ATP 3-34.40
MCTP 3-40D (MCWP 3-17.7)

GENERAL ENGINEERING

APRIL 2023

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

This publication supersedes ATP 3-34.40 (FM 3-34.400)/MCWP 3-17.7, dated 25 February 2015.

Headquarters, Department of the Army

FOREWORD

This publication has been prepared under our direction for use by our respective commands and other commands as appropriate.

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To receive APD's weekly publishing update, subscribe at https://armypubs.army.mil/News/RSSInstructions.aspx.
This publication is also available at the U.S. Marine Corps Doctrine website at:
https://usmc.sharepoint-mil.us/sites/MCEN_Support_MCDoctrine.

Army Techniques Publications
No. 3-34.40

Marine Corps Tactical Publication
No. 3-40D

Headquarters, Department of the Army
Washington, DC

Marine Corps Logistics Operations
Group Twentynine Palms, CA

14 April 2023

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Contents

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Figures

Tables

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Preface

This manual provides general engineering doctrine for the Army and Marine Corps. This manual is linked to joint, Army, and Marine Corps doctrine to ensure its usefulness for joint, Army, and Marine Corps commanders and staffs. To comprehend the doctrine contained in this manual, readers must first understand the Service mission, organization, and roles described in the capstone doctrine. They must understand the operations process, operational art, and warfighting functions described in Army Doctrine Publication (ADP) 3-0, joint engineer functions discussed in JP 3-34 and Navy warfare publication (NWP) 4-04, and Army engineer disciplines discussed in FM 3-34. Similarly, readers can find information pertaining to Marine Corps engineer activities conducted in support of distributed maritime operations in MCWP 3-34.

In addition, readers must also fully understand the discussion of engineer operations at echelons above brigade (EAB) in FM 3-34, the fundamentals of assured mobility found in ATP 3-90.4/MCTP 3-34A and ATP 3-90.8/MCTP 3-34B, the discussion of Seabee operations in the Marine air-ground task force (MAGTF) found in NTTP 3-10.1M/MCTP 3-34D, the discussion of base camps found in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N), and the protection tasks discussed in ADP 3-37.

The principal audience for this manual is all members of the military profession of arms. Commanders and staffs of Army and Marine headquarters serving as joint task force (JTF) or multinational headquarters should also refer to applicable joint or multinational doctrine concerning military activities conducted across the competition continuum. This manual will be used in training and by educators throughout the Army and Marine Corps. The other intended audiences for this publication are the leaders and staff sections within engineer units that are required to provide general engineering support.

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and in some cases host-nation laws and regulations. Commanders at all levels ensure that their Soldiers and Marines operate in accordance with the law of war and the rules of engagement. (See FM 6-27/MCTP 11-10C.)

ATP 3-34.40 uses joint terms where applicable. When this manual uses two terms separated by a slash (/), the first term is the Army term and the second term is the Marine Corps term. For example, Army sustainment and Marine Corps combat service support are written in this manual as sustainment/combat service support. Selected joint, Army, and Marine Corps terms and definitions appear in the glossary and the text. For definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition. This publication is not the proponent for any Army terms.

ATP 3-34.40 applies to the Active Army, Army National Guard/Army National Guard of the United States and United States Army Reserve, total force Marine Corps unless otherwise stated.

The Army proponent of this publication is the Army Engineer School. The preparing agency is the Fielded Force Integration Directorate, Doctrine Division. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, Army Maneuver Support Center of Excellence (MSCoE), ATTN: ATZT-FFD, 14000 MSCoE Loop, Suite 270, Fort Leonard Wood, MO 65473-8929; e-mail the DA Form 2028 to usarmy.leonardwood.mscoe.mbx.cdidcodddengdoc@army.mil; or submit an electronic DA Form 2028.

The Commanding Officer of the Marine Corps Engineer School is appointed as the author of Marine Corps content in this publication. Marine Corps personnel can submit suggestions and changes by e-mail to MCES_S3_Doctrine_SMB@usmc.mil or by mail to the Commanding Officer (ATTN: S-3), Marine Corps Engineer School, PSC Box 20069, Camp Lejeune, NC 28542-0069.

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Introduction

ATP 3-34.40/MCTP 3-40D provides doctrine for the conduct of general engineering support by the Army and Marine Corps. It emphasizes the general engineering unity of effort by providing a common philosophy, language, and purpose. General engineering is a joint and Marine Corps engineering function and an Army discipline. This publication discusses how general engineering enables commanders to achieve their objectives in supporting multinational, joint, and service-specific missions. This publication also introduces subordinate doctrine.

This manual builds on the collective knowledge, wisdom, and military expertise gained through recent operations, numerous lessons learned, and doctrine revisions. This doctrine has also been adjusted to reduce the duplication of technical detail already contained in the referenced subordinate manuals.

This publication describes how engineer commanders, staffs, and subordinate leaders conduct general engineering to support Army and Marine Corps forces within the framework of joint and multinational operations. Additional considerations for engineers in coalition operations are reviewed in Allied Joint Publication 3.12 and Allied Tactical Publication 3.12.1.

The general engineering doctrine provided in this manual presents an overview of a wide range of topics and allows the reader to understand how the topics fit together. The engineer must refer to the referenced materials throughout the manual to gain a complete understanding of the general engineering life cycle activities. This manual is not meant to be a substitute for the creative thought, innovation, and initiative among engineer leaders, Soldiers, or Marines. Rather, its intent is to build, enhance, and strengthen their present knowledge and understanding. General engineers take their training, experience, capabilities, and understanding of doctrine and apply them to solve and unravel unique and obscure challenges to meet operational needs.

This manual uses the term *planning process* to indicate the military decision-making process (MDMP)/Marine Corps planning process (MCPP) and troop leading procedures. This manual uses the term *mission variables* to indicate the Army and Marine Corps uses of the term mission, enemy, terrain and weather, troops and support available-time available and civil considerations and mission, enemy, terrain and weather, troops and support available-time available.

This manual uses the term *operational variables* to indicate the Army and Marine Corps uses of the term. For the Army, operational variables consist of political, military, economic, social, information, infrastructure, physical environment, and time. For the Marine Corps (and in joint doctrine), operational variables consist of political, military, economic, social, information, and infrastructure (PMESII).

A complete listing of preferred metric units for general use is contained in Federal Standard 376B at https://www.nist.gov/system/files/documents/2017/05/09/fs376-b.pdf.

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

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Chapter 1

General Engineering Discipline and Function

Within Army doctrine, general engineering is considered a discipline; in Marine Corps and Joint doctrine, it is a function (see JP 3-34). *General engineering* is those engineering capabilities and activities, other than combat engineering, that provide infrastructure and modify, maintain, or protect the physical environment (JP 3-34). It complements and supports combat and geospatial engineering and encompasses the engineer tasks required to conduct and sustain military operations across the competition continuum. General engineering tasks are usually conducted in coordination with unified action partners and are integrated into the commander's plan. General engineer units may be led by any of the Services, and general engineering support may come from other Service engineers, contractors, HN capabilities, or the engineers of other nations. General engineering occurs throughout the area of operations and competition continuum. This chapter discusses general engineering employment considerations and provides guidance on integrating and synchronizing general engineering with joint theater and maneuver commanders' strategic, operational, and tactical plans. It also introduces the general engineering life cycle activities and employment considerations for engineering that are used to frame discussions in the other chapters in this manual.

LIFE CYCLE ACTIVITIES

1-1. General engineering life cycle activities are used to visualize the major activities required to produce a desired effect and are conducted during the life cycle of both operations and specific projects. To effectively and efficiently conduct any single general engineering life cycle activity, all life cycle activities must be considered together with their interrelationships and their impact on other activities. These life cycle activities should not be viewed separately or be conducted alone, because each activity impacts the other. For example, a completed design should be based on planning guidance, the ability of the military unit to quickly construct the design, and the impact of the design on operation and maintenance (O&M). Each life cycle activity is considered in an economic evaluation of life-cycle costs.

1-2. General engineering life-cycle activities include—

- Planning and design.
- Construction.
- Operation.
- Maintenance.
- Transfer and closure.

PLANNING AND DESIGN

1-3. General engineering planning includes conceptual, detailed, and master planning. Significant general engineering is conducted in the joint operations area (JOA), so an understanding of joint planning and other Service planning and capabilities is required. See CJCSM 3130.03A, FM 3-34, JP 1 Vol 1, JP 3-34, and JP 5-0 for more information on joint planning.

1-4. Design should not be confused with the Army design methodology (or operational design) discussed in ADP 3-0 and ADP 5-0. Design in this manual is an extension of planning that matches and links engineering principles and construction means against mission requirements to create the necessary engineering and construction details needed for building and dismantling facilities and infrastructure. The general life-cycle activities of planning and design are interdependent, although both apply critical and creative thinking to understand, visualize, and describe unfamiliar problems and the approaches to solving them.

CONSTRUCTION

1-5. Construction is the art or process of building or assembling structures such as base camps, bed-down facilities, or infrastructure. It consists of a wide range of activities, methods, and techniques used to combine individual parts and to assemble resources together to create a greater whole. Construction is performed by military units, contractors authorized to accompany the force (CAAF), and non-CAAF. Facilities and infrastructure are built using various methods that are evaluated and determined during planning and design. See JP 4-10 for more information on CAAF and non-CAAF construction.

Army Baseline General Engineer Units

1-6. Baseline general engineer units that support construction efforts are engineer construction companies, engineer support companies, and vertical construction companies. Their capabilities are discussed in ATP 3-34.22 and FM 3-34.

Army Specialized Engineer Units

1-7. Specialized engineer units that support general engineers in construction efforts include engineer facilities detachments, engineer utilities detachments, survey and design teams, firefighting teams, construction management teams, forward engineer support teams (FEST), diving teams, asphalt teams, concrete teams, well-drilling teams, geospatial engineering teams, quarry teams, and prime power teams.

1-8. Specialized engineer unit capabilities are applied in general support or general support reinforcing roles to enhance general engineering efforts, as described by the following:

- Dive teams assist in seaport or bridging efforts.
- Asphalt teams assist in paving for airfields and roads.
- Quarry teams assist in quarry, borrow pit, and rock-crushing.
- Concrete sections assist in concrete production.
- Engineer facilities detachments and engineer utilities detachments assist in facility assessments, inspections, services, maintenance, and repair.
- Construction management teams, geospatial engineering teams, equipment support platoons, and survey and design teams assist in construction planning and maintain updates to the common operational picture for construction updates. If required, the Geospatial Planning Cell can assist in infrastructure efforts for humanitarian assistance, domestic response, and defense support of civil authorities (DSCA).
- Engineer prime power teams plan and design power systems and install, operate, and maintain deployable prime power systems.
- FEST–advance is a deployable team that provides infrastructure assessment; engineer planning and design; and environmental, geospatial, and other technical engineer support (from theater army to brigade echelon) and augments the staff at those echelons.
- FEST–main is a deployable capability that provides minor contract construction administration, environmental, geospatial, and other engineer support (typically to the theater army).

Note. Specialized engineer unit organizations and capabilities are discussed in ATP 3-34.22 and FM 3-34.

Marine Corps General Engineer Units

1-9. The Marine Corps primary general engineering unit is the Engineer Support Battalion. The Marine wing support squadron performs limited general engineering to support aviation operations conducted by the aviation combat element. There are no specialized engineer units in the Marine Corps. See MCWP 3-34 for details on Marine Corps engineer unit capabilities.

OPERATION

1-10. This manual discusses the operation of engineer-specific equipment and systems that produce engineering effects. The operation of these systems usually requires specifically designed, equipped, organized, and trained units or trained individuals. Some facility engineer organization examples include facility engineer detachments and engineer utilities detachments. Some equipment or system examples are power systems, waste treatment systems, and float bridges. The tasks of O&M are often grouped together but are sometimes separated in this manual because the engineer may be required to maintain some things that they are not required to operate, such as an airfield that is operated by an Army aviation unit.

1-11. Base camp operation is the O&M of the base camp physical plant and the provision of base camp services and support measures that are needed to achieve the purpose of the base camp and to fulfill functional requirements. The skills needed for operating and managing base camps do not reside in any single branch or functional area. A grouping of capabilities is required to produce synergic effects within the base camp. Success hinges on placing the right people with the right skill sets at the right time. Shortfalls in skills or capabilities at base camps are filled through tenant units, augmentation reachback measures, or contracted support methods. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for additional information on base camps.

MAINTENANCE

1-12. Maintenance is the process of keeping facilities and infrastructure in good working condition so that they can continue functionality and good service for the community they support. Engineers review maintenance service records, conduct physical inspections, order parts, request services, and schedule repair or service maintenance of individual facilities or of the overall infrastructure.

1-13. Facility maintenance responsibility has always been a teamwork process for the following reasons:

- The commander has the overall responsibility to ensure that maintenance gets the proper attention it deserves and the adequate resources it requires. The commander leads the maintenance efforts.
- The using units or tenant units are responsible for properly maintaining their own facilities. Because they use the facilities on a daily basis, they are responsible for performing routine upkeep and for reporting facility maintenance issues beyond their repair capabilities.
- Engineers are responsible for assisting in facility maintenance areas that are beyond the training and expertise of tenant units. This includes providing engineer expertise and resources to resolve facility maintenance issues and bringing in external specialized engineering services. Engineers can conduct facility assessments, inspections, services, maintenance, and repair.

1-14. This manual discusses the maintenance of completed general engineering projects and engineer-specific equipment and systems. Maintenance and repair tasks are also often grouped together but are sometimes separated in this manual because engineers may be responsible for repairing some things that they are not responsible for maintaining, such as a finished well that has been turned over to a sustainment/logistics unit for O&M.

1-15. The life cycle activities of O&M are discussed within the chapters of this manual for each specific area. This manual discusses specific O&M requirements for construction, seaports, airfields, heliports, roads, railroads, bridges, base camps, real estate, power systems, and water production.

TRANSFER AND CLOSURE

1-16. All or part of the facilities may be transferred, destroyed, abandoned, or closed. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for a discussion on the transfer and closure of base camps.

1-17. The combatant commander (CCDR) develops policies and procedures for transfer and closure as part of the theater-based strategy. General engineering supports the overall plan to transfer or close facilities. Engineers have specific procedures to transfer individual projects or facilities, such as bridges or drilled wells. Transfer and closure has documentation requirements to maintain and archive records and documents. The planned end state for each facility is considered during each general engineering life-cycle activity.

EMPLOYMENT CONSIDERATIONS

1-18. *General engineering* consists of those engineering capabilities and activities, other than combat engineering, that modify, maintain, or protect the physical environment (JP 3-34). General engineering encompasses the engineer tasks that establish and maintain the infrastructure required to conduct and sustain military operations. Examples include the construction, repair, maintenance, and operation of infrastructure, facilities, lines of communications, and bases; terrain modification and repair; and selected explosive hazard activities (see JP 3-34).

1-19. This manual serves as the primary reference for planning and executing general engineering as an engineer function at the Marine Corps level and as an engineer discipline at the Army level. It is directly linked to ADP 3-0, FM 3-34, JP 3-34, and MCWP 3-34.

1-20. General engineering is the most diverse of the three interrelated engineer functions and is usually the largest percentage of all engineer support provided to an operation. General engineering missions are typically performed in a joint, interagency, and multinational environment. Besides occurring throughout the area of operations at all levels of warfare and aside from being executed during every type of military operation, general engineering may employ many of the engineer military occupational specialties within the Army and Marine Corps.

1-21. General Engineering units are organized and equipped to respond to requirements. Engineer units with a general engineering mission must be trained and prepared to integrate engineer disciplines or functions to support the maneuver commander. They must also be able to use and integrate geospatial products into their operations and be capable of conducting limited combat engineering functions to facilitate the construction mission. General engineers must be technically and tactically proficient to conduct tasks under all threat conditions. They must also be well trained in small-unit tactics, including convoy security, work site security, and limited offensive operations.

1-22. General engineering includes—

- Constructing or repairing existing logistics support facilities, supply and LOC routes (including bridges and roads), airfields, ports, water wells, power systems, water and fuel pipelines, base camps, and force bed-down facilities. Firefighting and engineer diving may be critical enablers to these tasks.
- Conducting engineer tasks through a modified table of organization and equipment or through the United States Army Corps of Engineers (USACE).
- Conducting engineer tasks by using a combination of joint engineer units, civilian contractors, HN forces, or allied engineer capabilities. As the area of operations matures, the general engineering effort may transfer to civilian contractors, such as to those who operate under the logistics civil augmentation program.
- Incorporating field force engineering to leverage its capabilities. This includes linkages that facilitate engineer reachback.
- Requiring various engineer reconnaissance measures and assessments to be performed before, or early on in, a particular mission. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4).
- Supporting disaster preparedness planning, response, and DSCA. See ADP 3-28 for more information about DSCA.
- Acquiring and disposing of real estate and real property.
- Supporting the engineer protection planning and construction tasks that are not considered survivability tasks under combat engineering.
- Conducting camouflage, concealment, and deception tasks. See ATP 3-37.34/MCTP 3-34C.
- Performing environmental support engineering missions.
- Conducting base or area denial missions.
- Obtaining large quantities of construction materials, which must be planned and provided for in a timely manner.

- Producing construction materials.
- Integrating environmental considerations. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) for environmental considerations related to general engineering.
- Clearing areas of unexploded explosive ordnance and landmines before executing general engineering tasks if area clearance capabilities are not available.
- Reducing obstacles in an unopposed or nonhostile environment.

GENERAL ENGINEERING SUPPORT

1-23. General engineering supports combat engineering (including mobility and countermobility); enhances protection (including survivability); enables force projection and sustainment/logistics; builds partner capacities; and develops, maintains, and restores infrastructure. General engineering also supports theater level sustainment/logistics.

COMBAT ENGINEER SUPPORT

1-24. *Countermobility* is a set of combined arms activities that use or enhance the effects of natural and man-made obstacles to prevent the enemy freedom of movement and maneuver (ATP 3-90.8/MCTP 3-34B). See ATP 3-90.8/MCTP 3-34B for more information about countermobility. General engineering may enhance combat engineering effort, but general engineering normally supports countermobility with earthwork and timber construction in the support or sustainment area for operational area security and survivability. See ATP 3-90.8/MCTP 3-34B, FM 3-34, and JP 3-34 for additional information on countermobility.

1-25. General engineering support to combat engineering efforts is not limited to countermobility. If combat engineering assets are completely committed or if requirements exceed combat engineering capabilities and the situation requires augmentation or greater engineer support, general engineers may be tasked to assist with mobility for units or be assigned other general support tasks. However, the primary focus of general engineering is to develop infrastructure to support mobility, force projection, sustainment/logistics, base camps, force bed-down facilities, stability operations, and DSCA.

FORCE PROTECTION

1-26. General engineering enhances protected sites through the planning, design, construction, maintenance, and hardening of facilities for—

- Area security.
- Antiterrorism measures.
- Survivability.
- Detainees and dislocated civilian areas.

FORCE PROJECTION

1-27. General engineering enables shaping by the planning, design, and construction to deploy forces. This includes peacetime and contingency locations, intermediate staging bases, support accesses, and force bed-down facilities.

SUSTAINMENT/LOGISTICS

1-28. General engineering enables sustainment/logistics by the planning, design, construction, maintenance, and repair of LOCs, base camps, and bed-down facilities. LOCs support logistics but are not incorporated into this consideration area of sustainment/logistics.

PARTNER CAPACITY

1-29. General engineering builds partner capacity by training and developing local leaders and engineer assets and by involving the local community. General engineers develop partner infrastructure and perform tasks alongside partner engineers to develop technical and tactical engineer capacities.

1-30. Engineer partnerships can be local, national, joint, interagency, or multinational based on the mutual cooperation to achieve common engineering goals and purposes. Partnerships can be beneficial in sharing construction efforts, ideas, or techniques, which leads to overall improvements. An example of building capacity is USACE assistance with a water resource study and engineer unit completion of water infrastructure projects with HN involvement.

1-31. General engineers may be involved in building partner capacity in the development of infrastructure. Engineers combine the capabilities of all three disciplines (combat, general, and geospatial engineering) to build partner capacity and develop infrastructure, which is vital to stability and counterinsurgency tasks that yield the greatest return. Partner capacity building is not exclusively limited to only performing general engineering tasks; it can also include other tasks to achieve the overall purpose and desired effect. (For example, performing general engineering tasks that enable force projection and sustainment/logistics that change the manner in which the task is executed.)

1-32. The overall purpose of building partner capacity is to support the commander in improving the conditions of HN leaders, institutions, and infrastructure development capabilities and influencing them to achieve military objectives for self–defense and national self-sufficiency (political, military, economic, social, information, infrastructure, physical environment, and time). See FM 3-34 for more information on building partner capacity.

1-33. In support of building partner capacity, general engineering tasks may include—

- Building, repairing, and maintaining various infrastructure facilities.
- Providing essential services.
- Building roads to improve economic conditions using local labor resources.
- Assisting the local population in improving the quality of wastewater and drinking water systems.
- Training, educating, and developing local leaders and engineers in public works projects, including exchange programs and conferences to build stronger relations and bonds.
- Developing local engineer projects that involve the community to a greater degree, such as parks and recreational centers that improve the quality of life.
- Using geospatial engineers and USACE resources to assist in locating and mapping local water sources.
- Improving local water distribution systems, such as adding pumping stations or constructing new water wells.

INFRASTRUCTURE

1-34. General engineering develops infrastructure to support mobility, force projection, sustainment/logistics, base camps, force bed-down facilities, stability operations, and DSCA. Infrastructure support includes the construction, rehabilitation, repair, maintenance, and modification of landing strips, airfields, check points, main supply routes (MSRs), LOCs, supply installations, building structures, bridges, and other related aspects.

1-35. General engineer units (in support of infrastructure development) may also perform repair and limited reconstruction of railroads or water and waste facilities. The basic capabilities of general engineer units can be expanded by augmenting them with additional personnel, equipment, and training from specialized engineer units or other sources. Such augmentation can expand general engineer capabilities to conduct bituminous mixing and paving, quarrying and crushing, pipeline support construction, and dive support to complete major construction projects (highways, storage facilities, seaports, airfields).

1-36. Specialized engineer units also support infrastructure maintenance, improvement, and repair efforts. General engineering infrastructure capabilities can be expanded with assistance from—

- Laboratories and research centers, such as the USACE Reachback Operations Center (UROC).
- Centers of expertise (USACE, Naval Facilities Engineering Systems Command [NAVFAC], United States Army Engineer School).
- FFE.
- Technical Search and Rescue.

UNIVERSAL JOINT TASK LIST

1-37. CJCSM 3500.04F contains a hierarchical listing of tasks that are performed by a joint military force. The manual provides a common language and reference system for joint commanders, staffs, planners, combat developers, and trainers. As applied to joint training, the *Universal Joint Task List* is a key element of the requirements-based mission for task analysis. It contains strategic national and theater operational and tactical tasks. Each task contains measures of performance and criteria that support its definition.

1-38. At the tactical level, the *Universal Joint Task List* links the operational tasks to tactical tasks by requiring the Services to produce Service-specific tactical task lists. For example,—

- For the Army, this is codified in unit mission essential tasks. Although an analysis of the *Universal Joint Task List* is important, the most relevant links for general engineering tasks (since they are typically considered tactical tasks in this hierarchy) are listed on the Army Training Network website https://atn.army.mil, which outlines general engineering tasks that units may use as a source to establish their mission-essential task list and the Army tactical tasks that are subordinate to providing general engineering support. While there may be examples of general engineering tasks not listed under Army tactical tasks, the vast majority are included as subtasks.
- For the United States Marine Corps, this is codified in the Marine Corps task list–2.0. The Marine Corps task list–2.0 outlines Marine Corps general engineering and combat engineering tasks. The Marine engineers develop the mission-essential task list from these and other documents in support of the commander's assigned mission.

PRIMARY AND SUBORDINATE TASKS

1-39. General engineering primary tasks provide a construct to categorize the tasks performed during general engineering life-cycle activities. The following paragraphs include the typical subordinate tasks for each primary task.

1-40. Life cycle activities subtasks include—

- Planning.
- Design.
- Construction.
- Maintenance.

1-41. Planning and design task subtasks include—

- Determining requirements.
- Determining standards.
- Developing options.
- Conducting engineering reconnaissance.
- Performing site reconnaissance and site selection.
- Producing site layout.
- Performing economic analysis.
- Recommending priorities, including engineer effort, construction material allocation, and contractor support.
- Performing master planning.
- Performing program and project management.

1-42. Construction support subtasks include—

- Performing construction planning and estimating.
- Performing project management.
- Procuring construction materials.
- Producing construction materials.
- Performing construction techniques.
- Performing contract construction management.

1-43. LOC task subtasks include—

- Constructing and maintaining seaports of debarkation.
- Constructing and maintaining airfields and heliports.
- Constructing and maintaining roads and railroads.
- Constructing and maintaining bridges.

1-44. Base camp and force bed-down facilities task subtasks include—

- Performing bed-down development planning.
- Performing base camp development planning.
- Performing planning and facilities design.
- Modifying existing facilities.
- Conducting site selection and layout.
- Constructing base camps.
- Providing force bed-down facilities.
- Performing facilities O&M.

1-45. Real estate and real property maintenance activities task subtasks include—

- Acquiring real estate.
- Managing real estate.
- Managing utilities.
- Transferring real estate and real property.

1-46. Power system support task subtasks include—

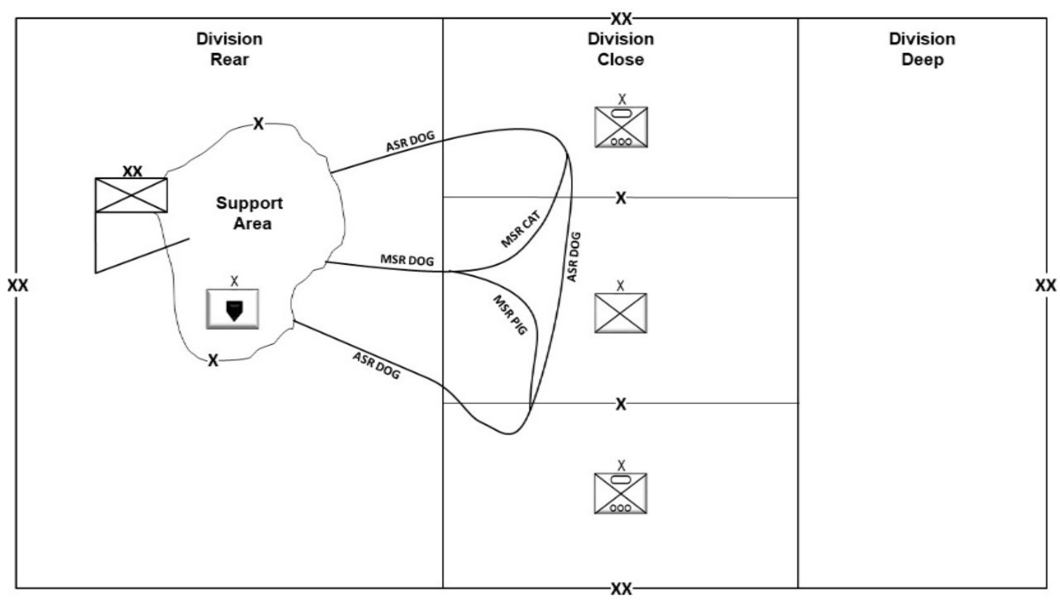
- Assessing power system requirements.
- Planning and designing power systems.
- Constructing, installing, and connecting power systems.
- Operating and maintaining power systems.
- Expanding or deconstructing power systems.
- Providing base closure support.

1-47. Water production and distribution task subtasks include—

- Performing water planning and design.
- Supporting field water supply.
- Performing water detection.
- Conducting well-drilling.
- Supporting water production and distribution.
- Installing and maintaining potable water and sanitary sewage piping systems.
- (USMC) Conducting reconnaissance to identify sources of water and to calculate the quality and quantity of water at each location surveyed.

General Engineering In Contiguous and Noncontiguous Areas

1-48. Commanders visualize the concept of operations and describe their intent in the area of operations in spatial terms of deep, close, support, and rear areas. These terms are more useful to general engineers when such operations are contiguous and against a clearly defined symmetric enemy force. The operational environment may seldom allow the commander the luxury of describing the area of operations in such terms. Figure 1-1 graphically describes a possible means by which the commander may visualize a contiguous area of operations.



Legend:
ASR alternate supply route
MSR main supply route

Figure 1-1. Contiguous areas

1-49. The concept of contiguous and noncontiguous operations includes the following:

- A contiguous area of operations is where all of a commander's subordinate forces' areas of operations share one or more common boundaries (see FM 3-90-1). Because they share some boundaries, units can more easily pool resources together and plan a common defense.
- A noncontiguous area of operations is where one or more of the commander's subordinate force's areas of operation do not share a common boundary (see FM 3-90-1). This makes it difficult to acquire, distribute, and share resources and plan a common defense due to geographic distance or separation.
- The Navy/Marine Corps concepts of Distributed Maritime Operations and Expeditionary Advanced Base Operations are the naval equivalent of noncontiguous areas of operations operational area framework.

1-50. The combination of contiguous and noncontiguous operations impacts the planning and execution of general engineering tasks for the following reasons:

- In a contiguous area of operations, tasks are typically performed to the rear of division boundaries by engineer units assigned to higher echelon headquarters.
- In a less contiguous area of operations, general engineering tasks are required in forward areas in proximity to combat units. Because some general engineering equipment is not organic to the brigade combat team (BCT), the BCT is normally augmented with the necessary engineer capacity to perform tasks within the BCT area of operations. The types of general engineering capabilities that augment the BCT depend on the types of missions to be accomplished and their availability. Selected general engineering tasks may need to be performed by combat engineers. See FM 3-90-1, JP 3-0, and JP 3-34 for additional information on contiguous and noncontiguous operations.

1-51. The impact of the noncontiguous battlefield on general engineering tasks is numerous and includes increased—

- **Work site security.** Because units perform general engineering near forward elements, contact with the enemy is much more likely. Units performing general engineering tasks also maintain individual and collective protection tasks to provide for their own defense against such threats. Engineer units performing general engineering tasks require local security because they have insufficient personnel and weapons systems to perform their assigned tasks and secure work sites.
- **General and local work site security.** During contiguous operations, units receive general security from forward maneuver units. Local security is performed by internal assets. On the noncontiguous battlefield, units face the same threat level as maneuver units operating in the area of operations. In addition, there is the loss of ability to mass when attached or placed in direct support.
- **Numbers and lengths of LOCs and MSRs.** Noncontiguous areas create a dilemma for the construction and maintenance of LOCs and MSRs due to security and, typically, greater distances. Engineer planners can expect smaller-size units to be spread over greater geographic distances than during contiguous operations. Increased personnel security along those routes is needed, and greater convoy security measures are required.
- **Facility construction efforts.** Units operate with more autonomy within their own area of operations and require facilities for deployment, supply, maintenance, and other sustainment/combat service support activities.
- **Combat engineer units performing general engineer tasks.** Maneuver commanders at BCT, battalion landing team (BLT), and higher levels must be able to task organic or assigned combat engineer elements to conduct selected general engineer tasks. However, Marine engineers are task-organized and can have different command relationships than other services. BLTs do not have organic engineer units but are normally designated engineer units in direct and general support relationships. Some tasks can be performed without augmentation. A conscious trade-off of potential combat engineering tasks being performed must precede a commander's decision to have these tasks executed. Selected additional general engineer tasks can be performed by combat engineer units when they receive additional specialized equipment and expertise. However, combat engineers cannot perform all general engineer tasks.
- **General engineer task-organization at lower echelons.** Because of the great distances involved in a noncontiguous area of operations and the impact on the geographical span of control, engineer commanders may not be able to effectively provide general engineering in a manner that is responsive to a commander's needs without decentralization of authority. General engineer capabilities are most effective when in a direct support or attached command support relationship.

GENERAL ENGINEERING PRINCIPLES

1-52. In an effort to improve effectiveness, achieve greater efficiency, and retain best practices, engineers employ principles to aid them in their profession. These are retained due to their continuing importance, relevance, and value. A principle is a comprehensive and fundamental law or an assumption of central importance that describes how an organization or function approaches the conduct of operations. Principles are considerations that should guide the employment of an organization or function.

1-53. General engineering tasks are guided by the principles of—

- Sustainability.
- Scalability.
- Modularity.
- Standardization.

Sustainability

1-54. Sustainability is related to solutions that may be a facility, service, technique, or procedure. Sustainability helps to achieve increased effectiveness through increased operational efficiencies, reduced logistics requirements and, ultimately, reduced costs.

1-55. General engineering tasks pursue a goal of delivering effective, resilient, sustainable, and efficient solutions. There is a balance between efficiency and effectiveness. Sometimes operational requirements allow the balance to shift to increased efficiency. At other times, operational requirements shift the balance toward increased effectiveness, regardless of efficiency. When conditions permit, sustainable design and construction practices are considered in all solutions.

1-56. Sustainability is integrated and supported by—

- Applying sustainable design, construction, and O&M practices.
- Developing cost-effective solutions by using available resources to produce desired results.
- Developing more efficient solutions that reduce the consumption of resources (energy, water, labor, equipment, time, materials, money).
- Reducing demands on sustainment/combat service support systems.
- Reducing energy consumption by reducing demand, enhancing efficiencies, and using renewable energy sources.
- Developing sustainable facilities and infrastructures. (Reduce, recycle, and reuse waste with solutions that are simple and inexpensive to operate, maintain, and repair.)
- Developing initial life cycle planning cost estimates and economic analysis.

Notes.

1. See Unified Facilities Criteria (UFC) 1-200-02 for additional information on sustainable building requirements development.

2. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for more information on sustainable base camps.

3. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) for more information on sustainable environmental considerations.

Scalability

1-57. Scalable solutions enable general engineering projects to expand or contract to meet changing requirements without the need to redesign. Scalable solutions remain efficient and practical when applied to a larger or smaller requirement.

1-58. The use of modular and multifunctional designs and systems contributes to scalability. Some comprehensive, scalable solutions are integrated and developed at the joint and Service level.

Modularity

1-59. Modular solutions complement scalability and may be scalable without being modular. Modularity is the degree to which system components may be separated or recombined. For example, most military LOC bridge systems are modular. The use of modular systems and prefabricated or pre-engineered components is maximized to facilitate rapid development and achieve scalability when large projects or systems combine smaller subprojects or smaller systems.

1-60. Modular construction techniques use standard materials and component sizes to build a single structure or mass-produce components of the structure for quicker assembly. The use of modular construction techniques does not ensure that the design is scalable.

Standardization

1-61. Standardizing plans, designs, and construction methods or techniques simplifies maintenance and repair. Standardization—

- Reduces uncertainty in meeting mandatory requirements and provides for more accurate estimates of materials, schedules, and costs.
- Helps to improve and sustain proficiency and readiness through the universal application of approved practices and procedures.
- Reduces the adverse effects of personnel turbulence associated with reassignments and facilitates interoperability between different organizations.
- Uses standardized, scalable, and adaptable designs and construction methods.
- Simplifies construction programming activities, improves early planning techniques, and provides consistency in solution deliveries.
- Uses standard solutions for one set of requirements that can be modified or adapted to meet similar requirements.
- Reduces costs and inventory requirements without having to maintain large inventories of diverse parts or equipment.
- Increases sustainability.
- Seeks to standardize Service construction standards to provide commanders with consistent expectations and the use of proven best practices and tactics, techniques, and procedures. (A standard solution may not always be the best solution to meet unique requirements.)

1-62. An example of standardization is the development of the UFC. This is a Department of Defense (DOD)-developed standardized facility planning, design, construction, and O&M criteria system for use by all Service components. The Joint Construction Management System (JCMS) contains standardized criteria used to construct a variety of buildings.

Other Key Considerations

1-63. There are other key considerations for executing general engineering tasks. These include—

- Speed.
- Economy.
- Flexibility.
- Decentralized authority.
- Establishing priorities.

1-64. Effective proactive planning and engineer initiative combine to accomplish challenges inherent in each of the considerations. These considerations are discussed in the following paragraphs.

Speed

1-65. Speed is fundamental to all activities. Construction tasks tend to be resource-intensive for time, materials, labor, and equipment. Planning and prioritization are essential to achieve the desired effect. Key practices that best support speed include—

- **Prior planning**. Speed is a relative term if the planning before the operation did not set the conditions for facilitating real speed in terms of mission completion. Speed requires effective, broad, inclusive, proactive, and synchronized planning across all staff sections and engineer capabilities.
- **Use of existing facilities.** Engineer units must rapidly provide facilities that enable forces to deliver maximum combat power. The use of existing facilities greatly contributes to achieving speed by eliminating unnecessary construction support. The use of existing ports, pipelines, warehouses, airfields, and roads during operations is critical. Commanders and staffs must be capable of planning and conducting real estate and real property acquisition to facilitate this effort. Often, the joint force commander (JFC) must effectively negotiate with the host government for

HN support to use existing facilities. In mature theaters, such as the Republic of Korea, status of forces agreements may dictate procedures for using existing facilities.

- **Standardization.** Standard materials and plans save time and construction efforts and permit the streamlining of production line methods, including the prefabrication of structural members. Standardized assembly and erecting procedures increase work crew efficiency by reducing the number of methods and techniques required. This supports simplicity. Standardization between Service engineers is essential for successful interoperability. For contracted construction, design build enables standardization and streamlines resourcing and process.
- **Simplification.** The simplicity of design and construction reduces requirements when faced with limited labor resources, materials, and time allowances. When scarce resources are available, simple methods and materials allow installation in a minimum amount of time. This may also allow HN supplies and labor use to support construction.
- **Bare-bones construction**. Military construction is characterized by using the minimum necessities when possible. The theater commander typically makes the decision on construction standards early in the planning process.
- **Phased construction.** Phased construction allows for the rapid completion of critical components of buildings or installations and uses these components for their intended purpose. Engineers primarily use standardized time-phased automated planning tools to plan, track progress, and visualize project progress.

Economy

1-66. General engineering requires the efficient use of personnel, equipment, and materials. To most effectively accomplish the tasks assigned to engineers, it is necessary for commanders to carefully consider augmentation requirements. Therefore, it is imperative that the proper assets be allocated from the engineer force pool when task-organizing engineers. Proactive planning is the first step in the application of economy. Other considerations include—

- **Conserving labor**. Construction tasks are time-consuming, and engineer commanders must address skilled and unskilled labor shortages. Laborers must be conserved, and every skilled engineer capability must function at the peak of their efficiency to accomplish the mission. Careful planning and coordination of personnel are necessary. Missions must be well organized and supervised, and personnel must be carefully allocated for the task. Select tasks can be performed by combat engineers or other general laborers but require a conscious decision by the commander to trade off to further general engineering tasks.
- **Conserving equipment.** Military construction equipment might be in short supply, particularly at the beginning of contingency operations. Also, the operational readiness of equipment may be impaired by shortages in repair parts and maintenance personnel. Contracting for local equipment and repair parts to alleviate shortages is a way to remedy this issue. However, contracting for locally sourced equipment can take 60 days or more from bidding to awarding of the contract. Preventive maintenance of equipment is essential to ensure the availability of long-term use. Commanders must ensure that time is allocated for scheduled preventative maintenance checks and services to maximize equipment availability.
- **Conserving materials.** The critical aspect of completing a task is often the availability of appropriate materials. Although planners should maximize the use of local resources in their area of responsibility (AOR), these resources may not be available or may be in short supply. Planners must anticipate shipping materials from outside the area of operations, which may require longer transit times. The conservation of materials while executing tasks is an essential consideration.

- **Evaluating environmental factors.** Apply environmental considerations early in the process. While some situations require putting aside risk associated with environmental considerations, the earlier the risk is mitigated, the easier and less complex mitigation procedures will need to be to be employed later. As the staff proponent for environmental issues, engineers must analyze environmental considerations and recommend appropriate courses of action (COAs) to the commander. If an environmental baseline survey (EBS) and an occupational and environmental health site assessment (OESHA) are required, ensure that they are performed early in the process. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) and NTRP 4-02.9/AFTTP 3-2.82_IP/ATP 4-02.82 for more information on environmental forms and evaluation procedures.
- **Evaluating financial factors.** The types of funding and financial considerations involved are identified in FM 3-34, JP 3-34, and MCWP 3-34. Identifying appropriate funding sources and properly using funding resources are important economic applications.

Flexibility

1-67. Units must be flexible enough to rapidly transition from all types of operations, and engineers must be agile in applying the general engineering principle of flexibility to facilitate this transition. To meet this requirement, use standard plans that allow for adjustment, expansion, and contraction when possible. For example, a standard building plan may be easily adapted for use as an office, barracks, hospital ward, or dining facility. Forward airfields should be designed and located so that they can later be expanded into more robust facilities that are capable of handling larger aircraft and a larger maximum (aircraft) on ground (MOG) capacity. Standardization enhances flexibility.

1-68. Flexibility facilitates versatility between Service engineers and within engineer organizations to accomplish tasks. This includes providing selected technical expertise and equipment to a variety of engineer organizations to perform general engineering missions that they are not specifically designed for or organized to perform. Mission command is an approach to command and control that empowers engineer leaders and decentralized execution appropriate to the situation. It capitalizes on subordinate ingenuity, innovation, and decision-making to achieve the commander's intent during ambiguous situations (see ADP 6-0). Engineer units must take a mission command approach and display a multifunctional ability when performing engineer tasks outside their mission-essential task list. An example is using combat engineer organized units tasked to perform selected general engineering tasks. However, this type of decision requires a risk analysis and higher echelon commander approval. This ensures that the engineers are not removed from performing other, more critical missions in supporting movement and maneuver for BCTs and other combat forces.

1-69. The basic deployability of engineer organizations and their designed modularity is due to the enablers of flexibility and command and control. Engineers must be ready to send only those assets specifically required to perform a mission. They must establish functional, high-performing teams from a variety of Army engineer units while maximizing capabilities from multi-Service engineer organizations. The integration of commercial engineer equipment and the flexibility of command-and-control systems must be able to support subordinate decision-making and decentralized execution.

Decentralization of Authority

1-70. The wide dispersion of forces in the area of operations requires decentralizing engineer authority as much as possible. The engineer commander or engineer staff officer responsible for operations at a particular location must be granted authority that is consistent with responsibilities. As previously noted, this is particularly important in noncontiguous areas.

1-71. The decentralization of authority requires effective command and control, normally employing mission command and flexibility of its application to integrate the variety of engineer capabilities and accomplish selected general engineering tasks or missions. Service engineers must strive for seamless integration between units and capabilities to meet joint or component commander needs.

Priority Establishment

1-72. A lack of resources (planning and design capability and capacity, funding, equipment, personnel, systems, logistics) severely impedes the commander from executing necessary general engineering tasks concurrently. Therefore, careful prioritization must occur. It is essential to establish priorities to determine how much general engineer effort must be devoted to a single task. While detailed mission orders for the priority systems are usually the concern of lower echelon commands, all levels (beginning with the JFC, Army Service component command [ASCC], and Marine Corps component commands [MCCCs]) must issue directives that establish broad system priorities to serve as guides for implementation. Resources are initially assigned only to the highest-priority tasks. Low-priority tasks are left undone, while recognizing and assessing the risk of doing so. At the theater level, planners can assume general priorities for initial phases of an operation and refine the priorities as the planning effort matures. Project approval processes and acquisition review boards ensure an equitable distribution of resources according to established priorities.

1-73. (USMC) Computers can be used to manage the collaborative activities related to prioritizing and approving general engineer projects. Electronic collaboration can be very beneficial, especially when units are operating in a noncontiguous or distributed manner. Ideally, business rules for managing general engineer projects should be included in an organizational SOP. When this is not the case, these rules should be established so that units requesting engineer support—and units capable of fulfilling engineer support requests—can be connected with the engineer staff that reviews, prioritizes, and submits support requests for approval by the common senior commander. Other factors to consider in business rules include standard formats for support requests, timelines for submission, and required documentation.

GENERAL ENGINEERING COMMAND AND SUPPORT RELATIONSHIPS

1-74. One of the most critical aspects of ensuring adequate support is assigning the proper command and support relationship to subordinate units. Engineer staff officers must carefully examine the required effort when recommending command and support relationships. See ADP 6-0, FM 3-34, and JP 3-34 for additional information on command and support relations.

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Chapter 2
General Engineering Support to Operations

This chapter discusses the general engineering support required across the competition continuum spanning the levels of warfare—from the theater and operational level to the tactical level. It also discusses how general engineering supports offensive, defensive, and stability operations and DSCA tasks. Engineers are considered to be a force multiplier and are employed by the commander to maximize their capabilities in enhancing operations. Engineers play a key role in contributing to the support of military operations.

COMPETITION CONTINUUM

2-1. Commanders use engineers to support mobility, enhance protection, enable force projection and sustainment/logistics, build partner capacity, and develop and maintain infrastructure. General engineering is the engineering capabilities and activities (other than combat engineering) that modify, maintain, and protect the physical environment. It is primarily focused on affecting terrain and may include support to the range of military operations in the homeland and abroad.

2-2. General engineering occurs throughout the area of operations at all levels of warfare during every type of military operation and may include the employment of DOD Civilians, USACE, contractors, HN forces, and multinational engineers. Army general engineering organizational capabilities are discussed in ATP 3-34.22 and FM 3-34. Marine Corps organizational capabilities are discussed in MCWP 3-34.

2-3. General engineering tasks may occur simultaneously at different levels and may support multiple operations. The purpose, priority, effort, and timeline to complete a task may be changed significantly based on a change in priority of the primary operation it supports or based on a change in the strategic, operational, or tactical situation.

2-4. The Army has specialized engineer units that are normally employed at the theater or operational levels and that augment capabilities at the tactical level. Most of the specialized engineer units are teams or sections that require support from the supported unit. These specialized units may provide limited support, in quantity and duration, at the tactical level without sustainment/combat service support.

2-5. General and combat engineers perform engineering tasks at different levels. For example, general engineers typically perform mobility at the operational level, while combat engineers focus on mobility at the tactical level. Likewise, survivability (see ATP 3-37.34/MCTP 3-34C) is supported by general engineers at the operational level, while combat engineers support survivability at the tactical level.

2-6. The general engineer effort at the theater or operational level is coordinated and synchronized with tactical level combat. At the operational level, general engineer activities are not normally conducted as part of a combined arms mission because of the inherent nature of direct-fire potential with the enemy. All tasks are coordinated with the maneuver commander responsible for the area of operations.

2-7. General engineer units may follow and support combat engineers as they transfer bridges, roads, bypasses, or forward tactical airfields to allow forward movement with maneuver units. These tactical efforts may then become operational efforts that have to be maintained or upgraded. For example, in some situations, tactical trails may become roads, and those roads may be upgraded to MSRs. To reduce the construction effort, it is more likely that existing roads would be upgraded.

STRATEGIC, THEATER, AND OPERATIONAL LEVELS

2-8. General engineering provides support at strategic, theater, and operational levels to enable force projection and sustainment/logistics, enhance protection, build partner capacity, and develop infrastructure. USACE typically operates at the theater level in support of national strategic objectives as the Army's defense construction agent and to provide FFE capabilities to the theater.

2-9. At the operational level, the theater engineer command (TEC) or engineer brigade planners anticipate the impact of geography, force projection infrastructure, and available general engineer units within the area of operations to support the CCDR's theater campaign plan or operational design. These planners must understand the capabilities and limitations of all available general engineer forces (including U.S., allies, HN, and contracted capabilities), prioritize limited assets, and mitigate risks. They also develop the scheme of basing and environmental assessments, request geospatial products and services, recommend survivability measures, and request the capabilities to meet requirements. As the link to tactical engineer integration, general engineer planners set the conditions for success at the tactical level by adequately anticipating requirements and by ensuring that general engineering capacity is available and requested from higher headquarters.

GENERAL ENGINEERING SUPPORT

2-10. General engineering at theater and operational levels includes support to—

- Force projection.
- Force deployment.
- Theater access.
- Assured mobility.
- Theater opening and closing.
- Infrastructure planning.
- Infrastructure development.
- Partner capacity building.
- Master planning.
- LOC.
- Base camp development.
- Base camp operation.
- Base camp maintenance and closure.
- Construction management.
- Protection.
- Logistics.

2-11. General engineer units support the offense, defense, stability, or DSCA operations at theater and operational levels. Combat engineer units may provide support at theater and operational levels if it is available or if the condition requires close support to maneuver forces that are in close combat.

2-12. General engineers may also be involved in countermobility intended to achieve operational or strategic effects. These engineering efforts focus on denying the adversary the freedom of movement and maneuver by slowing or diverting the enemy to increase target acquisition and weapons effectiveness.

2-13. Although primarily a combat engineer task, prevalently organized general engineering units may be assigned to supplement combat engineer efforts with engagement area development and survivability position construction. See ADP 3-90, ATP 3-90.8/MCTP 3-34B, FM 3-34, JP 3-34, and TM 3-34.85/MCRP 3-17A for additional information on countermobility.

FORCE PROJECTION

2-14. General engineers may be required to support force projection efforts (see ADP 4-0). *Force projection* is the ability to project the military instrument of national power from the United States or another theater, in response to requirements for military operations (JP 3-0). Force projection includes general engineering tasks that enhance area access from the strategic to the operational level and from peacetime locations to assembly areas, base camps, expeditionary advanced bases, and advanced naval bases. Tasks that support force projection may simultaneously support logistics.

ACCESS

2-15. General engineers contend with the following access types:

- Informational access to USACE resources and higher-level engineering expertise to support engagement strategies and wartime.
- Physical access, such as forcible entry into a theater.

2-16. General engineers may be required to support efforts to gain access into a theater. Engineer efforts ensure the mobility and flow of forces by establishing and securing an initial foothold, beachhead, or entry point into the theater to enable follow-on forces to continue onward penetration to the objective. Like forcible-entry, access efforts by friendly forces may be stopped and repelled by the adversary use of counterattacks, coordinated and synchronized weaponry systems, and layered obstacle systems. See ATP 3-90.4/MCTP 3-34A, FM 3-34, JP 3-18, JP 3-34, and TM 3-34.85/MCRP 3-17A for additional information on mobility.

2-17. The support to early-entry includes reconnaissance that mitigates antiaccess and area-denial mechanisms to clear and open aerial ports of debarkation and seaports of debarkation. These tasks are often considered combat engineering tasks, even though general engineer units can perform them when conditions allow (see FM 3-34). Geospatial engineers can provide high-resolution mapping to clarify situational understanding of early-entry and initial area of operations at landing sites.

2-18. During access, combat engineers usually support forcible entry and the seizure and establishment of lodgments. General engineers normally support the establishment and expansion of lodgments and bed-down facilities.

2-19. General engineering tasks in support of area access may be required to augment combat engineers to—

- Clear beaches and remove barriers and obstacles from roads, airfields, and ports.
- Construct initial combat roads and trails, wet gap crossing entry and exit ramps, LOCs, MSRs, support and LOC bridges, airfields, base camps, and ammunition and supply depots.
- Support countermobility and survivability efforts earlier in the entry to repel enemy counterattacks to recover lost land.

ASSURED MOBILITY

2-20. *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 (ATP 3-90.4/MCTP 3-34A). The assured mobility framework is enabled by the fundamentals of predict, detect, prevent, avoid, neutralize, and protect. Assured mobility is applied at strategic, operational, and tactical levels of warfare to facilitate the commander's planning and awareness for freedom to move and maneuver. Combat engineering enables tactical mobility, while general engineering enables operational mobility and supports strategic mobility. The general engineering effort is directed at providing mobility of forces—from ports of debarkation to forward areas.

2-21. The fundamentals of assured mobility and the specific linkages to general engineering are—

- **Predict.** Engineers and other planners must accurately predict potential enemy impediments to mobility by analyzing enemy tactics, techniques, procedures, capabilities, and evolutions. Prediction requires an updated understanding and awareness of the operational environment. Planners apply predict to understand the impact of enemy and military operations on the infrastructure required to maintain mobility and momentum. For example, they must predict the damage to an MSR caused by the movement of a large mechanized force over a single route.
- **Detect.** Using information collection assets, engineers and other planners identify early indicators for the location of natural and man-made obstacles, make preparations to create or emplace

obstacles, and determine potential means for obstacle creation. They also identify actual and potential obstacles and propose solutions and alternate COAs to minimize or eliminate potential effects. Planners must be aware of the effects to strategic, operational, and tactical mobility impacted by general engineering function solutions.

- **Prevent.** Engineers and other planners apply this fundamental by denying the enemy the ability to influence mobility. This is accomplished by forces acting proactively before obstacles are emplaced or activated, including executing aggressive action to destroy enemy assets and capabilities before they can be used to create obstacles. Political considerations and the rules of engagement may hinder the ability to apply this fundamental early in a contingency. Commanders apply general engineering capabilities in a timely manner to prevent mobility impediments to the force. An example of support to this fundamental is constructing a bridge bypass before a bridge becomes unusable.
- **Avoid.** If prevention fails, the commander maneuvers forces to avoid impediments to mobility if it is viable within the scheme of maneuver. General engineering is an integral part of the maneuver unit ability to avoid such impediments. Examples of tasks that support this fundamental are building roads around natural or man-made obstacles, constructing alternate airfields, and implementing other actions that allow maneuver units to operate effectively.
- **Neutralize.** Engineers and other planners plan to neutralize, reduce, or overcome obstacles and impediments as soon as possible to allow the unrestricted movement of forces. The breaching tenants and fundamentals apply to the fundamental of neutralize. An example task to support this fundamental is building a support or LOC bridge that neutralizes a river obstacle.
- **Protect.** Engineers and other elements plan and implement survivability and other protection/force protection measures that deny the enemy the ability to inflict damage on maneuver units. This includes executing countermobility missions to deny the enemy the ability to maneuver and providing protection to friendly maneuvering forces. Commanders can ensure that general engineering efforts focus on survivability support (berms, bunkers, hardened facilities, and other protective works), which is primarily centered on the hardening aspect of survivability as described in ATP 3-37.34/MCTP 3-34C.

2-22. The assured mobility construct enables a joint force to achieve the commander's intent. Assured mobility emphasizes proactive mobility and countermobility, supports survivability, and integrates engineer functions to accomplish this. Assured mobility is broader than mobility and should not be confused with the limited application of mobility as described in ATP 3-90.4/MCTP 3-34A. Assured mobility focuses on supporting the maneuver commander's ability to gain a position of advantage in relation to the enemy. This can be accomplished by conducting mobility to negate the impact of enemy obstacles, conducting countermobility to impact and shape enemy maneuver, or conducting a combination of mobility and countermobility.

2-23. Assured mobility is an integrating process related to each Army warfighting function and is similar to targeting, risk management, and intelligence preparation of the battlefield/battlespace. As an integrating process, assured mobility provides linkage between the tasks associated with mobility, countermobility, and survivability and their roles across the warfighting functions. Assured mobility applies in all operations and across the competition continuum. While it is an enabler of warfighting functions and other integrating processes, other integrating processes also enable assured mobility. The purpose of assured mobility is to ensure the freedom of maneuver, preserve combat power throughout the area of operations, and exploit superior situational understanding.

Infrastructure Development

2-24. General engineers may be required to support infrastructure development in support of force projection, theater opening, and sustainment (see ADP 4-0). Theater opening is the ability to establish and operate ports of debarkation (air, sea, and rail) to establish a distribution system and sustainment/combat service support bases. It also facilitates port throughput for the reception staging, onward movement, and integration of forces (see ADP 4-0). Engineer efforts focus on ensuring that the structural framework is in place to support a network of bases, a logistics network, a transportation network, and interconnecting service facilities to sustain forces.

2-25. General engineering tasks supporting infrastructure development may include—

- Establishing and maintaining the infrastructure necessary for supporting early-entry and follow-on forces in support of force projection and for sustaining military operations.
- Conducting master planning and design, construction, and real estate actions.
- Coordinating for environmental and geospatial support, O&M, and assessment.
- Continuing to improve, upgrade, and expand infrastructure as the theater matures and requirements increase.
- Preparing for drawdown or closure as operations change or near completion.
- Constructing seaports, airfields, bases, and mass logistics storage facilities.
- Developing water, power, and integrated waste management systems (see ADP 4-0 and JP 3-34).

PROTECTION

2-26. Army and Marine Corps forces face *hybrid threats*, which are described as the diverse and dynamic combination of regular forces, irregular forces, terrorist forces, and/or criminal elements unified to achieve mutually benefitting effects (ADP 3-0). These forces and elements can employ hostile actions to inflict serious damage on personnel, physical assets, or information. Such hostile actions pose threats to survivability requiring adequate protection of personnel and physical assets.

2-27. Survivability has two aspects: avoiding and withstanding. Avoiding can include concealment, camouflage, and dispersion. Withstanding can include construction or the hardening of protective positions. There are a variety of protective measures that can be employed. These measures are discussed in the following paragraphs.

2-28. Hostile actions usually involve the employment of weapons. ATP 3-37.34/MCTP 3-34C addresses various types of weapons effects and the design considerations to mitigate them.

2-29. Adversaries use sensors to increase the effectiveness of weapons. Sensor systems are categorized based on the component of the electromagnetic spectrum in which they operate. ATP 3-37.34/MCTP 3-34C addresses sensor systems and the principles and techniques for using camouflage and concealment to defeat them.

2-30. Concealment protective measures include the use of weather effects, battlefield dust, debris, smoke munitions, or other potential obscurants to hamper observation and target acquisition capability or to conceal activities or movement. Battlefield obscuration is typically provided by smoke grenades, generated smoke, or fires, which can conceal friendly positions and screen maneuvering forces from enemy observation. See ATP 3-11.50 for additional information on the employment of obscurants. See ATP 3-37.34/MCTP 3-34C for more information on camouflage, concealment, and decoys.

2-31. Hazards associated with the surrounding environment also pose threats. Weather conditions, natural disasters, diseases, and terrain-related hazards are common examples.

2-32. Although it is often considered to be a part of countermobility, another protective measure is the use of obstacles, which is a key enabler to ATP 3-37.34/MCTP 3-34C. Obstacles provide friendly forces with close-in protection, which enhances the effectiveness of survivability positions. See ATP 3-90.8/MCTP 3-34B for additional information on protective obstacles.

2-33. Military forces are composed of personnel and physical assets, each having their own inherent survivability qualities or capabilities that can be enhanced through various means and methods. Although units conduct survivability planning within the limits of their capabilities, the Army and Marine Corps have a broad range of diverse engineer capabilities that can enhance unit survivability, which is discussed in ATP 3-37.34/MCTP 3-34C.

2-34. General engineers may be required to support the preservation of the force so that the commander can apply maximum combat power (see ADP 3-37). Engineers possess unique equipment and personnel capabilities that can be used directly to support survivability and related protection efforts. General engineer support to protection and survivability continues as improvements are continuously reassessed and additional assets are made available. See ADP 3-37, ATP 3-37.34/MCTP 3-34C, ATP 3-90.8/MCTP 3-34B, FM 3-34, JP 3-15, JP 3-34, TM 3-34.30, and TM 3-34.85/MCRP 3-17A.

2-35. At the operational level, general engineer support is continuously conducted to harden and prepare positions for facilities and installations. Engineers possess unique equipment and personnel capabilities that can be used directly to support survivability and related protection efforts.

2-36. General engineer tasks in support of protection may include—

- Constructing field fortifications.
- Hardening critical infrastructure and facilities.
- Preparing protective positions.
- Emplacing protective obstacles around critical fixed sites, such as base camps and sustainment sites.
- Conducting signature management.

2-37. Tasks supporting protection tend to be equipment- and manual labor-intensive and may require the use of equipment timelines to optimize the use of low-density, critical equipment.

SUSTAINMENT/LOGISTICS

2-38. General engineering capabilities are often required to support sustainment (see ADP 4-0). Engineer efforts help ensure the continuous and uninterrupted flow of material, equipment, and supplies to the force. Engineers can combine all three disciplines to establish and maintain the infrastructure necessary for sustaining logistics in the area of operations.

2-39. Tasks supporting sustainment/logistics may include—

- Building, repairing, and maintaining roads, bridges, airfields, ammunition supply points, warehouses, supply points, maintenance facilities, waste management facilities, and open structures for aerial ports of debarkation, seaports of debarkation, MSRs, base camps, and (USMC) expeditionary advanced bases and advanced naval bases.
- Expanding the infrastructure base to accommodate increased logistics demands. Such tasks can include constructing larger storage facilities, enlarging seaports and airfields, and upgrading the transportation network (such as strengthening and widening roads and improving bridges) to accommodate increased volume and logistics traffic flow.
- Planning, acquiring, managing, and remediating real estate.
- Providing power system support, waste management support, environmental support, and firefighting support.
- Supporting joint logistics over-the-shore (JLOTS), force projection, or access (see FM 3-34 and JP 3-34 for more information on engineer support).

TACTICAL LEVEL

2-40. General engineering does not provide close support to maneuver forces that are in close combat and provides less direct support to offensive and defensive operations. General engineer support tasks to the offense and defense are mostly at the operational level, but they can accomplish tactical-level tasks that exceed the combat engineer force capability. General engineering may provide more support to defense in the rear area and provide significant support to stability and DSCA. General engineering also supports protection/force protection and logistics at the tactical level. See ADP 3-0, ADP 3-07, ADP 3-90, FM 3-34, and JP 3-34 for additional information. Marine Corps general engineering units can support distributed maritime operations from expeditionary advanced bases or advanced naval bases.

OFFENSIVE

2-41. The main offensive focus is using engineer support for movement and maneuver. General engineer support is primarily focused on the tasks that support mobility. The general engineer function reinforces combat engineering, enables logistics, and develops infrastructure. Enabling sustainment/combat service support includes the creation and sustainment of LOCs and bed-down facilities.

2-42. General engineer tasks that support the offense include—
- Supporting theater access (seaports, airfields, bed-down facilities).
- Supporting mobility.
- Constructing and repairing bridges.
- Constructing and repairing roads, airfields, and heliports that support the mobility of the maneuver force.
- Conducting earthmoving.
- Conducting engineer reconnaissance.
- Conducting area damage control that supports the mobility of the maneuver force.
- Constructing facilities for detainees, enemy prisoners of war and dislocated civilians.

DEFENSIVE

2-43. The primary defensive focus is using engineer support to enhance movement and protection. The general engineer function reinforces combat engineering and enables protection. Countermobility tasks are dominant, but some support to mobility may be provided to ensure the ability of forces to freely move and maneuver. The engineer primary protection task is support to survivability. (Countermobility and combined arms obstacle integration are discussed in ATP 3-90.8/MCTP 3-34B and JP 3-15. Protection is discussed in ADP 3-37. Survivability is discussed in ATP 3-37.34/MCTP 3-34C.

2-44. General engineer tasks that support the defense include—
- Constructing entry control points.
- Erecting barriers to deny access to fixed sites.
- Providing area damage control and assessments.
- Supporting survivability.
- Hardening facilities.
- Constructing sustainment sites.
- Constructing decontamination sites.

2-45. Horizontal and vertical engineer units will likely conduct combat engineering tasks to support the defense during large-scale combat operations. Additional security must be provided if tactical conditions do not exceed their capability to protect themselves (see ADP 3-90 and FM 3-90-1).

2-46. Engineer planners should use their knowledge of the conditions in a specific area of operations to predict and estimate the level of effort by examining the condition of the infrastructure (ports, roads, bridges, airfields, utilities). An assessment of the physical environment (including environmental considerations affecting the mission) assists in determining the scope, level, and type of general engineer requirements.

STABILITY

2-47. General engineers may be required to support stability operations. See ADP 3-07, JP 3-07, and MCIP 3-03.1i/NWP 3-07/COMDTINST M3120.11 for more information on stability. Stability tasks are conducted as part of operations outside of the United States, in coordination with other instruments of national power, to maintain or reestablish a safe and secure environment and to provide essential government services, emergency infrastructure reconstruction, and humanitarian relief.

2-48. The primary stability focus is using engineer support to stabilize a region by improving the infrastructure and integrating with and supporting other forces in their missions. Maritime force engineers (Marines and Seabees) are capable of performing emergency repair of maritime infrastructure under varying conditions of instability. These engineers may embark in amphibious ships or be airlifted to locations (see MCIP 3-03.1i/NWP 3-07/COMDTINST M3120.11). Most overall engineer effort during a stability operation is likely to be through the general engineering function.

2-49. General engineering tasks may support all stability tasks, but they are not only associated with stability. The purpose, desired effect, and conditions for the task may differ in stability, which may affect how the task is accomplished. For example, a task to support stability may be accomplished with the involvement of more HN participation.

2-50. In addition to their normal support of U.S. forces, general engineering tasks primarily focus on the reconstruction or establishment of services that support the population in conjunction with civilian agencies. Engineers conducting missions provide resources to assist in disaster or theater response in areas outside U.S. territory. Rapid and effectively emplaced sustainment/combat service support can reduce human injuries and fatalities and harden infrastructure.

2-51. General engineer support for the restoration of essential services and infrastructure development is the primary engineer focus in stability operations. Essential services for engineer considerations include food and water, emergency shelter, and infrastructure assessment. The infrastructure assessment is normally conducted by a core team of engineering specialties that integrate expertise in—and equipment with—other technical specialties (medical, CA, military police) to enhance the quality and completeness of the survey. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) for a full discussion of infrastructure reconnaissance. General engineering tasks may also support the movement of civilian populations.

2-52. General engineering support may be necessary for sustainment/combat service support units conducting stability operations. Stability operations tend to have a longer duration than offensive and defensive operations. See ADP 3-07 and FM 3-07 for additional information on stability. As such, the level of effort is very high at the onset and gradually decreases as the theater matures. As the area of operations matures, the general engineering effort normally transfers to civilian contractors, such as to those who operate under a logistics civil augmentation program. Given the nature of stability, the risks associated with environmental hazards may have greater importance and impact in stability than in offensive or defensive operations.

2-53. Support to stability is primarily focused on tasks to build partner capacity; build infrastructure; and assure mobility, sustainment/combat service support, and protection. Countermobility and survivability are dominant, but some support to mobility may be provided to ensure the ability of forces to freely move and maneuver.

2-54. General engineer tasks that support stability may include—

- Conducting infrastructure reconnaissance (survey and assessment).
- Providing infrastructure development (reconstructing or establishing infrastructure to provide essential services that support the population, developing HN capability and capacity, providing water resources).
- Constructing base camps and force bed-down facilities.
- Constructing survivability positions and other force protection support.
- Constructing support area facilities.
- Providing infrastructure support, including utilities and other essential services.
- Providing reliable electrical power.
- Providing LOC construction, maintenance, and repair.
- Conducting an *Environmental Baseline Survey* (DD Form 2993).

2-55. General engineering support to countermobility includes tasks such as traffic or population control. Entry control facilities may be required at base camps or support facilities.

2-56. Stability operations may include humanitarian and civic assistance. Army and Marine forces act as part of a joint force with the United States country team and the United States Agency for International Development.

2-57. General engineers may be required to provide support to Special Forces (see FM 3-34, JP 3-0, and JP 3-34). Such tasks could be diverse and range from military engagements to large-scale combat operations. They could also include training others in demining techniques, providing technical capabilities to restore essential services, and providing infrastructure reconstruction and humanitarian relief to demonstrate U.S. commitment.

HOMELAND DEFENSE

2-58. The military will continue to play a vital role in securing the homeland through the execution of homeland defense. General engineers must be prepared to provide the required effort and resources when necessary.

2-59. *Homeland defense* is the protection of United States sovereignty, territory, domestic population, and critical infrastructure against external threats and aggression or other threats as directed by the President (JP 3-27). DOD is the lead for these missions.

2-60. The strategy for homeland defense necessitates securing the United States from attack through an active, layered defense. DOD engineering capabilities, coupled with the commercial sector or with contractor capabilities, can provide extensive, in-depth engineering for homeland defense (see JP 3-27). Massive national general engineer support may be garnered from local, state, and federal resources via a multitude of avenues or agreements.

2-61. General engineers may be required to augment national efforts in homeland defense. Engineer support could be directed toward offensive and defensive operations if supporting homeland defense. See JP 3-27 for additional information on homeland security. See JP 3-26 for more information on the overarching homeland security framework.

2-62. Homeland defense and DSCA are separate mission sets with different leads. See JP 3-28 for a review of the relationship between homeland defense, homeland security, and DSCA.

DEFENSE SUPPORT OF CIVIL AUTHORITIES

2-63. During a major crisis or severe disaster, the military and DOD may be required to rapidly respond to requests for assistance from civil authorities. These requests may include domestic emergency support, law enforcement support, domestic activity support, or support from qualifying entities for special events. In a DSCA scenario, civil authorities are the lead for the missions while the military is in a support role.

