MCTP 12-10A

Mountain Warfare

U.S. Marine Corps

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UNITED STATES MARINE CORPS

3 July 2024

FOREWORD

Marine Corps Tactical Publication (MCTP) 12-10A, *Mountain Warfare,* is a reference for all unit commanders and their staffs (trained or untrained in mountain warfare) and all leaders from the company level through regiment or brigade for use in operations in mountainous terrain, snow, or cold weather. This publication is designed to be used with Marine Corps Reference Publication (MCRP) 12-10A.1, *Small Unit Leader's Guide to Mountain Warfare*; MCRP 12-10A.2, *Mountain Leader's Guide to Winter Operations*; MCRP 12-10A.3, *Mountain Leader's Guide to Mountain Warfare*; and MCRP 12-10A.4, *Cold Region Operations*. These publications cover unit planning considerations that can be used across a range of military operations. This publication references formal, individual, and collective mountain warfare training programs available within the Department of Defense.

Not all units' training plans align with a deployment to Marine Corps Mountain Warfare Training Center (MCMWTC) or the opportunity to train in other mountainous environments. Therefore, this publication—used in conjunction with MCRP 12-10A.1, MCRP 12-10A.2, MCRP 12-10A.3, and MCRP 12-10A.4—identifies the skills that Marines need to be successful in mountainous, snow, or cold-weather environments. During combat, these publications provide Marines with the doctrinal references they need to augment the instruction they receive from their unit's qualified mountain leaders.

The Marine Corps' doctrinal proponent for mountain and cold weather operations is MCMWTC, Bridgeport, California. Contact MCMWTC, Operations and Training, for further information.

This publication supersedes MCTP 12-10A, *Mountain Warfare Operations*, dated 28 February 2014, erratum dated 2 May 2016, and change 1 dated 4 April 2018.

Signed on this date,

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Contents

CHAPTER 1. OVERVIEW

CHAPTER 2. OPERATIONS

Chapter 3.
Intelligence, Surveillance, and Reconnaissance

Chapter 4.
Maneuver and Movement

Chapter 5.
Engineering

CHAPTER 6.
LOGISTICS AND SUSTAINMENT

CHAPTER 7.
AVIATION

CHAPTER 8.
FIRES

CHAPTER 9. COMMUNICATIONS

CHAPTER 10. TRAINING CONSIDERATIONS

APPENDICES

Glossary

References and Related Publications

CHAPTER 1.
OVERVIEW

Mountains establish formal and informal boundaries and barriers. When conflicts erupt in these rugged areas, commanders are presented with unique operational challenges, such as mountainous terrain, snow, and cold weather. Since the Marine Corps is an expeditionary force designed to fight in any clime and place, it must project force rapidly, sustain itself, and accomplish missions in any conditions.

The Marine air-ground task force (MAGTF) satisfies rapid-deployment requirements. For a unit to succeed, commanders and leaders must address environmental challenges and obtain the requisite skills, special equipment, and training required for the success of their units. As units train, they must prepare for most contingencies and the unique challenges that each contingency can bring.

HISTORICAL PERSPECTIVE

History is replete with examples of military forces becoming exhausted, defeated, and sometimes destroyed by a much smaller adversary because that adversary proved more skillful and or prepared to fight and sustain itself in specific terrain and the harsh weather that often accompanies it. The historical lessons learned, and the development of functional principles based on these lessons should guide future preparation and training. A historical study of mountain operations shows that the key to success is maintaining contact with the enemy while preserving one's own combat effectiveness. Such success requires effective command, control, and communications as well as mobility and logistics in an environment, which, by its nature, inhibits all these; therefore, an understanding and respect for the environment, accompanied by realistic training under similar environmental conditions, is a prerequisite to success.

World War II provided powerful examples that reinforce the need to properly prepare units for mountain operations. For example, the 1939–1940 Winter War in Finland illustrates how a well-prepared, small, elite force could dominate a much larger, general-purpose force. Although the Soviets enjoyed a 40-to-1 superiority in personnel, 20-to-1 superiority in aircraft, and a 100-to-1 superiority in tanks and artillery, the Finns were better prepared to operate in snow-covered terrain. The Finns' ability to adapt to the environment allowed them to use the mobility offered by skis and the cover and concealment of mountain forests to decimate the road-bound, Soviet logistic infrastructure. As a result, the Soviet's supply system completely broke down and they were unable to maintain operational-level mobility. Lacking food, winter clothing, and shelter, the harsh winter environment ultimately took its toll on the Russian forces, and they suffered heavy losses.

After attempts to capture Bologna failed during the winter of 1944–1945, allied commanders focused on the possibility of wide, sweeping movements aimed at encircling Bologna and all German forces in the region. The plan used the Army's 10th Mountain Division to capture a series of mountain peaks and ridges that dominated a 10-mile section of main routes leading from Pistoia through the northern Apennines. To surprise the Germans, the 10th Mountain Division's assault teams climbed the 1,500-foot cliff in the dead of night—hammering pitons into the rock, attaching links to them, and fastening ropes to the links—to move themselves to the top. They attacked the German defensive positions, achieving complete surprise. German counterattacks were repulsed, and the division's left flank was secured on Riva Ridge, opening the way for the rest of the division to accomplish its mission.

Even though US forces achieved successes in mountainous areas during World War II, they were woefully unprepared to tackle the extreme conditions they faced in the mountains during the Korean War. Many Marines who succumbed to Korea's extreme conditions were World War II-hardened combat veterans, yet the lack of extreme cold weather equipment and specialized training exacted a heavy toll on US forces. For example, although the Marines' breakout from encirclement at the Chosin Reservoir is heroic, more than half of its 6,818 non-battle casualties resulted from frostbite and other preventable cold weather injuries.

IMPERATIVE FOR MOUNTAIN WARFARE DOCTRINE

Similar events throughout history illustrate the need for the Marine Corps to focus on mountain warfare doctrine and training when preparing to conduct expeditionary operations in mountainous environments. Although a mountainous environment is challenging, expeditionary forces can operate effectively with proper training, equipment, and organization. Marines must learn the tactics, techniques, and procedures (TTP) required to conduct mountain operations in mountainous terrain to be best prepared.

Twenty states of interest in the world are located within an arc of instability (see Figure 1-1). Sixteen of the 20 states of interest have regions with elevations equal to or greater than 8,000 feet (2,438 meters), and average temperatures of 40 °F and below. The current and projected threats in many of these countries is posed by small, irregular forces operating in rugged, compartmentalized terrain. These forces leverage the inherent advantages that mountainous terrain and weather offer in against US technological advantages in information collection and firepower. Developing the ability to fight large- and small-scale contingencies against conventional and irregular, non-state actors is paramount.

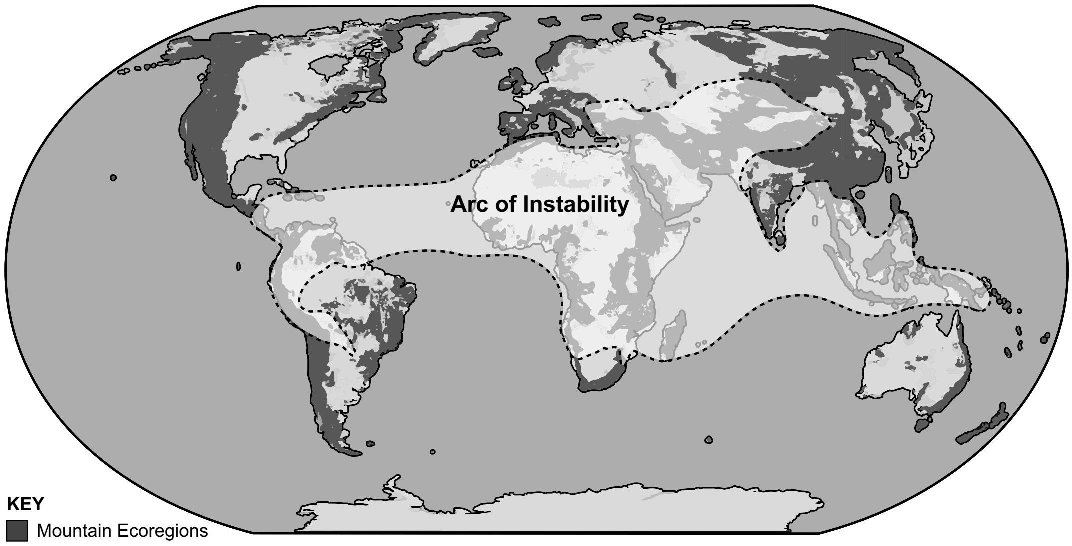

Figure 1-1. The Arc of Instability.

THE WORLD'S MOUNTAINOUS REGIONS

Figure 1-2, derived from data from the United Nations Environment Programme – World Conservation Monitoring Centre, shows the principal mountain ranges of the world lie along broad belts. These ranges (called *cordillera*, after the Spanish word for rope), encircle the Pacific basin and then lead westward across Eurasia into North Africa. A secondary, though no less rugged, chain of mountains lies along the Atlantic margins of the Americas and Europe.

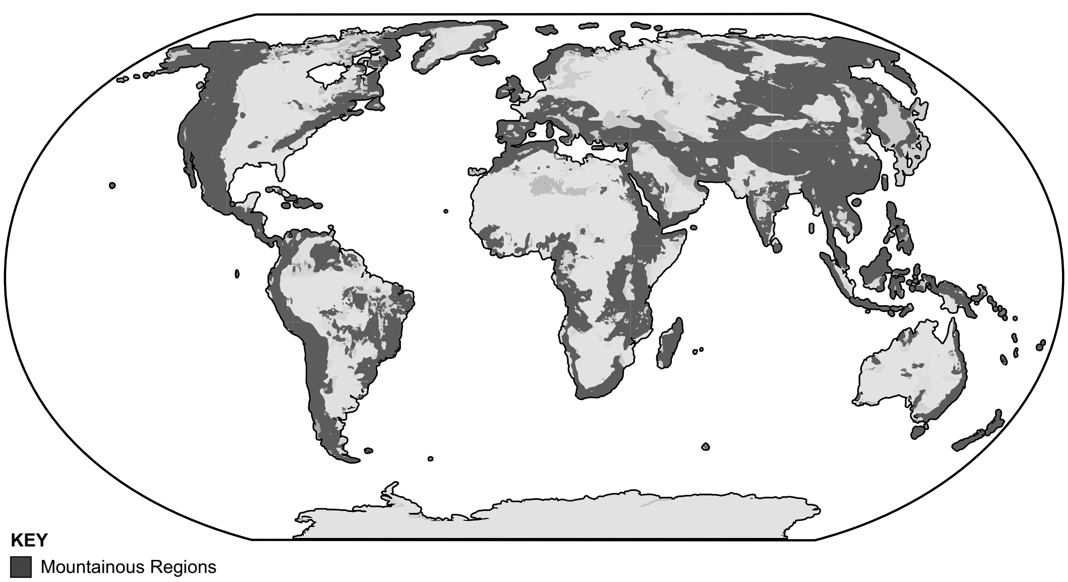

Figure 1-2. The World's Mountainous Regions.

The Rocky Mountain Range, a broad mountainous region approximately 1,609 kilometers (1,000 miles) wide, dominates northwestern North America. It occupies much of Alaska, more than a quarter of Canada and the United States, and all but a small portion of Mexico and Central America. It includes extensive high plains and basins. Numerous peaks in this belt rise above 3,048 meters (10,000 feet). Its climate varies along the range of seasonal and local extremes, from arctic cold to tropical heat.

The Andes stretch as a continuous narrow band along South America's western region. Narrower than its counterpart in the north, this range is less than 805 kilometers (500 miles) wide; however, it continuously exceeds an elevation of 3,048 meters (10,000 feet) for 3,218 kilometers (2,000 miles).

The Eurasian Mountain belt includes the Pyrenees, Alps, Balkans, and European Carpathian ranges. These loosely linked systems are separated by broad, low basins, and are cut by numerous valleys. North Africa's Atlas Mountains are also a part of this belt. Moving eastward into Asia, this system becomes more complex as it reaches the extreme heights of the Hindu Kush and the Himalayas. The Himalayas stretch over more than 2,414 kilometers (1,500 miles) and contain 9 of the 10 tallest peaks in the world. Just beyond the Pamir Knot on the Russia-Afghanistan frontier, this range begins to fan out across eastern Asia. Branches of this belt continue south along the rugged island chains to New Zealand and northeast through the Bering Sea to Alaska.

