L: <2 days	<u>CAC+</u> Free	<u>Global Enhanced GEOINT Delivery (G-EGD)</u> is a web-based application to identify/download Maxar image(s) for an AOI area of interest

## Appendix B: Commercially Available Geospatial Data Sources for Vegetative Terrain Feature Data (VTFD)

Table B-1. Remote sensing (passive sensor) data.

Data	Type	Organization	Acquisition (A), Release (R), and Latency (L)	Access and Cost
Sentinel-2 (MSI)	10 m cell raster	European Space Agency (ESA)	A: 5 days R: Unk L: 3 weeks w/ agreement	<u>ESA</u> Free
Landsat Operational Land Imager MSI	30 m cell raster	NASA USGS	A: 16 days R: Daily L: <2 days	<u>USGS</u> Free
USGS Spectral Library: Vegetation	286 sigs .2-200 $\mu$ UV-IR	USGS	Lab generated data	<u>USGS Spec Lab</u> Free
NASA Earth Science Data System (ESDS)	Raster	<u>NASA ESDS</u>	Varied	<u>EARTHDATA</u> Free

Table B-2. Remote sensing (active sensor) data.

Data	Type	Organization	Acquisition (A), Release, (R), and Latency	Access and Cost
ETH Global Canopy Height 2020	ML 10 m cell raster from Sentinel-2 and GEDI data	<u>EcoVision Lab</u> , Photogrammetry and Remote Sensing, ETH Zürich	A: 2020 R: 2022 L: n/a	<u>ETH Zurich</u> Free
Global Ecological Dynamic Investigation (GEDI) Lidar	Post processed (L2B) lidar 25 m cell raster	University of MD NASA	A: Daily R: Monthly L: 4 months	<u>LPDACC</u> <u>USGS</u> Free
GEDI Canopy Height (CHM) & Ground Elevation (DEM/DTM)	Post processed (L2A) lidar 25 m cell raster	University of MD NASA	A: Daily R: Monthly L: 4 months	<u>LPDACC</u> <u>USGS</u> Free
NASADEM (SRTM update)	Best available open-source DEM with SRTM as foundation 30 m cell raster	NASA/ <u>USGS</u>	A: 2000 R: 2020 L: n/a	<u>USGS</u> <u>Earthexplorer</u>
WorldDEM (TerraSAR-X & TanDEM-X)	X band stereo-SAR 12, 30, or 90 m cell raster	European Space Agency (ESA) Airbus	DEM 2016/2022 SAR A: 2-4 days R: Daily; L: <2d	<u>Airbus</u> Purchase <u>DLR esa</u> Free

Table B-3. Physical geography data.

Data	Type	Organization	Release (R) and Update (U)	Access and Cost	Thematic Classes/Variables Assessed
Global Ecological Land Units	250 m cell raster	USGS Esri	R: 2014 U: unknown ('17,'18,'19)	<u>USGS</u> Free	3,923 terrestrial ecological land units
World Terrestrial Ecosystems	250 m cell raster	USGS, Esri Nature Cons	R: April 2020 U: unknown	<u>AGOL</u> Free	431 terrestrial ecosystems ( <u>climate+landform+land cover</u> )
Esri Land Cover [2020]	10 m cell raster	Esri	R: July 2021 U: n/a	<u>AGOL</u> Free	10 classes: Water, Trees, Grass, Flooded Veg, Crops, Scrub/Shrub, Built, Bare Ground, Snow/Ice, Cloud
Esri Global Biomes	Webmap	Esri	Unknown	<u>AGOL</u> Free	15 classes: Boreal Forests (Taiga), Deserts, Savannas, Lake, Mangroves, Med Scrub, Mtn Grasslands, Rock & Ice, Temp Deciduous/Evergreen Forests/Grasslands, Tropical Coniferous Forests/Dry Forests/Moist Forests, Tundra
WorldClim v2.1 Bioclimatic Variables	1 km cell raster	WorldClim <u>KS State Univ</u>	1970–2000 data R: January 2020 U: unknown	<u>WorldClim</u> Free	19 variables: Represent annual trends (e.g., mean temp, total precip), seasonality (e.g., annual range in temp & precip), extreme or limiting environ factors (e.g., temp of the coldest & warmest month and total precip of the wet and dry quarters)
NOAA Annual Climate Data	csv by int'l wx station (lon, lat)	NOAA	R: Weekly <2day latency	<u>NOAA</u> Free	46 monthly/annual var: max/min/mean temps, max/min/mean/total precip, total sunshine, wind speed/direction, soil temp/depth
USGS Earth Resources Observation and Science (EROS) Center	Raster	USGS EROS	n/a	<u>USGS</u> <u>EROS</u> Free	Land cover Elevation Imagery

Table B-4. Forest data (USDA US Forest Service [FS]).

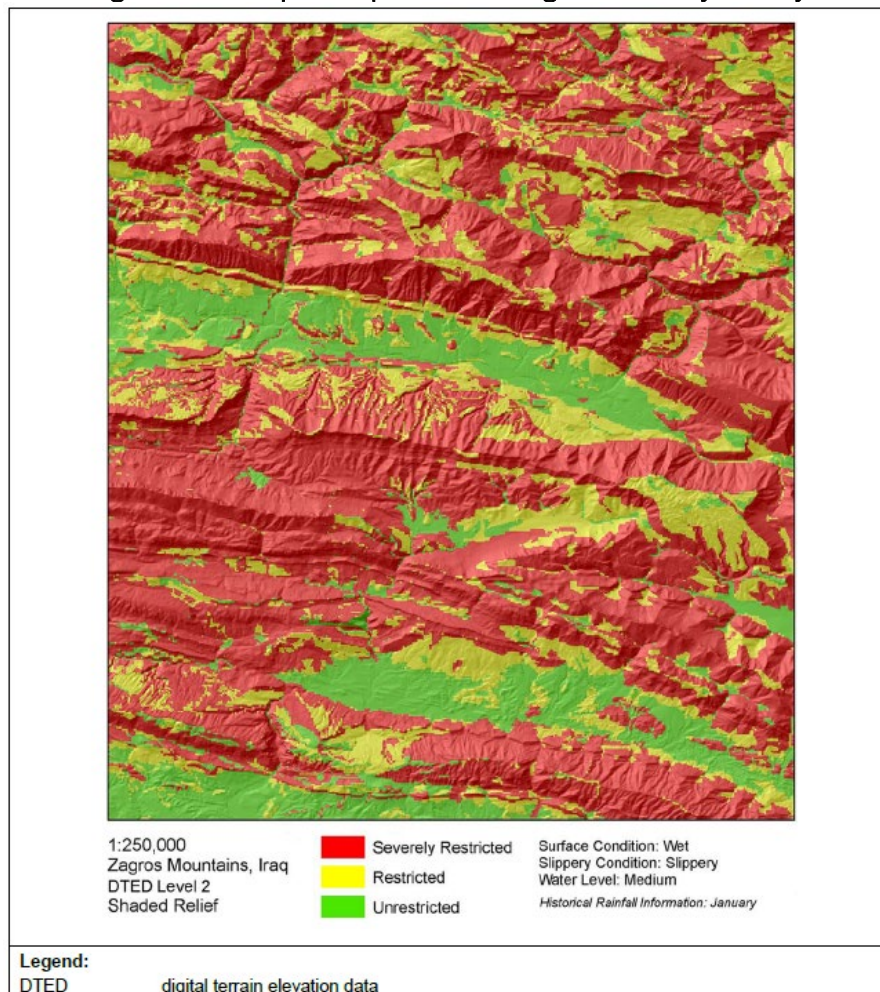
Name	Data Type	Organization	Release (R) and Update (U)	Access and Cost	Description
USDA FS Forest Inventory and Analysis Program Data Base (FIADB)	Vector data .xlsx .csv Sqlite	USDA FS	R: 1999 U: <15%/yr AOIs updated in 2019	<a href="#">USDA FS Datamart</a> Free	In situ plot assessment/6,000 ac [7,861 Phase 3 plots (forest health) + 124,463 Phase 2 (inventory) P2 metrics incl: DBH, stocking, forest type/age P3 metrics incl: Crown condition (density & transparency), growth (change in height in DBH), downed woody material Covers US + 5 territories & 3 possessions
USDA FS FIADB API: EVALIDator	Programming Interface	USDA FS	U: 2019	<a href="#">USDA FS Datamart</a> Free	EVALIDator allows users to produce a large variety of population estimates and their sampling errors based on the current FIADB.
USDA FS FIADB API: Forest Veg Simulator (FVS)	Programming Interface	USDA FS	R: 2001 U: 2020	<a href="#">USDA FS FVS</a> Free	Forest growth simulation model: vegetation change in response to natural succession, disturbances, and management. It recognizes all major tree species and can simulate nearly any type of management or disturbance at any time. Outputs include tree volumes, biomass, density, canopy cover, harvest yields, fire effects, and more.
USDA FS FIADB Tree-level Model: TreeMap	Programming Interface Raster data	USDA FS Rocky Mountain Research Station	R: 2016 (2014 data) U: 2021 (2014 data)	<a href="#">USDA FS Research Data Archive</a> Free	30×30 m gridded data set of forest plot identifiers for the conterminous US. Forest plots from FIADB were imputed to gridded c2014 landscape data provided by the LANDFIRE project using topographic, biophysical, and disturbance variables. Output = raster map of FIA plot identifiers. From the plot identifiers, users can link to tree- and plot-level attributes stored in the accompanying FIADB tables, and then produce maps of any of these attributes, including number of trees/acre, tree species, and forest type.
LANDFIRE: Landscape Fire and Resource Management Planning Tools	30 m cell raster data Compatible with FVS	Shared program: USDA US DOI	R: 2001 U: 2008, 2010, 2012, 2014, 2016, 2019	<a href="#">LANDFIRE</a> Free View only via AGOL	800,000 georeferenced sample units 20+ national, landscape scale geo-spatial layers (e.g., vegetation type/cover/height, fuel, disturbance, topographic), databases, and ecological models for the US and insular areas (Product Descriptions w/References) Sources: USDA FS FIA, USGS Gap Analysis Program, state natural heritage programs

## Appendix C: Tailored Geospatial Products Requiring Vegetation Inputs

Sourced directly from ATP 3-34.80 (HQDA 2017a, Appendix B). Additional examples may be found in Training Circular (TC) 3-34.80 (HQDA 2019f).