2-64. *Defense support of civil authorities* is support provided by United States Federal military forces, DOD civilians, DOD contract personnel, DOD Component assets, and National Guard forces (when the Secretary of Defense, in coordination with the Governors of the affected states, elects and requests to use those forces in title 32, U.S.C., status) in response to requests for assistance from civil authorities for domestic emergencies, law enforcement support, and other domestic activities, or from qualifying entities for special events (DODD 3025.18). General engineers are typically prominently tasked to support DSCA. See ADP 3-28; ATP 3-28.1/MCRP 3-30.6/NTTP 3-57.2/AFTTP 3-2.67/CGTTP 3-57.1, DODD 3025.18; DODI 3025.21; JP 3-28; and MCO 3440.7C for additional information on DCSA.

2-65. In national preparedness doctrine, any type of domestic disaster, emergency, or event requiring support may be called an incident. An *incident* is an occurrence, caused by either human action or natural phenomena, that requires action to prevent or minimize loss of life, or damage, loss of, or other risks to property, information or natural resources (JP 3-28). General engineers must be prepared to provide support to civil authorities by rendering assistance in any of those areas when required. Army National Guard engineers can be called on during emergencies by the governor of a state under Title 32, United States Code (32 USC). The term *civil support* has been superseded by DSCA, except when the National Guard is conducting these missions in state active-duty status or 32 USC status to civil authorities for domestic emergencies or for designated law enforcement and other activities.

2-66. For military forces, the primary tasks associated with DSCA include—

- Providing support for domestic disasters.
- Providing support for domestic chemical, biological, radiological, and nuclear (CBRN) incidents.
- Providing support for domestic civilian law enforcement agencies.
- Providing other designated support.

2-67. Support to DSCA is primarily focused on tasks that enable sustainment/combat service support and enhance protection. General engineering tasks supporting DCSA include—

- Focusing on first responder and population mobility.
- Reinforcing civil authorities.
- Supporting military forces by enabling logistics, repairing infrastructures, and restoring critical services.
- Repairing or restoring selected civil and commercial infrastructure that provides water, power, communication, transportation, and other essential utilities that military forces and DOD support organizations depend on to meet operational needs.

2-68. There are few unique general engineering tasks performed in DSCA that are not performed during other operations. The difference is the context in which they are performed (see ADP 3-28). Because of the unique nature of the hazard or threat, planning for DSCA is significantly different than planning for offense, defense, or stability tasks, although the basic missions may be similar to those of stability tasks. For example, the hazard or threat will most likely be a natural or man-made disaster with unpredictable consequences. The military will assume a support role to DSCA.

Notes.

1. See FM 3-34 for a discussion of engineer capabilities that could be applied to support DSCA requirements.

2. See ATP 3-28.1/MCRP 3-30.6/NTTP 3-57.2/AFTTP 3-2.67/CGTTP 3-57.1 for more information on specific DSCA tasks and planning considerations.

3. See ATP 3-37.34/MCTP 3-34C for information on considerations for stability or DSCA tasks.

2-69. General engineer support for the restoration of essential services after an incident is the primary engineer focus in DSCA. Engineer support may also be required for forces providing DSCA command to government agencies at all levels until they can function normally.

2-70. There are 15 national emergency support functions used by the federal government and states as the primary means to organize and provide assistance. General engineers may be tasked to support some of them. Each emergency support function is identified and discussed in ADP 3-28, ATP 3-28.1/MCRP 3-30.6/ NTTP 3-57.2/AFTTP 3-2.67/CGTTP 3-57.1, and JP 3-28.

2-71. For engineers, the most applicable function is the *Emergency Support Function #3–Public Works and Engineering Annex*. USACE is the primary coordinating agency for this emergency support function that is responsible for providing technical advice and evaluations, engineering systems, construction management and inspection procedures, emergency contracting procedures, emergency wastewater and solid waste facility repair, debris handling and removal, and roadway maintenance and openings following presidential disaster declarations (see ADP 3-28).

2-72. The overall scope of *Emergency Support Function #3–Public Works and Engineering Annex* includes infrastructure protection and emergency repair, infrastructure restoration, engineering service and construction management, and emergency contracting support for lifesaving and life-sustaining services. Some examples of general engineering support to provide or restore essential services may include—

- Supporting urban search and rescue.
- Providing food and water.
- Constructing base camps for emergency shelter.
- Providing emergency transportation.
- Providing boats during flooding.
- Providing trucks for hauling critical supplies and equipment.
- Providing hauling assets for population movement.
- Providing public works and other engineering support.
- Providing firefighting support.

- Providing deployable prime power systems.
- Providing basic sanitation (sewage and waste disposal).
- Assisting local responders in providing minimum essential access to affected areas.

2-73. General engineering support to DSCA, first responders, supporting units, or the population may include—

- Supporting mobility by rubble and debris removal.
- Restoring and maintaining transportation infrastructure networks (roads, bridges, airfields, seaports, heliports).
- Conducting infrastructure reconnaissance, assessment, and technical assistance.
- Conducting emergency demolition.
- Providing diver support.

2-74. General engineering support may be required for force sustainment/combat service support and protection requirements and may be extended to support other agencies during DSCA. Likely missions include—

- Debris removal.
- Route clearance.
- Expedient (temporary) road and trail construction and repair.
- Forward aviation combat engineering (including the repair of paved, asphalt, and concrete runways and airfields).
- Temporary bridging construction.
- Port, airfield, reception, staging, forward movement, and integration facility upgrades and construction.

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Chapter 3
Planning and Design

Effective planning and design are essential for enhancing mission success. At the CCDR level, planning and design are conceptual in scope; at lower levels, they are more detailed. At the lowest tactical level, planning and design capability is limited because the engineer unit is focused on mission execution. Planning and design are separate tasks, but this chapter discusses them together because they are closely related and influence each other. Design is an extension of planning, and both are interrelated and complementary processes. Planning and design integrate engineering capabilities and balance tactical, operational, sustainment/combat service support, protection, and engineering requirements. There is no single correct plan or design; instead, there is a range of acceptable solutions. This chapter provides an overview for general engineering planning and discusses its terminology, requirements, tools, MDMP/MCPP, engineer work line, UFC, and FFE.

JOINT GENERAL ENGINEERING PLANNING

3-1. The primary joint doctrinal publication for planning general engineering support is JP 3-34. The Air Force and Navy have a narrower focus for general engineering than does the Army and often refers to it as civil engineering. The Air Force and Navy consider general (civil) engineering to be primarily a logistics function that is executed to sustain forces in a contingency operation. Their activities tend to focus on missions, such as base camp and life support development, seaport of debarkation construction and repair, aerial ports of embarkation, and other facilities or sites. The Marine Corps is primarily organized and equipped to provide combat engineering; however, they do possess a limited general engineering capability to support operations.

3-2. Joint planning takes a comprehensive look at coordinating, integrating, and synchronizing the capabilities from each service and contractor support to produce the synergy of effort as the situation requires. This helps commanders and their staffs visualize and design a broad approach to mission accomplishment early in the planning process, which makes detailed planning more efficient (see JP 1 Vol 1 and JP 3-0.).

3-3. Engineers should contact the contracting command to determine existing contracting support and to plan for additional contractor support. Contracted support could include supplies (materials), services (design, operation, maintenance), labor, or construction. See *Defense Contingency Contracting Handbook*, ATP 4-10, JP 3-34, and JP 4-10 for an overview of each Service capability.

JOINT OPERATIONS PLANNING PROCESS

3-4. The joint operations planning process underpins planning at all levels and for missions across the competition continuum. Joint engineer planning may occur under several staffing options: an engineer special staff element or an engineer staff section within the operations or logistics directorate of a joint staff. The engineer staff actively participates in the planning process on the joint staff, addresses all potential engineer requirements, and provides the required products. They also plan for conducting an EBS and obtaining real estate support to obtain land leases.

3-5. Construction planning and design (along with preparation, execution, and assessment) are often collaborative efforts between higher headquarters, constructing units, facility commanders, and users or tenants. See JP 1 Vol 1 and JP 3-0 for a discussion of the joint operations planning process. See JP 3-34 for engineer contributions in operation plans (OPLANs) and operation orders (OPORDs).

3-6. Careful consideration during planning and execution for command and support relationships helps to effectively achieve a seamless integration of general engineering support to operations. The overarching doctrine for command and support relationships of engineer forces is contained in ADP 6-0, FM 3-34, MCWP 3-34, JP 3-0, and JP 3-34.

3-7. General engineering involves the application of technical knowledge and judgment to make trade-offs among competing requirements and to recommend solutions to difficult problems. Construction outside the United States may also be governed by DOD guidance, status of forces agreements, final governing standards, HN-funded construction agreements and, in some instances, bilateral infrastructure agreements. Planners and designers must ensure compliance with the more stringent standards, as applicable.

Joint Engineer Support Plan

3-8. The joint engineer support plan (Annex D, *Logistics*, and Appendix 6, *Construction Standards*) is produced by a joint staff engineer for input to the joint OPLAN as part of the deliberate planning process. It identifies the minimum mission-essential wartime requirement for engineering services and construction standards in support of military forces. Other portions of a joint OPLAN or OPORD for general engineering planning include—

- Appendix 9, Air Base Operability to Annex C, Operations.
- Appendix 14, Force Protection to Annex C, Operations.
- Appendix 15, Critical Asset Risk Management to Annex C, Operations.
- Appendix 5, Mobility and Transportation to Annex D, Logistics.
- Annex L, Environmental Considerations.
- Annex W, Operational Contract Support.

3-9. General engineers assigned as joint engineer staff officers must be well trained to effectively plan and synchronize joint engineering capabilities as members of a JFC staff. Action officers must be well versed in the complexities of the joint force capabilities of all Service engineer forces to maximize the use of their capabilities.

3-10. Army and Marine Corps engineers must recognize that other Service engineers organize and equip their engineer forces for different functions and adapt their capabilities to meet specific needs. This is particularly necessary where each Service has capabilities and limitations. JP 3-34 provides the necessary baseline planning information for all Service engineer capabilities.

Joint Engineer Boards

3-11. Various joint boards assist the JFC or JTF commander in establishing priorities and policies for general engineering capacity. Three typical boards include the joint civil-military engineering board, joint facilities utilization board, and joint environmental management board.

3-12. Other boards or cells may also be created as required. Each board addresses a separate need within the joint force and is described in JP 3-34. The JFC tailors the scope, roles, and responsibilities of each board to meet specific operational needs. To adequately integrate and synchronize general engineering efforts, engineers must possess a good working knowledge of the doctrinal aspects of the board and the theater-specific procedures.

Key Joint Terms That Affect General Engineering Planning

3-13. *Operational contract support* is the process of obtaining goods, services, and construction via contracting means in support of contingency operations (JP 4-10). Various continental U.S. or outside the continental United States acquisition regulations or policies may apply to the functions associated with contract support integration, contracting support, and contractor management. Operational contract support affects various commands and staffs that should address operational contract support requirements and incorporate operational contract support planning into the command planning and execution cycle.

3-14. A *contingency engineering management organization* is an organization formed by the combatant commander, or subordinate JFC to augment their staffs with additional Service engineering expertise for planning and construction management (JP 3-34). Contingency engineering management cells should be staffed with representation from Service component engineer personnel who possess expertise across the engineer functions.

3-15. A *Department of Defense construction agent* is the Corps of Engineers, Naval Facilities Engineering Command, or other such approved Department of Defense activity, that is assigned design or execution responsibilities associated with military construction programs, facilities support, or civil engineering support to the combatant commanders in contingency operations (JP 3-34). The responsibilities of DOD construction agents include the design, award, and management of construction contracts for projects associated with the peacetime military construction program. Overseas, USACE, NAVFAC, and the Air Force are assigned specific geographical areas under DODD 4270.5. These responsibilities include the leasing of real estate.

3-16. An *environmental baseline survey* is a multi-disciplinary site survey conducted prior to or in the initial stage of an operational deployment (JP 3-34). This survey helps to accomplish three primary goals: the documentation of initial site conditions, the identification of hazards and risks factors, and the determination of site selection and layout. The survey is completed using DD Form 2993, *Environmental Baseline Survey Checklist*, and DD Form 2994, *Environmental Baseline Survey Report*.

3-17. Environmental considerations (the spectrum of environmental media, resources, or programs that may affect the planning and execution of military operations [see JP 3-34]), play an important part in all phases of an operation, starting with planning, design, and construction. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) for more information about integrating environmental considerations into operations and for documenting environmental considerations throughout the operational phases of a deployment location.

3-18. An environmental conditions report is a concise summary of events or situations that created a negative or positive change in environmental conditions at a base camp site. It is completed to track changes that occur during occupation and is filed with the EBS. Examples of changes that require reporting include a hazardous material (HAZMAT) spill or leak, the discovery of a cultural or historical resource, the establishment or movement of a waste management area, and the cleanup of a contaminated area. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) for more information about environmental conditions reports.

3-19. Environmental site closure surveys are conducted in the final stages of an operational deployment to determine necessary closure actions and resources and to document the final environmental conditions at a base camp at the time of transfer/closure. It is completed at least three times, it is used to determine actions required to meet the negotiated standards for transfer/closure, and it facilitates the development of an environmental corrective action plan and request for resources. The surveys are completed using DD Form 2995, *Environmental Site Closure Survey*. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B), ATP 3-37.10/MCRP 3-40D.13, and TM 3-34.56/MCRP 3-40B.7 for more information about base camp transitions, transfers, and closures.

3-20. The final DD Form 2995 and the associated environmental closure report are completed before the unit or base camp commander is released of responsibility for the base camp (see ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]). To effectively complete the closure report, it is essential to reference the initial EBS (and update it if applicable) and the log of periodic environmental conditions reports that have been completed on the particular site or area. Units record the grid coordinates and take post closure digital photographs of each waste management site. This information is incorporated into the environmental site closure report and is archived for future reference. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) and ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for more information on base camps and environmental considerations for overseas construction standards. *Final governing standards* are a comprehensive set of country-specific substantive environmental provisions, typically technical limitations on effluent, discharges, etc., or a specific management practice (JP 3-34).

3-21. The Overseas Environmental Baseline Guidance Document specifies criteria and management practices for environmental compliance at DOD installations at overseas locations. It is designed to protect human health and the environment and reflects generally accepted environmental standards applicable to

DOD installations, facilities, and actions in the United States. It also incorporates requirements of U.S. law that apply to DOD installations and activities outside the United States and its territories (see JP 3-34). The OEBGD is published in multiple volumes as DODM 4715.05, Vol. 1–Vol. 5.

3-22. The Contingency Locations Environmental Standards define the environmental standards for implementation at contingency locations to protect force health, minimize environmental impact, and sustain mission effectiveness. They include minimum environmental compliance standards and best management practices, including those that avoid or mitigate adverse effects to recognized cultural, historic, and natural resources to the maximum extent practicable, given mission requirements (see DODI 4715.22).

ARMY AND MARINE CORPS GENERAL ENGINEERING PLANNING

3-23. Planning and design are separate activities, but they are grouped together because they are interdependent. Planning pertains to the specific tasks conducted in gathering, generating, and sharing the necessary information needed for support of mission objectives. The design task is an extension of the engineer planning task that matches engineering principles and construction means against requirements to create the necessary engineering and construction details needed for building, operating, maintaining, and dismantling facilities and infrastructure.

3-24. Planning and design efforts have the greatest impact on improving facility efficiencies, implementing cost-effective practices, and reducing costs. Planning and design continue during all phases of the operation and the life cycle of a facility and are integral parts of master planning.

3-25. Planning is the art and science of understanding a situation, envisioning a desired future, and laying out effective ways of bringing that future about (see ADP 5-0 or MCWP 5-10). In other words, planning is the means by which the commander visualizes a desired outcome or end state; crafts the means by laying out effective ways of achieving it; and successfully communicates to subordinates the commander's vision, intentions, and decisions, focusing on the results to achieve the desired outcome. Planning helps create a common vision that results in a plan and orders that synchronize the action of forces in time, space, and purpose to achieve objectives and accomplish missions.

PLANNING AND DESIGN CONSIDERATIONS

3-26. During planning, commanders and staffs must understand that the types and magnitude of tasks accomplished vary based on the type, capacity, and resources available to the engineer unit to which the mission is assigned. The continuous refinement of the mission analysis in the MDMP/MCPP, and the engineer estimate determines if the proper assets are available to accomplish all tasks. MDMP/MCPP is an iterative planning methodology that is used to understand the situation and the mission, develop a COA, and produce an OPLAN or OPORD.

Planning

3-27. Planning follows these general steps:

- Determine operational requirements.
- Conduct reconnaissance and site selection.
- Conduct initial engineering reconnaissance.
- Analyze existing infrastructure.
- Develop, repair, upgrade, or modify plans.
- Determine new construction requirements.
- Determine O&M requirements.
- Coordinate planning with concept or initial designs.

3-28. MDMP/MCPP helps engineers apply thoroughness, clarity, sound judgment, logic, and professional knowledge to understand situations, develop options to solve problems, and reach decisions. It helps facilitate collaboration and parallel planning and seeks the optimal solution.

3-29. Planning and design are continuous interactive and iterative processes throughout the military operation and life cycle of the facility or infrastructure. Planning and design can be conceptual, detailed and highly structured, or less structured. Plans and designs may be initial or final-approved and are often documented in master plans.

3-30. Planning affects design, and design affects planning. Each may provide information to, and constrain or restrict the options of, the other. Planning and design are interdependent efforts that are combined to help facilitate a desired outcome. Effective design hinges on the accuracy and completion of the information generated during planning, particularly information related to facility and infrastructure requirements, available resources, construction means, and site location. Automated planning and design tools are available to assist general engineers in expediting the process.

3-31. Critical information resulting from design that is integrated into planning includes construction estimates (bill of materials, equipment, personnel, cost, and time) that the commander needs to know in establishing priorities of support, priorities of effort, timelines associated with movement, the basing of forces, and the flow of the operation.

3-32. Failure to remain continuously linked and updated with mission planning as it progresses can result in design solutions that are unsustainable based on the concept of operations and are inadequate in meeting the commander's needs. Planners and design engineers develop an integrated collection plan for engineer reconnaissance to support planning and design.

3-33. Planners may use basic periods of time (such as the two-shift, 20-hour working day) or the days in a month to prepare estimated labor needs extending over a period of time. However, adverse physical conditions peculiar to the location must be considered. For example, severe icing conditions during the winter months, periods of extreme tide range, or severe seasonal winds may have a direct bearing on construction or rehabilitation work. When heavy seasonal rains, snowfall, icing, seasonal winds of unusual severity, frequent or seasonal fogs, or exceptionally high or low temperatures are typical to a coastal area, work time estimates should be modified accordingly to allow for such conditions. When operating in other countries, planners need to consider holidays, typical workdays, and working hours and their impact on local contractor work schedules. For example, Muslims observe Ramadan as a month of fasting and do not go to work for a few weeks.

Design

3-34. The design of structure construction is specified in the authorizing or construction directive. Normally, engineers build one of two structures—initial or temporary. Initial design life is up to 6 months; temporary design life is up to 2 years. The use and actual life of the structure may exceed the design life.

3-35. When possible, standard designs are used to save time in design, construction, and maintenance. Using standard designs and their accompanying bill of materials allows for the advance procurement of construction materials and equipment. The engineer must fit these designs to the site and adapt them to the existing conditions. Reconnaissance, construction surveys, soil-bearing tests, test piles and, perhaps, a sieve analysis of local sands and gravels are prerequisites to the preparation of final design drawings and bill of materials.

3-36. The design of nonstandard structures is usually carried out only if standard designs cannot be adapted or modified accordingly.

Planning and Design Tasks

3-37. General planning and design engineering planning tasks include—

- Determining requirements.
- Determining constraints.
- Determining standards.
- Developing options.
- Conducting engineering reconnaissance.
- Performing site reconnaissance and site selection.
- Producing site layout.

- Performing economic analysis.
- Recommending priorities, to include engineer effort, construction, material allocation, and contractor support.
- Performing master planning.
- Performing program and project management.

General Engineering Requirements

3-38. Most requirements are determined during mission planning; some of these requirements may emerge as operations, while other requirements emerge as the operating environment changes. Construction requirements come from a variety of sources, to include operational requirements, unit requirements, engineering principles, status of forces agreements, final governing standards, UFC, standards, rules of allocation, and the end user.

3-39. General engineering tasks may be performed by a variety of engineer units and Service members, such as DOD civilians, contractors, specially trained technicians, master planners, professional architects, professional engineers, or environmental specialists.

3-40. Defining life cycle requirements specifies the capabilities and attributes that the designed facility must have over its planned life cycle to achieve a specific purpose or function or fulfill a need of the intended users. Defining requirements must often balance competing requirements, such as commander's guidance, best engineering practices, and available funding.

3-41. Contingency construction plans and designs are characterized by the following traits:

- They are rapidly constructed or emplaced.
- They are standardized, modular, and scalable.
- They demonstrate the maximized use of pre-positioned stocks and locally procured materials (sizes, quality, military specifications).

Constraints

3-42. A constraint dictates an action or inaction, thus restricting how something can be done. Planning and design are constrained by—

- Base camp standards (facility allowances, construction standards, safety requirements).
- Construction resources availability (labor, equipment, materials, money).
- Terrain and climate conditions.
- Weather effects.
- Available and usable vacant land areas.
- Funding limits.
- Force protection requirements.
- HN agreements.
- Environmental considerations and impacts.
- Operational timelines.
- Civil considerations and impacts.
- Locally available commercial power characteristics.

Standards

3-43. General engineer planners and designers consider all standards established by the CCDRs or higher-level headquarters for their AOR. Some CCDRs publish guidebooks with rules of allocation and planning or construction standards. CCDRs often establish standards in orders that may take precedence over guidebooks. See Army Europe Regulation 420-100, *Standards for Base Camps* and United States Central Command Regulation 415-1, *Construction and Base Camp Development in the USCENTCOM AOR "The Sand Book"* for theater-specific construction standards.

3-44. Construction standards are established by the CCDR (or they default to UFC) and include design, construction, materials, O&M, quality of life, and environmental considerations. Some are in UFCs, technical manuals, or other publications or are provided by commanders. Standards help provide effective, efficient, and sustainable solutions. These are not to be confused with task standards that are used to assess individual or unit performance.

3-45. Standards can be viewed as a continuum with a wide range of professionally recognized specifications and expectations, from minimum to highly restrictive. Standards can have steps with different names and various levels of complexity and technical details. For example, airfield standards are initial or temporary contingency operations standards. The general engineer must be aware of these standards, whether they are Service-oriented, state, national, or international in nature.

3-46. The CCDR specifies the facility allowances, construction standards, and safety requirements for the theater to minimize the engineer effort expended on any given facility while assuring that the facilities are adequate for health, safety, and mission accomplishment. Typically, the CCDR develops the base camp construction standards for use in-theater utilizing the guidelines provided in JP 3-34. There can be construction quality standards and material property standards that must be checked using quality assurance and quality control activities. See EP 415-1-261 series for information on quality assurance representative activities. See NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-17.7F for information on project quality control plans.

3-47. The engineer must recommend the most feasible solutions to meet each requirement based on construction guidelines and other planning factors. Standards documents that provide specific construction examples are in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N). The commander may also establish standards in specific OPLANs, OPORDs, and directives. These standards are used as initial guides, provide planning tools, and may provide priorities for construction within base camps.

General Engineering Options

3-48. Planners and designers use multiple COAs in conceptual or initial plans and designs. These are developed during initial planning, when much of the needed information may not be available and assumptions help fill information gaps. This conceptual thinking helps frame the problem and narrow the range of possible options or COAs. Preliminary estimates are refined and documented in the staff running estimate.

3-49. As more information becomes available, planning and design may produce a series of more detailed plans and designs. The MDMP/MCPP is a routine process to develop and evaluate COAs. The engineering evaluation of options or COAs includes evaluation criteria based on the range of considerations discussed throughout this manual and is most important to the operation or the solution being evaluated.

3-50. The MDMP/MCPP or another technique may be used to reach a final decision on plans and designs. The designated approving authority ensures that the detailed plans and designs conform to approved standards and the master plan and approves them before contracting or construction begins.

Engineer Reconnaissance

3-51. Engineer reconnaissance enables planning and design by providing the information needed to perform planning and design. Availability and assessment information requirements include infrastructure (en route to and within the operational area), materials, LOC supportability, local labor, and contractor capabilities. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) for more information.

Site Reconnaissance

3-52. Each potential site should be reconnoitered to select the most economical use of available resources. General locations and potential sites are determined by tactical requirements and are initially analyzed by preliminary studies (intelligence or technical), reports, and interviews with locals and by remote reconnaissance, such as a review of maps, aerial reconnaissance, aerial or space images, and databases. An initial on-site reconnaissance may be made by the planning headquarters and later confirmed and expanded by the constructing unit.

Site Selection

3-53. An engineer reconnaissance should take place before, concurrently, and after land use agreements have been finalized. The exact site selection is normally made by the constructing unit after conducting a ground reconnaissance that considers the selection factors for the specific project, such as access routes, trafficability, soil characteristics, location, quality and quantity of materials, wind patterns, drainage, bivouac sites, and security. Other factors, such as real estate acquisition and EBS, should also be considered.

Site Layout

3-54. The site layout considers the access, environmental conditions, clearance, drainage, visitor center, parking area, break area, equipment staging area, equipment park, bivouac sites, borrow sites, quarries, aggregate supplies, haul routes, material storage areas, facility locations, utilities, and security. A simple site layout sketch for some projects may evolve to detailed plans in master planning documents. Site preparation requirements are discussed in TM 5-301 series.

Economic Analysis

3-55. Analysis is done for the projected life cycle cost and potential mission impact of engineering solutions and helps to provide recommendations to the commander based on this analysis. The economic analysis is conducted by considering all resources, including labor, materials, equipment, and funds. Economic analysis may affect planning, design, construction, O&M methods, materials, and procedures.

3-56. A detailed cost estimate is developed to allow a cost comparison of concept designs or to help analyze the engineering trade-offs made to complete the detailed plans and designs. Economic analysis may need to be made at specific intervals over the life of a program or project as new information that changes initial conditions becomes available. For example, the use and upgrade of existing facilities can save resources, but the risk may be significant due to the impacts of unknown or unforeseen conditions.

3-57. An economic analysis is done to determine how construction and facilities may impact the HN and local population. This analysis should include the impacts of water usage, increased resources, demands for utilities/waste disposal, and noise impacts on sensitive populations/agriculture stock. While these impacts might not be avoided or mitigated, they will impact relations with the local population. Consult a civil affairs officer for support to develop mitigation or information dissemination plans.

Priorities

3-58. Joint engineer boards recommend priorities and resource allocation to deconflict issues, while the final resolution is left to the approval of the commander ordering the tasks. Priorities are identified and set at all levels. The priorities guide the application of limited resources. Priorities may be adjusted many times as operations progress.

Master Planning

3-59. Master planning is an integrated strategy for the long-range approval, design, construction, and maintenance of required facilities and infrastructure throughout their life cycle that integrates improvements for protection, quality of life for residents, and efficiencies and effectiveness at their best possible cost. Proper master planning enables scalable and sustainable facilities, conserves resources, and prevents wasted construction. Early master planning facilitates the transition to improved facilities of the right size, with the right capabilities, and at the right locations as the operation develops. At lower levels, the master planning is linked to the scheme of base camps and is the responsibility of the commander. A good master plan also incorporates an EBS. EBSs are an important part of the initial survey, development, and master planning for base camps.

3-60. Key features of master planning include—

- Producing a documented initial plan and plans for changes of operational requirements, capacity requirements, the purpose, construction standards, protection requirements, quality of life standards, resources, contracted support, efficiencies, and effectiveness.
- Seeking to attain cost-effective, scalable, and sustainable solutions.

- Serving as the long-term blueprint for the implementation of future improvements or changes to the service life of the base camp.
- Starting early to help facilitate the transition to more permanent facilities on the base camp as an operation develops (see JP 3-34).

Note. See TM 5-803-5/NAVFAC P-960/AFM 88-43 and UFC 2-100-01 for more information on installation master planning.

Master Planning for Base Camps

3-61. Each base camp with a lifespan of 6 months or more has a master plan that is linked to the higher headquarters broader master plan. Theater guidance addresses archiving requirements. Master planning is one of the base camp commander's most important responsibilities. The base camp commander, supported by a team, staff, or base camp master planning working group, develops the base camp master plan collectively with input from supported units. Base camp commanders involve tenant units and organizations in the process. Tenant units and organizations (military, government, and contractors) provide input into master planning, to include the necessary designs and details needed to fulfill operational requirements.

3-62. The tasks to conduct master planning are under the construct of base camp operation. The current and future operational requirements are analyzed, documented, and integrated into the master plan. The level of detail of the base camp master plan depends on the maturity of the location, the speed at which the operational need for a base camp develops, and the expected length of stay. Base camp master plans for expeditionary or initial standard camps may be simply a sketch of the camp, while base camp master plans for temporary or semipermanent camps include fully engineered construction plans based on complete surveys that integrate environmental considerations.

3-63. The CCDR establishes the policies and procedures for developing, approving, and implementing master planning in the JOA. These requirements for master planning are linked to the theater bed-down and basing strategy and are detailed in subordinate unit plans and orders. At the tactical level, commanders develop a scheme of base camps (see ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]).

3-64. Master planning for base camps generally follows the process used for permanent installations, except that it has a shortened planning horizon and is often not prepared to the same level of detail (see AR 210-20). The techniques and procedures of master planning can also be used to develop theater, JOA, or area of operations bed-down plans. See UFC 2-000-05N and UFC 2-100-01 for additional information on installation planning. Land use planning is also referred to as site design or site layout. See EP 1105-3-1 for additional information on base camp development.

TOOLS AND TECHNIQUES

3-65. The Army Facilities Components System (AFCS) is a set of standard facility designs managed and supported by USACE. The JCMS is an automated military engineering construction planning and execution support system that delivers AFCS engineering and construction information. Naval facility designs from the Navy's Advanced Base Functional Component system were combined into JCMS prior to the elimination of the Advanced Base Functional Component system.

3-66. There are a variety of other automated systems, tools, and applications that can assist in construction planning and design. One example is the base engineering survey tool kit. The base engineering survey tool kit is a stand-alone geographic information system application designed to simplify bed-down planning, such as planning tent city layouts and configurations. It is a decision support tool that provides the expedient forward infrastructure that is consistent with the requirements for rapid deployment, minimal logistics, and required protection. See the Army facilities component system website for more information.

GENERAL ENGINEER STAFF

3-67. The general engineer staff assists the commander by furnishing engineer advice and recommendations to the commander and other staff officers and by coordinating and supervising specific engineer activities for which the engineer staff is responsible. The engineer staff assists the commander by performing a variety of functions to synchronize engineer capabilities in the operational area. See FM 3-34, FM 6-0, and MCWP 3-34 for more information on engineer planning. General engineer staff functions include—

- Advising the commander on engineer capabilities and the best means to integrate and synchronize engineer efforts to achieve the desired outcome.
- Integrating and synchronizing engineer capabilities between multiple commands and organizations to achieve the commander's unity of effort.
- Preparing the engineering portion of plans, the engineer estimate, engineer fragmentary orders, and warning orders; producing supporting products; and updating the engineer estimate.
- Participating on project approval and acquisition review boards and other boards or working groups, as necessary.
- Providing real-time reachback linkage to USACE, the Army Engineer School, and supporting national assets.
- Planning and coordinating engineer support that uses military engineering units and contractors.
- Recommending policies and priorities for construction and real estate acquisition and for Class IV construction materials.
- Planning and coordinating the procurement and distribution of Class IV construction materials.
- Furnishing advice on the effect of bed-down facilities and base camps on the environment according to applicable U.S., international, and HN laws and agreements.
- Recommending appropriate construction standards.
- Standardizing infrastructure systems and design approaches.
- Identifying engineering support requirements that exceed funding authorizations and organized engineer capabilities.
- Furnishing advice on the feasibility, acceptability, and suitability of engineering plans.
- Coordinating with DOD construction agents and other engineer support agencies through appropriate channels.
- Coordinating the development of environmental and waste management plans.

United States Army Corps of Engineers

3-68. USACE provides the engineering standards for construction; guidance on scalability, standardization, and modularity; expertise on contingency standard designs; and management of the AFCS. They also manage a strategic reserve of nontactical generators and the Prime Power Program for the Army. USACE serves as the Army power procurement officer and is responsible for administering the purchase and sale of utilities services and for the policies, engineering, and rates related to all utility service transactions and contracts. USACE provides deployable augmentation teams to support commanders.

Military Decision-making Process

3-69. The MDMP/MCPP is well defined in FM 5-0. Likewise, the planning construct in a joint environment is well articulated in JP 5-0. Many tasks have unique requirements that must be considered when applying the MDMP/MCPP to a specific mission. Table 3-1 lists some potentially unique aspects of planning as they pertain to each MDMP/MCPP step. Although not nearly all-inclusive of the variations required of the engineer effort, this list demonstrates that general engineering tasks can be complex and resource-intensive and require extensive and proactive coordination.

Engineer Reconnaissance

3-70. *Reconnaissance* is a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or adversary, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area (JP 2-0).

3-71. Route classification is a classification assigned to a route using factors of minimum width and worst route type; least bridge, raft, or culvert military load classification; and obstructions to traffic flow (see ATP 3-34.81/MCRP 3-34.3 [MCWP 3-17.4]). Route classification results from collecting detailed technical information on various components of a designated route, such as the road network, the bridges along a selected route, and underpasses and/or overpasses. Route classification provides a graphical display of the load-carrying capacity and the rate-of-travel capacity of the selected route. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) and MCWP 3-34 for additional information.

Table 3-1. General engineering in the MDMP

Steps of the MDMP	*General Engineering Considerations*
Receipt of the mission	• Review joint orders. • Receive higher headquarters construction directives. • Request geospatial and medical information about the area of operations. • Establish engineer-related boards.
Mission analysis	• Determine the availability of construction materials. • Review the availability of Army, joint, multinational, HN, and contract assets. • Determine and review established construction standards and base camp master planning documents. • Review UFC. • Review existing geospatial and medical data on potential sites. • Conduct site reconnaissance (if possible). • Determine the threat, including environmental and explosive hazards. • Obtain necessary geologic, hydrologic, and climatic data. • Determine the level of interagency cooperation required. • Determine funding sources.
COA development	• Produce different designs that meet the commander's intent. (Use the JCMS when the project is of sufficient size and scope.) • Determine alternate construction locations, methods, means, materials, and timelines. • Determine real property and real estate requirements.
COA analysis	• Utilize the critical path method to determine the length of different COAs and the ability to crash the project. • Perform an economic analysis.
COA comparison	• Determine the most feasible, acceptable, and suitable methods for completing tasks. • Determine and compare the risks of each COA.
COA approval	• Gain approval of the construction management plan, safety plan, security plan, logistics plan, and environmental plan.
Orders production	• Produce construction directives. • Provide input to the appropriate plans and orders. • Ensure that resources are properly allocated.
Rehearsal	• Conduct construction prebriefings. • Conduct preinspections and construction meetings. • Synchronize the construction plan with local and adjacent units.
Execution and assessment	• Conduct quality assurance, quality control, and midproject inspections. • Participate on engineer-related boards. • Maintain as built and redline drawings. • Conduct project turnover activities.

Table 3-1. General engineering in the military decision-making process (continued)

Legend:	
COA	course of action
HN	host nation
JCMS	Joint Construction Management System
MDMP	military decision-making process
UFC	Unified Facilities Criteria

3-72. The five forms of reconnaissance are zone, area, route, force, and special. See ADP 3-90 for additional information on the forms of reconnaissance.

3-73. Site reconnaissance includes obtaining information to plan security, site layout, and site drainage. Survey and soil experts should participate in the site reconnaissance. Reconnaissance to support the construction of a new road may be classified as area or route reconnaissance. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) and FM 3-90-1 for more information on reconnaissance.

3-74. When available, an automated route reconnaissance kit can provide engineer units with an automated reconnaissance package that allows the reconnaissance element to collect and process reconnaissance information. An overlay is made with attachments that describe all pertinent terrain features. This overlay forms part of the mobility input to the common operational picture and is maintained by the engineer unit tasked to perform the reconnaissance. Marine Corps engineer units use the instrument set, reconnaissance and surveying (common name: ENFIRE) to conduct engineer reconnaissance. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) and MCWP 3-34 for more information on route reconnaissance.

3-75. An air or map reconnaissance includes a general study of the topography, drainage pattern, and vegetation. Construction problems, camouflage possibilities, and access routes should be identified. A route reconnaissance plan is developed by selecting the areas to investigate and the questions to be answered from the information available or, if time is available, to request and support the reconnaissance. An air or map reconnaissance can be used to eliminate unsuitable sites, but it cannot be relied on for site selection. Digital imagery greatly enhances the usefulness of this method of reconnaissance.

3-76. While air and map reconnaissance can effectively minimize needed ground reconnaissance, it cannot replace ground reconnaissance. It is on the ground that most questions must be answered or that most observations tentatively made from available information are verified.

3-77. There are two basic types of technical reconnaissance (assessments and surveys) discussed in ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) that may be performed as part of a reconnaissance. Assessments and surveys include—

- Bridge reconnaissance.
- Gap crossings and choke points.
- Engineer resource assessments.
- Infrastructure reconnaissance.
- Environmental reconnaissance.
- Airfield assessments.
- Seaport assessments.

3-78. Engineer reconnaissance includes two levels of detail: assessment and survey. The comparison and contrast is as follows:

- **Assessment.** An assessment, in the context of engineer reconnaissance, is a judgment about something based on a technical understanding of the situation. Within the range of technical reconnaissance, an assessment takes less time and technical expertise to perform than a survey but yields less technical detail than a survey. Reconnaissance elements do not require specialized technical expertise to perform an assessment. They conduct assessments following the same basic formats that a survey would use.
- **Survey.** A survey, in the context of engineer reconnaissance, allows one to look at or consider something closely, especially to form a technical opinion. Within the range of technical reconnaissance, a survey requires more time and technical expertise to perform than does an assessment, but it subsequently produces more technical detail. Specific technical expertise is

required to conduct a survey. The survey team is normally augmented by forward USACE personnel assigned to a FEST, other technical specialties (such as medical, civil affairs, other government agencies, contractors, and HN), and reachback as needed to enhance the survey quality.

3-79. General engineers working at the operational level conduct reconnaissance primarily to identify requirements for operational level sustainment/combat service support. Technical reconnaissance capabilities are typically conducted by a general engineer assessment team or survey team to gather the technical information required for—

- Maintenance and upgrades of ground LOCs.
- Bridge construction and repair.
- Support of airfields and heliports.
- Support of seaports.
- Support of protection procedures.
- Real estate and real property maintenance activities.
- Procurement and production of construction materials.
- Support of bed-down facilities, base camps, and support areas.
- Power systems.
- Support to petroleum pipelines and storage facilities.
- Water supplies and well drillings.
- Underwater and other specialized construction support requirements.
- Infrastructure surveys.
- Environmental baseline surveys.

ROUTE CLASSIFICATION

3-80. The route classification is assigned to a route using factors of minimum width and worst route type; least bridge, raft, or culvert military load classification; and obstructions to traffic flow. The military load classification is a standard system in which a route, bridge, or raft is assigned class number(s) representing the load it can carry. Vehicles are also assigned number(s) indicating the minimum class of route, bridge, or raft they are authorized to use. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) for more information on route classification.

3-81. Route reconnaissance is normally a combat engineer task. Route classification is normally a general engineering task. However, there is no clear dividing line between the technical effort required for the combat engineering task of classifying a route for combat vehicle traffic and the conduct of a road reconnaissance to estimate the effort required for the design of an upgrade of an MSR.

3-82. The combat engineering task effectively addresses classification of the route, but it also provides information that is useful in the general engineer estimate. Similarly, the general engineer estimate effectively addresses the effort required for an upgrade and provides the information required to properly classify the route. The general engineer conducts reconnaissance to obtain the information needed to classify and provide designs for upgrades.

3-83. Route reconnaissance is conducted to evaluate the proposed routes, soil properties, terrain, borrow sites, quarries, hydrology, and condition of existing roads. The information from route reconnaissance supports route selection decisions; the design of a new road; or the maintenance, repair, or upgrade of an existing road needed before a route can carry the proposed traffic.

3-84. Route reconnaissance is classified as hasty or deliberate. The way in which route reconnaissance is performed depends on the amount of detail required, the time available, the terrain problems encountered, and the tactical situation.

3-85. Hasty route reconnaissance determines the immediate military trafficability of a specified route. It is limited to critical terrain data necessary for route classification. The results are part of the mobility input to the common operational picture. Information concerning the route is updated with additional reports as required by the situation and/or the commander's guidance.

3-86. A deliberate route reconnaissance is conducted when sufficient time and qualified technical personnel are available. Deliberate route reconnaissance is usually conducted when operational requirements are anticipated to cause heavy, protracted use of the road. It may be the first reconnaissance conducted, or it may follow the conduct of a hasty route reconnaissance.

INFRASTRUCTURE RECONNAISSANCE (ASSESSMENT AND SURVEY)

3-87. Infrastructure reconnaissance is a multidiscipline variant of reconnaissance to collect detailed technical information on various categories of the public systems, services, and facilities of a country or region. The infrastructure reconnaissance develops the situational understanding of the local capability to support the infrastructure requirements of the local populace or military operations within a specific area. Infrastructure reconnaissance is accomplished in stages: the infrastructure assessment and the infrastructure survey. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) for additional information on infrastructure reconnaissance.

3-88. Coordinating with the combat engineer units for an on-site visit, an engineer reconnaissance team can be expected to conduct the initial assessment with available expertise from the supported unit. The initial assessment provides information to confirm or deny planning assumptions, update running estimates/staff estimates, determine immediate needs, develop priorities, obtain resources, and refine a plan. As operations continue, general engineer and other supporting technical support elements provide teams that are qualified to perform an infrastructure survey. These infrastructure survey teams use the infrastructure assessments from the engineer reconnaissance teams to prioritize categories and identify those parts of the infrastructure to be reassessed in more detail.

3-89. Reconnaissance capabilities, when not in direct support of combat engineers, are typically organized into assessment or survey teams. These task-organized teams have a specific focus for the collection of technical information and are less likely to be teamed directly with reconnaissance units in the BCT or BLT. The BLT tends to rely more heavily on joint Service support or other general engineering augmentation to provide the engineer technical reconnaissance.

3-90. Technical capabilities required to perform a comprehensive reconnaissance include robust support from joint Service, multiagency, contractor, HN, multinational, and reachback elements. FFE provides a broad range of expertise that can support reconnaissance by linking in through the engineer element on the ground to apply a higher degree of technical expertise to the assessment or survey mission. FFE, as it relates to reconnaissance, is discussed in ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4).

ENVIRONMENTAL RECONNAISSANCE

3-91. Environmental reconnaissance is focused on collecting technical information on existing environmental conditions and identifying areas that are environmentally sensitive or of relative environmental concern. The information collected is used to assess the impact of military operations on the environment and to identify potential environmental impacts on safety and protection.

3-92. Similar to infrastructure reconnaissance, environmental reconnaissance is a multidisciplinary task conducted by a base team, augmented as necessary with additional expertise. An engineer reconnaissance team may conduct the initial site assessment and gather information, which assists in determining whether a parcel of land is acceptable for military use. This assessment is as detailed as the situation permits and is focused on determining whether the site is healthy for occupancy.

ENVIRONMENTAL BASELINE SURVEY

3-93. The general engineer will likely be responsible for coordinating environmental reconnaissance to conduct the EBS but should rely on other branches (CBRN, medical, civil affairs, and explosive ordnance disposal) for assistance in those areas requiring specialized expertise.

3-94. If the tactical situation permits, commanders conduct an EBS before occupying a site. An EBS documents the original environmental condition of the land. An EBS is required if an area is to be occupied by U.S. forces for more than 30 days. To provide financial protection to the United States and its allies against unjust claims and charges for using, renting, or leasing real property, a completed EBS should be included (regardless of the duration).

3-95. An EBS identifies environmental hazards and issues that could impact area suitability for occupation by U.S. forces. This document is also critical during base cleanup and closure, when the U.S. military prepares to return the land back to the HN in its original condition. An EBS is also conducted to protect the U.S. government from future claims or liability.

3-96. Ideally, the EBS is conducted in conjunction with an OESHA since the two documents support each other. An OESHA is conducted by a medical base team augmented with other specialties (engineer, CBRN, or others).

3-97. An OESHA is conducted to determine whether environmental contaminants from current or prior land use, disease vectors, or other environmental health conditions that could pose health risks to deployed personnel exist at the deployment sites. Additionally, an OESHA identifies industrial facilities and commodities near the site that could, if damaged or destroyed, release contaminants harmful to personnel. While the EBS is generally more visual and engineer-related, the OESHA is more analytical (which includes a greater variety and detail of sampling), with a greater focus on health hazards.

Note. See ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B) for more information on conducting an EBS before the establishment of a base camp.

UNCERTAINTY

3-98. Commanders and staffs must have tolerance for the uncertainties (beyond their span of control) associated with planning solutions, specifically base camps and bed-down facilities, and be prepared to handle the inherent ambiguities and complexities through extensive planning and continuous coordination that effectively mitigate risk. Two of the most demanding challenges are as follows:

- **Projected population.** Projected population is accurately estimating the intended base camp population (personnel, vehicles, and equipment that will be on the base camp or facility at any one time). This can be difficult due to fluid changes in assigned units, transient personnel, contractors, and HN personnel.
- **Projected service lifespan.** Projected service lifespan is accurately determining the expected service life-span of the base camp or facility based on mission duration. The size and composition of the deployed force may change between planning and construction and will almost certainly change over the lifespan of a base camp or facility. In addition, the actual mission support timeline may also change over time and require adjustment.

3-99. These uncertainties force planners to plan and seek design solutions based on valid assumptions which, if proven false, can result in inadequate facilities and infrastructure or wasted construction that cannot support the mission. With this in mind, engineers strive for planning and designing scalable solutions that assist in mitigating the effects of uncertainty.

GENERAL ENGINEERING DESIGN

3-100. Most design is performed by trained architects and engineers of many disciplines, such as civil, architectural, geotechnical, structural, electrical, and environmental. Some engineers may be professionally registered, and others may be trained to perform simpler designs. Engineer designs for construction in contingency locations, up to the semipermanent duration of construction, do not require a professional engineer to certify the design. Engineer construction in enduring locations, built to semipermanent and permanent construction durations, are usually designed by U.S.-licensed architects and engineers. The Army has designated some duty positions that require a professional architect, a professional engineer, or an environmental engineer certification or registration.

3-101. Military engineers are trained to perform design by several methods: using basic engineering principles, equations, and design procedures; using step-by-step procedures with tables and charts; and using computer- or application-aided design. Each method may be needed to site-adapt standard facility designs. All methods of design require engineering judgment, the application of engineering principles, mathematical problem solving, and engineering knowledge.

DESIGN CONSIDERATIONS

3-102. Key design considerations include—

- Operational requirements.
- Resource constraints.
- Basing strategies.
- Base camp schemes.
- Master plans.
- Design criteria.
- Standards.
- Design life expectancies.
- Economic analysis.
- Available materials.
- Available units.
- Intended purposes or functions.

3-103. Design produces efficient and effective solutions. Ideally, if a new design is necessary, it should be simple and flexible and must reflect available materials and the level of training of construction personnel (see TM 3-34.51/MCRP 3-40D.15).

3-104. During design, engineering principles; construction means; standards; site conditions; and adaptable, scalable designs are matched against client facility and infrastructure requirements. The end result is the production of detailed site designs, plans, drawings, specifications, and special instructions needed for constructing facilities and infrastructure that meet requirements. Some higher headquarters designs may be conceptual, preliminary, detailed, or final-approved designs. Some designs cannot be finalized until the construction unit completes the engineering reconnaissance to obtain on-site information. Other standard or detailed designs may be site-adapted with or without higher headquarters approval.

Design Agency Process

3-105. The design agency may be a military headquarters engineer staff, a constructing unit, a service construction agent (USACE or NAVFAC), or a contracted architect or design firm. Design begins during initial project planning. DD Form 1391 (*FY____Military Construction Project Data*) is a programming tool used to request funding and justify a user need. The DD Form 1391 format enables the preparing official to systematically provide the data required for design, proper review, and validation of the project. Refer to AR 420–1, FC 1-300-09N, OPNAVINST 11010.20H, and UFC 1-300-08 for information on preparing DD Form 1391, project programming development, and design procedures.

> ***Note.*** Not all design work is based on DD Form 1391. Other projects may also be designed based on construction directives from higher headquarters, such as an OPORD to an engineer unit designated as the construction agent for a design-build project. The design period may begin before, during, or after force deployment.

Architect and Engineer Roles

3-106. The design architect or engineer is professionally liable for any failure in the functionality and safety of the design. Therefore, the architect and engineer have a vested and shared interest in ensuring that the project is correctly built according to plans and specifications. The contracting office or responsible design headquarters engineer organization coordinates with the architect or engineer to produce the plans and specifications and to design the change directives required to accommodate the differing site conditions, client-requested changes to the design, or problems encountered during construction.

3-107. The architect or engineer produces a set of plans and specifications (to include a submittal register for materials, equipment, and systems requiring approval before use) based on the concepts and requirements that define and meet the needs of the client. The architect and engineer may provide design and engineering assistance and oversight during military or contracted construction.

Site-Adapted Designs

3-108. Site-adapted designs are generally approved by the headquarters that completed the concept designs. The constructing unit may possess the necessary engineering expertise (or obtain it through reachback), automated design tools, access to standard designs, and network capability to share, archive, and print construction documents.

3-109. Planners and the constructing unit assess the progress and compare forecasted outcomes with actual events to determine overall effectiveness. Based on this assessment, adjustments are made, or new options are developed to achieve the desired results. Lessons learned and recommended improvements to standard designs and theater adaptations are captured to facilitate design modifications, and facility records and as-built designs are updated and maintained to facilitate future construction and transfer or closure.

3-110. One of the possible options for base camp and bed-down facility designs of new facilities should be the use of standard AFCS designs. As plans are finalized, the standard designs are site-adapted accordingly. If some or all existing facilities are used, the information from the AFCS can be used as planning factors to help estimate and assess facility requirements and design upgrades. Standard facility designs should be modular, scalable, sustainable, and energy efficient. The AFCS and Service doctrinal design and construction technical publications should provide metric designs and standards that can be used in regions that use the metric system.

3-111. When possible, the construction unit should be included in the design effort. Since the construction unit may not yet be identified during the initial design effort, an engineer with construction experience, knowledge of construction techniques, and unit capabilities should be part of the design team. The construction unit or its immediate higher headquarters should be included in the detailed design process if they are not directly responsible for it.

Drainage System Designs

3-112. The drainage system for each facility or project site should be planned and designed before occupying the site or starting construction. The planning and design of drainage systems are conducted by the higher headquarters design engineers and the constructing unit. The drainage system includes the overall drainage plan, area drainage structures, individual facility drainage structures, and temporary construction drainage.

3-113. Drainage system design includes construction drainage, a sedimentation control plan, and permanent drainage structures. The three basic procedures in drainage system design are—

- Determining the area that is contributing runoff.
- Estimating the quantity of runoff.
- Designing the drainage structure for maximum runoff.

3-114. In permanent, peacetime construction, underground drains are often used because the efficient use of space, environmental considerations, and safety practices does not permit large, open ditches, particularly for the disposal of collected runoff. In contrast, designs for road drainage in contingency operations use surface ditching almost exclusively because of limited pipe supplies and the absence of storm sewer systems to collect runoff. Design the drainage system to remove surface water effectively from operating areas, to intercept and dispose of runoff from adjoining areas, to intercept and remove runoff expected due to the selected design storm, and to minimize the effects of exceptionally adverse weather conditions.

3-115. The siting of base camps and individual facilities can have major effects on required drainage structures and their associated cost in terms of materials and construction effort. Inadequate drainage is the most common cause of road and airfield failure. Data on local drainage conditions for initial planning may be obtained from maps and aerial reconnaissance and can then be confirmed with on-site ground reconnaissance and information from local inhabitants. See TM 3-34.48-1 for a discussion on drainage system designs.

Design Variables

3-116. Some of the primary variables affecting design that must be resolved through planning and reconnaissance include—

- The availability of suitable existing facilities and infrastructure.
- The availability of suitable construction materials and means for performing construction (skilled labor and special equipment provided by troops or contractors).
- Facility allowances, construction standards, and safety requirements.
- The prescribed level of capabilities and linkages to other similar facilities.
- Terrain and weather effects at selected facility locations.
- Protection and security requirements (based on threat and vulnerability assessments).
- Civil and environmental considerations.
- Cost and time constraints.
- Governing U.S. regulations and policies and HN laws and customs.
- Weather data reports on rainfall and snowfall patterns.

Protection Considerations

3-117. Facilities should be designed to resist attack through selecting proper materials, limiting the number of doors and windows, and orientating openings to minimize overall blast radius exposure. Minimum contingency requirements normally are hardened walls and roofs that protect occupants and that are sized to adequately accommodate personnel.

3-118. Overhead blast protection designs can be incorporated into contingency construction facilities and are available as a retrofit for existing structures (such as low-emissivity glass [commonly referred to as e-glass]). The most common design is a layered structure, with one layer used to detonate incoming munitions and a second layer used to absorb the blast concussion and shrapnel.

3-119. The JCMS incorporates limited protection requirements into its designs. Protection designs fall into two main categories: isolation and hardening. For facility protection, planners consider using facility hardening, dispersion, standoff, and security. Some examples are as follows:

- For facilities that must be isolated, most designs need to be augmented. One means is the use of soil-filled containers to create a system of barriers that surround and separate the facility.
- The hardening of facilities is desirable when terrain constricts dispersion and the threat analysis indicates that the facilities are likely possible targets for enemy weapons. Concrete masonry walls can be hardened with reinforced concrete up to the blast height. The walls can also be reinforced with blast mitigation products as outlined in GTA 90-01-011. Hardening techniques are discussed in ATP 3-37.34/MCTP 3-34C.
- Widely dispersing facilities (where terrain conditions permit) should be established to prevent the enemy from inflicting massive damage in a single strike; however, precautions must be made to ensure that operations are not unduly hampered by ill-planned dispersion schemes.
- Standoff distances that equate actual distances from force protection barriers, such as fences, to the closest facility should also be considered. Avoid building facilities close to fences.

3-120. The force protection of a facility or installation may be accomplished by active and passive security measures, including facility hardening and dispersion. See ADP 3-37 and ATP 3-37.34/MCTP 3-34C for more information on protection and survivability. The enemy situation must be evaluated as carefully and thoroughly as possible. Threats to supply and maintenance facilities may include conventional and nonconventional ground forces, CBRN threats, and attacks delivered by direct and indirect systems. The remote delivery of mines should also be considered.

3-121. Insurgent activities may pose a threat to logistics assets. In determining how to best protect a facility against interdictory attacks, the commander must take into account the surrounding terrain, local weather and climate conditions, the availability of Class IV and V materials to support protective measures, rules of engagement/rules for the use of force and the current enemy situation.

3-122. Force protection primarily affects base camp development (site selection, layout, design, and construction), including base camp security and defense, antiterrorism measures, survivability, facilities for force health protection, safety techniques (including friendly fire avoidance), physical security systems and, if assigned the task, detainee, and resettlement facilities. The development of the base camp layout ensures the adequate protection of personnel and assets.

3-123. The key to the effective development of base camp protection is a working partnership between those personnel focused on antiterrorism and other protection issues and the site engineers. This partnership facilitates the development of integrated physical security protective measures and security procedures that are consistent with base camp design.

3-124. The early identification of protection requirements is essential to base camp planning efforts. Addressing the collective protection concerns early helps to ensure that site location and layout are compatible with security and mission accomplishment.

Notes.

1. See ADP 3-37, AFCS program guidelines, ATP 3-37.2, ATP 3-39.32, ATP 3-37.34/MCTP 3-34C, and GTA 90-01-011 for additional information on determining threats, assessing vulnerabilities, and integrating antiterrorism and protection measures within operations.

2. See UFC 4-010-01 for additional information on antiterrorism standards.

3. See UFC 4-010-03, UFC 4-010-05, UFC 4-020-01, UFC 4-020-03FA (FOUO), UFC 4-021-01, UFC 4-021-02, UFC 4-022-01, UFC 4-022-02, UFC 4-023-03, UFC 4-023-07, UFC 4-024-01, and UFC 4-025-01 for additional information on facility force protection planning, design, and construction.

4. See UFC 1-201-01 for additional information on the criteria for life safety- and habitability-related design requirements for nonpermanent facilities in support of military operations.

Fire Protection and Fire Prevention

3-125. An effective fire protection plan is critical to the safety of personnel, facilities, and equipment. Adequate fire protection must be included in the design of base camps. This includes proper tent and building spacing, means of egress, wiring standards, use of flame-retardant materials, firefighting vehicle access, availability of water supply, and fire protection and HAZMAT spill response equipment. See TM 3-34.30 and UFC 3-600-01 for more information on firefighting.

3-126. The Army engineer firefighting unit is discussed in TM 3-34.30. Engineer firefighting units are considered specialized units. They specialize in fire prevention, rescue, and firefighting to protect personnel, assets, and installations. They can assist in fire inspections and fire prevention training and can advise the commander on fire hazards. They are typically assigned to installations, seaports, and airfields.

3-127. Temporary structures generally use combustible materials. Austere environments often lack adequate water and maintenance resources to support modern fire suppression systems. Fire can result in the rapid loss of facilities and can spread quickly to other structures. Poor construction standards, flammable materials, and human error can make facilities very susceptible to fire damage and the catastrophic loss of life or materials. TM 3-34.30 gives specific guidance for firefighting and rescue procedures. This technical manual prescribes the assignment of firefighting assets based on the supported population or facility area. For example, airfields, troop populations of 5,000 to 10,000 persons, or storage areas containing more than 100,000 square feet of storage space are each allocated at least one fire pumper truck team.

3-128. The commander has full responsibility for implementing fire prevention and protection. All Army, command, and local fire regulations must be enforced. Programs of inspection must be established, self-help and firefighting responsibilities identified, and equipment assigned. AR 420-1 provides further information about fire prevention and protection.

3-129. Fire protection measures available to the commander include—

- Enforcing the rule.
- Setting up alarm and notification procedures.
- Procuring and making available extinguishers and other firefighting equipment.
- Training personnel in fire prevention and protection measures.
- Locating water tanks and reservoirs in key centralized areas to properly support firefighting activities.
- Ensuring that installation or base camp facilities allow access for firefighting personnel and their vehicles to move about freely to perform their duties unimpeded.

3-130. An additional requirement for the assets that provide fire protection is responding to HAZMAT spills. This support is an important part of environmental considerations that may have a direct effect on force health protection. See UFC 3-601-02 for additional information on dry chemical suppression systems.

Safety

3-131. Designers work together with safety specialists to mitigate hazards that are developed as part of risk management, which is initiated during planning and continues throughout the base camp life cycle.

3-132. The design influences safety considerations during construction. Some designs and the associated construction methods may be more difficult, especially when unskilled labor is used, and inherently more dangerous. Designers must ensure that the complexity of designs is reasonable and justifiable based on the construction means available and that the means for enforcing safety and mitigating risks during construction is achievable. HN laborers and contractors may not adhere to expected construction and safety standards.

3-133. Any specifications in component configurations, materials, and construction tasks that are essential for achieving the quality and safety features of the design must be clearly articulated and communicated to the constructing unit and become part of the overall quality assurance or quality control plan. Any incorrect design decisions, changes desired by the facility user, or material substitutions based on availability may require the reevaluation of designs. When possible, include firefighters in planning and design.

3-134. One of the possible options for the base camp and bed-down facility design of new facilities should be the use of standard AFCS designs. As plans are finalized, the standard designs are site-adapted accordingly. If existing facilities are used, information from the AFCS can be used as planning factors to help estimate and assess facility requirements and design upgrades. Standard facility designs should be modular, scalable, sustainable, and energy efficient. The AFCS converts U.S. standard designs to metric designs.

3-135. When possible, the construction unit should be included in the design effort. Since the construction unit may not yet be identified during the initial design effort, an engineer with construction experience, knowledge of construction techniques, and unit capabilities should be part of the design team. The construction unit or its immediate higher headquarters should be included in the detailed design process if they are not directly responsible for it.

Structural Integrity

3-136. The safety risks from structural collapse increase when existing buildings are used for a new purpose with greater loads or when damaged. Although contingency construction standards are generally conservative to address a wide range of loads in different environments, the structural integrity and conditions of an existing structure can vary greatly based on HN construction standards, the quality of construction, and the effects of battle damage. Existing structures may have little resistance to seismic activity, abnormal weather, or impact loads.

3-137. The general engineer or other qualified engineer representative must oversee the allowable use of existing structures. A proper structural analysis and materials evaluation must be completed before protection measures are affixed to an existing structure since they may increase the load-bearing structural capacity.

3-138. A qualified engineer oversees the repair, modification, or expansion of an existing building to ensure that it conforms to established policies and standards. Construction variances with structural components that deviate from the Service standards require a structural assessment and compliance with UFC. Material substitutions for structural members with standard designs require a structural assessment and compliance with UFC. This necessitates completing a structural assessment and repair before buildings can be occupied.

GENERAL ENGINEERING DESIGN PROCESS

3-139. JCMS is the primary design platform employed by military engineers. This specific design program is best suited for use in deployed locations, or a designer may be more experienced using another specific design program. Design is often a collaborative and interactive process with planners, engineers, and actual or potential users. A typical design process generally consists of the following steps:

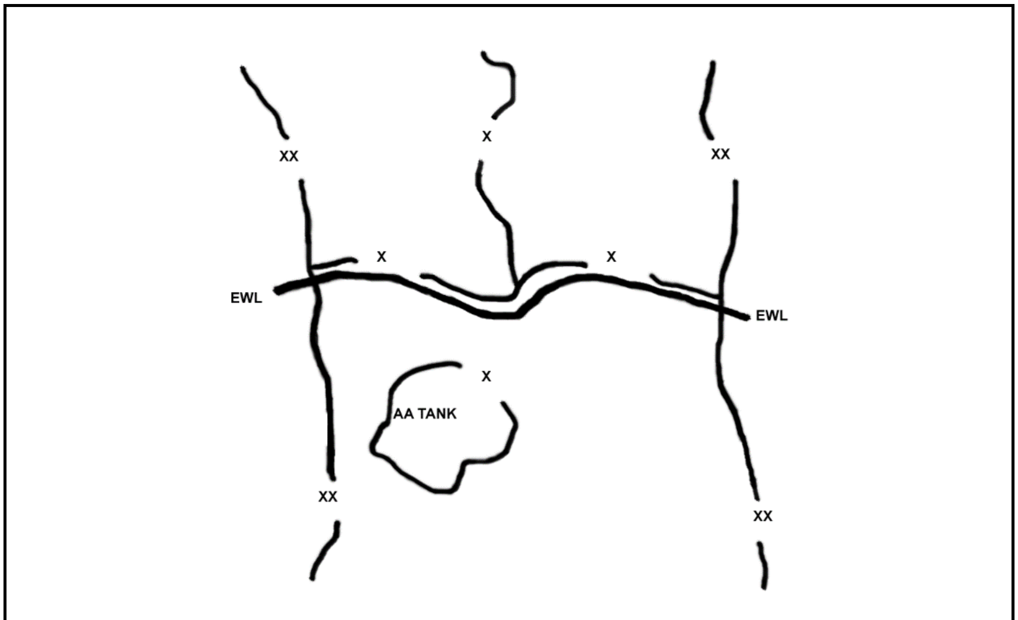
- Define life cycle requirements.
- Identify resources and constraints.
- Develop and conceptualize options.
- Evaluate options.
- Make a decision.
- Implement, assess, and adjust as necessary.

ENGINEER WORK LINE

3-140. An *engineer work line* is a coordinated boundary or phase line used to compartmentalize an area of operations to indicate where specific engineer units have primary responsibility for the engineer effort (FM 3-34). It may be used at the division level to discriminate between an area of operations supported by division engineer assets and an area of operations supported by direct support or general support corps engineer units. The engineer work line may also be used as a boundary between engineer organizations, but this should not be its primary purpose. It may or may not follow maneuver unit boundaries.

3-141. Traditionally, the engineer work line is used at the division level to delineate between engineer capabilities assigned to the division level and higher-echelon engineer units. It also serves as a visualization tool for the engineer staff officer. Forward of the engineer work line, efforts are focused on combat engineering functions and tasks. Most resource-intensive construction tasks are performed behind the engineer work line.

3-142. The use of the engineer work line as a visualization tool and graphic control measure (see figure 3-1, page 3-22) is effective when assigning responsibility and coordinating actions on the contiguous battlefield. This allows engineer units (who are organic and augment the division) to focus on providing robust engineering support forward of the engineer work line. To the rear of the engineer work line, uncommitted EAB engineer units in a direct support or general support role to the division can focus primarily on executing tasks that sustain the division. Such tasks may include LOC upgrade and repair, facilities construction, field landing strip repair, LOC bridging, and other sustainment/combat service support of the force.

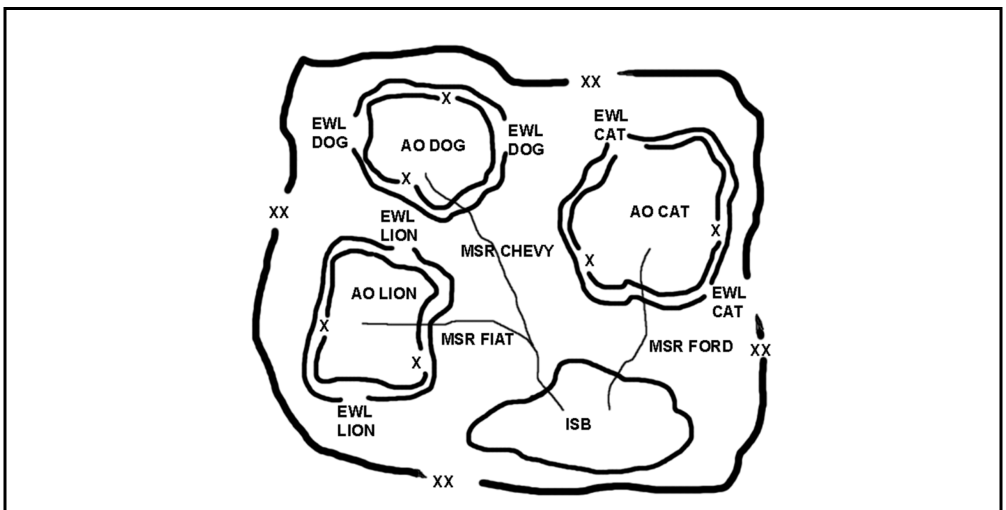


Legend:

AA	assembly area
EWL	engineer work line

Figure 3-1. Division engineer work line in contiguous operations

3-143. Figure 3-2 represents an example of multiple engineer work lines to depict responsibilities between engineers (who are organic and augment division) and BCT and EAB engineer units. In this case, engineers (who are organic and who augment BCTs) focus primarily on engineering tasks inside engineer work lines Dog, Cat, and Lion, while EAB engineers are responsible for tasks throughout the remainder of the division area of operations, including the intermediate staging bases. During the offense and defense, the focus shifts to providing support to the BCTs and providing combat engineering support to combat maneuver forces. However, during stability operations or DSCA, tasks are executed with EAB engineers operating throughout the area of operations.



Legend:

AO	area of operations
EWL	engineer work line
ISB	intermediate staging base
MSR	main supply route

Figure 3-2. Division engineer work line in noncontiguous operations

3-144. At corps, theater, or joint levels, the engineer staff officer for that echelon may establish a corps engineer work line or theater engineer work line in much the same manner as the division work line. The theater engineer staff officer augments subordinate echelons by assuming responsibility for specific support, on a task basis, forward to the appropriate engineer work line, thus releasing the direct support/general support engineer units to engage in activities as far forward as possible.

3-145. The engineer staff officer who assigns the engineer work line to a particular sector is responsible for planning and advising the commander when the engineer work line shifts. This occurs after a careful analysis of the ongoing operation, available engineer capabilities, and future requirements. Early in a contingency, it may be very difficult for the theater engineer staff officer to shift the theater engineer work line out of the theater staging base because of shortages in the general engineering capacity.

UNIFIED FACILITIES CRITERIA

3-146. The UFC provide facility planning, design, construction, operations and maintenance, sustainment/combat service support, restoration, and modernization criteria that apply to all DOD and Service components. The Army Facilities Standardization Program is a formal process for developing Army standards and standard designs. Standard design includes the drawings and specifications developed to ensure the application of sound engineering principles in the design process.

3-147. The Army Facilities Standardization Committee has final approving authority for all UFC that affect Army standards. Army standards are listed in a table of mandatory criteria containing the functional requirements necessary to complete military missions (present and future). These Army standards are coordinated with Army functional proponents and are approved by the HQDA Deputy Chief of Staff (G-9) in coordination with the Army Facilities Standardization Committee.

3-148. UFCs are used for all Service projects and work for other customers, where appropriate. Individual UFCs are developed by a single-disciplined working group and are published after careful coordination. UFC are jointly developed and managed by USACE, NAVFAC, and the Air Force Civil Engineer Center.