Different mountain chains can have different climates. Some chains are in dry, desert regions with temperatures ranging from extreme heat in the summer to extreme cold in the winter. In tropical regions and along the equator, small to medium mountains are covered in lush jungles with deep ravines that flood during the rainy season. Temperatures in these areas typically remain warm and humid year-round. High mountains in temperate climates have sparse vegetation at elevations above 11,500 feet (3,505 meters) and temperatures can drop below freezing in winter. Some mountainous environments vary, such as in Afghanistan where Marine Corps units have encountered several different mountainous environments within the same area of operations.

Mountainous Terrain

Some mountains extend sharply upward from the plains to form a giant barrier; others form a series of parallel ridges that extend unbroken for great distances. They consist of varying combinations of isolated peaks, rounded crests, eroded ridges, and high plains and may be cut by valleys, gorges, and deep ravines. High, rocky crags with glaciated peaks and year-round snow cover exist in mountain ranges at most latitudes along the western portion of the Americas and in Asia. Regardless of their appearance, rugged terrain is common among all types of mountains.

Mountain slopes generally vary between 15 and 45 degrees. Cliffs and other rocky precipices can be near vertical or even overhanging. Aside from rock formations and other local vegetation characteristics, slope surfaces are usually firm earth or grass. Grassy slopes can include grassy clumps known as tussocks; short alpine grasses; or tundra, which is more common at higher elevations and latitudes. Many slopes will be scattered with rocky debris deposited from the higher peaks and ridges. Extensive rock or boulder fields are known as talus; slopes covered with smaller rocks, usually fist-sized or smaller, are called scree fields. Slopes covered in talus often prove to be a relatively easy ascent route. On the other hand, climbing a scree slope can be extremely difficult because the small rocks tend to loosen and give way; however, this characteristic often makes scree fields excellent descent routes. Before attempting to descend scree slopes, commanders should carefully analyze the potential for creating dangerous rockfall and take necessary avoidance measures.

In winter and at higher elevations throughout the year, snow can blanket slopes, creating an environment with distinct effects. Some snow conditions can aid travel by covering rough terrain with a consistent surface. Deep snow, however, greatly impedes movement and requires Marines to be well trained in using snowshoes, skis, and over-the-snow vehicles. Steep, snow-covered terrain presents the risk of snow avalanches as well. Snow can seriously harm personnel not properly trained and equipped for movement under such conditions. More personnel have died from avalanches while engaged in mountain warfare than all other terrain hazards combined.

Commanders operating in the arctic and subarctic mountain regions, and high mountain elevation, might be confronted with vast glaciated areas. Many valleys in these areas are buried under massive glaciers and present additional hazards, such as hidden crevasses and ice and snow avalanches. The mountain slopes of these peaks can be glaciated—their surfaces generally composed of varying combinations of rock, snow, and ice.

Although glaciers present their own peculiar hazards requiring special training and equipment to overcome, dismounted movement over valley glaciers is often the safest way to travel through these areas. Different rock types, soil composition, and slope types affect how forces are employed. For example, granite produces fewer rock falls, but its jagged edges make pulling rope and raising equipment difficult. Granite is abrasive and can cut ropes or accessory cords. An in-depth analysis of individual factors that affect operations in mountainous environments is in Marine Corps Reference Publication (MCRP)12-10A.3, *Mountain Leader's Guide to Mountain Warfare*.

Appendix A provides detailed information on environmental threats unique to mountains.

Glaciers

Glaciers are frozen rivers of ice and rocks that slowly move down mountains. They are formed when the rate of snowfall or other precipitation exceeds the melting rate in summer months. After accumulations over hundreds of years, the snow compresses into ice that can range from 10 to several hundred feet thick. Glaciers can be small and only cover a portion of a mountain, or they can be massive with a series of glaciers covering a mountain range. Dismounted movement across glaciers is often dangerous because of icy conditions, landslides, ice falls, and deep crevasses that often crisscross glaciers. Reference MCRP 12-10A.3 and TC 3-97.61 for considerations regarding movement over glaciers. Melting glaciers can supply water for units on patrol. Units can purify that water to reduce the need for aerial or ground resupply.

Mountain Classifications

Mountain environments are difficult to classify. Soil composition, surface configuration, elevation, latitude, and climatic patterns determine the specific maintain range characteristics When alerted to the potential requirement to conduct mountain operations, commanders must carefully analyze each of these characteristics for the specific mountain region in which their forces will operate. Generally, however, mountains are classified or described according to their elevation. For military purposes, mountains may be classified according to operational terrain levels and dismounted mobility and skill requirements.

Elevation. Mountains are commonly classified according to elevation, which is the height of the immediate terrain above sea level, using the following descriptors (see Table 1-1):

Table 1-1. Elevation Descriptors.

Elevation Descriptor	Description
Very high	Greater than 3,048 meters (10,000 feet)
High	1,829 to 3,048 meters (6,000 to 10,000 feet)
Moderately high	914 to 1,829 meters (3,000 to 6,000 feet)
Moderately low	305 to 914 meters (1,000 to 3,000 feet)
Low	152 to 305 meters (500 to 1,000 feet)
Very low	Less than 152 meters (500 feet)

Low mountains have an elevation between 305 to 914 meters (1,000 to 3,000 feet) with summits usually below the timberline. High mountains usually exceed 914 meters (3,000 feet) and are characterized by barren alpine zones above the timberline. Glaciers and perennial snow cover are common in high mountains and usually present commanders with more obstacles and hazards to movement than do low mountains.

Mountain operations are generally carried out at three different operational terrain levels (see Figure 1-3), as follows:

- Level I terrain is typically located at the bottom of valleys and along the ideal locations for main lines of communications (LOCs). At this level, heavy forces can operate, but maneuver space is often restricted. Light and heavy forces are typically combined, since vital LOCs usually follow the valley highways, roads, and trails.
- Level II terrain lies between a mountains' valleys and shoulders and generally consists of narrow roads and trails, which serve as secondary LOCs, that cross this ridge system. Therefore, enemy positions on level III terrain dominate and influence the lower level II terrain. Similarly, units usually expend the energy to occupy level II terrain because it dominates level I terrain and can greatly influence operations.
- Level III terrain includes the dominant terrain of summit regions. Mobility in level III terrain is usually the most difficult to achieve and maintain even though travel across summit regions tend to consist of relatively gentle terrain. Level III terrain, however, can provide opportunities for well-trained units to attack the enemy from the flanks and rear. At this terrain level, acclimatized personnel with advanced mountaineering training can infiltrate to attack LOCs, logistic bases, air defense sites, and command infrastructures.

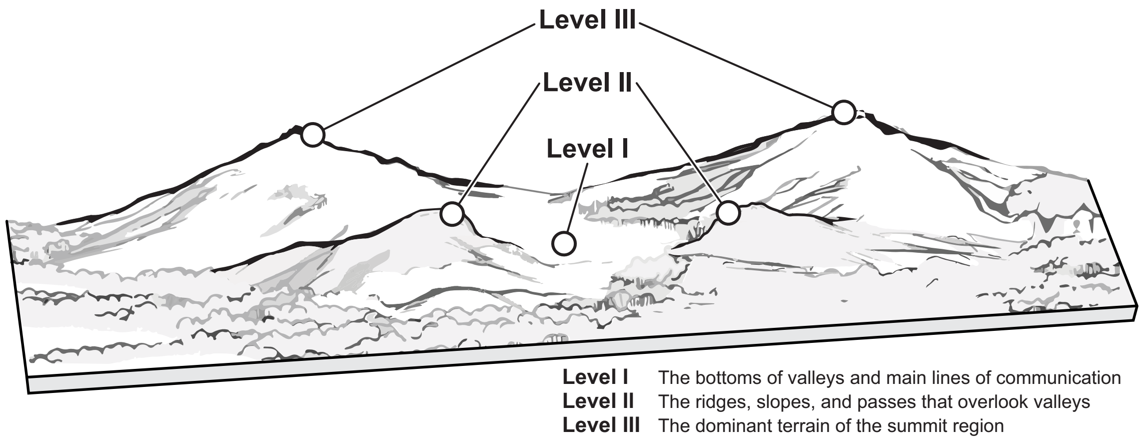

Figure 1-3. Operational Terrain Classifications.

Dismounted Mobility Classification. When conducting mountain operations, commanders must clearly understand the effect the operational terrain level has on dismounted movement. Therefore, in addition to the general mobility classifications contained in MCRP 2-10B.1, *Intelligence Preparation of Battlespace*—unrestricted, restricted, severely restricted—mountainous terrain can be categorized into five classes based on the type of individual movement skill required (see Table 1-2). Operations conducted in the first two classes require little to no mountaineering skills, but operations in the other three classes require a higher level of mountaineering skills for safe and efficient movement. Commanders should base plans and preparations for mountain operations on dismounted mobility classification, particularly noting that class 4 terrain kills more people than any other class because the risk the terrain poses is less obvious than class 5 terrain.

Table 1-2. Dismounted Mobility Classifications.

Class	Terrain	Mobility Requirements	Skill Level Required
1	Gentle slopes; easy trails	Walking techniques	Unskilled (with some assistance) and basic mountaineers
2	Steeper/rugged terrain	Some use of hands	
3	Easy climbing	Fixing ropes where exposed	Basic mountaineers (with assistance from assault climbers)
4	Steep or exposed climbing	Fixed ropes required	
5	Near vertical	Technical climbing required	Assault climbers and mountain leaders

Weather

Mountain climates tend to be cooler and wetter compared to the surrounding lowland climates. Most mountainous regions exhibit at least two different climatic zones—a zone at low elevations and another at elevations nearer the summit regions. Conditions change with elevation, latitude, and exposure to atmospheric winds and air masses. The climatic patterns of two ranges located at the same latitude and proximity may differ radically. These different weather patterns are known as micro-climates.

Major mountain ranges force air masses and storm systems to drop significant amounts of rain and snow on the windward side of the range. As air masses pass over mountains, the leeward slopes receive far less precipitation than the windward slopes. It is not uncommon for the climate on the windward side of a mountain range to be humid and the climate on the leeward side arid. This phenomenon affects coastal and inland mountains. The deepest winter snow packs will almost always be found on the windward side of mountain ranges. As a result, vegetation and forest characteristics may be markedly different between these two areas. Prevailing winds and storm patterns usually determine the severity of these effects.

Mountain weather can be erratic, varying from calm to strong winds and from relative warmth to extreme cold within a short time or a minor shift in locality. The severity and variance of the weather require personnel to be prepared for alternating periods of heat and cold, as well as conditions ranging from dry to extremely wet. At higher elevations, noticeable temperature differences may exist between sunny and shady areas or between areas exposed to wind and those protected from it. This greatly increases every Marine's clothing load and a unit's overall logistical requirements. For a more detailed list of mountain weather considerations, see Appendix B.

Climate Influences

Like most other landforms, oceans influence mountain climates. Mountain ranges near oceans and other large bodies of water usually exhibit maritime climates, which generally produce milder temperatures and more precipitation. Although mild winters produce heavy snowfalls, the summer temperatures are rarely excessively hot.

Mountains farther inland usually experience a more continental climate. Winters in this climate are often bitterly cold compared to summers, which can be extremely hot. Annual rainfall and snowfall in these inland areas is far less than that of a maritime climate and can be scarce for long periods. Shallow snowpacks often form during a continental climate's winter season.

Temperature

Personnel can expect to encounter a temperature drop of 3 to 5 °F per 305-meter (1,000-foot) gain in elevation. At high elevations, there can be differences of 40 to 50 °F between the temperature in the sun and that in the shade, which is similar in magnitude to the day-to-night temperature fluctuations experienced in some deserts. Besides permitting rapid heating, the clear air at high altitudes also results in rapid cooling at night. Consequently, temperatures rise swiftly after sunrise and drop quickly after sunset. The chilled air drains downward so that the differences between day and night temperatures are greater in valleys than on the slopes. Refer to MCRP 12-10A.4, *Cold Region Operations*, for more considerations for cold temperatures and weather phenomena.

Wind

Wind in a mountainous environment has the following characteristics:

- In high mountains, the ridges and passes are seldom calm; strong winds in protected valleys are rare.
- Usually, wind velocity increases with altitude and is intensified by mountainous terrain.
- Valley breezes moving up-slope are more common in the morning, while descending mountain breezes are more common in the evening.

- Wind speed increases when winds are forced over ridges and peaks (orographic uplift), or when they funnel through narrowing mountain valleys, passes, and canyons (venturi effect).
- Wind may blow with great force on an exposed mountainside or summit.
- As wind speed doubles, its force on an object nearly quadruples.