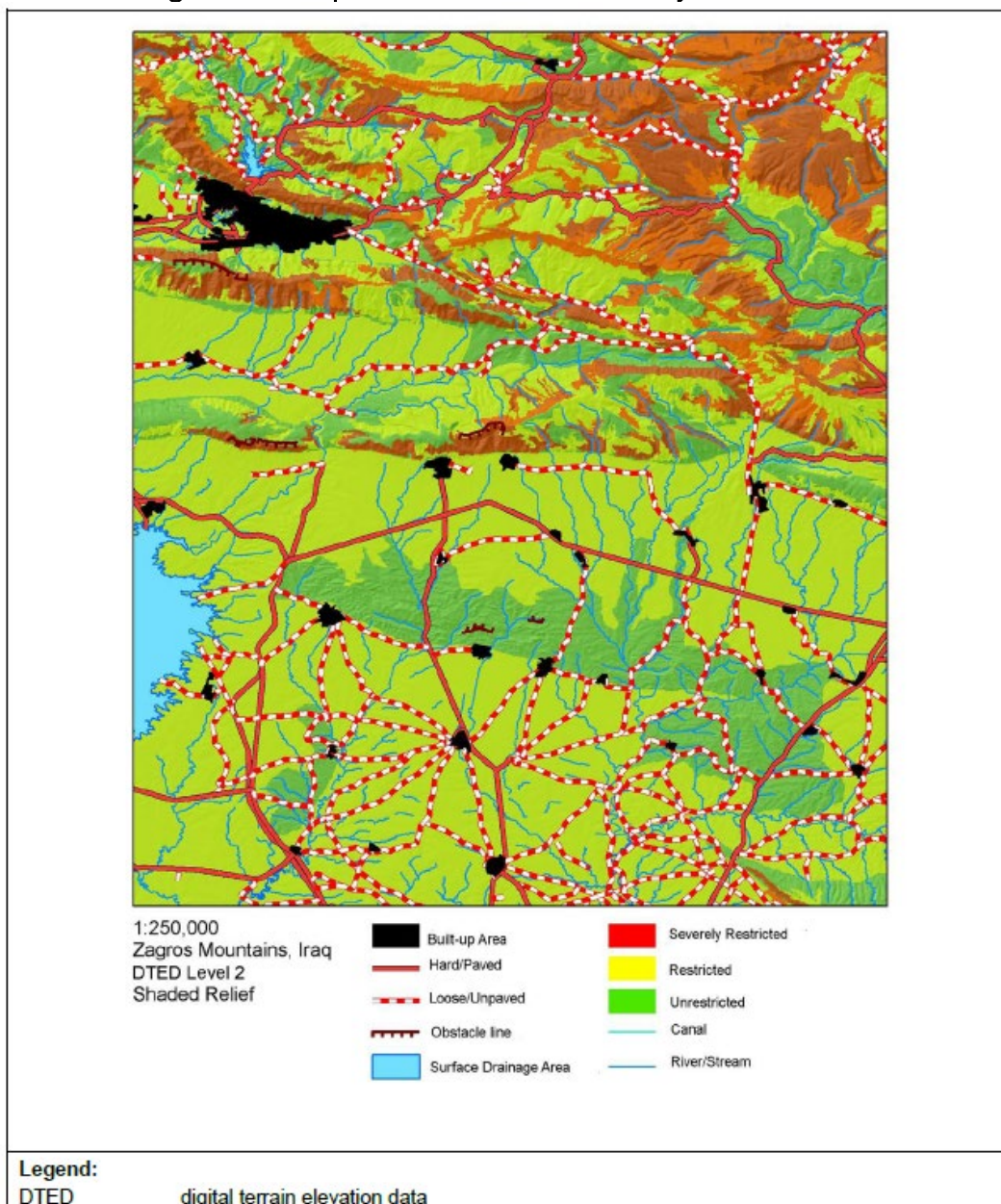
**Cross Country Mobility**—The cross-country mobility product demonstrates the off-road speed for a vehicle as determined by the terrain (soil, slope, and vegetation) and vehicle performance capabilities; however, it does not consider the effects of roads and obstacles (Figure C-1). Cross-country mobility is used to help identify avenues of approach and engagement areas.

Figure C-1. Example of a product showing cross-country mobility.



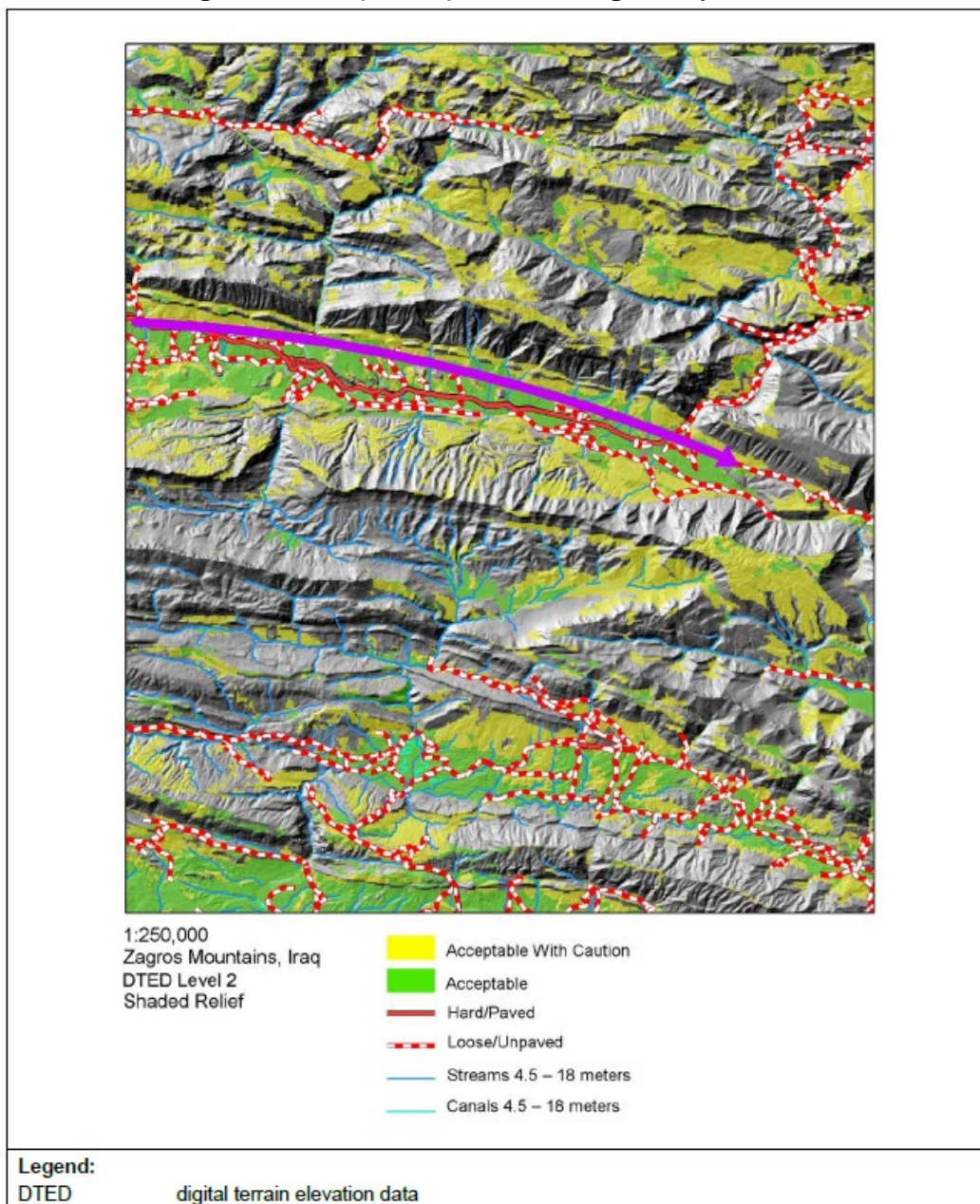
**Combined Obstacle Overlay**—The combined obstacle overlay provides a basis for identifying ground avenues of approach and mobility corridors (Figure C-2). Unlike the cross-country mobility overlay, the combined obstacle overlay integrates obstacles to vehicular movement (built-up areas, slope, soils, vegetation, hydrology) into one overlay. The overlay depicts areas that impede movement (severely restricted and restricted areas) and areas where friendly and threat forces can move unimpeded (unrestricted areas).

Figure C-2. Example of combined obstacle overlay linear obstacles.



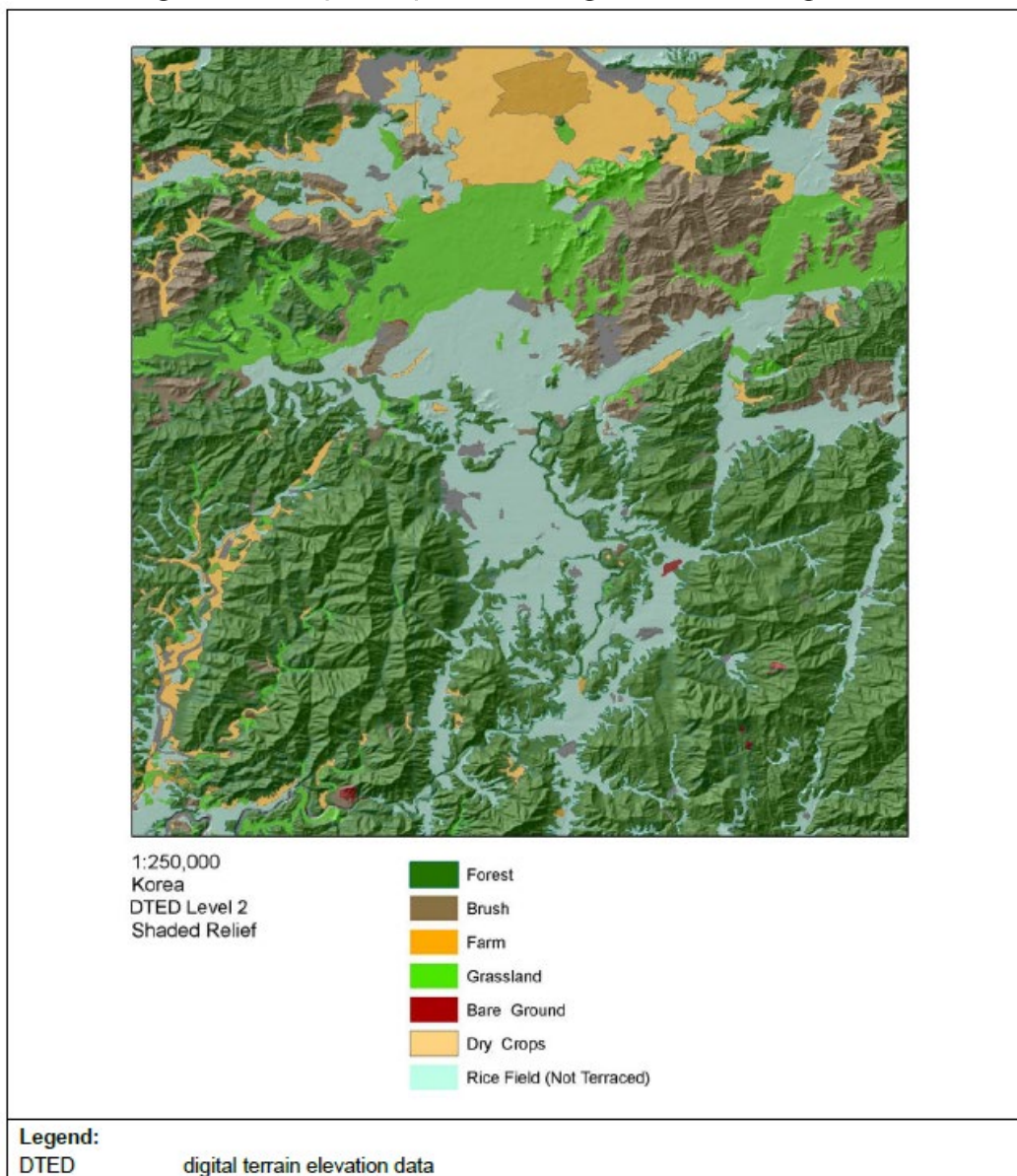
**Mobility Corridors**—The mobility corridor product is a combination of cross-country mobility, transportation, and linear obstacle overlays to show mobility corridors that are based on the restrictiveness of the terrain, vehicle capabilities, and preferred movement formations (Figure C-3). This product is used to identify avenues of approach, plan the size/echelon that support movements, and develop engagement areas.