3-149. Although UFC are written with semipermanent and permanent standards in mind, planners who are executing under initial, temporary, and semipermanent construction standards find them useful. Topics include pavement structure design, water supply systems, military airfields, concrete design and repair, plumbing, electrical systems, and many others.

3-150. The UFC system provides planning, design, construction, operations, and maintenance criteria and applies to all Service commands having military construction responsibilities. UFC are living documents and are periodically reviewed, updated, and made available to users to provide technical criteria for military construction. UFC are only published in electronic media form from—

- The Whole Building Design Guide website.
- The NAVFAC Engineering Criteria and Programs Office website.

FIELD FORCE ENGINEERING

3-151. The overarching concept of the FFE program is discussed in FM 3-34. It is the application of Army Engineer Regiment capabilities across the competition continuum facilitated by forward presence and reachback. FFE works to provide seamless specialized support to military operations and to provide military support to the Department of Homeland Security and the Federal Emergency Management Agency in federal military support to civilian authority response to catastrophic civil disasters. See MCTP 3-34D for a description of the Navy equivalent FFE capabilities associated with NAVFAC.

3-152. FFE fuses the capabilities resident in the USACE, Army Engineer School, theater engineer command, public works, and civilian contractors. It recognizes the critical need for early, integrated engineer participation in planning and optimizing engineer capabilities for mission analysis, development, and accomplishment.

FORWARD-PRESENCE CAPABILITY

3-153. FFE has the ability to form scalable modular teams that are capable of deploying into theater on short notice to provide engineering support to the CCDR and fill gaps in capabilities and expertise. Engineer planners must carefully analyze the mission to determine the required level of forward-presence support and tailor its requests. Because these teams can be tailored, specificity of requests in terms of the mission type is critical. To facilitate the engineer planning effort, USACE maintains established liaison officer planners at the combatant command and ASCC/MCCC levels.

3-154. Requests for USACE support should be channeled through the USACE liaison officer at the combatant command or ASCC/MCCC echelons. The USACE assistant chief of staff, operations (G-3) respond to requests for engineer support if coordination through a liaison officer is not possible.

FIELD FORCE TEAMS

3-155. FFE teams include the following:

- FEST (advance).
- FEST (main).
- Contingency real estate support team.

REACHBACK CAPABILITIES

3-156. Engineers have a variety of reachback capabilities at their disposal. These capabilities include the—

- Army Engineer School.
- Marine Corps Engineer School.
- Base development team.
- UROC.
- Reachback equipment.

United States Army Engineer School

3-157. The Army Engineer School plays a key role in training new generations of Soldiers in bridging construction, reviewing current practices, and developing new bridge training. The Army Engineer School can provide a reachback capacity to the engineer in the field by providing staff expertise. It also supports MSCoE in developing new bridging systems and gap-reduction capabilities. See FM 3-34 for additional information on the role of the Army Engineer School.

3-158. The Directorate of Environmental Integration ensures that the development and implementation of environmental training and doctrine programs and products that support military training and readiness operations are consistent with regulatory requirements and Army environmental policies (see AR 200-1). The Directorate of Environmental Integration can provide on-demand training and reachback support to unit environmental officers.

United States Marine Corps Engineer School

3-159. The Marine Corps Engineer School reachback capability is under development. See the Marine Corps Engineer School Training and Education Command website for more information. MCWP 3-34 provides information about reachback resources for distributed maritime operations.

Base Development Team

3-160. The base development team provides installation-level base development planning and facilities design expertise for intermediate staging bases, base camps, bases, and detainee or resettlement camps. It integrates environmental aspects into the design of these facilities. This 10-person, nondeployable organization is located in various USACE engineer districts and draws support from UROC and other USACE centers of expertise.

3-161. The base development team is capable of completing 30 percent of the design of a major base camp within three days. It uses the inherent capabilities of the AFCS and JCMS to prepare designs and passes them to forward presence organizations via the TeleEngineering Operations Center or the Secret Internet Protocol Router Network. The base development team is prepared to provide support for civil disaster response, as needed.

United States Army Corps of Engineers Reachback Operations Center

3-162. The UROC facilitates reachback for deployed troops to link up with subject matter expertise (professional engineers, scientists, and technicians; private industry; academia; and databases) that is not resident in the theater or area of operations. Troops are able to obtain a detailed analysis of complex problems that would be difficult to achieve with limited expertise or computational capabilities available in the field.

3-163. UROC staff members respond to incoming information requests and provide detailed analysis, such as flooding potential due to dam breaches, load-carrying capabilities of bridges, field fortifications and protection, the evaluation of transportation networks, and water resource data. It has access to the USACE Transportation System Center, which includes subject matter experts on airfields, roadways, and railroads.

3-164. The UROC serves as the focal point for videoconferences. It has a classified bridge with ports for videoconferences and an unclassified bridge with additional user ports. For more information, see the USACE Reachback Operations Center website.

Reachback Equipment

3-165. USACE and other engineer organizations distribute a variety of systems for facilitating reachback for technical engineering support for problems requiring rapid solutions. Reachback equipment includes the TeleEngineering Communication Equipment, geospatial assessment tool, automated route reconnaissance kit, environmental toolkit for expeditionary operations, and TeleEngineering Toolkit software.

TeleEngineering Communication Equipment

3-166. TeleEngineering Communication Equipment provides a secure and nonsecure communications link between deployed USACE personnel, their headquarters, engineer units, and subject matter experts to meet mission objectives. TeleEngineering Communication Equipment provides reachback capability using cutting edge, off-the-shelf communications equipment with added encryption. Videoconferences and data transfers can be conducted from remote sites where other means of communication are nonexistent or unavailable.

3-167. TeleEngineering Communication Equipment comes with its own satellite links and, therefore, does not use bandwidth from units deployed in-theater. Although originally designed for use by USACE organizations, TeleEngineering Communication Equipment sets have been fielded to a number of tactical units to enhance their reachback capability.

Geospatial Assessment Tool

3-168. The geospatial assessment tool is a suite of applications that allows field data collection. A desktop application serves as a conduit to synchronize data from the field to the desktop and then to an online data repository and geographic information mapping system. Such information can include the assessment of critical infrastructure, real estate environmental condition reports, access control points, and weather information.

Automated Route Reconnaissance Kit

3-169. The automated route reconnaissance kit is an adaptable, easy-to-use reconnaissance package that allows military units and civilian agencies to rapidly collect, process, and distribute route reconnaissance information.

TeleEngineering Toolkit Software

3-170. The TeleEngineering Toolkit software is a USACE-supported software product that provides a valuable analysis tool for a graphic display of engineer products, analysis, and digital data. By annotating an area of interest, a small reference file can be sent back to subject matter experts to provide information requests for a variety of information requests, such as a cross-country mobility analysis, a flood analysis, and vegetation information.

3-171. The response is sent back from the mission support element and is graphically displayed on the TeleEngineering Toolkit software system. It also works with the automated route reconnaissance kit using a global positioning system, a video camera, and a 3-D accelerometer to provide a mounted vehicle or airborne automated reconnaissance capability.

Chapter 4
Construction

Construction is the art or process of building or assembling structures such as base camps, bed-down facilities, or other infrastructure. It consists of a wide range of activities, methods, and techniques used to combine individual parts and for marshaling resources together to create a greater whole. Construction life cycle refers to the means and methods for constructing, modifying, upgrading, and deconstructing base camps and bed-down facilities that are devised through planning and design. Construction is performed by military units and CAAF and non-CAAF. Facilities and infrastructure are built using various methods that are evaluated and determined during planning and design. Existing facilities and infrastructure are used to the fullest extent to minimize the overall construction effort and reduce the logistics footprint. The military maximizes the use of modular systems and prefabricated or pre-engineered components, which facilitates rapid development, achieves scalability, and reduces the time required for closing facilities that are no longer needed. This chapter describes general construction planning and estimating, project management, methods of construction, and procurement and production of construction materials and provides an overview of construction techniques.

PLANS AND ESTIMATES

4-1. Construction planning and estimating begin at each level as early as possible to determine requirements, timelines, and COAs for construction methods, materials, construction techniques, and resulting unit requirements. There are two levels of construction planning: preliminary planning performed by service construction agents and engineer unit higher headquarters and detailed planning performed by the constructing engineer unit. Project estimates support construction project planning.

4-2. Each headquarters level verifies the planning and estimating facts, assumptions, and details from the higher level and develops additional information for subordinate staffs and units. The constructing unit produces the detailed construction plan. The detailed construction plan includes the site layout, safety, and jobsite security. Detailed estimates include material, equipment, and labor estimates.

4-3. NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12 provides all Services standard procedures, information, and data on the construction project estimating of projects built by military engineer units. Commercially available estimating tools and books are also available. Planners, designers, and project managers use the JCMS as a source for man-day estimates. JCMS supports engineer planners with facilities design information for outside of the United States or theater operation mission requirements. See the USACE website for additional information on JCMS.

4-4. Engineers should examine subordinate doctrinal TMs for more detailed discussion on planning and estimating. Appendix B provides engineer construction planning factors for base camps. Constructing unit standard operating procedures based on the unit equipment; level of training; and site-specific, demonstrated unit production rate may provide the best detailed estimates. For estimating quantities, use NTRP 4-04.2.3/TM 3-34.41/AFPAM 32-1000/MCRP 3-17.7M. Planning factors are found in doctrinal publications or unit standard operating procedures based on site-specific conditions and experience.

JOINT CONSTRUCTION MANAGEMENT SYSTEM

4-5. The JCMS is a personal computer-based, automated military construction planning system with a digital design, management, database, and reporting system that is used by military engineers for contingency construction activities in an operational area. It provides military planners, logisticians, and engineers the information necessary to plan, design, and manage theater construction projects where austere, temporary facilities are required. JCMS is the official tool for base camp development, planning, and design, including naval facilities and air bases.

4-6. The primary purpose of the JCMS is to support engineer planners with facilities design information for use outside of the United States to meet mission requirements. JCMS is the delivery vehicle of the AFCS program. The proponent agency of AFCS is the Army Office of the Chief of Engineers. Refer to the JCMS website for additional information.

4-7. JCMS is the approved method for distributing AFCS designs and related information. The AFCS provides logistics and engineering data that is organized, coded, and published to assist engineer planners and designers in executing construction missions in contingency environments. See the UROC REDi website for information on how to use the AFCS system.

4-8. Key features of JCMS include—

- **Planning.** Users can develop facility and installation plans to satisfy mission construction requirements using JCMS computer routines. The system determines personnel and material requirements and the cost, weight, and volume of materials needed for a specific project.
- **Design.** Users can prepare site-specific new design or construction drawings, use existing AFCS designs within the JCMS, modify the drawings as required, and adapt mission requirements using the JCMS computer-aided design and drafting capability. The system provides standard plans for base camp developments, utilities, and airfields.
- **Management.** Users can set up and manage construction progress and resource allocation and utilization throughout the construction time frame.
- **Reporting and communication.** The JCMS develops and transmits the necessary reports following the engineer chain of command to facilitate the decision-making process using intercomputer electronic and direct entry.

ARMY FACILITIES COMPONENT SYSTEM

4-9. AFCS is the primary tool that provides engineers the information needed to plan, design, and manage theater construction projects where austere, temporary facilities are required. AFCS is discussed further in the TM 5-301 series. AFCS and the TM 5-301 series provide a set of standard facility designs managed and supported by USACE. AFCS is an engineering construction support program for Army mission construction.

4-10. AFCS also supports emergency construction during disaster relief in any area when required. It provides planning guidance, construction drawings, a bill of materials, and labor and equipment estimates. AFCS designs include troop camps, hospitals, bridges, marine terminals, port facilities, petroleum storage and distribution facilities, and ammunition storage facilities.

4-11. The facilities and components in the AFCS satisfy many of the base camp and bed-down facility requirements identified during planning. The AFCS provides ready-made, on-the-shelf standard designs that are site-adaptable, scalable, and capable of serving many functions. The AFCS facilities have an expected design life of at least 24 months.

DRAINAGE

4-12. The constructing unit establishes construction drainage on the construction site to prevent water from interfering with the construction progress. Construction drainage may be temporary drainage structures or part of the permanent drainage system constructed early.

PROTECTION

4-13. The constructing unit constructs protective structures using protection designs, construction techniques, and methods discussed in AFCS program guidelines and ATP 3-37.34/MCTP 3-34C.

PROJECT MANAGEMENT

4-14. NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.5 (MCRP 3-17.7F) provides all Services the common methods, procedures, and formats for construction project management at the operational unit level required by military engineers to successfully plan, schedule, and execute construction projects in deployed locations. The duration and amount of effort for each phase depend on mission variables (the scope and complexity of the project involved, the time available for planning, and the operational environment). Project management does not replace the military planning process used by each Service for contingency and crisis action planning or troop leading procedures at the tactical level.

4-15. The Army has designated some duty positions that require program or project management professional certification. Planners use the construction project management as a tool to assist them in their process of coordinating the skill and labor of personnel using machines and materials to configure the materials into a desired structure.

4-16. Figure 4-1 shows the project management process that divides the effort into three parts: preliminary planning, detailed planning, and project execution. Preliminary planning may include the completion of detailed designs by the constructing unit or provide an adjustment to the designs as required by information obtained from the site investigation.

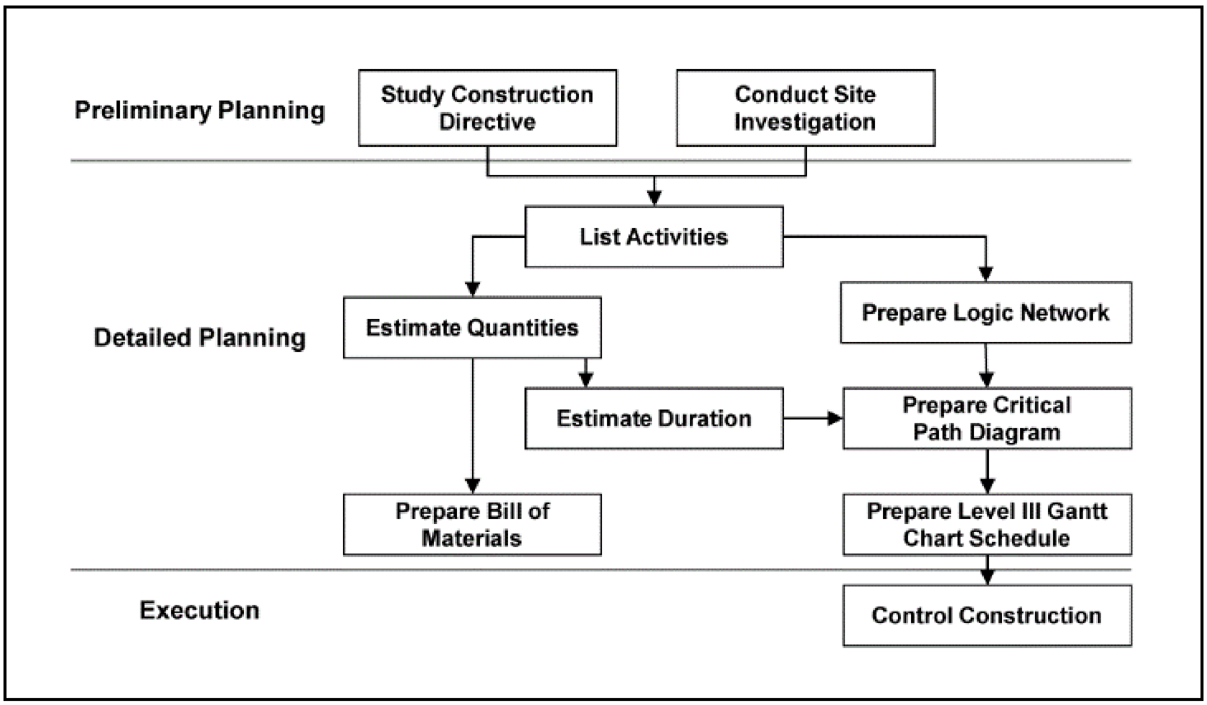


Figure 4-1. Project management process

4-17. General engineer planners and construction units rely extensively on the JCMS to produce the products required by the project management system. Effective products produced during the planning phases greatly assist during the construction phase. In addition to the JCMS, the engineer has various other reachback tools or organizations that can exploit resources, capabilities, and expertise that is not organic to the unit that requires them.

4-18. Digital, handheld devices can be used to document existing conditions, speed accurate reporting, and provide timely information to the construction site. They can decrease idle time on the construction site due to decreased wait time for information. They can also decrease the time spent by supervisors on nondirect construction tasks, such as reports and requests for information on-site and to or from higher headquarters.

4-19. Based on careful analysis, construction assignments, required facilities, and scheduled target dates for phased development as outlined in the OPORD, general engineers can formulate a construction schedule. Construction schedules are prepared to show a detailed time plan for operations in proper sequence. The equipment hours and man-hours required for each principal operation are then tabulated.

4-20. The construction schedule is based on the—

- Time allowed for completion.
- Available equipment and special assets required.
- Type of labor available (regular troop units, reserve troop units, newly activated troop units, local contractors, international contractors).
- Delivery of construction materials.
- Activity sequence and critical path.
- Necessary delays between activities.
- Projected weather and climate conditions.
- Force protection, antiterrorism considerations, and threat assessments.
- Environmental, health, and safety considerations.

JOBSITE SAFETY

4-21. Jobsite safety at the construction site is important in preventing injuries, avoiding accidents, and preventing death. The following are some of the resources that are available to assist engineers in safety considerations:

- AR 385-10, ATP 5-19, DA Pam 385-1, and DA Pam 385-10.
- Unit safety standard operating procedures.
- Commander's guidance and policies.
- United States Army Safety Center. See the U.S. Army Combat Readiness Center website for additional information.
- Center for Army Lessons Learned. See the CALL website for additional information.
- Engineer Manual 385-1-1. See the USACE Publications website for additional information.
- Naval Safety Center.
- Department of Labor Occupational Safety and Health Administration. See the Department of Labor Occupational Safety and Health Administration website for additional information on safety standards.

JOBSITE SECURITY

4-22. Jobsite security is of paramount importance in preserving the force. Engineers in a combat role may have limited personnel to accomplish their construction mission, yet they may find themselves devoting labor to provide jobsite security in high-threat areas. Consider requesting external augmentation from infantry or other combined arms units for jobsite security forces. This will allow the engineer to devote labor resources toward construction project completion.

METHODS OF CONSTRUCTION

4-23. The major construction methods used by military general engineers is on-site construction, design-build construction, and modular construction. The on-site construction of buildings is also called stick-built or stick frame if referring to carpentry. Larger post-and-beam or timber frames may be used for bunkers and protective structures. Most military construction units use on-site construction.

4-24. Planners determine the major construction methods for various requirements based on operational considerations and economic analysis. Standardizing the construction methods used throughout an operational area simplifies estimating methods, safety requirements, training requirements, quality assurance, quality control, and O&M. Each construction technique has various construction methods with considerations, advantages, and disadvantages. The construction unit adjusts the construction methods based on local conditions, material availability, local construction methods and labor skills, and the ability of the HN to maintain facilities intended to be turned over to them when no longer needed.

4-25. Construction is a broad term that may include the following tasks:

- Provide new construction.
- Upgrade existing facilities.
- Assemble or erect pre-engineered buildings or systems.

4-26. Deconstruction is done to scale down the size of a facility, structure, or building. During deconstruction, many of the same construction techniques may be used if the materials are to be reused on other projects. Deconstruction may simply be the reverse of a construction technique. Demolition may be carefully performed to allow the reuse of some construction materials, or demolition may be completed to prevent the enemy from reusing a facility.

4-27. Construction may be provided by—

- **Military units.** Troop construction is economical because it eliminates labor cost and contractor profit. Tactical considerations may create situations in which HN support contractors are unwilling or unable to undertake construction projects. Troop construction is more flexible because there are no contracts to negotiate for changes in plans, specifications, or required available time allowances.
- **Contractors.** Contractors bring laborers with specialized skill sets in the desired numbers with specialized equipment and required resources. Contractors have greater flexibility, as opposed to troop labor that is restricted by combat mission demands. Troop construction equipment may not be as specialized as contractor equipment because it must be rugged and flexible enough to meet combat conditions. Contractors bring a dedicated pool of talent to focus exclusively on the construction project, as opposed to troops who must focus on combat mission and other military duties. See JP 3-34 for military construction authorities, roles, and responsibilities.
- **Local labor.** Using local labor may be more economical than bringing in external contractors from the United States or other countries. Precautions should be taken to that ensure local labor is vetted.
- **HN labor assets.** Similar to local labor, HN labor may provide the right skill sets and resources to meet construction project needs within economical cost.

HOST-NATION SUPPORT CONSIDERATIONS

4-28. HN support can expand the capabilities of friendly forces by reducing the requirements for engineer units and expediting construction. In the rehabilitation of developed areas, it may be practical to arrange the employment of HN engineers, contractors, and superintendents with their organizations. These may include a variety of skilled workers. In many undeveloped areas of operations, local businesses have established organizations to employ and supervise labor in agriculture and other pursuits. Such organizations can often provide labor to assist in construction projects. Precautions should be taken to ensure that local labor is vetted.

4-29. The plans for employing civilian labor must include adequate consideration of housing costs, transportation methods, local customs, language difficulties, locally determined complications due to race or religion, and adapting construction plans to the methods and materials to be used. The use of local civilian labor may result in savings in mobilization and demobilization costs, and additional savings due to the local wage scale.

DESIGN BUILD

4-30. Design-build (also called design and build contracting process, or method of delivery) is a common construction method used by industry and Service construction agents. Typically, construction designs are completed by architectural engineer firms, who then request construction bids from civilian construction firms. Then, the project is built by construction firms (a design-bid-build contracting process). Design-build combines these two processes together by having a single organization perform them to achieve time and cost savings.

4-31. Concurrently, construction can begin based on some completed designs, while other designs are completed as construction progresses. As the project progresses, the constructing unit has the opportunity to provide immediate input to the design based on site conditions, available materials, and preferred construction methods. Most military unit construction is designed and then built, sometimes by the same unit. However, on a larger, more complicated project without all requirements known at the start, design and construction conducted concurrently as information becomes available is an effective construction method.

MODULAR CONSTRUCTION

4-32. Modular construction is a method of construction, not a building type. Modular construction involves procuring commercially prefabricated or military unit prefabricated buildings, components, or systems of multiple sections (called modules) that are joined together on-site. Engineers provide the contracting office, quality and construction standards, specifications, and codes that the contracted modules must meet.

4-33. The prefabricated sections are typically transported to the site by truck and then, depending on weight, are off-loaded, and positioned with a crane or other material-handling equipment. The constructing unit assembles the prefabricated sections with organic tools or special tools provided as part of the system. The modules may require limited site preparation or a foundation that can be constructed simultaneously with off-site module construction.

4-34. The modules may be prefabricated as a box that has more shipping volume or as flat panels or components that have less shipping volume but require more assembly time on-site. Depending on transportation restrictions, the modules may be up to 20 feet wide and 90 feet long. Precast or prefabricated concrete panels, structural insulated panels, or other major building components may be produced on-site, contracted for and shipped, or locally procured.

4-35. Modular construction may produce semipermanent facilities that may be disassembled and reused. Another possibility is to design and procure relocatable buildings that are partially or completely assembled. Relocatable modular buildings are designed to be reused multiple times and transported to different sites.

4-36. Modular construction may offer several advantages to site-built facilities, such as—

- Increased design time savings (comes predesigned).
- Increased construction speed.
- Fewer weather considerations.
- Increased flexibility of configurations and module layouts (modules that may be disassembled, refurbished, and reused).

CONSTRUCTION MATERIALS

4-37. Depending on the project type, required construction materials can be expensive, specialized, and unique. There are a variety of different materials that can be used in construction, including steel, rock, wood, and concrete. Class IV supplies include all construction materials and installed facility equipment.

4-38. Theater requisitions for engineer construction materials must take careful account of project requirements for special, large-scale combat operations. Issues from stocks are based on the requirements for the particular work on which the requisitioning unit is engaged. Critical items of Class IV supplies may be issued under policies approved by the assistant chief of staff, logistics (G-4); uncontrolled items are issued on-call.

4-39. The task of providing engineer construction supplies can be quite comprehensive and costly, and every effort must be made to simplify it through the use of local procurement channels and standardized designs. The unit supply officer maintains a local inventory of continuous stocks of construction materials and equipment. Class IV supplies suitable for local procurement may include lumber, cement, structural steel, sand, gravel, rock, plumbing and electrical supplies, hardware, and paint.

PROCUREMENT

4-40. Obtaining materials on time and in the quantity and quality needed must be coordinated and synchronized to support the assembly of other resources (time, personnel, equipment) to complete the project.

Construction of any kind will fail if the required materials (or suitable substitutes) are not available when needed. Efforts to obtain the proper material begin early during the planning phase (receipt of mission or construction directive) and do not end until the project is completed and turned over.

4-41. For procurement, engineers have the option of obtaining materials from the United States through the service supply system, from countries as adjacent to the AOR as possible, and from local suppliers. Each method has inherent costs and benefits. Environmental impacts (such as deforestation and erosion) of using natural resources is a consideration. Engineer units may be used—or a contractor hired—to produce the necessary materials. Whatever the method, obtaining resources must be an integral part of planning and executing tasks to properly accomplish the mission.

Class IV Materials

4-42. Units may obtain construction materials by using standard supply procedures that unify the way in which they are requested, managed, and distributed. Most construction materials are Class IV materials and are distributed according to unit standard operating procedures. Many Class IV materials are also used for field fortifications, fighting positions, and other types of protection work, making it likely that they are in high demand and necessitate engineer involvement in distribution decisions.

4-43. Class IV supplies are not maintained in significant quantities and are bulky. This makes handling and transporting supplies over strategic distances difficult. Obtaining construction materials through supply channels is considered the least efficient and desirable method for construction missions. Engineers should only use this method after determining that the materials are unavailable locally, the proper quantity and quality cannot be met locally, or the cost to obtain them is prohibitively high. Logisticians must constantly track the status of orders throughout the requisition process to ensure that they are fulfilled.

4-44. Maintaining Class IV supply points is a logistics function that engineer units are not organized or equipped to perform. Although engineer units should avoid operating Class IV supply points, recent and repeated experience in contingency environments has shown that engineers are habitually forced to do so to ensure the completion of construction missions, particularly when time constraints exist. Engineers should be involved, but they should not be required to run Class IV supply points. Units may need to be creative in the way they obtain Class IV supplies, such as using materials from base camps that are closing.

Other Procurement Methods

4-45. Engineers may also procure construction materials in-theater by using local-purchase procedures and contracting methods. In a contingency, logisticians must rapidly learn the methods and rules for obtaining construction supplies through the appropriate system. To maximize its benefits, local procurement should be coordinated to occur as close as possible to the actual construction site to minimize transportation requirements. Engineers must learn specific procedures and rules for local purchase procedures and contracting. Some of the options include a—

- **Government-wide commercial purchase card.** This card is a useful instrument for the purchase of supplies up to an established limit. It is an effective method for small purchases. When deploying, users must determine the specific rules for their card during the specific contingency. Depending on the deployment location, there may be problems with finding vendors who are willing to accept a government-wide commercial purchase card.
- **Blanket purchase agreement.** A blanket purchase agreement is a simplified method of filling anticipated repetitive needs for supplies by establishing charge accounts with qualified sources of supply. A blanket purchase agreement is a written understanding between the government and a supplier that eliminates the need for individual purchase and payment documents.

- **Prime Vendor Program.** This is a DOD-institutionalized program that is operated by the Defense Logistics Agency. It establishes a series of contracts with different vendors. When a specific item is needed, each vendor is given an opportunity to bid to fill the order in a set period of time.
- **Logistics Civil Augmentation Program.** This program is for the preplanned use of a civilian contractor to augment capabilities of selected forces during a contingency. Units may obtain logistics support, to include Class IV supplies, through this program.

Considerations

4-46. Although obtaining materials for construction missions is often the most advantageous method of needed requirements, engineers must consider the following factors:

- Standard sizes of construction materials may be different in the area of operations. Dimensional lumber is often cut to different standards in foreign countries. Voltage systems in overseas locations are also typically different from the United States.
- The quality of different items may be considered substandard. Lumber, concrete, and asphalt are three examples of construction materials that are typically not consistent with U.S. standards.
- Language and cultural differences may make it difficult to communicate and obtain supplies. In some situations, local vendors may feel that it is more important to try to please you in initial discussions than to tell you the truth about whether they are capable of providing materials in the quantity and quality needed.
- Military operations may drive up prices. Shortages caused by multiple units competing for the same resource may induce local suppliers to inflate prices and profiteer from ongoing operations.

4-47. Table 4-1 is a list of supplies that units might maintain in an engineer Class IV supply point during a contingency. Note that it contains only very basic materials and supplies.

Table 4-1. Sample stockage material for engineer Class IV supply point

Line		*Nomenclature*	*NSN*	*UI*
4	AA	Sandbags	8105-00-142-9345	HD
4	AB	Wire, barbed	5660-00-224-8663	RO
4	AC	Wire, concertina	5660-00-921-5516	RO
4	AD	Pickets, long, 6' long	5660-00-270-1510	EA
4	AF	Pickets, short, 3' long	5660-00-270-1589	EA
4	AG	Barrier, Hesco bastion, 2' x 2' x 10'	2590-99-169-0183	EA
4	AH	Barrier, Hesco bastion, 2' x 2' x 4'	2590-99-001-9392	EA
4	AI	Barrier, Hesco bastion, 3' x 3' x 2 1/2’	2590-99-001-9393	EA
4	AJ	Barrier, Hesco bastion, 3' x 5' x 2 1/2’	2590-99-001-9395	EA
4	AK	Barrier, Hesco bastion, 4 1/2’ x 3 1/2’ x 2 1/2’	2590-99-835-7866	EA
4	AL	Barrier, Hesco bastion, 4 1/2’ x 4' x 2 1/2’	2590-99-391-0852	EA
4	AM	Barrier, Hesco bastion, 7' x 7' x 7 1/2’	2590-99-335-4902	EA
4	AN	Lumber, 1" x 6" x 12'	5510-00-220-6080	EA
4	area of operations	Lumber, 1" x 4" x 12'	5510-00-220-6078	EA
4	AP	Lumber, 1" x 10" x 12'	5510-00-220-6084	EA
4	AQ	Lumber, 2" x 4" x 8'	5510-00-220-6194	EA
4	AR	Lumber, 2" x 4" x 10'	5510-00-220-6194	EA
4	AS	Lumber, 2" x 4" x 12'	5510-00-220-6194	EA
4	AT	Lumber, 2" x 6" x 8'	5510-00-220-6196	EA

Table 4-1. Sample stockage material for engineer Class IV supply point (continued)

Line / Lookup Value		*Nomenclature*	*NSN*	*UI*
4	AU	Lumber, 2" x 6" x 10'	5510-00-220-6196	EA
4	AV	Lumber, 2" x 8" x 14'	5510-00-220-6198	EA
4	AW	Lumber, 2" x 10" x 12'	5510-00-220-6200	EA
4	AX	Lumber, 2" x 12" x 12'	5510-00-220-6202	EA
4	AY	Lumber, 4" x 4" x 8'	5510-00-220-6178	EA
4	AZ	Lumber, 4" x 4" x 10'	5510-00-220-6178	EA
4	BA	Lumber, 4" x 4" x 16'	5510-00-220-6178	EA
4	BB	Timber, 6" x 6" x 8'	5510-00-550-6825	EA
4	BC	Timber, 6" x 6" x 10'	5510-00-550-6825	EA
4	BD	Plywood, ½” x 4' x 8' ply	5530-00-128-5143	EA
4	BE	Plywood, 5/8” x 4' x 8' ply	5530-00-128-5147	EA
4	BF	Plywood, 3/4" x 4' x 8' ply	5530-00-128-5151	EA
4	BG	Nail, common wire steel 5d	5315-00-010-4656	LB
4	BH	Nail, common wire steel 8d	5315-00-010-4659	LB
4	BI	Nail, common 3" 10d	5315-00-753-3883	LB
4	BJ	Nail, common 3 1/4” 12d	5315-00-753-3884	LB
4	BK	Nail, common 3 1/2” 16d	5315-00-753-3885	LB
4	BL	Nail, common 20d	5315-00-753-3886	LB
4	BM	Screening, insect nonmetal 48” wide	8305-00-559-5047	YD
4	BN	Bolt machine 3/4" x 12" with nut	5306-00-550-3697	EA
4	BO	Washer flat cad stl 13/16" id 2" od	5310-00-236-6478	EA
4	BP	Hinge butt steel leaves 3 1/2" x 1 3/4"	5340-00-243-6193	EA
4	BQ	Hook and eye door steel 3"	5340-00-243-3224	EA
4	BR	Nipple pipe steel galv 1/2" x 4" long	4730-00-196-1547	EA
4	BS	Union pipe galv for 1/2" pipe	4730-00-240-1674	EA
4	BT	Elbow pipe galv 1/2" x 90° angle	4730-00-278-4773	EA
4	BU	Elbow pipe galv 3/4" x 90° angle	4730-00-249-1478	EA
4	BV	Reducer, pipe galv 3/4" to 1/2"	4730-00-231-5650	EA
4	BW	Valve gate brz scr 3/4" class 125	4820-00-288-7567	EA
4	BX	Pipe steel galv 3/4" x 21 feet thds	4710-00-162-1019	EA
4	BY	Nipple pipe steel galv 3/4" x 4" long	4730-00-196-1500	EA
4	BZ	Nipple pipe steel galv 3/4" x 2" long	4730-00-196-1505	EA
4	CA	Union pipe galv fem 3/4" 300 psi/wog	4730-00-240-1675	EA
4	CB	Coupling pipe mall irn 1/2" std wt	4730-00-187-7612	EA
4	CC	Coupling pipe mall irn 3/4" std wt	4730-00-187-7613	EA
4	CD	Cap pipe galv mall iron 1/2"	4730-00-231-2424	EA
4	CE	Cap pipe galv mall iron 3/4"	4730-00-231-2425	EA
4	CF	Primer adhesive for PVC pipe	8040-01-001-2705	PT
4	CG	Pipe PVC dwv sch 40 20’ lg 2"	4710-00-476-5870	EA
4	CI	Outlet box, 4” x 4 1/2" to 3/4" knockout	5975-00-159-0969	EA

Table 4-1. Sample stockage level for engineer Class IV supply point (continued)

Line		Nomenclature	NSN	UI
4	CJ	Cover junction box 4” square flat	5975-00-281-0057	EA
4	CK	Jct box rect sfc mtd for sw or recp	5975-00-281-0090	EA
4	CL	Cable 1/c 6 AWG 7-str cu bare mhd	6145-00-299-4456	EA
4	CM	Cable 3/c&gnd 12 AWG sol cu nmc	6145-00-519-1332	FT
4	CN	Cable 2/c&gnd 12 AWG sol cu nmc	6145-00-519-2718	CL
4	CO	Cable 1/c 1/0 awg19-str cu thw black	6145-00-939-4951	FT
4	CP	Cable 1/c 1/0 awg19-str cu thw blue	6145-01-204-6473	FT
4	CQ	Cable 1/c 1/0 awg19-str cu thw white	6145-01-204-6477	FT
4	CR	Cable 1/c 1/0 awg19-str cu thw red	6145-01-204-6478	FT
4	CS	Lamp fluorescent f40t12 cool white	6240-00-152-2987	EA
4	CT	Lamp incandescent 115v 100 w a21 bulb	6240-00-990-8191	EA
4	CU	Fxtr ltg fluorescent incandescent rs 2-40 w stl	6210-00-865-8451	EA
4	CV	Fxtr ltg wp 100 w wall mtg stl	6210-00-893-7241	EA
4	CW	Cement port gen conc constr 94 lb	5610-00-250-4676	BG

Legend:

AWG	American wire gauge	NSN	national stock number
bg	bag	od	olive drab
brz	bronze	port	portable
c	copper	psi	per square inch
cad	cadmium	pt	pint
cl	class	PVC	polyvinyl chloride
conc	concrete	recp	receptacle
constr	construction	rect	rectangle
cu	copper	ro	roll
d	penny	rs	rustproof series
dwv	drain, waste, and vent	sch	schedule
ea	each	scr	screwed
fem	female	sfc	surface
ft	foot/feet	sol	solid
fxtr	fixture	st	set
galv	galvanized	std	standard
gen	general	stl	steel
gnd	ground	str	strand
hd	hundred	sw	solid wall
Id	inch diameter	thds	threads
irn	iron	thw	thermoplastic vinyl-insulated building wire
jct	junction		
lb	pound	v	volt
lg	long	w	watt
ltg	lighting	wog	water, oil, or gas
mhd	medium hard drawn	wp	wall plug
mtd	mounted	wt	weight
mtg	meeting	UI	unit of issue
nmc	National Electric Code Multi-Conductor	yd	yard

PRODUCTION

4-48. Certain types of materials are typically needed in such large quantities and are of such great weight that engineers must produce them locally (or contract a supplier). Soil for fill, sand, and gravel are examples of materials that are typically obtained from local sources. Contracted construction and the construction directive for engineer units should specify quality standards for the use of local materials that are verified through inspections as part of the quality assurance or quality control plan.

4-49. To produce more refined products, engineers may need to further process materials to obtain required construction materials, such as crushed rock, asphalt, and concrete. There are specialized engineer units (quarry teams, asphalt teams, concrete sections) that handle production missions for most types of construction materials. Significant environmental considerations may be placed on U.S. forces when creating or operating construction sites.

Geology and Materials Testing

4-50. TM 3-34.61 provides a comprehensive discussion on geology. Geology is the science that deals with the substance, structure, and origin of earth. It is the application of chemistry, physics, biology, and related sciences to study earth. In military operations, geologists can translate geologic information into concepts that can be used readily and effectively in conjunction with combat and engineer needs.

4-51. Combat units can benefit from geologic information in the evaluation of soil trafficability, the estimation of stream fordability, and the availability of cover and concealment. Engineers can use geologic information in the location and use of construction materials, the location of groundwater supplies, the siting of roads and airfields, the evaluation of the foundation suitability, the proper location of excavations, and the evaluation of possible sites for underground installations. Military commanders should incorporate geologic information with other pertinent information when planning military operations.

4-52. Material testing involves obtaining samples and performing engineering tests and calculations on soils, bituminous paving mixtures, and concrete. These materials include aggregates, bituminous materials, and stabilized soil, including stabilizing agents such as bitumens, cements, lime, fly ash, and chemical modifiers. Material testing is conducted to achieve proper design with these materials and adequate control over their use in construction. See TM 3-34.43/MCRP 3-40D.8 (MCRP 3-17.7H)/NAVFAC MO 330/ AFMAN 32-1034_IP for a further discussion on material testing. See TM 5-818-1/AFM 88-3 for information on soils and geology.

Borrow Pits and Quarries

4-53. TM 3-34.65/NTRP 4-04.2.12/AFMAN 10-903 provides discussions on opening and operating borrow pits and quarries. The specialized engineer unit that can assist is the quarry team. This team has trained personnel and equipment to support borrow pit and quarrying. Engineers plan, design, and use borrow pits and quarries. Pits and quarries are sites at which open excavations are made for the purpose of removing rock for use in construction projects. Pits are sites that generally do not require blasting, while quarries usually require drilling, cutting, or blasting. The rock is normally processed through a crushing and screening plant to produce crushed rock. See TM 3-34.65/NTRP 4-04.2.12/AFMAN 10-903 for information on geology and quarry selection, layout, and development; blast design; explosives and initiating devices; blasting; and safety. See TM 3-34.82/MCRP 3-34.2 (MCRP 3-17.7L) for additional information on explosives and demolitions.

4-54. Borrow pits are the preferred source of construction aggregate and fill material when resources are scarce and material quality is not critical. They are similar to quarries except that they tend to be smaller and generally require no blasting and minimal mechanical efforts. Materials in borrow pits seldom need to be blasted, crushed, or screened. Though the gravel, sand, and fines obtained in a borrow pit may not be as good as crushed stone, it is often acceptable. Equipment needed for a borrow pit includes dozers for grubbing and clearing; dump trucks for hauling; and scoop loaders, scrapers, or cranes with a shovel and dragline for loading.

4-55. Borrow pits are best located at the tops of hills close to or on the construction site for the ease of material handling. If borrow pits are located away from the construction site, careful consideration should be made in locating them to ensure operation efficiency and minimal environmental damage and impact on the local population. During planning, units should consider the time required to close the borrow pit in the overall timeline.

4-56. Quarries are similar to pits except that they generally require drilling, blasting, or the mechanical removal of aggregate to obtain suitable material. Although not specifically part of the quarry operation, planners may find it advantageous to collocate rock-crushing capabilities, asphalt plants, and concrete production facilities. Specific information on quarries is contained in TM 3-34.65/NTRP 4-04.2.12/AFMAN 10-903.

4-57. In a contingency operation, if it is determined that a quarry is required, extensive planning must occur to ensure that the operation is efficient, meets production requirements, and conforms to applicable environmental considerations. Unless there is an extremely large construction project, it is likely that one quarry will support multiple construction missions. Determining a quarry location must be considered in a holistic and centralized manner. The layout of the site consists of preplanning the location, dimensions, and arrangement of the quarry and the supporting roads and facilities. Planners must consider the mission, source geology, amount of overburden, equipment available, access, drainage, and traffic flow when determining a quarry location.

Crushed Rock

4-58. TM 3-34.65/NTRP 4-04.2.12/AFMAN 10-903 provides a discussion on aggregate production through rock-crushing. Rock of specific size and gradation is required for asphalt and concrete production. Crushed rock is used as the base course for roads and airfields. Rock from quarrying and borrow pits must be crushed, screened and, perhaps, washed to meet specific design standards. See TM 3-34.43/MCRP 3-40D.8 (MCRP 3-17.7H)/NAVFAC MO 330/AFMAN 32-1034_IP for more information on methods of testing materials for proper design characteristics.

4-59. Almost all contingency operations require some level of crushed-rock supply, and units with a rock-crushing capability are only in the Reserve Component. The quarry team (a specialized engineer unit) comes equipped with a rock crusher to support this type of operation. Planners must be aware that moving and establishing a rock-crushing capability is a time- and labor-intensive operation that must be well planned to meet specific project time constraints.

4-60. The rock-crushing plant must be sited within a short distance of the quarry, and the collocation of these may be ideal. The plant should be located on level ground with good drainage and adequate space for equipment, stockpiles, and maintenance areas. An adequate supply of water must also be available for the washing process. This water may require a settling basin or some other method to mitigate the environmental impacts of the operation.

4-61. The two most common rock-processing units have a 75- or 225-ton production capability per hour. Each plant consists of several large pieces of towed equipment, to include crushers, screening equipment, washing equipment, and conveyors. The mobile crushing, screening, and washing plant is diesel- and electric-motor-driven and consists of nine major components that are capable of producing a minimum of 150 tons per hour of aggregate that is suitable for cement or asphalt concrete.

4-62. The quarry team rock crusher components and accessories include the primary jawcrushing unit, the secondary conecrushing unit, the surge bin unit, the tertiary conecrushing unit, the washing and screening unit, the dolly unit, three generators, ten conveyors, and a water-pumping unit. All units are semitrailer- or trailer-mounted and can be operated independently, tandem, or both to meet aggregate production requirements. Planners must be aware that the actual output from a given plant differs from its normal capacity in that it is dependent on the specific product input, the desired size of the final product, and the proportion of the by-product.

4-63. The maintenance of rock-crushing equipment is a time-consuming process. Heavy loads and the abrasive action of the crushing operation, along with the movement of large quantities of material, inevitably lead to wear and damage of the equipment. The repair of older plants can be difficult because of a lack of spare parts. Dust, noise, and other environmental considerations must be considered when planning for the operation of a rock-crushing plant.

Asphalt

4-64. TM 3-34.63 provides information on asphalt production. The specialized engineer unit that can assist is the asphalt team. This team has the required trained personnel and equipment to support asphalt production. The typical Army asphalt plant is a portable, drum type, electric motor-driven facility that is capable of self-erection (major components) and satisfactory operation without permanent footings. It consists of major units, components, and accessories as required to assemble a complete plant that is capable of producing 150 tons per hour of graded asphalt paving mix.

4-65. The asphalt plant may be set up for batch and continuous mix. It is trailer-mounted and can be interconnected mechanically and electrically and operated to the rated capacity. A good road network is needed to avoid traffic jams and the resultant cooling of mixes. The planner must also consider the potential environmental problems, including dust that is generated by the plant and potential soil contamination from bitumen and fuel spills.

4-66. The construction paving unit will use some asphalt production equipment at the jobsite, to include an asphalt melter and an oil heater. The following are key features of asphalt equipment:

- The asphalt melter is a skid-mounted, 750-gallon-per-hour, dedrumming asphalt melter. The dedrumming tunnel is capable of removing 85- to 100-penetration cement from twelve 55-gallon drums at one time. The unit also contains a 3,000-gallon, hot-storage compartment for heating the asphalt to pumping temperature (235°F). Melters can operate individually, in pairs, or in trios and can operate in parallel from a single source of hot oil.
- The oil heater is a trailer-mounted, heavy-duty, high-output capacity unit that is designed to transfer oil and pump it through transmission lines to the asphalt melter and storage tank. It requires fuel and external electric power for operation.

4-67. Asphalt as a construction material has advantages and disadvantages. As a surface covering for roads and airfields, it provides a flexible and durable covering. However, it is impacted by extremes in climate and weather conditions affecting its structure. It requires continuous maintenance to remain serviceable and to extend its service life.

Concrete

4-68. TM 3-34.44/MCRP 3-40D.4 provides planners, designers, and general engineers information on the production of concrete. Planners refer to it when determining the design mixtures, form design and construction, concrete production, and testing required for a specific mission. The specialized engineer unit that can assist in concrete production is the concrete section. This section has the required trained personnel and equipment to support concrete mixing.

4-69. Concrete is produced by mixing a paste of cement and water with various inert materials. The most commonly used inert materials are sand and gravel or crushed stone. A chemical process begins as soon as the cement and water are combined.

4-70. Concrete as a building material has advantages and disadvantages. Concrete is fireproof, watertight, economical, easy to use, and available worldwide. However, concrete can crack, and other structural weaknesses can detract from its appearance, survivability, and useful life.

4-71. The Army has mobile mixers in its inventory for the mass production of concrete. They are mobile and self-contained units that can produce fresh quality concrete at the construction site.

Logging and Sawmills

4-72. The Engineer Regiment no longer maintains an organic capability to conduct logging or supply timber products for construction. Planners must procure timber products instead of producing them or contract for HN or civilian teams to directly support engineer requirements with logging and sawmilling if the demand is high enough.

4-73. Some allies may have organic units in their military forces to provide lumber. If required to set up a military logging and sawmill production site, consider using USACE reachback consultation.

4-74. Timber as a construction material has advantages and disadvantages. It can be durable and easily cut into desired shapes for furniture, framing, paneling, and bracing. However, wood is impacted by weather and temperature extremes, is flammable, and has load-bearing limitations. The use of wood depends on its availability via forests in the area. It can be more expensive if it must be imported externally, and attempts should first be made at local procurement.

CONSTRUCTION TECHNIQUES

4-75. Construction techniques are the result of time-proven best practices that are employed by general engineers. These construction techniques may be used for initial construction or the maintenance, repair, upgrade, or rehabilitation of existing facilities. They can also be used for some deconstruction.

4-76. Construction capabilities may be viewed as horizontal or vertical. The key features of each construction technique are described as follows:

- **Horizontal construction.** Horizontal construction is earthmoving efforts to bring about a desired design of an earth foundation. It can involve cutting and filling, the emplacement of drainage to create a level foundation, or the moving and shaping of earth to create berms. It involves the employment of heavy-equipment operators and a variety of heavy construction equipment. It can set the stage for follow-on vertical construction if structures are to be built on a foundation, or remain as a stand-alone project. Examples of horizontal construction projects are parking lots, runways, and roads.
- **Vertical construction.** Vertical construction involves efforts at building or assembling structures upwards above the ground. It can also involve underground structures, such as basements. It usually involves the employment of masons, carpenters, plumbers, electricians, and other skilled laborers to build floors, walls, windows, trusses, and roofs. It can involve heavy equipment to help erect the building components and use pneumatic power equipment. Examples of vertical construction projects are buildings and bunkers.

TOPOGRAPHIC SURVEYING

4-77. Topographic surveying is performed by a topographic surveyor. A geodetic survey considers the size and curved surface shape of the earth. A geodetic survey report is used for the positioning of field artillery units, air defense units, aviation units, intelligence units, communications, and construction control points. Most construction projects use plane surveys that require less accuracy and ignore the curvature of the earth. Survey classifications include—

- Artillery.
- Basic control.
- Satellite.
- Construction.
- Airfield engineering and navigation aid.
- Hydrographic.
- Field classification and inspection.
- Land.
- Inertial.

CONSTRUCTION SURVEYING

4-78. TM 3-34.55 discusses the methods and techniques used by military construction surveyors. Construction surveying supports planning with reconnaissance and preliminary data to aide in route and site selection. During the construction phase, the surveyor may extend geodetic survey control from a construction control point or use plane surveys to support the layout and quality control of the road, airfield, bridge, facility, utility, or building. Survey types may be reconnaissance survey, preliminary survey, final location survey, and construction layout survey. The accuracy of the survey is normally determined by the project manager.

EARTHMOVING

4-79. TM 3-34.62/MCRP 3-40D.9 discusses earthmoving. Earthmoving or horizontal construction is required on most construction projects. Major horizontal construction projects are typically roads and airfields. Depending on site conditions, earthmoving for site preparation may consume most of the construction resources.

4-80. Earthmoving efforts may include site preparation; excavation; embankment; construction; backfill; dredging; base course, subbase, and subgrade preparation; compaction; and road surface.

4-81. The phases of horizontal construction projects include—

- Preparing the subgrade.
- Placing and spreading fill material.
- Compacting fill material for the subgrade and base courses.
- Performing finishing and surfacing.

4-82. Earthmoving is conducted with dozers; scrapers; graders; loaders; dump trucks; forklifts; cranes; hydraulic excavators; air compressors and pneumatic tools; hauling equipment; and soil-processing, compaction, and surfacing equipment.

4-83. The types of equipment used and the environmental conditions affect the personnel and equipment required to complete a given amount of work. Each piece of equipment is specifically designed to perform certain mechanical tasks. Before preparing estimates, select the best method of operation and the best type of equipment to use based on economy and effectiveness for each earthmoving operation. Engineers estimate equipment production rates from experience, unit standard operating procedures, doctrinal manuals, or operator and maintenance manuals for the make and model of equipment being used.

Notes.

1. See TM 3-34.55 for information on the use of surveying to plan and estimate earthwork.

2. See NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12 for information on earthmoving estimates.

3. See EP 1110-1-8 series for information on cost estimates and the hourly usage cost for construction equipment.

CONCRETE AND MASONRY

4-84. TM 3-34.44/MCRP 3-40D.4 discusses concrete and masonry. Concrete and masonry refer to the materials used in building construction and construction techniques. Concrete work includes—

- Determining concrete mixtures (mix design).
- Designing and constructing forms (concrete slab on grade thickness design).
- Developing construction, reconnaissance, site preparation, excavation, and form procedures.
- Mixing, handling, transporting, placing, finishing, and curing concrete.
- Conducting form removal and repairing techniques.

4-85. Concrete may be reinforced by adding steel or other materials. Precast concrete products may also be procured. Precast concrete is a mixture of aggregates that are held together by a hardened paste, which is typically made by combining Portland cement with water. There are five common types and several special types of Portland cements, all with varying properties and uses. Admixtures can also be added to concrete to modify properties.

4-86. Concrete has a great variety of applications. It meets structural demands and lends itself to architectural treatment. In buildings, concrete is used in major building components (footings, foundations, columns, beams, girders, wall slabs, roof units). Other important concrete applications are in road and airfield pavements, bridges, dams, irrigation canals, water diversion structures, sewage treatment plants, and water distribution pipelines. Asphalt cement is used to make asphalt cement concrete for paving.

4-87. Masonry materials usually include concrete blocks, bricks, and structural clay tiles and may also include rubble stone masonry. Masons use specialized equipment to lay out and construct masonry walls and other building features. Masons determine the correct mixing proportions for mortar to bond the masonry units together and safely erect scaffolding.

4-88. Masonry construction procedures include—

- Modular coordination and planning.
- Rubble stone masonry.
- Bricklaying.
- Reinforced brick masonry.
- Structural clay tile masonry.

4-89. Each procedure has its own construction techniques. Modular coordination occurs when the design of a building, its components, and the building material all conform to a dimensional standard based on a modular system. Modular measure is the system of dimensional standards for buildings and building components that permit field assembly without cutting.

CARPENTRY

4-90. TM 3-34.47/MCRP 3-40D.3 discusses carpentry details; concrete forms (because concrete forms are constructed from wood); nonstandard, fixed, wood construction bridges (timber trestle bridges); and timber pile wharves. Carpentry is the skilled labor of making, finishing, and repairing wooden objects and structures. Carpentry work includes light wood framing, heavy wood framing (timber construction), finish carpentry, and roof construction. Carpenters use their skills to perform metal construction work and to erect metal buildings from a complete set of construction drawings (a set of plans).

4-91. Carpentry routinely uses two methods for erecting buildings as follows:

- The built-in-place method.
- The panel method (or preassemble method).

4-92. Carpenters are issued hand tool kits, power tool kits, and other equipment (such as pneumatic compressors and nail guns) to increase productivity. Carpentry tools include saws, blades, hammers, sawhorses, braces, and other specialized woodworking tools. Carpenters are assigned to vertical construction platoons and can be organized into work teams to ensure speed and efficiency.

FACILITIES ELECTRICAL SYSTEMS

4-93. TM 3-34.46/MCRP 3-17.7K discusses the design, layout, installation, and maintenance of facility electrical systems. Interior electricians install and maintain electrical wiring. Electricians are equipped with electrician tool kits and support equipment. They are assigned to vertical construction platoons and can be organized into work teams for construction projects.

Notes.

1. See UFC 3-501-01 for information on electrical engineering.

2. See TM 5-683/NAVFAC MO-116/AFJMAN 32-1083 for information on electrical facility maintenance.

3. See UFC 3-550-01 for information on power systems.

4. See UFC 3-520-01 for information on exterior and interior lighting.

5. See UFC 3-560-01 for information on electrical safety.

PLUMBING AND PIPEFITTING

4-94. TM 3-34.70/MCRP 3-17.7E discusses plumbing, pipefitting, and sewerage. Plumbing is a system of piping, apparatuses, and fixtures for water supply and distribution and waste disposal within a building. It includes the installation and maintenance of these systems. Plumbers are equipped with plumber tool kits and pipefitter kits and are assigned to vertical construction units. They can be organized into work crews for construction projects. Plumbers install and repair water systems, waste systems, fixtures, and heating systems; cut, ream, thread, and bend pipes; and caulk, solder, and test joints and systems for leaks. See ATP 4-43 for additional information on military petroleum pipeline systems.

WASTE MANAGEMENT

4-95. Waste management is the collection, transport, treatment, or disposal of waste materials in an effort to ensure a healthy and sanitary environment. For more information about waste management, see TM 3-34.56/MCRP 3-40B.7.

4-96. Integrated waste management is the management of the entire waste process, including generation, storage, collection, transportation, resource recovery, treatment, and disposal. It employs several waste control methods based on the waste hierarchy (avoidance, reduction, recycling, reuse, recovery, treatment, and disposal) and is aimed at minimizing the environmental impact of waste. For more information about waste management, see TM 3-34.56/MCRP 3-40B.7.

4-97. Engineers have staff proponency for waste management. Waste is categorized as nonhazardous solid waste, wastewater, hazardous and special waste, and medical waste. Waste management includes the construction, operation, and maintenance of new (and the upgrade of existing) utilities (examples are sewage collection and treatment or landfill construction) and the construction of facilities for the purpose of waste management.

4-98. JCMS provides some options for collection, treatment, and disposal facilities. See TM 3-34.56/MCRP 3-40B.7 and TM 3-34.70/MCRP 3-17.7E for a detailed discussion on waste management. See UFC 3-240-01 for information on wastewater treatment systems operation and management.

PAVING

4-99. To construct roads and airfields, the military typically conducts three types of paving and surfacing: bituminous pavements and surfaces, concrete pavements, and expedient pavements. Bituminous pavement (wearing surface) is a compacted mass of bitumen and aggregate.

4-100. Concrete pavements usually combine Portland cement, water, and aggregates with possible admixtures. TM 3-34.63 discusses construction materials and equipment; mix design; and the production, placement, and repair of bituminous and concrete pavements. It also provides a detailed discussion of expedient pavements and surfaces.

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Chapter 5
Seaports

Strategic sealift forces are employed in all phases of strategic mobility (predeployment [pre-positioned force, equipment, or supplies], deployment [surge], sustainment/combat service support, and redeployment). In general, sealift delivers and redeploys Army heavy combat and supporting units, Marine Corps forces, their equipment, and sustainment/combat service support (see JP 3-36). Obtaining adequate port facilities for sealift forces early in any contingency is essential to the efficient flow of troops and materiel (see JP 3-0 for additional information). Securing these facilities is often an initial objective of an overseas operation. This chapter discusses the scope of port activities, planning and design, construction methods, maintenance and repair, and logistics over-the-shore (LOTS) support. Seaport planning efforts may need to be applied to the front end and back end for deployment and redeployment. When a force is redeploying, the port from which they embark is called the seaport of embarkation in-theater and the seaport of debarkation in the United States. The seaport of debarkation is relative depending on which way the force is going. It is possible that a port which is being improved by engineers could be used as a seaport of debarkation for deployment and as a seaport of embarkation for redeployment. However, during redeployment, the original port of embarkation may not necessarily be used and another port may be assigned. During deployment and redeployment, seaport roles may need to be switched, capabilities adjusted, and capacity modified to accommodate throughput requirements. Space must be planned for future expansion and construction. This manual does not discuss construction support to U.S. seaports of embarkation or aerial ports of embarkation; such support to create ports with planned capacity would normally be completed before contingencies.

RESPONSIBILITIES AND CAPABILITIES

5-1. Port construction, expansion, rehabilitation, and conversion are of vital importance to the success of any mission because they support assured mobility at the strategic level and are most often inherently joint operations. Building and operating a port in a JOA is a large and vital undertaking, with many responsibilities divided between the Navy and branches of the Army.

5-2. The CCDR or ASCC/MCCC makes basic decisions concerning port location, capacity, utilization, wharfage, and storage facilities. Their decisions are supported by the United States Transportation Command headquarters (see ATP 4-0.1 and JP 3-36). The CCDR may assign construction responsibilities to Army, Navy, or engineer units, depending on their capabilities, their availability, and the overall situation. Mutually supporting or follow-on construction must be coordinated with other engineer units that are assigned to, or projected for, the area of operations.

5-3. The Army and the Navy maintain an organic capability to perform LOTS missions in support of their respective Service and can support the CCDR's requirement for JLOTS. See JP 3-36 for additional information on JLOTS. LOTS can be conducted over unimproved shorelines and through fixed ports. See JP 4-18 for additional information on JLOTS systems, requirements, capabilities, and limitations.

Joint Task Force Port Opening

5-4. A JTF port opening force provides the supported ground component commander rapid port opening capability in advance of other forces. This task force integrates Service organic capability and enables the United States Transportation Command to rapidly deploy (within 36 hours) and establish and initially operate (45–60 days) a seaport of debarkation and a distribution node. See JP 4-09 for additional information on port opening.

Army Service Component Commander

5-5. According to 10 USC, the ASCC may be tasked for the construction, expansion, rehabilitation, or conversion of a port, which may include—

- Studies of intelligence reports, assessments, and available reconnaissance information that apply to each port area considered for use.
- A tentative determination of the ports or coastal areas to be used as part of the overall strategic planning.
- Assignment of the port mission.
- A determination of port requirements.
- A tentative decision on the general methods of construction to be used.
- A determination of engineer units, special equipment, and materials required.

5-6. The ASCC assistant chief of staff, movements, is responsible for operating ports and furnishing liaisons with the Navy, Coast Guard, and other interested military and authorized civilian agencies of allied countries and the United States. The assistant chief of staff, movements, advises and makes recommendations concerning the engineer troops employed and the work concerned (see the annex in the joint OPLAN or OPORD for environmental considerations).

Navy

5-7. The Navy possesses many of the same capabilities for port construction as the Army (see JP 3-34). The Navy assigns its Seabees for pier, wharf, port, and waterfront construction and repair. See NTTP 3-10.1M/MCTP 3-34D. Close coordination between the forces must be done to avoid duplicate or counterproductive efforts. Naval civil engineering capabilities are discussed in NWP 4-04. The Navy can employ organic mobile underwater dive and salvage teams, underwater construction teams, and explosive ordnance disposal dive teams (depending on threatcon and conditions at the seaport). Navy explosive ordnance disposal teams can remove, dispose of, or neutralize unexploded explosive ordnance and explosive ordnance (including sea mines).

Marine Corps

5-8. The Marine Corps possess general engineer capacities with a smaller overall engineer force than the Army and have no special seaport capabilities (see MCWP 3-34). Most Marine engineer forces are primarily task-organized to support maneuver units and may only provide limited port construction that is sufficient to move Marine units through a port. Marine engineering capabilities are also discussed in NWP 4-04.

Army Engineer Units

5-9. Army engineer unit capabilities are discussed in FM 3-34. Army engineer units may be responsible for port construction, expansion, rehabilitation, conversion, and maintenance and for the coordination of work with that of Navy units. Army engineer dive teams perform minor to moderate salvage diving, such as clearing obstructions and debris from harbor entrances and improving channels. This does not include large-scale salvaging, which is a Navy responsibility.

Diving Support

5-10. Building new ports and facilities requires extensive diving support. A dive detachment is normally assigned to the ASCC to provide dive support in ports, harbors, and costal zones. Dive detachments are assigned and attached to the theater engineer command, which allocates them according to mission requirements. The detachment may be attached or assigned to a subordinate headquarters or task-organized with supporting units to provide direct-support diving capabilities.

5-11. Dive detachment capabilities are tailored to the mission (allowing the use of surface-supplied diving apparatus, scuba, and remotely operated vehicles), and they work closely with heavy equipment operators for large-scale combat operations. Supporting diver assets range from a small scuba team to multiple larger teams with a diverse range of capabilities. An engineer dive team has enough personnel and equipment to conduct multiple diving activities concurrently. Divers can work up to a depth of 190 feet.

Note. The Army does not have explosive ordnance disposal-trained diving teams.

5-12. The following are essential missions for engineer divers:

- Port opening, construction, repair, and rehabilitation.
- Reconnaissance.
- Hydrographic survey.
- Underwater inspection.
- Search and recovery.
- Salvage.
- Demolition.
- Force protection.
- Ships husbandry.
- Support to JLOTS.
- Civil assistance/civil defense.

5-13. Port opening, construction, and rehabilitation missions include planning and inspection, clearance, repair, and quality assurance inspections. Salvage missions include refloating and rigs for towing. Ship husbandry includes in-water hull inspections, in-water maintenance, and damage control and repair. JLOTS support includes hydrographic surveys, mooring systems, and off-shore petroleum systems. Diver civil assistance and civil defense missions include humanitarian support, port rehabilitation, construction, and peacetime missions.

5-14. Divers enhance force protection by conducting security swims and the emplacement or removal of underwater obstacles and barriers. This includes installing underwater security systems. Divers also enable expeditionary logistics by providing accurate waterway datum, surveys, and the repair of existing waterfront facilities. Engineer dive missions assist in building capacity through infrastructure support and sustainment.

5-15. Divers also provide technical assistance and staff planning support to the ASCC through brigade commanders. See ATP 3-34.84/MCRP 3-10.2/NTTP 3-07.7/AFTTP 3-2.75/CGTTP 3-95.17, SS521-AG-PRO-010, TM 3-34.73, and TM 3-34.83 for additional information on dive teams, diving support requests, and military diving.

Construction Support

5-16. Vertical and horizontal elements augmented with a concrete section, dive team, and other specialty teams or sections accomplish most construction or salvage tasks. In performing their mission of construction, expansion, rehabilitation, conversion, maintenance, and repair of a port, Army engineer responsibilities include—

- Construction and repair of breakwaters, docks, piers, wharves, quays, moles, and loading ramps.
- Construction and maintenance of port area roads.
- Construction and major maintenance of railway facilities required by the port.

- Construction of storage and marshaling areas to stage military supplies, equipment or vehicles inside the port.
- Construction or reconstruction of port utilities (water supplies, electrical power systems, sewerage).
- Construction and major maintenance of tanker unloading facilities (mooring facilities; submerged pipelines; surface pipelines; rigid petroleum, oils, and lubricant tank farms).
- Maintenance and operation of port-firefighting facilities.
- Dredging, except as accomplished by the Navy.
- Debris and explosive-hazard port area clearance.
- Real estate acquisition of buildings, facilities, and other properties within the port area for military use.
- Provisions of warehouses, depots, and quarters for port personnel and other facilities as required for port operation.
- Continuous study of the port situation.
- Preparation of tentative plans for possible contingencies.
- Requisitioning of the supplies and equipment required to carry out the mission.
- Provision of diver support.
- Liaison with naval units to coordinate construction with harbor clearance activities.
- Recommendations for real estate allocations.
- Recommendations based on environmental considerations, including force health and safety protection.
- Advisement to the CCDR and staff on engineering matters connected with the identification, classification, in-transit storage, movement, and distribution of engineer equipment and Class II and IV construction materials.

5-17. Key Army engineer capabilities include pile-driving, construction, or repair of port and waterfront structures; support to over-the-shore causeways; underwater construction/maintenance; support to bulk fuel storage; support to salvage and recovery; dredging; and the establishment of sites for LOTS or JLOTS (see JP 3-34, JP 4-18, and TM 3-34.73).

5-18. The Army engineer unit with overall responsibility to support port construction may be the theater engineer command or engineer brigade, battalion, or company, depending on the size and scope of work. For port construction, it is essential to task-organize construction capabilities with the right type and number of companies, platoons, sections, and teams. The modularized force may include horizontal and vertical elements, concrete sections, dive teams, survey design sections, and other units as the mission requires.

5-19. Reachback capabilities available via the USACE Reachback Operations Center, a TeleEngineering toolkit, or FEST capabilities, can assist general engineers in resolving unique and complex port issues in assessments, plans, construction, expansion, rehabilitation, conversion, maintenance, repair, and upgrades. Engineering or other experts can quickly provide the advice and expertise for achieving viable solutions. See FM 3-34 for more information on FEST teams or visit the USACE Reachback Operations Center website.

TRANSPORTATION UNITS

5-20. Army transportation units are responsible for opening and operating the port and conducting LOTS (see TM 3-34.73). Army equipment includes self-deploying watercraft, lighterage, modular causeway systems, logistics support vessels, landing crafts, causeway ferries, floating piers, Trident piers, small tugs, and barge derricks (see JP 3-36). The unit coordinates operational activities with the completion of necessary projects and provides liaison with the Navy and Coast Guard.

5-21. The transportation unit also conducts a continuous study of port facility requirements to ensure the smooth and orderly flow of personnel, supplies, and material through the port. The unit staff plans, supervises, and controls freight movement from the port by rail, motor, inland water transportation and, under special conditions, air transport.

5-22. The transportation unit is also responsible for establishing engineer port construction priorities and terminal operations. Transportation units have the capability of providing personnel and haul assets for the movement of mass volumes of supplies and material. See FM 4-01 for specific details on transportation unit equipment and capabilities.

QUARTERMASTER UNITS

5-23. Army quartermaster units are responsible for supplying potable water and operating petroleum pipeline systems, including off-vessel discharging and loading. Their capabilities include providing terminal service unit handling equipment, shore-based water storage systems, and inland petroleum distribution systems (see JP 3-36).

5-24. Quartermaster units coordinate with naval units, engineer units, and transportation units in determining the location of tanker unloading and vessel fueling facilities. Quartermaster units have the capability of providing personnel and equipment assets to support logistics and services. See TM 3-34.73 for more information on port construction and repair.

SCOPE OF PORT OPERATIONS

5-25. According to JP 3-34, port construction is considered a general engineer activity. This chapter is a guide for the construction and rehabilitation of ship-unloading and cargo-handling facilities in the JOA. The coverage includes special problems encountered in port construction and the construction of supporting structures located in and around the port facility. Conventional sealift shipping falls into four broad categories: dry-cargo ships or freighters, liquid-cargo carriers or tankers, roll-on/roll-off vehicle ships and passenger ships. Based on current trends in the commercial shipping industry, it is anticipated that up to 90 percent of all cargo arriving in future JOAs will be containerized. See JP 3-36 and JP 4-18 for conventional sealift shipping and sealift ship programs.