Mountain winds cause rapid temperature changes and may result in blowing snow, sand, or debris, which can impair a Marine’s movement and observation. Commanders should routinely consider the combined cooling effect of ambient temperature and wind (windchill) their personnel might experience (see temperature categories in Appendix B).

At higher elevations, air is considerably dryer than air at sea level. Because of this increased dryness, personnel must increase their fluid intake by approximately one-third. In this environment, equipment does not rust as quickly, and organic matter decomposes more slowly.

Precipitation

The rapid rise of air masses over mountains creates distinct local weather patterns. A mountainous environment has the following effect on precipitation:

- Precipitation increases with elevation and occurs more often on the windward side than on the leeward side of ranges.
- Maximum cloudiness and precipitation generally occur near 1,829 meters (6,000 feet) elevation in the middle latitudes and at lower levels in the higher latitudes.
- Usually, a heavily wooded belt marks the zone of maximum precipitation.

Common types of mountain precipitation include rain and snow, thunderstorms, and traveling storms.

Rain and Snow. Rain and snow are common in mountainous regions. Rain presents the same challenges as at lower elevations, but snow has a more significant influence on all operations. Depending on the specific region, snow could occur at any time during the year at elevations above 1,521 meters (5,000 feet). Heavy snowfall greatly increases avalanche hazards and can force changes to previously selected movement routes. In certain regions, the intensity of snowfall can delay major operations for several months. Dry, flat riverbeds might initially seem to be excellent locations for assembly areas and support activities; however, heavy rains and rapidly thawing snow and ice can create flash floods many miles downstream from the rain or snow location.

Thunderstorms. Although thunderstorms are local and usually last only for a short time, they can impede mountain operations. Interior ranges with continental climates are more conducive to thunderstorms than coastal ranges with maritime climates. In alpine zones, driving snow and sudden wind squalls often accompany thunderstorms. Ridges and peaks become focal points for lightning strikes, which occur most often in the summer. Although statistics do not show lightning to be a major mountaineering hazard, it must not be ignored and Marines must take precautions, such as avoiding summits and ridges, water, antennas, and contact with metal objects.

Traveling Storms. Storms resulting from widespread atmospheric disturbances involve strong winds and heavy precipitation and are the most severe weather condition that occurs in the mountains. If Marines encounter a traveling storm in alpine zones during winter, they should expect low temperatures, high winds, and blinding snow. These conditions can persist longer than in the surrounding low-lying areas.

Fog

Fog effects in mountains are much the same as in other terrain; however, because of the topography, fog occurs more frequently in the mountains. The high incidence of fog makes it a significant planning consideration because it restricts visibility and observation, which complicates reconnaissance and surveillance. Fog, however, can facilitate clandestine operations, such as infiltration. Routes in areas where fog occurrence is high could need to be marked and charted to better facilitate movement.

Pressure

Atmospheric pressure serves a dynamic role in rotary lift and must be considered when mission planning and executing operations. Pressure altitude impacts the aerodynamic power-weight limit with additional environmental constraints that drive helicopter operating capability. Depending on mission requirement, this puts constraints on ordnance, fuel capacity, personnel capacity, or overall useful load. There could be additional limitations and guidance required for flights above 10,000 feet cabin altitude in unpressurized aircraft without supplemental oxygen to aircrew and passengers.

CHAPTER 2.
OPERATIONS

Mountain operations are usually characterized by a series of separate battles for the control of key terrain, such as population centers, dominating ridges and heights, and other potential avenues of approach. As a result, mountain operations in the operational environment generally require smaller unit tactics of squad-, platoon-, and company-level organizations. Because of the nature of the environment and the extreme mental and physical challenges associated with operating in the mountains, the need for detailed planning is essential. Risk management is an integral part of planning and must take place at all phases of every operation. Planning for mountain operations must be based on sound mission, enemy, terrain and weather, troops and support available-time available (METT-T) analysis of the specific operational environment. The factors of METT-T provide the standard methodology for identifying threats and hazards, which is the first step in the risk management process.

PLANNING CONSIDERATIONS

Forces must plan for and be able to operate for extended periods of time as independent, small units. For this reason, commanders and planners should use the information in this chapter in conjunction with Army Techniques Publication (ATP) 3-21.50, *Infantry Small-Unit Mountain and Cold Weather Operations*, and MCRP 12-10A.1, *Small-Unit Leader's Guide to Mountain Warfare.* Because of the challenging human and physical environment and an elusive, adaptive, and complex enemy, operating forces must—

- Operate independently.
- Avoid an over-reliance on motorized and mechanized assets.
- Balance force protection requirements with the need to operate and live among the population.

Operating and maneuvering in a mountainous environment requires centralized planning and decentralized execution. Force dispersion is useful when conducting offensive and defensive operations and stabilization activities in the mountains. The task force elements' role in mountain operations remains unchanged, although the techniques for accomplishing the mission can vary considerably. Ground combat element (GCE) units are usually organized into highly mobile, self-sustained tactical groupings with only those weapons and equipment suited to the mission. This decentralization allows for greater flexibility and responsiveness across the operational environment. In mountainous environments, battalion-size units can increase the number of maneuver units available by reorganizing available units; for example, forming four units from the battalions' three table-of-organization rifle companies enhances the battalion's ability to cover more terrain.

While this technique is useful in a compartmentalized mountainous environment, this unorthodox approach of breaking down existing units into smaller units to compensate for environmental challenges requires units to be previously trained on this method of task organization. It also requires more detailed planning and rehearsals. Maneuver commanders and planners must be aware of potential equipment constraints, reduction in unit cohesion, and command and control issues. Equipment issues could arise since existing units might be fragmented to create additional units. Unit cohesion can suffer as personnel from existing units are split and reintegrated to create new units. Command and control can suffer due to the added complications of having more moving pieces in the area of operations and junior officers and noncommissioned officers leading new units.

The principles of patrolling do not change in a mountainous environment. For more information on patrolling principles see Marine Corps Tactical Publication (MCTP) 3-01A, *Scouting and Patrolling*; MCRP 12-10A.2, *Mountain Leader's Guide to Winter Operations*; and ATP 3-21.50.

Command and Control Considerations

The environmental factors associated with mountain operations offer unique command and control challenges. The compartmentalized terrain, expansive areas of operations, and severe environmental conditions limit communications systems and challenge command and control efforts. Large operating areas and the need to employ small-unit tactics require commanders to decentralize and disperse their forces. To effectively command and control dispersed forces, commanders must rely on decentralized execution, which is enabled by centralized planning, mission orders, and the commander's intent. Commanders must refrain from micromanaging subordinate leaders—an activity made easier by modern communications assets. Effective risk-management integration is critical at each command level in all phases of mountain operations to identify and mitigate hazards. During mountain operations command and control considers the following:

- Warning orders that allow subordinates ample time to prepare and plan for operations.
- Mission orders that empower subordinates and promote freedom of action.
- A commander's intent that clearly articulates the desired purpose.
- Command relationships that are clearly understood and facilitate the exercise of initiative by subordinates (unity of command where possible, unity of effort where it is not).
- Standing operating procedures that are understood and applied across the command to assure TTP excellence.
- Mobile reserves or reaction forces that are trained to move quickly across rough compartmentalized terrain with tailored loads.

Leadership

Marines must have confidence in their leaders. Confidence can diminish unless leaders demonstrate the ability to lead over challenging terrain and during weather conditions. A leader with only superficial knowledge, inaccurate estimation of capabilities, and underestimating hazards and environmental effects can contribute to mission failure and the unnecessary loss of life.

Effective leadership in mountain operations combines sound judgment with a thorough understanding of the characteristics of mountainous environments. Commanders must first develop flexible and adaptable leadership throughout the chain of command. They must then be able to understand and exploit the operational and tactical implications of mountainous environments and their effects on personnel, equipment, and weapons. The keys to meeting this challenge are proper training and operational experience in the mountains, which requires leaders to identify specialized clothing, equipment, and training needed. Commanders must recognize the importance small-unit leaders have in preventing environmental injuries and illnesses. To fight effectively, leaders creatively exploit the opportunities offered by the mountainous environment while minimizing the adverse effects it can have on their operations. Commanders must manage risks to their forces to accomplish the mission and take care of their Marines.

Command Posts

Effective command and control of the command post requires it to remain functional despite difficulties associated with the environment, such as cold temperatures, high winds, and high-altitude effects.

Displacement. Displacing the command post takes more time because of the environment and the terrain itself. Displacement exercises are critical. Future command post locations must be identified quickly and reconnoitered to ensure they will function effectively.

Headquarters should configure command posts in echelons with redundant and overlapping capabilities. The command post should be configured to survive the environment and be resilient enough to overcome enemy observation and attack. Such configurations usually comprise a forward, main, or rear command post, or an alpha or bravo construct to allow for continuous command and control and maintaining survivability by duplicating COC requirements. Configurations are conditional based on equipment and personnel able to support. Each echelon has a primary and secondary command and control responsibility. For example, the main command post may have primary responsibility for logistic operations and movement control while the forward command post has the responsibility for maneuvering forces and coordinating fire support. The main command post may have the secondary responsibility of monitoring those tactical communications networks associated with maneuvering forces and coordinating fires support so that it can assume command in the event the forward command post needs to displace or loses the ability to command and control. By organizing headquarters into forward, main, and rear posts and by assigning primary and alternate command and control responsibilities to each echelon, headquarters can exercise command and control while displacing echelons.

Usually, the commander establishes a position with the forward command element to have the best battlefield situational awareness. During displacement, the commander usually passes control to the main command post until the forward command post can reestablish reliable communications.

Watch Personnel. Because a mountainous environment can quickly sap Marines' strength and energy, a three-watch system is recommended for command posts operating under harsh, mountain conditions. Headquarters personnel augmentation is essential to provide extra watch standers, to assist command post displacements, and to provide more depth for security personnel. In many situations, command posts need to provide for their own defense, particularly when conducting displacement operations. Multiple command post configurations (forward, main, jump) should be rehearsed in hardstand, tentage, and mobile forms. Their displacement should also be rehearsed.

OFFENSIVE OPERATIONS

Offensive operation activities in the mountains vary depending on the degree of restrictions that are dictated by different mountain heights and other mountain characteristics. Conventional mountain operations are generally conducted to gain control of key or decisive terrain, such as LOCs, mountain passes, ridges, and chokepoints. Every attempt must be made to attack from higher elevations to lower elevations to conserve troop energy, increase movement speed, and have superior observation and fields of fire. Frontal attacks against defended heights have little chance of success. Attacks are usually made along the flanks and to the rear of the enemy. Consequently, flanking attacks and envelopments are the preferred form of maneuver.

A well-trained force using mobility skills that mitigate the effects of the mountainous environment can achieve surprise by infiltrating and attacking the enemy's rear or attacking during periods of limited visibility, such as night, rain, or snow. Marines can use helicopters and their technical mountaineering skills to conduct decisive operations throughout the area of operations.

The mountainous terrain increases the threat to concentrated formations. Usually, it is difficult to coordinate all forces by time and location so they can rapidly support each other and achieve massed effects. This type of terrain is often referred to as compartmented or compartmentalized terrain as it separates adjacent unit and can preclude mutual support and adversely affect supporting distances. Therefore, it is critical to anticipate the concentration of forces and fires before the battle begins to achieve effective synchronization.

The preparatory phase typically takes longer in a mountainous environment than in other environments. Offensive action taken against a well-defended enemy must be based on thorough reconnaissance and orderly preparation. When planning, commanders must take advantage of the weaknesses found in the enemy's defenses. Many reconnaissance assets and additional time may be needed to determine the strength of enemy positions and to identify favorable routes to and beyond the objective.

Difficult approach routes should be marked and prepared for safe passage. Easily traversed slopes, broad hills, plateaus, and valley floors, and mountainous terrain with well-developed road and transportation networks create opportunities for the force to deploy in breadth. High ranges with ridges and crests leading to the objective require organization in depth with extended LOCs. Units should attempt to have overwatch when moving in the mountains. Traveling overwatch is the preferred technique when preparing for the offense.

In trackless, mountainous terrain, company-sized units usually conduct attacks. If the area assigned to a battalion permits, companies approach the objective separately on multiple routes, never moving without overwatch on adjacent high ground. In restrictive terrain, adequate maneuver space is not always available, and several units could be required to move along the same avenue of approach. It may even be necessary to conduct shaping operations to seize terrain that dominates movement routes.

Types of Offensive Operations

The types of offensive activities are movement to contact, attack, and exploitation and pursuit. They are addressed in the following paragraphs:

Movement to Contact. Movement-to-contact activities in the mountains are highly vulnerable to attack and ambush. Limited mobility and dependence on restrictive LOCs limit deployment of the force from movement formations. Plans and movement formations should focus on maintaining flexibility and providing continuous security.