Figure C-3. Example of a product showing mobility corridors.



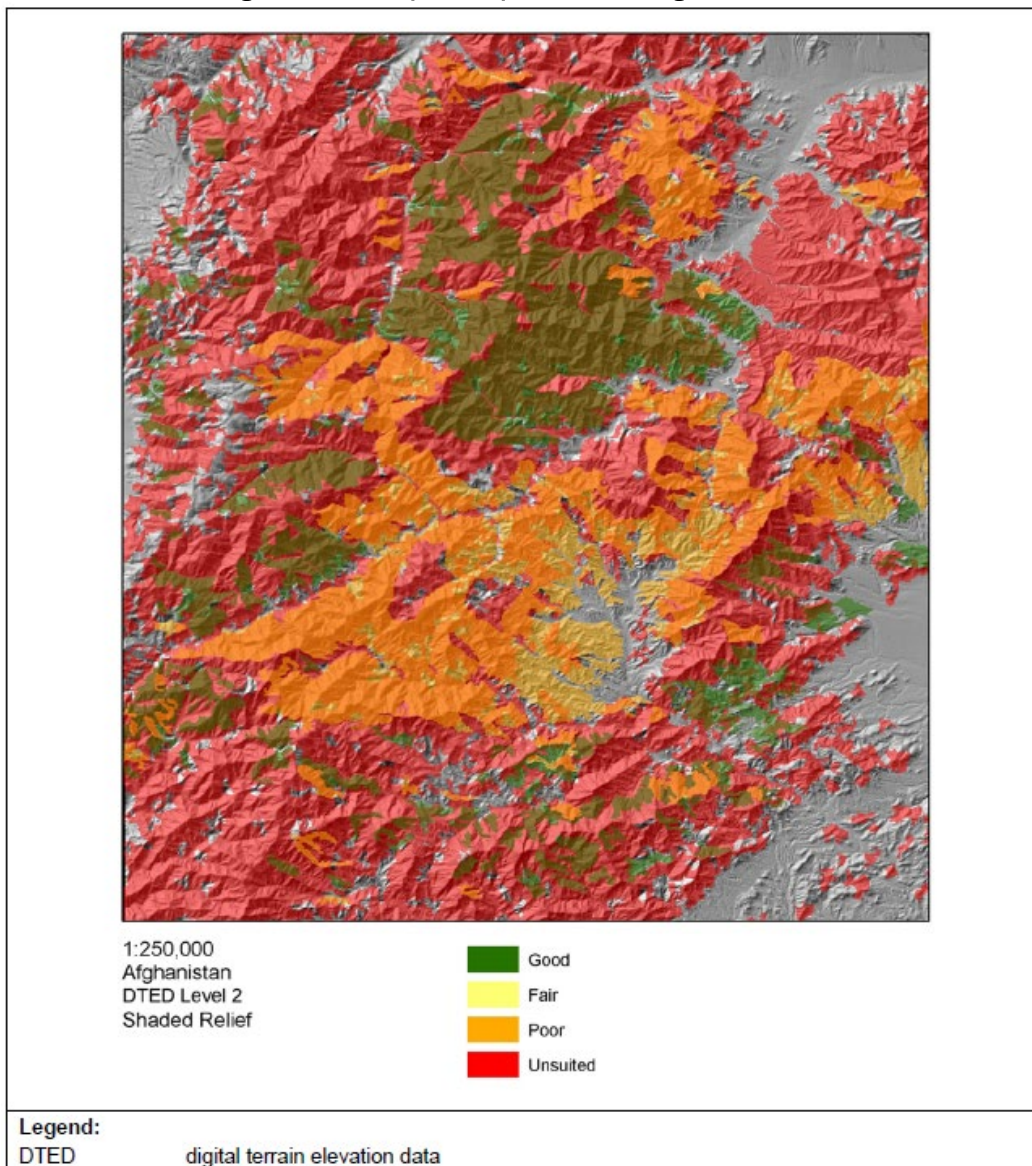
**Vegetation Analysis**—The vegetation analysis product shows the effects of vegetation in an operational area based on the tree types (coniferous, deciduous, or mixed), tree heights, stem diameter, stem spacing, and canopy closures (Figure C-4). It also reflects information about cultivated areas (crop types, wet or dry conditions) and whether the area is terraced or not. This product is used to create more complex products such as cross-country mobility, combined obstacle overlay, and zone of entry products. It helps planners to determine the suitability of an area based primarily on the availability of cover and concealment and restrictions to mobility.

Figure C-4. Example of a product showing the “effects” of vegetation.



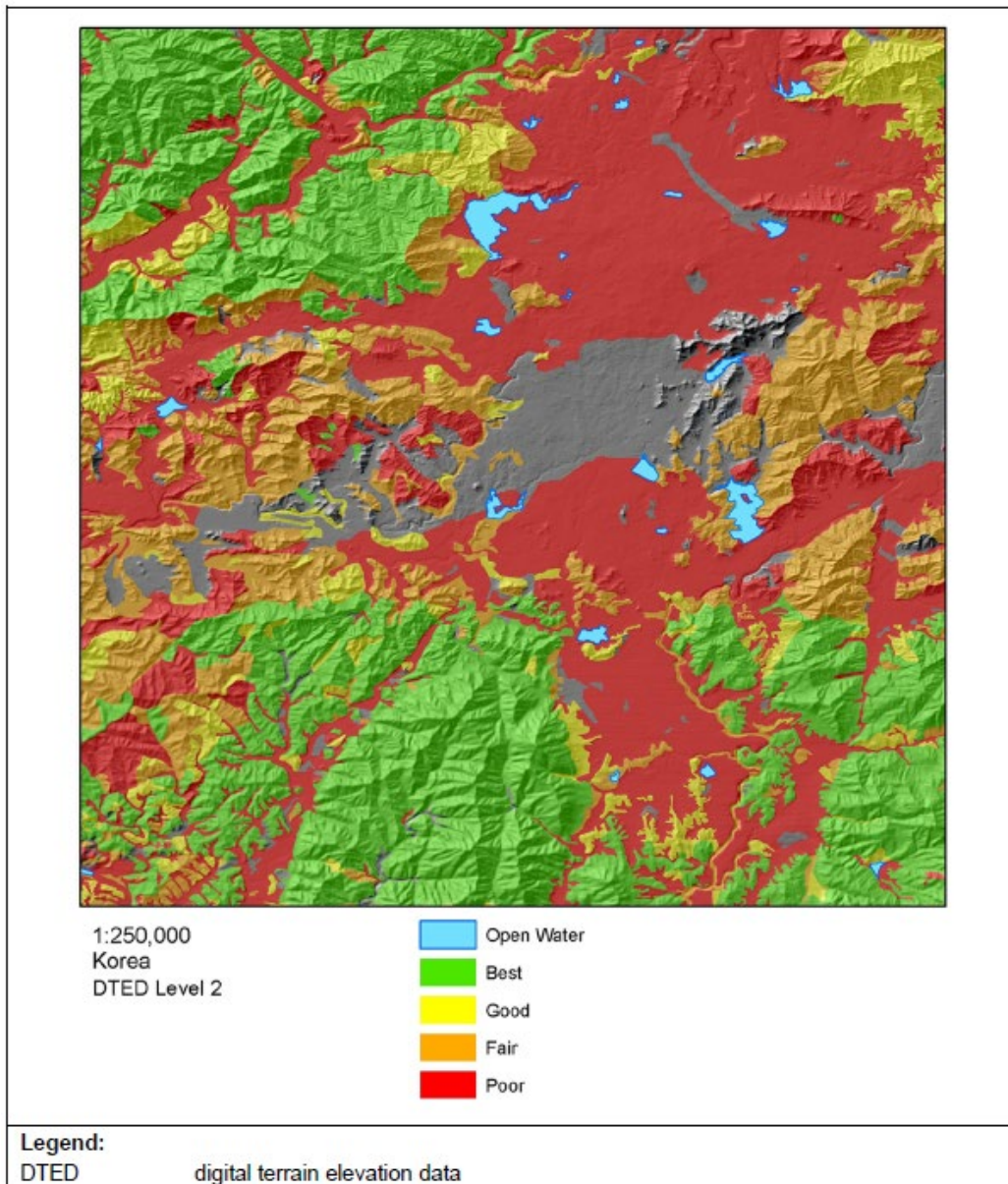
**Field of Fire**—A field-of-fire product shows the area that can be effectively covered from a specific position based on LOS and weapon capabilities (Figure C-5). This product is used to locate defensible terrain, identify potential engagement areas, and position fighting systems to allow mutually supporting fires. It can also reveal where maneuvering forces are more vulnerable to ambush.

Figure C-5. Example of a product showing fields of fire.



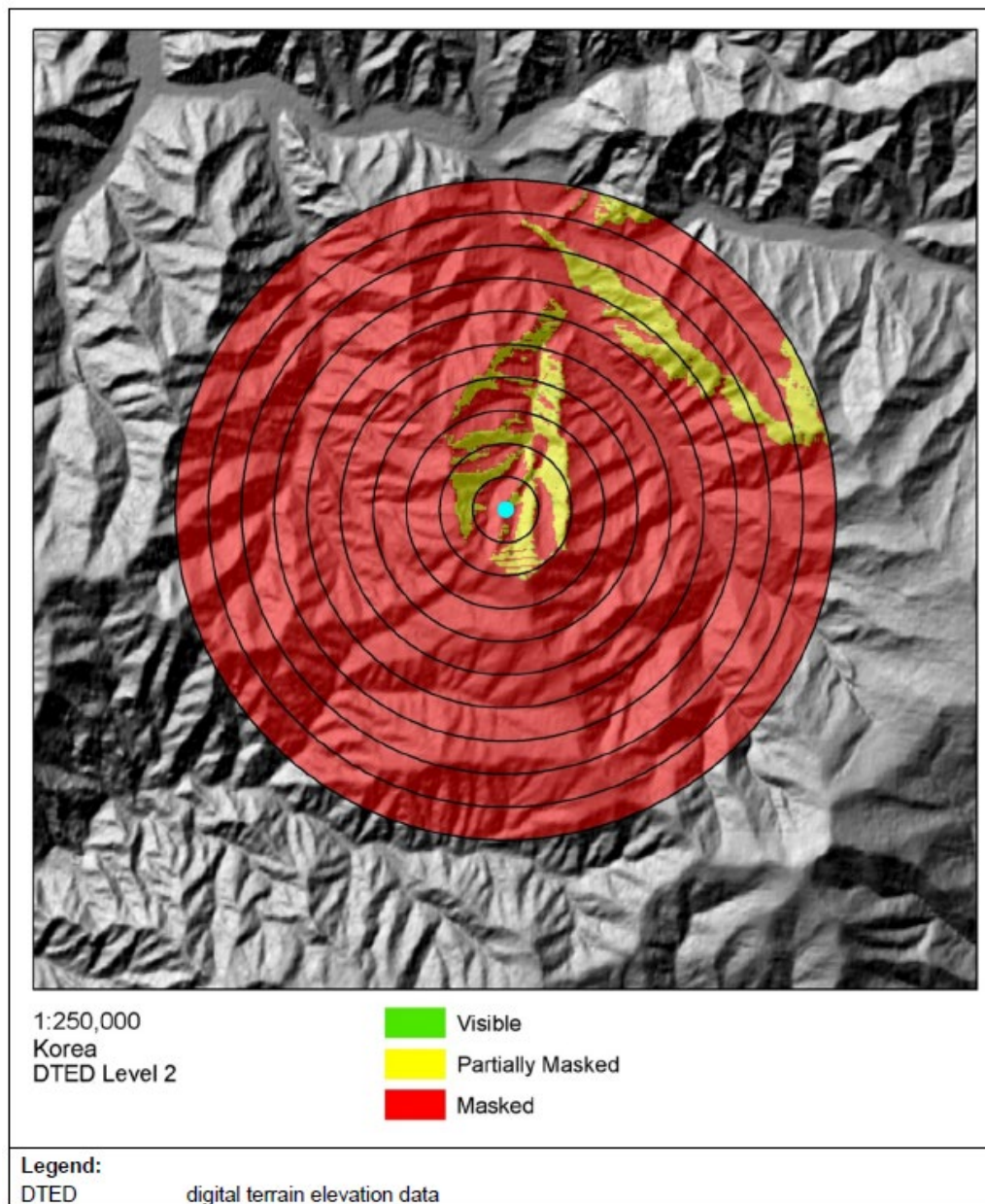
**Aerial Concealment**—The aerial concealment overlay shows the most suitable areas to conceal a force from overhead detection based on the analysis of woods, underbrush, tall grass, and cultivated vegetation (Figure C-6). This product is predicated on canopy closure information within the vegetation layer. It is particularly useful in templating areas where threat forces may be operating. It can also help friendly forces identify concealed movement routes and staging areas.