5-26. Containerized shipping requires dock and road surfaces that are capable of withstanding severe loads and heavy lift equipment that is capable of transferring the largest loaded container (8 feet wide, 40 feet long, and 67,200 pounds) from large, oceangoing vessels to shore facilities. These factors should be considered during port planning. The guidelines concerning facilities for handling containerized cargo and container shipping outlined within this chapter represent the most current developments in this industry.

5-27. Strategic sealift includes the requirement to achieve over-the-shore cargo discharge capability to provide minimum sustainment/combat service support to expeditionary forces for not more than 60 days (see JP 3-36). While the situation dictates the COA, assault landing facilities are usually used for supply and replenishment in the initial phase of a campaign, followed by LOTS and JLOTS, as discussed later in this chapter.

5-28. As established port areas are acquired or rehabilitated, LOTS sites are normally abandoned (see JP 4-18). However, certain areas of operations may require the use of beach sites for extended periods of time or indefinitely due to the lack of existing facilities, the geography, the terrain, or the enemy situation.

5-29. For long-term military operations, the rehabilitation and renovation of existing port facilities is the preferred practice. The construction of new ports is normally undesirable because it requires a large amount of labor, materials, and time and would probably lack the desirable related facilities, such as connecting road and rail networks. Therefore, existing ports are usually targeted for rehabilitation and upgrade. The engineer mission is to support the construction, maintenance, and repair of a wide variety of facilities above and below the waterline.

5-30. The planner assists in the development of a port inspection plan and provides guidance to the inspection team for initial, on-site port surveys. After completing the initial inspections, the team leader designates the appropriate diving element that is most capable of performing the mission. In the event that the operation requires extensive diving assets (such as major salvage, construction, or harbor clearance), multiple dive detachments may be task-organized to support the mission. If the inspection is being done in an unsecure port, diving elements may require the support of security personnel.

5-31. A completed port inspection provides the water terminal commander a report of the existing conditions of underwater port facility structures. A detailed report may include a hydrographic survey depicting water depths, obstruction locations, and side scan sonar images. The information provided helps the area engineer and unit responsible for port construction determine the scope of construction required for port repair. The report may assist in the development of a port repair plan and time estimate. Army and Navy dive teams have the ability to provide detailed surveys and reports using divers or robotic platforms.

5-32. A detailed report includes—

- Descriptions of structures.
- An assessment of underwater damage to existing pier facilities.
- Recommendations for restoration.
- The location and condition of sunken vessels or other obstructions.
- Water depths of ship channels within the port.
- Recommendations for vessel or obstacle removal.
- Locations of underwater explosive hazards and munitions.

PLANNING AND DESIGN

5-33. Supporting strategic transportation requirements is a four-step process discussed in JP 3-36 and JP 4-09. Engineers are involved in transportation planning at all levels. They assist in analyzing existing facilities and estimating and planning for construction, maintenance, and repair requirements (see TM 3-34.73). Engineers also recommend measures for protection, security, and port defense.

5-34. Before occupying a port, planners must carefully consider the current and expected physical condition and logistics of the port. This includes the quantity and nature of the cargo and personnel that the port will handle. Army and Navy engineers would be involved in the initial reconnaissance and survey team activities to determine the physical condition, repair requirements, bare-beach transfer sites, and in-leasing of port facilities. See TM 3-34.73 for planning considerations.

5-35. Reconnaissance and survey teams should be identified and sent into existing port facilities as soon as possible to assist planners by collecting crucial data on the existing port and infrastructure. This includes construction and hydrographic surveys. Planners study the relative value of rehabilitation and construction and the value of specific facilities to the construction effort required. The JFC coordinates indicated changes and their impact on logistics through Army engineer, transportation, and other command channels and Naval units engaged in clearance, dredging, and other harbor or waterfront projects. See JP 3-34 and TM 3-34.73 for more information on seaport planning. See TM 3-34.55 for more information on hydrographic surveys.

5-36. When possible, port construction efforts in the JOA should consider the rehabilitation and expansion of existing facilities rather than initiating new construction. Rehabilitation and construction priorities, the choice of construction materials, and plans of operations for the port are factors that help gain the greatest capacity from the port while using the least expenditure of labor and material.

5-37. After the location of the port has been decided at the theater headquarters, the mission is assigned to an appropriate engineer level of command. The location of the port is made based on an analysis of the projected capacity of the facility, the quantity and nature of cargo to be handled, the tactical and strategic situation, and the construction materials and assets available. Engineers may provide solutions to eliminate facility constraints, increase or restore port throughput capacity or capabilities, and provide follow-on movement to unit assembly areas or the objective. See ATP 4-12, ATP 4-13, FM 4-01, and JP 4-09 for information on transportation planning considerations and requirements. See JP 4-18 for information on joint terminal operations. See JP 4-09 for information on highway systems, rail networks, and logistics support facilities.

5-38. Careful, comprehensive planning based on extensive and detailed reconnaissance is essential to successful port construction. A thorough initial reconnaissance helps planners to estimate more accurate logistics requirements by providing essential data on the physical condition of the seized or occupied port. Reconnaissance is conducted with physical or remote capabilities.

5-39. Geospatial products may assist before, during, and after seaport reconnaissance.

Notes.

1. See ATP 4-13 for information on a marine beach profile diagram on sea, shore, and beach slope construction requirements.

2. See FM 4-01 for information on a seaport and supporting facility layout.

4. See ATP 4-13 for information on seaport facilities.

5. See UFC 4-152-01 for designs on piers and wharves.

6. See TM 3-34.73 and TM 3-34.83 for information on dive team support planning.

5-40. There are a variety of designs for different types of port facilities and structures, including wharves (floating and stationary), piers, causeways, breakwaters, seawalls, landing ramps, anchorages, mooring, and support facilities.

Notes.

1. See TM 3-34.73 for port layouts.

2. See UFC 4 series for port designs and specifications.

3. See TM 5-850-1 for information on military port engineering designs.

4. See UFC 4-440-01 for information on port-supporting storage depots.

5-41. ATP 4-0.1 gives planning factors for approximate materials and man-hour requirements for the overall planning and estimating of general and break-bulk cargo port construction. TM 5-301-2, TM 5-301-4, and TM 5-303 provide information on design, material, and labor requirements for port structures.

5-42. After the port has been occupied, planners must carefully and critically examine previous plans in light of the physical condition and structural integrity of the port. Major proposed changes that impact logistics and scheduling must be coordinated through engineer, transportation, and command channels. Priorities established in the OPORD may have to be modified after construction is started based on current conditions and on-site information. Planning and scheduling are based on meeting all immediate needs, while ensuring that all work contributes toward successful project completion.

5-43. Comparative studies are made to determine the relative value of rehabilitation of the existing port versus new port construction. These studies compare the benefits to be gained from specific facilities within a port to the construction effort required. Among other factors, the selection of the best ports for further development is determined by the need for dispersion, location of logistics requirements, time and effort required to move construction units, local availability of materials, and civilian labor.

5-44. The Army theater sustainment command estimates port capacity requirements. The engineer usually makes an independent estimate of the port capacity under various alternative methods of construction, repair, or rehabilitation. This procedure serves as an aid in determining the most advantageous, relative priorities of engineer projects. However, the capacity estimates of the sustainment brigade or theater opening element must govern with respect to military loads. Several software packages exist that are helpful in determining port capacity and expansion requirements. Consult the reachback capabilities available through the USACE Reachback Operations Center for information on such software packages.

5-45. On the basis of port capacity estimates, the engineer recommends schedules for the construction, rehabilitation, and maintenance of port cranes and facilities; road and railroad construction within the port area; preparation of storage and marshaling areas; and others. Port openings may require support for reconnaissance, clearing obstacles, and constructing facilities.

UNIFIED FACILITIES CRITERIA

5-46. The UFC handbooks are guides for engineers, planners, construction workers, and facility personnel in the scheduling, inspection, maintenance, and repair of mooring hardware at waterfront facilities and related facilities.

5-47. The following UFC apply to port construction: UFC 4-150-02, UFC 4-150-06, UFC 4-150-07, UFC 4-150-08, and UFC 4-151-10.

WHARF FACILITIES

5-48. Port capacity estimates are based on the discharge rates of ships at the wharf or in the stream, which are associated with ships at anchor in connection with a JLOTS. Priority is given to methods that allow ships to be discharged more quickly. Construction is scheduled in coordination with transportation units so that construction activities interfere as little as possible with the discharge of ships.

ANCHORAGE

5-49. When sheltered anchorage is available, lighterage provides a means of discharging cargo while deep-water wharves are under construction or repair. By providing lighterage while construction and rehabilitation work go forward, continued unloading is possible through the use of the following alternatives:

- The continuous dredging of the deep-water wharf approach channel by using a shallow-draft approach and discharge outside dredging work areas.
- The use of shallow-draft parts of the wharf systems while some of the deep-water wharves are under construction.
- The unloading of shallow-draft vessels over deep-draft wharves during construction.

LOGISTICS OVER-THE-SHORE

5-50. At least 90 percent of the tonnage required to support deployed forces in the area of operations must be provided by sea LOCs. Although air LOCs usually carry high-priority shipments and personnel, sea LOCs will likely bear the main burden due to greater carrying capacities of strategic sealift vessels. The uninterrupted delivery of materiel requires that vulnerable fixed port facilities be backed up by a flexible system, and LOTS provide that system. LOTS is the process of loading and unloading ships without the benefit of deep draft-capable, fixed port facilities or as a means of moving forces closer to tactical assembly areas. The scope of LOTS depends on geographic, tactical, and time considerations.

5-51. JLOTS include Marine Corps forces and occur when the Navy and Army LOTS forces conduct LOTS together under a JFC. Armed forces LOTS involve transferring, marshaling, and dispersing materiel from a marine system to a land transport system. The rule of thumb for planners is that 40 percent of all cargo entering contingency theaters by surface means need to be delivered through LOTS terminals. In some theaters, this proportion may be much greater. Beaches that are distant from fixed port facilities serve as LOTS sites. The rapid establishment of a viable LOTS system depends on engineer construction and maintenance support. See JP 4-18, NWP 4-0M/MCTP 13-10K (MCWP 4-2), and NTTP 3-02.1M/MCTP 13-10E (MCWP 3-31.5).

5-52. Initial LOTS planning and site selection are coordinated between the theater opening element or sustainment brigade commander (Transportation Corps) and the Navy/Military Sealift Command. The initial site selection is based on map studies, hydrographic charts, and aerial reconnaissance.

RESPONSIBILITIES

5-53. Proper logistics planning to support deployed forces on a foreign shore always begins with an evaluation of in-place, fixed port facilities and capacities. These, combined with connecting railway, highway, and inland waterway networks, are the major logistics systems required for military operations. When a reckoning of available resources is complete, planners determine the need for LOTS terminals to supplement and back up the transportation network. See ATP 4-13 for information on LOTS layouts. See ATP 4-13 and JP 4-18 for information on JLOTS.

5-54. The overall responsibility for LOTS lies with the Army Transportation Corps for the Army and with the Navy for the Marine Corps. Each LOTS terminal acts under the direct control of a transportation terminal battalion that comprises two service companies and appropriate lighterage units. The CCDR may assign construction responsibilities to Army, Navy, and/or Marine Corps engineer units, depending on their availability and the overall situation. Mutually supporting or follow-on construction must be coordinated with other engineer units assigned to or projected for the area of operations.

5-55. Army engineers must be prepared to support the LOTS mission because—

- Existing ports may be damaged, incomplete, or unavailable.
- Existing ports may be unable to handle resupply.
- Existing port facilities are vulnerable to enemy activities, such as mining, CBRN, or air interdiction.
- Ports under repair may be unavailable for long periods.

5-56. Engineer units give construction, repair, and maintenance support to LOTS. An engineer unit may expect the following missions when supporting a JLOTS operation:

- Construct semipermanent piers and causeways.
- Prepare and stabilize beaches.
- Construct access and egress routes from beaches to backwater areas.
- Construct access routes to marshaling areas and/or adjoining LOTS sites.
- Construct marshaling and storage areas.
- Construct road and railroad links to existing LOCs.
- Construct utility systems.
- Construct petroleum, oils, and lubricant storage and distribution systems.
- Construct container collection sites.
- Provide other assistance or maintenance determined by the terminal commander.

RECONNAISSANCE

5-57. The reconnaissance party includes representatives of the terminal group commander, the terminal battalion command, the supporting engineer, the supporting signal officer, military police, Navy personnel to provide advice on mooring areas, and an Army engineer dive team to conduct a detailed hydrographic survey of the site. Hydrographic surveys provide a depiction of underwater bottom profiles of an operational shoreline or port area. Such a survey can provide accurate water depths, bottom depth gradients, ship channels, and the locations and types of underwater obstructions or other hazards that may impede vessel traffic. Others participate if the situation dictates or at the terminal commander's request. The reconnaissance party briefs the terminal commander on its findings. The briefing must cover the—

- Engineer effort required to prepare and maintain the site based on available units, equipment, and materials.
- Signal construction and maintenance required for necessary communications within the beach area and between the beach and the terminal group headquarters.
- Types of lighterage craft that may be used, based on beach conditions.
- Safe haven for lighterage craft in stormy weather.
- Location and desirability of mooring areas.
- Adequate egress from the beach. This and the beach dimensions are key factors in determining throughput capacity for the beach.
- Intensity of wave action and tidal range.
- Climatic and weather conditions.

5-58. The supporting engineer must be informed about the layout of the LOTS site and should be involved early in staff planning and coordinating because the layout determines the required engineer effort. A LOTS layout varies with the situation and existing geographic conditions. The physical size of the individual site depends on security considerations, soil trafficability, the number of ships to be unloaded at the site, and the type of cargo coming ashore. For example, a LOTS terminal may need to be very large if ammunition and/or petroleum, oils, and lubricants are being unloaded over a beach that is subject to enemy attack. General cargo unloaded over a secure beach requires less area. See ATP 4-13 for information on layout figures.

LANDING CRAFT UNLOADING POINTS

5-59. Knowledge of the beaching positions designated for landing craft is important to the supporting engineer, especially if landing points are used for extended periods of time without matting. A common maintenance problem regarding beaching positions is the creation of troughs or pits in the beach above and beyond the waterline. This can also impact routes from the beaches to backwater or remote areas. Troughing is caused by landing craft ramps, which dig into the inclined beach at a steep angle. This problem is exacerbated when wheeled vehicles dig into the sandy beach material and water washes the loosened material away. If matting is not used, vehicles can easily bog down, stall, and get stuck in these troughs, thus slowing or halting unloading. Engineers can reduce the troughing by placing sufficient quantities of stone or gravel at the unloading point or by cutting down the slope of the beach. Both of these measures require periodic maintenance for as long as the unloading points are used.

CONSTRUCTION

5-60. As discussed in other instances of construction in this publication, many construction practices apply to, and remain constant for, seaports. Special consideration for seaport construction is discussed in the following paragraphs.

PHASED CONSTRUCTION

5-61. Current procedures for port construction in undeveloped areas usually fall under the following phases:

- **Phase One, Preliminary.** This phase includes all requirements, from the arrival of construction units to the beginning of construction of deep-draft wharves (35 feet or deeper). The LOTS are conducted during this phase.
- **Phase Two, Initial Construction.** This phase continues to the point at which the first cargo ship berth is fully operational, including road and railroad connection; water supply and electrical services; and bulk petroleum, oils, and lubricant handling facilities that can receive liquid fuels directly from oceangoing tankers.
- **Phase Three, Completion.** This phase ends when construction is complete and authorized facilities are fully operational.

PORT CONSTRUCTION

5-62. Commercial records indicate that at least 9 months are required for a skilled construction crew of 30 to construct a modern (approximately 80 by 1,000 feet) steel or concrete pile wharf by conventional (cast-in-place and/or on-site job erection) methods. This time requirement, even allowing for larger construction crews, is excessive for current military operations and indicates that neither steel nor concrete pile wharves will likely be built by military units using conventional methods in the future. Recent studies indicate that although steel and concrete are the most common building materials used in new military port construction, their use is limited to new, unconventional construction and lower cost methods. See TM 3-34.73 for additional information on port construction and repair.

Steel Wharves or Piers

5-63. The use of steel in future military port construction is expected to occur mainly in the construction of expedient container ports with large, self-elevating, self-propelled, spud type barge pier units. These can be placed into service in comparatively short periods of time with less effort and can also be retrieved for subsequent uses.

5-64. These structures have been used extensively in the oil exploration industry. Their recommended use in expedient port construction is their actual use in situations that are as demanding as those found in similar modern military operations. The newer versions of these barges use truss type supports rather than caissons. They may be elevated at a much faster rate (50 feet per hour) and are more relocatable than older barges.

Concrete Wharves or Piers

5-65. Commercial port engineers are continuing to improve existing designs for precast concrete pier pilings, caps, decks, and curbs and for the use of new high-strength, quick-curing concrete options. These new techniques should considerably reduce the efforts and time requirements for conventional concrete port construction.

Support Facilities

5-66. A large amount of construction effort goes into building port support facilities. If a port is located in an area where an adequate railway or roadway network exists, then cargo-handling will be more efficient when there are like connectors on the wharves. Engineer units are responsible for the construction of railway and roadway facilities required by the port. Plans are staffed and coordinated with Transportation Corps requirements.

5-67. Designs currently being recommended to the Army for future expedient military container port construction include the use of tractor-trailers to transport individual International Standards Organization shipping containers from the wharves. The wharf must be of sufficient load-bearing strength (capable of supporting up to 1,000 pounds per square foot of live loads) and width (usually 80 to 100 feet) to accommodate fully loaded tractor-trailers. They must be constructed in such a manner as to avoid excessive breakover, approach, and departure angles and allow suitable gradients for connections to existing or planned roadway networks. See ATP 4-12 for additional information on Army container missions.

5-68. Other on-shore construction requirements include—

- Potable and nonpotable water supply for the port and ships docked or moored in the port.
- Electric power systems, which may require overhead and underground systems.
- Firefighting facilities and special systems as needed, such as special facilities for petroleum, oils, and lubricant terminals.

5-69. Suitable water depths must be maintained at ports to accommodate deep-draft (35 feet) sea vessel maneuvering requirements. According to TM 3-34.73, the normal draft for a container ship is 40 feet. Daily tidal ranges can exceed 20 feet and, therefore, must be taken into consideration when determining acceptable channel and pier side depths. A minimum low-tide water depth of about 35 feet should be used for planning purposes, because it will accommodate most deep-draft vessels. Current commercial container-shipping capacity requires port depths of at least 40 feet. The planned construction of wharves in shallow water may also be justified where—

- It is established that the required depth can be obtained by dredging, that such dredging is practical as part of the construction project, and that dredging can be performed without endangering the in-place wharf structure.
- Short-term use is anticipated, thus making the use of lighterage a more feasible option than dredging or wharf relocation.

5-70. Minimum water depths for new wharf construction are dictated by the intended use of the wharf (petroleum, oils, and lubricant wharf; container wharf; and lighter wharf), the type of wharf, and the size of the sea vessels to be accommodated. These depths are determined well in advance and are given in the operations order and/or construction directive.

5-71. Dredging may be necessary to establish and maintain required depths. Experience gained during World War II and the Vietnam War indicates that there are a number of specific problems associated with dredging projects in an area of operations. Hopper dredges and side-casting dredges are the only ones that are seagoing. The transportation of other types of dredges to the area of operations can be difficult, and they must be towed to the site or assembled from components transported aboard cargo ships.

5-72. It may also be difficult to provide adequate security for dredges during seize the initiative or dominate phases of operations. The routine patterns followed by dredges greatly limit the effectiveness of any passive defense measures. Pipeline dredges are virtually stationary targets. The availability of dredges and crews for use in the early stages of deployment in an area of operations can also be a major problem. The Army has no trained military dredge crews or portable dredges that are suitable for use in an area of operations. USACE does possess dredges and trained crews, but the availability of these is not certain and must be planned for and requested well in advance.

5-73. Sweeping, covered in TM 3-34.55, is a method of locating pinnacles or other obstructions that limit the accessibility of some ships to use the area. Sweeping is always used as a final check after dredging. When feasible, obstructions may be partially removed by explosives or other methods to allow unfettered access. If a sufficient operating area with adequate water depths is available, hazards may be properly marked with the appropriate use of lights and other signals placed on or near structures, sunken vessels, and other obstructions for the protection of vessels navigating inside the seaport.

Pier and Causeway Construction

5-74. TM 3-34.72 and TM 3-34.73 provide data on the types and use of pile material in the construction of piers and causeways. Piers and causeways allow cargo vessels direct beach access, thus eliminating the multiple handling of material and speeding unloading times. Piers are structures with working surfaces that are raised above the water on piles. Piers on open coasts typically project beyond the surf zone. The primary advantage of piers is the stability afforded by having working surfaces above the influence of wave attack, which permits consistent unloading at times when intensive wave action would otherwise prevent or inhibit landing craft from directly accessing a bare-beach site.

5-75. The sectionalized floating pier is a self-contained pier that can be brought to the LOTS site and emplaced in a comparatively short time. Specially trained engineer personnel from Army horizontal and vertical units can support the installation of this equipment. Army modular causeway units include organic equipment and forces to assemble floating modular causeway placement (see TM 3-34.73).

5-76. Other engineer assistance is required at the beach end of the pier to prepare the beach and anchor the pier. Causeways are floating structures, which project out from the beach. In some applications, they are used as rafts to ferry equipment from ship to shore. Causeways are more susceptible to intense wave action than are piers, but they are much more easily deployed. In areas where wave action is not a significant problem, causeways can be used as floating piers. Engineers provide beach preparation and anchoring for causeways.

Road Construction

5-77. Seaport road construction supports the LOTS site layout, road network within the port, and roads connecting the port to the transportation network. The major engineer effort in LOTS is invested in road construction and maintenance. Considerable effort must be spent to adequately stabilize soil conditions to ensure a suitable foundation and improve trafficability in the beach area. Constructed roads must withstand the large volume and impact of material-handling equipment carrying extremely heavy loads. Roads that support LOTS are usually constructed in a loop to reduce their required width, eliminate vehicle turning as much as possible, and prevent vehicle congestion.

OPERATION AND MAINTENANCE

5-78. Ports are operated by Army transportation units or Naval Expeditionary Combat Command Forces. Operation units perform maintenance within their capabilities. General engineer units perform port maintenance and repair within their capabilities. Maintenance involves routine engineering efforts to keep port facilities in good working order and service. Repair involves the correction of critical defects to restore damaged facilities to operational service. The repair and maintenance of conventional and expedient construction could include emergency repair, major repair, rehabilitation of breakwater structures, and expedients. See TM 3-34.73 and TM 5-622/NAVY MO-104/AFM 91-34 for additional information on port maintenance.

MAINTENANCE

5-79. Routine maintenance is essential to allow the port to continue its functionality and good service. Inspections are scheduled to review maintenance service records and conduct physical inspections of port infrastructure and individual facilities. This includes underwater inspections and assessments of port facilities with the use of dive teams. Based on the inspections, repairs are scheduled and repair parts/materials are ordered.

EMERGENCY REPAIR

5-80. Emergency repair is immediate work required to repair storm, accident, or other damage to prevent additional losses and larger repairs. Emergency repairs include—

- Repairs to breached breakwaters to prevent further damage to harbor installations.
- Repairs of wharf damage caused by ships, storms, or enemy action to restore structural strength.
- Adding rock to control foundation scour or breach erosion.

MAJOR REPAIR

5-81. Major repair is required when there is significant damage to the port facilities that requires replacement work or rebuilding. This includes—

- Replacing wharf decks.
- Resurfacing access roads and earth-filled quays.
- Replacing wharf bracings and anchorages that have been destroyed by decay or erosion.
- Replacing entire spud barge pier, spud, or other major barge pier accessories.

EXPEDIENT REPAIR

5-82. The use of expedient repair methods should be encouraged during limited port operations while major repair and rehabilitation go forward (see TM 3-34.73).

5-83. Possible measures to speed repairs are as follows:

- Use launches or tugboats with a line to the shore for various hauling and hoisting functions in construction work at the waterfront.
- Erect a derrick or install a crawler or truck-mounted crane on a regular barge, a mechanized landing craft, a barge of pontoon cubes, or a barge fabricated for military floating bridge units.
- Fabricate rafts for pile bent bracing from oil drums, heavy timbers, spare piles, or local material.
- Improvise floating dry docks for small craft from Navy pontoons.
- Improvise light barges, floating wharf approaches, and small floating wharves from steel oil drums.

- Lay diagonal flooring over existing decking to strengthen a structure by distributing the load over more stringers.
- Remove the decking to add stringers, or place smaller stringers on the pile cap between existing stringers from beneath the decking and wedged tight against the deck.
- Drive the piles through the hole, move several floor planks, and then cap new pile bents and wedge them tight against the stringers. (This can only be done if the wharf can support the weight of the pile driver.)
- Use a rock- or ballast-filled timber crib to replace a gap in a pile wharf structure or to extend the offshore end on the wharf. The timber crib may be built on land, launched by using log rollers, floated into position, and filled with rock or ballast to hold it in place.
- Use standard military floating bridges or Navy pontoons to supplement or temporarily replace damaged causeways.
- Use standard military floating bridges or Navy pontoons to provide access between undamaged sections of off-loading piers.
- Restore the face of the wharf first if a section of a wharf has been destroyed so that ships may be worked while the area behind the face is being restored.
- Use the shore end of a pier for lighters or other short vessels while the pier is being extended.
- Use standard or nonstandard fixed bridging to bridge part of a solid-fill wharf (see TM 3-34.22/MCRP 3-34A.2 [MCRP 3-17.1B]).
- Use camels, barges, or other devices to block slips that are filled with rubble. This prevents ships from being brought to the face of the wharf and allows them to be retained in deep water for unloading. Alternatively, it may be possible to use standard trestles, fixed bridging, and assembled Navy pontoons to extend the width of the pier.
- Use the hull of a capsized or sunken vessel as the substructure for a pier.
- Anchor the shore end of a causeway constructed from Navy pontoon cubes onshore by excavating a section of beach, floating the pontoons into the temporary inlet thus made, and then backfilling to provide a solid anchorage.
- Use field-expedient matting.

REHABILITATION OF BREAKWATER STRUCTURES

5-84. Breakwaters are used to protect a harbor, anchorage, basin, or area of shoreline from waves. Breakwaters reflect or dissipate wave energy and thus prevent or reduce wave action in the protected area. These structures must be designed to effectively serve competing requirements for wave blockage and safe vessel passage from fully exposed waters through a constricted entrance into tranquil harbor waters.

5-85. Breakwaters are often constructed as shore-connected structures, thereby allowing access from land for construction, operation, and maintenance. However, this design may have an adverse impact on water quality or sediment transport, so detached offshore breakwaters are used in certain situations. Many systems utilize a combination of shore-connected and offshore breakwaters to protect anchorage or mooring areas.

5-86. It is preferable for breakwaters to prevent wave energy from entering a harbor rather than try to dissipate excessive wave energy inside the harbor. It is also important that breakwaters be constructed to limit wave reflection, which can cause hazardous navigation conditions.

5-87. Most breakwaters built on the open coasts of the United States consist of rubble-mound construction. Other structural types include concrete caisson, timber crib, sheet pile, composite, and floating. All breakwaters must be high enough to prevent excessive wave overtopping and sufficiently impermeable to deter wave transmission through the structure.

5-88. Breakwaters are subject to damage and overtopping by large storms, which can lead to extensive damage to protected port facilities, infilling of channels, and significant reductions of navigation channel availability. Therefore, the repair of breakwaters and similar structures is required to protect the structural integrity of the port from intensive wave action; prevent harbor erosion; and allow safe navigation, harborage, and port activities. Breached breakwater structures are repaired by placing individual rocks or engineered concrete armor in interconnecting mounds. The stone rubble is placed in graded layers to provide filtering and limit wave penetration through the porous structure. Armor size is engineered and depends on the wave and water level climate. Breakwater layout can be parallel, perpendicular, or at any angle to the coast, depending on what will maintain tranquil harbor conditions. In situations where large rock is not available, artificial rubble and protective armor units may be fabricated relatively close by and delivered to the site for emplacement.

MARSHALING AREAS

5-89. Marshaling areas serve as centralized collection points at which unloaded materials and equipment can be temporarily stored while awaiting distribution to the proper units. The size of the marshaling area varies with the size and type of shipping, the unloading rate, the exposure to hostilities, and the units being supported. Marshaling areas are tailored to specific operations and can need as much as 500 acres for large-scale combat operations (see ATP 4-13 for layout information).

5-90. In hostile environments, marshaling areas are dispersed, with acreage divided into many small parcels. Other protection considerations must be integrated into the design of marshaling areas as well. See ATP 4-13 for specific details on planning, constructing, organizing, managing, and maintaining marshaling areas.

5-91. Marshaling area surfaces and foundations must be sufficiently stable to support a fully loaded piece of material-handling equipment that weighs up to 100,000 pounds. Access and egress roads must be capable of supporting the same loads. The surface must be protected with adequate drainage.

5-92. International Standards Organization container collection areas must be planned and provided. These areas must have the same trafficability, drainage, and access/egress characteristics as the marshaling areas and can require nearly as much space. Most material shipped to a JOA via surface transportation is containerized. Once ashore, the containers are opened and unpacked for distribution to the intended units. Empty containers are collected and reloaded aboard ships and then returned to their point of origin. See ATP 4-12 and JP 4-09 for information on container requirements, operations, and management.

AMMUNITION STORAGE AREAS

5-93. Areas in which ammunition is to be unloaded, sorted, and temporarily stored require the same type of planning and engineer effort as marshaling areas. In addition, engineer units will have to perform additional horizontal construction work by making earthen berms and revetments. Ammunition supply points that will be used for an extended time must be provided with overhead protection from the elements. See ATP 4-35.1 for site layout information.

5-94. Ammunition storage areas must be remote from other activities on the beach. They must be dispersed, concealed, and camouflaged. Each site requires access and egress routes, preferably arranged so that vehicles do not back up and block the traffic flow. See ATP 4-35 and ATP 4-35.1 for additional information.

PETROLEUM, OIL, AND LUBRICANTS STORAGE AREAS

5-95. Fuel storage areas on the beach will likely be the largest concentration of fuels in the distribution system. Although not a general engineering task, Army engineers may be required to assist the Quartermaster Corps by constructing rigid storage tanks of sufficient size, building a distribution network of pipelines, installing collapsible tank farms, or constructing related facilities.

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Chapter 6

Airfields and Heliports

Airpower affords great flexibility because aircraft can travel great distances quickly while performing a wide variety of missions. Military aircraft can conduct ISR, attack, and transport missions within an AOR or across the globe. Infrastructure, such as airfields and heliports, are essential to support the projection of military airpower where and when needed. This chapter focuses on the planning, design, construction, and O&M of airfields and heliports.

RESPONSIBILITIES AND CAPABILITIES

6-1. Airfields and heliports are considered a mobility engineer function. Army, Marine Corps, Navy, and Air Force engineers have the capability to plan, design, construct, repair, and maintain airfields and heliports. Due to the resources required to construct a new airfield/heliport, seizing or using an existing airfield/heliport is preferred. Airfields seized or recovered may require repairs to restore them to their full capacity/capability. Because airfields are vital to the execution of combat operations, the enemy can be expected to attack them. To account for this, units capable of conducting airfield damage repair (ADR) and obtaining ADR materials should be located at operational airfields/heliports. All Services have the capability to conduct ADR and may be called on to assist in operations. See JP 3-34 for additional information on Service capabilities. See DODD 4270.5 for specific information on the repair responsibilities of each Service.

ARMY

6-2. Army engineers may be tasked to support initial ADR or rapid runway repair as part of a forcible-entry operation as outlined in AFPAM 10-219 V5; DODD 4270.5; JP 3-34; TM 3-34.48-1; and TSPWG Manual 3-270-01.3-270-07. Forward aviation combat engineering is performed by combat engineers to enhance mobility. See ATP 3-90.4/MCTP 3-34A for a further discussion of forward aviation combat engineering.

6-3. Forward aviation combat engineers prepare or repair expedient landing zones, forward arming and refueling points, landing strips, or other aviation support sites in the forward combat area. These are considered combat engineering tasks and are focused on providing support to tactical combat maneuver forces. All other airfield and heliport planning, design, and construction tasks are considered general engineering tasks. Army engineers may assist other engineers, as directed, in airfield and heliport assessment, planning, design, construction, repair, and maintenance. See GTA 90-01-045, TM 3-34.48-1, TM 3-34.48-2, and UFC 3-260-01.

MARINE CORPS

6-4. Marine Corps engineers, as part of the engineer support battalion, also have organic horizontal assets for expedient airfield construction and repair. The Marine wing support squadron has primary responsibility for expedient airfield construction and repair. Although it is a secondary mission, Marine engineers can construct expedient airstrips and landing zones. They can also clear helicopter landing zones; conduct air base damage repair, improve and sustain airfields; conduct rapid runway repair; and build, improve, and sustain expeditionary airfields. See MCTP 3-20.B for additional information.

NAVY

6-5. The naval mobile construction battalion (Seabees) capabilities include organic horizontal assets to construct and repair airfields. The construction of expedient airfields (matting) is part of their role in facilitating the landing and movement of troops, equipment, and supplies from the beachhead. As a general engineering task, Seabees repair and improve bare-base existing airfields and can conduct expedient airfield damage repair in support of distributed maritime operations. See JP 3-34 and NWP 4-04 for additional information.

AIR FORCE

6-6. Due to their specialized expertise, Air Force engineers take the lead to open, establish, and sustain airfields that support large and high-performance aircraft at locations where Air Force aircraft operate. See JP 3-34 for a further description of Air Force capabilities.

6-7. Air Force engineers are organized into the prime base engineer emergency force (Prime BEEF) and the rapid engineer deployable heavy operational repair squadron engineer (RED HORSE) units. The Prime BEEF provides rapid-response civil engineer capabilities, which include airfield construction, repair, and maintenance. The RED HORSE is a self-sufficient, mobile heavy construction unit capable of rapid response and independent operations, to include heavy repair and construction capabilities when the requirements exceed Prime BEEF capabilities. See Air Force Doctrine Publication 3-34 for more information.

6-8. Air Force engineers are responsible for establishing air bases to support the projection of airpower. As such, the Air Force is responsible for the emergency repair of established air bases (see Air Force Doctrine Publication 3-34). This includes the emergency repair of air base paved surfaces, which is called rapid runway repair. When Air Force engineering capabilities are exceeded, the Army provides construction support (see JP 3-34).

6-9. The preponderance of work may be performed by Army engineers due to the availability of general engineer assets and, in some cases, it may be preferable for Army (or other Service) engineers to take the lead in supporting airfield operation. Army engineer support to Air Force-controlled airfields is as follows:

- Develops engineering design criteria, standard plans, and material to meet Air Force requirements.
- Performs the reconnaissance, survey, design, construction, or improvement of airfields, roads, utilities, and structures.
- Repairs Air Force bases and facilities beyond the immediate emergency recovery requirements of the Air Force (semipermanent and permanent repair).
- Supplies construction materials and equipment.
- Assists in the emergency repair of war-damaged air bases.
- Assists in providing expedient facilities (force bed-down).
- Manages war damage repair and base development.
- Supervises Army personnel. (The Air Force base commander sets priorities.)
- Performs emergency and permanent repair of war damage to forward tactical airlift support.

SERVICE RESPONSIBILITY

6-10. The branch of Service that is the primary user of the airfield or heliport has the responsibility for certifying that facility for flight control. In most cases during airfield contingency operations, this is an Air Force responsibility. Air Force engineers may assist Army engineers, Navy Seabees, or Marine Corps engineers, as directed, in airfield and heliport planning, design, construction, repair, and maintenance. See Air Force Doctrine Publication 3-34.

6-11. The Air Force provides the following engineer support:

- Performs the primary emergency repair of war damage to air bases and other ADR tasks.
- Constructs expedient facilities for Air Force units and weapon systems. (This excludes the responsibility for Army base development.)
- Operates and maintains Air Force facilities.

- Performs maintenance tasks.
- Provides crash rescue and fire suppression.
- Provides HAZMAT response.
- Manages the emergency repair of war damage and force bed-down construction.
- Provides infrastructure support for the disposal of solid and hazardous waste.
- Supplies resources for its own engineering mission.
- Provides the EBS and OESHA for the airfield and its support facilities.

PLANNING AND DESIGN

6-12. Airfield planning requires airfield reconnaissance and an understanding of the airfield types and classifications. Airfield design includes design considerations, geometric design, pavement structure design, drainage system design, support facility design, protection design, and special airfield designs discussed in this chapter.

AIRFIELD PLANNING

6-13. Engineers are responsible for airfield planning. This includes conducting site reconnaissance, making recommendations, designing the airfield or heliport, and conducting the actual construction of the individual airfield. Airfield and heliport planning and design include the runway or helipad and the supporting facilities. The planning and design may include conceptual planning to support aircraft bed-down, evaluation to rehabilitate or upgrade existing facilities, site adaption of existing standard designs, preliminary plans and designs, detailed plans and designs, and project management planning. Key planning actions include site selection, designation of controlling aircraft, construction standards (airfield and support facilities), and estimation of required construction effort.

6-14. Airfield designs may be provided by one of the Services obtained from JCMS, TSPWG M 3-270-01.3-270-07, and UFC 3-260-01; developed by engineers using manual procedures discussed in TM 3-34.48-1 or TM 3-34.48-2; or developed by engineers using computer-aided processes. The JCMS provides information on how to obtain detailed standard designs for the airfield type and capacity. However, the planner may need to alter and adapt the designs to meet time and material restrictions, or the limitations imposed by local topography, area, or obstruction characteristics. Engineers may alter designs, but they must obtain approval from the user for major changes before starting work.

6-15. Early in the planning process, operations, logistics, and engineer planners should identify potential forward airfields to support offensive air operations and logistics buildup and outline the engineer tasks required to open the airfields. It is critical that joint engineers ensure early and effective coordination between airfield planners and the commands that will operate aircraft at the airfields. Many of the decisions made early in the planning process can have a critical impact on an airfield utility for aircraft (see JP 3-34).

6-16. Most planning factors for road designs are also applicable for airfields. The most important factors for engineer planners include the mission variables plus several other categories:

- **Mission**. Airfield design relies on operational considerations, including the number, type, model, and series of aircraft expected to be assigned to the airfield, the desired sortie rate, and the airfield purpose (fighter base, unmanned aircraft system reconnaissance, transportation hub, or a combination).
- **Enemy.** Devise an adequate plan to ensure that construction troops can protect themselves, equipment, and materials against harassment and sabotage during airfield or heliport construction. Consider requirements for additional security forces. Design will also account for enemy weapons that can be employed against the airfield to damage critical facilities, destroy aircraft and supplies, and kill personnel.

- **Terrain and weather.** Within mission and operational requirements, establish reasonable site requirements for each airfield type. Choose geographic locations based on topographic features (grading, drainage, and hydrology), soils, vegetation, utilities, climatic conditions, and accessibility of materials. Accurate airfield design requires a topographic survey with minimum 5-foot contour intervals. Other site characteristics to be studied include forecasted weather effects (such as temperature, barometric pressure, precipitation, seasonal weather variations, and wind speed and direction) and flight path obstacles. Evaluate all existing transport facilities to determine the best methods and routes to logistically support the project. These include ports, rail lines, road nets, and other nearby airfields that might be used for assembling construction equipment and materials and moving them to the construction site.
- **Troops and support available.** Evaluate the availability and type of engineer construction forces to determine if construction capability is sufficient to carry out the required airfield construction. Weigh the type and availability of local construction materials against the overall needs for proposed construction. Consider examining naturally occurring materials and other possible sources of materials for subgrade strengthening. Requirements for importing special materials for surfacing, drainage, and dust control must be feasible for available construction time and resources. Have a working knowledge of forces dedicated to ADR. Depending on the base location, local agreements, and the overall military situation, any combination of Army, Air Force, HN, or contract engineer support may be possible. Consider time-phased force and deployment data or population flow into the airfield when developing the airfield master plan.
- **Time available.** Operational and mission requirements dictate when airfields are needed to support aviation operations.
- **Civil considerations.** Consider what civilian construction resources are available in the local area and what structures already exist that could be used to support airfield construction, repair, and maintenance. Consider the environmental impact, restricted areas, political and cultural factors, and other factors that could impact airfield layout and construction.
- **Maximum [aircraft] on ground (MOG).** MOG is the maximum number of aircraft that can be accommodated on an airfield. MOG is normally expressed in terms of C-17s. A minimum of MOG 2 is desired for contingency airfields. (Refer to AFPAM 10-1403 for aircraft dimensions.) The types of MOG include the—
    - **Working MOG.** The maximum number of aircraft at a given location that can be simultaneously quick-turned within the standards published in AFPAM10-1403. Working MOG is the most restrictive of active passenger MOG, fueling MOG, maintenance MOG, operating MOG, and parking MOG.
    - **Passenger service MOG.** The number of high-reach/wide-body aircraft that can be serviced simultaneously with passenger service based on complete download and upload requirements. The figure is based on 24-hour sustained capability, high-reach/wide-body, quick-turn ground times.
    - **Fleet service MOG.** The number of aircraft that can be serviced simultaneously with fleet service. The figure is based on 24-hour sustained capability.
    - **Cargo MOG.** The number of high-reach/wide-body aircraft that can be serviced simultaneously with cargo loading operations based on complete cargo download and upload requirements. The figure is based on 24-hour sustained capability, high-reach/wide-body, quick-turn ground times.
    - **Fueling MOG.** The number of aircraft that can be simultaneously refueled given the use of fuel hydrants and/or fuel trucks, the manpower to operate them, and the capacity of the system.
    - **Maintenance MOG.** The number of aircraft that can be simultaneously ground-handled for standard maintenance items during a quick turn/remain overnight. Standard maintenance items include: launch/recovery, servicing, inspections, debrief, minor maintenance, and forms management (requires 3 qualified aircraft maintenance personnel per transient aircraft).

- **Operating MOG.** The maximum number of aircraft (operating under or supporting U.S. missions) permitted at a location, restricted by: HN restrictions, diplomatic clearances, aircraft rescue and firefighting, slot times, air traffic control restrictions, or other items not directly related to the airfield infrastructure or aircraft servicing capability.
- **Parking MOG.** The physical parking spaces available for DOD airlift aircraft and/or contract carriers. It should not exceed the number of spots identified on the most current parking plan and may be limited by factors such as an HN agreement, hazardous parking spots available, or other infrastructure limitations. It should be expressed in two exclusive numbers—wide-body (C-17 equivalent) MOG and narrow-body (C-130 equivalent) MOG. Airfield managers may identify a contingency parking MOG (number of aircraft that could be parked on the airfield in the event of contingency operations). A contingency parking MOG will always equal or exceed the standard parking MOG.
- **Active passenger MOG.** The most restrictive of passenger MOG, fleet service MOG, and cargo MOG.

Airfield Reconnaissance

6-17. Airfield reconnaissance differs from road reconnaissance in that more comprehensive information is typically required. An airfield project involves more effort in labor hours, machine hours, and material than road projects. Air traffic also imposes stricter requirements on traffic facilities than does vehicular traffic. Consequently, the site selected has to be the best available.

6-18. When new construction is undertaken, the planner and the reconnaissance team must choose a site with soil characteristics that meet strength and stability requirements or a site that requires minimum construction effort to attain those standards. Airfields present more drainage problems than roads. Their wide, paved areas demand that water be diverted completely around the field or that long drainage structures be built. Sites at the low point of valleys or other depressed areas should be avoided because they tend to be focal points for water collection. As in road construction, subsurface water should be avoided. A desirable airfield site lies across a long, gentle slope because it is relatively easy to divert water around the finished installation. See TM 5-820-1/AFM 88-5 for information on drainage and erosion control for airfields and heliports.

6-19. Airfield reconnaissance must consider the quality and quantity of land available. To accommodate missions efficiently, airfields require large areas of relatively flat land. Advance location and layout planning will avoid the overcrowding of facilities. To obtain the required area, the airfield may have to be spread over a large area. This may call for a complex network of taxiways and service roads. Runways should be aligned in the direction of the prevailing wind.

6-20. Airfield reconnaissance must consider elevation and the obstacles obstructing aircraft approaches. The safe operation of fixed- or rotary-wing aircraft requires that all obstacles above elevations specified by design criteria be removed. These criteria vary according to the operating characteristics of the aircraft that use the airfield. For example, most heliports require an approach zone with a 10:1 glide angle, whereas heavy cargo aircraft in the rear area require a glide angle as flat as 50:1. To achieve the right glide angle, it is often necessary to remove hills and do major earthwork on distant approaches to the airfield proper. The reconnaissance team should avoid locations requiring extensive earthwork to achieve the necessary glide angle. Clearances are also required along the sides of runways, taxiways, and parking aprons. An area of specified width must be cleared of all obstacles and graded according to specifications.

Airfield Types and Classifications

6-21. There are three types of airfields and heliports:

- Initial (drop zones, extraction points, expedient airfields).
- Temporary (sustained for use 6 to 24 months and include a higher standard of construction).
- Semipermanent (have highest standards of construction and are located in rear areas and used by all mission aircraft).

Note. See TM 3-34.48-2 for additional information on the types of airfields and heliports.

6-22. Classifying runways in terms of their length is still common among military planners. Typical runway lengths are 2,000, 2,500, 3,000, 3,500, 6,000, and 10,000 feet. A controlling aircraft or combination of controlling aircraft has been designated for each category to establish limiting airfield geometric and surface strength requirements. Pavement structures are classified as rigid (Portland cement) or flexible (surfaced or unsurfaced). Runways are classified as follows:

- Class A runways are primarily intended for small, light aircraft. These runways do not have the potential of a foreseeable requirement for development for use by high-performance and large, heavy aircraft (see UFC 3-260-01).
- Class B runways are primarily intended for high-performance and large, heavy aircraft (see UFC 3-260-01).

6-23. Army airfields and heliports are divided into six classes:

- **Class I.** Helipads and heliports (Type B) with aircraft 25,000 pounds (11,340 kilograms) or less. The controlling aircraft is a UH-60 aircraft at a 16,300-pound (7,395-kilogram) operational weight.
- **Class II.** Helipads and heliports (Type B) with aircraft over 25,000 pounds (11,340 kilograms). The controlling aircraft is a CH-47 aircraft at a 50,000-pound (22,680-kilogram) operational weight.
- **Class III.** Airfields with three traffic areas (Type A, B, and C). The controlling aircraft combination is a C-23 aircraft at a 24,600-pound (11,200-kilogram) operational weight and a CH-47 aircraft at a 50,000-pound (22,680-kilogram) operational weight. Class A runways are primarily intended for small aircraft, such as C-12s and C-23s.
- **Class IV.** Airfields with Class B runways. The controlling aircraft is a C-130 aircraft at a 155,000-pound (70,310-kilogram) operational weight or a C-17 aircraft at a 580,000-pound (263,100-kilogram) operational weight. Class B runways are primarily intended for high-performance and large, heavy aircraft, such as C-130s and C-17s.
- **Class V.** Contingency heliports or helipads (Type B) contingency supporting Army assault training missions. The controlling aircraft is the CH-47 aircraft at a 50,000-pound (22,680-kilogram) operational weight.
- **Class VI.** Assault landing zones for contingency airfields or airstrips (Type A) supporting Army missions that have semiprepared or paved surfaces. The controlling aircraft is the C-130 aircraft at a 155,000-pound (70,310-kilogram) operational weight or the C-17 aircraft at a 580,000-pound (263,100-kilogram) operational weight.

Note. See UFC 3-260-02 for additional information on the classes of airfields and heliports.

6-24. Air Force airfields are classified into one of six types based on their airfield mission and operational procedures. A controlling aircraft or combination of controlling aircraft has been designated for each type to establish limiting airfield geometric and surface strength requirements. These airfield types include—

- Light—F-15 and C-17.
- Medium—F-15, C-17, and B-52.
- Heavy—F-15, C-5, and B-52.
- Modified Heavy—F-15, C-17, and B-1.
- Auxiliary—F-15.
- Assault Landing Zone—C-130 and C-17.

Note. See UFC 3-260-02 for additional information.

6-25. A bare-base airfield has the minimum essentials to house, sustain, and support operations and can include a stabilized runway, taxiways, and aircraft parking areas. A bare base must have a source of water that can be made potable. Other requirements to operate under bare-base conditions form a necessary part of the force package deployed to the bare base. See Air Force Doctrine Publication 3-34 and JP 3-05.

6-26. The airfield must be capable of supporting assigned aircraft and providing other mission-essential resources, such as a logistics support and services infrastructure composed of people, facilities, equipment, and supplies. This concept requires modular, mobile facilities; utilities; and support equipment packages that can be rapidly deployed and installed. A bare-base airfield forms the baseline for contingency operations airfield planning (see TM 3-34.48-1 and TM 3-34.48-2 for additional information).

6-27. Preplanned design layouts within JCMS for each type of field are based on the assumption that previously unoccupied sites will be chosen. However, the layouts have been coordinated so that, within terrain limitations, it is practicable to develop a larger field from a smaller one with minimal construction effort. An existing airfield or a bare-base site can be used if it meets minimum requirements or can be upgraded to meet operational or mission requirements.

6-28. The Air Force issues Engineering Technical Letters (ETL) to provide engineers with criteria and guidance for the design, construction, maintenance, and evaluation of airfields and other support facilities. Many ETL's have been revised and converted into UFC. ETLs are available at the Whole Building Design Guide ETL website.

AIRFIELD DESIGN

6-29. There are a variety of airfield designs that must be considered by the engineer. There are design processes and steps that can be applied. These airfield designs include geometric, pavement, drainage, support facility, protection, and special.

6-30. Airfield design steps include the following:

- Select the runway location.
- Determine the runway length and width.
- Calculate approach zones.
- Determine the runway orientation based on the wind rose, which statistically quantifies prevailing winds.
- Plot the centerline on graph paper, design the vertical alignment, and plot the newly designed airfield on the plan and profile.
- Design the transverse slopes.
- Design taxiways and aprons.
- Select visual and nonvisual aids to navigation.
- Design logistics support facilities.
- Design aircraft protection facilities.

Geometric Design

6-31. Airfield geometric design consists of meeting the minimum geometric requirements for the elements that compose the airfield—runway, overrun, taxiway, apron, shoulders, graded area, transitional area, runway end clear zone, turnarounds (hammer heads), imaginary surfaces (approach-departure clearance surface), and accident potential zones.

Notes.

1. See TM 3-34.48-1 and TM 3-34.48-2 for information on the geometric design requirements for each airfield type.

2. See UFC 3-260-01 for information on C-130 and C-17 airfield dimensional criteria.

Pavement Structure Design

6-32. The pavement structure designs for airfields are similar to the pavement structure designs for roads. The same structural principles apply. The design of airfield pavement structure is also called the thickness design procedure because the design determines the total thickness and cover requirements for each layer. Several pavement type designs are possible for a specific site. The designer provides analysis to recommend the most economical design that meets operational requirements and site conditions.

6-33. There are four categories of airfield surfaces:

- Expedient-surfaced (unsurfaced and surfaced).
- Aggregate-surfaced.
- Flexible pavement.
- Rigid pavement.

6-34. There are four types of airfield pavement system surface structures above the subgrade. They are—

- Semiprepared airfield (unsurfaced, in-place soils or improved subgrade or surfaced, membrane-surfaced, and mat-surfaced).
- Semiprepared airfield (aggregate-surfaced layered structure over compacted subgrade).
- Surfaced airfield (flexible pavement or bituminous pavement).
- Surfaced airfield (rigid pavement).

6-35. On operational airfields, pavements are grouped into four traffic types based on their intended use and design load. These types include—

- **Type A.** Those traffic areas that receive concentrated traffic and the full design weight of the aircraft. These traffic areas require a greater pavement thickness than other areas on the airfield and include all airfield runways and, in most cases, runway ends and primary taxiways. All airfield pavement structures on contingency operations airfields are considered Type A traffic areas.
- **Type B.** Those traffic areas that receive a more even traffic flow and the full design weight of the aircraft. These traffic areas include parking aprons, pads, and hardstands.
- **Type C.** Those traffic areas with a low volume of traffic or those where the applied weight of the operating aircraft is generally less than the design weight (use 75 percent of the design weight of aircraft to determine the applied weight). These traffic areas include secondary taxiways, washrack pavements, access aprons, interior portions of runways, and hangar floor areas trafficked by aircraft.
- **Type D.** Those traffic areas with an extremely low volume of traffic or those where the applied weight of the operating aircraft is considerably lower than the design weight (use 75 percent of the design weight of aircraft to determine the applied weight).

Notes.

1. See UFC 3-260-02 for additional information.

2. See ETL 97-9 and UFC 3-260-02 for information on the strength and thickness of pavement and structural evaluation criteria of semiprepared and matted airfields for the C-17.

6-36. There are several types of bituminous pavement; however, flexible-pavement airfields usually have an asphalt concrete wear surface. The frost filter layer to prevent pavement heaving and thermal cracks is more common in airfield construction than in roads.

Notes.

1. See TM 3-34.63 and UFC 3-260-02 for a discussion on the design of pavements for frost action.

2. See TM 3-34.63 for structural design and pavement specifications.

3. See UFC 3-260-03 for pavement evaluations.

Drainage System Design

6-37. Drainage system designs are similar to road and railroad designs and are discussed in TM 3-34.48-1.

Support Facility Design

6-38. Airfield and heliport base development planning and support facility planning, design, and construction are similar to the procedures used for base camp and bed-down facilities. Facilities may include access and service roads, storage areas, navigation aids, hardstands, maintenance aprons, warm-up aprons, corrosion control facilities, control towers, airfield lighting, and fortifications for parked aircraft.

6-39. The design of support facilities should be based on the number and type of other organizations collocated on, or supported by, the airfield. The base camp technique of using a design population can help properly design the airfield support facilities and services. Considerations for airfield or heliport development, master planning, facility siting, and layout planning include—

- Airfield location.
- Functional effectiveness and efficiency, sustainability, resiliency, security, expandability, and ease of construction.
- Layout space for land use functions and relationships, facilities, separation distances, accesses, protection methods, and expansion procedures.
- Adequate drainage.
- Environmental considerations.

6-40. An airfield consists of seven categories of facilities:

- **Category 1.** Airfield (runways, taxiways, hardstands, aprons, and other pavements; shoulders; overrun; approach zones; air traffic control landing systems; and design related facilities [access and service roads; ammunition and petroleum, oils, and lubricant storage areas; arresting systems; airfield marking and lighting; corrosion control facilities; fixed control towers; and other support facilities]).
- **Category 2.** Sanitary facilities (kitchens, dining areas, showers, and latrines).
- **Category 3.** Direct operational support facilities (munitions, aviation fuels and lubricants, HAZMAT, and waste storage sites).
- **Category 4.** Maintenance, operations, and supply (aircraft maintenance, base shops, operations buildings, base communications, photography labs, fire stations, weather facilities, general storage, and medical facilities).
- **Category 5.** Indirect operational support facilities (roads and exterior utilities, such as water supply and electric power systems).
- **Category 6.** Administration (headquarters, personnel services, recreation, and welfare facilities).
- **Category 7.** General housing and troop quarters.

Protection Design

6-41. The planning and design of protective measures and structures on airfields and heliports are based on the evaluation of the threat.

Notes.

1. See TM 3-34.48-2, for information on fortifications for parked Army aircraft.

2. See ADP 3-37 and ATP 3-39.32 for information on force protection measures.

3. See ATP 3-37.34/MCTP 3-34C for information on survivability (hardening) support, including the construction of revetments for helicopters.

4. See AFMAN 91-201 for information on Air Force aircraft survivability.

Special Designs

6-42. Special airfields include—

- Drop zones.
- Extraction zones.
- Special operations forces airfields.
- Blacked-out airfields.
- Airfields for unmanned aircraft systems.

6-43. New construction for some unmanned aircraft systems should only be required when they are operated from a location without a paved road or an existing runway. To support mobile, unmanned aircraft systems, most unmanned aircraft system airfields are constructed with matting. Unmanned aircraft system operators must provide runway design criteria for systems that do not have standard designs already developed (see UFC 3-260-01 for additional information).

6-44. It may be required to build airfields and heliports in arctic and subarctic conditions (see TM 5-852-1/AFR 88-19, Volume 1; TM 5-852-2/AFR 88-19, Volume 2; TM 5-852-4/AFM 88-19, chapter 4; TM 5-852-5/AFR 88-19, Volume 5; TM 5-852-6/AFR 88-19, Volume 6; and TM 5-852-3 for more information).

HELIPORTS

6-45. There are four levels of heliport development: landing zones of opportunity, austere forward area fields, substandard but operational support area fields, and deliberate rear area fields (see TM 3-34.48-2). The geometric design requirements for helicopter landing areas can be simplified into four types:

- Helipads.
- Heliports with taxi hover lanes.
- Heliports with runways.
- Mixed battalion heliports.

6-46. The design of a pavement structure for a heliport or helipad is similar to the pavement structure design for airfields. The three types of heliport and helipad pavement structures include—

- Unsurfaced.
- Surfaced (membrane-surfaced or mat-surfaced design).
- Flexible pavement (thickness design procedure).

6-47. For additional airfield and heliport planning and design information, see the following sources:

- AFCS (practically applied through the JCMS system).
- ATP 3-90.4/MCTP 3-34A.
- TM 3-34.48-1.
- TM 3-34.48-2.
- UFC 3-260-01.
- UFC 3-260-02.
- UFC 3-260-17.
- UFC 4-141-10.

6-48. Reachback resources include the—

- USACE Reachback Operations Center website .
- Transportation Systems Center website.

CONSTRUCTION

6-49. TM 3-34.48-2 provides a complete discussion of airfield and heliport construction. The construction directive usually provides the airfield and heliport geometric design, pavement structure design, and drainage system design. The constructing unit may site-adapt the designs to local conditions. Airfield and heliport construction planning tasks to determine earthwork quantities, material, equipment, personnel, quality control, and environmental requirements are similar to those for roads and railroads.

CONSTRUCTION ESTIMATES

6-50. Developing an accurate construction estimate can be difficult, and each project must be considered on a case-by-case basis. A reasonable estimate of construction effort and time required can be made after thorough research and planning. Engineers estimate the construction of airfields and heliports based on the following key factors:

- Volume of earthwork required.
- Difficulties of grading and constructing.
- Drainage required.
- Site clearance required.
- Previous construction experience.
- Capability of the engineer unit assigned.

6-51. Construction may involve new construction or the restoration or upgrade of existing airfields or heliports simultaneously. A complete air base is a complex construction project. However, careful project planning, a strict focus on essentials, and phased construction can result in a facility that will support air operations soon after construction begins. Subsequent improvements and modifications can be made during use. If construction is guided by a master plan, the staged completion of each structure can be designed to serve the expedient operation and meet the criteria for the final design plan.

6-52. It is best to complete an air base to its ultimate design in a single construction program. It may be necessary to initially design it to a lower construction standard to expedite getting the base into operation within the available time with the available construction support. In such cases, every effort must be made to proceed to the ultimate design standard for the airfield. The repeated modification of a facility plan is to be avoided.

PRIORITIES AND STAGES

6-53. Priorities for expanding and rehabilitating an existing airfield are generally parallel to those for new airfield or heliport construction. Procedures, personnel, and construction material requirements for expanding or rehabilitating airfields are usually similar to new construction requirements and ADR. Before using an existing facility for personnel, inspections (ideally, an EBS and OESHA are performed in conjunction) should be done by environmental and preventive medicine personnel to prevent exposure to existing environmental and occupational health hazards.

6-54. The first goal in building an airfield is to make it operational. Therefore, construction is designed to support air traffic as soon as possible. See TM 3-34.48-1 and TM 3-34.48-2 for more information on airfield priorities and stages. The order for construction proceeds according to the following priorities of work:

- **First priority.** Emphasis is on providing protection and security. Provide the facilities that are most essential for air operations as soon as possible. Build airfield operational facilities, such as runways, taxiways, approaches, and aircraft parking areas of minimum dimensions. Provide minimum storage for aviation ordnance and aviation fuel. Provide essential airfield lighting, fire protection services, medical services, attack warning systems, sanitation, power systems, and water facilities. Survey facility groups, air traffic control, and landing systems.
- **Second priority.** Emphasis is on improving protection and increasing the capacity, safety, and efficiency of air base operations. Provide indirect support operational facilities. Construct access and service roads and essential operational, maintenance, and supply buildings.

- **Third priority.** Emphasis is on improving protection and operational facilities. Provide facilities for administration and special housing, such as leach fields, washracks, landfills, and an explosive-ordnance disposal range.
- **Fourth priority.** Emphasis is on improving protection and providing general housing. Institute a base operation and facilities maintenance plan. Sustain environmental and medical surveillance of the airfield and its supporting facilities.

6-55. Construction stages establish a sequence for constructing an airfield. These stages build the airfield in parts to construct the least amount of operational facilities in the shortest possible time. For example, a priority task may be reduced to smaller stages as follows:

- **Stage I.** Construct a loop that permits landing, takeoff, and circulation with a limited apron. Runway lengths and widths are the minimum required for critical aircraft.
- **Stage II.** Construct a new runway. The Stage I runway now becomes a taxiway; and aprons, hardstands, and additional taxiways are built.
- **Stage III.** Further expand facilities to accommodate additional aircraft as needed. If an existing surface in the rear area is inadequate for all-weather operations in support of heavy transport aircraft or high-performance fighter aircraft, an appropriate pavement structure is designed and constructed.

Note. See TM 3-34.48-1 and TM 3-34.48-2 for additional information.

PRINCIPLES

6-56. Except for staking requirements, the techniques and principles for conducting airfield and heliport construction surveys are identical to those for roads. An accurate estimate of earthwork volume is essential to the proper control and management of a horizontal construction project. Following mass diagram construction and analysis, equipment is scheduled and project durations are determined. An analysis of the mass diagram will also determine haul routes, locations of equipment work zones, and areas for waste and borrow sites.

6-57. Earthwork balancing may also occur between adjacent projects (such as runway and taxiway). The constructing unit selects materials that meet design specifications from soils in cuts, borrow pits, quarries, or local procurement.

6-58. During construction, permanent drainage structures are essential to the successful completion of an airfield or heliport. Planning considerations are similar to those used for road construction.

PAVEMENT

6-59. The decision to pave an airfield or heliport during contingency operations is based on the urgency to complete the airfield, the tactical situation, the amount and type of anticipated traffic, the soil-bearing characteristics, the climate, and the materials and equipment of availability. Surfacing must meet the allowable roughness criteria for each type of aircraft that will use the facility. Soil stabilization improves strength, controls dust, and renders surfaces waterproof. The process is discussed in TM 5-822-14/AFJMAN 32-1019.

EXISTING FACILITIES

6-60. Maximize the use of existing facilities if they meet the minimum design requirements or can be economically upgraded to meet requirements. Existing airfields and heliports may need an additional pavement layer (airfield pavement upgrade). There may be requirements to construct or expand an existing airfield structure (geometric upgrade) or support extensive new support facility construction. Consider the expansion and rehabilitation of existing infrastructure over new construction. There is generally a substantial savings in time, effort, and materials to upgrade rather than to build from scratch. Except in highly developed areas, existing airfields are seldom adequate to handle modern, high-performance aircraft.

6-61. The evaluation of existing airfield pavements is generally a reverse of the design process. The existing airfield evaluation technical details are fully discussed in TM 3-34.48-1, TM 3-34.48-2, and UFC 3-260-03. Consider the following general guidelines:

- Determine the airfield physical characteristics.
- Determine if the design aircraft can operate from the existing field, based on its minimum geometric requirements.
- Determine the allowable number of passes based on an evaluation of the existing airfield, soil strength, and pavement condition.
- Outline corrective actions to meet minimum geometric requirements or increase the allowable number of passes.

6-62. Existing airfield dimensions and pavement structures must be evaluated by the reconnaissance team, based on mission and operational requirements, to determine if the airfield can support air traffic. They also determine the construction effort required. Some airfields can be made adequate with minimal effort. They may also serve as the nucleus for larger fields that meet the specifications of high-performance aircraft.

6-63. Helicopters and light planes can often use existing roads, pastures, and athletic fields. Combat engineers can upgrade these for initial or temporary use through forward aviation combat engineering. Support facilities are converted to standards per the theater construction policy. The imaginative use of existing facilities is preferable to new construction. The ground reconnaissance of an airfield previously occupied by enemy forces must be cautious because facilities may contain explosive hazards. Coordinate facility use with HN authorities because existing airfields, particularly in the rear area, may be needed by HN air forces or for commercial purposes.

OTHER CONSIDERATIONS

6-64. Expedient surfaces include matting and membranes. Matting gives the Army and Marine Corps the capability to build a runway quickly with minimum effort. Membranes provide airfield surfacing (but no structural strength), dustproofing, and waterproofing (see ATP 3-90.4/MCTP 3-34A, TM 3-34.48-1, and TM 3-34.48-2).

6-65. Upon airfield construction completion, the airfield manager or other authorized individual monitors and controls the on-site aircraft certificate. The senior airfield authority issues a notice to airmen to change the airfield status.

OPERATION AND MAINTENANCE

6-66. O&M of the airfield or heliport is performed by the Service controlling the airfield. General engineering support is provided when the O&M tasks exceed the ability of the unit controlling the airfield. General engineer O&M tasks include supporting airfield and heliport maintenance, road maintenance, drainage structure maintenance, fire prevention, firefighting, and traffic control signage. O&M of engineer-specific systems includes maintaining utilities and power systems. This support may also include contracting for electrical power, waste management, and ADR.

MAINTENANCE

6-67. Airfield maintenance is the routine prevention and correction of damage and deterioration caused by normal use, wear and tear caused by aircraft, and exposure to the elements. Routine maintenance includes inspections; stockpiled materials for repair and maintenance work; maintenance and repair of pavement surfaces and drainage systems; dust control; and snow, ice, and foreign object damage repair. Foreign object damage removal is generally accomplished using motorized sweepers. The user of the airfield coordinates with engineers, who are responsible for airfield maintenance, to conduct routine foreign object damage inspections.

6-68. The procedures and considerations for airfield maintenance are similar to those for road maintenance and repair. The materials used for airfield maintenance are generally the same as those used for airfield construction and repair. See TM 3-34.48-1, TM 3-34.48-2, UFC 3-260-01, UFC 3-270-01, and UFC 3-270-08 for additional information.

6-69. Upon completion of an airfield repair or maintenance mission, crater repair evaluations are conducted before resuming aircraft take-off and landings. When conducting repair evaluations, consider the following:

- **Repair compaction.** Verify the strength of the backfill, debris, or subgrade materials. Depending on the repair method used, verify the thickness and strength of all surface and base course materials. Test the soil structure using a dynamic cone penetrometer to determine the California bearing ratio of each layer. Conduct these tests before placing foreign object damage covers, AM-2 matting, stone and grout, asphalt, concrete, or other surface materials that would prevent the use of the dynamic cone penetrometer.
- **Surface roughness.** Check the final grade of the repair using line-of-sight profile measurement stanchions, upheaval posts, or string lines to ensure that the repair meets surface roughness criteria. In the case of a crushed-stone repair without foreign object damage cover, check the repair surface for loose aggregate or potential foreign object damage.
- **Foreign object damage cover.** Ensure that foreign object damage covers are no more than 5° off parallel with the runway centerline. Check connection bolts and verify that all connections between panels are tight and secure. Check anchor bolts and verify that all bolts are secure and that the foreign object damage cover is held snugly against the pavement surface. In taxiway and apron applications, anchor the leading and trailing edges of the foreign object damage cover. Anchor the side edges if the cover is located in an area where aircraft are required to turn.
- **Setting and curing.** If the repairs are capped with concrete, stone and grout, or rapid-set materials, verify that the surface material has set and that adequate cure time is allowed prior to aircraft landing and taking-off.
- **Cleanup.** For all repair methods, verify that the repair and adjacent areas are clear of any excess repair materials.
- **Airfield certification.** The on-site engineer who is responsible for the repair certifies that the repair was accomplished according to the procedures in the appropriate UFC and other applicable publications. The repair procedures are documented on an ADR journal, which is updated to reflect subsequent aircraft traffic and required maintenance throughout the repair history. If another team replaces the initial repair team, this form is transferred to the follow-on team. The information is useful in planning or performing further maintenance or upgrade of the repairs. Upon completion of repairs, provide the airfield repair status to the airfield manager or other individual authorized to monitor and control on-site aircraft. This individual then issues a notice to airmen to change the airfield status.

AIRFIELD DAMAGE REPAIR

6-70. Airfields are subject to damage by a complex array of destructive weapons, including cannon fire, rocket fire, bombs, and bomblets. Explosive hazards (such as unexploded ordnance [to include scatterable mines and unexploded bomblets] and improvised explosive devices), barriers, and other hindrances may challenge efforts to make airfields capable of supporting air traffic. ADR includes airfield pavement repair, damage assessment, explosive-ordnance disposal reconnaissance, minimum operating-strip selection, quality control repair, and aircraft arresting system and utility system repair.