During a movement to contact, the advance guard advances in column, moving continuously or by bounds until it makes contact with the objective. While requiring less physical exertion, moving along the topographical crest of a ridgeline increases the possibility of enemy observation and should usually be avoided. Given adequate concealment, this exposure can be reduced by moving along the military crest. Ridgelines and crests can often provide a tactical advantage to the force that controls them by allowing rapid movement from one terrain compartment to another and affording excellent observation. Commanders must address the control or clearance of ridgelines that dominate their planned avenues of approach.

The main body should never be committed to canalizing terrain before forward elements have advanced far enough to ensure that the main body will not become encircled—a critical factor when employing mixed heavy and light forces that have sharp differences in operational tempo. Combat service support (CSS) units must be decentralized and readily available to sustain the combat elements. Major terrain compartments can physically separate maneuver units moving as part of a larger force. Conducting continuous reconnaissance to the front and maintaining flank security are essential to prevent the enemy from infiltrating the gaps between units.

As the enemy situation becomes better known, commanders can shorten the distance between elements to decrease reaction time, or they may begin to deploy in preparation for the attack. Lateral movement between adjacent columns can be difficult or impossible; however, every attempt should be made to maintain at least visual contact. Connecting files or mountain pickets are effective for lateral connection. Commanders must emphasize the use of checkpoint reporting, contact patrols, and phased operations to coordinate and control the movement of the overall force. Control measures should not be so numerous as to impede operations and stifle initiative. Proper control ensures that units and fires are mutually supporting, objectives are correctly identified, and units are in position to attack. Permanent occupation of key terrain is unrealistic; therefore, engagements occur repeatedly on the same pieces of terrain. Commanders should plan to control those historic points whenever operating within their vicinity. Fixing and finishing the enemy is often accomplished by direct and indirect fire, respectively, in mountainous terrain.

Attack. Speed, flexibility, and surprise usually provide advantage to the attacker; however, these elements are limited by restrictive terrain and the defender's ability to see and acquire targets. These limitations make it difficult for units above the company team level to conduct hasty attacks against prepared positions. Additional time should be allocated to conduct deliberate planning for fire support coordination, route selection, and command and control coordination.

Planning an Attack. When planning and conducting attacks, commanders must recognize that the enemy generally seeks to control the valleys and trail networks, including adjacent slopes and high ground. The enemy attempts to engage the attacker in the valleys and low ground with flanking fires and artillery, often in a direct-fire mode. Commanders must analyze the terrain to determine how the enemy organizes its defensive positions, and how the terrain might contribute to the enemy's ability to counterattack. As friendly forces attempt to deploy for the attack, the enemy, using advance knowledge of the terrain and prepared routes, can maneuver forces to counterattack from the flank or rear.

Terrain. All terrain features that can be occupied by even a small enemy force should be secured. In many instances, overwatch positions may not be readily available within the range or capability of organic weapons. Infiltration, technical climbing, and extensive breaching can be required to position weapons to support the assault. On many occasions, artillery support, especially in high mountains, might not be available. Commanders must identify fire support requirements and allocate fires based on the ability to support and available ammunition. Because resupply may be limited and extremely difficult, they may need to place restrictions on the amount of ammunition expended on specific targets. Dominating terrain may give a commander great situational awareness, while being beyond the range of fires, such as the enemy used during Operation ANACONDA in the Arma Mountains of Afghanistan.

Obstacles. Breaching obstacles and preparing bypass routes that allow the assault force to move into the defensive position must be an integral part of the commander's plan. In rugged terrain, man-made obstacles that are covered by fire create a particularly dangerous and formidable barrier. Command and control of breaching operations are more difficult than in open terrain and mobility support is extensive if the obstacle cannot be reduced. Assaults in mountainous terrain involve preparing routes that allow the assault force to rapidly move over difficult natural obstacles and into the objectives.

Raid and Ambush. Mountainous areas with restrictive terrain also afford increased opportunities for conducting raids and ambushes. These operations should take advantage of limited visibility and terrain that the enemy might consider impassable. In steep terrain, movement time increases significantly, and only light equipment can be taken. The force should use special climbing techniques to negotiate the difficult routes during limited visibility. Commanders must carefully consider the routes and methods used for extraction to ensure that the combat force does not become isolated after executing the mission. They can ensure a successful operation by avoiding detection through proper movement techniques and by skillfully using natural cover and concealment. It may be necessary to reposition some indirect fire support assets to cover dead space or use attack helicopters and close air support (CAS). The ambush or raid commander must know in advance whether supporting fires can cover the routes to and from the objective.

Demonstrations and Feints. Maneuver space is usually limited or confined and restricts the several avenues of approach for heavier forces, deception serves an important role in the mountain battle. To mislead the enemy regarding friendly intentions, capabilities, and objectives, commanders should plan systematic measures of deception.

Exploitation and Pursuit. In a mountainous environment, exploitation and pursuit operations must be conducted discriminately and the commander must always prepare for success. A battalion can exploit its own success to a limited extent, but it usually participates in the exploitation as part of a larger force. Air assault and attack helicopter units can be used to augment exploitation and pursuit operations.

The exploiting commander must compensate for the ground mobility restrictions imposed by terrain and weather. Speed can be best achieved by isolating enemy positions with the smallest force possible. Engineer support must be well forward with the necessary equipment to enable combat personnel to maintain momentum and avoid delay by enemy obstacles. The commander must be careful to prevent overextending either the exploiting force or its sustaining logistics. A withdrawing force can establish numerous delaying and firing positions on heights, quickly dissipating the exploiting force's combat power.

Forms of Offensive Maneuver

The forms of offensive maneuver are common to environments, including mountainous terrain; only considerations for mountain operations are addressed in the following paragraphs. Although often used in combination, each form of maneuver attacks the enemy in a different way, and some pose different challenges to the commander when attacking in the mountains.

Frontal Attack. The frontal attack is an offensive maneuver in which the main action is directed against the enemy force's front. It is used to rapidly overrun or destroy a weak enemy force or to fix a force in place to support a flanking attack or envelopment. Aviation forces and supporting arms should be used to create gaps in the enemy's front or to prevent or delay enemy reinforcements from reaching the front lines. The frontal attack is generally the least preferred form of maneuver because it strikes the enemy where the enemy is the strongest. Frontal attacks in hilly or mountainous areas, even when supported by heavy direct and indirect fires, have a limited chance of success. Mountainous terrain adds to the defender's relative combat power, requiring that the ratio of attacking forces exceeds three times to those defending, such as in military operations on urban terrain.

Flanking Attacks, Envelopments, and Turning Movements. Flanking attacks, envelopments, and turning movements are used extensively in mountain operations. These techniques are a superior form of offensive maneuver used by the attacker to bypass the enemy's principal defensive positions. These forms of maneuver are used to avoid the enemy's strength and to attack where the enemy is weakest or unprepared. The enemy's defensive positions can be bypassed using ground, air, or vertical envelopment. When conducting dismounted movements, Marines must consider the corridors through which their maneuver elements travel. Commanders must place considerable emphasis on using mountain pickets as connecting files and providing overwatch as maneuver forces move across the valley floor to achieve surprise. The forces' ability to successfully execute flanking attacks, envelopments, and turning movements is enhanced by employing organizational mountaineers, airborne insertions, and air assaults.

Infiltration. Infiltration is frequently used in the mountains. The difficult terrain and recurring limited visibility periods allow for undetected movement. Infiltration in a mountainous environment is used to shape the battlefield by attacking the enemy's positions from the flank or the rear, securing key terrain to support decisive operations, or disrupting enemy sustainment operations. Infiltration is usually conducted using one of three techniques—movement in small groups along one axis, movement in one group, or movement in small groups along several routes at the same time. Regardless of the technique used, units conduct tactical movement and employ noise and light discipline while leveraging existing natural concealment to reduce the chance of enemy contact.

Movement in Small Groups Along One Axis. When moving in small groups along one axis, all members of the force use the best route. Small groups are harder to detect, are easier to control, and do not compromise the total force if detected. This technique is time consuming and requires guides, lead climbing teams, and an assembly area or link-up point prior to conducting the decisive action. The risk of enemy detection and of follow-on groups being ambushed is significant with so many groups.

Movement in One Group Along One Axis. The enemy can more easily detect one large group's movement along a single axis of advance than many groups. If the force is detected, the overall mission could be endangered. This technique, however, does not require reassembling the force prior to going into the attack. Because everyone uses the same route, navigation is easier and there is less requirement for guides and lead climbing teams than for many axes. A large force can fight out of a dangerous situation more easily than a small one can. This technique also minimizes coordination problems among infiltrating units.

Movement in Small Groups Along Multiple Axes. Movement in small groups along several axes avoids putting the total force in danger and makes them less likely to be seen. It forces the enemy to react in many locations and makes it harder for them to determine the size of the force or its mission. The challenges associated with this technique include reassembly of the force, command and control, sustainment, and the need for more specialized training, equipment, and personnel.

Penetration. Mountainous terrain usually makes penetration actions extremely dangerous due to the difficulty of concentrating overwhelming combat power at the objective area. Mobility restrictions make it difficult to develop and maintain the momentum required to move through the point of penetration, and the area of penetration is vulnerable to flank attack, particularly in mountainous terrain.

A penetration action can be useful when attacking an enemy that is widely dispersed or overextended in the defense. Flank defensive positions must be eliminated before the initial breach of enemy positions. Successful penetrations require surprise, security, and covered and concealed terrain at selected breach points.

Motti Tactics

Motti tactics demonstrate how forces can exploit superior mobility skills and knowledge of snow-covered and mountainous terrain and the environment to defeat a road-bound enemy. The Motti is a double envelopment maneuver, using the ability of light troops to travel over rough ground to encircle and cut off road-bound enemy forces. Forces with superior mobility can easily immobilize a larger enemy force. Motti tactics were used extensively by Finland's forces in the Russo-Finnish War of 1939–1940. This tactic was effective against mechanized units of the Soviet Army that were restricted to the long and narrow forest roads. Poor training and limited mobility kept the Russian forces road bound and vulnerable to the more mobile and highly trained Finnish units. The Finnish troops moved quickly through the forests on skis to break the armored columns into small chunks, such as by felling trees along the road. Once a large column was split into smaller units, the Finns attacked the isolated Soviet units. By cutting Soviet columns into smaller groups and then encircling them with light, mobile forces, the Finnish army was able to overwhelm a much larger force.

Generally, a force using Motti tactics avoids becoming decisively engaged. It disrupts the enemy's supply lines, denies them warmth and shelter, infiltrates bivouacs, and destroys the rear areas to the point where they must remain in a high state of alert. These attacks, combined with the environmental advantages, help to destroy the enemy's will to fight. Commanders should not only develop a thorough understanding of how to apply Motti tactics, but also understand the conditions that can leave their own forces vulnerable to their use. Motti tactics generally follow the sequence of—

- Locating and fixing the enemy.
- Isolating the enemy.
- Attacking to defeat or destroy the enemy.

Reconnaissance is conducted to locate an enemy force moving in or toward an area that restricts movements to roads, trails, or linear terrain. Once identified, the force must be fixed so that it presents a linear target along the axis of advance, to which it is bound by using obstacles and a series of squad- and platoon-sized ambushes and raids. Obstacles can be natural (snow, crevices, deep mud, steep terrain, and water obstacles) or man-made (mines, landslides, avalanches, or destroyed bridges).

The ambushes and raids not only fix the enemy, but disturb their composure, create uncertainty, and prevent sleep and rest. Attacking units attack from the high ground. They maximize night-vision devices as well as the difficult restrictive terrain. They avoid enemy security and interdict their operations, compelling them to use more forces on security tasks. Unless the enemy can be easily defeated or destroyed, the attacking force rapidly withdraws after forcing the enemy to deploy. This series of attacks confuses the enemy as to the attacking unit's location and intent and slows the decision-making cycle so the enemy reacts ineffectively to subsequent operations.

The attacking force then isolates the enemy into smaller groups and maneuvers to envelop and attack to defeat or destroy the isolated elements. As the enemy exhausts itself trying to break out, the attacking force can regroup and repeat the sequence. It is imperative that the attacking force seal off the enemy, keep avenues of approach closed, and not ignore the threat to its flanks, which can increase as the attack progresses.