Figure C-6. Example of a product showing aerial concealment.



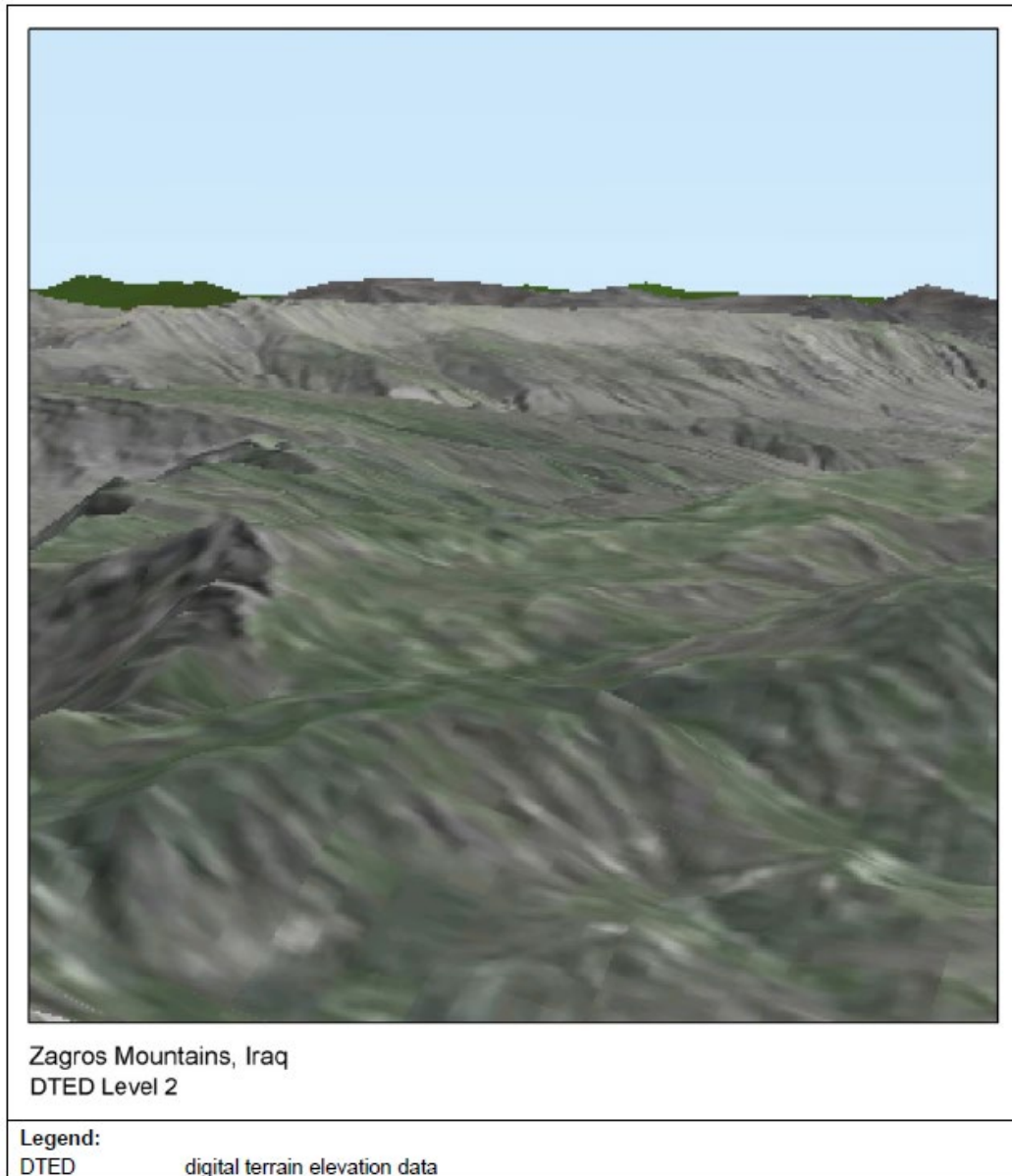
**Viewshed Analysis**—A viewshed analysis, often misnamed LOS profiles, shows an area of observation that is possible from a 360° perspective based on elevation (Figure C-7). Viewshed or LOS analysis is used in templating threat positions, positioning friendly capabilities (such as LOS-based communications and observation platforms), and developing engagement areas. The accuracy of this analysis is directly proportional to the level of resolution of existing elevation data. This is not to be confused with direct observation, another form of LOS analysis, which is the visibility from one single point to another single point.

Figure C-7. Example of a viewshed analysis.



**Perspective View**—The perspective view product is a 3D depiction of an area from an observer point of view that is produced by combining imagery layers with elevation data (Figure C-8). The display can include roads, rivers, operational graphics, text to enhance the terrain visualization, and anything typically displayed on a two-dimensional map.

Figure C-8. Example of a perspective view.



## Appendix D: Geospatial Intelligence Software and Application Tools

Sourced directly from Appendix A Section III of ATP 2-22.7 (HQDA 2015).

**ARCGIS:** The Arc Geographic Information System (ArcGIS) is a geographic information system for working with maps and geographic information. Users can create, share, and manage geographic data, maps, and analytical models.

**ENVI:** Environment for Visualizing Images (ENVI) is designed for analyzing and visualizing remote sensing data. Users can incorporate their own functions, handle many data types, and visualize data in multiple dimensions. ENVI is a standalone application that allows users to load and view imagery (multiple bands from multiple datasets), apply color tables and contrast stretches, animate imagery, define regions of interest, dynamically link images, import spectral libraries, perform subpixel analysis, select radar polarizations, analyze scattering patterns, and extract textual information.

**ERDAS IMAGINE:** The Earth Resource Data Analysis System (ERDAS) Imagine is a raster graphics editor and remote sensing application. It is aimed primarily at geospatial raster data processing that allows the user to display and enhance digital images. ERDAS Imagine allows users to create value-added products such as two-dimensional images, mosaics, three-dimensional fly-through movies, vectors derived from imagery, and cartographic-quality map compositions from geospatial data.

**FALCONVIEW:** FalconView is map viewing software that allows users to easily display various types of maps and geographically referenced overlays. In addition to NGA's compressed arc digitized raster graphics, CIB, and Digital Aeronautical Flight Information File, FalconView users can view DTED levels 1 and 2. All maps and source data are rectified to an equal arc projection.

**GOOGLE EARTH:** Google Earth is a commercial mapping and imagery software program that can be used for quick referencing and geolocation. With near up-to-date maps and country information, Google Earth is a useful tool for creating more credible intelligence products. Google Earth

is sponsored by NGA, which provides multiple servers for Google Earth on the SIPRNET.

**GOOGLE EARTH ENTERPRISE:** The Google Earth Enterprise allows GEOINT imagery analysts and geospatial engineers to store and process terabytes of imagery, terrain, and vector data on the server. It publishes maps securely for users to view using their Google-based applications. The U.S. Northern Command and the National Guard Bureau both leverage the Google Earth Enterprise in order to share geospatial data layers with subordinate units and the National Guard Joint Force Headquarters–State of each state and territory.

#### **NET-CENTRIC GEOSPATIAL-INTELLIGENCE DISCOVERY**

**SERVICES:** Net-Centric Geospatial-Intelligence Discovery Services is an imagery search or retrieval interface that replaces the Web-based Access and Retrieval Portal (also called WARP) at all three security levels. At the unclassified level, Net-centric Geospatial-Intelligence Discovery Services allows users to query its copy of unclassified national information library holdings and retrieve or download imagery directly to their computer via the Internet. Net-Centric Geospatial-Intelligence Discovery Services provides access to the following libraries:

- Saint Louis Information Library
- National Information Library
- Image Product Library
- Command information libraries
- Commercial data provider

**REMOTE VIEW:** Remote View, an electronic light table application, is a software image viewer that can import, view, and analyze commercial remote sensing data. The product has capabilities for image enhancement, terrain visualization, geographic information system/vector integration, multispectral analysis, image mosaicing, and mapping.

**SOCET GXP:** The Softcopy Exploitation Toolkit Geospatial Exploitation Product (SOCET GXP) is a GEOINT software package that uses imagery from commercial, satellite, tactical, and aerial sources to identify, analyze, and extract ground features quickly, allowing for rapid product creation. SOCET GXP enables GEOINT imagery analysts, geospatial production

technicians, and decisionmakers at all levels to use a common operating framework to create, store, and share map data.

## Appendix E: Glossary of Terms

Sourced directly from the source listed after the term. This is not an exhaustive list of terms and acronyms. Additional or duplicate definitions may be available through other doctrinal sources.

**Area of influence**—A geographical area wherein a commander is directly capable of influencing operations by maneuver or fire support systems normally under the commander's command or control (JP 3-0 pg GL-6). The area of influence includes terrain inside and outside the AO and is determined by both the G-2/S-2 [intelligence] and G-3/S-3 [operations]. ATP 2-01.3 (HQDA 2019a, p. 3-3).

**Area of interest (AOI)**—The area of concern to the commander, including the area of influence, areas adjacent thereto, and extending into enemy territory (JP 3-0 pg GL-6). The AOI also includes areas occupied by threat forces who could jeopardize mission accomplishment. ATP 2-01.3 (HQDA 2019a, p. 3-3).

**Area of operations (AO)**—An operational area defined by a commander for land and maritime forces that should be large enough to accomplish their missions and protect their forces (JP 3-0 pg GL-6). The AO comprises an external boundary that delineates adjacent units. ATP 2-01.3 (HQDA 2019a, p. 3-3).