6-71. All Services accomplish ADR pavement repair in a similar manner. Major differences in the Services methodology are in the final 18 to 24 inches of crater repair and capping due to mission differences, team configuration, and available resources. Army engineers normally conduct minimal ADR as part of a forcible-entry operation by focusing on runway clearance and surface repair. ADR also include the infrastructure required to conduct operations at a base that is seized from the enemy or offered for use by a friendly HN. It also includes repairs required to sustain or to reestablish flights after enemy attack (see ETL 07-8, ETL 13-3, and TSPWG M 3-270-01.3-270-07 for additional information).

6-72. The Marine Corps has specially organized and equipped units to conduct ADR, which are the damage assessment teams or damage assessment response teams. Marine Corps aviation ground support detachment teams are trained to task-organize damage assessment teams and damage assessment response teams to respond to hostile-induced rapid runway repair.

6-73. Engineers must conduct a damage assessment, prepare for explosive hazard reconnaissance and removal, understand the repair quality criteria, and know the requirements for the minimum aircraft-operating surface. Consider including Air Force technical experts and airborne RED HORSE elements as a part of the Army combat engineer element participating in the forcible-entry operation. They can assist in approving the aircraft-operating surface, control aircraft landing and departure, and serve as liaison to the airfield-opening team. The airfield-opening team can work with general engineer elements to take the airfield to a higher standard of repair after the lodgment area has been secured.

6-74. For intelligence on all existing airfields and their dispositions or to request airfield damage assessment and pavement evaluations, see the Air Force Civil Engineer Center website.

Repair Packages and Categories

6-75. A light airfield repair package is an Army capability-based organization. Its composition varies according to mission specific requirements, such as the type of flight landing strip, number of pallets available, and engineer parachute allocations. It consists of 8 to 16 personnel and 7 airdrop platforms or 5 external loads on a CH 47D helicopter. Army airborne and air assault engineer units have the capability of repairing airfields to obtain a required minimum operating strip during joint forcible-entry. They use an air-transportable ADR kit, which is an expedient pavement repair kit, with the materials and nonorganic unit equipment required to repair one crater 7.6 meters (25 feet) in diameter or 3-5 small craters, on a concrete- or asphalt-surfaced runway. To install this kit, Army units use a light airfield repair package with organic construction equipment and the ADR kit. Marine wing support squadron is capable of repairing airfields and obtaining a required minimum operating strip during any operation.

6-76. Pavement damage categories are shown in figure 6-1, page 6-16. Damage to the pavement includes the apparent crater damage and the upheaval of pavement around the crater. The damage category for a given munition depends on the delivery method, penetration extent, and charge size. See TSPWG M 3-270-01.3-270-07 for more information on ADR.

Repair Priorities

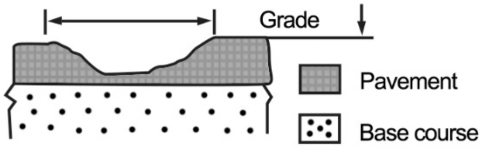
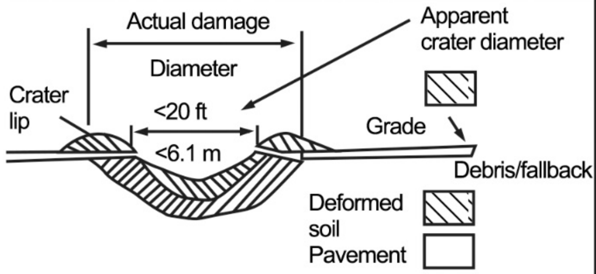
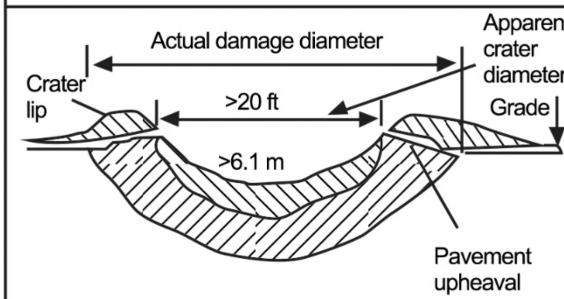
6-77. The airfield commander prioritizes essential ADR missions, usually in the following order:

- Reconnaissance and damage assessment.
- Explosive-ordnance disposal.
- Minimum airfield-operating surface repair.
- Repair to operational facilities, communication systems, ammunition storage facilities, essential maintenance facilities, fuel storage and distribution areas, utilities, on- and off-base access routes as a result of indirect damage due to direct-attack explosives that missed their primary targets.
- Environmental and occupational health hazards.

Emergency Repair

6-78. Emergency repairs provide an expedient and temporary fix to allow the earliest resumption of air missions. The Service that is responsible for the airfield determines the minimum operating strip and performs crater and surface repair. The minimum operating strip is the minimum width and length required for an aircraft to land and take off. Normally, the largest area of the airfield with the least amount of damage is selected and identified as the minimum operating strip. All explosive hazards, including remotely delivered mines, must be cleared from the minimum operating strip before surface repair starts.

6-79. Army engineers organic to the BCTs will typically conduct the initial forcible entry. ADR is performed by airborne and air assault engineer elements who center on combat engineering skills and use specific force packages or modules to conduct emergency repair primarily using a sand grid. Forward aviation combat engineering is a combat engineering mission. At this level of repair, this is a forward aviation combat engineering task enables mobility. See ATP 3-90.4/MCTP 3-34A for a discussion on forward aviation combat engineering.

Damage Category	Probable Munitions	Probable Charge Size
 A. Spall/scab	Small rocket Cannon fire Contact-fused munitions	5-8 lb (2.3-3.6 kg)
 B. Small crater	Large rocket Clustered munitions Small concrete penetrators	5-35 lb (2.3-15.8 kg)
 C. Large crater	Bombs Delay-fused munitions Large concrete	<100 lb (45 kg)

Legend:

ft	foot/feet
kg	kilogram(s)
lb	pound(s)
m	meter(s)

Figure 6-1. Airfield damage categories

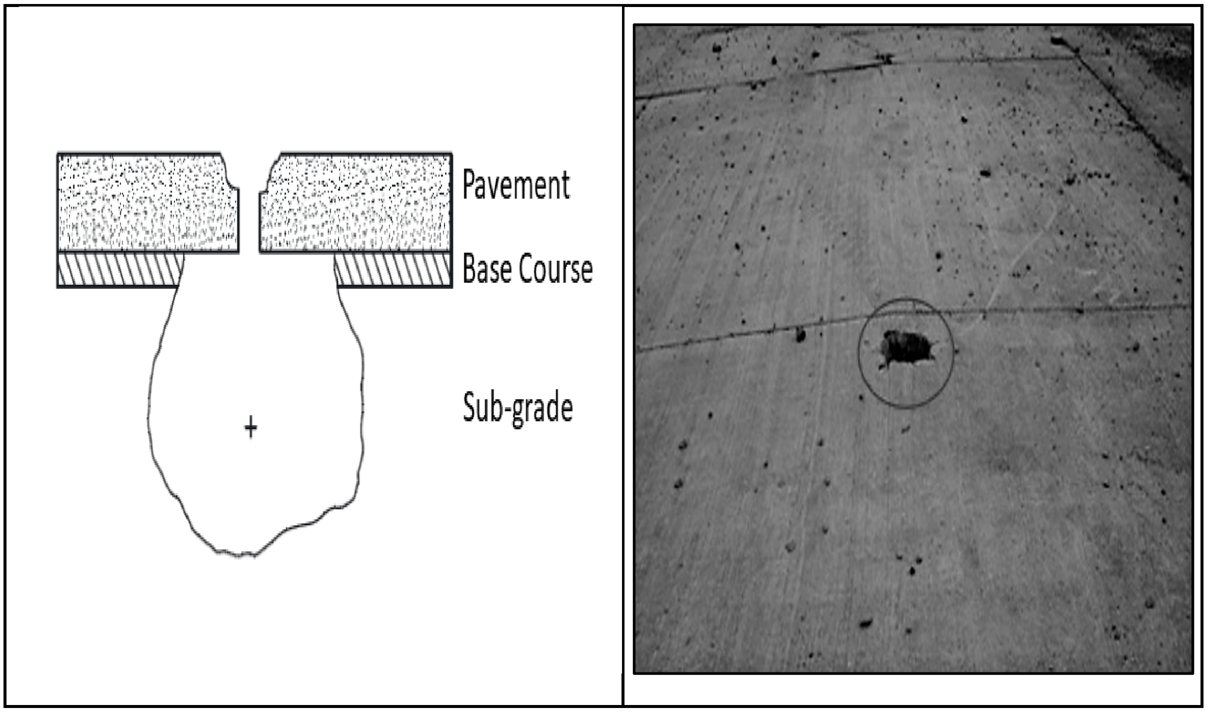


Figure 6-2. Camouflet

6-80. Figure 6-2 provides a profile diagram and photo of a camouflet. A camouflet is a crater with relatively small apparent diameter but deep penetration and subsurface void created by the munition puncturing through the pavement surface and exploding in the base material. They are produced by large, penetration-type projectiles with hardened warheads and time-delay fuzes. Camouflets can collapse and are full of poisonous gasses, void of oxygen.

6-81. Air Force engineers have sole responsibility for conducting emergency repair of established air bases. The goal is to achieve sustained operations within 4 hours. This is done by specific force packages or unit types formed from Air Force RED HORSE or Prime BEEF units. The Air Force uses the following emergency repairs, depending on the nature of the damage:

- Crushed stone over debris.
- Choke ballast repair.
- Choke ballast over debris.

6-82. Army engineers use two methods to make beyond-emergency repairs to established air bases: stone and grout repair and concrete cap repair.

6-83. Air Force, Navy, and Marine Corps engineers use similar techniques. The airfield commander directs the priority of pavement repair effort, allowing permanent repair to begin as soon as the tactical situation, available equipment, and labor permit. Pavements outside the minimum operating strip, including taxiways, usually have a lower repair priority. Deliberately marking or clearing explosive hazards (to include unexploded ordnance and improvised explosive devices) must be completed before permanent repairs can begin. Explosive-ordnance disposal personnel are usually available for these types of area clearance. However, engineers may have to perform these tasks if time is critical, and the risk is acceptable. MCTP 3-20B describes ADR procedures and techniques used by Marine wing support squadrons. TACMEMO 4-04.2-22 describes procedures and techniques used by Navy task units when conducting expeditionary rapid ADR.

6-84. Army engineers are responsible for assisting Air Force RED HORSE or Prime BEEF teams to repair critical airbase support facilities when such repairs exceed the Air Force capability. Methods for repairing indirect damage are much the same as ordinary engineer construction techniques.

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Chapter 7

Roads and Railroads

Militaries throughout history have relied on ground transportation networks to facilitate rapid movement and sustainment/combat service support to influence the outcome of conflicts. Maintaining forward-deployed forces during contingency operations requires an extensive logistics network. An adequate ground LOC network is a critical part of this network and is a key to facilitating sustainment/combat service support. Depending on the mission variables, roads and railroads may form the primary LOCs during a contingency operation. Roads and railroads primarily support operational mobility through the movement of personnel, equipment, and supplies and link support to military ground operations. Railroads provide an efficient and economic means to convey large volumes of equipment and supplies over ground. Engineers play a key role in the transportation network by being responsible for road and railroad construction, limited operations, maintenance, and repair. This chapter will focus on road and railroad capabilities, planning and design, construction, and O&M.

RESPONSIBILITIES AND CAPABILITIES

7-1. The Army has responsibilities and limited capabilities for constructing or repairing roads and railroads. These Army capabilities are primarily related to horizontal and vertical general engineering. Marine Corps engineer units are capable of constructing and repairing roads.

ROADS

7-2. Whether they are temporary or permanent, roads require some degree of Service support. This section discusses the similarities and differences between each Service in providing road repair or construction.

Army

7-3. Army engineers consist of three disciplines—combat, general engineers, and specialized engineers. The three engineer disciplines are inextricably linked and mutually supportive of one another.

Combat Engineers

7-4. Combat engineers are responsible for combat trails and roads. Building combat trails and roads is a combat engineering task that is conducted in close support to ground maneuver forces that are in close combat and to support mobility (see ATP 3-90.4/MCTP 3-34A).

7-5. Baseline Army combat engineer units consist of combat engineer company – infantry – armor, and multirole bridge companies. Their basic capabilities include earthmoving assets for the hasty (expedient and temporary) construction of combat trails, roads, or protective berms. Combat engineers can perform route clearance, to include demolitions for blasting, removing, and hauling away road obstructions, such as rock or heavy debris. They may be required to link these combat trails and roads across gaps by bridging. Combat engineer tasks related to the construction of combat roads and trails includes clearing and grubbing of vegetation and small trees (see ATP 3-34.22 and FM 3-34).

7-6. Combat engineers have the capability to deny enemy access to combat roads and trails through obstacle systems and networked munitions in support of their countermobility mission (see ATP 3-90.8/MCTP 3-34B).

7-7. There are limitations to combat engineer road-building capabilities. Combat engineers lack the personnel, equipment, and expertise to construct surveyed and graded roads or to improve road surfaces. Combat engineers may require augmentation with additional engineering assets and training. Therefore, general engineers may be tasked to assist in the construction and repair of combat roads and trails if the repair exceeds combat engineer capabilities. See FM 3-34 and ATP 3-34.22 for more information on capabilities of combat engineer units.

General Engineers

7-8. General engineers are responsible for military roads. Higher-level road work is a general engineer task. General engineers have the capability to plan, design, construct, and maintain military roads. General engineers possess horizontal and vertical assets, which expand and enhance their capabilities beyond combat engineers. They can construct and repair roads, MSRs, and railroads and handle large-scale projects. They possess specialized expertise, such as the ability to perform quality road construction and improve road surfaces and include surveyors and soil analysts. See ATP 3-90.4/MCTP 3-34A for more information on general engineer support to mobility.

7-9. General engineers can be augmented and enhanced with specialized engineer units to support road-building efforts. They include construction management teams, topographic units, equipment support platoons, survey and design teams, asphalt teams, concrete sections, and geospatial planning cells.

7-10. General engineers possess a variety of heavy construction equipment, to include graders, scrapers, loaders, large dump trucks, excavators, cranes, concrete trucks, asphalt producers, and pavers. Their capabilities also include quarry platoons with rock-crushers to produce and haul road base construction material and asphalt teams for road surface paving.

7-11. The basic capabilities of engineers can be expanded through the augmentation of additional expertise, personnel, and equipment for extensive road construction projects. Engineers also have the capability of reachback for accessing additional construction expertise as needed. See ATP 3-34.22 for additional information on capabilities. General engineers coordinate geospatial support as needed. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) and TM 3-34.48-1 for more information on reconnaissance requirements for routes.

7-12. Army engineer construction units have the following responsibilities and capabilities:

- Route, road, and bridge reconnaissance.
- Road base materials testing.
- Maintenance, repair, and upgrade of existing roads.
- Construction of new roads.
- Recommendations for traffic control procedures.
- Construction and installation of signs and other route-marking materials.
- Regulating traffic where engineer work is being performed.

Marine Corps

7-13. The primary Marine Corps engineer tasking is combat engineering and limited general engineering in support of the MAGTF. Marines organized under an engineer support battalion have organic horizontal capabilities to construct combat trails and roads. The Marine wing support squadron also possesses horizontal capabilities to perform this task in support of aviation operations. Marines have no capabilities for road-paving, and it is not an assigned task. See MCWP 3-34, NWP 4-04, and NTTP 3-10.1M/MCTP 3-34D for additional information on Marine capabilities.

Navy

7-14. The Navy mobile construction battalion has organic capabilities for conducting road work. In their combat support role, Seabees can provide the temporary repair and maintenance of existing roads and construct unpaved combat trails and roads. In their base construction and civil works construction support role, they can construct asphalt roads if necessary. See NTTP 3-10.1M/MCTP3-34 for additional information on Seabee capabilities.

Air Force

7-15. Although their primary mission is airfields, Air Force engineers are trained and equipped with organic capabilities to construct, repair, and improve routes and railroads. Their capabilities include pavement evaluation and repair and concrete, asphalt, and paving. Air Force engineer units are organized as Prime BEEF and RED HORSE units, and they can provide a broad array of general and adaptable engineering capabilities (see Air Force Doctrine Publication 3-34).

RAILROADS

7-16. The process for authorizing the construction, acquisition, or operation of railroad lines is discussed in 49 USC 10901. Military construction projects are discussed in 10 USC 2801. USACE designs, inspects, and contracts for construction of railroads. The USACE Engineer Research and Development Center can also provide tailored training for Army general engineer units to maintain and repair railroads.

7-17. Engineer construction companies, engineer support companies, and engineer vertical construction companies, perform repairs to restore railroads to service and perform the limited construction of railroads. Army general engineers have no railroad-specific technical training, but apply their road and facilities capabilities to railroads.

7-18. The Expeditionary Railway Center is a modular force consisting of a single headquarters element and five deployable railway planning and advisory teams (commonly known as RPATs). The Expeditionary Railway Center is capable of conducting rail network capability and infrastructure assessments, rail safety assessments, and using these assessments to inform and advise the combatant commander on the employment of rail in a theater of operations. Additionally, the expeditionary railway center is capable of partnering with HN rail and advising and assisting in the effective management of its railway system.

7-19. Railway planning and advisory teams provide direct assistance to the HN. They also function as primary advisors on railway operations to a corps or theater sustainment command. The railway planning and advisory team advises on HN rail infrastructure and employment of HN assets in support of military operations. They coordinate and communicate with the HN, supported unit, or contracted entity to facilitate rail operations. See ATP 4-14 for additional information on the Expeditionary Railway Center. The Army capacity to operate railways does not include the equipment needed to mount a railway operation. For this reason, the Army ability to use rail transportation depends largely on the existing capacity of the area of operations. Rail is a strategic asset and an operational-level-of-warfare asset. The military's Surface Deployment and Distribution Command arranges for all rail movements of cargo and personnel to the seaport of embarkation. Outside of the United States, the ASCC/MCCC is responsible for doing the same when deploying armed forces in support of a military operation. Because of limited military resources, the use of HN personnel or contractors may become the primary source of O&M capability (see FM 4-01).

7-20. During combat operations or in austere environments, rail loading and unloading areas may not be available or suitable for military equipment. General engineering units should be prepared to build expedient loading and unloading areas for equipment being transported by rail.

PLANNING AND DESIGN

7-21. The military uses roads and railroads to allow ground traffic to get from one point to another quickly and efficiently, for as long as necessary, based on operational requirements. An analysis of the requirements for roads and railroads can be completed by the phase of the operation or by the purpose. The analysis by the phase of the operation may determine the need for roads or railroads to support access, theater opening, force bed-down, offense, defense, base camps, stability, DSCA, or redeployment.

7-22. The analysis by the purpose may determine the roads or railroads to assure operational mobility, enable force projection and logistics, or build partner capacity and develop infrastructure. Based on operational requirements, the planner determines locations that must be connected, the degree of permanence or use, the characteristics of estimated traffic type, and the volume of traffic. LOCs may determine the locations of some military facilities, or the location of some military facilities may determine the location of some LOCs.

7-23. Road site preparation includes the following procedures:
- Establish security.
- Establish bypass and detour for existing traffic.
- Stage equipment and materials.
- Construct temporary support facilities.
- Survey and stake out the road geometric design.
- Rehearse on a test strip to verify quality assurance and quality control plans.

7-24. Road construction planning methods and tools include—
- Equipment and personnel task organization.
- Earthwork and time estimates.
- Mass diagrams.
- Personnel and equipment schedules.
- Procurement.

ROUTE SELECTION

7-25. Based on operational requirements and reconnaissance data, the engineer and transportation staff officers propose an initial route for roads and railroads. This proposed route is analyzed based on obstacles, route restrictions, grades, and the best horizontal and vertical alignment. The original route survey consists of straight-line segments or tangents that are then connected through an iterative design process with horizontal and vertical curves to achieve the shortest, smoothest, most efficient route that requires the least construction resources.

ROADS

7-26. Military roads are classified according to their degree of permanence and the characteristics of traffic they are designed to support—wheeled or tracked of a specific volume (number of vehicles per day). Military roads are classified as Type A, B, C, or D, depending on the amount of traffic they are expected to sustain per day. Type A roads (four-lane) are designed for the highest capacity, while Type D roads (one-lane) are designed for the lowest. Normally, Types B, C, and D apply to theater construction. See TM 3-34.48-1 for additional information.

Combat Roads and Trails

7-27. Combat roads and trails are a combat engineering mission because they are typically performed in close support of ground maneuver forces; however, combat, and general engineers build them. Combat roads and trails are usually characterized by expedient construction methods and are intended to handle low volumes of traffic for a short duration to meet immediate requirements. Combat trails are intended to last only a few days and consist of the bare minimum considerations for drainage. Combat roads have a temporary surface of material (such as crushed rock) to increase trafficability. Since combat engineers do not have the time, equipment (graders, water distributors, compactors), and training of general engineers, they cannot construct a road to meet all geometric design for military roads. See ATP 3-90.4/MCTP 3-34A for additional information on combat roads and trails.

7-28. Military roads are rarely constructed to meet the exacting standards of comparable civilian construction, to include environmental standards. Their degree of permanence varies, depending on how long they are needed. The primary difference between combat roads and conventional roads is the degree of permanence and the characteristics of the traffic they are designed to support. Combat roads are built to handle low volumes of traffic for a short duration.

7-29. A combat trail is a travelled way that has been cleared of obstacles but has not been temporarily surfaced. A trail may be roughly graded by combat earthmoving equipment to provide a relatively smooth surface. Combat trails are usually adequate for tracked and wheeled combat vehicles. A combat trail is a route through areas where routes do not exist.

7-30. A combat road is a travelled way that has been cleared of obstacles and temporarily surfaced by an expedient means to increase its trafficability. Combat roads usually do not have bituminous or concrete surfaces and consist of the bare minimum considerations for drainage. Combat roads require more effort to build than combat trails, but they support a broader range of vehicles and tend to last longer.

Unsurfaced and Surfaced Roads

7-31. Unsurfaced roads consist of hastily cut pathways with native soil that is graded and drained to form a surface to carry traffic. Unsurfaced roads are the result of the first three steps of the construction sequence (clearing, grubbing, and stripping); this could become the subgrade for later surfaced roads. Unsurfaced roads—

- Are used in combat areas where the speed of construction is required, and equipment and personnel are limited.
- Are used generally in dry weather or by light traffic.
- Are used as haul roads in construction areas and as service roads on base camps or bases.
- Require periodic maintenance and, possibly, dust control.
- Are designed to initial standards to enhance mobility for a short time (less than 6 months).

7-32. Surfaced roads are laid out, designed, and constructed to specific criteria. The subgrade is compacted to design specifications, and layers are added to create the road structure. Surfaced roads—

- Are used in rear areas or support areas where general engineers and resources are available.
- Are not limited by most weather and are designed for specific traffic loads.
- Are used as more permanent road networks, such as MSRs and primary LOCs.
- Require periodic maintenance and can be easily upgraded.
- Are designed to temporary standards to sustain mobility for a longer period (up to 2 years).

7-33. During contingency operations, nearly all roads are constructed to temporary standards. In some rare cases, semipermanent and permanent roads may be designed to provide long-term mobility (up to 20 years). Permanent roads are often planned, designed, and constructed in conjunction with USACE or similar organizations. The employment of civilian contractors or Service general engineer organizations may be used.

7-34. Most new, two-lane military roads are surfaced with aggregate (sand; gravel; crushed rock; slag; or recycled, crushed concrete), stabilized soil, or the best locally available materials. This allows for future upgrades and permits the maximum use of readily available materials to complete the road rapidly. Selected high-use portions, such as intersections, may be surfaced with more durable materials to support heavier loads. Only a few highly used, new military roads receive asphalt concrete or Portland cement concrete surfaces due to the time required and the added cost for this type of construction.

7-35. Asphalt is a petroleum-based product with two primary subgroups used in construction: asphalt cement and liquid asphalt materials. Asphalt cement is mixed with aggregate and sand to make asphalt concrete. Liquid asphalt materials are sprayed on roads for various purposes. Bitumen (a generic term) is a broad category of materials that occur naturally, or it could be an asphalt that is distilled from petroleum or a tar that is distilled from coal. Bitumen and asphalt are often used interchangeably; bitumen is often used outside the United States. Asphalt concrete (often called asphalt) and bituminous concrete are made with a bituminous material as a binder for sand and gravel. Bituminous design is described in TM 3-34.63.

Road Networks

7-36. An assessment of the mission variables is considered when establishing any road network. These considerations should include the following:

- **Mission.** Operational and mission requirements will determine the minimum road classification and design requirements, based on the expected period of usage and the anticipated traffic load.
- **Enemy.** Threat capabilities and anticipated types of action could affect the methods of construction and the road location and design. Avoid creating choke points and other potential ambush points when possible.
- **Terrain and weather.** The location of a road is dictated by operational and mission requirements. Existing slopes, drainage, vegetation, soil properties, weather patterns, and other conditions may affect layout and construction.
- **Troops and support available.** Use local materials, labor, and equipment when and where possible. Use simple or preexisting designs, such as those in the JCMS that require minimal skilled labor and specialized equipment when possible.
- **Time available.** Speed is critical when establishing a road network during a contingency operation because of the rapid and dynamic tempo of military operations. It is essential to save as much time as possible by efficiently using the minimum amount of resources. Use effective project management techniques to save resources. When possible, use staged construction to allow the early use of roadways while further construction, maintenance, repair, and upgrades continue.
- **Civil considerations**. Civilian property restrictions, real estate actions, existing structures, restricted areas, cultural beliefs, environmental considerations, and other factors may also affect road layout and construction.

Route Reconnaissance

7-37. It may be necessary to conduct bridge reconnaissance and classification computations. See ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4) for additional information on route reconnaissance.

7-38. Proper site selection is a crucial step in new road construction. Future construction problems can be avoided by the careful reconnaissance and wise consideration of future operational requirements. A road project that is poorly laid out will not meet the requirements for construction ease and efficiency, maintainability, usability, capacity, and convenience.

Engineer Reconnaissance Team

7-39. The engineer reconnaissance team is briefed as to the anticipated traffic (wheeled, tracked, or a combination) and the anticipated traffic flow. Single-flow traffic allows a column of vehicles to proceed while individual oncoming or overtaking vehicles pass at predetermined points. Double-flow traffic allows two columns of vehicles to proceed simultaneously in the same or opposite directions.

7-40. The reconnaissance team may also be asked to determine the grade and alignment, horizontal and vertical curve characteristics, and nature and location of obstructions. Obstructions are defined as anything that reduces the road classification below what is required to support the proposed traffic efficiently.

7-41. Prior to the start of the actual route reconnaissance, the engineer reconnaissance team should conduct a map reconnaissance of the site or area, to include studying aerial photos, reviewing available geological and hydrological information and other geospatial information, and considering any other available, relevant information. The engineer reconnaissance team may request the following sources of information to aid in planning reconnaissance missions and in making the preliminary study of a specific mission:

- Existing intelligence reports, assessments and products, and threat analysis.
- Strategic and technical reports, studies, and summaries.
- Road, topographic, soil, vegetation, or geologic maps or other geospatial information.
- Existing aerial reconnaissance reports.
- Existing road design information or maintenance plans.

Soil Properties

7-42. The engineer reconnaissance team may also determine soil properties on-site and at potential borrow pits and quarry sites along the proposed route. Soil properties (such as the liquid limit, plasticity index, California bearing ratios, and gradation) are required to properly design a new road pavement structure or upgrade an existing road pavement structure, based on the anticipated traffic that the road will support. These soil properties are also required to evaluate the suitability of aggregate taken from potential borrow pits and quarries for use in road construction, maintenance, and repair. In low-lying areas, the use of culverts, corduroy roads, or matting may be required to reinforce the ingress and egress of these areas or to improve fording sites.

Drainage

7-43. Drainage patterns impacting roads are also important in site selection. When the tactical situation permits, roads should be located on ridgelines. Thus, natural drainage features minimize the need for the costly and time-consuming construction of drainage structures. When possible, avoid excessive subsurface water. If it is impossible to avoid road construction in locations with saturated terrain, water tables must be lowered during construction. Steps must also be taken to minimize adverse effects of water on the strength of the supporting subgrade and base course.

Obstacles

7-44. Where possible, avoid obstacles (such as rivers, ravines, and canals) to minimize the need for bridge construction or similar structures. Such construction is time-consuming and calls for materials that may be in short supply. Make maximum use of existing structures to decrease total work requirements. Do not bridge an obstacle more than once. Should gap-crossing be necessary, ensure that the proper type of bridging or other methods provides an adequate and sustainable solution.

7-45. To sustain traffic, roads have a crowned driving surface and pavement structure, a shoulder area that slopes directly away from the driving surface to provide drainage off the driving surface, and side ditches for drainage away from the road itself. The shoulder areas and side ditches along many roads may be minimal, depending on their location and their road classification.

Road Design

7-46. The four major road designs that can be applied are—

- Geometric design.
- Pavement structure design.
- Drainage system design.
- Bridge design.

7-47. The road geometric design consists of the selection of road type, estimated traffic volumes, grade and alignment, horizontal curves, and vertical curves. Each road type has geometric design data, such as cross section elements and alignment elements that provide safe and rapid traffic movement. The geometric design data is provided to the constructing unit that lays out the design information on the ground with the construction survey. The construction survey provides stakes with survey details that construction equipment operators can use to conduct earthmoving.

7-48. Unsurfaced roads use the natural soil or borrow soil as the road surface. The design of unsurfaced roads is based on traffic characteristics and the compacted in-place soil strength. Unsurfaced roads meet all geometric design data for the selected road.

Pavements

7-49. During contingency operations, consider whether to pave a road by considering the urgency of its completion, the tactical situation, the expected traffic, the soil-bearing characteristics, the climate, the availability of materials and equipment, and the necessity of dust control (see UFC 3-260-17).

7-50. Pavements, including the surface and underlying courses, may be rigid and flexible. The wearing surface of rigid pavement is made of Portland cement concrete. Asphalt cement concrete pavements are classified as flexible pavements. The typical road pavement structure (cross section) consists of layers (pavement or surface course, base, subbase, and select material) on top of a compacted subgrade (see UFC 3-250-04 and UFC 3-270-01).

7-51. There are four types of road pavement structure designs, which are distinguished by the pavement or surface layer. These types are as follows:

- Unsurfaced roads.
- Aggregate-surfaced roads (see UFC 3-250-09FA).
- Bituminous-surfaced roads.
- Concrete-surfaced roads.

7-52. Flexible pavements are used almost exclusively in contingency operations. They are adaptable to almost any situation and fall within the construction capabilities of normal engineer troops. Rigid pavements are not usually suited to construction requirements during contingency operations. Because flexible pavements reflect distortion and displacement from the subgrade upward to the surface course, their design is based on complete and thorough investigations of subgrade conditions, borrow areas, and sources of select materials, subbase, and base materials (see UFC 3-250-03 and UFC 3-250-08FA for more information on flexible pavements).

7-53. A road pavement structure sits on top of the subgrade or the soil in place. A layer of compacted subgrade sits on top of the subgrade, and a layer of select material sits on top of the compacted subgrade. A layer of subbase material sits on top of the select material, and the base course sits on top of the subbase. A road may have a flexible pavement (asphalt) or a rigid pavement (concrete) surface on top of the base course. The thickness of a layer depends on the strength of the layer below it. Depending on design requirements, some layers may not be required. These pavement structures are designed to distribute wheel loads over a wider area of each subsequent underlying layer within the pavement, thereby reducing pressure on the subgrade soils.

7-54. During contingency operations, nearly all roads are constructed as aggregate-surfaced roads. These designs permit the maximum use of readily available materials and are easy to upgrade–permitting great flexibility to respond to changing operational and mission requirements. When possible, the roadbed should be aligned to take advantage of the most favorable surface and subsurface terrain. An alignment over soil with good properties meets the design standards for strength and stability and minimizes the need to remove undesirable materials.

Other Road Considerations

7-55. The pavement structure design considers traffic characteristics, soil and construction aggregate conditions, compaction, and cover requirements. The most common military road is constructed with an aggregate pavement structure design. The pavement structure design produces the layer material properties, thickness, and compaction design and final design profile with cut-and-fill information. TM 3-34.48-1 provides additional detailed information on the design of bituminous- and concrete-surfaced roads. TM 3-34.63 covers rigid-pavement structure design for roads and airfields (see UFC 3-250-01).

7-56. The overall road design consists of many factors. It may include chemically stabilized layer design, frost design, and geotextile design. One option to improve the ability of the road to support traffic is soil stabilization. The goals of soil stabilization are the stabilization of expansive soils, soil waterproofing, and dust control. Soil strength improvement increases the load-carrying capability of the road. Dust control alleviates or eliminates dust generated by vehicle and aircraft operation (see TM 5-818-7; TM 5-818-8/AFJMAN 32-1030, TM 5-822-14/AFJMAN 32-1019; and UFC 3-260-17).

7-57. Soil waterproofing maintains the natural or constructed strength of a soil by preventing water from entering it. Soil stabilization is generally accomplished by either mechanical or chemical methods. In mechanical stabilization, soils are blended and then compacted. In chemical stabilization, soil particles are bonded to form a more stable mass, using additives such as lime, bitumen, or Portland cement (see UFC 3-250-11 for additional information).

7-58. Traffic flow over roads is far more efficient if curves and grades are held to a minimum. Even gentle curves significantly decrease traffic capacity if there are too many on a route. Therefore, lay out all routes with a minimum of curves by making the tangent lines as long as possible. The availability of long tangents is influenced by terrain. It is also limited by other principles of efficient location, such as minimizing earthwork, avoiding excessive grades, and obtaining desirable soil characteristics.

> ***Note.*** When excessive curves are required based on limiting terrain, consideration should be given to reinforcement of curves (concrete pads) to support tracked vehicle traffic.

RAILROADS

7-59. The ability to rapidly move troops and materiel to key locations may well decide the outcome of a conflict. Railroads provide one of the most effective and efficient forms of land transportation available to forces during contingency operations. They can move great volumes and tonnages of materiel and large numbers of personnel over long distances with considerable regularity and speed in nearly all weather conditions. Railroads are flexible and versatile, and rolling stock may be tailored for transporting cargo. Extensive railway systems exist in most regions of the world and have an interoperability provided by standard equipment and common gauge, which may vary depending on the theater of operations. These capabilities make railroads a preferred means of transportation during contingency operations.

7-60. Maximizing a rail system may depend on its capacity (length and condition of existing track, condition of rolling stock and other facilities) and its ability to support operational and mission requirements while still maintaining essential commercial traffic. ATP 4-14 describes the organizations, processes, basic construction and maintenance standards, and systems involved in rail movement. See UFC 4-860-01 for additional information on railroad design. See UFC 4-860-03 for more information on railroad track standards.

7-61. All existing facilities should be used to the maximum extent possible to minimize construction time and effort. Transportation units in coordination with engineers conduct a reconnaissance and select new routes. New railroad construction will normally consist of short spurs to connect existing networks with military terminals or to detour around severely damaged areas. The focus of engineer effort should be on modifying and repairing existing railroads to meet operational and mission requirements.

7-62. Local labor and management are key to the rapid modification and continuing maintenance of existing facilities. Local personnel can often supply materials and skilled labor to speed the work and relieve military personnel for other projects. Local railway operating personnel can be a good source of information on existing conditions, operations, and supply facilities in a given area.

7-63. In order to expedite operations, railroads constructed during contingency operations may have accepted lower safety factors, sharper curves, and steeper grades than recommended by the American Railway Engineering Association. Once the minimum standard for immediate service has been determined, phased improvements can be made, provided the importance of the line justifies the effort. Derive Army construction standards from AR 420-1. Per AR 420-1 and UFC 4-860-01, the American Railway Engineering and Maintenance of Way Association Manual for Railway Engineering is used for new construction or major rehabilitation. Use UFC 4-860-03 for routine maintenance and inspection. UFC 4-860-03 references also track safety standards.

Railroad Bridges

7-64. A railroad bridge is a LOC bridge and is classified as a nonstandard bridge. The Army does not have design criteria for nonstandard railroad bridges, nor does it possess railroad float bridge equipment. Many varieties of standard railroad bridges are available through AFCS. Construction details and bills of material are addressed in TM 5-302-1. The current engineer bridge reconnaissance procedure allows for determining the MLC of a rail bridge for vehicle traffic but does not include a methodology for conducting rail bridge assessment for the use of rail. An assessment would require the use of reachback or an on-site subject matter expert to make the crossing determination.

7-65. The railway bridge construction process begins with a proper determination of design requirements. The engineer determines the appropriate load-bearing capacity of the intended bridge to support the full weight of the train itself, plus its maximum cargo load. In most cases, the design criteria should consider Cooper E80 loads (train with a locomotive weight of 520 metric tons and axle loads equal to 37 metric tons).

7-66. Panel bridge equipment can be used as a field expedient for the assembly of railway bridges. Panel bridge design has to take into consideration rail design criteria and the associated deflections of these loadings to meet rail crossing requirements.

7-67. The engineer coordinates with the Transportation Corps for support in railroad planning. The following information is needed:

- Mission and required capacity of the proposed systems.
- Type, size, and weight of rolling stock to be operated.
- Track gauge.
- Initial, intermediate, and final terminal points along the route.
- Servicing and maintenance facilities required.
- Connections with other railway systems.
- Maximum gradient and degree of curvature required.
- Scheduling or timetable for completing construction.
- Direction of future development and expansion.
- Outbound movement—the ready track and wye.

7-68. Railroad service facilities should be laid out so that servicing can be performed in proper sequence as the locomotive moves through the terminal. The usual relationship of operations and facilities from terminal entrance to terminal exit is—

- Inspections. Inspection pits or platforms.
- Lubrications. Oil and grease service areas.
- Ash pits. Ash pits for cleaning fires if steam locomotives are used.
- Facilities. Coal, sand, diesel oil, and water-appropriate facilities.
- Repairs. Running repairs (engine house).

7-69. The urgency of the situation or lack of additional bridging assets may require that a railroad bridge be converted into a highway bridge by constructing a smooth roadway surface. The use of the bridge by rail, wheeled, and tracked vehicles can be achieved by constructing planks along the ties between and outside the rails, up to the level of the top of the rail.

7-70. The repair and reinforcement of existing railroad bridges is a much more viable option than new construction. Nonstandard railroad bridging can be repaired or improved using any available and suitable materials. Railroad bridges will require specialized construction equipment and is labor-intensive. This generally precludes the construction of railroad bridges at locations away from existing rail lines. When a site is selected, use the basic criteria for general bridge sites.

Railroad Reconnaissance

7-71. After design requirements have been determined, transportation unit representatives and engineers will conduct a field reconnaissance to determine the siting of the rail system. The surveys, studies, and plans required for railroad construction are necessarily more elaborate than those for most road construction. Studies of the best available topographic maps, imagery, and other geospatial products narrow the choice of routes to be reconnoitered. Factors that affect the location of a route include logistics, length of line, curvature, gradients, load-bearing capacity of travelled surface, and ease and speed of construction. Each of the mission variables can impact on railway site selection, just as they affect the location of a road. Terrain analysis procedures for railroads can be found in Engineer Technical Letter 0311.

Logistics

7-72. Logistics is a major consideration in selecting a rail route during contingency operations. Normally, a rail line will extend from a seaport of debarkation, aerial port of debarkation, beachhead, or another source of supply in theater to the logistics support areas sustaining the forces present. Alternate routes are desirable for greater flexibility of movement and as insurance against cases of mainline obstruction because of threat actions, wrecks, washouts, floods, fires, landslides, or enemy activity. An assessment is conducted to determine the vulnerabilities of rail lines to provide input to the threat assessment and security plan. These considerations include transfer switches, constrictions, centralized routing systems, junctions, and offload stations.

7-73. The length of line (mileage from point of origin to terminus) is important only when it adds materially to the time of train movement. As much as a 30 percent increase in mileage is permissible when it proves advantageous to the other factors involved.

Curvatures

7-74. Minimize sharp curves as much as possible, consistent with the need for speed during construction. Determining the curvature for a military railroad will depend largely on the maximum rigid wheelbase of train cars and locomotives. Super-elevation is used to counteract centrifugal force on curves by raising the outer rail higher than the inner rail (see TM 3-34.55).

Ruling Grades

7-75. The ruling grade of a route is the most demanding grade over which a maximum-tonnage train can be handled by a single locomotive. Where diesel-electric units are used, a single locomotive may consist of two or more units that are coupled and controlled from the cab of the leading unit. The ruling grade is not necessarily the maximum grade. Steeper grades can be negotiated with the use of an additional locomotive as a helper engine; or if the grade is very short, the train may be carried over the crest by momentum. Since military railroads operate at slow speeds, the ruling grade should be kept to a minimum. As always, the necessity for rapid construction should be a top priority.

Ground Reconnaissance

7-76. Select a good route that will allow the rail line to be rapidly constructed using minimal resources. Many additional hours of earthwork and grading can be avoided by a careful route selection. See UFC 4-860-01 for additional information on railroad inspection standards. See TM 3-34.55 for more information on railway reconnaissance techniques.

7-77. A complete ground reconnaissance of the possible railroad routes is required. The reconnaissance team should note distance and elevation odometer and barometer observations, general terrain characteristics, controlling curvatures, soil and drainage conditions, bridge and tunnel sites, bridge sizes and types, railway or important road intersections, ballast and other construction material availability, and points at which construction units would have access to the railway route. Factors to be taken into consideration include the roadbed, rock cuts, hillsides, drainage, security, water supply, passing track, and surveys.

Roadbed

7-78. The roadbed should be built on favorable soils. Clay beds, peat bogs, muck, and swampy areas are unstable foundations and provide unsuitable soils for building fills. Cuts through unfavorable soils will slough and slide. Seek minimum earthwork in locating the roadbed and track. Where rock cuts are proposed, select locations that will allow the bedding planes to dip away from the track to prevent rockslides. Avoid locations at the foot of high bluffs, which will subject the track to rock falls, slides, and washouts. Rockwork is time-consuming; avoid it when practicable. In a temperate zone, choose sites along the lee side of hills. This prevents snowdrifts and resists wind effects.

Site Selection Considerations

7-79. The proposed railroad site should facilitate drainage or prevent the need for it. Ridge routes are best for this purpose but may be exposed to enemy fire or observation. Avoid locations that require heavy bridging. Note that diesel equipment cannot be operated over track inundated above the top of rail, because water will damage traction motors. Suitable sites for passing sidings are planned. Passing-track spacing depends on traffic density and expected peak conditions of traffic flow.

Surveys

7-80. The preliminary railroad survey includes cross sections along the feasible routes. Trail locations are plotted and adjusted to give the best balance of grades, compensated grades, cuts, and fills. This establishes or fixes the line of the railroad. Field survey parties locate the precise line and then stake it. This requires much more precision than the location survey of most new roads, since curves and super elevations must be accurately computed.

7-81. Once the necessary railroad reconnaissance and surveys are complete, the engineer prepares an estimate of the work and materials required and a plan for carrying out the construction. The engineer schedules the priority and rate of construction and provide for the even flow of material to ensure orderly progress. Schedules are continually be updated to accommodate changed field conditions or other exigencies. In addition to their planning function, the schedules can also serve as progress charts.

CONSTRUCTION

7-82. Road and railroad construction require carefully planned methodologies. This section discusses the reconnaissance, steps, processes, estimating, and sequence required for sound construction and the upgrading requirements.

ROADS

7-83. The construction directive usually provides the road geometric design, pavement structure design, and drainage system design, but probably not the temporary construction drainage structures. Road construction encompasses the following considerations:

- Site reconnaissance.
- Site preparation.
- Construction planning.
- Construction survey.
- Construction sequence of execution.
- Existing intelligence reports, assessments and products, and threat analysis.
- Strategic and technical reports, studies, and summaries.
- Road, topographic, soil, vegetation, and geologic maps or other geospatial information.
- Existing aerial reconnaissance reports.
- Existing road design information or maintenance plans.

Construction Steps and Processes

7-84. Road construction processes encompass the following considerations:

- Clearing.
- Grubbing.
- Stripping.
- Cutting and filling.
- Grading and shaping.
- Ditching and sealing.
- Road maintenance.

7-85. Clearing, grubbing, and stripping are the same in road and airfield construction. Earthmoving is usually the largest single work item on any project involving the construction of a road, unless the road will have significant gaps to cross. Any step that can be taken to avoid excessive earthwork will increase job efficiency.

7-86. Adequate drainage is essential during the construction of a military road or airfield to control water runoff. A construction drainage system is temporarily established to prevent construction delays and structural failure before completion. The construction drainage system requires continuous inspection and maintenance.

7-87. Consider the proposed use of the road. If it is to be used only for a short time, such as 1 or 2 weeks, a detailed drainage system design is not justifiable. However, if improvement or expansion is anticipated, design drainage so that future construction does not overload ditches, culverts, and other drainage facilities. See TM 3-34.48-1 for more information on drainage.

7-88. Drainage problems are greater when all-weather use occurs as opposed to intermittent use. Consider the availability of engineer resources. Heavy equipment (such as dozers, graders, scrapers, and excavators) is commonly used on drainage projects. However, where unskilled labor and hand tools are readily available, drainage work can be done by hand.

Work Estimates

7-89. When the necessary reconnaissance and mission analysis are complete, the engineer prepares an estimate of the work and materials required and a plan for carrying out the construction. The engineer schedules the priority and rate of construction and provide for the even flow of material to ensure orderly progress. Schedules are continually be updated to accommodate changed field conditions or other exigencies. In addition to their planning function, the schedules can also serve as progress charts.

Construction Sequence

7-90. Once earthwork estimation, equipment scheduling, and necessary surveys are complete, the construction sequence can begin. Prepare the construction site by clearing, grubbing, and stripping. These activities are usually done with heavy engineer equipment. Use hand or power felling equipment, explosives, or fire when applicable. The factors determining the methods to be used are the acreage to be cleared, the type and density of vegetation, the effect of the terrain on equipment operation, the availability of equipment and personnel, and the time available for completion. For best results, use a combination of methods, choosing each method for the operation in which it is most effective.

7-91. Conduct cut and fill when clearing, grubbing, and stripping are finished. Cut and fill are the biggest part of the earthwork in road construction. The goal of cut and fill work is to bring the route elevation to design specifications. Throughout the fill operation, compact the soil in layers (lifts). Achieve soil compaction with self-propelled or towed rollers. The end state is a structure that minimizes settlement, increases shearing resistance, reduces seepage, and minimizes volume change.

7-92. The advantages that accompany soil compaction make this process standard procedure for constructing embankments, subgrades, and bases for road and airfield pavements. Cut, fill, and compaction efforts are intended to achieve the final grade. This alignment takes into consideration superelevation along curves to ensure load stability and falls within military road grade specifications. When final grade is achieved, cut ditching to control drainage runoff and crown the road along its centerline. The road is now ready for surfacing.

Surfacing Considerations

7-93. All unpaved roads will emit dust under traffic, making it an inherent problem. The amount of dust that an unpaved road produces varies greatly depending on local climatic conditions and the quality and type of aggregate used for road construction. Common dust control agents include chlorides, resins, natural clays, asphalts, and other commercial binders and membranes. Dust control and soil waterproofing can be carried out by applying these agents in a spray (soil penetrants) or admixture or by laying aggregate, membrane, or mesh as a soil blanket. See UFC 3-260-17 for additional information on dust control measures.

7-94. The agronomic method (using vegetation cover) is suited to stable situations but is rarely useful during contingency operations. To effectively apply stabilizers and dust control agents, ensure that the aggregate road surface has good gradation, construct a good crown on the driving surface, ensure good drainage, ensure that the equipment is calibrated accurately and is working properly, and rehearse the application of the agent using a test strip.

7-95. Use expedient surfaces as temporary means to quickly cross small areas with extremely poor soil conditions (such as swamps, quicksand, and wetlands) when lacking the time or resources for standard road construction. These are unsurfaced roads where some material has been placed on the natural soil to improve trafficability. There are two types of expedient roads—hasty and heavy. Hasty expedient roads are built quickly to last only a few days. Heavy expedient roads are built to last until a durable standard road can be constructed. Expedient surfacing methods include cross-country tracks, corduroy, chespaling landing mats, Army track, plank tread, wire mesh, snow and ice, and sand grid.

7-96. The availability of construction material determines the types and strength of roads that can be constructed. Naturally occurring materials, such as rock and wood, may be scarce or of poor quality. Portland cement may not be available or may be prohibitively expensive to use. Sand grid material is excellent for use in areas of cohesionless soil. Matting, steel planking, or geotextiles may be used if they are available. When roads are constructed in areas of poor soil conditions, roadways should be well marked, and adequate drainage is provided (see ATP 4-13).

7-97. Spray applications and surface treatments are the most economical, troop-constructed surfaces. Surface treatment can be divided into two categories—sprayed treatments and sprayed bitumen with aggregate surface. Bituminous materials are tars, road tar cutbacks, or asphalt emulsions. Spray applications provide soil or aggregate with the following surface treatments:

- Prime coat (waterproofing).
- Tack coat (binds bituminous pavement to the surface).
- Dustproofing.

7-98. Spray bitumen with an aggregate surface provides a waterproof, abrasive, wear-resistant surface with no significant structural strength.

Upgrades

7-99. Where possible, use existing road facilities. In most areas, an extensive road network already exists. With the expansion and rehabilitation of the roadway and the preparation of adequate surfaces, the road network can be improved to carry required traffic loads. Upgrading an existing road, combined with routine maintenance and repair, usually involves reducing or eliminating obstructions. It is the preferred method of improving the trafficability of a selected route.

7-100. Techniques, equipment, and materials needed for upgrading roads are generally the same as those for new construction. A changing tactical situation and unpredictable military operations may also require that military engineers modify and expand completed construction. The location of a road should allow for potential expansion. Expanding an existing route or facility conserves labor and material and permits speedier completion of a usable roadway. Understanding the capacity of the existing roads and bridges is critical in developing a network of bypasses and alternate routes as threat levels escalate on designated LOCs and supply routes.

Railroads

7-101. As a first stage in organizing railroad construction work, the engineer divides the line into sections in which special features (such as bridges, stations, yards, and rock cuts) can be constructed while other work is in progress. Work can proceed concurrently at several locations. The standard construction sequence is as follows:

- Clear and grub.
- Prepare the subgrade by cutting or filling and compacting.
- Unload and distribute track materials.

- Align and space cross ties. See Technical Report FM 94/01 for information on fastenings and other track materials inspections.
- Place line rails or ties.
- Place gauge rail on ties to ensure proper spacing.
- Line the track.
- Unload the ballast.
- Raise and surface the track.
- Make final alignments.

7-102. In addition to the actual rail line, certain facilities are necessary to rail movement or are required due to particular physical conditions. Sidings are auxiliary tracks next to the main line, which are used for meeting and passing trains, for separating and storing equipment that breaks down en route, and for storing rolling stock that cannot be moved to its destination. The railway transportation unit will determine siding locations in coordination with engineers. Sidings are built parallel to the rail line and should be 250 feet longer than the longest train that will use it and have a turnout at either end.

7-103. Avoid highway and road crossings at grade when possible. When crossings are installed, construct them so that the road axis is approximately perpendicular to the railroad centerline. Rail crossings carry one track across another at grade and permit the passing of wheel flanges through opposing rails. The design of frogs to allow these crossings depends on the angle at which they cross. In military railroads, most frogs are made of precast, immobile rails that can be easily installed.

7-104. Wyes are used in place of turntables, which are impractical for use in contingency operations. A wye is a triangular-shaped arrangement of rail tracks with a turnout at each corner where two or more rail lines join to allow trains to pass from one line to the other. Wyes may be installed at engine terminals, summits, junctions, and railheads as time permits. In some cases, the stem of the wye may be long enough to permit the turnaround of the entire train.

7-105. Structures needed for supporting railroad transportation include—

- Facilities for train crews and maintenance personnel.
- Yards and terminals.
- Shop facilities for train and rail repair.
- Engine house.
- Water stations.
- Storage areas for material and tools.
- Loading ramps for cargo.
- Block stations (facilities that house the switching and signaling equipment that controls train movements).

7-106. A railhead is at the end of a railroad. Yards are a system of tracks that serve three basic functions. These functions include—

- One or more tracks long enough to receive an entire train.
- A system of shorter tracks for the storage or classification of freight.
- Departure tracks on which rolling stock from the classification yard may be assembled for dispatching.

7-107. In addition to the auxiliary facilities described above, other specific construction requirements may be dictated by the terrain or operational requirements. Special equipment, materials, and expertise may be required to construct a railroad and its accompanying facilities to quickly and efficiently support units.

OPERATION AND MAINTENANCE

7-108. Roads and railroads require O&M to extend their service life and usefulness to support the force. This section discusses the routine and scheduled requirements and considerations.

ROADS

7-109. The operation of roads is often performed and controlled by transportation units or movement control teams when they are designated MSRs or alternate supply routes. Operation involves controlling traffic with orders, signs, checkpoints and, possibly, patrols.

7-110. Road maintenance requires a substantial amount of resources and technical expertise on a continuous basis. Roads should be maintained and repaired for safe and speedy traffic movement. Maintenance is the routine prevention and correction of damage and deterioration caused by normal use and exposure to the elements. Repair restores damage caused by abnormal use, accidents, hostile forces, and severe weather actions. Repair includes the resurfacing of a road or airfield when maintenance can no longer accomplish its purpose. Rehabilitation restores roads or airfields that have not been in the hands of friendly forces and do not meet operational requirements. Rehabilitation resembles war damage repair, except that it is accomplished before occupancy.

7-111. Routine maintenance and repair include inspections, stockpile of materials for maintenance and repair work, maintenance and repair of road surfaces and drainage systems, dust and mud control, and snow and ice removal. The main purpose of maintenance and repair work is to keep road surfaces in usable and safe condition. Routine maintenance and repair also maintain route capacity and reduces vehicle maintenance requirements. Effective maintenance begins with a command-wide emphasis that stresses good driving practices to reduce unnecessary damage. Once damage has occurred, prompt repair is vital. After deterioration or destruction of the road surface begins, rapid degeneration may follow. A minor maintenance job that is postponed becomes a major repair effort involving the reconstruction of the subgrade, base course, and roadway surface.

7-112. The following guidelines should be observed in conducting sound road maintenance and repair:

- **Minimize interference with traffic.** To keep surfaces usable, maintenance and repair activities should interfere as little as possible with the normal flow of traffic. A temporary bypass may be required.
- **Correct the basic cause of surface failure.** Efforts spent to make surface repairs on a defective subgrade are wasted. Any maintenance or repair should include an investigation to find the cause of the damage or deterioration. That cause is remedied before the repair is made. To ignore the cause of the damage is to invite prompt reappearance of the damage.
- **Reconstruct the uniform surface.** Maintenance and repair of existing surfaces should conform as closely as possible to the original construction in strength and texture. Simplify maintenance by retaining uniformity. Spot strengthening often creates differences in wear and traffic impacts, which are harmful to the adjoining surfaces.
- **Assign priorities.** Priority in making repairs depends on the operational requirements, commander's guidance, traffic volume, and hazards that would result from the complete failure of the facility.

Maintenance Inspections

7-113. The purpose of road maintenance inspections is to detect early defects before actual failure occurs. Frequent inspections and effective follow-up procedures early in the process prevent minor defects from becoming serious and causing major repair jobs later. Prompt and adequate maintenance (care of joints, repair of cracks, replacement of broken areas, and correction of settlement) and drainage involves retaining a smooth surface and keeping the subgrade as dry as possible. A smooth road surface protects the pavement from the destructive effects of traffic, and it reduces vehicle wear and tear (see TM 3-34.63 for more information).

7-114. Road inspections are essential to prevent road failure. When inspecting road surface and drainage defects, look for actual causes of the defects. Potholes are the most common type of road failure in bituminous wearing surfaces. Potholes and pavement defects can usually be attributed to excessive, heavy loads and traffic; inferior surfacing material; frost in the base; poor subgrade; excessive settlement in the base; inadequate drainage; or a combination of these conditions. Ensure that all drainage channels and structures are kept unobstructed. Exercise extra vigilance during rainy seasons and spring thaws and after every heavy storm.

Notes.

1. See TM 3-34.63, UFC 3-270-01, and UFC 3-270-08 for additional information on road inspections and repairs.

2. See TM 3-34.48-1, for additional information on drainage system maintenance.

3. See TM 5-626 for information on unsurfaced road maintenance.

Other Maintenance Considerations

7-115. Generally, the materials used in road maintenance and repair are the same as those used in new construction. Maintenance activities may include opening pits and stockpiling sand and gravel, base materials, and premixed cold patching material. Place materials in convenient, centralized locations and stock in sufficient quantities for emergency maintenance and repair. Arrange stockpiles for quick loading and transportation to key routes.

7-116. In some areas, extensive repairs are required to make roads usable. Advance engineer units usually do this repair work. Under the pressure of combat conditions, repairs are sometimes temporary and rapidly made using the most readily available materials. Such expedient repairs are intended only to meet immediate minimum needs. As advance units move forward, other engineer units take over additional repair and maintenance. Early expedient repairs are supplemented or replaced by work that is more permanent. Surfaces are brought up to a standard that can fully withstand the required use. Maintenance becomes a matter of routine.

7-117. Engineer units establish a patrol system to cover the road network for which the unit is responsible. Periodic patrols by elements, such as military police personnel, who use the road net on a sustained and frequent basis can assist with patrolling. Engineer road maintenance and repair modules are organized with proper personnel, equipment, and supplies to accomplish road repair and maintenance in a specific area. As many modules as needed are organized to cover the AOR.

7-118. The heavy traffic level and limited road durability may make it necessary to conduct maintenance on a 24-hour basis. A squad-sized road maintenance and repair module equipped with a dump truck, grader, and hand tools can conduct maintenance and minor repairs encountered on a 5- to 15-mile stretch of road. This module can be increased or decreased, and more or fewer miles can be assigned to a module as the mission dictates. Security conditions also influence the size and composition of these elements and the employment methodology.

7-119. During contingency operations, severe winter weather may present challenging maintenance problems. Regions of heavy snowfall require special equipment and material to keep pavements and other traffic areas open. Low temperatures cause icing on pavements and frost effects on subgrade structures. Alternate freezing and thawing may cause damage to road surfaces and block drainage systems with ice. Spring thaws could cause surface and subgrade failures and may damage bridging.

7-120. Winter maintenance consists of removing snow and ice, sanding icy surfaces, erecting and maintaining snow fences, and keeping drainage systems free from obstruction. Each command should publish a comprehensive snow and ice control plan that clearly specifies the responsibilities of engineer and nonengineer units. Engineer and nonengineer reconnaissance is established to monitor snow and ice conditions within the area of operations. Adequate personnel and snow and ice control equipment and supplies are allocated to support the plan.

7-121. A detailed discussion of pavement failures, maintenance and repair methods, and rigid pavement maintenance is covered in TM 3-34.63, UFC 3-250-08FA, and UFC 3-270-01.

RAILROADS

7-122. Railroads may be operated by the HN, private companies, contractors, or military transportation railway personnel. Although transportation units have the responsibility for routine maintenance, engineers should be prepared to provide construction support when additional maintenance beyond the organic capabilities of transportation units is required. Rail lines and supporting facilities are inspected regularly to ensure adequate maintenance and proper operation. Necessary action is undertaken as quickly as possible to minimize future repair requirements.

7-123. Railroad preventive maintenance, including the proper cleaning and lubrication of equipment and machinery, will minimize the need for unnecessary maintenance and repair. Railroads are susceptible to maintenance problems and are vulnerable to enemy attack, guerilla warfare, and sabotage. Railroads used by the transportation railway service already exist. Maintenance is required on supporting facilities, road crossings, railroad bridges, tracks, sidings, and switching equipment. See ATP 4-14 for additional information on railroad maintenance.

Chapter 8
Bridging

Rivers and dry gaps have posed serious problems for military forces by obstructing their freedom of maneuver. Strategically and tactically, bridges are vital and vulnerable since they influence mobility and access to key terrain. Very few LOCs exist without a bridge, bypass, or detour. Engineers play a pivotal role in assisting ground maneuver forces with bridge reconnaissance crossing and fording site selection analysis. The Army has a variety of bridges that it can deploy, assemble, or construct according to situation and mission requirements. The Marine Corps has no bridging equipment. This chapter will discuss bridge types, designs, uses, and planning considerations in determining the best bridge to use for tactical, support, and LOC.

RESPONSIBILITIES AND CAPABILITIES

8-1. ADP 3-90 discusses the key role of bridging in the offense. Rivers and gaps are major obstacles, despite advances in high-mobility weapon systems and extensive aviation support. Wet-gap crossings are among the most critical, complex, and vulnerable combined arms actions that use tactical and assault bridging. A crossing is conducted as a hasty crossing and as a continuation of the attack, when possible, because the time needed to prepare for a gap crossing allows the enemy more time to strengthen the defense.

8-2. The size of the gap and the enemy and friendly situations will dictate the specific tactics, techniques, and bridging procedures used in conducting the crossing. The Army has the capability to conduct a combined arms gap crossing with organic engineers and tactical bridge sets. Combat engineers are responsible for conducting tactical and assault bridging with tactical units, while general engineers are responsible for LOC bridging. Bridging is fulfilled by both combat and general engineering.

Notes.

1. See ATP 3-90.4/MCTP 3-34A for more information on combined arms gap crossings.

2. See ADP 3-90 for more information on offense and defense.

3. See ADP 4-0 for more information on bridging to support sustainment and the LOC transportation system network.

ARMY

8-3. Theater engineer commands have the theater engineering planning oversight, to include bridging, with a senior engineer planning staff, with command and control of assigned engineer brigades. Engineer brigades have staffs for planning bridging. Engineer battalions are assigned bridge missions and control of assigned engineer units performing the actual bridge building execution. See FM 3-34 and ATP 3-34.22 for more details on Army engineer unit organization.

8-4. Army engineer units can provide trained personnel and working equipment in support of bridging missions. The Army has multirole bridge companies with the expertise, personnel, and equipment for building a variety of bridges. Engineer units can complement mission support with heavy equipment like cranes, bulldozers, and dump trucks to move weight-intensive bridge parts. Engineer units can provide specialized tool sets, kits, and outfits to aid in bridge building. Army engineers can advise and assist maneuver forces with bridging expertise by conducting specialized site reconnaissance, conducting existing bridge structure assessments, and providing geospatial and terrain visualization products. Army engineers can also provide topographic services. Combat engineers can remove damaged bridge structures through demolitions.

8-5. Engineer dive teams can assist in providing critical support to the engineer commander during river-crossing by conducting nearshore and far-shore reconnaissance; performing hydrographic surveys to depict bottom composition; conducting underwater and surface reconnaissance of bridges to determine structural integrity and capacity; repairing or reinforcing bridge structures; emplacing, marking or reducing underwater obstacles using underwater demolitions. Divers may also assist in installing impact booms, antimine booms, and antiswimmer nets to prevent damage to fixed bridging. Engineer divers support countermobility by denying enemy access to bridging assets. Divers can be used to survey, emplace, prime, and detonate explosives on bridge supports to degrade or destroy bridges. See TM 3-34.83 for information on United States Army engineer organizations and capabilities. See ATP 3-90.4/MCTP 3-34A for information on bridge unit details.

UNITED STATES ARMY CORPS OF ENGINEERS

8-6. The CCDR may use USACE for the design, award, and management of bridge construction contracts in support of military operations. USACE has a professional staff of engineering subject matter experts for consulting or collaborating on bridge designs or engineering concepts and for providing technical assistance. USACE has an extensive system of research laboratories for materials testing, structural integrity, and product development. In addition, it also has reachback capabilities for the field engineer or can deploy teams to the field for resolving unique bridging issues. USACE is a DOD construction agent for the construction of bridges. See FM 3-34 and JP 3-34 for information on the role of USACE.

NAVY

8-7. Naval mobile construction battalions and Seabees have extensive heavy horizontal and vertical construction capabilities, to include constructing and maintaining roads and bridging for supply routes. Naval mobile construction battalion tasks include the installation of standard and nonstandard bridging. They can also install, repackage, and redeploy panel bridges. NAVFAC is a DOD construction agent for the construction of bridges. See NTTP 3-10.1M/MCTP 3-34D for information on Naval mobile construction battalion capabilities, roles, and missions.

MARINE CORPS

8-8. The Marine Corps has engineering units organic to its MAGTF that possess the capability to construct military nonstandard fixed bridging. See ATP 3-90.4/MCTP 3-34A and TM 3-34.22/MCRP 3-34A.2 (MCRP 3-17.1B) for bridging details.

OTHER COUNTRIES

8-9. U.S. military allies can be a viable option for obtaining additional bridging assets. Countries like Great Britain and Germany maintain organic bridging assets with military engineers. Specific, allied bridging assets are discussed later in this chapter. See ATP 3-90.4/MCTP 3-34A for additional information.

PLANNING AND DESIGN

8-10. There are two basic bridging types: standard and nonstandard (see ATP 3-90.4/MCTP 3-34A). While the two types could be combined as a hybrid of some nature, the bridge will normally be identified by its predominant components. Standard bridging includes any bridging derived from manufactured bridge systems and components that are designed to be transportable, easily constructed, and reused. Nonstandard bridging is purposely designed for a particular gap and typically built utilizing commercial, off-the-shelf or locally available materials. Nonstandard bridging is normally used when time permits; materials and construction resources are readily available; standard bridging is inadequate, unavailable, or being reserved for other crossings; and the situation allows for unique construction. These bridges are normally left on-site, even when they are no longer necessary to support military movement. Nonstandard bridging is typically constructed by construction engineers or contractors utilizing steel, concrete, and/or timber.

8-11. There are three bridging categories that are broadly defined by their intended purpose (see ATP 3-90.4/MCTP 3-34A). These categories include tactical bridging, support bridging, and LOC bridging. The bridging category is typically dictated by the operational environment, time, gap characteristics, and equipment availability. They are subordinate to the bridging types and, therefore, can be standard or nonstandard. As the situation changes, crossing sites may be eventually abandoned, improved, or replaced with appropriate bridging alternatives.

TACTICAL BRIDGING

8-12. Tactical bridging is rapidly deployable and has the mobility to maintain the pace of operations with the maneuver force that it supports. Tactical bridging is typically linked to combat engineers and the immediate support of ground maneuver forces. Tactical bridging criteria includes the following:

- The bridge can be deployed and recovered.
- There is little bank preparation work required.
- There is minimum time needed to recover.

8-13. The actual bridge can usually be deployed and recovered without exposing the crew to direct or indirect fire. There are little to no requirements for bank preparation when using tactical bridging assets. It takes minimal time to deploy and recover for temporary crossings.

8-14. Engineers primarily use three bridge systems to conduct tactical bridging. These systems include—

- The armored vehicle-launched bridge.
- The joint assault bridge.
- A rapidly employed bridge system.

8-15. Although tactical bridging can be used on LOCs, planners should consider using this limited resource temporarily until it is replaced by a better bridging solution. Tactical bridging is not designed to sustain or support the heavy volume of vehicle traffic sustained through LOC bridging. Tactical bridging assets should be freed up as soon as possible to ensure that they support combat maneuver and sustain the tempo of operations. See ATP 3-90.4/MCTP 3-34A for additional information on bridging.

SUPPORT BRIDGING

8-16. Support bridging is used to establish semipermanent or permanent support to planned movements and road networks. Support bridges are normally used to replace tactical bridging as they provide greater gap-crossing capability to the force than tactical bridging. Units typically deploy and recover these systems when and where little or no direct fire threat exists. Bank preparation and improvement are important planning factors for support bridging. For more information on bridging capability, see ATP 3-90.4/MCTP 3-34A.

Commercial Bridging

8-17. Another support bridging option is procurement of commercially available panel bridges. See ATP 3-90.4/MCTP 3-34A for more information on employing semipermanent and permanent LOC bridges.

Float Bridging

8-18. A float bridge is designed as a rapid and temporary means to cross maneuver forces over wet gaps by building raft configurations to transport forces across the wet gap or by emplacing bays to span the entire width of the wet gap. U.S. forces can use float bridge rafts as assault bridging assets if needed. These rafts can be used during buildup to assist in assembling full floating bridges during bridgehead. Floating causeways can be used as floating bridges to augment standard floating bridge capability. There is generally no design limit to the length of this bridge. The normal limiting factor is the quantity of bays and boats; however, the velocity or current of the water, tidal variations, water depth, underwater obstructions, floating debris, and entry and exit bank slopes can also limit float bridging. Descriptions and construction techniques for the standard ribbon bridge are found in TM 3-34.85/MCRP 3-17A, and techniques for the improved ribbon bridge are explained in TM 5-5420-278-10.

8-19. Float bridging may be used when there is a lack of existing fixed facilities or no suitable construction materials to fabricate, reinforce, or repair existing bridges. When the situation calls for prolonged use or heavy traffic, an existing bridge should be upgraded, or new construction initiated. See ATP 3-90.4/MCTP 3-34A for technical information on employing float bridging.