Overall, Motti tactics wear the enemy down to where they are vulnerable to more direct attacks or where it is no longer beneficial or feasible to continue operations in the area. Motti tactics employed alone only prove decisive over a long period of time, depending on the enemy's capabilities, strength, and resolve. Based on METT-T, friendly forces typically increase the operation's tempo to gain a quick, decisive outcome. Still, this tactic can complement other more direct offensive operations in support of the plan. Forces can use Motti tactics when they—

- Have superior technical mobility skills necessary to negotiate Class 4 and 5 terrain.
- Can operate effectively in a noncontiguous area of operations with limited support and despite temperature extremes and inclement mountain weather.
- Can navigate in high, mountainous terrain, dense vegetation, darkness, storms, and fog while making good use of available cover and concealment.
- Maintain the element of surprise.

Forces are vulnerable to Motti tactics when they—

- Operate within noncontiguous areas of operations.
- Have limited mobility skills, restricting their movements to roads, trails, and Class 1 and 2 terrain.
- Have inadequate reconnaissance and security.

DEFENSIVE OPERATIONS

The mountainous defense's immediate objective is to deny the enemy access to key terrain that helps conduct further operations. Therefore, it is necessary to defend in terrain that restricts and contains the enemy, and to control the high ground that dominates this terrain. The terrain provides the defender with cover, concealment, and camouflage that can deceive the enemy regarding the friendly force's strength and dispositions. The defender should know the terrain, control the heights, fortify positions, emplace weapons in advance, stockpile supplies, and prepare lateral trail networks to allow for mobility.

Restrictive terrain inherent to mountainous areas is one of a Marine's primary defensive advantages because it interferes with the attacker's synchronization, canalizes movement, and impedes the ability to maneuver. To capitalize on this advantage, commanders should carefully analyze the vertical and horizontal terrain components from friendly and enemy viewpoints. Although a screening force is usually considered the preferred form of security in rugged terrain, all forms of security operations (screen, guard, and cover) can be employed. When conducting security operations commanders must consider the following:

- Forces available for security operations.
- Ability to maintain a mobility advantage.
- Security area size and avenues of approach.
- Likelihood of enemy action.
- Size of the expected enemy force.
- Early warning and reaction time needed.

A screening force provides early warning to the protected force and is usually an economy-of-force measure. The compartmented nature of mountainous terrain can lead to gaps and exposed flanks. The rugged terrain also restricts friendly and enemy forces movement. In these instances, commanders can choose to use minimum combat power to observe, identify, and report enemy actions at these locations and engage and destroy enemy reconnaissance within the screening force's capability. The screening force can avoid being decisively engaged by withdrawing into restrictive terrain.

In mountainous terrain, the screening force should adjust to the enemy advance and continue to screen as far forward as possible, even though the force elements may have to withdraw. Retaining selected forward positions might allow surveillance and targeting forward of the area of operations, upsetting the enemy's coordination. By allowing the enemy to bypass advance positions, the screening force can facilitate a counterattack since it can observe and access the flanks and rear of the attacking forces.

If a significant enemy force is expected or a significant amount of time and space is required, commanders can employ a guard or covering force. Security forces that can maintain a mobility advantage over the enemy can effectively delay and counterattack the enemy force. Using a guard or covering force provides greater depth in the security area.

Defending forces must prevent enemy infiltration by carefully positioning observation posts and conducting continuous patrols and ambushes. Reconnaissance patrols can rely heavily on technical climbing skills. Ground surveillance, radar, and ground sensors can be used to add greater depth to the defense.

Defensive positions along ridges or on dominating heights should include forward and reverse slopes to add greater depth and security. Fighting positions and observation posts should be echeloned vertically and in depth. When defending a mountain valley, forces establish fighting positions that are located on adjacent heights and in depth to permit covering the valley with interlocking fires. Defensive positions must be anchored to restrictive terrain or adjacent defensive forces to prevent enemy infiltration or envelopment. In wooded terrain, defensive positions can be organized on the forward edge of the woods, and on commanding heights. Obstacles should be widely employed to slow or stop enemy movement.

Mountain warfare demands that forces defend aggressively. Defending units must infiltrate enemy units and attack headquarters, supply lines, and rear areas. Small patrols and observation posts deploy well forward to direct artillery fire and attack aircraft on targets of opportunity and to conduct personnel and anti-armor ambushes. Operations should be conducted to force the enemy to deploy additional assets and to disrupt preparations.

Commanders can rely on their reserve as the principal means of restoring a defense's integrity or exploiting opportunities through offensive action. Movement can be difficult because small reserves can be located near primary defensive positions, ready for immediate counterattack. This type of small, responsive counterattack may be more effective than a large-scale, major counterattack. Large, centrally-placed counterattack forces are usually unable to intervene in time, unless the terrain permits mounted movement or sufficient helicopter lift assets are committed to the reserve force or made rapidly available. Reserve forces should be mobile enough to react to enemy action in any portion of the perimeter. Less mobile reserve forces are positioned to block the most dangerous avenues of approach and are assigned on-order positions on other critical avenues. Sharply compartmented terrain can require more than one reserve force to be created.

To minimize the vulnerability of sustaining operations, sustainment resources must be dispersed, redundant, and as far from enemy approaches as possible. Because of limited space available in rear areas, the commander must carefully select and locate positions for CSS and sustainment unit activities. These positions are likely to be confined to small valleys. A perimeter defense is planned for each operating base within the defensive area. Defensive positions should be selected on the dominating high ground. Sensors, observation posts, and radar are used to cover avenues of approach and gaps between positions. For more information on perimeter defense see MCRP 12-10A.1; ATP 3-21.50; and Army Field Manual (FM) 3-90, *Tactics*.

The four fundamental types of defense are mobile, position, retrograde, and counterlanding.

Mobile Defense

In a mobile defense, the defender withholds a large portion of available forces for use as a striking force in a counterattack. Mobile defenses require enough depth to let enemy forces advance into a position that exposes them to counterattack. The defense separates attacking forces from their support and disrupts the enemy's command and control. As enemy forces extend themselves in the defended area and lose momentum and organization, the defender surprises and overwhelms them with a powerful counterattack. The counterattack focuses on destroying the attacking force by permitting the enemy to advance into a position that exposes them to counterattack and envelopment. The commander commits the minimum possible combat power to the fixing force that conducts shaping operations to control the depth and breadth of the enemy's advance. The fixing force also retains the terrain required to facilitate the striking force's decisive counterattack.

A mobile defense relies heavily on the defender's ability to maintain a mobility advantage. This mobility advantage can result from or be enhanced by countermobility actions directed against the enemy force. In the mobile defense plan, the commander seeks to ensure that the force—including reserves and the striking force—can move freely around the battlefield, while restricting the enemy's mobility, slowing momentum, and guiding or forcing them into areas favorable for engagement. Mountainous terrain favors the defender because it has many choke points and fire sacks. Choke points have limiting terrain on two sides and fire sacks have limiting terrain on three sides.

Position Defense

A position defense focuses on retaining terrain by absorbing the enemy into interlocked, mutually supporting positions. Mobility restrictions and the requirement to control key terrain favor position and area defenses. Defending forces are relied upon to maintain their positions and to control the terrain. This defense uses battle positions, strongpoints, obstacles, and barriers to slow, canalize, and defeat the enemy attack. Position defenses rely on security forces, continuous reconnaissance and combat patrols, and many observation posts for depth and early warning. The natural canalization effect of mountainous terrain offers tremendous advantages in the defense.

In a position defense, the commander positions the bulk of the combat power in static defensive positions with small mobile reserves. This depends on the static forces to defend their positions and on the reserves to blunt and contain penetrations, to counterattack, and to exploit opportunities the enemy presents. Helicopters can be used to deploy reserves, but their use depends on suitable, secure landing zones (LZs) and favorable weather conditions. Commanders must prevent the enemy from concentrating overwhelming combat power against isolated sections of their defense.

Reverse slope defenses (see Figure 2-1) are well- suited to mountain operations. Reverse slope defenses are used to reduce the effects of massed indirect fire from mortar, artillery, and CAS and draw the battle into the small arms range of infantry weapons. The reverse slope defense goal is to make the enemy commit their forces against the forward slope of the defense, causing them to attack in an uncoordinated fashion across the exposed topographical crest.

All or parts of the defending force can use reverse slope techniques. In many instances, mountainous terrain favors a defense that employs forward and reverse slope positions to permit fires on enemy approaches around and over the crest and on the forward slope of adjacent terrain features. Key enablers to a reverse slope defense are ——

- Mutually supporting covered and concealed positions.
- Numerous natural and man-made obstacles.
- The ability to bring fire from all available weapons onto the crest.
- A strong and mobile counterattack force.

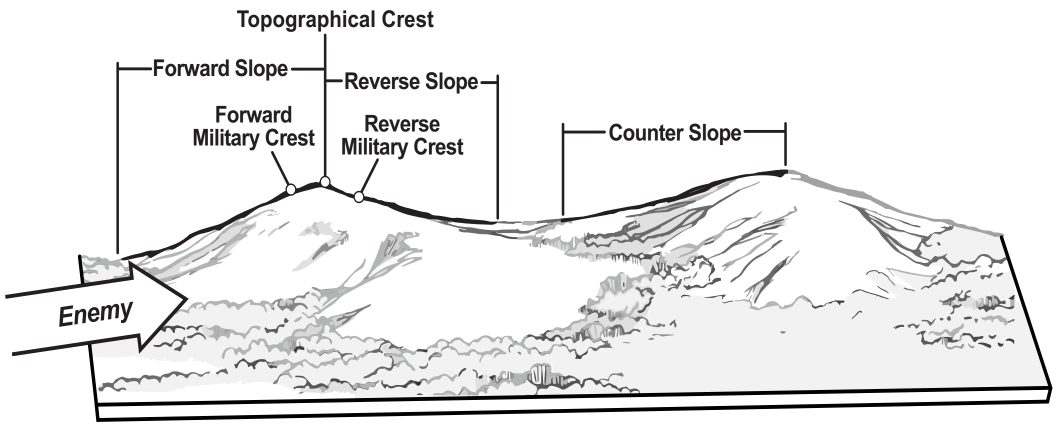

Figure 2-1. Reverse Slope Defense.

The reverse slope defense is organized so that the main defensive positions are masked from enemy observation and direct fire by the topographical crest. It extends rearward from the crest only to the maximum effective range of small arms fire. Observation and fires are maintained over the entire forward slope as long as possible to continue to destroy advancing enemy forces and prevent them from effectively massing for a final assault. A successful reverse slope defense is based on denying the topographical crest to the enemy, either by fire or by physical occupation. Although the crest may not be occupied in strength, control of the crest by fire is essential for success.

Retrograde

Retrograde operations in the mountains require fewer assets to delay an advancing enemy. Numerous positions may exist where elements as small as a machine gun or sniper team can significantly delay a large force. When conducting retrograde operations in mountainous terrain, the friendly force must—

- Use and reinforce existing obstacles.
- Conduct detailed reconnaissance of routes to rearward positions. Routes of withdrawal are not as numerous in mountainous terrain and often do not intersect as they do on flat terrain. These factors complicate subsequent linkup operations and necessitate meticulous planning.
- Protect the flanks and rear to prevent encirclement, particularly by air assault.

Operational Advantages and Disadvantages

The forms of maneuver and types of offensive operations does not change for mountainous environments; however, there are unique elements that must be considered before conducting offensive operations. One primary advantage when conducting offensive operations is that the attacker can choose when and how to attack. This point is emphasized even further in the mountains due to the many avenues of approach to a tactical objective, limited ground LOCs the defender must rely on for sustainment, and the difficulty the defender faces in constructing defensive positions.

Despite these offensive advantages, the aggressor is usually at a disadvantage in the mountains because the mountainous terrain favors defensive operations. The primary advantage to the defender in mountainous terrain is the ability to choose defensive positions that canalizes offensive forces, denying the attacking force the ability to maneuver effectively. If the defender controls the heights, observation precludes the attacking force from achieving surprise. Observation and canalization give the defender the opportunity to mass fires; however, if the attacking force is highly trained and able to negotiate the complicated mountainous terrain, the advantages the defender gains is nullified.

Weather and environmental hazards may provide both advantages and disadvantages to maneuver in these environments. Mobility means may be impacted depending on conditioning, training, and equipment. For more information on movement, weather, and sustainment considerations relative to maneuver in these environments see MCRP 12-10A.1.