**Area of responsibility (AOR)**—The geographical area associated with a combatant command within which a combatant commander has authority to plan and conduct operations. JP 3-0 (CJCS 2022b, p. xvi).

**Army Geospatial Center (AGC)**—A major subordinate center organized under the US Army Corps of Engineers in 2009 to support ground operations with the dissemination of terrain data. The AGC collects, analyzes, manages, and delivers geospatial data and products, provides acquisition support, and develops innovative solutions to solve the toughest geospatial challenges. USACE, AGC (n.d.).

An AGC mission is to provide timely, accurate, and relevant geospatial information, capabilities, and domain expertise for AGE implementation in support of [multidomain] operations. This includes providing geospatial support, training, and products to the Army and mission

partners; developing and fielding enterprise-enabled geospatial systems; and providing domain expertise and support to the Army mission command systems and acquisition community. ATP 3-34.80 (HQDA 2017a, p. 1-7).

**Army Geospatial Enterprise (AGE)**—An integrated system of technologies and processes that provides an SSGF upon which data from all warfighting functions can be used to display the COP. A comprehensive framework for systematically exploiting and sharing GI&S (including associated spatial and temporal data) to enable decisive action. Its components: the Standard and Shareable Geospatial Foundational Data (SSGF), the Ground-Warfighter Data Model (GGDM), and the Army's DOD Distributed Ground/Surface System (DCGS-A). ATP 2-22.7 (HQDA 2015, p. 3-1) and ATP 3-34.80 (HQDA 2017a, p. 2-1).

**Avenue of approach (AA)**—A path used by an attacking force leading to its objective or to key terrain. Avenues of approach exist in all domains (ADP 3-90). Identifying AAs is important because all COAs that involve maneuver depend on available AAs. During offensive tasks, the evaluation of AAs leads to a recommendation of the best AAs to a command's objective and to the identification of AAs available to the threat for counterattack, withdrawal, or the movement of reinforcements or reserves. During defensive tasks, it is important to identify AAs that support threat offensive capabilities and AAs that support the movement and commitment of friendly reserves. AAs consist of a series of mobility corridors through which a maneuvering force must pass to reach its objective. AAs must provide ease of movement and enough width for dispersion of a force large enough to affect the outcome of the operation significantly. AAs are developed by identifying, categorizing, and grouping mobility corridors and evaluating AAs. Evaluating AAs is a combined effort by the entire staff to identify those AAs that best support threat or friendly capabilities. ATP 2-01.3 (HQDA 2019a, p. 4-8, 4-9, and figure 4.6).

**Battalion (BN)**—A unit consisting of two or more company-, battery-, or troop-size units and a headquarters. ADP 3-90 (HQDA 2019e, Glossary-3).

**Brigade (BDE)**—A unit consisting of two or more battalions and a headquarters company or detachment. ADP 3-90 (HQDA 2019e, Glossary-3).

**Brigade Combat Team (BCT)**—A combined arms organization consisting of a brigade headquarters, at least two maneuver battalions, and necessary supporting functional capabilities. A BCT is a close combat force that can operate as part of a division or a joint task force. BCTs, with unified action partners, conduct land operations to shape security environments, prevent conflict, prevail in ground combat, and consolidate gains. BCTs provide the Army with multiple options for responding to and resolving crises. The BCT, within the division or corps scheme of maneuver, defeats enemy forces, controls terrain, secures populations, and preserves joint force freedom of action. FM 3-96 (HQDA 2021a, p. xi and 1-1).

**Combat power**—The total means of destructive, constructive, and information capabilities that a military unit or formation can apply at a given time (ADP 3-0). Combat power has eight elements: leadership, information, command and control, movement and maneuver, intelligence, fires, sustainment, and protection. The last six elements are the warfighting functions. The purpose of combat power is to accomplish missions. It also helps commanders conceptualize capabilities to execute combined arms operations. ADP 1-01 (HQDA 2019d, p. 4-2); see also **Warfighting function**.

**Combined obstacle overlay (COO)**—Provides a basis for identifying ground AAs and mobility corridors. Unlike the cross-country mobility, the combined obstacle overlay integrates all impediments to mobility, such as built-up areas, slope, soils, vegetation, and hydrology into one overlay. This overlay also allows the staff to visualize impediments to mobility for both friendly and threat forces. The overlay depicts areas that impede mobility (severely restricted and restricted areas) and areas where friendly and threat forces can move unimpeded (unrestricted areas). ATP 2-01.3 (HQDA 2019a, p. 4-13).

**Common operational picture (COP)**—A single identical display of relevant information shared by more than one command that facilitates collaborative planning and assists all echelons to achieve situational awareness (JP 3-0 pg GL-8). 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. ATP 2-22.7 (HQDA 2015, p. 1-2) and ATP 3-34.80 (HQDA 2017a, p. 2-1).

**Concealment**—Protection from observation or surveillance (FM 3-96). It degrades the threat’s ability to observe forces, equipment, or positions. Concealment can be provided by trees, underbrush, tall grass, cultivated vegetation, weather conditions (such as snow, fog, or rain), as well as man-made camouflage. Concealment does not necessarily provide cover. ATP 2-01.3 (HQDA 2019a, p. 4-12).

**[Army] Corps**—An echelon of command and tactical formations that employs divisions, multifunctional brigades, and functional brigades to achieve objectives on land. JP 3-31 (CJCS 2023) and JEL+ (n.d.).

**Course of action (COA)**—Any sequence of activities that an individual or unit may follow. A scheme developed to accomplish a mission. JEL+ (n.d.).

**Cover**—Protection from the effects of fires (FM 3-96). Cover is the physical protection from bullets, fragments of exploding rounds, flame, nuclear effects, and biological and chemical agents. Cover and concealment can be provided by (but are not limited to) ditches, caves, riverbanks, folds in the ground, shell craters, buildings, walls, and embankments. Cover does not necessarily provide concealment. An example of cover without concealment is a bunker in plain sight that is intended for personnel survivability. ATP 2-01.3 (HQDA 2019a, p. 4-12).

**Decisive action**—The continuous, simultaneous execution of offensive, defensive, and stability operations or defense support of civil authority tasks. Army forces conduct decisive action. Commanders seize, retain, and exploit the initiative while synchronizing their actions to achieve the best effects possible. ADP 3-0 (HQDA 2019b, p. 3-1).

Table E-1. Elements of decisive action (DSCA and Stability Operations omitted from this table) from ADP 3-0 (HQDA 2019b, p. 3-2).

<i>Offense</i>	<i>Defense</i>
<b>Types of Offensive Operations</b>	<b>Types of Defensive Operations</b>
<ul style="list-style-type: none"> <li>• Movement to contact.</li> <li>• Attack.</li> <li>• Exploitation.</li> <li>• Pursuit.</li> </ul>	<ul style="list-style-type: none"> <li>• Mobile defense.</li> <li>• Area defense.</li> <li>• Retrograde.</li> </ul>

Table E-1 (cont.). Elements of decisive action (DSCA and Stability Operations omitted from this table) from ADP 3-0 (HQDA 2019b, p. 3-2).

<i>Offense</i>	<i>Defense</i>
<b>Purposes</b>	<b>Purposes</b>
<ul style="list-style-type: none"> <li>• Dislocate, isolate, disrupt, and destroy enemy forces.</li> <li>• Seize key terrain.</li> <li>• Deprive the enemy of resources.</li> <li>• Refine intelligence.</li> <li>• Deceive and divert the enemy.</li> <li>• Provide a secure environment for stability tasks.</li> </ul>	<ul style="list-style-type: none"> <li>• Deter or defeat enemy offense.</li> <li>• Gain time.</li> <li>• Achieve economy of force.</li> <li>• Retain key terrain.</li> <li>• Protect the population, critical assets, and infrastructure.</li> <li>• Refine intelligence.</li> </ul>

**Decisive terrain**—Key terrain whose seizure and retention is mandatory for successful mission accomplishment (ADP 3-90). Key terrain is not necessarily decisive terrain. Decisive terrain has an extraordinary impact on the mission. The successful accomplishment of the mission depends on seizing, retaining, or denying the use of the terrain to a threat force. Commanders designate decisive terrain to communicate to the staff and subordinate commanders about the importance of the terrain to the concept of operations. ATP 2-01.3 (HQDA 2019, p. 4-11).

**Defense**—The purpose of the defense is to create conditions for the offense that allows Army forces to regain the initiative. Other reasons for conducting the defense include: retaining decisive terrain or denying a vital area to an enemy, attriting or fixing an enemy as a prelude to the offense, countering enemy action, increasing an enemy’s vulnerability by forcing an enemy commander to concentrate subordinate forces. ADP 3-90 (HQDA 2019e, p. 4-1).

*A defensive operation* is an operation to defeat an enemy attack, gain time, economize forces, and develop conditions favorable for offensive or stability operations. ADP 3-0 (HQDA 2019b, p. 3-4).

*Defense [exploit the advantages of terrain]*—Defending commanders exploit the advantages of occupying the terrain where an engagement will occur. A defending force engages an attacker from locations that give that defending force an advantage. Defensive positions in the MBA [main battle area] make use of existing and reinforcing obstacles. Commanders may shape the battlefield by defending in one area to deny terrain to an enemy force while delaying in another area. This is to deceive an enemy commander into believing that an attacking enemy force has achieved success. Generally, defending forces have the advantage of preparing the

terrain by reinforcing natural obstacles, fortifying positions, and rehearsing operations. Terrain features that favor the defense include: a series of parallel ridges across the line of hostile advance, unfordable streams, swamps, lakes, and other obstacles on the front and flanks, high ground with good observation and long-range fields of fire, concealed movement routes immediately behind defensive positions, a limited road network in front of the line of contact to confine an enemy force to predictable avenues of approach, a good road network behind the line of contact that allows commanders to reposition forces as a battle progresses. ADP 3-90 (HQDA 2019e, p. 4-1).

Dismounted infantry forces facing an armored enemy force are primarily used in static roles within the MBA or in security roles within their echelon support and consolidation areas. When facing armored enemy forces, dismounted infantry forces are most effective when fighting from prepared defenses or in close terrain, such as swamps, woods, hilly and mountainous areas, and urban areas. From those positions they can take advantage of their foot mobility and short-range infantry and anti-armor weapons. ADP 3-90 (HQDA 2019e, p. 4-10).

**Distributed Common Ground System–Army (DCGS-A)**—The geospatial engineering component that automates terrain analysis and visualization; database development, updates, and management; and graphics reproduction in support of mission requirements. The DCGS-A provides the hardware and software necessary to develop and manage a geospatial database and a software suite of geospatial information-processing capabilities that support the Army by supplying GI&S and special map reproduction. ATP 3-34.80 (HQDA 2017a, p. E-1) and ATP 2-22.7 (HQDA 2015, p. A-2; contains a for official use only [FOUO] explanation).

**[Army] Division**—An echelon of command and tactical formation that employs brigade combat teams, multifunctional brigades, and functional brigades to achieve objectives on land. ADP 3-90 (HQDA 2019e, Glossary-5).

**Echelon**—A formation or element troops and associated equipment; for example, Corps, Divisions, and BCTs (inferred from JEL+ [n.d.]).

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 [Army Service Component Command] 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. ATP 3-34.80 (HQDA 2017a, p. 3-1).