LINE OF COMMUNICATIONS BRIDGING

8-20. LOC bridging is generally conducted in areas that are free from the direct influence of enemy action. LOC bridging is an ASCC, or JFC managed asset assigned to the Corps for implementation. The corps has specific fundamental planning and resourcing responsibility. Corps-assigned bridging capabilities provide assault float bridging and follow-on LOC bridging. General engineering tasks are executed to maintain LOCs (see FM 3-34 for more information on bridging capabilities). Typically, its primary purpose is to facilitate the sustainment of the force according to ADP 4-0. It can be used as a semipermanent or permanent structure. LOC bridges are built with the assumption that, once emplaced, will not likely be removed until replaced by a more permanent structure. LOC bridges may be tactical fixed bridges if the intention is to leave the system in place for an extended period and they are not required to support combat maneuver.

PLANNING CONSIDERATIONS

8-21. Planning factors should account for the extended use of the bridge and increased wear because of extended use. When planning for LOC bridging, planners should consider that an existing permanent bridge may be damaged or may not be strong enough for mission requirements. Engineers repair and reinforce a bridge using standard or nonstandard materials to meet mission requirements. The new construction of LOC bridges is possible; however, improving existing structures is most desirable to avoid the intense resource and time requirements associated with new construction. See ATP 3-90.4/MCTP 3-34A for more information on LOC bridging.

BRIDGE SITE SELECTION

8-22. Selecting an adequate site for a bridge requires special considerations. This section discusses the reconnaissance requirements for new and existing bridges.

Geospatial Considerations

8-23. Engineers use the engineer function of geospatial engineering to greatly improve situational understanding (to include terrain) and select optimal bridging sites through enhanced terrain visualization using high-resolution satellite imagery or unmanned aircraft system video. The requirement for the engineer is to have the appropriate software. Engineer terrain teams should assist in reconnaissance and assessment conditions in areas at or around potential gap-crossing sites. Terrain teams have software that can assist in mission planning by determining soil conditions, hydrology, vegetation types, general weather conditions, and other useful aspects of the terrain. See ATP 3-34.80 for additional information on geospatial engineering.

Bridge Reconnaissance

8-24. ERTs should be used to collect data to determine acceptable terrain and conditions for new bridge construction. Through reconnaissance information, planners can determine which type of bridge or bridge combinations are right for the mission based on available resources (see ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4).

8-25. The final selected bridge site is determined by numerous factors, which are reflected in its structural design. Primary screening considerations include—

- Floodplain encroachment analysis.
- Access and approach roads. Determine if the preexisting roads are adequate. The time to construct approaches can be a controlling factor in determining if a crossing site is feasible. Approaches should be straight, with two lanes, and have less than a six percent slope.
- Widths. Determine the width of the gap to be spanned at normal and flood stages for wet gaps.

- Banks. Estimate the character and shape of the banks accurately enough to establish abutment positions. The banks should be firm and level to limit the need for extensive grading. Select straight reaches to avoid scour.
- Flow characteristics. Determine the stream velocity and erosion data, taking into consideration the rise and fall of the water. A good site has steady current that runs parallel to the bank at less than 3 feet per second.
- Stream bottoms. Record the characteristics of the bottom. This will help determine the type of supports and footings required. An actual soil sample is useful in the planning process, particularly in wide gaps that may require an intermediate pier.
- Elevations. Determine and record accurate cross-sectional dimensions of the site to determine the bridge height. Planners identify any existing structures that the bridge crosses over.
- Materials. Determine the availability and accessibility of firm material, such as rock, for improving bank conditions.

8-26. If these primary considerations for bridge site selection appear favorable, planners may apply the following evaluation criteria:

- Proper concealment for personnel and equipment on both sides of the gap.
- The location of bivouac and preconstruction storage sites.
- Firm banks with less than a five percent grade to reduce preparation work. Less than one percent grade will also require site preparation.
- Terrain that permits the rapid construction of short approach roads to existing road networks on both sides of gap.
- Turnarounds for construction equipment.
- Large trees or other holdfasts near the banks for fastening anchor cables and guy lines.
- A steady, moderate current that is parallel to the bank.
- A bottom that is free of snags, rocks, and shoals and is firm enough to permit some type of spread footing.
- Determination of the number of assembly sites (upstream or downstream) for floating portions of the bridge. If the current is strong, locate all assembly sites upstream from the bridge site.
- Proper siting of logistics support activities to mitigate the possible effects of flooding.

8-27. Criteria for establishing a float bridge site may be the same as those for general bridge site selection. The following are specific float bridge site considerations:

- Banks should be low, firm, moderately sloping, and free from obstructions. Existing or easily prepared assembly sites are desirable.
- The stable bank should have a slope of 8° or less and a water depth of at least 48 inches on the near shore.
- The water velocity near the shore should be less than 5 feet per second. If the current is faster (up to 10 feet per second), additional boats, personnel, and time will be required to emplace the bridge.
- Natural holdfasts for anchorages are desirable. Float bridging is installed far enough downstream from a demolished or under-capacity bridge to avoid interference with reconstruction or reinforcement being undertaken. Unstable portions of a demolished bridge and other debris that may damage the float bridge should be removed before emplacing the float bridge.

Reconnaissance of Existing Bridges

8-28. Part of the site selection process is a reconnaissance of existing structures to evaluate the physical condition of existing bridges. ERTs inspect the bridge to determine its load-carrying capacity (classification) and its structural integrity. The engineer reconnaissance team should determine whether the situation warrants emplacing a tactical, support, or LOC bridge. When a damaged bridge is being considered for repair or replacement, reconnaissance information should include a report on the serviceability of the in-place structural members, local materials that might be reused in other construction, and the potential for overbridging (see ATP 3-90.4/MCTP 3-34A and TM 3-34.22/MCRP 3-17.1B). Maximum use should be made of existing bridge sites to take advantage of existing roads, abutments, piers, and spans that are serviceable.

8-29. Bridge reconnaissance is classified as hasty or deliberate, depending on the amount of detail required, time available, and security in the area of operations. Both types of reconnaissance are fully discussed in ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4). A deliberate reconnaissance is usually conducted in support of MSR and LOC bridging since greater traffic requirements dictate that time and qualified personnel be made available to support the task.

8-30. The use of the automated route reconnaissance kit will assist the engineer reconnaissance team by tracking the location, speed, curve, and slope of roads and the obstacles encountered along the route. An engineer light dive team can assist with the deliberate reconnaissance by providing nearshore and far-shore crossing site data. Additionally, they can mark and prepare landing sites, riverbanks, and exit routes for the crossing force. A deliberate reconnaissance includes a thorough structural analysis; a report on approaches to the bridge site; a report on the nature of the crossing site, abutments, intermediate supports, and bridge structure; repair and demolition information; and the possibility of alternate crossing sites. After a proper reconnaissance, a bridge study is completed. This is the detailed analysis of the selected site. To complete the bridge study, the engineer should—

- Request a topographic map to a scale of approximately 1:25,000. The map is used to plot the location and obtain the distances and elevations for design purposes.
- Determine whether physical characteristics at the site limit normal construction methods or interfere with construction plant installation.
- Make a detailed survey to furnish accurate information from which the bridge layout can be developed, materials requisitioned, and the construction procedure outlined. Submit the survey as plan and profile site drawings.
- Conduct a foundation investigation. Develop a soil profile along the proposed bridge centerline and at pier and abutment locations.

BRIDGE DESIGN

8-31. Bridges are designed to match the specific site conditions, proposed traffic, load-bearing capacity, type of materials available, and time available for actual construction. The various combinations of bridge types allow for a variety of designs, ranging from beam bridges, arch bridges, suspension bridges, and truss bridges. Bridges are usually designed to be standard or nonstandard. Consult the specific standard bridge model technical manuals for detailed information on applying design variations. See TM 3-34.22/MCRP 3-17.1B for more information on designs for military nonstandard fixed bridges.

BRIDGE CLASSIFICATION

8-32. An efficient MSR network should be capable of carrying expected traffic loads. Often, bridging is the weak link in the load-carrying capacity of a route. Military standard bridging is assembled in modules that result in a bridge of known capacities. Support bridging is designed to pass an uninterrupted flow of combat and tactical vehicles that generally fall within a military load classification below 60. However, some combinations of vehicle size and weight may exceed a given bridge design capacity.

8-33. Where heavier loads are anticipated, it is best to designate MSRs along routes that already possess bridges with appropriate classification ratings or to design and emplace bridges that can carry these loads. The selective use of fords, in conjunction with MSR bridge sites, can provide a solution in selected cases.

8-34. Situations may arise when it is not possible to safely accommodate all traffic designated to cross MSR bridges. Guidelines are set for special crossings (caution and risk) for oversize or overweight loads on military standard, nonstandard, and float bridging. Specific guidance for determining special crossings is contained in TM 3-34.85/MCRP 3-17A, TM 5-5420-278-10, and TM 5-5420-279-10. Unit engineer planners make recommendations for appropriate circumstances of risk or caution crossings to the commander and receive the delegation of authority for approval of such crossings.

8-35. A structural engineer periodically inspects the bridge for signs of failure when routine caution crossings are made and after each risk crossing. Structurally damaged parts are replaced, repaired, or reinforced before traffic can resume. An engineer light dive team can assist in determining the extent of any subsurface damage and can complete repairs. See UFC 3-310-08 for additional information on nonexpeditionary bridge inspections, maintenance, and repair.

8-36. All civilian bridges are not designed to support military MSR traffic, and the required load classifications may not be known when forces initially enter the area of operations. There are numerous bridge types that forces may encounter in a given area of operations, and there is no single, easy approach to classifying all of them.

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Chapter 9

Base Camps and Bed-Down Facilities

Military base camps have played an instrumental and historical role through various forms and configurations to support the warrior, whether serving as a platform for sustainment or as a stronghold to repel enemy attacks. Operating from base camps is a fundamental tactic of ground-based forces. Base camps may have a specific purpose, or they may be multifunctional (see ADP 4-0). Army and Marine Corps base camp doctrine is provided in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N). The use of the term base camp in this chapter includes the descriptive purpose of facilities that meet the definition of a base camp, such as en route facilities, access facilities, theater-opening facilities, bed-down facilities, logistics support facilities, and facilities designated as bases. All force bed-down facilities are not within base camp perimeters. This chapter discusses the distinct differences between base camps and bases. It focuses on the general engineering aspects of base camps (including planning and design, standards, site layout, construction, and O&M) and other support facilities.

RESPONSIBILITIES AND CAPABILITIES

9-1. This section discusses the responsibilities and capabilities of the Army, Marine Corps, CCDR, Service component commander, engineer commander, USACE, and Installation Management Command. Each entity plays a unique and important role in the support required for base camps or bed-down facilities.

ARMY AND MARINE CORPS

9-2. Army and Marine Corps engineers have key responsibilities and capabilities to support base camps and force bed-down facilities, but they do not own base camp life cycle activities or provide all bed-down capabilities. Base camp development and force bed-down are team efforts. Army forces typically rely on a mix of bases or base camps to deploy combat power to an operational depth (see ADP 4-0).

9-3. The designated base camp commander temporarily owns the base camp. An engineer may be designated as a base camp commander, generally with no higher priority than any other officer. Engineers can be assigned to fill some of the staff positions to operate and maintain a base camp. For example, an engineer unit may be assigned the responsibility to plan, design, construct, operate, or maintain a base camp to complete these tasks for a base camp as a turnkey project and then command (own) and operate from the base camp.

9-4. All Services are capable of planning and executing bed-down support activities. General engineers can plan, design, and construct base camps and operate and maintain engineer systems for base camps and force bed-down support (see JP 3-10).

COMBATANT COMMANDER

9-5. The CCDR is responsible for the major decisions involving base camp location and development within the area of responsibility. The CCDR may delegate authority for base camp decision-making to Service component commanders or to commanders exercising Title 10 USC Service responsibilities. Decisions are often made in consultation with the HN, subordinate commanders, and Department of State representatives. The CCDR establishes the policies, requirements, and procedures for master planning in the JOA. The requirements for master planning are linked to the theater-basing strategy. The CCDR specifies (in OPLANs and OPORDs) the construction standards for the overall operation of facilities in the theater to minimize the construction effort expended on any given facility, while assuring that the facilities adequately support the mission and meet all environmental, health and safety requirements. Command emphasis is key to any environmental or engineer related task.

SERVICE COMPONENT COMMANDER

9-6. The Service component commander establishes a staff engineer section with a facilities and construction department that manages engineering and construction within the area of operations under the appropriate Title 10 USC responsibilities. The staff engineer section is responsible for developing the base camp and bed-down plan for Service personnel and equipment arriving in the AOR. With guidance from the CCDR and approval from the Service component commander, the staff engineer section provides guidance on engineering and construction missions; establishes standards for construction; conducts coordination with the HN; participates in funding, utilization, and resourcing boards; and coordinates with USACE or the NAVFAC and the theater engineer command. Their responsibilities include integrating the legal, force health protection, and other aspects of environmental considerations provided from the respective areas of staff expertise. Service component commanders produce a service level scheme of base camps that subordinate commanders use as the framework to develop their scheme of base camps.

ENGINEER COMMANDERS

9-7. Engineer commanders and staff are responsible for assisting the supported commanders by furnishing engineer advice and recommendations to the commander and other staff officers; preparing the engineering portions of plans, estimates, and orders that pertain to base camps; participating on project approval and acquisition review boards and base camp working groups as necessary; and coordinating and supervising specific engineer activities for which the engineer staff is responsible. The engineer staff assists the commander by performing a variety of functions to synchronize engineer activities in the operational area. See FM 3-34 and MCWP 3-34 for more information.

THEATER ENGINEER COMMAND

9-8. The TEC will assist in the operational management and tactical execution of bed-down facilities. They conduct base master planning, engineer estimates, assign and mange troop construction and conduct contract construction management.

UNITES STATES ARMY CORPS OF ENGINEERS

9-9. USACE is responsible for providing standards for construction; guidance on scalability, standardization, and modularity; expertise on contingency standard designs; and management of the AFCS. They also manage the worldwide power contingency contracts that provide power system services in conflict and disaster response locations. USACE provides deployable augmentation teams to support base camps.

INSTALLATION MANAGEMENT COMMAND

9-10. The Installation Management Command is responsible for providing guidance on Army installation and facility management. The Army organization with premier knowledge on best practices can be transferred to facilities and base camp operations and management. The Installation Management Command may provide deployable augmentation teams to support base camps.

PLANNING AND DESIGN

9-11. Combat engineers normally support initial entry or access into enemy-held territory through a beachhead, airhead, or bridgehead. The initial secured and defended area is then expanded into a substantial defended area, also referred to as a lodgment. General engineering may support the initial entry or access through LOTS or JLOTS and airfield or port construction, maintenance, or repair. General engineers replace combat engineers so that they can move forward with maneuver forces. General engineers then provide support to expand the lodgment in size and capabilities as it progresses to a support area or joint security area, and then base development may begin. Some of the expedient bed-down facilities may be upgraded and may be contained within base camps. Base camps should be planned from the start of the mission, but requirements may evolve over time. Bed-down facilities may be required before, during, and post combat.

9-12. Base camps may also be established in nations adjacent to the operational area to support deployment before or after initial entry into an area. For example, an intermediate staging base may also serve as a base camp. Base camps and bed-down facilities may include new or prefabricated construction and make maximum use of existing structures (with and without repair or modification).

SPECIFIC JOINT TERMINOLOGY

9-13. *Base development (less force beddown)* is the acquisition, development, expansion, improvement, construction and/or replacement of the facilities and resources of a location to support forces. An EBS is a multi-disciplinary site survey conducted prior to or in the initial stage of an operational deployment (JP 3-34).

9-14. *Force beddown* is the provision of expedient facilities for troop support to provide a platform for the projection of force (JP 3-24). Force bed-down and base camp development is described in JP 3-34 as separate sub-functions under the sustainment function. See JP 3-34 for a discussion on bed-down engineering, including troop and aircraft bed-down.

SPECIFIC ARMY AND MARINE CORPS TERMINOLOGY

9-15. A *base camp* is an evolving military facility that supports the military operations of a deployed unit and provides the necessary support and services for sustained operations (ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]). Base camps are nonpermanent by design and designated as a base when the intention is to make them permanent. A base or base camp has a defined perimeter and established access controls and should take advantage of natural and man-made features. A commander designates an area or facility as a base or base camp and often designates a single commander as the base or base camp commander who is responsible for protection, terrain management, and day-to-day operations of the base or base camp. Units located within the base camp are under the tactical control of the base camp commander for security and defense. According to ADP 4-0, base camps may be joint or single Service and will routinely support U.S. and multinational forces. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) and JP 3-34 for additional information on base camps.

9-16. Base camp location selection is the process of evaluating a series of possible locations for a base camp (see EP 1105-3-1). It is part of the overall base camp planning development process. Selecting the best location for a base camp is a balance between operational, sustainment, and engineering requirements, and the operational and mission variables. All sites considered as potential base camp sites should be scalable and easily expanded. The most desirable site locations are those that are easiest to secure and defend. When the establishment of a base camp is being considered, identify at least three suitable, possible locations (COAs or options) before recommending the most advantageous COA. The entire staff should be involved in evaluating potential base camp sites. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N), EP 1105-3-1, and JP 3-34 for additional information.

9-17. *Base camp development planning* is a time-sensitive and mission-driven, cyclical planning process that determines and documents the physical layout of properly located, sized, and interrelated land areas, facilities, utilities, and other factors to achieve maximum mission effectiveness, maintainability, and expansion capability in theater (EP 1105-3-1). The process also addresses the eventual cleanup and closure of the base camp after the U.S. military mission is completed. Base camp development planning products include the planning report, maps, plan drawings, and other geophysical information. Further, the tabulation of existing and required facilities is essential in defining real property assets and shortfalls and, subsequently, in developing projects and other actions to mitigate deficiencies. Some documents, such as selected maps, are used on a daily basis by assigned units and by those individuals who are responsible for operating and maintaining the base camp. For more detailed information, see EP 1105-3-1.

9-18. Base development (less force bed-down) is the acquisition, development, expansion, improvement, construction and/or replacement of the facilities and resources of a location to support forces (see JP 3-34). According to ADP 4-0, a base camp is an evolving military facility that supports the military operations of a deployed unit and provides the necessary support and services for sustained operations (see JP 3-34 for more information).

9-19. A design guide is a design tool for standardizing sustainable energy and water efficiency, safety, and protection measures; and promoting visual order and consistent architectural themes. The design guide is a written and graphically depicted set of standards that governs the design, development, visual aspects, and maintainability of a specific base camp. A design guide applies mostly to longer-duration base camps and those that will likely be transferred and become permanent facilities/sites in the HN. The guide also may be used to define performance and customer service standards for various base camp functions. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) and EP 1105-3-1 for additional information.

9-20. The EBS documents the original environmental condition of the land. An EBS is required if an area is to be occupied by U.S. forces for more than 30 days. Documenting initial site conditions helps to prevent liability to the U.S. government for damage or contamination that was present before site occupation. Also, by identifying existing environmental hazards and potential health risks during the planning phase of a contingency operation, the overall suitability of a site can be used in the site selection process, and concerns can possibly be mitigated with proper planning. For example, water or soil contamination, air pollution, poor site drainage, and improper waste management are environmental hazards and health risk factors that impact site suitability and planning. Hazards may be generated on and off of the survey site, and hazards include both those impacting personnel on the survey site and those impacting the surrounding indigenous populations and institutions. The survey can help planners determine the best site layout, including locations (from an environmental and health standpoint) for life support areas, maintenance, sanitation, hazardous material storage, and so forth. See ATP 3-34.5/MCRP 3-40B.2, EP 1105-3-1, and JP 3-34 for additional information on the EBS and other environmental documentation, as well as environmental considerations.

9-21. *General site planning* is finding and plotting, to scale, a logical location for every aboveground area, facility, and infrastructure requirement, along with the portrayal of the various, often invisible, major utility corridors, safety clearance zones, and various boundaries that influence and support the base camp development plan (EP 1105-3-1). It requires multidisciplinary expertise in a process that links architecture, engineering, military operations planning, antiterrorism/force protection, the environment, social science, and community planning. The result of this process establishes plan-view dimensions, corridors, zones, and boundaries for the development of a base camp, usually portrayed on overlays to maps of the area (see ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) and EP 1105-3-1 for additional information).

9-22. Land use planning is the process of mapping and planning the allocation of land use areas based on general use categories, mission analysis products, functional requirements and interrelationships, and criteria and guidelines (ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]). A land use plan is like a jigsaw puzzle, because each piece of the plan is intended to fit together to form a whole that is greater than the sum of the parts. The plan is sized and shaped to account for constraints that cannot be overcome, to take advantage of opportunities that exist, to accommodate existing requirements, and to allow for future expansion. Compatible land uses are placed close to each other, and incompatible land uses are not. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) and EP 1105-3-1 for more information on land use planning.

9-23. The master planning for base camps generally follows the process that is used for permanent installations, except it has a shortened planning horizon and may not be prepared to the same level of detail. See AR 210-20, ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N), and EP 1105-3-1 for additional information on master planning.

9-24. Site design (sometimes referred to as site planning) includes the actions taken by a design professional to draw up and prepare detailed plans, specifications, and cost estimates for the construction or renovation of facility complexes, individual buildings, infrastructure, and supporting utilities. The term site design is used to avoid confusion with the terms site planning and general site planning (ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]).

9-25. Base camp cleanup and closure is the process of preparing and executing alternative COAs to vacate a base camp after a U.S. military mission is complete. An archival record is prepared that includes the operational history of the base camp, the actions taken to clean up and close the base camp, and a description of cleanup and closure tasks that could not be completed which may lead to land use, health, safety, and environmental problems in the future (see ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N] and EP 1105-3-1 for more information).

BED-DOWN FACILITIES

9-26. Some expeditionary or initial bed-down facilities are located within a base camp after base development begins. The CCDR may choose to develop some base camps very early in a campaign or operation so that some bed-down facilities are within base camps from the start. Bases and base camps support the reception, bed-down, and employment of personnel, equipment, and logistics. Bed-down facilities are expeditionary or initial operating facilities with construction standards designated by the CCDR. Force bed-down facilities include billeting, dining halls, religious support facilities, medical clinics, hygiene facilities, motor pools, and aircraft facilities.

9-27. The planning for bed-down is fully integrated with the CCDR basing strategy, since some of these initial facilities will later be expanded and upgraded. Life cycle planning flows from bed-down, to a scheme of base camps, to transfer or close. The information generated from master planning facilitates future cost benefit analyses that enable decision-making for other aspects of base camp activities. See AR 210-20 for additional information on real property master planning for Army installations for considerations that can be applied to contingency operations.

BASE CAMP DOCTRINE

9-28. The base camp life cycle, classification system, principles, and functional areas are discussed below. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for additional information on base camp doctrine.

Base Camp Life Cycle

9-29. The base camp life cycle embodies the major activities that are involved in base camps. These activities are mutually reinforcing, not mutually exclusive, and include—

- Strategic system and policy integration.
- Planning and design.
- Construction.
- Operations.
- Transfer and closure.
- Command and control.

Base Camp Classification System

9-30. Base camps are broadly classified by size, level of capabilities, and purpose. This classification system provides common terminology and a framework that aids the conduct of all base camp life cycle activities. The four sizes of base camps are extra small, small, medium, and large; each size has a range of population that the base camp is designed to support. The levels of capabilities are basic, expanded, and enhanced. The levels of capabilities describe the characteristics of a base camp in terms of support and services (overall quality of life) that are provided. This includes the nature of the construction effort applied that is commensurate with the anticipated duration of the mission.

9-31. Base camps are developed to serve a specific purpose (such as an intermediate staging or forward operating or logistics base or as support for reception, staging, onward movement, integration, training, detainee processing, and resettlement); or they may be developed to serve a multifunctional purpose. The designated purpose of the base camp and the operational requirements of tenant units serve as primary guides in designing the base camp.

Base Camp Principles

9-32. Successful base camps are characterized by four principles that are incorporated throughout the life cycle. (ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]) Commanders and staffs use the base camp principles as a guide for analytical thinking. These principles are as follows:

- Scalability.
- Sustainability.
- Standardization.
- Survivability.

Base Camp Functional Areas

9-33. Base camp functional areas are related base camp tasks and activities, and they are grouped together to facilitate planning and execution (see ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N] for more information). During mission planning, the base camp functional areas help commanders and staffs organize the broad range of base camp requirements and the supporting information and tasks required for execution. The following are the five base camp functional areas:

- Operations.
- Logistics.
- Services.
- Protection.
- Facilities and infrastructure.

STANDARDS

9-34. Table 9-1 provides an example of CCDR construction standards for various types of construction that guide general engineering activities.

Table 9-1. Sample base camp construction standards

Type of Construction	*Initial*	*Temporary*	*Semipermanent*
Site work	Minimal to no site work; maximized use of existing facilities	Clearing and grading for facilities (including drainage and revetments); petroleum, oil, and lubricants; ammunition storage; aircraft parking; aggregate for heavily used hardstands; and soil stabilization	Engineered site preparation, including paved surfaces for vehicle traffic areas and aircraft parking, building foundations, and concrete floor slabs
Troop housing	Unit tents	Tents (may have wood frames and flooring)	Wood frame structures, relocatable structures and modular building systems
Electricity	Tactical power system	Tactical power system or deployable prime power system	Sustained power system
Water	Water points and bladders	Water points, wells, and potable water production and pressurized water distribution systems	Limited pressurized water distribution systems that support hospitals, dining facilities, firefighting units, and other high-volume users
Cold storage	Contracted or unit-purchased	Portable refrigeration with freezer units for medical, food, and maintenance storage	Refrigeration installed in temporary structures
Sanitation	Unit field sanitation kits, pit latrines	Organic equipment, evaporative ponds, pit or burnout latrines, lagoons for hospitals, and sewage lift stations	Waterborne to austere treatment facilities—priorities are hospitals, dining facilities, bathhouses, decontamination sites, and other high-volume users

Table 9-1. Sample base camp construction standards (continued)

Type of Construction	*Initial*	*Temporary*	*Semipermanent*
Airfield pavement[1]	NA	Tactical surfacing, including matting, aggregate, soil stabilization, and concrete pads	Conventional pavements
Fuel storage	Bladders	Bladders	Bladders and steel tanks
[1]The type of airfield surfacing to be used is based on soil conditions and the expected weight and number of aircraft involved in operations.			
Legend: NA not applicable			

9-35. DOD construction agents are the principal organizations to design, award, and manage construction contracts in support of some semipermanent facilities and permanent facilities.

9-36. Major construction standards are as follows:

- **Semipermanent.** Semipermanent construction standards allow for finishes, materials, and systems selected for moderate energy efficiency, maintenance, and life cycle cost with a life expectancy of more than 2 years, but less than 10 years.
- **Permanent.** Permanent construction is designed and constructed with finishes, materials, and systems selected for high-energy efficiency and low maintenance and life cycle cost. Permanent construction has a life expectancy of more than 10 years. The CCDR approves permanent construction.

BASE CAMP DEVELOPMENT PLANNING

9-37. Engineers should be familiar with numerous planning considerations and design factors when planning the base camp. Major base camp planning and design considerations include the base camp doctrine and standards highlighted in the previous sections of this manual and also include the following areas:

- **Protection.** Force protection considerations are critical to the development of base camps.
- **Facility standards identification.** The CCDR establishes the base camp standard for the JOA by an OPORD or fragmentary order. These standards are intended to provide the CCDR's expectations for base camp living and operating conditions to component commanders.
- **Master planning.** The CCDR establishes the policies and procedures for developing, approving, and implementing base camp master planning in the JOA. (ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N] for additional information.)
- **Construction management.** Responsible components (often USACE, theater engineer command engineers, or facility engineer teams) will track the development of base camp construction according to the master plan priorities and report progress.

9-38. Base camp planners should be familiar with the appropriate publications, references, and planning tools required to develop a base development site plan. A base development site plan is an overlay of a topographic map or a computer-aided design that shows the location of a future development site and the planned physical site layouts and locations of required areas (facilities and infrastructure required for a specific base camp). The base development site plan is dimensioned to scale with plan-view outlines of proposed buildings, utility systems, road networks, and site improvements and the necessary topographic features. A base development site plan is prepared as part of the overall base camp development planning.

9-39. Preparing a base development site plan is a team effort and requires multidisciplinary expertise that links architecture, engineering, military operations planning, protection, the environment, social sciences, and community planning. It includes a set of interrelated documents that record the planning process involved in laying out, determining the scope, and initiating implementation actions for a base camp during contingency operations.

9-40. There is no right answer in developing a base development site plan. Each base development site plan is unique and is shaped by the mission; the units it will support; the land upon which it will be developed; and the respective backgrounds, skills, and contributions of the planning team members. Once the base development site plan is completed, an action plan is developed for its implementation. The appropriate CCDR or theater commander designates the proper level of command authority to approve the base development site plan.

9-41. The decision to establish a base camp is made at any time during the process of planning and executing a military operation. Ideally, it should be made very early in the process to allow appropriate planning in a proactive, rather than reactive, environment. USACE usually has the mission to plan or assist in the planning and development of base camps in support of contingency operations. Engineers and planners should be prepared to support and assist users (whose first priority is the mission) in making effective base camp site selection and layout decisions. A base camp could be established in a hostile nation after active combat actions cease (such as in Iraq), in a friendly nation as a location to be used in the event of a deployment (such as in Kuwait or Turkey), or in a friendly nation to support active combat operations in a nearby country (such as in Qatar).

9-42. USACE initiated base camp development planning to assist military planners and establish a process. Key considerations in base camp development planning include—

- Selecting suitable base camp locations, while coordinating with CCDRs, the Department of State, the Federal Emergency Management Agency, other federal agencies (as appropriate), and the HN.
- Planning and documenting the detailed actions needed for a properly located and sized base camp that consider related land areas, facilities, utilities, and other factors to provide U.S. forces with the safest, healthiest, and best living and working conditions.
- Planning and executing the cleanup and closure of a base camp in a manner that meets U.S. and HN standards or those approved by the theater command.

9-43. The base camp development planning process focuses primarily on the engineer-specific areas of base camp planning, but also requires team effort contributions from many participants. Base camp planners assist in the location, design, construction, cleanup, and closure of base camps that support military forces or governmental organizations across the competition continuum.

9-44. Integral to the base camp development planning process is the expectation that base camp development has a limited time frame and, therefore, will require rapid planning and fast-track construction. Other factors (such as rapidly changing military and political situations, parallel missions in the same or neighboring regions, or a reintroduction of combat operations into the target area of the proposed base camp) may require the steps in the planning process to be altered. Also, the requirement to serve HN needs and address concerns regarding the establishment of a single base camp or a series of base camps may change the described steps of the planning process and the options influencing flexibility within each planning step. The intended life-span of the facilities and infrastructure of a base camp depends on mission-driven and economic decisions. A likely component of this effort is the FFE support that USACE will provide to the tactical commanders who determine the need for a base camp.

9-45. The base camp development planning process is a time sensitive and mission driven, cyclical planning process that determines and documents the physical layout of properly located, sized, and interrelated land areas, facilities, utilities, and other factors to achieve maximum mission effectiveness, maintainability, and expansion capability in theater. The base camp development planning process is depicted in figure 9-1. Planners rarely perform these steps in exact sequence; consequently, numbers are not assigned to these steps. At times, planners may enter the process when it is well under way, since planning is iterative and intuitive in nature. See EP 1105-3-1 for more information on base camp development planning.

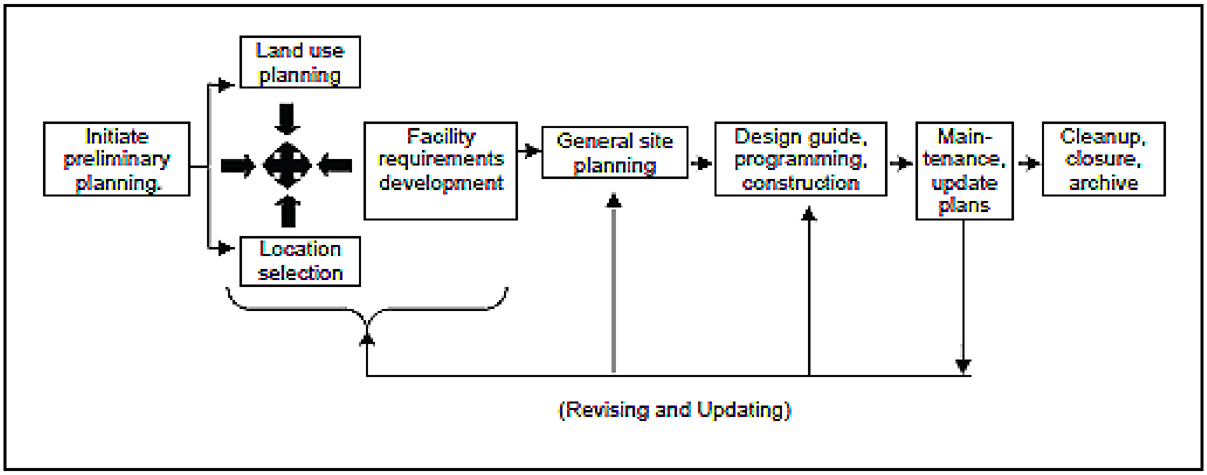


Figure 9-1. Base camp development planning process

9-46. The base camp development planning process requires a multidisciplinary, multistaff team approach to efficiently identify, analyze, and develop workable solutions to the many challenges that will require addressing. Base camp planning team members may consist of commanders and staffs from the units that will occupy, or may already be occupying, the base camp; operational planners and protection experts; civil affairs specialists; technical experts in engineering and other design professions; environmental and preventive medicine experts; resource managers; range and training experts; program analysts; contracting, real estate, and other legal specialists; and HN planners. In other words, organizations that have a major role or will impact the base camp development planning should be included in the team.

9-47. The base camp development planning process is an iterative process that is continuous; it is not finished until the facilities and land are turned back over to the HN. Base camp development plans are shaped to improve base camp living and working conditions. For example—

- Tents convert to shelters; shelters convert to buildings.
- Field sanitation converts to chemicals; chemicals convert to waterborne systems.

9-48. All levels of command are involved in real property planning and its related facility programming actions. Therefore, base camp development planning is reviewed and approved by the base camp commander or designated representative by means of a base camp planning board and by higher echelons as appropriate. This procedure has the added advantage of serving as a check and balance against hasty or capricious planning. The additional technical review and approval of development plans for specialized projects and facilities (such as the planning of munitions storage and handling facilities, ranges and training areas, and high-security and aviation facilities) are required.

9-49. Base camp development planners should consider the objective end state condition of the base camp facilities and the land area it occupies from the very start of the planning process. Initial agreements should address the cleanup, closure, and disposal or turnover of facilities to the HN that were once occupied by U.S. forces. The objective condition of formerly occupied land is defined, because in many cases, the original owners want it returned in the same condition that it was in prior to U.S. occupancy.

Note. The JCMS is the official tool for base camp development planning and design.

FACILITY PLANNING AND DESIGN

9-50. Adequate bed-down, base camp, and support area facilities are as vital across the competition continuum as they are critical to sustainment. Engineers at the strategic, operational, and tactical levels construct, maintain, and repair facilities for receiving, storing, and distributing all classes of supply and supporting all other logistics functions. Engineers are involved in the procurement, construction, maintenance, and repair of logistics facilities and associated environmental considerations for general supply and the more specialized purpose of storing munitions.

9-51. Engineers tasked to support logistics installations have four major missions: provide new facilities, maintain existing facilities, recover and repair facilities damaged by hostile actions, and upgrade existing facilities to meet minimum standards or usage requirements. In some CCDR area of responsibility, peacetime construction and HN agreements have provided extensive facilities. In less-developed theaters, there may be no preexisting logistics facilities. In such theaters, adapting and converting commercial property to military use or constructing new facilities may be required to provide logistic support facilities.

9-52. Due to the magnitude of new construction and maintenance and repair of existing infrastructure generally associated with support facilities, it is recommended that planners and designers research the applicable Army regulations, Department of the Army pamphlets, doctrine manuals, UFC, standard design guides, technical manuals, and other applicable guidance. This includes—

- AR 415-16.
- TM 5-301-2.
- TM 5-301-4.
- TM 5-304.
- UFC 4 series.

PLANNING FACTORS

9-53. The ASCC engineer staff and subordinate commands rely heavily on FFE, in the form of forward deployment and reachback, to accomplish base camp design, construction, and management functions. The facilities engineering team is ideally suited to serve as a directorate of public works for a base camp in a contingency operation (see FM 3-34 for a discussion on the teams and resources available).

Note. Planning factors can be found in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N).

BASE CAMP PLANNING AND DESIGN

9-54. There is no single correct design to a base camp. There are many possible designs and variations that are efficient and functional. Specific variables include whether the constructing unit will be—

- Occupying existing facilities or building from the ground up.
- Using local labor and materials or bringing them in from other nations.
- Using a standards book or specific commander's guidance.

9-55. The design also considers the operational aspects of the base camp and includes base camp land use categories that will support the purpose of the base camp. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for information on base camp land use categories.

9-56. To determine the requirements for land, facilities, and infrastructure, base camp development planners assess the mission, population, purpose, lifespan, construction standards, and commander's guidance.

Population

9-57. The base camp population includes tenant and transient units and organizations, which can include U.S., multinational, and HN personnel, units, and organizations (CAAF and non-CAAF). Transient units and organizations are those that come to the base camp for specified services and support, which may not necessarily require overnight stays. Determining the number of transients that a base camp will serve is a critical factor in accurately identifying requirements for base camp facilities, infrastructure, services, and support. Sources of population data for a base camp include—

- Table of organization and equipment documents.
- Table of distribution and allowance documents.
- Nonappropriated fund documents and other U.S. government documents that provide data on segments of the population, such as contractor personnel and local national employees.
- The time-phased force and deployment list.
- The civilian tracking system, which provides information regarding U.S. civilians present or scheduled to be present in theater.

- U.S. government contracting documents that authorize U.S. and foreign contractors and HN employees. Add a personnel count to the personnel count of the assigned military units to determine the total planned population of a proposed base camp.
- The purpose or reason for using the facility to support the mission.
- The projected service life for the use of the facility.
- Construction standards as found in UFC and local building codes.
- Commander's guidance as outlined in the OPLAN or OPORD.

Fire Protection

9-58. Plan fire protection into the design of all base camps. Tent separations, wiring standards, and Soldier or Marine education are all critical components in reducing or preventing base campfires and mitigating their effects on Soldiers, Marines, and equipment. On a historical note, more than 50 tents in Kuwait were lost due to fires during Operation Enduring Freedom/Operation Iraq Freedom. Most fires were due to improper electrical wiring connections and involved contractor-supplied tents that lacked the same flame-retardant material that military-issued tents have. A lack of proper spacing, cleanliness, unit discipline, fire protection equipment, and training contribute to fire hazard.

Note. It is possible to retrofit tents that are not flame-retardant.

Utilities

9-59. Design utility systems based on current applicable UFC, technical manuals, and guidance. Use engineering calculations to determine the size system employed. Where economically supportable and practicable, electric grids should be connected to commercial power. Smaller or remote bases should construct central power plants or micro-grids that are capable of supporting 125 percent of the camp maximum demand load or use distributed generators of sufficient capacity to support maximum demand loads. When stand-alone, distributed generators are the main power source, size them so that no generator set is loaded at less than 50 percent output capacity.

9-60. Base camp utilities should be tied into local municipalities if it is economically reliable, feasible and if they meet clean energy, health, and other protection standards. There should be a minimum of two wells per camp—one primary and one backup (located within the camp boundaries). The last choice is to use the tactical water purification systems, potable-water trucks, or bottled water.

Land Use Plan

9-61. A land use plan depicts general locations for areas in relation to any existing development patterns and any existing major constraints identified by earlier data analysis. A land use plan should lay out the basic scheme for main vehicular and rail networks, and it should designate the most advantageous locations and alignments for the mains, sub-stations, and plants associated with the utility systems. Land use relationships should achieve the most efficient arrangement of functions, should resolve existing problems, and should provide logical and desirable locations for all mission and functional requirements. Use the distances shown in Table 9-2, page 9-12, as minimum spacing for specific types of facilities. Drainage planning is done up front based on rainfall expectations over the duration of occupancy.

Planning and Design of Other Bed-Down Facilities

9-62. Support area facilities in a contingency operation can vary widely. The simplest facility may be a hardstand surface with rudimentary surface drainage and a supporting road system. More complex installations may look like urban industrial parks and include warehouses; maintenance and repair facilities; water, sewage, and electrical utilities; refrigeration or other climate control capability; and supporting roads, railroads, ports, airfields, protective fencing, fire services, personnel, and support and administration facilities. Logistics installations include general, ammunition, and maintenance depots; storage sites (to include fuel storage); and hospitals.

9-63. It is necessary to determine requirements for time-phased facility construction, war damage repair, construction material, and other engineering needs for supporting deployed forces. In developing and evaluating alternatives, planning should result in—

- The determination of critical requirements, duration of construction projects, and acquisition of information for scheduling and requisitioning.
- A logical task sequence based on the priorities necessary to accomplish the mission.
- An accurate estimate of required materials and labor that takes into account HN guidelines and resources.
- The determination of command and support relationships, providing for engineering coordination throughout the theater or area of operations.
- The identification method for controlling the situation as it develops or changes.
- The identification of environmental considerations that may impact planning decisions.
- Compliance with meeting the commander's guidance if possible.

Table 9-2. Minimum distances between facilities (in feet)

Facility	***Solid Waste***	***Ammunition***	***Helipad***	***Maintenance***	***Parking Lot***	***Roads***	***Billets***	***60 kilowatt Generator***	***Bulk Fuel***	***Potable Water***	***Wastewater***	***Shower***	***Laundry***	***Food Service***	***Latrine***
Latrine	300	300	500	200	200	15	200	50	300	100	200	0	50	300	
Food service	300	300	500	300	300	15	200	50	300	50	200	300	300		
Laundry	300	300	500	200	200	15	200	50	300	50	200	50			
Shower	300	300	500	200	200	15	200	50	300	50	300				
Wastewater	300	200	300	200	200	15	200	50	200	300					
Potable water	300	200	300	300	300	15	200	50	200						
Bulk fuel	300	500	300	200	200	15	200	200							
Generators	50	300	300	50	200	15	50								
Billets	300	200	500	200	200	15									
Roads	15	15	300	15	15										
Parking lot	200	200	300	50											
Maintenance	300	300	300												
Helipad	300	300													
Ammunition	300														
Solid waste															

CONVERSION OF EXISTING FACILITIES

9-64. The use and modification of existing facilities are more advantageous than pursuing new construction based on the availability of time, labor, and materials. HN agreements may require compensation for using or converting such facilities. Engineers, HN parties, and civilian contractors are encouraged to use ingenuity, imagination, and inventiveness to adapt existing facilities for military use.

9-65. A cost benefit analysis will be one of the factors used to determine if new construction is more prudent or appropriate. An infrastructure reconnaissance (assessment or survey) is recommended to document the condition of, and preexisting deficiencies in, existing structures adapted for military use. Conducting an EBS and OESHA together is highly recommended to ensure that HAZMAT, which can endanger Soldier or Marine health, is not present in the existing structures or their surrounding areas and to limit claims against the U.S. government later in the life of the facility. The EBS and OESHA are completed as soon as possible if they cannot be coordinated before the area is inhabited.

CONSTRUCTION

9-66. The CCDR, JFC, and ASCC/MCCC with Title 10 USC responsibilities identify the minimum-essential engineering and construction requirements for facilities, including the new construction and repair of war-damaged facilities. For the ASCC, the theater engineer command is normally responsible for planning, prioritizing, and tasking subordinate units for project execution. The theater engineer command can provide construction assistance and restoration support to the other Services when assets are available or as directed by the ASCC/MCCC. Support may also be provided to allied forces when they are assisting U.S. objectives. The CCDR or JFC may designate a regional wartime theater construction manager to coordinate and prioritize engineer construction activities of Services in a geographic area.

SITE SELECTION AND LAYOUT

9-67. Planners conduct a preliminary reconnaissance (initially a map reconnaissance) that is usually followed by a field reconnaissance. The field reconnaissance team may be composed of, but not limited to, representatives of the units that the facility will support, the operations staff officer (S-3) of the unit responsible for construction, a command group representative, a civil affairs personnel representative, other specialists (real estate, medical, chemical, radiological, nuclear, legal, environmental) as required, and a representative of the HN. For more climate-specific guidance, see ATP 3-90.97, ATP 3-90.98/MCTP 12-10C, and ATP 3-90.99/MCTP 12-10D.

Site Selection

9-68. Site selection and layout are shared responsibilities between the engineer and architects and the site user. The engineer, protection officer, operations officer, and logistician may each have their own ideal site location, but trade-offs are made based on a priority of criteria or restrictions.

9-69. Emphasis should be placed on the—

- Tactical situation.
- Capability to defend the site.
- Local terrain features.
- Distance from population centers.
- Availability of suitable existing facilities that may be occupied immediately or modified to desired specifications.
- Environmental restrictions that may limit the size of the required facility. (These may be caused by weather or HN policies.)
- Other environmental considerations that may affect facility locations, designs, or requirements.
- Accessibility to projected traffic.
- Distance from road networks.
- Availability of construction materials and local labor assets.

- Local weather conditions and climatic extremes that may demand refrigeration or other climate control measures.
- Potential mission expansion and surge requirements.

Layout

9-70. When locating and positioning each support area facility, the commander evaluates all information gathered in the planning and reconnaissance phases. Once the commander or designated representative has finalized a decision on where the installation is to be built, the engineer develops a construction plan that takes into consideration the location and available resources (military, HN, or contract construction personnel, materials, and equipment). The layout should be well communicated, coordinated, and organized in such a way that it can be completed in time to meet the operational priorities and minimize future controversies.

9-71. Internal operating efficiency may also be considered in the facility layout. The JCMS and AFCS illustrate typical standardized installation layouts. New construction and use of nonstandard designs must be held to a minimum. When feasible, facility requirements must be met first by the use of existing facilities (United States and HN), organic unit shelters, and portable or relocatable facility substitutes.

9-72. The standards for new construction (initial or temporary) are dictated by the CCDR or ASCC/MCCC based on the expected duration of use, availability of materials, man-hours of construction effort, and material cost. Locally available materials may dictate design and construction criteria. Plans are provided for many supply and maintenance facilities in the JCMS. Modification may be required to adapt to local conditions. Consult the contingency location master list and enduring location master list for specific guidance on building standards at known base locations.

Specific Facilities Within Base Camps

9-73. Other facilities that may be contained in base camps include housing, administration and support, ammunition and storage, medical treatment, dislocated civilian camps, and detention facilities. See U.S. Army European Command Regulation 420-100 as an example for theater basing standards.

Housing Facilities

9-74. Army Europe Regulation 420-100 and United States Central Command Regulation 415-1 are examples of CCDR guidance that provide very specific recommended minimum planning factors and construction standards for facilities within base camps. The Southeast Asia hut is a frequently used solution for bed-down and base camp facilities (see figure 9-2).

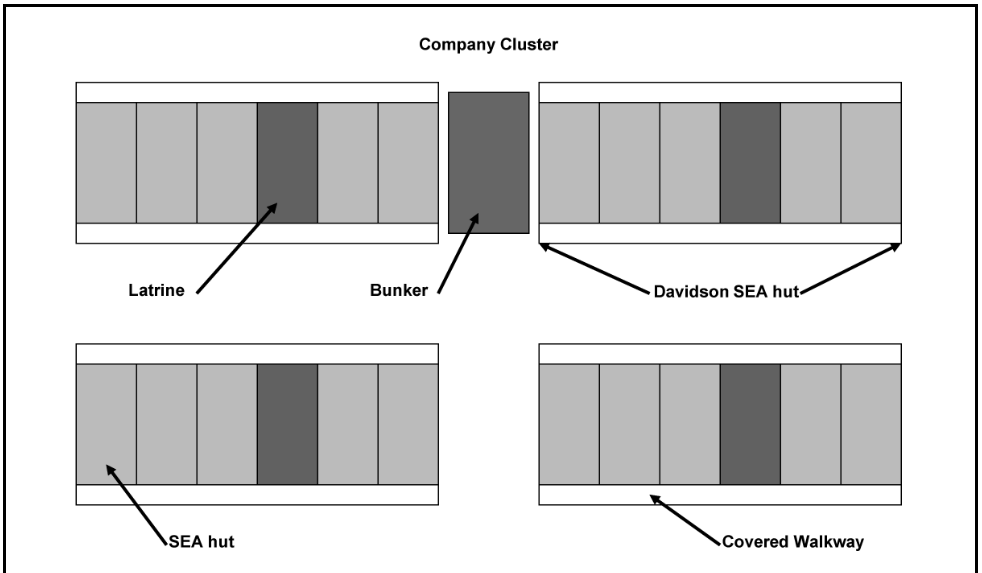
9-75. Southeast Asia huts, as shown in a cluster configuration in figure 9-2, are 512 square feet (16 feet x 32 feet). A Southeast Asia hut has eight 110- or 220-volt electrical outlets. Normally, there is an environmental control unit on each end for climate control. A Southeast Asia hut is constructed of wood with a sheet vinyl floor, 5/8-inch gypsum walls and ceiling, flat latex paint, metal roof, precast concrete pilings, painted exterior, and a nail board 6 feet above the floor (which allows Soldiers or Marines to put a nail on the wall to hang things).

9-76. A variation of the Southeast Asia hut is the Davidson Southeast Asia hut, which combines six Southeast Asia huts to save materials. When in a Davidson configuration, there are five Southeast Asia hut units, with one 12-foot by 32-foot latrine, for a total of 2,944 square feet of enclosed space. There is a 5-foot-wide walkway on each side. An administrative configuration has 3,072 square feet, but the latrines only take up 256 square feet. It has walkways all around the building. The entire footprint is 42 feet by 106 feet, including walkways.

Life Support Areas

9-77. A standard life support area has 20 tent, extendable, modular, personnel tents in various configurations. The large spacing between tents is for fire lanes and to allow cranes and other heavy equipment to move around to service air conditioners without damaging the existing tents or wires. The wide fire lanes also double as firebreaks and allow maneuver room for firefighting equipment.

9-78. Wooden buildups should not be constructed on or inside the tents, as the wind tends to drag the tent fabric across the rough wooden edges, causing the tents to be destroyed. The tent city has a 4-inch (100-millimeter) gravel pad surrounded by a ditch. The ditch is for drainage when it rains and to separate the no-drive area of the life support area from the rest of the camp. The size and depth of the ditch should be adequate to contain anticipated local rainfall and runoff and to prevent vehicular traffic from entering and exiting at nondesignated points across the ditch. Geotextile is normally not used to construct ditches.



Note. Each SEA hut is 16' x 32', same size as a general purpose medium tent.

Legend:
SEA Southeast Asia

Figure 9-2. Southeast Asia hut company cluster

Surge Housing

9-79. Base camps should maintain the ability to expand to house an additional 10 percent of the total population as transients and surges. During surge periods that exceed 10 percent, Tier 2 tents (maximum) will be used for housing. The definition of construction standards for tents includes—

- **Tier 1.** Tier 1 consists of a general-purpose, medium field tent with plywood floor panels.
- **Tier 2.** Tier 2 consists of a general-purpose, medium field tent with plywood floor panels, two electrical light fixtures, two electrical outlets, and space heaters.
- **Tier 3.** Tier 3 consists of a general-purpose, medium field tent with a full wooden tent frame, plywood panel sidewalls, raised insulated flooring, four electrical light fixtures, eight electrical outlets, and space heaters.

Toilet and Shower Facilities

9-80. Toilet and shower facilities are normally lighted, heated, and equipped with running hot and cold water. A sanitary wall board is the preferred wall covering for latrines. Sheetrock, if used, should be waterproof, with a waterproof finish for cleaning. The female-to-male facility ratio will be based on the actual percentage of the sexes on a base camp at the current time or anticipated for the near future. The shower and toilet construction goals for base camps are as follows:

- **Showers.** A shower head per population ratio of 1:20–1:10.
- **Toilets.** A toilet per population ratio of 1:20–1:10.

Note. Considerations should be given to shower water reuse systems or other water reuse systems.

Administrative and Support Facilities

9-81. See AFCS or JCMS and ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for specific details on constructing administrative and support facilities.

Ammunition Supply and Storage Facilities

9-82. A mature theater requires a network of ammunition supply and storage facilities. Well-situated and -stocked ammunition supply and storage facilities are critical to the timely distribution of required munitions. Ammunition must be stored with maximum attention to protection against natural and man-made threats, including accidents caused by careless storage and handling. Class V and Class V (aircraft ordnance) supply items are explosive and often contain sensitive components.

9-83. Properly designed, constructed, ventilated, and maintained ammunition supply and storage facilities help limit the possibility of accidents. Appropriate storage ensures maximum serviceability and shelf life of stocks and keeps maintenance requirements to a bare minimum. Planners must address concerns contained in DA Pam 385-64 or NAVSEA OP-5 Volumes 1 and 3 to ensure the effective and safe storage of ammunition.

Theater Ammunition Storage Locations

9-84. A combat service support sustainment brigade, augmented with a theater distribution element, provides the distribution of theater munitions. Ammunition may be pushed forward to combat service support battalion ordnance ammunition units, where further distribution is made to forward ammunition supply points. These are located in a secure area. Units may then draw directly from ammunition supply points. Ammunition may be brought further forward to ammunition transfer holding points, where munitions are transferred from corps haul assets to user resupply vehicles. Generally, the farther to the rear the ammunition facility is, the more elaborate the construction and the more extensive the construction support required.

Ammunition Storage Planning Considerations

9-85. Planners must consider a number of factors when they are designing ammunition supply and storage facilities. Planning considerations include—

- **Drainage.** Munitions can be damaged by excessive moisture and must be kept dry. Proper grading and, where possible, the planning and installation of drainage facilities in the area of the ammunition facility will divert rainfall, flash floods, and groundwater away from ammunition stacks.
- **Shelter.** Ammunition and explosives must be well sheltered and properly protected from the elements and the enemy. Depending on the situation and the assets available, these shelters may range from approved steel to arch earth-mounded igloos, to an outdoor modular storage system reinforced with earthwork berms. These systems are discussed in ATP 4-35.1.
- **Ventilation.** Adequate ventilation is required to protect stocks from moisture and to prevent the buildup of toxic and combustible gases.
- **Size.** The size of the facility depends on the kinds and quantities of munitions being handled and local supply demands. The facility size is determined by the logistics unit commander, based on standards set forth in DA Pam 385-64 or NAVSEA OP-5 Volumes 1 and 3 and the tactical situation.
- **Vehicle access.** Vehicles that use the ammunition facility must be able to travel to and from the appropriate pickup points. Road networks and traffic flow patterns inside the facility must support concurrent resupply and provide for the rapid evacuation of all vehicles in case of emergency. Firefighting equipment must have ready access to all parts of the facility.
- **Water supply.** Water tanks and reservoirs must be located in key centralized areas to properly support firefighting activities.
- **Facility protection.** The adequate protection of an ammunition facility may be provided through a combination of facility hardening and dispersion and active and passive security measures. Generally, the area damage control plan will stipulate what specific measures must be taken before, during, and after a damage incident and who will be responsible for each measure.

- **Environmental considerations.** With its associated force health protection, environmental considerations are an aspect of protection that must be properly planned and evaluated.
- **Adjacent property use.** Present and potential future uses are important. Deeds of restriction may be required for adjacent properties near the ammunition storage areas to reduce premature detonation caused by outside hazards.

Ammunition Storage Site Selection

9-86. The logistics unit commander determines the best location for ammunition supply points that best supports the scheme of maneuver and meets the commander's intent. The ammunition supply points should be located within a reasonable support distance of maneuver elements, and it is desirable to place the ammunition supply points near an established MSR (road or rail) to facilitate transportation network access, stocking, and distribution. Considerations should be given to the characteristics of stored material relative to major facilities such as airfields; petroleum, oils, and lubricant storage facilities; or ports. Taking this precaution will reduce the overall extent of massive collateral destruction if the enemy targets other facilities. Having input from ammunition personnel on the net explosive weight of planned ammunition stored at each site is crucial to ensuring the safety of all personnel in the surrounding areas. See Department of Defense Safety Regulation 6055.9 and Ordnance Pamphlet 5, Volumes I and II, for additional information on munition storage.

9-87. Ideally, choosing a location with level terrain, existing natural barriers, and good drainage is preferable. This will serve to minimize earthwork cut and fill requirements. If possible, existing facilities or structures suitable for conversion to storage areas should be used first before pursuing new construction.

9-88. The engineer advises the logistics unit commander on such matters as the location of construction materials, topography, drainage, and the condition of local road and bridge networks. Consideration must also be given to security measures and the ease of defense. Where possible, sites should provide a decent defilade to provide concealment from direct enemy observation.

9-89. The specific layout of an ammunition supply or storage facility depends on the tactical situation, terrain, and type and amount of ammunition being handled. Engineers supporting the construction of ammunition supply and storage facilities advise the appropriate commander on construction and maintenance matters. If required by the urgency of the tactical situation, the facility may be required to receive and issue ammunition before construction is complete.

9-90. Engineers may have to alter construction plans and techniques to allow for the safe and efficient handling of ammunition while construction proceeds. Ammunition storage facilities are ideally arranged in dispersed storage areas. The separation of facilities provides greater protective dispersion; expedites the handling, receipt, and issue of materials; and facilitates inventory management and segregation.

9-91. The road network is designed so that each area can be entered and exited independently. This prevents crossing traffic in all areas. Firebreaks wide enough (50 feet minimum) to prevent fires from spreading should be constructed and maintained. Soil that contains enough organic matter to allow it to easily burn must be excavated to the mineral subsoil. However, since firebreaks around ammunition stacks are easily detected by aerial reconnaissance, their use may have to be restricted or camouflaged.

9-92. Existing buildings may be used for ammunition storage as long as the rated floor has sufficient load-bearing capacity. Chemical, incendiary, and white phosphorus rounds should not be stored on wooden floors since they are a fire hazard. Ammunition and explosives may be stored outdoors according to DA Pam 385-64 or NAVSEA OP-5 Volumes 1 and 3, which detail site and layout requirements for the outdoor storage of ammunition. Ammunition and explosives may be stored temporarily on vehicles for adequate dispersion and rapid deployment.

9-93. The effects imposed by local weather and climate conditions must be taken into consideration in the design and construction of ammunition storage facilities. Drainage is an important consideration in certain climates and areas, including desert environments. Key planning considerations include the following:

- **Desert.** The need for dispersion is extremely important since natural concealment is generally quite sparse. Shadows and regular-shaped patterns are conspicuous and can be avoided by the use of small, irregular stacks and the elimination of regular lines and rows. In this environment, engineers are seldom required to develop extensive road networks.
- **Cold climates.** Care must be taken to provide adequate dunnage for ammunition storage. Defilades must be avoided because they may be susceptible to natural flooding after a thaw. Engineer assets may be required to clear and maintain the road network in snow and icy conditions (see TM 3-34.48-1).
- **Wet climates.** Particularly in the tropics, the maximum effort must be made to combat the effects of moisture. Adequate shelter, dunnage, and ventilation must be provided.
- **Very hot and very cold areas.** Static electricity is an important consideration.

Ammunition Storage Construction

9-94. Engineer units have the following construction responsibilities when supporting ammunition supply and storage:

- Reconnaissance, improvement, and construction of roads and bridges, which provide access to, and egress from, the ammunition facility. Engineers will also construct internal road networks within the facility.
- Location of local water sources for firefighting, construction of required reservoirs, and a water distribution system.
- Construction of standard ammunition storage magazines for indoor storage and berms and pads for outdoor storage. Engineers may be tasked to supply appropriate dunnage for ammunition stacks according to DA Pam 385-64 or NAVSEA OP-5 Volumes 1 and 3.
- Construction of housing and support facilities for ammunition facility personnel and security forces. This includes associated power and sanitation requirements.
- Construction and maintenance of perimeter security fences or other required security, infrastructure protection, and protection measures.
- Construction of firebreaks in and around the facility.
- Staff proponency for the integration of environmental considerations and the linkage to the surgeon on matters of the included force health protection issues.
- Adequate lightening protection system plans and installation.

Medical Treatment Facilities

9-95. Regardless of the size, intensity, or duration of a conflict, medical treatment facilities are needed within base camps. With the fielding of deployable medical systems equipment to the intermediate staging base and area of operations, construction requirements are greatly reduced. However, the requirements for site preparation remain high. The following are some of the planning considerations for establishing medical facilities:

- Site preparation.
- Trash and garbage pits.
- Soakage pits or a liquid disposal system.
- Incinerators (in addition to solid-waste requirements).
- Facilities such as showers, latrines, laundry services, food preparation, and dining.
- Water distribution.
- Hazardous-waste accumulation, storage, and disposal.
- Regulated medical-waste accumulation, storage, and disposal to include testing and disposal of ashes if incinerating waste.
- Motor vehicle parking.

- Landing zones.
- Perimeter security.
- Fuel storage.
- Power system support.

9-96. The longer the anticipated duration of the conflict, the greater the need to support medical treatment through fixed facilities. While medical facilities always entail a considerable amount of environmental considerations in temporary and fixed facilities, the importance of these considerations will increase over time and they should be applied as early as possible. These facilities are designed and built with the capacity and means to adequately treat injuries, shelter-in-place in case of HAZMAT release, and other health problems sustained during the contingency.

9-97. Medical treatment facilities must facilitate rapid, high-quality treatment within the theater to expedite Service member return to duty. In addition, U.S. forces are responsible for the well-being of enemy prisoners of war, DOD employees, contractors, and other nonmilitary personnel who accompany combat forces, such as the mass media and nongovernmental organizations. The emergency treatment of allied Service members or the civilian population may also be required.

Health Service Support System

9-98. In the absence of a deployable medical system-equipped hospital, consider the use of an existing facility that was originally designed as a medical treatment facility or is readily adaptable to use as a medical treatment facility. Attention to the types of buildings, their potential patient capacity, and their effective use prior to the conduct of an operation may result in the selection and use of facilities that will save precious time and resources. Requirements for fixed facilities are generally restricted to the intermediate staging base, where hospital units do not move in conjunction with the redeployment of major tactical units. USACE has the capability of providing contingency real estate support teams that can assist in real estate matters and deploy in support of these requirements. The forward engineer support team–main provides the localized command for USACE teams in the operational area and provides sustained USACE engineering execution capabilities within the operational area. Its capability includes real estate acquisition and disposal. See FM 3-34 and JP 3-34 for information on the USACE role in real estate support.

9-99. The degree of permanence may range from an expeditionary field hospital to a semipermanent hospital center, to the permanent construction of an Air Force theater hospital. Site selection is the responsibility of health service support planners who, in turn, must coordinate with the logistics staff officer. The logistics staff officer allocates the site and coordinates for the required support. These facilities should be located so that patients can be brought in by ground and air ambulance and can be transferred within the intermediate staging base in preparation for intra- or inter-theater medical evacuation. Inter-theater medical evacuation will require quick access to airfields to transfer patients onto fixed wing aircraft. It is highly desirable to choose locations near ground transportation networks and air terminals.

9-100. Hospitals may also be located to support high-density troop populations. Medical treatment facility requirements are based on casualty estimates and the theater patient evacuation policy. Casualty estimates are derived from the number of personnel deployed, as well as environmental and combat intensity planning factors. Casualty estimates are prepared by the personnel staff officer/assistant chief of staff, personnel. The patient medical workload is determined by the Army Health System support planner system. The theater evacuation policy establishes the number of days that patients may be held within the theater for treatment before they return to duty, convalescence, or are evacuated to a facility outside the AOR.

9-101. Shortcomings in existing hospital facilities and new requirements must be identified so that construction or rehabilitation can begin. Except when they are located in existing structures, Army hospitals require more than three days before they become fully functional. Once established, they can be moved only with substantial difficulty and time-consuming effort. JCMS or AFCS contains bills of materials, estimates of construction labor-hours, and plans for hospital facilities and associated clinics.

Medical Treatment Facility Planning

9-102. Ideally, the best sites for medical treatment facilities have preexisting utilities, such as a potable-water supply, sewage disposal, and electrical power. When new medical treatment facility construction must be initiated, the site should be on a relative geospatial high point, with subsoil that is free draining. The site should be isolated from areas where sanitation may be difficult, away from noise, smoke, odors, and other nuisances.

9-103. The site should be located in an area that is conducive to expansion and safe for storing fuel needed for auxiliary power generation equipment. The site should also be located near waste collection facilities that can easily accommodate large volumes of contaminated material, including discarded food products and contaminated solids. The principles of phased construction will be enforced.

9-104. Lower-priority, complementary facilities near a medical treatment facility may include a helicopter landing site, waste collection facilities, motor pools, laundry areas, vehicle parking areas, supply receiving and shipping facilities, and recreation areas. Even though waste collection facilities have low priority at the initial planning phase, the importance of this facility increases in direct proportion to the intensity and duration of the conflict since vast amounts of contaminated waste may be generated.

9-105. Expedient methods for disposing of contaminated waste must be considered during the initial stages of planning. Such efforts must be designed to avoid any possibility of contaminating ground water supplies. Expedient methods of landfills and incinerators should be planned to enhance medical treatment facilities. These methods should also be planned for semifixed facilities to prevent contamination of the groundwater supply, thus potentially exposing patients, and staff to infections.

Medical Treatment Facilities Protection

9-106. Precautionary measures taken to prevent or minimize medical treatment facility damage as a result of natural disasters, accidents, and enemy activity are specified in the area damage control plan. A medical treatment facility should not be located immediately adjacent to potential tactical targets such as airfields; ammunition supply and storage facilities; petroleum, oils, and lubricant storage facilities; and major bridges. When the medical treatment facility must lie within an established defensive position, it should be located away from the outer perimeter and away from critical infrastructure. If the lack of camouflage endangers or compromises tactical operations, the camouflage of the MTF may be ordered by a NATO commander of at least brigade-level or equivalent. North Atlantic Treaty Organization STANAG 2931 provides for camouflage of the Geneva emblem and Red Crescent on medical facilities where the lack of camouflage might compromise tactical operations. Camouflage of the Red Cross means covering it up or taking it down. For an in-depth discussion of the Law of Land Warfare refer to FM 6-27/MCTP 11-10C.

Detention Facilities and Dislocated Civilian Camps

9-107. Commanders should plan for expeditious facility and camp construction. Detention facilities and dislocated civilian camps are set up and operated the same as any basic base camp (see ATP 3-37.10/MCRP 3-40D.13). The basic planning criterion for all base camps is valid for detainee facilities and dislocated civilian camps; however, there are specialized considerations that must be added to that baseline criterion.

Note. Detention facilities and dislocated civilian camp construction standards, bills of material, and estimates of construction labor-hours are contained in the JCMS and AFCS. The length of time that the facility will operate must be considered when determining the standard of construction. In addition, engineers must complete an EBS, in conjunction with an EHSA, for the site.

Detention Facilities

9-108. Detention involves the detainment of a population or group that poses some level of threat to military operations. Detention operations are conducted by military police to shelter, sustain, guard, protect, and account for populations (detainees or U.S. military prisoners) as a result of military or civil conflict or to facilitate criminal prosecution. U.S military prisoners and detainees must be housed in separate facilities.

9-109. Battlefield detention and confinement facilities are capable of providing the necessary pretrial and post-trial confinement for U.S. military prisoners, DOD Civilian employees, DOD contractor personnel, and other persons serving with (or authorized to accompany) the U.S. military during declared war and in contingency operations. A field confinement facility is established at the theater level and is responsible for longer term confinement before the evacuation of U.S. military prisoners from the theater. Field detention facilities are possible as low as the BCT level. See FM 3-39 for additional information on battlefield detention and confinement facilities and planning considerations.

9-110. Detainee facilities are classified as detainee collection points, detainee holding areas, or theater detainee facilities. All three facilities are built to directed construction standards and vary in size and capacity, depending on the number and classification of detainees. Under certain circumstances, semipermanent facility construction may be authorized. As with any construction, existing facilities that can be used directly or modified with a justifiable effort are preferable to new construction. See FM 3-63 for additional information on detainee facilities and planning considerations.

Dislocated Civilian Camps

9-111. *Dislocated civilian* is a broad term primarily used by the DOD that includes a displaced person, an evacuee, an internally displaced person, a migrant, a refugee, or a stateless person (JP 3-29). Legal and political considerations define these categories. Dislocated civilians are removed from or leave their homes or places of habitual residence for reasons such as fear of persecution or to avoid the effects of armed conflict, situations of generalized violence, violations of human rights, natural or man-made disasters, or economic privation.

9-112. The requirement to establish a dislocated civilian camp may occur across the range of military operations. Although the United Nations or other international organizations and NGOs typically build and operate dislocated civilian camps and provide basic assistance and services to the affected population, U.S. military forces may be tasked to perform this mission. Establishing dislocated civilian camps requires a combined arms approach to harness the necessary expertise in a variety of fields such as logistics, engineering, protection, CA, environmental conditions, preventive medicine, military police, and resource management. For additional information on dislocated civilian planning considerations for dislocated civilian camps see ATP 3-39.30 and ATP 3-57.10.