Conducting stabilization activities in mountain population centers establishes conditions that enable the efforts of the other instruments of national and international power. By providing the requisite security and control to stabilize an operational area, those efforts build a foundation for transitioning to civilian control and, eventually, to the host nation. Military forces operating in this environment try to establish or restore basic sustainable civil functions and protect them until a civil authority or the host nation can provide these services for the local populace. In many cases, the restrictive terrain and cultural barriers found in isolated mountain communities prevents the host nation from fulfilling its role. Military forces can be called on to significantly increase their role to include providing the government's basic civil functions. Government reconstruction and stabilization is a slow development process and can become frustrating and difficult to manage as units and commanders' cycle through deployments to mountainous operational environments. Integrating the planning efforts of all the agencies and organizations involved in a stabilization activities is essential to long-term peace.

PLANNING AND INTELLIGENCE PREPARATION OF THE BATTLESPACE

Existing intelligence processes is used in mountainous environments. Marines should reference MCRP 2-10B.1 for further details on intelligence preparation of the battlespace (IPB), determining environmental effects, identifying hazards, and managing risks in an area of operations.

The Marine Corps uses operational risk management as its primary decision-making process to mitigate risks associated with any hazard that can injure or kill personnel, damage, or destroy equipment, or affect mission effectiveness. For the Marine Corps, risk management is an ongoing process that continues from mission to mission. Within the mission, leaders must know when the process begins and who has responsibility. Such knowledge must be integral to the military decision.

CHAPTER 3. INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

This chapter on specific effects mountainous environments have on intelligence operations concentrates on two areas of the intelligence process—planning and direction, and collection. ?A significant challenge of mountainous environments includes compartmentalized terrain, which has potential to disrupt or impede communications. The Marine Corps uses the generic term intelligence, surveillance, and reconnaissance (ISR) assets for all units, personnel, and equipment that conduct ISR activities. Therefore, to maintain ease of reading and limit redundancy throughout the rest of this publication, the term ISR assets will be used. Refer to the following for more information:

- Marine Corps Warfighting Publication (MCWP) 2-10, *Intelligence Operations*.
- MCRP 2-10A.8, *MTTP for Intelligence, Surveillance, and Reconnaissance (ISR) Optimization.*
- MCRP 2-10B.1, *Intelligence Preparation of the Battlespace*.
- MCTP 2-10A, *MAGTF Intelligence Collection*.
- Army FM 3-55, *Information Collection*, which discusses ISR measures.
- Army ATP 2-01, *Collection Management*.

PLANNING

Generating intelligence knowledge begins before the mission is received and provides the relevant knowledge required regarding the operational environment for the conduct of operations. Intelligence is the foundation for performing IPB and problem framing. Its primary products are the initial data files and the intelligence survey. To generate intelligence knowledge, planners must conduct the following tasks:

- Develop the foundation to define threat characteristics.
- Obtain detailed terrain information and intelligence.
- Obtain detailed weather information, weather effects, and weather intelligence.
- Obtain detailed civil considerations information and intelligence.

The results of each of the first four tasks are translated into a database or data files based on the commander's guidance to support the commander (see MCWP 2-10 and Army FM 2-0, *Intelligence* for more details).

Marines conduct planning to identify intelligence requirements, plan intelligence operations, and to support the commander's estimate of the situation. In this phase, intelligence gaps are identified, and collection is planned to satisfy those intelligence gaps. The harsh weather effects and compartmented terrain make accuracy and efficiency in the planning and directing phase critical to intelligence operations in mountainous environments. Planners must also note that caves could be used extensively in mountainous environments and should refer to MCRP 12-10A.3 and ATP 3-21.50.

The ISR plan is challenging and can take much longer than estimated to execute because of poor trafficability, severe weather conditions, and the rugged topography. Caves, overhangs, crevices, gorges, boulders, and crags afford excellent cover and concealment for the enemy. These unique terrain conditions pose multiple problems for ground commanders and their staffs in maneuver and security. High altitudes and extreme weather conditions impact negatively on the ability of aerial platforms and all types of imaging systems. As a result, commanders and their staffs must allow significantly more time for reconnaissance and surveillance in this unforgiving environment. Emphasis must be placed on confirming data collected from sensors and terrain analysis tools. These tools provide intelligence personnel with valuable data, but that data can lack sufficient detail. Mountain weather phenomena are localized, which increases the requirement for meteorological and oceanographic mission support teams. Due to the decentralized nature of mountain operations, mission support teams need to be pushed down to the battalion level if assets are available. Intelligence personnel cannot rely solely on regional forecasts when conducting planning and should use METOC personnel as needed.

Most mountainous terrain places severe demands on the maneuverability of troops. In this environment, Marines use ISR assets to verify trafficability, identify routes that support the movement of dismounted and mounted elements, and maintain friendly situational understanding for commanders and their staffs can be critical to a successful operation. Constant surveillance of the limited routes and avenues can contribute greatly to the friendly force's situational awareness. While the ideal solution is to maintain constant surveillance in a mountainous environment, leaders must realize that doing so consumes significant resources, which could affect the number of available named areas of interest that can be monitored. Even if no intelligence is gathered while surveying an area of interest, there is a greater chance of operational success if maneuver forces know that enemy forces have not been operating in the battlespace.

Combat in mountainous environments presents challenges to commanders and their staffs in locating and defeating an enemy that can be arrayed in multiple tiers along the slopes of key terrain, such as a critical mountain pass, dominating height, gorge, or trail. Since the restrictive terrain often does not support massing combat power against decisive points, commanders and their staffs need to use the ISR plan to precisely focus the maneuver assets and fire support.

COLLECTION

Collection consists of the activities of organic, attached, and supporting ISR assets to gather new data and deliver it to the appropriate processing or production agency. Though all ISR assets can be hindered by weather and terrain, Marines can consult intelligence personnel for ISR capabilities and limitations or METOC personnel to determine the environmental effects on ISR assets, if necessary.

The intelligence and collection process, combined with assigned intelligence personnel are leveraged to overcome the challenges of mountainous terrain.??Intelligence personnel, in coordination with operations personnel work to produce the ISR annex and the supporting collections tab – these products support the commander's critical information requirements.

CIVIL ENVIRONMENT

Mountain populations exhibit certain traits that significantly impacts operations. Although there will be variations depending on the location of the operation, case studies have revealed some generalizations that distinguish mountain populations from other populations. These populations tend to have the following traits:

- Independent nature.
- Enhanced loyalty to their group.
- Homogeneous.
- Tribal or clannish.
- Emphasis on religion.
- Less economically developed than more accessible areas.
- Lack formal education.
- Adherence to a strict social code.
- Different norms to determine economic status.
- Less infrastructure.
- Decreased access to information.
- Less emphasis on centralized governance.

While individual mountain populations tend to be homogenous due to the compartmentalized terrain, the districts, provinces, and states in which they reside tend to be heterogeneous. Clans or tribes from one valley can differ from those in the next. The operational impact is that small-unit leaders are forced to conduct functions that are usually done at the battalion level and higher. As a result, assets are being pushed to lower levels to compensate for this operational need. For example, the company level intelligence cell, in most cases, pull information from human environment databases.

The small unit's composition is not uniform and depends on the parent unit's position. Since this is an emerging requirement, there is no official doctrine, regulation, or table of organization and table of equipment outlining the roles, responsibilities, and number of analysts assigned to the company. MCRP 2-10B.7, *Company-Level Intelligence Cell*, can assist with planning company-level intelligence operations. Companies must also have access to and develop shared databases that help them identify key mountain community members.

IRREGULAR WARFARE CONSIDERATIONS

To facilitate intelligence activities in support of irregular warfare, intelligence planners in a mountainous environment select teams of analysts who examine and share the information different field elements provide. These analysts collect information from the grass-roots level and incorporate that information at their command level. For example, they integrate information collected by civil affairs officers, provincial reconstruction teams, liaison officers (LNOs), female engagement teams, military information support operations teams, civil-military engagement teams, and infantry battalions into a shared database.

Leaders and planners must put time and energy into selecting the best and most eager analysts to serve in the fusion cells. The highly complex mountainous environment requires an adaptive way of thinking and operating, such as vetting a single source from one tribal valley compartment against the adjacent terrain and tribal compartment. These efforts facilitate stabilization activities and allow the commander to better respond to the needs of the populace.

RECONNAISSANCE AND SURVEILLANCE

At the beginning of a campaign in a mountainous environment, requirements can be usually answered by aerial or overhead platforms using radar systems to detect man-made objects. Terrain can significantly impact the employment of overhead reconnaissance platforms. These systems can be adversely impacted by the masking effect that occurs when mountainous terrain blocks the radar beam, so radar coverage cannot extend across the reverse slope of a steep ridge or a valley floor. Attempts to reposition the overhead platform to a point where it can "see" the masked area can result in masking occurring elsewhere. This limitation does not preclude using such systems; however, commanders and their staffs should employ air reconnaissance with overhead reconnaissance platforms, such as balloons and satellites, when available to minimize these occurrences.

Ground reconnaissance uses assets to verify the data that can be gathered by overhead and electro-optical platforms to ensure that commanders do not fall prey to deliberate enemy deception efforts that capitalize on the limited capabilities of some types of overhead platforms in this environment. In mountainous areas of operations, it may often be necessary to commit ground reconnaissance assets to support strategic and operational information requirements. Conversely, strategic and operational reconnaissance systems may be employed to identify or confirm the feasibility of employing ground reconnaissance assets. Surveillance teams can be inserted to gather information that overhead systems cannot collect or to verify data that has already been collected. In this instance, satellite imagery is used to analyze a specific area for inserting the team. The potential hide positions for the teams are identified using imagery and, terrain and weather permitting, are verified by unmanned aircraft systems (UASs).

On harsh mountainous terrain, ground reconnaissance operations are often conducted dismounted. Commanders and their staffs must assess the slower rate of ground reconnaissance elements to determine its impact on the entire reconnaissance and collection process. They must develop plans that account for this slower rate and initiate reconnaissance as early as possible to provide additional time for movement (see Chapter 4 for movement planning tools). Commanders may also need to allocate more forces, including combat forces, to conduct reconnaissance, surveillance, or limited objective attacks to gain needed intelligence. Based on METT-T, commanders may need to prioritize collection assets, accept risk, and continue with less information than from their initial reconnaissance efforts. In these cases, they must use formations and schemes of maneuver that provide maximum security and flexibility, to include robust security formations, and allow for the development of the situation once in contact.

Although reconnaissance patrols should usually use the heights to observe the enemy, they may need to send small reconnaissance teams into valleys or along the low ground to gain suitable vantage points, conduct countersurveillance (as mountain villages often serve as a network of informants on friendly movements), or physically examine routes that will be used by mechanized or motorized forces. In mountainous environments, reconnaissance elements are often tasked to determine—

- The enemy's primary and alternate LOCs.
- Locations and directions from which the enemy can attack or counterattack.
- Heights that allow the enemy to observe the various sectors of terrain.
- Suitable observation posts for forward observers.
- Route portions that provide covert movement.
- Mountaineering skills required to negotiate routes (dismounted mobility classification) and route sections that require specific mountaineering equipment, tools, or facilities (e.g., bivouac sites, tents, and huts) and mountaineering installations (e.g., fixed ropes or raising and lowering systems).
- Trafficability of existing trails and routes to support sustained military movement requirements, using an engineer estimate of the effort required to improve or maintain this capacity.
- The enemy's location, obstacles and barriers, including minefields, and feasibility of breach or bypass.
- Bypass routes.
- Potential airborne and air assault drop zones, pickup zones, and aircraft landing areas.
- Location of locally available engineer resources, such as construction materials, borrow pits, water, and construction equipment.

Mobility Considerations

Snow can pose a serious threat to Marine Corps units not properly trained and equipped for movement under such conditions: avalanches have taken the lives of more troops engaged in mountain warfare than all other terrain hazards combined. Reconnaissance units must do a thorough reconnaissance of the battlespace to determine areas where avalanches and rock slides are most prevalent and most likely to hinder mobility. This information should be included in their reconnaissance overlays to generate a full picture for the commander (see Chapter 5 for mitigation procedures).

Reconnaissance in Force

The compartmented and inherent mobility restrictions of mountainous terrain pose significant risk for reconnaissance in force operations. Since the terrain usually allows enemy units to defend along a much broader front with fewer forces, a reconnaissance in force can be conducted as a series of smaller attacks to determine the enemy situation at selected points. Commanders and their staffs should carefully consider mobility restrictions that could affect exploitation or withdrawal plans. They should also position small reconnaissance elements or employ surveillance systems throughout the threat area of operations to gauge the enemy's reaction to friendly reconnaissance in force operations and alert the force to possible enemy counterattacks. In the mountains, the risk of having at least a portion of the force cut off and isolated is extremely high. Mobile reserves and preplanned fires must be available to reduce the risk, decrease the force's vulnerability, and exploit any success as it develops.