**ENVI**—Image processing and analysis software. NV5 (n.d.).

**Esri ArcGIS**—Location based analytics software. Esri (n.d.).

**Field of fire**—The area that a weapon or group of weapons may cover effectively from a given position (FM 3-90-1). A unit's field of fire is directly related to its ability to observe. Evaluation of observation and fields of fire identifies: potential engagement areas; defensible terrain, which offers good observation and fields of fire; specific equipment or equipment positions; areas where forces are most vulnerable to observation and fires; and visual dead space. Analysis of fields of fire includes an evaluation of all direct and indirect fire weapon systems in a command's inventory. An ideal field of fire for direct fire weapon systems is an open area where the threat can be seen and has no protection out to the maximum effective range of that weapon. ATP 2-01.3 (HQDA 2019a, p. 4-7).

**Geospatial decision aids (GDAs)** (new definition pending updated ATP 3-34.80 publication)—Tailored geospatial products that support DoD and DSCA operational planning processes and mission execution by providing decisional authorities with an understanding of advantages and disadvantages of the terrain against critical aspects over a given operational environment and timeframe. Revised ATP 3-34.80 (not yet released).

**Geospatial engineering**—Those engineering capabilities and activities that contribute to a clear understanding of the physical environment by providing geospatial information and services to commanders and staffs.

FM 3-34 provides additional information on engineer disciplines and their role in support of [multidomain] land operations. Geospatial engineering is the art and science of applying geospatial information to enable an understanding of the physical environment for military operations. The art is the ability to understand mission, enemy, terrain and weather, troops and support available, time available, civil considerations, and geographic information available (including the intent of use and limitations); to explain the military significance of the terrain to the commander and staff; and to create geospatial products for decision making. The science is the ability to exploit geographic information to produce spatially and temporally accurate products and services for mapping, visualization, analysis, and modeling within an Army enterprise construct to meet the mission needs of the commander and staff. ATP 3-34.80 (HQDA 2017a, p. 1-2).

**Geospatial engineering** (updated definition pending updated ATP 3-34.80 publication)—Those engineering capabilities and activities that contribute to a clear understanding of the physical environment by employing geographic information systems (GIS) to provide geospatial information and services (GI&S) to commanders and staffs. JP 3-34 and FM 3-34 provides additional information on engineer disciplines and their role in support of multidomain operations. Geospatial information identifies the geographic location and characteristics of natural or constructed features and boundaries on Earth. Geospatial engineering is the art and science of applying geospatial information to enable an understanding of the physical environment for military operations. The science is the ability to collect geospatial information about the physical dimension of the OE, analyze the geospatial information to identify phenomenon, and exploit the geospatial knowledge gained in support of military operations. The art is the ability to utilize cartographic techniques and principles to produce mission-tailored geospatial information and knowledge, geospatial decision aids, and visualization products providing the commander and staff with a situational understanding of the physical dimension and effects of the OE. The geospatial engineering discipline is also considered the foundation supporting the combat and general engineering disciplines and lines of engineer support.

**Geospatial engineers**—Create geospatial products [along with GEOINT analysts] to exploit geographic information to produce spatially and temporally accurate products and services for mapping, visualization,

analysis, and modeling to enable decision making of the commander and staff. Geospatial engineers, in combination with other engineers and other staff members, provide mission-tailored data, tactical decision aids, and visualization products that define the character of the operational environment for the maneuver commander. They also provide the commander with a common view of the terrain, through terrain visualization, that enables him to understand and describe his intent. 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. ATP 3-34.80 (HQDA 2017a, p. 1-2, 3-7, and 3-19).

**Geospatial engineers** (updated definition pending updated ATP 3-34.80 publication)—At each echelon, are responsible for deriving geospatial information from organic information collection activities, including reconnaissance reports or remote sensed data collection; and capturing the information in standardized geospatial formats. These formats include georeferenced imagery, elevation matrices (rasters), geospatial features (vector), and military standard maps.

**Geospatial engineer team (GET)**—The day-to-day managers of the geospatial foundation data. ATP 3-34.80 (HQDA 2017a, p. 2-2).

**Geospatial Intelligence (GEOINT)**—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. ATP 2-22.7 (HQDA 2015, Glossary-3).

**Geospatial planning cell (GPC)**—At Army Service Component Commands (ASCCs), geospatial engineering support is provided by geospatial planning cell (GPC) engineering detachments. These detachments are composed of geospatial engineer soldiers and warrant officers and an engineer officer who serves as the detachment officer in charge (OIC) and the ASCC GI&S officer. Geospatial engineers make up a low-density, high-demand discipline across the Army. ATP 3-34.80 (HQDA 2017a, p. 1-2).

**Geospatial planning cell (GPC)** (updated definition pending updated ATP 3-34.80 publication)—provide geospatial support to deployed units that require augmentation. Geospatial engineering capabilities include analysis, collection, generation, management, finishing, and printing. GPCs generate, manage, and disseminate geospatial data, information, and products in support of ASCC headquarters and geographic combatant commands. GPCs are responsible for the management of the theater geospatial database, which contains detailed information about geographic features within the ASCC AOR.

**GMAD**—Generate, manage, analyze, and disseminate. ATP 3-34.80 (HQDA 2017a, p. 1-7).

**Ground-Warfighter Geospatial Data Model (GGDM)**—Consists of a logical data model, physical data model, and a data dictionary. It supports geoservices across the Army Geospatial Center and other ground-warfighter organizations such as the Marine Corps. The model is designated for collecting, maintaining, and disseminating vector data (including rivers, roads, buildings, vegetation, and bridges) with identifying attributes related to features (such as function, height, type, physical condition, operational status, and metadata) describing the accuracy, content, origin, and classification level. GPCs generate and maintain data in the Ground-Warfighter Geospatial Data Model using Army Geospatial Center-produced geospatial datasets, DCGS-A, and other Army and Marine Corps systems (see ATP 3-34.80 [HQDA 2017a, p. 2-5] for more information on the geospatial data models). ATP 2-22.7 (HQDA 2015, p. 5-7).

**Intelligence preparation of the battlefield (IPB)**—The systematic process of analyzing the mission variables of enemy, terrain, weather, and civil considerations in an area of interest to determine their effect on operations (ATP 2-01.3 pg 1-1). Led by the intelligence officer, the entire staff participates in IPB to develop and sustain an understanding of the enemy, terrain and weather, and civil considerations. IPB helps identify options available to friendly and threat forces. IPB consists of four steps. Each step is performed or assessed and refined to ensure that IPB products remain complete and relevant. The four IPB steps are: define the OE, describe environmental effects on operations, evaluate the threat, determine threat COAs. ADP 5-0 (HQDA 2019c, p. 1-16).

**Key terrain**—An identifiable characteristic whose seizure or retention affords a marked advantage to either combatant (ADP 3-90 pg 3-10). In natural terrain environments dominated by restrictive terrain features, high ground can be key terrain because it dominates an area with good observation and fields of fire. In an open or arid environment, a dry river-bed, channel, or valley can be key terrain because it offers good cover and concealment. ATP 2-01.3 (HQDA 2019, p. 4-10 and fig. 4.7).

**Line of sight (LOS)**—The unobstructed path from a soldier's weapon, weapon sight, electronic sending and receiving antennas, or piece of reconnaissance equipment from one point to another. In other words, a LOS is a straight line from one point to another. There are two types of LOSs normally evaluated during terrain analysis: Horizontal LOS is an unobstructed path from a soldier's weapon, weapon sight, laser designator, and electronic sending and receiving antennas; Oblique (or vertical) LOS assists in planning ADA system locations, selecting landing zones and drop zones, and selecting forward arming and refueling points. LOS analysis determines the observation, fields of fire, and cover and concealment the terrain will provide to both friendly and threat forces. ATP 2-01.3 (HQDA 2019a, p. 4-7 and 4-12).

**Main battle area (MBA)**—The area where the commander intends to deploy the bulk of the unit's combat power and conduct decisive operations to defeat an attacking enemy. ADP 3-90 (HQDA 2019e, Glossary-7).

**Maneuver**—(Army) Movement in conjunction with fires. ADP 3-90 (HQDA 2019e, Glossary-7). (Joint) Employment of forces in the operational area, through movement in combination with fires and information, to achieve a position of advantage in respect to the enemy. JP 3-0 (CJCS 2022b, p. GL-12).

**METT-TC**—see **mission variables**.

**Military aspects of terrain (OAKOC)**—For tactical operations, commanders and staffs analyze terrain using the five military aspects of terrain (observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment [OAKOC]), as performed during step 2 of the IPB process. ATP 2-01.3 (HQDA 2019a, p. 3-6).

**Military decision-making process (MDMP)**—An iterative planning methodology. It integrates activities of the commander, staff, subordinate headquarters, and other partners. This integration enables them to understand the situation and mission; develop, analyze, and compare courses of action; decide on the course of action that best accomplishes the mission; and produce an order for execution. The military decision-making process applies to both conceptual and detailed approaches. It is most closely associated with detailed planning. For unfamiliar problems, executable solutions typically require integrating the Army design methodology with the military decision-making process. The military decision-making process helps leaders apply thoroughness, clarity, sound judgment, logic, and professional knowledge, so they understand situations, develop options to solve problems, and reach decisions. This process helps commanders, staffs, and others to think critically and creatively while planning. (See ADP 5-0 [HQDA 2019c] for more information on the military decision-making process.) ADP 3-0 (HQDA 2019b, p. 4-2).

MDMP integrates the commander and staff in a series of steps to produce a plan or order. Key integrating processes that occur throughout the operations process include: intelligence preparation of the battlefield, information collection, targeting, risk management, and knowledge management. ADP 5-0 (HQDA 2019c, p. 1-15 and 1-16).

**Mission variables (METT-TC)**—Once a mission is assigned, a commander and staff's analysis is framed by the mission variables (mission, enemy, terrain, troop available, time, and civilian considerations), which narrows down the operational variables to those that affect a specific mission. ADP 1-01 (HQDA 2019d, p. 5-1). Also see **operational environment**.

**Mobility**—Ease of movement (inferred from ATP 2-01.3 [HQDA 2019, p. 4-8]).

Mobility is necessary for the execution of the offense. It mainly focuses on enabling friendly forces to move and maneuver freely. ADP 3-90 (HQDA 2019e, p. 3-12).

*Assured mobility* is a framework—of processes, actions, and capabilities—that assures the ability of a force to deploy, move, and maneuver where and

when desired, to achieve the commander's intent (ATP 3-90.4 [HQDA 2022c, p. 1-2]). The assured mobility fundamentals of prediction, detection, prevention, avoidance, neutralization, and protection support framing staff planning of subordinate unit tasks and activities. The assured mobility framework enables planners to recommend COAs that achieve the commander's intent. Assured mobility emphasizes integrated proactive mobility, countermobility, and protection tasks to increase the probability of mission accomplishment. While engineers are principal staff integrators for the assured mobility framework, all staff planners are essential to ensuring the effective application and integration of mobility, countermobility, and protection tasks. (See ATP 3-90.4 [HQDA 2022c] for more information on combined arms mobility.) ADP 3-90 (HQDA 2019e, p. 3-11).

*Mobility tasks* are those combined arms activities that mitigate the effects of obstacles to enable freedom of movement and maneuver. ATP 3-90.4 (HQDA 2022c, p. 1-3).