9-113. Resettlement is conducted by military police to shelter, sustain, guard, protect, and account for dislocated civilians as a result of military or civil conflict or natural or man-made disasters. Resettlement includes dislocated civilians, refugees, migrants, expellees, internally displaced persons, evacuees, and stateless persons.

9-114. General engineers may be required to support the construction of detention or resettlement facilities. See FM 3-63 for additional information on detention facility designs and logistics considerations.

9-115. Depending on the duration and extent of the conflict, requirements for the evacuation of internees may warrant the establishment of internee holding areas within the corps area and semipermanent detainee facilities within more secure locations. Further evacuation to semipermanent or permanent facilities outside the area of operations may also require provisions for total evacuation. The discussion of detainee facilities in this chapter is limited to the BCT, BLT, division, and theater levels. Generally, internees are evacuated for their own safety, for interrogation, for medical treatment, or to relieve troops in the capturing unit.

9-116. Once detainees are gathered at detainee facilities, they may constitute a pool of potential labor assets. They are, however, subject to special considerations and limitations. Detainees constitute a significant labor force of skilled and unskilled individuals. These individuals should be employed to the fullest extent possible in work that is needed to construct, manage, perform administrative functions for, and maintain the detainee facility. Per AR 190-8, detainees may be employed in other essential work only when other qualified civilian labor is not available.

9-117. Detainee labor, which is external to the DOD, is regulated through contracts. See AR 190-8 for a complete discussion on the employment and compensation of detainees.

9-118. Exercise caution when contemplating the use of internees for labor and contact the office of the staff judge advocate for guidance. The staff judge advocate or their representative ensures that the policy complies with domestic law and international legal obligations. See *Convention [III] relative to the Treatment of Prisoners of War, Geneva*, FM 3-63.

OPERATION AND MAINTENANCE

9-119. Base camp operation is the O&M of the base camp physical plant and the provision of base camp services and support that are needed to achieve the base camp purpose and fulfill functional requirements. The skills needed for operating and managing base camps do not reside in any single branch or functional area. A grouping of capabilities is required to produce synergic effects within the base camp. Success hinges on placing the right people, with the right skill sets, at the right time. Any shortfalls in skills or capabilities at a base camp are filled through the tenant units or reachback for augmentation or contracted support. ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for more information on base camp O&M.

BASE CAMP OPERATIONS

9-120. The base operations center is the centralized facility on a base camp that issues guidance pertaining to the O&M of the base camp. It is the base camp commander's primary means of maintaining situational awareness and managing the performance of the base camp function and the provision of services and support to ensure efficiency and effectiveness. (ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for more information on the base operations center. See ADP 5-0, ADP 6-0, and MCWP 5-1 for more information on the operations process.)

9-121. The ground component commander or Service component commanders may share responsibilities for O&M of access; reception, staging, onward movement, and integration; and initial bed-down facilities, depending on their assigned areas of responsibility. General engineer assets may be assigned specific tasks to support the O&M of specific base camps or bed-down facilities, or they may be supported on an area basis as implied tasks within their supported areas.

9-122. The CCDR and supported commands may share responsibilities for O&M of en route base camps or facilities and initial bed-down facilities, depending on where they are located with respect to the area of operations. For base camps, the primary responsibility for O&M rests with the base camp commander and assigned tenant units. Anything above and beyond their capabilities can be handled by general engineers or contactors with specialized skill sets.

9-123. Engineers can support the base camp as a directorate of public works or facility engineer. Directorates of public works on base camps are supported with assigned personnel and equipment assets to handle infrastructure O&M improvements, master planning, energy, water, waste, housing, and environmental compliance. Facility engineers can provide the base camp with O&M support services that include building maintenance; facility repair; road repair; ice, snow, and sand removal; grounds maintenance; refuse removal; recycling; utility operations; and pest control. See AD-A243-233 for more information on public works.

9-124. For bed-down facilities, the designated commander and the assigned tenant units are responsible for the general O&M of their facilities. Anything beyond their capabilities can be handled by general engineers. Engineers can be requested to handle O&M activities requiring specialized skill sets. The maintenance of bed-down facilities is performed at lower standards than that of base camps since bed-down facilities are used for a limited period of time. Because of the brief utility of bed-down facilities, engineer resources are limited, and the focus is on an economy of effort. That is, engineers would implement field-expedient and temporary measures for repairing bed-down facilities rather than investing in costly upgrades and major improvements to the quality of life.

9-125. Commanders may defer routine maintenance during initial bed-down until the tactical situation allows resources to be committed. Some engineer-specific facilities, systems, and the repair of most facilities will require the early entry of engineering and maintenance units to bring facility systems back on line. Depending on real estate agreements, and when no longer needed, some bed-down facilities may require maintenance and repair to return them to owners in an agreed-upon condition.

Base Camp Maintenance

9-126. Temporary construction in base camps is not intended for long-term use, thus increasing the need for proper maintenance and repair to keep base camps in good operating condition. The base camp commander has the overall responsibility for maintenance and repair. Capabilities that extend beyond tenant units require support by general engineers.

9-127. Units and organizations that occupy facilities are encouraged to establish internal teams that perform routine maintenance and repair of facilities. Engineers perform maintenance and repair work that exceeds the capabilities of user units. This support usually requires specialized skills or heavy equipment.

9-128. General engineers can assist the base camp commander by providing routine maintenance and services on base camp facilities. This can include facility inspections, structural assessments, construction material orders, and work schedules. Because materials and parts can be in short supply, base camp commanders, with the assistance of engineer advisors, must be vigilant in establishing a proactive maintenance program.

9-129. Base camp commanders are responsible for establishing, directing, and controlling 24-hour emergency response to base camp incidents due to acts of nature, accidents, or enemy activity (see ATP 3-37.10/MCRP 3-40D.13 [MCRP 3-17.7N]). General engineers can also provide rapid response, which includes—

- Performing immediate repair required after natural disasters (floods, tornadoes, hurricanes).
- Restoring power outages.
- Fixing water main leaks that impact key facilities.
- Responding to fuel and HAZMAT spills and leaks.
- Fighting fires and dealing with the aftermath of explosions.
- Repairing perimeter fencing, barriers, and obstacles to prevent enemy penetration.
- Repairing lighting and other security systems to restore observation and monitoring.
- Repairing facilities that are deemed mission-critical and -essential to base activities.

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Chapter 10

Real Estate and Real Property Maintenance

Real estate plays a key role in supporting the warfighter with land and facilities for mission requirements. Real estate procurement is provided by USACE. Military forces must acquire, manage, and dispose of real estate, land, and fixed facilities within the area of operations to support committed forces. Included in this support is the acquisition of real estate for use as office space, billeting, dining facilities, material storage areas, staging areas, maintenance functions, training, ports, roads, buffer or safety zones, and so forth. These facilities may be used to house the operations cell, planning, administrative, logistics, maintenance, and other services. Existing facilities are used, when possible, to reduce construction requirements. The engineer construction and other military support effort can then be invested in other immediate commitments. This chapter discusses real estate management and real property maintenance.

RESPONSIBILITIES AND CAPABILITIES

10-1. The following paragraphs discuss the responsibilities, capabilities, objectives, policies, and planning and maintenance activities and the transfer of real estate and real property.

CHIEF OF ENGINEERS

10-2. The chief of engineers is the DA staff officer responsible for real estate functions and, as such, exercises staff supervision over Army real estate activities of overseas commands (see AR 405-10). The chief of engineers is responsible for carrying out the following duties:

- Establish real estate records and reporting systems necessary to administer responsibilities.
- Provide technical advice and assistance in handling real estate acquisition, management of lease actions, and disposition.
- Issue instructions to ensure that real estate activities are conducted according to applicable directives, policies, and regulations.
- Review real estate data, including estimates, justifications, records, and reports.

UNITED STATES ARMY CORPS OF ENGINEERS

10-3. USACE has the capability of providing contingency real estate support teams that can assist in real estate matters and deploy in support of these requirements. The FEST–main provides the localized command for USACE teams in the operational area and provides sustained USACE engineering execution capabilities within the operational area. Its capability includes real estate acquisition and disposal. See FM 3-34 and JP 3-34 for information on the USACE role in real estate support.

ENGINEER REAL ESTATE TEAM

10-4. Joint engineer real estate teams or USACE contingency real estate support teams can provide real estate support to U.S. forces in the United States and during contingency operations by obtaining land and facilities and managing leases and use agreements. The Army has a contingency real estate support team with appropriate delegations from the Army Secretariat or the Chief of Engineers who is responsible to the area support command or other command, as appropriate.

10-5. The real estate teams conduct real estate management within their assigned areas according to the directives, instructions, and standard operating procedures. A contingency real estate support team is deployable and can acquire, manage, and dispose of real estate on behalf of the U.S. government. The contingency real estate support team has the capability to—

- Acquire land or facilities, manage lease and use agreements, dispose of land or facilities, and pay rents and damages for real estate used within the area of operations.
- Investigate, process, and settle real estate claims.
- Conduct utilization inspections.
- Record, document, and prepare reports on the real estate used, occupied, or held by the Army (or joint forces, as appropriate) within their assigned areas.
- Coordinate with agencies of the friendly HN to execute joint, United States, and HN real estate functions.
- Coordinate with the staff judge advocate for legal issues and claim settlements.
- Include an EBS and OESHA, when possible and appropriate, in all real estate actions.

Note. See EP 500-1-2 and FM 3-34 for more information on the organization and roles of the contingency real estate support team.

FACILITIES ENGINEER SUPPORT TEAM–ADVANCE

10-6. The facilities engineer support team–advance has the capability to deploy support elements to the CCDR or JTF commander with real estate acquisition and disposal and to receive a task-organized contingency real estate support team, when required. See FM 3-34 and JP 3-34 for more information on FEST–advance.

NAVAL FACILITIES COMMAND

10-7. NAVFAC is responsible for providing all real estate functions required by the Navy and Marine Corps. NAVFAC has experts who can deploy in support of real estate management requirements, but has no standing, deployable real estate units. NAVFAC has the capacity and capability to support real estate transactions in contingency environments with planning, acquisition, management, maintenance, and disposal of facilities.

10-8. When deployed in theater, Marines normally use the combatant command-designated agent for real estate procurement. Otherwise, Marines rely on NAVFAC for that support. NAVFAC procures real estate according to its policies and procedures. When tasked to support a contingency deployment real estate requirement, NAVFAC task-organizes in a manner best suited for the circumstances. See JP 3-34, NAVFAC P-73: Real Estate Procedural Manual, NTTP 4-04.3, and SECNAVINST 11011.47C for additional information.

AIR FORCE

10-9. The Air Force is responsible for providing the real estate functions required by the Air Force. It considers real estate as assigned to the responsibility area of Prime BEEF and RED HORSE units. These units have the capability of providing real estate acquisition, management, maintenance, and disposal.

10-10. When a component-numbered Air Force serves as the Air Force warfighting component to the CCDR, Air Force civil engineers are assigned or attached to an installation and mission support directorate to serve as engineer advisors to the commander of the Air Force forces. They serve as an interface for other Service regional wartime construction management support and conduct real estate activities for the lease or use of HN facilities and bases. See Air Force Doctrine Publication 3-34 and JP 3-34 for additional information on Air Force engineer capabilities.

COMBATANT COMMANDER

10-11. A CCDR is responsible for all real estate activities within the area of operations. This responsibility may be delegated to a designated deputy or to the Army, Navy, or Air Force Service component commander with the greatest requirements and the appropriate authority and technical real estate staff expertise. Maintaining a single inter-Service real estate facility use policy consolidates activities, reduces duplication, and limits the impact on the local economy. The theater commander may establish a central real estate office to direct and record all real estate activities or direct that the commander assigned real estate responsibility establish such an office. The CCDR develops the policies and procedures for real property and base camp transfers as part of the theater basing strategy. Associated guidance on environmental considerations will be provided in an annex of the OPLAN or OPORD. The commander of the assigned area of operations is responsible for the timely identification and mitigation of negative environmental impacts within the area of operations. See ATP 3-34.5/MCRP 3-40B.2 for more information on the environmental real estate considerations.

JOINT FORCE COMMANDER

10-12. A JFC is responsible for carrying out the following real estate support duties:

- Determine real estate requirements for the force.
- Plan, execute, and analyze real estate requirements according to the pertinent directives, policies, and regulations.
- Prepare budget estimates and justifications as directed.
- Secure funding for lease payments from the appropriate using command.
- Prepare and submit real estate reports as directed.
- Conduct utilization inspections according to the instructions and criteria furnished by the Chief of Engineers.
- Notify the Chief of Engineers of utilization problems that require action at the DA level.
- Furnish the Chief of Engineers with copies of all intercommand real estate and space utilization directives.

JOINT FORCE ENGINEERS

10-13. Joint force engineers are responsible for planning the acquisition of uncontaminated land and facilities and their management and ultimate disposal to support joint operations. Their capabilities include real estate acquisition, management, maintenance, and disposal as a sustainment function for joint engineer support. The command engineer staff, and the subordinate joint force engineer staff recommend policies and priorities for construction, real estate acquisition, and Class IV construction materials (see JP 3-34 for additional information).

10-14. The JFC may establish a joint facilities utilization board that is responsible for assisting and managing the Service component use of real estate and existing facilities. The joint facilities utilization board is a temporary board, chaired by the CCDR or subordinate joint force engineer, with members from the joint force staff, components, and other special activities. The joint facilities utilization board has the capability to evaluate and reconcile component requests for real estate, use of facilities, inter-Service support, and construction to ensure compliance with priorities established by the JFC.

ARMY SERVICE COMPONENT COMMANDER

10-15. The real property acquisition and lease management will be accomplished by qualified and delegated real estate teams or the contingency real estate support team. The theater Army commander may retain control of real estate in the combat zone and delegate responsibility for rear areas only.

ARMY SERVICE COMPONENT STAFF ENGINEER

10-16. The ASCC/MCCC staff engineer has the capability to operate and manage real estate and property acquisition, maintenance, and disposal functions. ASCC/MCCC engineer responsibilities include—

- Furnishing technical real estate guidance and advice to the commander, staff, and all echelons of command.
- Recommending real estate policies and operation procedures to the logistics officers.
- Preparing, coordinating, distributing (in coordination with the logistics officer), and exercising staff supervision over the execution of theater real estate directives.
- Acquiring land or facilities, managing leases and use agreements, disposing of land or facilities, paying rents and damages, handling claims, and preparing records and reports for the real estate used within the area of operations.
- Maintaining a real estate office in the AOR.
- Preparing long-range real estate plans and requirements.
- Ensuring compliance with international agreements and the law of land warfare.
- Coordinating with the authorities of the friendly HN.
- Ensuring the integration of appropriate environmental considerations in all real estate policies, operational policies, and operations.

10-17. The ASCC/MCCC staff engineer executes all real estate functions in the AOR when delegated such responsibility by the CCDR. When the commander of another Service component command is responsible for real estate activities, the ASCC/MCCC engineer executes only ASCC/MCCC real estate functions.

Subordinate Command Engineer

10-18. Engineers of commands below the ASCC/MCCC staff engineer are responsible for furnishing technical real estate guidance to the commanders, staffs, and subordinate echelons of the commands. They have the capability of handling assigned or delegated real estate duties.

Facility Engineer and Army Engineer Facilities Detachment

10-19. A facility engineer is normally responsible for real property maintenance, also called O&M, on an installation, facility, or base camp. The facility engineer may work for a directorate of public works, a facility engineer team, or an engineer staff section and coordinates with higher-level engineer real property maintenance staff.

10-20. An Army engineer facilities detachment, normally located in a sustainment brigade or higher headquarters, provides facilities management for troop concentrations. The detachment has the following O&M capabilities:

- Provides O&M training.
- Implements short- and long-range facility work plans.
- Coordinates service and support contracts.
- Provide technically qualified contracting officer representative for all initiated service contracts.

OBJECTIVES

10-21. The efficient conduct of real estate activities depend largely on a command-wide understanding of the objectives of the real estate program in overseas commands. These objectives are to—

- Acquire and administer real property that is essential to the mission.
- Acquire and use existing facilities to keep new construction to a minimum.
- Acquire environmentally safe real property and facilities that promote force health protection and coordinate for the performance of an OESHA when applicable.

- Protect the United States and its allies against unjust and unreasonable claims and charges for using, renting, or leasing real or personal property. Linking an EBS to the signing of a lease, when possible, is an excellent method of providing desired financial protection for the government.
- Provide reasonable compensation to individuals or private entities for the use of real property, except enemy-held property or, possibly, property that is located in a combat zone or enemy territory.

ARMY POLICIES

10-22. DA policy concerning real estate acquisitions is described in AR 405-10, DODD 4165.06, and TM 5-300. Real estate in overseas theaters are based on the following general principles:

- **Adhere to international conventions.** U.S. forces will adhere to the provisions of Convention (IV) respecting the Laws and Customs of War on Land and its annex: Regulations concerning the Laws and Customs of War on Land, Hague; Convention (IV) relative to the Protection of Civilian Persons in Time of War, Geneva; The Convention Respecting the Laws and Customs of War on Land (Hague IV) and its annex; Geneva Convention Relative to the Protection of Civilian Persons in Time of War (Fourth Geneva Convention); The Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict and its supplements; and FM 6-27.
- **Conform to international agreements.** The Army real estate program will conform to international agreements and all other agreements affecting the United States, such as treaties, memoranda of understandings and land leases and reciprocal aid, military assistance, status-of-forces, and civil affairs agreements.
- **Make appropriate compensation.** When required, fair and reasonable rent will be paid for real estate used, occupied, or held by the Army. Payment for the occupation of land will not be made to any person or persons who are members of the enemy government or who are hostile to interests of the United States. Compensation will not be made for any real property located in the combat zone that is lost, damaged, or destroyed as a result of military action.
- **Honor HN laws.** U.S. forces will honor the real estate laws of the host country to the fullest extent possible, consistent with military requirements.
- **Use existing facilities.** U.S. forces will use existing facilities as much as possible to reduce the need for new construction and to conserve resources, time, and personnel.
- **Facilitate antiterrorism and other protection requirements.** U.S. forces will recognize, understand, and adhere to theater command antiterrorism and other protection requirements for facilities with regard to security and protection.
- **Minimize acquisition.** Real estate acquisition will be held to an absolute minimum, consistent with military requirements, to minimize the disruption of the local economy. Joint utilization should be encouraged, and the duplication of function and services should be avoided.
- **Follow appropriate acquisition policies.** The full use of HN governmental agencies will be made when possible if not restricted by treaties. The acquisition of real estate in a deployed location will be by requisition, by lease, or through consignment by the HN to the United States where the property is in the territory of an ally or by requisition, confiscation, or seizure when the property is owned by the enemy.

NAVY POLICIES

10-23. Navy policy for the acquisition, management, and disposal of real property and real property interests is provided in SECNAVINST 11011.47C.

PLANNING

10-24. These are key terms related to real estate and real property maintenance:

- Real estate is interests in real property as referred to as rights or estates, hence real estate is similar to real property (AR 405-45).

- A facility is a real property entity consisting of one or more of the following: a building, a structure, a utility system, pavement, and underlying land (JP 3-34).
- A joint facilities utilization board is a joint board that evaluates and reconciles component requests for real estate, use of existing facilities, inter-Service support, and construction to ensure compliance with Joint Civil-Military Engineering Board priorities (JP 3-34).
- Maintenance is the routine recurring work required to keep a facility in such condition that it may be continuously used at its original or designed capacity and efficiency for its intended purpose (JP 4-0).
- O&M is the maintenance and repair of real property, operation of utilities, and provision of other services such as refuse collection and disposal, entomology, snow removal, and ice alleviation (JP 3-34).
- Real property is lands, buildings, structures, utilities systems, improvements, and appurtenances, thereto that includes equipment attached to and made part of buildings and structures, but not movable equipment (JP 3-34). AR 405-45 provides additional clarity by stating, "It includes equipment affixed and built into the facility as an integral part of the facility (such as heating system), but not movable equipment (such as plant equipment). In many instances, this term is synonymous with 'real estate'".
- Solid waste is garbage, refuse, sludge, or other waste material (except those deemed hazardous and excluded by Federal regulation) in the form of solid, liquid, semisolid, or contained gaseous material that has been discarded or is being accumulated, stored, or treated prior to being discarded as a result of institutional, industrial, commercial, mining, agricultural, or community activities. Hazardous waste, recycling and infectious waste materials are not included in this category. See Section 261.2, Title 40, Code of Federal Regulations for additional information.

Real Estate Management

10-25. According to JP 3-34, real estate management involves planning, acquisition, management, and disposal of land and facilities to support military operations. General engineering encompasses real estate management from acquisition of real property to final turnover of land and facilities upon completion of an operation. USACE (contingency real estate support team), AFCEC, and NAVFAC have experts who can deploy in support of these requirements. See JP 3-34 and TM 5-300 for information on real estate team deployments.

10-26. The acquisition of privately owned property overseas, whether improved or unimproved, will almost always be accomplished through leasing. The use of HN land and facilities should be via written agreement. Acquiring real estate in other counties can be complex since many landowners do not have actual titles to the land, such as in Afghanistan. This can delay acquisition and cause multiple claims against the U.S. government.

10-27. Trained and qualified personnel are essential for the proper handling of real estate management responsibilities. Real estate activities must be well managed to avoid facing major consequences or damage in relations between U.S. forces and the HN. Military legal officers, USACE or NAVFAC counsel, and civilian lawyers familiar with the laws of countries within the theater must be included to assist the planning group with sound advice and comprehensive technical reviews of proposed real estate policies and procedures impacting the United States and its allies.

10-28. During COA development, the engineer staff assists in determining real property and real estate requirements. Real estate involves planning, acquisition, management, and disposal of land and facilities to support military operations. See FM 3-34 and JP 3-34 for more information on real estate requirements and real estate management.

10-29. Real estate plans and policies are based on directives or instructions issued to the CCDR by the Joint Chiefs of Staff or by the Service commander appointed as executive agent for the Joint Chiefs of Staff.

PLANNING GROUP

10-30. A planning group, which includes the combatant command staff and representatives of all Service commanders, must initiate real estate planning during the preparatory phases of a campaign. The agency that will execute real estate acquisition and planning when the campaign begins is organized at this time and should participate in all planning activities. Real estate support enables force projection and enables logistics support for theater opening. In addition to plans for real estate requirements during hostilities, consideration should be given to real estate requirements for the occupation period after hostilities cease. This may be most critical for those requirements that will be met by new construction, such as base camps.

10-31. The site selection process is a joint effort that is conducted by several members. If available, a USACE contingency real estate support team member should be included as an integral part of the site selection team, helping to ensure site acquisition through a HN use agreement or lease of private property. The site selection team should also include engineer, medical, or other required subject matter experts to conduct an EBS and OESHA and integrate appropriate environmental considerations when possible. See ATP 4-45 for more information on on-site selection team and site selection considerations.

EXISTING FACILITIES

10-32. Facilities are grouped into six broad categories that emphasize the use of existing assets over new construction, as discussed in JP 3-34. Consolidate and use existing facilities as much as possible to reduce the need for new construction. To the maximum extent possible, facilities or real estate requirements should be met from the following categories, in the priority listed:

- U.S.-owned, -occupied, or -leased facilities (including captured facilities).
- U.S.-owned facility substitutes pre-positioned in theater.
- HN and multinational support facilities where an agreement exists for the HN or partner nation to provide specific types and quantities of facilities at specific times in designated locations.
- Facilities available from commercial sources.
- U.S.-owned facility substitutes stored in the United States.
- Newly constructed facilities identified during an assessment of available existing assets.
- Existing facilities should be used when they are available. The use of existing facilities—
- Allows swift occupation by military activities.
- Uses existing utilities; existing telephone service; and connecting air, ground, and sea LOC facilities.
- Uses available, on-site administrative and industrial equipment.
- Permits less diversion of troops from combat missions.
- Uses a smaller outlay of government funds and resources.
- Provides some inherent camouflaging of military activity.

Note. The location may be near major government, industrial, transportation, or resource centers.

10-33. The advantages of using existing facilities normally outweigh the disadvantages. However, there may be some disadvantages that make the facilities strongly undesirable for military use. Planners should consider alternatives when existing facilities cannot be adapted to the desired mission requirements, such as when—

- Facilities cannot be adapted to desired survivability and force protection standards.
- Dispersion is difficult or impossible.
- Facilities are inflexible and cannot be tailored to meet military needs.
- Environmental considerations and associated force health protection issues make the site undesirable or questionable for occupation.

Real Estate Acquisition

10-34. During conventional combat in the active combat zone, real estate required by U.S. forces is acquired by seizure or requisition, without formal documentation. Seizure is resorted to only when it is justified in the accomplishment of mission requirements, is driven by urgent military necessity, and is done with the expressed approval of the commander who has area of operations responsibility. HN property may be occupied without real estate documentation to the extent that tactical situation dictates. After the cessation of hostilities, private property may be leased if there are valid mission requirements for its continued use, if the property is required at least 30 days or longer, and if the property owner is known.

10-35. Normally, real estate property is obtained through requisition, which is a demand placed on the owner of the property or the owner's representative. No rent or other compensation is paid for requisitioned or seized property in the combat zone. This includes its use, or its damage resulting from acts of war or caused by ordinary military wear and tear.

10-36. Outside the active combat zone, property is normally acquired only by requisition and lease and all transactions are documented thoroughly under the applicable provisions of theater directives. Large tracts of real estate are required for ports, staging areas, training, and maneuver areas, leave centers, supply depots, base camps, and headquarters installations. Some of this property may be highly developed and have considerable value to the civilian population. Established procedures must be followed to acquire required property, while also ensuring that the legal rights of its owners are protected. Occupying units are responsible for providing funds for lease payments (see AR 405-10).

10-37. Use local government officials to help identify available facilities or properties that meet approximate military requirements. The military would obtain permission to modify or upgrade the facility to meet the requirements. Another resource is for the engineer to seek assistance from military intelligence in identifying facilities, such as airfields or seaports, for adequate use (a good historical example is the Bagram Airfield in Afghanistan). This teamwork approach capitalizes on the use of existing intelligence to aid in the proper selection of facilities. Civil affairs personnel and Army engineer real estate or contingency real estate support teams may work through local government officials or directly contact property owners to achieve agreements. When possible, local government officials normally evict and resettle civilians from property requisitioned by the military forces. U.S. military forces evict tenants or occupants only in the most urgent circumstances or upon refusal or inability of local authorities to act.

10-38. Normally, a local government representative assists in preparing property inventories for local government-owned property. It is particularly important that requisitions carry the correct real estate property descriptions and that local government officials check requisitions against corresponding entries in permanent records. An EBS is also desirable to protect the U.S. government from future claims.

10-39. If local records have been lost or destroyed, local authorities must establish a correct legal identification for the requisitioned property. The signature of the local official charged with real estate responsibility must be obtained on the initial and release inventories. This official signature is required by international agreement to ensure that the U.S. government is protected from unjust claims and liability for loss of, or damage to, property used by U.S. forces.

10-40. When possible, integrate an EBS and OESHA into the process of obtaining real property and real estate. This is to ensure that EBSs and OESHAs meet acceptable levels of appropriate inquiry into the previous ownership and that the uses of the property are consistent with good commercial or customary practice. The goal of this process is to identify environmental conditions that may present a material risk of harm to public health or the environment.

Facility Modification

10-41. The situation may require the modification of existing facilities to better serve military needs. This could result from changing existing mission requirements, accommodating special unit needs, correcting deficiencies, or conducting upgrades and improvements. Correcting deficiencies should be the primary focus of engineers, as it preventive measures are an all arms task. Theater planning should identify deficiencies and required corrective actions. Theater requirements for antiterrorism and other protection tasks must be considered in the initial planning stages. AOR real estate principles for property acquisition apply as discussed above. These changes could require additional compensation to property owners and should be factored into the initial planning and budget. Draw on the expertise, ingenuity, and innovation of engineers, HN experts, and civilian contractors to resolve these issues. In addition, use tools such as JCMS or the automated distribution illumination system, electrical program to modify existing facilities for military use and to upgrade to applicable UFC.

NEW FACILITY CONSTRUCTION

10-42. New construction in the area of operations is strictly limited to mission-essential facilities that are vital to the accomplishment of the overall mission when existing facilities do not meet the criteria required by commanders. It is likely that base camps will require new construction due to land location and protection requirements.

REAL PROPERTY MAINTENANCE

10-43. Real property maintenance are those actions taken to ensure that real property is maintained in a timely manner. Real property maintenance includes the operation, maintenance, and repair of facilities and utilities.

10-44. Real property maintenance does not include the maintenance and repair of mobile and portable equipment or other items not classified as real property. Some of the coordination aspects of real property maintenance, however, do include many tasks not normally associated with minor construction and routine maintenance and repair.

10-45. Maintenance is the routine prevention and correction of damage and deterioration caused by normal use and exposure to the elements. Repair restores damage caused by abnormal use, accidents, hostile forces, and severe weather actions. Repair includes the resurfacing of a road or airfield when maintenance can no longer accomplish its purpose. Rehabilitation restores facilities that have not been in the hands of friendly forces and do not meet operational requirements. Rehabilitation resembles war damage repair, except that it is accomplished before occupancy.

10-46. Routine maintenance and repair include performing inspections, stockpiling materials for maintenance and repair work, maintaining and repairing road surfaces and drainage systems, controlling dust and mud, and removing snow and ice. The main purpose of maintenance and repair work is to keep road surfaces in a usable and safe condition. It also maintains route capacity and reduces vehicle maintenance requirements.

RESPONSIBILITIES

10-47. Per AR 405-10, the Chief of Engineers is the DA staff officer responsible for real estate functions exercising staff supervision over Army real estate activities in overseas commands. Real property maintenance is administered by the theater Army area command through its subordinate area support groups (see TM 5-300).

10-48. The Installation Management Command supports the Army warfighting mission by working to provide standardized, effective, and efficient services, facilities, and infrastructure to Soldiers, civilians, and families. Support for real property maintenance is provided on an area basis to all installations, organic activities, and tenant units. The theater engineer command at the theater Army level provides overall supervision and technical assistance. The administration of real property maintenance forward of the corps rear boundary is a corps responsibility. Command and support relationships in the theater Army are described in FM 3-34.

PLANNING

10-49. The theater engineer command (or senior engineer brigade) and the responsible engineer staff must consider current and anticipated real property maintenance requirements for the area of operations. These include—

- Maintaining and repairing the LOC.

- Estimating potential requirements for repairing war damage.
- Coordinating phase planning and target date requirements.
- Reviewing after action reviews and lessons learned from recent military operations.
- Considering contract support (such as the logistics civil augmentation program [Army]), preplacement of contract vehicles, and mechanisms for the management of such contracts in theater (such as engineer advisory board or Contracting Support Brigade).
- Considering other U.S. agencies (such as the Department of State and the United States Agency for International Development) that may be in the AOR concurrently, considering how the competencies of each might be leveraged, and establishing working relations across the agencies in peacetime.
- Determining the limitations (such as political) on using a cost-effective local work force and local contractors.
- Ensuring that a management system is in place that identifies facilities to support U.S. facility needs.
- Identifying procedures for the accountability, security, maintenance, and training of appropriate local national facilities personnel if they are to be transferred to local authorities after the ceasing of hostilities.
- Integrating appropriate environmental considerations and related force health protection concerns.

10-50. Any alteration or renovation work that is planned for existing structures should be designed according to AFCS guidance and should essentially be nonpermanent in nature. Plans for major repairs, renovations, or alterations on existing structures must include estimates for labor and materials. Planners may also use estimating sources, such as the engineer performance standards or a commercial estimating guide (means estimating guide).

10-51. There may be situations in the theater where the estimated materials or labor resources are insufficient or unavailable. Local materials, labor, and services should be used to accomplish real property maintenance when possible. With the approval of the theater Army engineer and support of the theater engineer command or assigned engineer brigade, the local responsible engineer may change the design or scope of planned project work to capitalize on locally available personnel, resources, and services.

Operation of Utilities

10-52. O&M or upgrade of existing utilities and the construction, operation, and maintenance of new utilities systems may be an engineer responsibility. Utility systems include electric power, wastewater collection and treatment, and other systems (cooling and refrigeration, compressed air, heating). Operating these systems requires specially certified, licensed, or trained personnel. These personnel may be available through the theater engineer command or assigned engineer brigade, trained locally, or hired from the local work force.

10-53. Utility systems must be reliable, properly operated, and protected. Appropriate measures should be implemented to ensure their correct operation and servicing. Measures should be implemented to provide increased or upgraded physical security if the situation warrants. Such measures include controlled access, continuous inspection, and adequate security personnel. See ATP 3-39.32 for more details on facility physical security.

Wastewater Collection and Treatment Systems

10-54. Large troop concentrations at fixed facilities generate increased requirements for handling sewage and wastewater collection and treatment. When existing fixed facilities are occupied, they usually include wastewater systems. However, these systems may not be fully operational or suitable for use by military forces. These systems should be properly inspected, operated, maintained, repaired, or upgraded by engineer elements or qualified indigenous personnel.

10-55. The construction, operation, maintenance, and repair of adequate sewage disposal systems are described in AR 420-1.

10-56. Field sanitation measures (such as pit latrines and grease sumps), portable chemical toilets, and waste treatment plants may be used temporarily until fixed facilities are completed and in operation. Force health protection is facilitated through good unit standard operating procedures, leadership enforcement, and field discipline in conjunction with the conduct of an OESHA and medical monitoring procedures (see ATP 4-25.12 and TC 4-02.3).

10-57. As with all AFCS designs in the area of operations, the standard of construction for wastewater systems will nearly always be nonpermanent and designed to require minimum maintenance during the limited time anticipated for the period of occupation. Locally available materials may be used if approved by the ASCC/MCCC engineer. Engineers will perform real property maintenance and operate the system as directed by the ASCC/MCCC engineer. Guidance on environmental considerations will be provided in an annex of the OPORD. See the AFCS for standard designs of wastewater systems.

Shower and Laundry Systems

10-58. The Army Quartermaster sustainment brigades can provide a system of mobile shower and laundry systems. The laundry system includes a giant mobile washer and dryer facility that stands on a flatbed tractor-trailer. The shower system includes a multipoint shower facility, which features separate stalls that are erected under a large tent. See ATP 4-93 for more information on shower and laundry systems. Shower and laundry support is an engineer function in the Marine Corps. See ATP 4-44/MCRP 3-40D.14 for additional information on Marine Corps units and equipment.

Other Utility Systems

10-59. In some areas, other types of central utility systems may have to be operated by theater forces. These systems include heating, cooling, or refrigeration. Utility equipment in existing facilities must be repaired and/or maintained if it is to be operated. The responsibility for supervising this work will be directed by the ASCC/MCCC engineer.

10-60. Local, portable, or unit systems (such as stoves and portable refrigeration units) will be ordered, maintained, repaired, and operated by the using unit. Engineers usually inspect and maintain central utility systems, such as steam plants, cold storage warehouses, or cooling plants. Where existing facilities are used, the theater engineer command may ensure the maintenance of these systems.

Maintenance and Repair of Facilities

10-61. The maintenance and repair of facilities are the responsibility of the local commander who is supported by engineer assets. Existing facilities that need maintenance and repair before they can be used are repaired to minimum standards. Early in planning, engineers should ensure that repair materials are properly estimated and prestocked to assure their availability when needed.

10-62. Much short-term maintenance and repair work can be performed by local troops who are organized into self-help teams. These teams coordinate with local logistics sources or supporting engineers to obtain the required expertise, materials, and tools. The early identification of spare parts requirements and the establishment of supply sources in the early stages of planning are critical. Adequately trained and supported self-help teams can perform most maintenance and repair work on facilities, releasing engineer troops to accomplish more critical duties, complex repair work, and major construction projects.

10-63. When major repairs are required, the engineer unit assigned to the area support group, augmented when necessary, with supporting assets from the theater engineer command or assigned engineer brigade, makes repairs as prioritized by the theater Army engineer. Generally, these priorities are developed and scheduled based on the impact that the work has on the mission.

10-64. After immediate and ongoing maintenance and repair requirements are determined, the commander's senior engineer will establish a repair and maintenance program for the installation, base, or facility using self-help, supporting engineer assets, and/or local personnel or contracted support to accomplish the work. If the program is extensive or long-term, the unit commander should coordinate with the ASCC/MCCC engineer to initiate a continuing facility engineer operation at the facility or installation.

The facility engineer will then coordinate requirements and resources needed to accomplish the mission. Further guidance on facilities maintenance and repair may be found in AR 420-1 and TM 5-610.

SOLID-WASTE MANAGEMENT

10-65. Solid-waste management includes collection, recycling, and disposal. Improperly handled solid waste can be a safety and health hazard. The local commander is usually made responsible for solid-waste collection and disposal, and engineers accomplish the task. Guidance on solid-waste collection and disposal is found in AR 420-1 and NAVFAC MO-213/AFR 91-8/TM 5-634.

10-66. Placing in a landfill, burning, and removing are normal means for solid-waste disposal in an area of operations. Because of potential surface and groundwater contamination, the explosive hazard associated with uncontrolled methane gas production, increased vermin activity, and the obvious problems with solid-waste odors, it is imperative that landfills be properly planned, designed, managed, and maintained. Options available to lessen the quantity and/or eliminate specific types of solid waste in sanitary landfills include—

- Using incineration equipment.
- Using recycling programs and services.
- Using appropriate compost methods.
- Using a combination of several methods.

Note. See UFC 3-240-11 for more information on landfills in support of military operations. The DODI Burn pit reference DODI 4715.19, title Use of Open-Air Burn Pits in Contingency Operations.

10-67. Compaction and selective disposal are two alternate methods for reducing the volume of solid waste:

- **Compaction.** Compaction is accomplished with specialized equipment for collecting and compacting solid waste prior to it being dumped into a landfill. At the landfill site, special mobile compaction equipment may be used to reduce the volume of solid waste before it is buried and covered. Other compaction and solid waste-handling techniques include compacting and baling solid waste for burial or removal from the area.
- **Selective disposal.** Selective disposal is the separation of certain types of solid waste, such as wood or metal, from the waste stream. The separated material is then stored or reused.

10-68. Table 10-1 shows an example of estimated solid-waste disposal requirements in tons per day for supported populations for standard base camp sizes and levels of base camp capabilities (basic, expanded, and enhanced). The top end of the population range is multiplied by planning factors from ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N). These estimates can be used for the initial, field-expedient planning of the total daily, solid-waste disposal requirements for base camps when no other information is available.

Table 10-1. Example of base camp estimated solid-waste disposal in tons per day

Size	*Population*	*Basic Waste Disposal Requirements (4 lbs/person/day) / 2,000*	*Expanded Water Requirements (6 lbs/person/day) / 2,000*	*Enhanced Water Requirements (10 lbs/person/day) / 2,000*
Extra small	299	0.6	0.9	1.5
Small	1,999	4.0	6.0	10.0
Medium	5,999	12.0	18.0	30.0
Large	>6,000	Estimate waste disposal requirements based on the planned population and planning factors.		
Legend: lbs pounds				

10-69. The waste management principles of reduce, reuse, and recycle can reduce the generated waste amounts and reduce the required capacities of disposal facilities or other waste management options. TM 3-

34.56/MCRP 3-40B.7 provides information on developing more detailed waste generation rates that are tailored to a specific situation and waste management options.

10-70. Solid-waste collection and disposal techniques depend on the volume of waste generated, the duration of facility occupation, existing collection facilities, the resources available to perform the work, the facility location, the situation, and the environmental aspects of the area. In some cases, selected recycling may be enacted.

10-71. Special consideration should be given to hazardous waste, especially waste products generated by medical facilities and maintenance. Hazardous waste should be disposed of according to regulations, laws, treaties, and agreements. Specific guidance should be contained in an annex of the OPORD. The improper disposal of hazardous waste may cause serious illness or death to those who operate landfills or cause irreversible environmental damage. Specialized environmental and medical expertise exists to support the engineer and the commander when dealing with hazardous waste. See TM 5-814-7 for more information on hazardous-waste disposal in land treatment facilities.

REAL ESTATE OR REAL PROPERTY TRANSFER

10-72. The transfer of real estate or real property to another Service, a multinational force, a governmental or nongovernmental organization, or the HN is an extensive process that can vary between commands and theaters of operation. It requires advanced planning and coordination between the current occupant and the receiving organization.

10-73. If the transfer involves coalition or HN forces, there are special requirements to ensure that the United States is fully relieved of liability and that monetary reimbursements are made for any improvements. Activities include providing legal requirements, conducting real estate reconciliation, executing property distribution (retrograde and disposal), descoping contractual requirements, monitoring environmental cleanup, and documenting records and archives to capture relevant transactions and agreements.

10-74. Proper transfer procedures facilitate the timely withdrawal of U.S. forces, reduce costs, prevent undue liabilities, protect U.S. interests, and promote good relations. See UFC 1-300-08 for guidance and criteria on the transfer and acceptance of DOD real property. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for information on base camp transfer and closure. See AR 405-90 for real estate disposal.

10-75. During initial occupation, the inbound unit should focus on documenting facility conditions, inventorying the property, and reviewing existing records. It is imperative that units properly manage and maintain records and reports as they will ease the transfer of future real estate or real property transactions with other units. Real estate documents (property agreements, location, description, condition, surveys, value, and maps) should be requested from the outbound unit, kept on file, and updated as changes occur (see AR 405-45 and DODI 4165.03).

10-76. To support redeployment and transition, engineers may be required to repair, refurbish, and turn over property and real estate to the HN. Closure actions may include the need to terminate leases and curtail services and facility contracts. Engineers can also support in planning and executing the destruction of facilities to prevent enemy use.

10-77. To complete a transfer, units must properly complete the list of transfer requirements and comply with applicable laws and regulations before finalizing the transaction. Once the transfer is approved for acceptance or return, commands—

- Coordinate with authorized representatives of units receiving the property, usually the real property accounting officer or designated representative (when feasible or required).
- Conduct a joint inspection of the property or facility and prepare and sign a verification of joint inspection and record of return.
- Prepare and sign an outgoing inventory report.
- Prepare and sign a condition report.
- Prepare and sign an environmental site closure report.

- Complete DD Form 1354 (*Transfer and Acceptance of DOD Real Property*), ensuring that real property accountable officers or designated representatives of both organizations receive copies (see UFC 1-300-08 for details on completing DD Form 1354).

Chapter 11
Power Systems

Military operations require electrical power to support command and control, communications, targeting, force protection, logistics, and force sustainment functions throughout all phases of military operations. Powered networks include interior wiring, distribution, and power generation systems. Safe, reliable, efficient, scalable, and sustainable power systems are essential and require adequate planning and consideration by all military units, from the tactical to the strategic level. Power systems (consisting of standardized and compatible modular components) may range from small systems powering single facilities to large systems with multiple power sources and may incorporate alternative fuels, power storage options, and renewable energy sources. General engineers play a key role in synchronizing the construction, operation, and maintenance of power systems. This chapter provides an overview of Service capabilities and includes all phases of power systems.

RESPONSIBILITIES AND CAPABILITIES

11-1. During the initial phases of military operations, power systems will be low-voltage, tactical power systems that are common to all Services. These tactical power systems include limited distribution and lighting capabilities. As operations progress and power requirements change, each Service possesses varying, complementary capabilities to support operations.

11-2. Small, engine-driven generators are the main source of electrical power for armed forces in the field. Other power-generating capabilities can be used, such as commercial power systems, renewable energy (water, wind, solar) electric-generating systems, and rechargeable battery systems.

ARMY

11-3. Army units own, operate, and maintain organic tactical generators to meet command requirements and essential life support electrical power requirements. Army and Navy units own, operate, and maintain deployable prime power generators and can assist in using commercial power. Engineer prime power units provide temporary power from their organic generators or from local power grids.

Responsibilities

11-4. General engineers have the capability to plan, design, construct, operate, and maintain basic power generation and secondary distribution systems. Army engineer prime power assets can reach back to USACE and provide power planning beyond the capability of assigned engineers.

11-5. There is a division of labor among the specialized Army electricians who handle interior, distribution, and power plant systems. This includes the following:

- **Interior system electricians.** Interior electricians are trained and equipped to perform electrical work within the interior of the building, up to the circuit box. This includes reading electrical system blueprints; installing wiring, transformers, circuit breakers, service panels, switches, electrical boxes, and lighting systems; and inspecting, testing, repairing, and replacing electrical systems within facilities.
- **Distribution system electricians.** Power distribution specialists are trained and equipped to perform tasks associated with electrical distribution. They connect service drops and conduits on deenergized systems. Their duties also include installing—

    - Electrical prime power distribution systems.
    - Exterior services.
    - Utility poles.
    - Guy wire.
    - Anchors.
    - Crossarms.
    - Conductors.
    - Insulators.
    - Transformers.
    - Other electrical hardware.
- **Power plant system electricians.** Prime power production specialists are trained and equipped to perform electrical assessments and facility power system maintenance. They can perform quality assurance or quality control operations and supervision. They can operate, install, and perform direct support/general support level maintenance on electric power plants. They can work on prime power generator sets of 500-kilowatt capacity and higher and associated auxiliary systems and equipment. Other duties include the liaison officer and technical advisor to the Federal Emergency Management Agency and other federal organizations as necessary.

11-6. Every Army element that is authorized power system components (such as generators and electrical distribution equipment) on their modified table of organization equipment is required to have a unit power manager who is trained and licensed to operate the unit tactical power system. The tactical power system will typically be a plug-and-play power system that provides power to the unit tactical operations center, communication facility, or maintenance facility.

Prime Power Units

11-7. When power requirements exceed the capabilities of the unit power manager, or the unit's organic tactical power system, units normally request support from Army engineer prime power unit or Navy mobile utilities support equipment. Service prime power units provide theater-wide expertise and technical assistance on all aspects of electrical power. These Service power production capabilities provide utility grade power to support larger military power requirements than BCT/BLT through division units have the capacity to provide. Prime power capabilities must be closely coordinated, integrated, and synchronized across the whole of spectrum of power to ensure that sufficient, reliable, and resilient electrical power is available to support all operations (see ATP 3-34.45/MCRP 3-40D.17).

11-8. Engineer prime power units can help plan, install, operate, and maintain their organic power system. The prime power system can help support a variety of military facility requirements, to include bases/base camps, seaports, airfields, major headquarters, and medical treatment (hospitals) or other critical facilities. They may also repair, operate, and maintain nonstandard or commercial power plants and electrical distribution systems during military operations. Engineer prime power units may perform other technical, power-related tasks, to include—

- Providing power-related planning and staff assistance.
- Conducting power requirement assessments and electrical-load surveys.
- Analyzing existing power systems and recommending COAs for improvement or expansion.
- Drafting the scope of work for contracted power system support.
- Serving as the technical representative of the contracting officer.

MARINE CORPS

11-9. Marine Corps utility units are organized and equipped to deliver power across the MAGTF. Each element of the MAGTF possesses an organic utility capability. MAGTF power systems are scalable to the level of activity and the mission. MAGTF utility personnel plan, install, operate, and maintain military standard 120, 208, 240, and 416 volts alternating current power generation and distribution equipment for base camps and vertical construction projects. Utilizing the MAGTF mobile electric power systems, utility units safely deliver electric power using equipment that produces from 2 to 100 kilowatts. Enduring power requirements, such as those needed at air facilities, can be operated for up to 2 years. When power requirements exceed the capabilities of the organic utility units, the MAGTF requests augmentation from external sources, such as the Seabees or commercial contractors. Additional information pertaining to Marine Corps power generation and distribution capabilities (including tactics, techniques, and procedures) can be found in *Theater of Operations Electrical Systems*.

NAVY

11-10. The Navy construction battalion maintenance unit provides follow-on public works to maintain and repair existing advanced base shore facilities or facilities constructed by the Naval mobile construction battalion during contingency operations. The mobile construction battalion is capable of manning, equipping, and maintaining steam and electrical power generation and distribution systems for advanced base facilities, up to 5,000 personnel. See NTTP 3-10.1M/MCTP 3-34D for more information on construction battalion maintenance units and Naval mobile construction battalion capabilities.

11-11. The Navy has mobile utility support units that provide power plants, substations, steam plants, and technical expertise to support DOD utility shortfalls worldwide. Mobile utility support equipment technicians attend the prime power production specialist course and a mobile utility support equipment familiarization course. Technicians are rapidly deployable within a 24-hour notice to provide technical assistance for organic and nonorganic utilities. Technicians install, repair, maintain, and operate power generation, electrical distribution, transformation, and steam-generating equipment and infrastructure. Mobile utility support equipment teams are compact and multidimensional and have expertise and skills to resolve a wide range of utility issues. See NTTP 4-04.3 for more information on mobile utility support equipment.

AIR FORCE

11-12. The Air Force has Prime BEEF and RED HORSE units that are stand-alone squadrons. They are highly mobile, largely self-sufficient, and rapidly deployable. Both of these units are capable of providing electrical-system installation. Prime BEEF are mobile assets that are deployed to air bases, where they can combine to form a main operating base combat engineer force of 200 to 320 people, depending on the threat and number and type of aircraft. RED HORSE units provide heavy repair capability and construction support when requirements exceed normal base civil engineer capabilities and where Army engineer support is not readily available (see Air Force Doctrine Publication 3-34 for additional information).

BASE CAMPS

11-13. Base camps may provide power from generators, a central power plant, or commercial utility power sources to meet operational and life support requirements. Base camps can connect a variety of power sources to the base camp distribution system to create a self-contained microgrid. A microgrid is a localized grouping of electricity generation, energy storage, and loads that normally operate connected to a traditional, commercial centralized grid (microgrid).

11-14. A microgrid may provide more efficient distribution and use of electrical power. Base camp power generation and distribution systems may also include power storage capabilities into their grid for supporting mission-essential facilities or equipment. The installation, operation, and maintenance of power storage capabilities may be performed by units, interior electricians, prime power personnel, or contractors.

OTHER SOURCES

11-15. The HN may operate regional or national power systems or have commercial utility power systems that are capable of supporting military operations. However, HN power may not be sufficient, reliable, or compatible with U.S. military equipment or facilities. Exercise caution when considering HN power, as it may undermine counterinsurgency goals and actions.

11-16. Contracted power support may be available through local military contracts, the USACE worldwide power contract, or the logistics civil augmentation program. Contract support may range from simple O&M

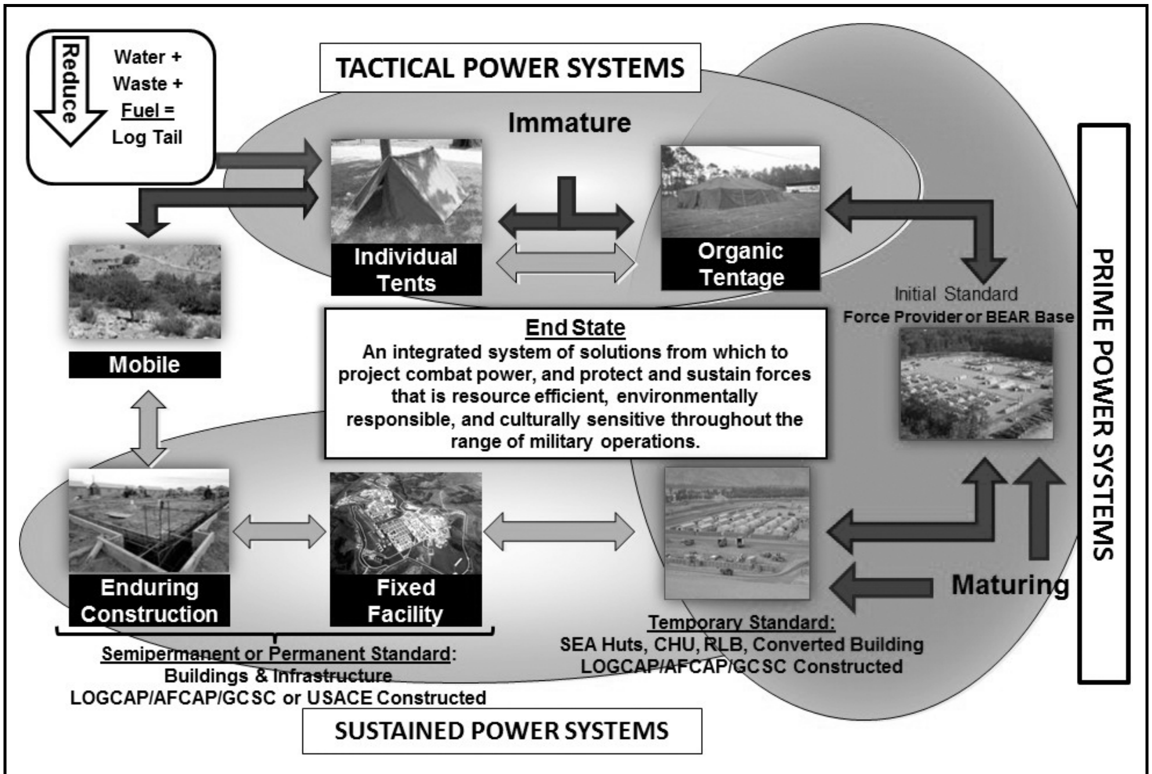
of military power systems to the construction and leasing of large power systems to support large base camps. (ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for additional information.)

PLANNING AND DESIGN

11-17. There is no one-size-fits-all solution to supplying electrical power throughout the range of military operations. The capacity, mobility, and flexibility requirements of the electrical system for a C2 node during large-scale combat operations are very different from those of a base camp or logistics hub. Typically, a site occupied at the cessation of combat operations develops into an enduring location as the phases of an operation change.

POWER CONTINUUM

11-18. Figure 11-1 depicts an example of electrical power system transitions. The power systems are employed in a scalable fashion to use minimal resources to support changing electrical power demands. Typically, a power system begins with an organic tactical power system, transitions to the prime power system, and then ultimately transitions to a civilian or contractor-managed utility power system for enduring locations. These transitions can occur consecutively or concurrently. The goal is to employ power systems that support and build on one another while meeting mission requirements.



Legend:

AFCAP	Air Force contract augmentation program
BEAR	Base Expeditionary Airfield Resources
CHU	containerized housing unit
GC SC	global contracting support contract
LOGCAP	logistics civil augmentation program
RLB	relocatable building
SEA	southeast Asia
USACE	United States Army Corps of Engineers

Figure 11-1. Tactical power systems

11-19. Typically, a power system will begin with a unit-owned tactical power system, transition to a deployable prime power system and, ultimately, progress to the civilian- or contractor-managed sustained power system for long-term engagements. However, the phases of the power continuum do not have to occur consecutively and several or all phases can occur concurrently. The goal is to employ power systems that support and build on one another.

11-20. The following power systems are depicted in the power continuum in figure 11-1:

- **Tactical power system.** This is a highly mobile contingency power system that produces and distributes electrical power at user voltage and is installed, operated, and maintained by Soldiers. Initial tactical power systems are composed of modified table of organization equipment-authorized, Army standard generators and power distribution equipment; but they may include commercial, off-the-shelf power equipment as missions dictate. User voltage is typically 120/208 volts at 60 hertz, but may also be 230/400 volts at 50 hertz, depending on the deployed location. Tactical power is generated by a mobile, electrical-power unit that is dedicated to supporting the missions of units engaged in combat operations. Tactical power uses two classes of generators: precise and utility. These standard military generators are highly mobile, produce low voltages, and do not require the use of transformers. They have an output capacity that ranges from 0.5 to 200 kilowatts. These generators are in the unit table of organization and equipment and are referred to as tactical generators. Distribution systems for tactical power are usually very simple. They often consist of standard components, such as field wiring, distribution illumination sets, and electrical sets. The installation, operation, and maintenance of tactical generators and distribution equipment are the responsibility of the using unit.
- **Deployable prime power system.** This is a deployable contingency power system that produces and distributes electrical power at medium voltage; uses transformers to produce user voltage; and is installed, operated, and maintained by Soldiers. Medium-voltage is typically a 2400- to 13,800-volt power system that is capable of distributing power.
- **Sustained power system.** This is a contingency power system that is site-specific and may be composed of low- or medium-voltage power equipment, fixed generators, and commercial electrical equipment. It is installed, operated, and maintained by contracted civilian personnel. See ATP 3-34.45/MCRP 3-40D.17 for additional information on power systems.

POWER SYSTEMS

11-21. There are many sources of electrical power. Each source varies in complexity, efficiency, and reliability. Routine power sources are tactical generators, prime power generators, and commercial power. Engineers estimate power requirements; plan for sources over time; and design and construct basic power generation systems, secondary distribution systems, and fixed-site storage systems. Power requirements evolve as a theater matures and populations grow. Detailed planning to forecast and estimate future power demands ensures that usage does not exceed supply over time.

Power System Planning Considerations

11-22. Power system master planning consolidates and interprets the information gathered from the initial assessment and merges it with geospatial information. This information includes terrain, existing and planned facilities, and vehicle and pedestrian traffic patterns to determine the optimum placement of power system components. Additional planning considerations include—

- **Survivability.** Do not locate power system components near installation perimeter walls. Protection from direct and indirect fire (such as using T-shaped walls or sandbag walls) may be required. Ensure that installed obstacles or barriers do not physically restrict cooling air flow.
- **Drainage.** Do not locate power system components in low areas that may be prone to flooding, or near streams, ponds, or rivers where water levels could rise unexpectedly.
- **Fuel storage location.** Locate remote fuel tanks and reserve fuel supply (5-gallon fuel cans) into secondary containment close to equipment as authorized by the UFC and national fire code.

- **Utility corridors/utility space.** A utility corridor is a linear strip of land, normally running parallel with roads, that is identified for present or future locations of utility lines. Locate power cables in dedicated utility corridors out of main traffic patterns to minimize damage and to ensure access for repair or expansion/modification of the power system. Do not locate power cables under facilities, T-shaped walls, sandbags, or other obstructions to access. Provide a dedicated space for generators and other power system components out of main traffic patterns to prevent physical damage but allow access for maintenance or replacement.
- **Equipment standards.** Use only commercial power system components that have been approved by one of the nationally recognized testing laboratories or that have been inspected and approved by the authority with jurisdiction. Military power system components must meet military standards or adhere to military specifications. Do not use nonlisted components of existing facilities. Replace discovered parts not listed (see DA Pam 385-26).

11-23. Power system planners should be integrated into the planning committee or working group to coordinate with facility master planners, communications personnel, force protection personnel, and logistics personnel. This is needed to ensure that the power system will best meet the needs of all supported and minimize conflicts with other mission requirements.

11-24. Always consider personnel and system safety with respect to locating overhead power lines in close proximity to facilities or in areas that frequently use tall combat vehicles with tactical radio antennas, high-lift forklifts, or cranes. Work on energized circuits during system installation or maintenance requires an energized work permit. A complete power system design will require a short-circuit analysis of potential fault currents to aid in determining proper circuit breaker and component sizing and ratings. The data from the short-circuit analysis is used in an arc flash hazard analysis to determine arc flash protection boundaries, incident energy at the working distance, minimum requirements of arc-rated protective clothing, and potential risks to personnel performing system maintenance and to develop risk mitigation strategies.

11-25. Automated planning and design tools, such as the JCMS, are available to provide baseline standard designs and produce a construction bill of materials. The Auto Distribution Illumination System, Electrical, is a computer model developed to simulate the use of the Distribution Illumination System, Electrical, or the Power Distribution Illumination Systems, Electrical. The Distribution Illumination System, Electrical, refers to the military family of power distribution equipment (military customized electrical breaker boxes). These tools can aid in proper system configuration and component selection.

11-26. Additional references are as follows:

- See TM 3-34.46/MCRP 3-17.7K for detailed design, layout, installation, and maintenance of electrical systems.
- See the AFCS program guidelines for standard electrical designs.
- See UFC 3-500 series for commercial power system guidance, and UFC 3-501-01 for details of electrical engineering.
- See ATP 3-34.45/MCRP 3-40D.17 for deployable power systems.
- See TM 5-683/NAVFAC MO-116/AFJMAN 32-1083 for guidance on the facilities maintenance of interior electrical systems.
- See TM 5-684/NAVFAC MO-200/AFJMAN 32-1082 for the maintenance and repair of exterior electrical distribution systems.
- See DA Pam 385-26, TM 5-682, and UFC 3-560-01 for details on safe electrical practices.

Power System Requirements

11-27. The initial assessment of what the power system must do is the critical first step, which must be performed before construction begins or installation commences. The observations made, questions asked, and resulting answers set the framework for establishing a safe, reliable, and efficient power system. Executing an effective initial assessment requires a combination of technical expertise, engineer art, and forecast of future requirements. Some considerations are—

- What size area will the base camp or facilities occupy? The geographic area is a very important consideration when determining if power must be provided by one power system or multiple power systems. This also affects the distribution system used; for example, overhead or buried cables. A relatively large, spread-out installation will likely require multiple power systems, regardless of population, because excessively long power cables will degrade the performance and efficiency of the power system. The available area will also determine whether expansion (of services/capabilities and/or population) can occur within the existing perimeter or will require additional land.
- What is the projected population to be served? This is important because, generally, larger populations have greater power requirements.
- How soon must the power system be operational? The need for speed will often override the ability to design and resource materials to construct a more efficient power system. However, if the initial power system is emplaced in power system modules, consolidation into a more sustainable system will be easier to achieve and more cost effective.
- How long will the power system be required? It is difficult and inefficient to operate and sustain multiple small power systems for an extended period of time (years). If longer duration missions can be properly determined or planned for, power systems can be properly planned for consolidation or upgraded accordingly to the deployable prime power system or a long-term sustained power system.
- Will the power system utilize an existing power system or facilities? The decision to utilize existing facilities may be expedient and enhance force protection, but may require repair, modification, or upgrade to be made suitable for military use. The commercial standards of construction may require modification to adapt to military power systems. The repair and/or expansion of existing commercial facilities will require additional planning and design consideration and may place challenges on logistics sustainment. Changes must equal or exceed applicable building codes and standards.
- What voltage and frequency will be required? U.S. military power systems and equipment are designed to operate at 120/208 volts at 60 hertz, and must comply with U.S. safety and construction standards. The HN power system will almost certainly operate at a different voltage or frequency and may not comply with U.S. safety and construction standards. Most HN power systems will operate at 50 hertz and voltage will range from 220 to 240 volts and 380 to 415 volts. Some office equipment may operate at either voltage standard, but adapters will most likely be required to enable office equipment plugs to be inserted into HN power outlets (receptacles). It is highly recommended to select a single standard and eliminate the necessity for disparate power systems or utilization of complex power conversion equipment (transformers).
- What type of installation will the power system serve? ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) discusses several levels and capabilities of base camps and resultant power considerations. The types of facilities and equipment, projected power consumption, and level of services available will have a large impact on determining power system requirements. Getting the right information will enable better planning and design decisions. Consider the following:
  - Will the installation have large numbers of personnel or personnel centers requiring large industrial-sized heating, ventilation, and air conditioning systems?
  - Will there be large, consolidated dining facilities? Will there be a hospital? Will there be extensive, refrigerated/frozen food?
  - Will Army and Air Force Exchange Service facilities, vendors, or support contractors be on-site?

  - Will there be large logistics, transportation, and maintenance facilities or water purification and ice production equipment?
  - Will there be a large, consolidated laundry facility?
- What power system assets are available, and are they sustainable? An initial assessment includes a listing of serviceable power system equipment on-site or readily available. Decisions to utilize or purchase nonstandard, commercial equipment must carefully consider whether the power system is sustainable with readily available service and repair parts and whether trained technicians are available to operate and maintain the equipment.

Note. An effective planning rule of thumb is that, for standard 120/208-volt power systems, the total distance from the power source to the point of consumption should not exceed 300 feet. See ATP 3-34.45/MCRP 3-40D.17 for additional information on electrical planning.

POWER PLANT SIZES FOR BASE CAMPS

11-28. Table 11-1 shows an example of estimated power plant sizes, in kilowatts, for supported populations in standard base camps (basic, expanded, and enhanced). The top end of the population range for each base camp size is multiplied by planning factors from ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N). These estimates can be used for the initial, field-expedient planning of the total power requirements and plant sizes for base camps when no other information is available. The base or base camp power system may initially be constructed from tactical generators and then converted to prime power or may initially be constructed using prime power plants and then be converted to commercial power generation systems, as discussed in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N). TM 5-811-6 provides detailed procedures for designing power plants.

Table 11-1. Example of estimated power plant sizes, in kilowatts

Size	*Population (x 1.25)*	*Basic Power Plant (1.5 kw/per)*	*Expanded Power Plant (2.5 kw/per)*	*Enhanced Power Plant (3.5 kw/per)*
Extra small	374	561	935	1,309
Small	2,499	3,749	6,248	8,747
Medium	7,499	11,249	18,748	26,247
Large	> 7,500	Estimate the power plant size based on the planned population and planning factors.		
Legend: kw/per kilowatt(s) per person				

DESIGN OF POWER SYSTEMS

11-29. Electrical systems include basic power generation, secondary distribution or wiring, and storage capabilities.

Notes.

1. See TM 3-34.46/MCRP 3-17.7K for electrical system designs, layouts, installation requirements, and maintenance.

2. See the AFCS program guidelines for standard electrical designs.

3. See UFC 3-500 series for electrical criteria requirements.

4. See ATP 3-34.45/MCRP 3-40D.17 for deployable prime power system designs.

5. See UFC 3-501-01 for electrical engineering details.

6. See TM 5-683/NAVFAC MO-116/AFJMAN 32-1083 for information on the maintenance of interior electrical systems (600 volts and less).

7. See TM 5-684/NAVFAC MO-200/AFJMAN 32-1082 for the maintenance and repair of exterior electrical distribution systems.

8. See DA Pam 385-26, TM 5-682, and UFC 3-560-01 for electrical safety practices.

CONSTRUCTION, INSTALLATION, AND CONNECTION

11-30. Commanders, train, and license assigned personnel in the unit as tactical electric power system operators, regardless of the personnel military occupational specialty (MOS). Marine Corps personnel licensed as incidental operators may only operate power generation equipment up to 20 kilowatts in size. Only personnel who hold MOS 1141 may establish power generation sites, operate power generation equipment over 20 kilowatts in size, or install power distribution equipment. Licensed personnel operate assigned equipment according to the operator instructions in technical manuals.

11-31. Licensed and electrical MOS trained personnel installs low-voltage tactical power systems, install medium-voltage deployable prime power systems, construct or install facilities (interior) electrical systems, and connect facilities to the power system.

11-32. Tasks related to constructing, installing, and connecting power systems include—

- Trenching and backfilling power cables in utility corridors.
- Placing concrete foundations for power system components.
- Constructing secondary containment berms for fuel systems.
- Installing power system components (includes generators, switchgears, transformers, and fuel tanks).
- Installing utility poles and overhead conductors.
- Terminating, testing, and connecting power cables.
- Constructing enclosures for power system components.
- Testing and commissioning power systems prior to use.
- Assist in writing the scope of work for power system construction contracts.

11-33. The proper power system grounding and bonding of electrical components are essential to ensure reliable system operation and protective device operation. This will also ensure that personnel are protected from electrocution and shock due to equipment malfunction. The Institute of Electrical and Electronics Engineers Standard 142-2007 (commonly referred to as the Green Book) provides guidelines for electrical system grounding and bonding. Additional standards govern power system construction and safe electrical work practices.

11-34. Power systems that operate or will operate at the U.S. military standard 120/208 volts at 60 hertz must be constructed to meet the standards outlined in National Fire Protection Code 70: National Electrical Code; the Institute of Electrical and Electronics Engineers Standard 142-2007; the National Electrical Safety Code; and applicable military standards and directives. Power systems that operate at different voltages or frequencies must be constructed to meet HN electrical construction and safety standards. If the HN electrical code is inadequate, then use the JCMS to plan electrical system construction.

OPERATION AND MAINTENANCE

11-35. Operating and maintaining power systems are labor-intensive. The continuous operation of large, fixed plants exceeds the labor capabilities of the prime power platoons so plan accordingly.

11-36. Engineer prime power units will install, operate, and maintain the deployable prime power system. They will be responsible for designing and safely employing the system. They will be responsible for the interconnection between the deployable prime power system and the tactical power system. They will coordinate fuel support and perform maintenance or repair as required. Construction unit support may be required for trenches, concrete foundations, or other support to facilitate power system installation.

11-37. O&M for a sustained power system may range from a simple service contract for operator level preventive maintenance checks and services to the more typical full service contract, which includes daily operation, fueling services, periodic maintenance, and repair as needed. A sustained power system contract may include system construction and facility connections and repair. The sustained power system may utilize power system equipment provided by the contractor or equipment purchased by the government to be used by the contractor, or it may be a tactical power system or deployable power system whose operational responsibility has been transferred to a contractor. See ATP 3-34.45/MCRP 3-40D.17 for additional information on power system configurations.