Engineer Reconnaissance

Engineer reconnaissance assumes greater significance in a mountainous environment to ensure that supporting engineers are properly task-organized and have specialized equipment to quickly overcome natural and reinforcing obstacles. Engineer reconnaissance teams conduct the following functions:

- Assessing the resources required for clearing obstacles on precipitous slopes.
- Constructing crossing sites at fast-moving streams and rivers.
- Improving and repairing roads, erecting fortifications, and establishing barriers while defensive operations are ongoing.
- Integrating into mountain reconnaissance operations, as the restrictive terrain promotes the widespread employment of point obstacles.
- Providing subterranean and ice reconnaissance.

Additional information on engineer reconnaissance can be found in MCRP 3-34.3, *Engineer Reconnaissance*. In some regions, maps might be unsuitable for tactical planning due to inaccuracies, limited detail, and inadequate coverage. In these areas, engineer reconnaissance should precede, but not delay, operations.

Because rugged mountainous terrain makes ground reconnaissance time consuming and dangerous, a combination of ground and aerial or overhead platforms should be used for engineer reconnaissance. Data on the terrain, vegetation, and soil composition, combined with aerial photographs and multispectral imagery, enable engineer terrain intelligence teams to provide detailed information that may be unavailable from other sources.

CBRN Reconnaissance

The mountainous environment presents unique challenges when conducting chemical, biological, radiological, nuclear, and high-yield explosives reconnaissance. See MCRP 10-10E.7, *Multi-Service Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Reconnaissance and Surveillance*, and MCRP 3-40A.6, *Multiservice Tactics, Techniques, and Procedures for Health Service Support in a Chemical, Biological, Radiological, and Nuclear Environment*, for information that can be useful in conducting such reconnaissance.

Air and Overhead Reconnaissance

Except during the most adverse weather conditions, air or overhead reconnaissance may be the best means for gathering information, as it covers large areas that are difficult for ground units to traverse or observe. Airborne standoff intelligence-collection devices, such as side-looking radar, provide excellent terrain and target isolation imagery. Missions must be planned to ensure that critical areas are not masked by terrain or other environmental conditions. Additionally, air or overhead photographs may compensate for inadequate maps and provide the level of detail needed to plan operations. Infrared imagery and camouflage detection film can be used to determine an enemy's precise location, even at night. Furthermore, sensor equipped aircraft, can provide commanders and their staffs with critical day or night video reconnaissance using television or forward-looking infrared.

The UAS flight patterns might be adversely affected by mountainous terrain. Line-of-sight (LOS) command links could limit UASs from flying into valleys, which also limits signals collection or electro-optical resolution. They would require much higher operating elevations to maintain positive command and control, use satellite-based command links, or operate in autonomous mode more often.

Radar shadowing is a phenomenon in which a distortion occurs in a radar return image when the angle of an observed object, such as a mountain side, is steeper than the sensor depression angle. This occurrence can cause ghost images or distorted images in mountainous terrain. Commanders and intelligence officers should consider employing manned or unmanned systems that employ nonradar sensors to minimize such images. Overhead systems that employ electro-optical or infrared sensors may realize greater success than radar systems when weather conditions facilitate their use. The subsequent employment of ISR assets to verify data provided by overhead sensors helps ensure that the commander does not fall victim to deception targeted against specific overhead sensors.

Signals Intelligence

Weather and compartmented terrain reduces the effectiveness of signals intelligence (SIGINT) assets, but mountainous terrain presents a special challenge to SIGINT collection. Mountain mineral deposits can create dead zones for frequency modulation communications, making SIGINT collection pointless. Extreme changes in elevation create radio frequency blind spots, known as terrain masking. Radio frequency terrain masking, in many instances, becomes the determining factor for placing and employing SIGINT collection assets. Higher elevations provide better area coverage for radio frequency signals; however, weather conditions rapidly deteriorate as elevation increases, limiting effective deployment of SIGINT collection teams to higher ground. To maintain effective SIGINT collection operations, a balance must be struck between the adversary's location and communications capabilities and that of the SIGINT collection team. Effective and accurate IPB is critical to ensuring optimal SIGINT collection. For more elaboration on SIGINT effects, see MCTP 2-10A.

Human Intelligence

Terrain and poor weather slow the mobility of all personnel on the ground, including human intelligence (HUMINT) collectors. Also, disparate populations and their sometimes-long-term isolation can result in language barriers. A limited supply of interpreters and linguists would likely limit the HUMINT collection efforts; moreover, in many areas of the world, different mountain group inhabitants speak different languages or dialects from the rest of the country and even the rest of the area. These language and dialect variations, coupled with a likely distrust of outsiders can make HUMINT collection extremely challenging.

Ground reconnaissance assets are a key source to enable HUMINT operations. Any information or activity that ground reconnaissance units observe must be reported up through the chain of command. Only trained and certified HUMINT collectors are authorized to collect information. Frequent low-visibility periods, severe weather, and compartmented terrain affects the range and observation capabilities of these assets.

Geospatial Intelligence

Weather and terrain also limit imagery collection. Terrain masking precludes imagery collection from national collection assets at some angles. Precipitation, icing, winds, low cloud cover and dense fog limits or precludes the UASs and manned reconnaissance aircraft employment. Such operations can also be influenced by rapidly changing weather. Long-endurance UAS operations requires careful planning for dramatic changes in weather over a mission's course. Additionally, mountainous regions often experience extremely high wind velocities. Smaller UAS platforms may be unable to fly or may be lost due to violent winds experienced at higher altitudes. Fog, cloud cover, and precipitation also limit electro-optical and infrared sensors' effectiveness and degrade the imagery's quality collected. A unit with carefully calculated weather and terrain effects and a focused and efficient collection plan can more effectively mitigate these limitations.

Geospatial information and services considerations can be found in MCRP 2-10B.4, *Geospatial Information and Intelligence*. Such considerations are useful for examining unique natural terrain aspects that affect all types of operations in a mountainous environment. For example, geospatial information and services can model rock types and analyze the amount of water a given rock type can provide, which could impact sustainment and stabilization activities. However, commands that direct a thorough engineer reconnaissance or battlefield assessment significantly increase the fidelity of information available within geographic information system media.

Ground and Long-Range Surveillance

In the mountains, surveillance of vulnerable flanks and gaps among units is accomplished primarily through well-positioned observation posts. Depending on the threat, these observation posts can be inserted by air or ground. These observation posts are staffed by small elements equipped with sensors, enhanced electro-optical devices, and appropriate communications. Commanders and their staffs must develop adequate plans that address not only their insertion, but also their sustainment and ultimate extraction. The METT-T considerations might dictate that commanders provide more personnel and assets than they would to operations in other terrain types to adequately conduct surveillance missions. Commanders and their staffs must also ensure that surveillance operations are fully integrated with reconnaissance efforts to provide adequate coverage of the area of operations.

Long-range surveillance units and snipers trained in mountain operations also contribute to surveillance missions and benefit from the restrictive terrain and excellent LOS. Overhead platforms and attack reconnaissance helicopters can also be used for surveillance missions of limited duration; however, weather might impede air operations, decrease visibility for air and ground elements, and reduce ground surveillance elements' ability to remain hidden for prolonged periods without adequate logistical support. Terrain can mask overhead surveillance platforms.

Mountain Pickets

The Marine Corps has historically used mountain pickets to provide security, mobility, and fires in mountainous environments. Mountain pickets are usually dismounted but can consist of either mounted or dismounted elements. Mounted maneuver elements should use scouts as forward reconnaissance elements. These elements should be small, light, mobile units that conduct route reconnaissance for the main body. In addition to a route reconnaissance, these elements should establish security at danger areas by securing the high ground and establishing mountain pickets. The use of pickets can decrease the speed at which a unit can move due to the difficulty of moving along the top of ridgelines and the tactical situation due to the likelihood of encountering adversary and needing to provide fires. Tasks of mountain pickets are to—

- Provide flank security for the main body.
- Provide adjacent compartment surveillance.
- Provide observed fires into and across adjacent compartments.
- Serve as a relay for voice communications.
- Serve as connecting files in offensive operations.
- Be either static or mobile along ridgeline tops.
- Patrol for periods of 3 to 14 days.
- Be acclimatized and in a high state of physical fitness and maintained specialized equipment needed to move across the specific ridge complex, such as crampons, ice axes, and ropes.

CHAPTER 4.
MANEUVER AND MOVEMENT

Maneuver in mountainous terrain is inherently difficult. The complex and compartmentalized terrain, time of year, weather, and adversary influence maneuver and movement in the mountains. Detailed planning, specialized equipment and training, and strong leadership are required for successful operations. Low temperatures, reduced visibility, snow and ice, avalanche hazards, rock-fall hazards, and an adversary who is familiar with fighting in the mountains all combine to make the mountains one of the most challenging environments for military operations.
Further maneuver considerations that are unique to the different types of operations is located in Chapter 3.

AIR MOVEMENT

Aviation is well suited for conducting operations in a mountainous environment. Using assault support aircraft is essential to rapid movement of forces and equipment in the mountains; however, commanders must be continuously mindful of potential weather and elevation effects on the assault support aircraft. Assault support aircraft can provide the commander with tremendous maneuver capabilities, enabling units to concentrate combat power quickly and decisively. However, any operation that depends primarily on continuous aviation support to succeed is extremely risky. High elevations and rapidly changing weather, common to mountainous regions, are restrictive to aviation operations and make aviation support availability unpredictable. Higher altitudes restrict helicopter lift capabilities and decrease aircraft payloads. Commanders must be familiar with the conditions that limit aviation effectiveness during mountain operations. A more detailed discussion is located in Chapter 7.

MOUNTED MOVEMENT

Mechanized and motorized operations in complex and compartmentalized terrain are severely hampered by terrain, infrastructure, and weather. Narrow roads and movement corridors can limit vehicle traffic to predictable patterns. Although simplifying traffic control, maneuvering and recovering vehicles can be problematic.

Terrain and weather can limit the type of vehicles that can travel on certain roads, particularly during inclement weather conditions that can reduce traction (i.e., slippery conditions, mud). Roads that are wide enough for light tactical vehicles might not support larger wheeled or tracked vehicles (e.g., light armored vehicles, amphibious combat vehicles or mechanized vehicles, such as armored personnel carriers or amphibious assault vehicles). Where practicable, movement planners should ensure turnaround points are constructed in support of ground LOCs. A vehicle's fuel consumption also increases with increased road slope and grade.

Precipitation (i.e., snow and rain) hampers mechanized and motorized mobility assets. For example, roads close to rivers can flood during spring when snow packs start to melt at higher elevations. The seasonal effects on vehicle movement must always be considered when planning convoys in complex terrain.

Generally, mountainous terrain severely limits wheeled vehicles' movement and is too restricted for tracked vehicles. Trafficable terrain, such as roads and trails, tend to contour rugged terrain features, which makes mounted movement vulnerable to ambushes and attack aircraft. Recovery vehicles must accompany mounted forces in mountainous terrain to remove disabled vehicles from the limited and narrow road networks. See Chapter 6 for vehicle recovery information.

Armored vehicles are generally limited to movement in valleys and existing trail networks at lower elevations. Even at lower elevations, roads and trails can require extensive engineer work to allow tracked vehicle usage.

Due to terrain limitations, tracked vehicles rarely accompany dismounted infantry in the assault. Infantry fighting vehicles can assist forces conducting dismounted movement by occupying support by fire positions and by using their firepower to isolate objectives. If employed above Level I terrain, mechanized vehicles can decentralize and operate as smaller units, but they should be complemented by dismounted forces. Mechanized vehicles are more vulnerable in mountainous terrain because they are susceptible to attack from higher elevations and unable to elevate their weapon systems sufficiently to return fire.

The lower atmospheric pressure at higher elevations considerably increases water evaporation in batteries and vehicle cooling systems and impairs cylinder breathing. Consequently, vehicles expend more fuel and lubricant and experience engine power reductions by 4 to 6 percent for every 1,000-meter increase in elevation above sea level. As a result, mileage and load-carrying capacity is reduced during operations, and fuel and oil requirements increase approximately 30 to 40 percent. Additional movement considerations are discussed in MCRP 12-10A.4.

Driving

Drivers should not be permitted to drive in mountainous environments until they have had adequate training. Though specified requirements vary due to operational environment, experience, platforms, and time available, the following general considerations are recommended for training:

- Orientation to the environment.
- Platform capabilities and limitation.
- Rollover battle drills rehearsals.
- Iterations of rough terrain driving to prepare drivers and crews for the rigors of driving in complex, compartmentalized terrain.