**Mobility corridor**—Areas that are relatively free of obstacles where a force will be canalized due to terrain restrictions allowing military forces to capitalize on the principles of mass and speed (JP 2-01.3). They use unrestricted terrain that provides enough space for a freedom of action by breaching or bypassing obstacles. The geospatial team provides terrain visualization products for mobility corridors. Identifying mobility corridors requires knowledge of friendly and threat forces and their preferred tactics. (For more information on terrain visualization products, see ATP 3-34.80.) Mobility corridor requirements are directly proportional to the type and mobility of the force being evaluated. Military forces, such as mechanized infantry or armored units, have more freedom of movement and maneuver in open areas. Dismounted forces are less impacted in wooded areas, where mechanized units would be delayed. Geospatial teams can produce cross-country mobility-terrain visualization products corresponding with the type of element being employed in a specific area. Reconnaissance should be conducted to validate computer-generated products. ATP 2-01.3 (HQDA 2019, p. 4-8).

**Modified combined obstacle overlay (MCOO)**—A joint intelligence preparation of the operational environment product used to portray the militarily significant aspects of the operational environment, such as obstacles restricting military movement, key geography, and military objectives. The MCOO is tailored to the mission and is a

collaborative effort involving input from the entire staff. The staff uses its warfighting function expertise to determine how the terrain will impact that function. For example, the S-6 provides input on how the terrain may affect LOS communications for friendly and threat forces. The nuclear, biological, chemical officer provides information on how terrain may affect the use of persistent and nonpersistent chemical agents. ATP 2-01.3 (HQDA 2019, p. 4-13).

**MOS**—Military occupational specialty. ATP 2-22.7 (HQDA 2015, Glossary-2).

**Movement**—In the context of Army tactics, movement is the positioning of combat power to establish the conditions for maneuver. To direct movement, Army forces use movement techniques, use movement formations, and conduct battle drills to mitigate the risk of making contact with the enemy before maneuvering. ADP 3-90 (HQDA 2019e, Glossary-8 and p. 2-14).

**Multidomain operations (MDO)**—The combined arms employment of joint and Army capabilities to create and exploit relative advantages to achieve objectives, defeat enemy forces, and consolidate gains on behalf of joint force commanders. FM 3-0 (HQDA 2022e, Glossary-10).

**National Geospatial-Intelligence Agency (NGA)**—The proponent for the National System for Geospatial Intelligence (NSG) and serves as the primary source of national level geospatial information in support of MDO. ATP 3-34.80 (HQDA 2017a, p. 1-7) and ATP 2-22.7 (HQDA 2015, p. 1-6 and 1-7).

**National Ground Intelligence Center (NGIC)**—A United States Army Intelligence and Security Command (INSCOM) functional command with operational control exercised by the Army G-2. NGIC develops and disseminates all-source capabilities on foreign ground forces under the federated Defense Intelligence Analysis Program. It provides scientific and technical intelligence and general MI on foreign ground forces to support senior defense and Army leadership, warfighting commanders, and force and materiel developers. ATP 2-22.7 (HQDA 2015, p. 3-7).

**National System for Geospatial Intelligence (NSG)**—Manages operations through guidance, policy, programs, and organizations.

Managed by the National Geospatial-Intelligence Agency (NGA), the NSG is designed to be a mutually supportive enterprise that fosters collaboration between echelons, the Services, U.S. Government departments and agencies, and multinational partners to provide decisionmakers, commanders, intelligence users and producers, and civil authorities a better understanding of GEOINT to effectively execute assigned missions. For more on the NSG reference Appendix F of ATP 2-22.7. The two main Army entities that support the NSG are the National Ground Intelligence Center (MI proponent) and the US Army Corps of Engineers (USACE) Army Geospatial Center (AGC). Formal support to the NSG continues down through the Army echelons all the way to the Brigade Combat Team (BCT). ATP 2-22.7 (HQDA 2015, p. 1-6).

**OAKOC**—See **military aspects of terrain**.

**Observation**—The condition of weather and terrain that permits a force to see the friendly, enemy, and neutral personnel and systems, and key aspects of the environment. Commanders evaluate their observation capabilities for electronic and optical LOS surveillance systems, as well as for unaided visual observation. The highest terrain normally provides the best observation. ATP 2-01.3 (HQDA 2019a, p. 4-6).

**Obstacles**—Any natural or man-made obstruction designed or employed to disrupt, fix, turn, or block the movement of an opposing force, and to impose additional losses in personnel, time, and equipment on the opposing force. ATP 2-01.3 (HQDA 2019, p. 4-11).

**Offense**—The decisive form of war. The offense is the ultimate means commanders have of imposing their will on enemy forces. Army forces conduct the offense to defeat and destroy enemy forces as well as gain control of terrain, resources, and population centers. Commanders may also conduct the offense to deceive or divert an enemy force, develop intelligence, or hold an enemy force in position. Commanders seize, retain, and exploit the initiative when conducting the offense. Specific operations may orient on an enemy force or terrain objective to achieve a position of relative advantage. Taking the initiative from an enemy force requires the conduct of the offense, even in the defense. The main purposes of the offense are to defeat enemy forces, destroy enemy forces, and gain control of terrain, resources, and population centers. Additionally, commanders conduct the offense to: secure decisive terrain, deprive the enemy of

resources, gain information, deceive and divert an enemy force, fix an enemy force in position, disrupt an enemy force's attack, and set the conditions for successful future operations. The offense supports friendly operations in the air, maritime, space, and cyberspace domains, and in the information environment. These operations destroy, dislocate, disintegrate, or isolate an enemy force.

Armored units are particularly effective when conducting mobile combat against enemy forces in open terrain. Stryker units use terrain to maneuver outside of direct fire range and then employ their infantry to close with the enemy. The combat vehicles in these forces allow commanders to rapidly maneuver subordinate forces to positions of advantage against defending enemy forces and then immediately move to other locations to disrupt the integrity of an enemy's defense.

Dismounted infantry forces are best suited for the offense in complex terrain. Dismounted infantry forces employ any forms of maneuver to secure objectives and achieve exploitable positions of advantage over an enemy force. Those positions of advantage may allow follow-on armored and Stryker forces to exploit that success, or they may block enemy counterattacking forces. Dismounted infantry forces can conduct air assaults, providing a division commander with a rapidly deployable force. Any application of dismounted infantry requires considerations for protection and supporting systems. ADP 3-90 (HQDA 2019e, p. 3-1 and 3-10).

**Operational environment (OE)**—Everything related to the conduct of operations is part of an operational environment, the one category that accounts for all political, military, economic, social, information, infrastructure, physical environment, and time considerations that influence operations and training for operations. These variables need to be captured and continuously updated by analysis in running estimates and understood by the commander and staff even before the assignment of a mission. Operational variables may reside in any of the domains (air, land, maritime, space, and cyberspace). Once a mission is assigned, a commander and staff's analysis is framed by the mission variables (METT-TC), which narrows down the operational variables to those that affect a specific mission. ADP 1-01 (HQDA 2019d, p. 5-1).

**Operations order (OPORD)**—Plans and orders come in many forms and vary in the scope, complexity, and length of time they address. Generally, commanders and staffs develop an operation plan (OPLAN) well in advance of execution; it is not executed until directed. An OPLAN becomes an OPORD when directed for execution based on a specific time or event. A FRAGORD is an abbreviated form of an OPORD issued as needed to change or modify an OPORD during the conduct of operations. (See FM 6-0 [HQDA 2022b] for Army formats for plans and orders.) ADP 5-0 (HQDA 2019c, p. 1-9 and 2-2).

**Operations process**—The major command and control activities performed during operations: planning, preparing, executing. And continuously assessing the operation. ADP 5-0 (HQDA 2019c, p. vi).

**Operational tempo (OPTEMPO)**—See **tempo**.

**Operational variables (PMESII PT)**—Political, military, economic, social, information, infrastructure, physical environment, and time. ADP 1-01 (HQDA 2019d, p. 5-1). Also see **operational environment**.

**PMESII PT**—See **operational variables**.

**Procedures**—Standard, detailed steps that prescribe how to perform specific tasks. ADP 1-01 (HQDA 2019d, p. vi). Also see **TTP**.

**Restricted terrain**—Terrain that hinders movement to some degree. Little effort is needed to enhance mobility, but units may have difficulty maintaining preferred speeds, moving in combat formations, or transitioning from one formation to another. Restricted terrain slows movement by requiring zigzagging or frequent detours. Restricted terrain for armored or mechanized forces typically consists of moderate-to-steep slopes or moderate-to-dense obstacle compositions, such as restrictive slopes or curves. Swamps or rugged terrain are examples of restricted terrain for dismounted infantry forces. Logistical or sustainment area movement may be supported by poorly developed road systems. A common and useful technique to depict restricted terrain on overlays and sketches is marking the areas with green diagonal lines. ATP 2-01.3 (HQDA 2019a, p. 4-13, 4-14, and Appendix B).

**Severely restricted terrain**—Terrain that severely hinders or slows movement in combat formations unless some effort is made to enhance mobility, such as committing engineer assets to improving mobility or deviating from doctrinal tactics (moving in columns instead of line formations or at speeds much lower than those preferred). For example, severely restricted terrain for armored and mechanized forces is typically characterized by steep slopes and large or dense obstacle compositions with few bypasses. A common technique to depict this type of terrain on overlays and sketches is marking the areas with green crosshatched diagonal lines. ATP 2-01.3 (HQDA 2019, p. 4-13 and Appendix B).

**Situational understanding**—The product of applying analysis and judgment to relevant information to determine the relationship among the operational and mission variables to facilitate decision making. ATP 2-01.3 HQDA 2019a, p. 1-2).

**Standard Shareable Geospatial Foundational (SSGF) data**—A set of geospatial data that provides a common framework for visualizing an area of interest (AOI) to enable mission command and the planning and execution of operational goals. It consists of four data types (elevation, map background, georeferenced imagery, and geographic feature data) presented in standard digital and paper formats. Because it is the basis of the COP, the SSGF is relevant to all phases of operations and includes personnel, units, systems, platforms, and processes that use, produce, store, manage, or disseminate geospatial data that can be shared within and between the six warfighting functions. The SSGF relies on a logical and physical data model and a data dictionary known as the GGDM. ATP 3-34.80 (HQDA 2017a, p. v and 2-3).

**Tactical decision aid (TDA)** (see also **geospatial decision aid**)—Products that enable commander's decisions (e.g., MCOOs and terrain effects evaluations, weather forecast charts, weather effects matrices, and light and illumination data tables). Applications of tactical decision aids include: promoting the timely development of the modified combined obstacle overlay during IPB to assist in the development of threat COAs and the identification of avenues of approach, mobility corridors, and choke points; enhancing rehearsals and reconnaissance missions with the use of 3D fly-throughs, 3D anaglyphs, or simulations; and facilitating the positioning and routing of ground and aerial surveillance assets through LOS analysis. Geospatial engineers create tactical decision aids and other

products that enable a commander to visualize and understand the operational environment. ATP 3-34.80 (HQDA 2017a, p. 1-2, 3-4, and 3-5) and ATP 2-01.3 (HQDA 2019a, p. 2-4).