POWER SYSTEM EXPANSION OR DOWNSIZING

11-38. Military operations usually require adding, moving, or upgrading facilities and equipment, which necessitates changes in the power system. A well-designed power system should be able to support some load growth without requiring major modification to the system. There are two basic methods:

- **Over build.** This method advocates intentionally overbuilding the system beyond initial forecasted/calculated requirements. This easily allows for anticipated expansion or a surge in demand. However, this is also very costly and is not an efficient use of power sources.
- **Scalable build.** This method allows a power system to be designed and constructed as scalable modules for expansion or contraction. See ATP 3-34.45/MCRP 3-40D.17 for more information about the modular design of power systems.

11-39. Smaller tactical power system modules can be consolidated onto larger tactical generators, with the smaller generators remaining as redundant backup power for high-priority circuits/tactical facilities. The larger modules can be further consolidated when transitioning to the deployable prime power system, which provides much greater efficiency and reliability and minimizes the number of personnel required for O&M.

11-40. Mixing military and commercial power equipment requires specialized design considerations to ensure that the system functions safely and efficiently.

11-41. Downsizing a power system requires safety considerations to ensure that any remaining or abandoned equipment has been properly disconnected and isolated to minimize residual danger to personnel. Downsizing may require consolidation of facilities to ensure that entire modules can be removed from the power system, which minimizes isolated facilities remaining outside the power system footprint.

REDEPLOYMENT AND BASE CLOSURE

11-42. Redeployment and base closure require deliberate planning, which begins with a mission statement of the desired end state. The command must determine which facilities and systems, if any, will remain for HN use, which facilities and systems will be demolished, and which equipment is excess and requires disposal. Plan to relocate supported units to allow the orderly demolition of facilities and systems. Conduct an assessment to determine the serviceability of facilities, systems, and equipment and whether the assets are suitable for transfer to the HN, if applicable.

11-43. Population and power requirements may temporarily increase during a retrograde. Plan temporary lodging for a population surge, as required. If the location is a logistics or transportation hub, plan to seek out additional areas that are suitable for temporary staging and equipment storage. Consider plans for security lighting and additional support, as required.

11-44. Base closure and demolition work require an assessment of energized circuits and conductors before any demolition work begins. Complete an electrical safety survey, and communicate the results to using organizations who will be affected throughout the redeployment, transfer, or closure activities. Carefully identify all energy sources and deenergize all circuits to prevent fires or electrocutions.

11-45. Plan accordingly to allow sufficient time for base closure activities. Contracted support for a sustained power system may require 90 to 120 days or more prior to base closure, to terminate service, and to dismantle and remove power system equipment. Engineer prime power units can assess the power system and, if necessary, reestablish a deployable prime power system to support an orderly build-down process. As redeployment progresses, the power system will eventually revert back to a tactical power system with unit responsibility. Additional tactical generators may be needed for the final closeout. (ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for additional base closure information.)

Chapter 12

Water Production, Well Drilling, and Distribution

Water is vital to sustaining the force and must be made available in sufficient quantity and quality for Soldier consumption, sanitation, medical, CBRN decontamination, construction, and equipment maintenance. Water is an essential service to support DSCA, stability, and foreign humanitarian assistance. Water supply requirements depend on climatic and environmental conditions, terrain, and the type of operation conducted. Water production and distribution are team efforts conducted by engineer, quartermaster, medical, and tactical units. Logistics officers estimate unit water requirements and plan required procurement, production, and distribution needs. Commanders request engineer support when the logistics plan includes well drilling or support for water supply points, the establishment of distribution systems, or water utilities on base camps. This chapter covers water capabilities, planning and design methods, detection procedures, production techniques, operation measures, and distribution methods.

RESPONSIBILITIES AND CAPABILITIES

12-1. This section discusses the responsibilities and capabilities of each Service in providing water production, well drilling, and distribution. Capabilities vary between Services.

ARMY

12-2. The Secretary of Defense designated the Army as the executive agent for the management of land-based water resources in support of contingency operations. This applies to the support of land-based forces. The Army is responsible for developing and maintaining an intelligence database to provide data on the location, quality, and quantity of land-based water resources. USACE supports the Army G-4 in this effort (see AR 700-136 and DODD 4705.1E).

12-3. The combat sustainment support battalion (attached to a sustainment brigade) executes logistics, including water. Water production and distribution are sustainment unit tasks. Water production is a field service and supply function. Quartermaster supply units normally perform water purification in conjunction with the storage and distribution of potable water (see ADP 4-0).

12-4. The Army sustainment brigade provides material and supply management for water and synchronizes the supply and distribution of water. Water supply includes the receipt, storage, inspection, testing, issue, distribution, and accountability of water stocks for the area of operations. The combat sustainment support battalion may contain water purification, distribution, and augmentation support companies that provide water production, package capability, storage, and purification and distribute bottled and bulk water to the area of operations. Tactical units have limited water production and distribution capabilities. In temperate climates, water purification, packaging, storage, and distribution take place in the brigade support battalion. Water reconnaissance is primarily a sustainment/combat service support unit responsibility. General engineers assist the water reconnaissance team in water detection. The task to provide water support includes purification, distribution, storage, and quality surveillance (ATP 4-93). See ATP 4-44/MCRP 3-17.7Q for quartermaster water unit capabilities.

12-5. Army engineer units locate and develop water resources; provide well drilling; and construct, maintain, and operate permanent and semipermanent water utility systems. Army engineer units provide infrastructure support, facilities engineer support, and other engineer support, including well drilling, to bases and installations. Tasks include the planning, design, construction, repair, maintenance, and operation of permanent and semipermanent water facilities. This includes water supply and distribution systems within base camps, facilities, or buildings. Plumbing is a system of piping, apparatus, and fixtures for water distribution and waste disposal within a facility or building. The facility engineer manages water utilities on an installation or base camp.

12-6. USACE is another professional reachback resource for seeking comprehensive solutions to complex water issues. With a staff of subject matter experts and an extensive system of testing and research laboratories, USACE can assist in resolving unique water system challenges. USACE is capable of repairing water purification, distribution, and storage systems.

12-7. Well drilling units turn wells over to a quartermaster unit or facilities engineer. Army engineer organizations are responsible for the following water-related actions:

- Surveying, identifying, and compiling data pertaining to surface water sources to supplement existing data.
- Compiling data using information (such as well-drilling logs and ground surveys) to establish groundwater well-drilling sites.
- Providing well-drilling teams that are task-organized to nondivisional engineer units.
- Constructing and repairing rigid water storage tanks and water pipelines.
- Improving water point sites that require construction support.
- Constructing and maintaining permanent and semipermanent water utilities, including water wells, at fixed Army installations.

Marine Corps

12-8. The Marine Corps maritime pre-positioning force has ships with the capability to purify water and transfer it ashore.

Navy and Air Force

12-9. The Navy and Air Force have engineer units designated to support infrastructure and well-drilling. Navy ships have the capability to make potable water. In dire situations, some of that water can be transferred ashore without impacting the ship's crew.

Water Detection, Testing, and Well Drilling

12-10. The water detection response team is sponsored by USACE, which is the primary DOD organization for assisting military well drillers for military, humanitarian, or nation-building activities. The water detection response team provides military well drillers with specific information to help mission planners make informed decisions and meet mission requirements. The primary function of the water detection response team is to assist and advise well-drilling teams on the locations of the best well-drilling sites and depths and to provide information on well-drilling conditions for logistics planners.

12-11. The hydrologic analysis team is staffed on an as-needed basis from a pool of civilian scientists and engineers that represent various government agencies. The team possesses state-of-the-art, remote sensing and geophysical equipment and has numerous bibliographic sources readily available for most areas of the world. The water detection response team also offers a Hydrogeology for Military Well Drillers short course upon request. Hydrologic analysis team support can be requested through the USACE Water Resource Database website.

12-12. The Hydrologic Data Resources Application is an unclassified smartphone application created to provide the water detection community with a way to access water resources information through data collection, visualization, and dissemination. The water resources database is a geodatabase that contains the location, quantity, and quality of land-based surface, ground, and existing water resources to support DOD water logistics decisions. The Hydrologic Data Resources Application allows engineers in the field to view, collect, and edit water resource features on smartphones, using mobile technology and government databases. For more information on current Hydrologic Data Resources Application systems, see the USACE website.

12-13. Water testing is normally conducted at the lowest level through local medical teams. See the Center for Disease Control and Prevention website for further assistance. As a reachback resource, the center has comprehensive water-testing capabilities that exceed those of local medical teams and a staff of subject matter experts beyond local medical teams.

PLANNING AND DESIGN

12-14. Water support requirements are considered in the initial phases of each military operation. The planning for water is initially based on the sustainment preparation of the operational environment. Logistics planners use ATP 4-44/MCRP 3-40D.14 to estimate the required quantity and quality, based on the mission, size of the supported force, dispersion of forces in the area of operations, and availability of various sources of water supply. Logisticians use ATP 4-44/MCRP 3-40D.14 to plan water supply point, which include water reconnaissance, source and point development, treatment, purification, storage, and distribution. See UFC 3-230-01 and UFC 3-230-03 for design criteria for water storage, treatment, distribution, and transmission.

12-15. Water information determines the need for the early deployment of well drilling, water production, and distribution units. Reconnaissance should include the evaluation of potential water sources, field reconnaissance to support water detection, the evaluation of infrastructure, and the determination of support requirements.

WATER QUALITY MONITORING

12-16. The production, treatment, and distribution of water provided by military forces and contractors are monitored for sanitary control. The intent is to provide the highest-quality water to support and sustain the health and performance of deployed personnel (see TB MED 577/NAVMED P-5010-10/AFMAN 48-138_IP for more information).

12-17. The Army Public Health Command website provides information on drinking-water protection and updates on other health-related issues. It also provides military units with technical support and expertise in the areas of preventive medicine, public health, health promotion, and wellness.

12-18. There is a variety of technology available to monitor water on-site. Most are handheld devices that are linked to digital platforms, which transfer data to laboratories that identify basic water quality parameters and detect a wide range of microbial pathogens and chemical health hazards. The USACE can assist in identifying the best devices for use by military units.

WATER WELLS

12-19. Water wells are engineer construction projects and must be planned, designed, managed, and reported in the same manner as other projects. The detailed planning, designing, and drilling of wells is discussed in NTRP 4-04.2.13/TM 3-34.469/AFMAN 32-1072. The Navy and Air Force maintain well-drilling capabilities, which are also addressed in this manual. Wells should be drilled in a secure area within the area of operations and, if possible, within base camps or other facilities for which the water will be used. The well-drilling team is inherently modular and deploys to the area of operations with the organic equipment for well drilling.

12-20. Well-drilling teams are a theater engineer command asset and should be deployed, and employed by, an engineer brigade or battalion capable of providing expertise and sustainment/logistics support. Because the well-drilling team has limited personnel, the engineer headquarters must plan security at the work site.

WATER FOR STABILITY AND HUMANITARIAN ASSISTANCE

12-21. In planning support for stability tasks and foreign humanitarian assistance, consider water an essential service. Engineers may restore the HN water service or develop the HN capability and capacity to operate, maintain, and improve the water service.

12-22. Water may be required for human consumption, agriculture, livestock, or industrial use or to support sanitary measures. The U.S. military may have to temporarily take over the repair and operation of a municipal water system until the local capability is restored. See the USACE website to obtain information on water resources, including dams, irrigation systems, and transmission systems (aqueducts and tunnels).

12-23. When drilling a water well, avoid drilling into the same aquifer that the local populace is using. This will eliminate the perception that the U.S. military is taking water from the local water supply.

BASE CAMP WATER SYSTEMS

12-24. Water systems include basic water supply and distribution systems for base camps, facilities, and buildings. A water supply system receives and purifies water and then moves it to a storage tank or distribution system. The water may come from a sustainment/combat service support unit distribution system or from a surface water or groundwater source. The water distribution system is an arrangement of connected pipes, control valves, pumps, and water heating equipment that carries the water to its destination.

12-25. When engineers or architects design a facility or building, they produce prints and specification plans that detail the types and quality of materials to be used in the plumbing systems. Plumbing systems must meet national plumbing code standards. The designer may provide a bill of materials, or a plumber may compile it. The AFCS also provides a bill of materials for standard facilities. Plumbers use the prints, specifications, and bill of materials to layout and plan the project. See TM 3-34.70 for the detailed planning and design of plumbing systems, including basic water supply and distribution systems, sewerage systems, hot-water supply systems, fire protection water systems, heating systems, and plumbing repair and maintenance techniques.

12-26. Planning and designing for the efficient use of water on fixed facilities reduces resources that could be best used for other operations. The efficient use of water includes using water-efficient fixtures in buildings, using storm water runoff, and recycling and reusing water.

12-27. AFCS and JCMS provide planning and design details for water production, distribution, and utility facilities. See ATP 4-44/MCRP 3-40D.14 for information on details of engineer support to sustainment/combat service support unit water production and distribution. See ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for water planning factors for base camps.

12-28. UFC 3-230-01 provides information on the design criteria for water storage, distribution, and transmission. Transmission systems convey water from the source to the treatment plant and to the distribution system. The water may be treated or untreated, depending on the location of the treatment plant. Transmission system types include pipelines, aqueducts, and tunnels. See UFC 3-230-03 for additional information on water treatment. See UFC 3-240-01 for design criteria for wastewater collection. See for design criteria for wastewater treatment. See UFC 3-240-01 for information on industrial and oily wastewater control. See TM 3-34.56/MCRP 3-40B.7 for details on waste management system design. See TM 3-34.70/MCRP 3-17.7E for details on plumbing system design. See UFC 3-230-02 for information on the O&M of water supply systems. See UFC 3-240-13FN for information on the O&M of wastewater treatment systems.

WATER PRODUCTION

12-29. Sustainment and engineer units contribute to water production to meet operational requirements. Water supply units produce potable water. Water distribution units distribute potable water. Preventive medicine personnel analyze, test, and certify water supplies. Together, these units ensure that there is enough quality water production and distribution to continuously support the forces.

12-30. Engineer units support water production by conducting tasks including—

- Building combat roads and trails to establish traffic control patterns at the distribution site.
- Connecting existing roads.
- Clearing, preparing, and maintaining the site.
- Constructing water storage and production sites.
- Constructing improvised dams for impounding small streams to obtain a steady source of water.
- Constructing gravel pads to ensure a steady platform for operating reverse osmosis water purification units.

- Constructing a brine pit (reverse osmosis water purification units support).
- Digging intake galleries along banks of streams.
- Improving drainage at the facility to prevent muddy conditions that may cause the area to become unstable or unsafe.
- Constructing pads for water storage blivets.
- Constructing or repairing troop bed-down, protection, antiterrorism, and maintenance facilities.
- Providing diving support for the emplacement and inspection of underwater utilities and offshore water hoses and pipelines.
- Rehabilitating damaged wells and distribution points.

12-31. Water-well drilling is provided to support water production. Well drilling may occur when—

- Surveys, analytical data, or hydrology studies confirm the likely presence of subsurface water in areas.
- Surface sources of water are inadequate (due to quantity or quality) to support the force. (This is likely to occur in arid terrain where the quantity of water required is high and surface sources are low.)
- The distribution system lacks the capacity to support the force. (Haul distances may be significantly reduced by a well that is drilled close to the consumer.)
- CBRN or other contamination is expected that would render surface sources unsafe.
- The mission is part of a humanitarian and civic assistance mission. A major portion of the world population lacks access to sufficient sources of potable water. This makes well drilling a decisive operation in stability or reconstruction and a critical part of the overall inform and influence activities.) See ATP 3-57.10 for more information on relief activities.

WATER DETECTION

12-32. The effective detection of groundwater sources is critical for successful well-drilling. Without proper analysis, the potential for finding an adequate source is less likely. Determining the most suitable sites to drill for groundwater falls primarily on geospatial teams and water detection response teams.

12-33. Geospatial teams use data from the worldwide water resources database, terrain products, field reconnaissance, geophysical surveys, and other geospatial products to recommend the best sites to conduct well-drilling. They also have the reachback capability to access experts at the Army Geospatial Center to obtain data and analysis from historical records and subject matter expertise to identify areas with a high potential for developing water supply sources. Geospatial teams are not equipped or trained for actual detection, only predictive analysis.

12-34. In unfamiliar terrain, well-drilling teams may drill exploratory test holes to detect groundwater, but this method is costly and time-consuming. It is only recommended if other water detection methods are not available or have been proven to be unsuccessful.

WELL-DRILLING OPERATIONS

12-35. Wells provide water to deployed forces. Well-drilling projects should be managed the same as any construction project. The well-drilling team commander must coordinate closely with the construction or operations officer of the higher headquarters unit to ensure timely reporting. Because well-drilling equipment is inherently large and heavy, engineers must ensure its mobility in areas with poor trafficability. As the team moves from project to project, the operations officer arranges the transfer of completed work to the user, movement to the new project site, and additional sustainment/logistics and security arrangements.

12-36. Well-drilling includes auxiliary activities that consist of exploratory drilling, soil and rock sampling, well installation monitoring, and construction and demolition support.

12-37. Drilling rigs are truck- or semitrailer-mounted. Current well-drilling and well completion equipment consists of a 600-foot, well-drilling system (referred to as the LP-12) that includes—

- A truck-mounted drilling machine.
- A truck-mounted tender vehicle.
- A lightweight, well completion kit (including accessories, supplies, and tools required for drilling a well).

12-38. The Army also uses the CF-15-S trailer-mounted, 1,500-foot, well-drilling machine and the 1,500-foot well completion kit. The LP-12 replaced the CF-15-S and 1,500-foot well completion kit, but the CF-15-S may still be forward-deployed for contingency operations.

12-39. The LP-12 can be deployed to anywhere in the world with minimal preparation and support equipment. With the completion kit, drillers can construct a well to a depth of 600 feet using mud, air, or a down-hole hammer equipped with or without foam injection. With the augmentation of an auxiliary 250-cubic-feet-per-minute air compressor, a drill pipe, and 400 feet of drilling stem, the LP-12 can drill to depths of 1,500 feet in a variety of soil conditions, using mud or drilling foam. Additional equipment includes casing elevators and slips, larger drill bits, and an additional drill stem. Well-drilling teams should ensure that they have the rig accessory kit for the LP-12 to be fully mission-capable. Although well-drilling systems can be deployed rapidly, they are thin-skinned vehicles and need protection when moving around the battlefield.

12-40. The LP-12 is—

- Air-transportable by a C-130, C-5, or C-17.
- Equipped for tie-down and air-lift during transport.
- Equipped for air percussion drilling and for rotary drilling with mud or air.
- Equipped to drill wells up to a depth of 600 feet.
- Adaptable for drilling to a depth of 1,500 feet.
- Truck-mounted for mobility.
- A three-mode, water transfer pumping system.

DISTRIBUTION

12-41. Sustainment and engineer units both support water distribution tasks. Sustainment units deliver water in packages, by line haul distribution in trucks, or by hose and pipelines. They distribute water to units, storage tanks, bulk distribution areas, and hoses or pipelines that connect to plumbing supplies.

12-42. The tactical water purification system provides the military with mobile, tactical water purification for a broad range of water sources to meet water requirements. The Army tactical water purification system configuration is mounted on a load handling system-compatible flat rack, while the Marine version is skid-mounted. The tactical water purification system platform can be efficiently transported by truck, marine vessel, or fixed-wing aircraft. Although the system is intended for use by the Army and Marines, it can also be used to provide potable water to civilian agencies or HNs during emergencies, disaster relief efforts, humanitarian efforts, and peacekeeping missions.

12-43. The tactical water purification system uses state-of-the-art reverse osmosis technology to produce 1,500 gallons of potable water per hour from any source, including freshwater, seawater, brackish water, and contaminated freshwater that contains nuclear, biological, and chemical agents. The tactical water purification system can be operated by a small crew and includes a pretreatment system, a chemical injection kit, a high-pressure pump, reserve osmosis elements, valves, piping, a wastewater collection system, an ocean intake system, and a storage tank system. See TM 10-4610-309-10 (Army)/TM 10802A-OI/1A Vol 1 (Marine Corps) for more information on the tactical water purification system. Engineer units plan, design, construct, and provide limited maintenance to water distribution systems internal to base camps and facilities. They also support sustainment/combat service support unit water distribution by planning, designing, constructing, and maintaining fixed distribution facilities, such as rigid storage tanks and pipelines. The water supply may come from existing sources, existing distribution systems, sustainment/combat service support units, or base camp water sources or wells. On a facility or installation, water is also called a utility. Distribution pipelines enter a building and become plumbing to the point of use; then they become waste collection systems to the point of storage, treatment, or recycling. Water distribution tasks include support to sustainment/combat service support units installing—

- Pipelines.
- Plumbing supplies.
- Pipe fittings.
- Sewage matter.

HOSES AND PIPELINES

12-44. Purified water enters the distribution system from onshore or offshore water sources. Most water supply units are equipped with two 10-mile segments of the tactical water distribution system. The tactical water distribution system is composed of hoses used to transport potable water from wells, desalination plants, and other sources over distances of less than 10 miles (per segment) to 20,000-gallon fabric storage tanks. The system is capable of transporting water forward up to 80 miles at a rate of 600 gallons per minute across level terrain. Sustainment unit water distribution is discussed in ATP 4-44/MCRP 3-17.7Q.

12-45. Engineers support the tactical water distribution system by providing horizontal and vertical work for distribution points, leveling water storage pads, and assisting with the emplacement of the hose system (including gap-crossing). The need to cross hard-surfaced roads and other obstacles requires engineers to install culverts or emplace suspension kits at various locations throughout the hose system. Engineers assist in water hose route selection, clearing, preparation, and maintenance.

PLUMBING, PIPE FITTING, AND SEWERAGE

12-46. Engineers support the life cycle of water, including plumbing, pipe fitting, and creating sumps for water collection for recycling. Plumbing systems include water supply methods, water distribution systems, plumbing fixtures, sewerage or waste systems, and recycling systems. See TM 3-34.70 for additional information on plumbing, pipe fitting, and sewerage.

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Appendix A
Base Camp Construction Planning Factors

This appendix provides engineers with basic, necessary, common planning factors and considerations for base camp construction. Use the information in this appendix for initial planning to estimate requirements if there is no other-directed planning guidance or theater-specific information provided. Additional information can be found in ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N), NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.5 (MCRP 3-17.7F), EP 1105-3-1, JP 3-34, the JCMS, FM 6-0, and other documents as identified throughout this appendix. See UFC 4-010-01 for planning factors used for the standoff and separation of facilities. See ATP 4-25.12 and TM 3-34.56/MCRP 3-40B.7 for standoff planning factors for waste management areas. Army Europe Regulation 420-100, *Standards for Base Camps* and Central Command Regulation 415-1, *The Sand Book*, are examples of CCDR guidance that provide very specific recommended minimum planning factors and construction standards for facilities within base camps. Ammunition holding area planning factors may be found in DA Pam 385-64. For medical facilities information, see the Health Facility Planning Agency website.

BASE CAMP PLANNING SUMMARY

A-1. The tables in this appendix do not show an extra small base camp; they show small (population 500 and 1,500), medium (population 3,000), and large (population 10,000) base camps. (ATP 3-37.10/MCRP 3-40D.13 (MCRP 3-17.7N) for additional information.)

A-2. Planners can interpolate and extend the planning factors to other base camp populations. These tables are intended to be used during the initial phase of planning for base camp construction and are not intended to be a substitute for the required detailed planning. Table A-1 and table A-2, page A-2, provide a summary of the engineer work effort and aggregate necessary for supported populations for indicated base camp populations.

Table A-1. Summary table—base camp engineer construction effort

Short Tons	*Equipment Hours*	*Man-Hours*			
		Horizontal	*Vertical*	*General*	*Total Man-Hours*
2,755	77	3,506	33,175	10,232	46,913
7,698	247	8,124	86,047	26,331	120,502
15,138	503	15,093	171,012	53,730	239,835
50,460	1,680	51,093	570,040	179,100	800,233

Table A-2. Summary table—base camp aggregate requirements

Base Camp Population	*Fine Aggregate, in Cubic Yards*	*Course Aggregate, in Cubic Yards*
500	450	620
1,500	1,700	2,485
3,000	3,320	4,820
10,000	11,200	16,066

GENERAL CONSTRUCTION EFFORT REQUIREMENTS

A-3. Table A-3 and table A-4 describe the general construction effort requirements for site preparation and basic facilities for a 500-man base camp.

Table A-3. Construction effort—site preparation requirements

Facility	*Size*	*Basis*	*Qty*	*Man-Hours*			
				Hor	*Ver*	*Gen*	*Total*
Road, Class A, 1-inch, multisurface, 1 mile	NA	As required	0.2	58	NA	10	68
Hardstand	1,000 sq yd	As required	4.0	168	NA	80	248
Road, Class A, graded, drained	NA	As required	0.2	235	NA	84	319
Hardstand	1,000 sq yd	As required	4.0	288	NA	104	392
Site prep, 1 acre	NA	As required	5.0	440	NA	160	600

Legend:

gen	general
hor	horizontal
NA	not applicable
prep	preparation
qty	quantity
sq yd	square yard(s)
ver	vertical

Table A-4. Construction effort—facilities requirements (temporary to semipermanent standard/temperate climate/wood frame)

Facility	*Size, in feet*	*Basis*	*Qty*	*Man-Hours*			
				Hor	*Ver*	*Gen*	*Total*
Shop, motor repair	48x48x14	1/100 veh	1	55	1,185	287	1,527
Storehouse	20x50x8	2 sq ft/man	1	32	461	136	629
Dispensary	20x60x8	1/500 men	1	33	1,290	115	1,438
Headquarters/unit supply	20x40x8	1/200 men	3	84	1,293	240	1,617
Barracks, 50-man	20x100x8	40 sq ft/man	10	450	7,510	1,860	9,820
Kitchen	Varies	1/250 men	2	154	10,352	3,788	14,294
Bathhouse/latrine	20x30x8	1 shower/10 men	1	24	941	61	1,026
Bathhouse/latrine	20x80x8	1 shower/24 men	1	39	1,754	150	1,943
Quarters (office)	20x100x8	80 sq ft/office	1	45	869	186	1,100
Guardhouse	20x60x8	1–250 men	1	33	626	115	774
Dayroom	40x60x8	5 sq ft/man	1	43	868	178	1,089
Power system	500 man	light/power	1	56	460	192	708
Boiler plant	Varies	1/2 dining/1/2 sleeping	1	208	4,112	1,200	5,520
Drainage	500 man	17.5 gpd	1	205	384	490	1,079
Water supply well	Varies	As required	1	396	45	230	671
Water tank	200 gal	As required	1		105	4	109
Water distribution	500 man	25 gpd/man	1	352	812	416	1,580
Sump fire	10,000 gal	effective radius, 500 feet	1	16	108	16	240

Legend:

gal	gallon(s)
gen	general
gpd	gallons per day
Hor	horizontal
qty	quantity
sq ft	square foot (feet)
veh	vehicle
Ver	vertical

SUPPORT AND STORAGE FACILITIES CONSTRUCTION PLANNING FACTORS

A-4. Table A-5, page A-4, and table A-6, page A-4, provide construction planning information on motor parks and Personnel or Marine support facilities.

Table A-5. Motor park

Base Camp Population	*Area in Square Feet*
500	61,760
*1,500	242,160
*3,000	541,200
*10,000	721,600
*Based on combinations of 500-man, 1,000-man, and 5,000-man estimates.	

Table A-6. Soldier or Marine support facilities

Facility	*Criteria*	*Population*			
		500	***1,500***	***3,000***	***10,000***
Dining	sq ft/person varies by unit size	NA	NA	NA	NA
Fire station	2.6 x size of vehicle + 90 sq ft	NA	NA	NA	NA
Detainee	250 sq ft/MP + 50 sq ft/confinee	NA	NA	NA	NA
Bakery	0.6 sq ft/person supported	300	900	1800	6000
Laundry	sq ft/person varies by unit size	4.4	4.4	3.3	3.0
Dry cleaning	sq ft/person varies by unit size	4.4	4.4	1.75	1.0
Chapel	1.785 sq ft/person	893	2,678	5,55	17,850
Craft/hobby	1 sq ft/person	500	1,500	3,000	10,000
Gymnasium	3.3 sq ft/person	1650	4,950	9,900	33,000
Library	0.75 sq ft/person	375	1,125	2,250	7,500
Service club	7.5 sq ft/NCO; 9.5 sq ft/officer	NA	NA	NA	NA
Post exchange	1.2 sq ft/person	600	1,800	3,600	12,000
Post office	sq ft/person varies by unit size	NA	NA	0.5	0.5
Theater	sq ft/person varies by unit size	NA	NA	5.5	5.5
Legend: NA not applicable					

A-5. Table A-7, table A-8, and table A-9 provide examples of selected storage requirements planning factors for base camps.

Table A-7. Covered/open storage requirements for 14 days of stockage

Base Camp Population	*Covered Storage, in Square Feet*	*Open Storage, in Square Yards*
500	44	1,330
1,500	132	3,990
3,000	265	7,980
10,000	882	26,600

Table A-8. Cold storage requirements for 14 days of stockage

Base Camp Population	*Class I, in Cubic Feet*	*Class VI, in Cubic Feet*	*Class VIII, in Cubic Feet*	*Class IX, in Cubic Feet*
500	585	155	34	12
1,500	1,755	465	101	36
3,000	3,510	930	202	72
10,000	11,690	3,095	672	238

Table A-9. Fuel storage

Base Camp Population	*F-24/JP-8* (Barrels)*	*MOGAS* (Barrels)*
500	1,980	4
1,500	5,940	12
3,000	11,880	24
10,000	39,600	80
*Assuming a stock objective of 8 days.		
Legend: F fuel JP jet petroleum MOGAS motor gasoline		

SOLDIER OR MARINE HOUSING

A-6. Table A-10, table A-11, and table A-12, page A-6, provide basic planning guidance for Service member housing.

Table A-10. Service member housing

Base Camp Population	*Officer, in Square Feet*	*Enlisted, in Square Feet*
500	11,000	28,800
1,500	33,000	86,400
3,000	66,000	172,800
10,000	220,000	576,000
Note. Assumes 20/80 officer to enlisted ratio, 110 square feet/officer, and 72 square feet/enlisted.		

Table A-11. Quality-of-life standards for tentage

Tier Level	*Bed-Down and Base Camp Living Standards*
Tier I	Simple tent setup without floor, nonpermanent
Tier II	Wood floor, lights, pole-supported, two electrical outlets
Tier III	Slightly nicer wood floor, two-thirds wooden wall structure with frame, more than two electrical outlets

Table A-12. Selected tentage planning factors

Tent Type	*Floor Area, in Square Feet*	*Weight, Packed, in Pounds*	*Volume, Packed, in Cubic Feet*
Tent, GP, small	198.9	163	26.2
Tent, GP, medium[1]	512.0	534	33.0
Tent, GP, large	936.0	665	69.0
Tent, expandable modular (temper)	640.0	2,192	200.0
Tent, maintenance, medium	640.0	1,798	62.0
[1]The Operation Joint Endeavor living standard was 10 Soldiers or Marines per each GP, medium, tent.			
LEGEND: GP general purpose			

ADDITIONAL PLANNING CONSIDERATIONS

A-7. Table A-13 and table A-14 provide general planning factors for water, utilities, and transportation requirements.

Table A-13. General planning factors for potable and nonpotable water requirements

Consumer	*Rate of Consumption*	*Remarks*
Individual	3–6 gpd/per man	NA
Base camp (basic-enhanced)	20–50 gpd/per man	Include waterborne sewage
Vehicles (tactical)	1/2–1 gpd/per vehicle	NA
Support Facilities		
Hospital	200 gpd/per bed	20-hour operation
QM laundry company	64,000 gpd	20-hour operation
Construction Equipment		
Road construction	10,000 g/km	Nonpotable, clean
Rockcrusher	22,500 gph	Nonpotable, clean
Concrete mixer	560 gph/140 gph	Nonpotable, clean
Other Considerations		
Sewage treatment requirements	2.5 gpd/per man	Nonpotable, clean
LEGEND: g/km gallons per kilometer gpd gallons per day gph gallons per hour QM quartermaster		

Table A-14. Selected transportation information

Air[1]			*Sea*		*Land*			
Aircraft	***Allow-able Cabin Load, in pounds***	***Allow-able, in Cubic Feet***	***Ship/ Barge Type***	***Capacity, in Long Tons***	***Motor Vehicle***	***Load, in Short Tons***	***Rail[2]***	***Usable Cube***
C-5A	204,000	18,368	7,029	2,207.8	2.5-ton	2.5	Well flatcar	50 short tons
C-130	35,000	2,818	7,005	570.0	12-ton S&P	12.0	Small flatcar	12 short tons
C-17	167,000	NA	231A	585.0	22.5-ton flatbed	15.0	Boxcar	10 short tons
KC-10A	169,350	12,980	231B	578.0	34-ton trailer	25.0	Coach	40 pax
B-747	180,000	NA	2,001	24/24 pax	60-ton tractor-trailer	40.0	Sleeper	32 pax

[1]Estimates are for peacetime payload planning.

[2]The maximum length of a train is 40 cars; the maximum net load of a train is 400 tons or 1,000 Soldiers or Marines.

LEGEND:

NA	not applicable
pax	passengers
S&P	stake and platform

SUMMARY

A-8. The preliminary estimate performed when planning for base camp construction should contain the following:

- Real estate required, in square feet or meters.
- Equipment hours required for construction.
- Man-hours required for construction, by construction skill.
- Materiel requirements, in short tons.
- Detailed cost estimate to allow a cost comparison of one or more base camp concept designs.

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Glossary

The glossary lists acronyms and terms with Army or joint definitions. Where Army and joint definitions differ, (Army) precedes the definition. Terms for which ATP 3-34.40 is the proponent are marked with an asterisk (*). The proponent publication for other terms is listed in parentheses after the definition.

SECTION I – ACRONYMS AND ABBREVIATIONS

ADR	airfield damage repair
AFCS	Army Facilities Components System
AOR	area of responsibility
ASCC	Army Service component command
BCT	brigade combat team
BLT	battalion landing team
CAAF	contractors authorized to accompany the force
CBRN	chemical, biological, radiological, and nuclear
CCDR	combatant commander
COA	course of action
DA	Department of the Army
DD	Department of Defense (form)
DOD	Department of Defense
DODD	Department of Defense directive
DODI	Department of Defense instruction
DSCA	defense support of civil authorities
EAB	echelons above brigade
EBS	environmental baseline survey
OESHA	occupational and environmental health site assessment
EP	engineer pamphlet
ETL	engineering technical letter
G-3	assistant chief of staff, operations
G-4	assistant chief of staff, logistics
G-9	assistant chief of staff, civil affairs operations
HAZMAT	hazardous material
JCMS	Joint Construction Management System
JFC	joint force commander
JLOTS	joint logistics over-the-shore
JOA	joint operations area
JTF	joint task force
LOTS	logistics over-the-shore

MAGTF	Marine air-ground task force
MCCC	Marine Corps component commands
MCPP	Marine Corps Planning Process
MDMP	military decision-making process
MOG	maximum (aircraft) on ground
MSCoE	Maneuver Support Center of Excellence
MSR	main supply route
NAVFAC	Naval Facilities Engineering Systems Command
NTTP	Navy tactics, techniques, and procedures
NWP	Navy warfare publication
O&M	operation and maintenance
OPLAN	operation plan
OPNAVINST	Chief of Naval Operations instruction
OPORD	operation order
Prime BEEF	prime base engineer emergency force
RED HORSE	rapid engineer deployable heavy operational repair squadron engineer
S-3	battalion or brigade operations staff officer (USA); operations and training officer/operations and training office (USMC)
SECNAVINST	Secretary of the Navy instruction
TB MED	technical bulletin (medical)
TC	training circular
TEC	theater engineer command
TM	technical manual
TSPWG	Tri-Service Pavement Working Group
TWPS	Tactical Water Purification System
UFC	Unified Facilities Criteria
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USCENTCOM	United States Central Command
USMC	United States Marine Corps

SECTION II – TERMS

This section contains no entries.

References

All websites accessed on 12 December 2022.

REQUIRED PUBLICATIONS

These documents must be available to the intended users of this publication.

DOD Dictionary of Military and Associated Terms. November 2022.

FM 1-02.1. *Operational Terms*. 9 March 2021.

FM 1-02.2. *Military Symbols*. 18 May 2022.

Marine Corps Supplement to the DOD Dictionary of Military and Associated Terms. 12 February 2018 (as amended through 10 September 2020).

RELATED PUBLICATIONS

These documents contain relevant supplemental information.

DEPARTMENT OF DEFENSE AND JOINT PUBLICATIONS

Most Department of Defense publications are available online at https://www.esd.whs.mil/DD/. Most joint publications are available online at http://www.jcs.mil/doctrine/.

CJCSM 3130.03A. *Planning and Execution Formats and Guidance.* 25 November 2014.

CJCSM 3500.04F. *Universal Joint Task Manual.* 1 June 2011.

Contingency Contracting. *Defense Contingency Contracting Handbook*. April 2017.

https://www.acq.osd.mil/asda/dpc/cp/cc/ctr-handbook.html.

DODD 3025.18. *Defense Support of Civil Authorities (DSCA).* 29 December 2010.

DODD 4165.06. *Real Property.* 19 July 2022.

DODD 4270.05. *Military Construction.* 12 February 2005.

DODD 4705.01E. *Management of Land-Based Water Resources in Support of Contingency Operations*. 3 June 2015.

DODI 4165.03. *DOD Real Property Categorization.*5 January 2023.

DODI 3025.21. *Defense Support of Civilian Law Enforcement Agencies.* 27 February 2013.

DODI 4715.19. *Use of Open-Air Burn Pits in Contingency Operations*. 13 November 2018.

DODI 4715.22. *Environmental Management Policy for Contingency Locations*. 18 February 2016.

JP 1 Vol 1. *Joint Warfighting*. 29 June 2020.

JP 2-0. *Joint Intelligence*. 26 May 2022.

JP 3-0. *Joint Campaigns and Operations*. 18 June 2022.

JP 3-05. *Joint Doctrine for Special Operations*. 22 September 2020.

JP 3-07. *Joint Stabilization Activities*. 11 Feb 2022.

JP 3-10. *Joint Security Operations in Theater.* 25 July 2019.

JP 3-15. *Barriers, Obstacles, and Mine in Joint Operations*. 26 May 2022.

JP 3-18. *Joint Forcible Entry Operations*. 27 June 2018.

JP 3-24. *Counterinsurgency*. 25 April 2018

JP 3-26. *Joint Combating Terrorism*. 30 July 2020.

JP 3-27. *Homeland Defense*. 10 April 2018.

JP 3-28. *Defense Support of Civil Authorities*. 29 October 2018.

JP 3-29. *Foreign Humanitarian Assistance*. 14 May 2019

JP 3-34. *Joint Engineer Operations*. 6 January 2016.

JP 3-36. *Joint Air Mobility and Sealift Operations*. 4 January 2021.

JP 4-0. *Joint Logistics.* 4 February 2019.

JP 4-09. *Distribution Operations*. 14 March 2019.

JP 4-10. *Operational Contract Support*. 4 March 2019.

JP 4-18. *Joint Terminal and Joint Logistics Over-the-Shore Operations*. 5 December 2022.

JP 5-0. *Joint Planning*. 1 December 2020.

ARMY

Unless otherwise indicated, Army publications are available online: https://armypubs.army.mil/.

ADP 3-0. *Operations*. 31 July 2019.

ADP 3-07. *Stability*. 31 July 2019.

ADP 3-28. *Defense Support of Civil Authorities.* 31 July 2019.

ADP 3-37. *Protection*. 31 July 2019.

ADP 3-90. *Offense and Defense*. 31 July 2019.

ADP 4-0. *Sustainment*. 31 July 2019.

ADP 5-0. *The Operations Process*. 31 July 2019.

ADP 6-0. *Mission Command: Command and Control of Army Forces*. 31 July 2019.

AR 190-8. *Enemy Prisoners of War, Retained Personnel, Civilian Internees and Other Detainees*. 1 October 1997.

AR 200-1. *Environmental Protection and Enhancement.* 13 December 2007

AR 210-20. *Real Property Master Planning for Army Installations.* 16 May 2005.

AR 385-10. *The Army Safety Program.* 24 February 2017.

AR 405-10. *Acquisition of Real Property and Interests Therein*. 14 May 1970.

AR 405-45. *Real Property Inventory Management*. 1 November 2004.

AR 405-90. *Disposal of Real Property*. 08 June 2020.

AR 415-16. *Army Facilities Components System*. 5 January 2018.

AR 420-1. *Army Facilities Management*. 12 February 2008.

AR 700-136. *Tactical Land-Based Water Resources Management*. 5 June 2009.

ATP 3-11.50. *Battlefield Obscuration*. 15 May 2014.

ATP 3-28.1/MCRP 3-30.6/NTTP 3-57.2/AFTTP 3-2.67/CGTTP 3-57.1. *Multi-Service Tactics, Techniques, and Procedures for Defense Support of Civil Authorities (DSCA)*. 11 February 2021.

ATP 3-34.5/MCRP 3-40B.2 (MCRP 4-11B), *Environmental Considerations*. 10 August 2015.

ATP 3-34.22. *Engineer Operations–Brigade Combat Team and Below*. 14 April 2021.

ATP 3-34.45/MCRP 3-40D.17. *Electric Power Generation and Distribution*. 6 July 2018.

ATP 3-34.80. *Geospatial Engineering*. 22 February 2017.

ATP 3-34.81/MCRP 3-34.3 (MCWP 3-17.4). *Engineer Reconnaissance*. 1 March 2016.

ATP 3-34.84/MCRP 3-10.2 [3-35.9A]/NTTP 3-07.7/AFTTP 3-2.75/ CGTTP 3-95.17. *Multi-Service Tactics, Techniques, and Procedures for Military Diving Operations.* 2 Jan 2019.

ATP 3-37.10/MCRP 3-40D.13. *Base Camps*. 27 January 2017.

ATP 3-37.34/MCTP 3-34C. *Survivability Operations*. 16 April 2018.

ATP 3-39.30. *Security and Mobility Support*. 21 May 2020

ATP 3-39.32. *Physical Security.* 8 March 2022.

ATP 3-57.10. *Civil Affairs Support to Populace and Resource Control*. 6 August 2013

ATP 3-90.4/MCTP 3-34A. *Combined Arms Mobility Operations*. 10 June 2022.

ATP 3-90.8/MCTP 3-34B. *Combined Arms Countermobility*. 30 November 2021.

ATP 3-90.97. *Mountain Warfare and Cold Weather Operations*. 29 April 2016

ATP 3-90.98/MCTP 12-10C. *Jungle Operations.* 24 September 2020.

ATP 3-90.99/MCTP 12-10D. *Desert Operations*. 7 April 2021

ATP 4-0.1. *Army Theater Distribution*.29 October 2014.

ATP 4-10/MCRP 4-11H/NTTP 4-09.1/AFMAN 10-409-O. *Multi-Service Tactics, Techniques, and Procedures for Operational Contract Support*. 16 December 2021.

ATP 4-12. *Army Container Operations*. 12 February 2021.

ATP 4-13. *Army Expeditionary Intermodal Operations*. 16 April 2014.

ATP 4-14. *Expeditionary Railway Center Operations.* 22 June 2022.

ATP 4-25.12. *Unit Field Sanitation Teams.* 30 April 2014.

ATP 4-35. *Munitions Operations.* 31 January 2023.

ATP 4-35.1. *Ammunition and Explosives Handler Safety Techniques*. 8 November 2021.

ATP 4-43. *Petroleum Supply Operations*. 18 April 2022.

ATP 4-44. *Water Support Operations*. 16 December 2022.

ATP 4-45. *Force Provider Operations*. 24 November 2014.

ATP 4-93. *Sustainment Brigade.* 11 April 2016.

ATP 5-19. *Risk Management*. 9 November 2021.

DA Pam 385-1. *Small Unit Safety Officer/Noncommissioned Officer Guide*. 23 May 2013.

DA Pam 385-10. *Army Safety Program.* 23 May 2008.

DA Pam 385-26. *The Army Electrical Safety Program*. 1 February 2013.

DA Pam 385-64. *Ammunition and Explosives Safety Standards*. 24 May 2011.

FM 3-07. *Stability*. 2 June 2014.

FM 3-34. *Engineer Operations*. 18 December 2020.

FM 3-39. *Military Police Operations*. 9 April 2019.

FM 3-63. *Detainee Operations*. 2 January 2020.

FM 3-90-1. *Offense and Defense, Volume I*. 22 March 2013.

FM 4-01. *Army Transportation Operations.* 3 April 2014.

FM 5-0. *Planning and Orders Production.* 16 May 2022.

FM 6-0. *Commander and Staff Organization and Operations*. 16 May 2022.

FM 6-27/MCTP 11-11C. *The Commander's Handbook on the Law of Land Warfare*. 7 August 2019.

GTA 90-01-011. *Deployed Forces Protection Handbook*. 1 July 2019. https://rdl.train.army.mil/catalog/dashboard.

GTA 90-01-045. *Flight Landing Strip Assessment, Clearance, and Repair.* 1 August 2013

TB MED 577/NAVMED P-5010-10/AFMAN 48-138_IP. *Sanitary Control and Surveillance of Field Water Supplies*. 1 May 2010.

TC 4-02.3. *Field Hygiene and Sanitation*. 6 May 2015.

TM 3-34.22/MCRP 3-17.1B. *Military Nonstandard Fixed Bridging.* 17 October 2013.

TM 3-34.30. *Firefighting*. 23 April 2015.

TM 3-34.43/MCRP 3-17.7H/NAVFAC MO 330/AFMAN 32-1034_IP, *Materials Testing*, 3 April 2015

TM 3-34.44/MCRP 3-40D.4. *Concrete and Masonry*. 23 July 2012.

TM 3-34.46/MCRP 3-17.7K. *Theater of Operations Electrical Systems*. 3 May 2013.

TM 3-34.47/MCRP 3-40D.3. *Carpentry*. 29 July 2022.

TM 3-34.48-1, *Theater of Operations: Roads, Airfields, and Heliports—Road Design*, 29 February 2016.

TM 3-34.48-2, *Theater of Operations: Roads, Airfields, and Heliports—Airfield and Heliport Design*, 29 February 2016

TM 3-34.51. *Construction Drafting.* 15 June 2012.

TM 3-34.55. *Construction Surveying.* 3 August 2012.

TM 3-34.56/MCRP 3-40B.7. *Waste Management for Deployed Forces*. 29 March 2019.

TM 3-34.61. *Geology*. 12 February 2013.

TM 3-34.62/MCRP 3-17.7I. *Earthmoving Operations*. 29 June 2012.

TM 3-34.63. *Paving and Surfacing Operations*. 13 August 2013.

TM 3-34.65/NTRP 4-04.2.12/AFMAN 10-903. *Quarry Operations.* 30 October 2013.

TM 3-34.70/MCRP 3-17.7E. *Plumbing, Pipe Fitting, and Sewerage*. 23 July 2012.

TM 3-34.72. *Pile Construction.* 15 November 2013.

TM 3-34.73. *Port Construction and Repair*. 4 January 2013.

TM 3-34.82/MCRP 3-17.7L. Explosives and Demolitions. 7 March 2016.

TM 3-34.83. *Engineer Diving Operations*. 2 August 2013.

TM 3-34.85/MCRP 3-17A. *Engineer Field Data.* 17 October 2013.

TM 5-300. *Real Estate Operations in Oversea Commands*. 10 December 1958.

TM 5-301-1. *Army Facilities Components System–Planning (Temperate).* 27 June 1986.

TM 5-301-2. *Army Facilities Components System–Planning (Tropical).* 27 June 1986.

TM 5-301-3. *Army Facilities Components System–Planning (Frigid).* 27 June 1986.

TM 5-301-4. *Army Facilities Components System–Planning (Desert).* 27 June 1986.

TM 5-302-1. *Army Facilities Components System: Design.* 28 September 1973.

TM 5-303. *Army Facilities Components System–Logistic Data and Bills of Materiel.* 1 June 1986.

TM 5-304. *Army Facilities Components System User Guide*. 1 October 1990.

TM 5-610. *Preventive Maintenance Facilities Engineering Buildings and Structures*. 1 November 1979.

TM 5-622/NAVY MO-104/AFM 91-34. *Maintenance of Waterfront Facilities*. 1 June 1978.

TM 5-626. *Unsurfaced Road Maintenance Management*. 16 January 1995.

TM 5-682. *Facilities Engineering Electrical Facilities Safety*. 8 November 1999.

TM 5-683/NAVFAC MO-116/AFJMAN 32-1083. *Facilities Engineering Electrical Interior Facilities*. 30 November 1995.

TM 5-684/NAVFAC MO-200/AFJMAN 32-1082. *Facilities Engineering Electrical Exterior Facilities*. 29 November 1996.

TM 5-803-5/NAVFAC P-960/AFM 88-43. *Installation Design*. 1 March 1981.

TM 5-811-6. *Electric Power Plant Supply*. 20 January 1984.

TM 5-814-7. *Hazardous Waste Land Disposal/Land Treatment Facilities.* 29 November 1984.

TM 5-818-1/AFM 88-3, chapter 7. *Soils and Geology Procedures for Foundation Design of Buildings and Other Structures (Except Hydraulic Structures).* 21 October 1983.

TM 5-818-7. *Foundations in Expansive Soils*. 1 September 1983.

TM 5-818-8/AFJMAN 32-1030. *Engineering Use of Geotextiles*. 20 July 1995.

TM 5-820-1/AFM 88-5, chapter 1. *Surface Drainage Facilities for Airfields and Heliports*. 20 August 1987.

TM 5-822-14/AFJMAN 32-1019. *Soil Stabilization for Pavements*. 25 October 1994.

TM 5-850-1. *Engineering and Design of Military Ports*. 15 February 1983.

TM 5-852-1/AFR 88-19, Volume 1. *Arctic and Subarctic Construction General Provisions*. 4 September 1987.

TM 5-852-2/AFR 88-19, Volume 2. *Arctic and Subarctic Construction Site Selection and Development*. 21 May 1990.

TM 5-852-3. *Arctic and Subarctic Construction for Runway and Road Design*. 29 October 1954.

TM 5-852-4/AFM 88-19, chapter 4. *Arctic and Subarctic Construction Foundations for Structures*. 15 October 1983.

TM 5-852-5/AFR 88-19, Volume 5. *Arctic and Subarctic Construction Utilities*. 31 August 1987.

TM 5-852-6/AFR 88-19, Volume 6. *Arctic and Subarctic Construction Calculation Methods for Determination of Depths of Freeze and Thaw in Soils*. 25 January 1988.

TM 5-5420-278-10. *Operator's Manual for Improved Ribbon Bridge (IRB)*. 23 November 2015.

TM 5-5420-279-10. *Operator's Manual for Dry Support Bridge (DSB).* 10 May 2004.

TM 10-4610-309-10 (Army)/TM 10802A-OI/1A Vol 1 (Marine Corps). *Operator Manual for Tactical Water Purification System (TWPS).* 15 May 2008.

AIR FORCE

Most Air Force doctrinal publications are available online at http://www.e-publishing.af.mil/.

AFMAN 91-201. *Explosives Safety Standards.* 28 May 2020.

AFPAM 10-219 V5. *Bare Base Conceptual Planning.* 30 March 2012.

AFPAM 10-1403. *Air Mobility Planning Factors.* 23 October 2018.

Air Force Doctrine Publication 3-34. *Engineer Operations.* 6 October 2021. https://doctrine.af.mil/DTM/dtmengineerops.htm.

FACILITIES CRITERIA

Most Facilities Criteria documents are available online at www.wbdg.org/ccb/browse_cat.php?c=4.

FC 1-300-09N. *Navy and Marine Corps Design Procedures.* 1 May 2014.

TSPWG M 3-270-01.3-270-07. *O&M: Airfield Damage Repair*. 21 May 2020

UFC 1-200-02. *High Performance and Sustainable Building Requirements*. 1 December 2020

UFC 1-201-01. *Non-Permanent DOD Facilities in Support of Military Operations.* 04 March 2022.

UFC 1-300-08. *Criteria for Transfer and Acceptance of DoD Real Property*. 16 April 2009.

UFC 2-000-05N. *Facility Planning for Navy and Marine Corps Shore Installations*. 15 June 2021.

UFC 2-100-01. *Installation Master Planning*. 30 September 2020.

UFC 3-230-01. *Water Storage, Distribution, and Transmission*. 1 September 2018.

UFC 3-230-02. *Operation and Maintenance: Water Supply Systems*. 10 December 2019.

UFC 3-230-03. *Water Treatment*. 1 November 2012.

UFC 3-240-01. *Wastewater Collection*. 1 May 2020.

UFC 3-240-11. *Landfills in Support of Military Operations*. 24 March 2021.

UFC 3-240-13FN. *Industrial Water Treatment Operation and Maintenance*. 25 May 2005.

UFC 3-250-01. *Pavement Design for Roads and Parking Areas*. 14 November 2016.

UFC 3-250-03. *Standard Practice Manual for Flexible Pavements*. 30 May 2018.

UFC 3-250-04. *Standard Practice for Concrete Pavements*. 16 January 2004.

UFC 3-250-08FA. *Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements*. 16 January 2004.

UFC 3-250-09FA. *Aggregate Surfaced Roads and Airfields Areas*. 16 January 2004.

UFC 3-250-11. *Soil Stabilization and Modifications for Pavements*. 30 November 2020.

UFC 3-260-01. *Airfield and Heliport Planning and Design*. 4 February 2019.

UFC 3-260-02. *Pavement Design for Airfields*. 30 June 2001.

UFC 3-260-03. *Airfield Pavement Evaluation*. 15 April 2001.

UFC 3-260-17. *Dust Control for Roads, Airfields, and Adjacent Areas*. 22 May 2018.

UFC 3-270-01. *O&M Manual: Asphalt and Concrete Pavement Maintenance and Repair*. 21 February 2018.

UFC 3-270-08. *Pavement Maintenance Management*. 16 January 2004.

UFC 3-310-08. *Non-Expeditionary Bridge Inspection, Maintenance, and Repair.* 17 July 2018.

UFC 3-501-01. *Electrical Engineering*. 6 October 2015.

UFC 3-520-01. *Interior Electrical Systems*. 6 October 2015.

UFC 3-550-01. *Exterior Electrical Power Distribution*. 1 September 2016.

UFC 3-560-01. *Operation and Maintenance: Electrical Safety*. 24 July 2017.

UFC 3-600-01. *Fire Protection Engineering for Facilities*. 6 May 2021.

UFC 3-601-02. *Operation and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems*. 7 October 2021.

UFC 4-010-01. *DoD Minimum Antiterrorism Standards for Buildings*. 12 December 2018.

UFC 4-010-03. *Security Engineering: Physical Security Measures for High-Risk Personnel*. 8 February 2011.

UFC 4-010-05. *Sensitive Compartmented Information Facilities Planning, Design, and Construction*. 1 February 2013.

UFC 4-020-01. *DoD Security Engineering Facilities Planning Manual*. 11 September 2008.

UFC 4-020-03FA. *Security Engineering: Final Design (FOUO)*. 1 March 2005.

UFC 4-021-01. *Design and O&M: Mass Notification Systems*. 9 April 2008.

UFC 4-021-02. *Electronic Security Systems*. 1 October 2013.

UFC 4-022-01. *Security Engineering: Entry Control Facilities/Access Control Points*. 27 July 2017.

UFC 4-022-02. *Selection and Application of Vehicle Barriers*. 8 June 2009.

UFC 4-023-03. *Design of Buildings to Resist Progressive Collapse*. 1 Nov 2016.

UFC 4-023-07. *Design to Resist Direct Fire Weapons Effects*. 7 July 2008.

UFC 4-024-01. *Security Engineering: Procedures for Designing Airborne Chemical, Biological, and Radiological Protection for Buildings*. 1 February 2017.

UFC 4-025-01. *Security Engineering: Waterfront Security*. 1 November 2012.

UFC 4-141-10. *Design: Aviation Operation and Support Facilities*. 22 September 2022.

UFC 4-150-02. *Dockside Utilities for Ship Service*. 12 November 2020.

UFC 4-150-06. *Military Harbors and Coastal Facilities*. 19 October 2010.

UFC 4-150-07. *Maintenance and Operation: Maintenance of Waterfront Facilities*. 19 June 2001.

UFC 4-150-08. *Mooring Hardware Inspection*. 28 October 2020.

UFC 4-151-10. *General Criteria for Waterfront Construction*. 10 September 2001.

UFC 4-152-01. *Design: Piers and Wharves*. 24 January 2017.

UFC 4-440-01. *Warehouses and Storage Facilities*. 1 April 2019

UFC 4-860-01. *Railroad Design and Rehabilitation*. 23 June 2022.

UFC 4-860-03. *Railroad Track Maintenance and Safety Standards*. 13 February 2008

Marine Corps

Most Marine Corps doctrinal publications are available online: https://www.marines.mil/News/Publications.aspx

MCIP 3-03.1i/NWP 3-07/COMDTINST M3120.11. *Maritime Stability Operations.* 25 May 2012.

MCO 3440.7C. *Marine Corps Roles and Responsibilities in Defense Support of Civil Authorities (DSCA).* 15 May 2019

MCWP 3-34. *Engineering Operations.* 14 February 2000.

MCWP 5-10. *Marine Corps Planning Process*. 10 August 2020.

Navy

Most Navy doctrinal publications are available online at https://doctrine.navy.mil. (Requires DOD-approved certificate login.).

NAVFAC MO-213/AFR 91-8/TM 5-634. *Solid Waste Management.* 1 May 1990.

NAVFAC P-73, *Real Estate Procedural Manual.* 10 September 2014. http://www.navfac.navy.mil/products_and_services/am/about_us/resources.html.

NAVSEA OP-5 Volume 1, Ammunition and Explosive Safety Ashore. July 2017.

NAVSEA OP-5 Volume 3, Ammunition and Explosive Safety Ashore for Contingencies, Combat Operations, Military Operations Other Than War, and Associated Training. April 2007.

NTRP 4-02.9/AFTTP 3-2.82_IP/ATP 4-02.82, *Occupational and Environmental Health Site Assessment*, April 2012

NTRP 4-04.2.3/TM 3-34.41/MCRP 3-40D.12. *Construction Estimating*, October 2021.

NTRP 4-04.2.5/TM 3-34.42/AFPAM 32-1020/MCRP 3-40D.6 (MCRP 3-17.7F). *Construction Project Management.* December 2012.

NTRP 4-04.2.13/TM 3-34.469/AFMAN 32-1072. *Water-Well Drilling Operations.* 1 December 2008.

NTTP 3-02.1M/MCTP 13-10E. *Ship-to-Shore Movement*. October 2018.

NTTP 3-10.1M/MCTP 3-34D. *Seabee Operations in the Marine Air-Ground Task Force (MAGTF)*. March 2015.

NTTP 4-04.3. *Naval Contingency Engineering Operations*. December 2008.

NWP 4-0M/MCTP 13-10K. *Naval Logistics*. March 2020.

NWP 4-04. *Naval Civil Engineering Operations*. December 2007.

OPNAVINST 11010.20H. *Navy Facilities Projects.* 24 June 2015.

SECNAVINST 11011.47C. *Acquisition, Management, and Disposal of Real Property and Real Property Interests by the Department of the Navy.* 26 June 2019.

SS521-AG-PRO-010. *U.S. Navy Diving Manual*. 1 December 2016. http://www.supsalv.org/pdf/Dive%20Manual%20Rev%206%20with%20Chg%20A.pdf.

TACMEMO 4-04.2-22, Expeditionary Rapid Airfield Damage Repair. August 2022.

Other Publications

These publications are available at http://uscode.house.gov/. United States Law publications are available at https://www.ecfr.gov/.

10 USC. *Armed Forces.* http://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title10-front&num=0&edition=prelim.

10 USC 2801. *Armed Forces, General Military Law.* http://uscode.house.gov/view.xhtml?req=(title:10 section:2801 edition:prelim).

32 USC. *National Guard.* http://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title32-front&num=0&edition=prelim.

49 USC 10901. *Transportation, Interstate Transportation.* http://uscode.house.gov/view.xhtml?req=(title:49 section:10901 edition:prelim).

40 CFR 261.2. *Protection of the Environment.* http://www.ecfr.gov/cgi-bin/text-idx?SID=06350259669347fcd740addc950ae27f&node=pt40.26.261&rgn=div5#se40.26.261_12.

Convention for the Protection of Cultural Property in the Event of Armed Conflict. The Hague. http://www.icrc.org/ihl/INTRO/400.

Convention (III) relative to the Treatment of Prisoners of War. Geneva. http://www.icrc.org/ihl/INTRO/375?OpenDocument.

Convention (IV) relative to the Protection of Civilian Persons in Time of War. Geneva. http://www.icrc.org/applic/ihl/ihl.nsf/385ec082b509e76c41256739003e636d/6756482d86146898c125641e004aa3c5.

Convention (IV) respecting the Laws and Customs of War on Land and its annex: Regulations concerning the Laws and Customs of War on Land. The Hague. http://www.icrc.org/applic/ihl/ihl.nsf/385ec082b509e76c41256739003e636d/1d1726425f6955aec125641e0038bfd6.

EM 385-1-1. *Safety and Health Requirements - English.* 30 November 2014. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_385-1-1.pdf?ver=7Cpck_22Ct_-w6QSGyOKVQ%3d%3d.

Emergency Support Function #3–Public Works and Engineering Annex. http://www.usda.gov/documents/ESF03.pdf.

EP 415-1-261. *Quality Assurance Representative's Guide - Architectural and Structural Features in Building Construction -Vol 3*. 1 August 1992. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_415-1-261_Vol-03.pdf?ver=rSykHTmMOXnwemHAD0QV6w%3d%3d.

EP 500-1-2. *Emergency Employment of Army and Other Resources - Field Force Engineering - United States Army Corps of Engineers Support to Full Spectrum Operations*. 1 August 2010. https://www.publications.usace.army.mil/USACE-Publications/Engineer-Pamphlets/u43545q/3530302D312D32/.

EP 1105-3-1. *Planning: Base Camp Development in the Theater of Operations*. 19 January 2009. https://www.publications.usace.army.mil/USACE-Publications/Engineer-Pamphlets/u43545q/313130352D332D31/.

EP 1110-1-8. *Construction Equipment Ownership and Operating Expense Schedule.* 30 November 2018. https://www.publications.usace.army.mil/USACE-Publications/Engineer-Pamphlets/u43545q/313131302D312D38/.

Federal Standard 376B. *Preferred Metric Units for General Use by the Federal Government.* 27 January 1993. http://www.nist.gov/pml/wmd/metric/upload/fs376-b.pdf.

The Geneva Conventions of 1949 and their Additional Protocols. http://www.icrc.org/eng/war-and-law/treaties-customary-law/geneva-conventions/.

Institute of Electrical and Electronics Engineers Standard 142-2007. *Institute of Electrical and Electronics Engineers Recommended Practice for Grounding of Industrial and Commercial Power Systems.* https://standards.ieee.org/standard/142-2007.html.

National Electrical Safety Code. https://standards.ieee.org/products-services/nesc/index.html.

National Fire Protection Act 70®, *National Electrical Code.* https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70.

STANAG 2931. *Orders for the Camouflage of the Red Cross and Red Crescent on Land in Tactical Operations.* 03 April 1998

TSPWG M 3-270-01.08-2 *Testing Protocol For Rapid Setting Rigid Repair Material.* 5 October 2020. https://www.wbdg.org/ffc/dod/supplemental-technical-criteria/tspwg-m-3-270-01-08-2.

Universal Joint Task List (UJTL). <https://utdt.js.mil/>, accessed on 8 December 2021.

WEBSITES

Center for Disease Control and Prevention website, http://www.cdc.gov/, accessed on 8 December 2021.

Health Facility Planning Agency website, http://www.armyhealthfacilities.amedd.army.mil/index.html.

NAVFAC Engineering Criteria and Programs Office, National Institute of Building Sciences website, https://wbdg.org/ffc/navy-navfac.

JCMS website, https://uroc-redi.usace.army.mil/sites/afcs/default.aspx.

Transportation Systems Center website, https://transportation.erdc.dren.mil/tsmcx/.

Unified Facilities Criteria Index, National Institute of Building Sciences website, https://www.wbdg.org/ffc/nibs/criteria.

Army Combined Arms Center, Center for Army Lesson's Learned website, https://usacac.army.mil/core-functions/lessons-learned.

Army Public Health Command website, https://phc.amedd.army.mil/Pages/default.aspx.

Army Safety Center Website, https://safety.army.mil/.

Air Force Civil Engineer Center Website, http://www.afcec.af.mil/.

Department of Labor Occupational Safety and Health Administration Website, https://www.osha.gov/pls/oshaweb/owastand.display_standard_group?p_part_number=1926&p_toc_level=1.

Marine Corps Engineer School Training and Education Command Website, https://www.trngcmd.marines.mil/Units/South-Atlantic/MCES/.

USACE Engineer Pamphlets Website, http://www.publications.usace.army.mil/USACEPublications/EngineerPamphlets.aspx?

USACE Hydrology Website, http://www.agc.army.mil/Missions/Hydrology/AboutHyDRA.aspx.

USACE Publications Website, http://www.publications.usace.army.mil/.

USACE Reachback Operations Center Website, https://uroc.usace.army.mil.

USACE Technical Information Website, http://www.hnc.usace.army.mil/Missions/Engineering/TECHINFO.aspx.

USACE Water Resource Database Website, https://water.usace.army.mil/a2w/f?p=100:1:0:#.

Whole Building Design Guide ETL Website, http://www.wbdg.org/ccb/browse_cat.php?c=125.

Whole Building Design Guide Website, http://www.wbdg.org.

PRESCRIBED FORMS

This section contains no entries.

REFERENCED FORMS

Unless otherwise indicated, DA forms are available on the Army Publishing Directorate website at https://armypubs.army.mil/. DD forms are available on the Executive Services Directorate website at https://www.esd.whs.mil/Directives/forms/.

DA Form 2028. *Recommended Changes to Publications and Blank Forms.*

DD Form 1354. *Transfer and Acceptance of DOD Real Property.*

DD Form 1391. *FY____ Military Construction Project Data.*

DD Form 2993. *Environmental Baseline Survey Checklist.*

DD Form 2994. *Environmental Baseline Survey (EBS) Report.*

DD Form 2995. *Environmental Site Closure Survey.*

RECOMMENDED READINGS

ADP 2-0. *Intelligence*. 31 July 2019.

AR 415-28. *Real Property Category Codes*. 15 April 2014.

AR 415-32. *Engineer Troop Unit Construction in Connection With Training Activities*. 18 June 2018.

ATP 2-01.3. *Intelligence Preparation of the Battlefield/Battlespace.* 1 March 2019.

ATP 3-50.21. *Survival*. 18 September 2018.

DA Pam 405-45. *Real Property Inventory Management*. 15 September 2000.

DODD 4270.5. *Military Construction Responsibilities*. 12 February 2005.

FM 3-57. *Civil Affairs Operations*. 28 July 2021.

FM 3-90-2. *Reconnaissance, Security, and Tactical Enabling Tasks, Volume 2*. 22 January 2013.

JP 3-57. *Civil-Military Operations. 28* July 2021.

JP 4-01. *The Defense Transportation System*. 18 July 2017

JP 4-03. *Joint Bulk Petroleum and Water Doctrine*. 11 January 2016.

STANAG 2238. *Allied Joint Doctrine for Military Engineering*–AJP-3.12, Edition 4. 20 January 2021. https://nso.nato.int/protected/.

STANAG 2394. *Allied Tactical Doctrine for Military Engineering*—ATP-3.12.1, Edition A. 3 February 2016. https://nso.nato.int/protected/.

TM 3-34.64/MCRP 3-17.7G. *Military Soils Engineering*. 25 September 2012.

TM 5-627/NAVY MO-103/AFM 91-33. *Maintenance of Trackage*. 1 January 1980.

TM 5-698-1. *Reliability/Availability of Electrical & Mechanical Systems for Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) Facilities*. 19 January 2007.

TM 5-814-3/AFM 88-11. *Domestic Wastewater Treatment*. 31 August 1988.

TM 5-822-9/AFM 88-6, chapter 10. *Repair of Rigid Pavements, Using Epoxy Resin Grouts, Mortars, and Concretes.* 20 January 1989.

TM 5-822-11/AFP 88-6, chapter 7. *Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements*. 11 June 1993.

TM 5-830-3/AFM 88-17, chapter 3. *Dust Control for Roads, Airfields, and Adjacent Areas*. 30 September 1987.

UFC 3-510-01. *Foreign Voltages and Frequencies Guide*. 1 March 2005.

UFC 3-520-05. *Stationary Battery Areas*. 1 May 2015.

Index

Entries are by paragraph number.

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ATP 3-34.40
CTP 3-40D
(MCWP 3-17.7)

14 April 2023

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