**Tactical mobility**—The ability of friendly forces to move and maneuver freely on the battlefield relative to the enemy. ADP 3-90 (HQDA 2019e, Glossary 1-1).

**Tactics**—The employment and ordered arrangement of forces in relation to each other. ADP 1-01 (HQDA 2019d, p. vi).

**TCPED**—Tasking, collection, production, exploitation, and dissemination ATP 2-22.7 (HQDA 2015, p. 2-7, E-7, and table 2-3).

**Techniques**—Nonprescriptive ways or methods used to perform missions, functions, or tasks. ADP 1-01 (HQDA 2019d, p. vi).

**Tempo**—The relative speed and rhythm of military operations over time with respect to the enemy. It reflects the rate of military action. Controlling tempo helps commanders keep operational initiative during combat operations or rapidly establish a sense of normalcy during humanitarian crises. During combat operations, commanders normally seek to maintain a higher tempo than enemy forces do. A rapid tempo can overwhelm an enemy force's ability to counter friendly actions. During other operations, commanders act quickly to control events and deny enemy forces positions of advantage. By acting faster than the situation deteriorates, commanders can change the dynamics of a crisis and restore favorable conditions. ADP 3-0 (HQDA 2019b, p. 2-8).

**Terrain analysis**—The collection, analysis, evaluation, and interpretation of geographic information on the natural and man-made features of the terrain, combined with other relevant factors, to predict the effect of the terrain on military operations. It also involves the study and interpretation of natural and man-made features within an area, their effects on military operations, and the effects of weather and climate on these features. Terrain analysis is a continual process since changes in the OE may alter the analysis of terrain effects on operations. A command may operate in two types of terrain: natural and complex. ATP 2-01.3 (HQDA 2019a, p. 4-5).

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.

Terrain analysis and visualization is a combination of art and science. It is a fundamental leadership skill and involves seeing the terrain and understanding the impact on the situation, including the effects on friendly and threat capabilities. It is the identification and understanding of terrain aspects that can be exploited to gain advantage over the threat and those terrain aspects most likely to be used by the threat. It is the subjective evaluation of the physical attributes of the terrain and the performance capabilities of vehicles, equipment, and personnel that must cross over and occupy the terrain. ATP 3-34.80 (HQDA 2017a, p. 1-4).

**TTPs**—Tactics, techniques, and procedures (see individual definitions).

**Unified Land Operations (ULO)**—(See multidomain operations). ULO was replaced by multidomain operations in FM 3-0 in October 2022. ULO introduced many multidomain considerations and ideas in the 2017 version of FM 3-0.) The Army's warfighting doctrine: the simultaneous execution of offense, defense, stability, and defense support of civil authorities across multiple domains to shape operational environments, prevent conflict, prevail in large-scale ground combat, and consolidate gains as part of unified action. The goal of unified land operations is to establish conditions that achieve the JFC's end state by applying land power as part of a unified action to defeat the enemy. ULO is how the Army applies combat power through simultaneous offensive, defensive, and stability, or DSCA; to then seize, retain, and exploit the initiative; and consolidate gains. Military forces seek to prevent or deter threats through unified action, and, when necessary, defeat aggression. ULO is an intellectual outgrowth of both previous operations doctrine and recent

combat experience. It recognizes the nature of modern warfare in multiple domains and the need to conduct a fluid mix of offensive, defensive, and stability operations or DSCA simultaneously. ADP 3-0 (HQDA 2019b, ch. 3, p. 3-1).

**Unrestricted terrain**—Terrain is free from any restriction to movement. Nothing is required to enhance mobility. Unrestricted terrain for armored or mechanized forces is typically flat to moderately sloping terrain with few obstacles such as limiting slopes or curves. This terrain allows wide maneuver by the forces under consideration and unlimited travel supported by well-developed road networks. No symbology is needed to show unrestricted terrain on overlays and sketches. ATP 2-01.3 (HQDA 2019, p. 4-14).

**Vegetative terrain feature data (VTFD)**—Geospatial information products related to the terrain (i.e., physical environment). Application of VTFD occurs in two main settings: Support to planning and operations as previously discussed in relation to IPB and MDMP and support to the COP. (Author definition).

**Warfighter** (authors' definition)—Individuals or groups of personnel currently enlisted or commissioned into service in the United States Department of Defense “to deploy, fight and win decisively against any adversary, anytime and anywhere, in a joint, combined, multi-domain, high-intensity conflict, while simultaneously deterring others and maintaining its ability to conduct irregular warfare”.<sup>10</sup> Officially undefined as of October 2022 per Joint Electronic Library Plus (JEL+ n.d.), DoD Dictionary of Military and Associated Terms.

**Warfighting function**—A group of tasks and systems united by a common purpose that commanders use to accomplish missions and training objectives (ADP 3-0). The Army's warfighting functions are fundamentally linked to the joint functions. A number of subordinate tasks, missions, and related capabilities help define each function; some apply to more than one function. The warfighting functions are the physical means that tactical commanders use to execute operations and accomplish missions assigned by superior tactical- and operational-level commanders. The purpose of warfighting functions is to provide an intellectual

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10. Adapted from the Army Vision and Strategy accessed 2 November 2022 at <https://www.army.mil/about/>

organization for common critical capabilities available to commanders and staffs at all echelons and levels of war. Commanders integrate and synchronize capabilities of one warfighting function with other warfighting functions to achieve objectives and accomplish missions. These grouped and related capabilities and activities help commanders and staffs integrate, synchronize, and direct operations. Commanders and staffs use the warfighting functions to ensure major groupings are accounted for in every operation and to conceptualize and apply capabilities to accomplish the mission through synchronizing forces and warfighting functions in time, space, and purpose. Combined arms operations use the capabilities of each warfighting function, along with leadership and information, in complementary and reinforcing capabilities. In 2008, the Army established six warfighting functions that linked to the joint functions established in JP 3-0 (CJCS 2022b). The Army defines each of these six warfighting functions (ADP 3-0 [HQDA 2019b]):

- The *command and control warfighting function* is the related tasks and a system that enable commanders to synchronize and converge all elements of combat power (ADP 3-0).
- The *movement and maneuver warfighting function* is the related tasks and systems that move and employ forces to achieve a position of relative advantage over the enemy and other threats (ADP 3-0). Direct fire and close combat are inherent in maneuver.
- The *intelligence warfighting function* is the related tasks and systems that facilitate understanding the enemy, terrain, weather, civil considerations, and other significant aspects of the operational environment (ADP 3-0).
- The *fires warfighting function* is the related tasks and systems that create and converge effects in all domains against the adversary or enemy to enable operations across the range of military operations (ADP 3-0).
- The *sustainment warfighting function* is the related tasks and systems that provide support and services to ensure freedom of action, extend operational reach, and prolong endurance (ADP 3-0).
- The *protection warfighting function* is the related tasks and systems that preserve the force so the commander can apply maximum combat power to accomplish the mission (ADP 3-0).

The successful execution of operations requires the use of all the warfighting functions in various combinations and with the other two

elements of combat power—leadership and information. ADP 1-01 (HQDA 2019d, p. 4-2), and ADP 3-0 (HQDA 2019b, p. 5-2) and ADP 3-90 (HQDA 2019e, p. 2-2 and 2-3). See also **Combat power**.

## Abbreviations

AA	Avenue of approach
ADP	Army doctrine publication
AGC	Army Geospatial Center
AGE	Army Geospatial Enterprise
AO	Area of operation
AOI	Area of interest
AOR	Area of responsibility
APD	Army Publications Directorate
ASCC	Army Service Component Command
ASCOPE	Areas, structures, capabilities, organizations, people, events
ATP	Army Techniques Publication
AUSA	Association of the United State Army
BCT	Brigade Combat Team
CAC	Common access card
CHM	Canopy height model
CJCS	Chairman of the Joint Chiefs of Staff
COA	Course of Action
COO	Combined obstacle overlay
COP	Common operational picture
CUI	Controlled unclassified information
DCGS-A	Distributed Common Ground System–Army

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DoD	Department of Defense
DSCA	Defense support to civil authorities
DTED	Digital terrain elevation data
EA	Engagement area
ENVI	Environment for Visualizing Images
ERDAS	Earth Resource Data Analysis System
ERDC	Engineer Research and Development Center
EROS	Earth Resources Observation and Science
ESA	European Space Agency
ESDS	Earth Science Data System
Esri	Environmental Systems Research Institute (private company)
FIADB	Forest Inventory and Analysis Program Data Base
FM	Field Manual
FOUO	For official use only
FS	Forest Service
FVS	Forest Veg Simulator
GDA	Geospatial decision aid
GD&I	Geospatial data and information
GEDI	Global Ecological Dynamic Investigation
GEOINT	Geospatial intelligence
GGDM	Ground-Warfighter Geospatial Data Model
GI&S	Geospatial information and services
GIS	Geographic information system

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GMAD	Generate, manage, analyze, and disseminate
GPC	Geospatial Planning Cell
GRiD	Geospatial Repository and Data Management System
HQDA	Headquarters, Department of the Army
IPB	Intelligence preparation of the battlefield
IR	Information requirement
JECOP	Joint Engineer Common Operating Picture
JP	Joint Publication
LOS	Line of sight
MBA	Main battle area
MCOO	Modified combined obstacle overlay
MDMP	Military decision-making process
MDO	Multidomain operations
METT-TC	Mission, enemy, terrain, troop available, time, and civilian
MOS	Military occupational specialty
MSI	Multispectral imagery
NGA	National Geospatial-Intelligence Agency
NGIC	National Ground Intelligence Center
NSG	National System for Geospatial Intelligence
OAKAC	Observations and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment
OE	Operational environment
OIC	Officer in charge

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OPORD	Operations order
OPTEMPO	Operational tempo
PIR	Priority intelligence requirement
PMESII PT	Political, military, economic, social, information, infrastructure, physical environment, and time
REDi	Reachback Engineer Data Integration
SOCET GXP	Softcopy Exploitation Toolkit Geospatial Exploitation Product
SSGF	Standard Shareable Geospatial Foundation
STP	Soldier Training Publication
TC	Training Circular
TCPED	Tasking, collection, production, and dissemination
TDA	Tactical decision aid
TM	Technical Manual
TPO-GEO	TRADOC Proponent Office–Geospatial
TRADOC	Training and Doctrine Command
TTP	Tactics, techniques, and procedures
U	Unclassified
USACE	US Army Corps of Engineers
USDA–FS	US Department of Agriculture–Forest Service
VTFD	Vegetative terrain feature data
WARP	Web-based Access and Retrieval Portal
WfF	Warfighting functions

## REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b> There is a significant knowledge gap for Army doctrine concerning civilian research scientists. A relatively small number of soldiers make the transition from warfighter to research and development at the basic and applied levels. That number is even less when considering former warfighters that have applied Army doctrine in an operational or advanced Army schooling environment. This special report is intended to focus solely on the Army’s current capabilities and doctrinally defined processes to analyze vegetation as an essential component of the natural terrain. The objective of this report is to review current Army doctrine related to analysis of the vegetated terrain; to explore currently leveraged tactics, techniques, and procedures (TTPs); and identify valuable geospatial resources as they apply to military planning. For ease to readers unfamiliar with US Army doctrine, much of the referenced material is directly presented herein as tables and figures throughout the document and appendices (e.g., data sources, product examples, and glossary).					
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