Drivers must become skilled at driving in reverse on narrow mountain passes; if the road only allows for one-way traffic and drivers encounter oncoming traffic, then one driver has to back up to a spot that allows passage.

Convoy Planning

To facilitate convoy planning, planners should conduct a physical network analysis. The physical network analysis should encompass roads, bridges, obstacles, population centers, and potential danger areas. Due to the complex nature of mountainous terrain, assets other than maps and dated imagery should be used. Roads that appear viable on maps may be impassable during certain times of the year. Additional convoy planning considerations include—

- Type and maximum number of vehicles that the road network can support, including each route's throughput.
- Requirement for new road construction or road improvements.
- Bridge classifications.
- Likely locations for ice and snow. Considerations for briefing and catching features and identifying vulnerable locations, tire chains, heavy equipment to move snow, and over-the-snow vehicle options.
- Likely vehicle rollover locations.
- Existing roads' potential for bottlenecks, deployment areas, passing places, and turnarounds for various vehicles. There is a requirement for early location and marking these areas. Alternative routes must be identified and allocated as soon as possible.
- Potential alternatives for at least two routes if possible; one for vehicle traffic and the other for troops on foot, animal transport, and refugees. If possible, additional separate routes for wheeled and tracked vehicles should also be allocated, particularly if the latter are likely to damage the road surfaces.
- Depending on the situation and support available, routes can be classified as one- or two-way and schedule development for the use of one-way routes.
- If the tactical situation permits, placement of signs can mitigate confusion and risk on difficult and dangerous routes.
- Communication quality, particularly between start and finish points, on congested portions of the route, and at any passing points.
- Dedicate organization to rapidly clear obstacles enemy actions cause, the elements, or broken-down vehicles.
- Plans for integrated route clearance operations to be executed prior to convoy movement along designated routes.

Most mountainous areas around the world have unimproved roads unsuitable for heavy tactical vehicles. In such areas, existing roads and trails are few and primitive and cross-country movement is particularly challenging. Highways usually run along features that have steep slopes on either side, making them vulnerable to attack. Rivers can become major obstacles because of rapid currents, broken banks, rocky bottoms, and the lack of bridges. Natural and man-induced landslides and avalanches can also pose serious obstacles to vehicle movement. In late winter or early spring, mud becomes a concern for unimproved road trafficability, and roads can become flooded as snow begins to melt. The run-off from melting snows in the spring and torrential rains in the summer, or fall can wash away roads and flood low ground. All vehicles must maintain survival equipment for all personnel.

Mines and improvised explosive device (IED) locations include choke points, compartmented terrain, and restricted roads. Using host-nation route clearance units is recommended, if available. Additionally, commanders can mitigate enemy obstacle emplacement (reseeding mines) by providing overwatch (pickets) to the main supply route (MSR) and alternate supply route or critical ground LOCs areas, such as bridges or tunnels. More information pertaining to route clearance and obstacle reduction is found in MCTP 3-34A, *Combined Arms Mobility*, and MCTP 10-10C, *MAGTF Counter-Improvised Explosive Device Operations*.

DISMOUNTED MOVEMENT

Dismounted movement is often extremely slow and arduous and could require highly skilled mountaineering teams to secure the advance. For example, movement in Level II terrain might dictate that elements secure the high ground in Level III terrain. As with any type of movement, some of the keys to successful dismounted movement include using proper movement techniques and formations and constant security to avoid unplanned enemy contact.

Route Planning

Units with trained mountain leaders should use them for route planning. A tool available during the planning process is the time-distance formula, which assumes acclimatized forces. The following considerations helps planners determine time requirements for movements:

- Altitude at which forces would be operating.
- Amount of time a unit has had to acclimate to the environment.
- Weight each individual is required to carry.
- Unit’s fitness level.

Foot marches in the mountains are measured in time and elevation, rather than just distance. For a map reconnaissance, map distance plus one-third is a good estimate of actual ground distance to be covered. One hour is planned for each three kilometers (about two miles). An additional hour is added for each 300 meters (1,000 feet) of ascent or each 600 meters (2,000 feet) of descent. The shortest person (and shortest gait) in the unit needs to be placed in the front of the formation, allowing the unit to maintain a uniform march rate.

The terms broken and unbroken trail have specific meanings. When moving through undisturbed (unbroken) snow greater than 30 centimeters (12 inches), the lead 2 or 3 persons must pack the snow for the rest of the file. Once accomplished, the trail becomes broken. Since the lead persons exert more effort while breaking the trail, they need to be cycled to the rear of the formation every 15 to 30 minutes. Personnel complete this cycling similarly to how they execute a “last-man-up” physical training run. Leaders replace personnel in the lead every 15 to 30 minutes, depending on fitness level.

If dismounted, troops deploy into column (wedge) formation outside the file formation and the unit moves more slowly. With no one breaking the trail, all personnel must now move through undisturbed snow. In temperate regions, column formation is ideal since it maximizes fields of fire and allows for greater command and control; however, when operating in a snow-covered environment, the ideal formation is the file formation. Leaders only deploy into column formation if enemy contact is imminent because the rate of movement is constrained. Table 4-1 shows dismounted movement rates of march in the mountains.

Table 4-1. Rates of March for Unit Movement.

Movement Mode	Unbroken Trail	Broken Trail
On foot, no ski or snowshoe Less than 1 foot of snow	1.5 to 3 kph	2 to 3 kph
On foot, no ski or snowshoe More than 1 foot of snow	0.5 to 1 kph	2 to 3 kph
Snowshoe	1.5 to 3 kph	3 to 4 kph
Skiing	1.5 to 5 kph	5 to 6 kph
Skijoring	NA	8 to 24 kph (for safety, 15 kph is the highest recommended speed)
LEGEND kph kilometers per hour NA not applicable		
Note: Time-distance formula: Add 1 hour for every 300 meters (1,000 feet) of ascent and 1 hour for every 600 meters (2,000 feet) of descent.		

Commanders cannot permit straggling or deviations from the selected route. March discipline must be rigorously enforced to keep a column closed. To prevent an accordion effect, unit members must allow enough distance between themselves to climb without causing the following individual to change pace. In mountainous terrain, a slow, steady pace is preferred to more rapid movement with frequent halts.

Commanders must incorporate scheduled rests into movement plans based on distance and availability of covered and concealed positions. As a general rule, units should stop and rest for 5 minutes after 25 minutes of movement. If possible, commanders should not conduct rest halts during steep ascents or descents. At the start of a march, everyone should dress lightly so that they begin the march cool. A short halt should be taken to adjust clothing and equipment after the first 15 minutes of movement.

In glacial areas, the principal dangers and obstacles to movement are crevasses and snow and ice avalanches. Exposure to glaciated mountain hazards increases at the company-level and above; hence, movement should be limited to separate platoons and lower levels. When moving on glaciers, an advance element should be used. The advance element identifies the best advance routes, marks the trail, and provides directions and distances for follow-on units. A marked trail is particularly important during inclement weather and low visibility and provides a route for retrograde. Commanders must carefully weigh the advantages of a marked route against the possibility of ambush and the loss of surprise.

Individual Loads

Economizing the individual combat load is essential for conducting dismounted operations in the mountains. In steep terrain at elevations above 1,524 meters (5,000 feet), individual loads may need to be reduced by 50 percent. For example, water purification and the amount of bulky ammunition, such as pyrotechnics, must be considered. First class lightweight assault packs, however, are vital. Leaders at all levels must ensure they review and modify an existing unit's packing lists and standing operating procedures when conducting dismounted operations in mountainous terrain. Consider using the memory aid DROP—

- **D**ecide mobility Levels.
- **R**educe Unnecessary Equipment.
- **O**rganize Resupply Methods.
- **P**olice The Ranks and conduct inspections.

Terrain Analysis

Unlike flat with terrain, on which the quickest way from point A to point B may be a straight line, moving in a straight line on mountainous terrain is often more difficult and time consuming. Route planning includes—

- Analyzing the physical network.
- Contouring to prevent forces from gaining or losing elevation.
- Observing obstacles, such as population centers, rivers, and bridges.

Mountain Streams and Fords

Stream and river crossing operations are difficult and are usually accomplished quickly. Bridging operations in mountainous terrain are usually limited to spanning short gaps and reinforcing existing bridges by using prefabricated materials and fixed spans from floating bridge equipment. However, standard design or improvised suspension bridges could still be needed for longer spans. Because existing bridges may have low-vehicle load classifications, standard fixed tactical bridges and bridging materials should be on hand to reinforce or replace them. In extremely rough terrain, cableways and tramways can be constructed to move light loads and personnel across gorges and up and down steep slopes. For additional information on considerations for water obstacle crossing, refer to MCRP 12-10A.1.

Swift Water. Operations conducted in mountainous terrain can often require crossing swift flowing rivers or streams. Such crossings should not be taken lightly. The flowing water's force can be extremely great and is often underestimated. All rivers and streams are obstacles to movement. Marines should treat them as danger areas and avoid them if possible. Not all mountain rivers or streams are fordable. If a water obstacle is too wide, swift, or deep, then an alternate route should be used or engineers will have to build a bridge that Marines can cross, or rafts or boats can be used. Reconnaissance is essential with questionable crossing sites.

Map, photo, and air reconnaissance of the route may not always reveal water obstacles. In a swamp, for example, unfordable sloughs may not show on the map or they could be concealed from aerial observation by a vegetation canopy. Whenever a unit crosses a water obstacle, its commander must plan some type of crossing capability.

Fords. A ford is a location in a water barrier where the current, bottom, and approaches allow personnel, vehicles, and other equipment to cross and remain in contact with the bottom during crossing. Fords are classified according to their crossing potential (or trafficability) for pedestrians or vehicles. Fordable depths for vehicular traffic can be increased by suitable waterproofing and adding deep-water fording kits. These kits permit fording depths up to an average of 4.3 meters (14 feet). Vehicle technical manuals provide further fording information.

Reconnaissance of potential fording sites is critical and should include the soil composition of the approaches and the current's speed. Approaches can be paved or covered with mat or trackway, but they are usually unimproved. The composition and the slope of the approaches to a ford should be carefully noted to determine the trafficability after fording vehicles saturate the surface material of the approaches. The velocity of the water and the presence of debris are used to determine the effect, if any, on the ford's condition. Currents are categorized as—

- Swift (more than 1.5 meters [5 feet] per second).
- Moderate (1 to 1.5 meters [3 to 5 feet] per second).
- Slow (less than 1 meter [3 feet] per second).

The ford's stream-bottom composition largely determines its trafficability. It is important to determine whether the bottom is composed of sand, gravel, silt, clay, or rock and in what proportions. For more information on trafficability and fording see Joint Publication (JP) 3-34, *Joint Engineer Operations*.

Casualty Evacuation

Casualty evacuation in the mountains is resource intensive in manpower, equipment, and time. Planned routes should identify casualty collection points that are accessible to multiple transportation assets, if possible. Units must consider how they will move casualties if vehicles or aircraft cannot be used due to terrain and weather restrictions. Personnel should be trained in rough terrain evacuation techniques prior to deployment, to include raising, lowering, and nonstandard casualty evacuation (CASEVAC) platforms. Leaders should plan and rehearse contingencies for mounted, dismounted, and aviation evacuations. Realistic time-distance analysis must be conducted to ensure proper allocation of assets and to maximize casualty survivability. Units should consider pushing medical assets to lower echelons to reduce CASEVAC requirements. Chapter 6 provides more information on casualty evacuation.

General Considerations

Mountainous environments limit mobility, employing mutually supporting large forces, and using sophisticated weapons and equipment. These limitations mitigate many strengths US military forces bring to the fight; however, they benefit the indigenous adversaries whose lesser sophistication better suits the environment.

Mountain operations restrict ground and air movement of units. Movement requires careful planning and execution with the understanding that distance over arduous terrain can be as difficult to overcome as the adversary. Marine forces must adapt their standing operating procedures and develop innovative TTPs to successfully accomplish the mission.

Unit movement requires the proper integration and use of all appropriate resources, including aircraft, wheeled and tracked vehicles, watercraft, porters, pack animals, and individual means. Successful terrain negotiation and overcoming the environmental effects depend on specialized mountain training and proper equipment.

CHAPTER 5. ENGINEERING

Engineering activities require more preparation, resources, and time in the mountains than those in any other environment. Steep elevation changes, extreme weather, unmoving rock, and lack of oxygen at high altitude all present challenges for the engineer that can be overcome by proper planning. The other warfighting functions—effective communications, sustainment, fires, and maneuver with traditional methods—that enable the engineer to accomplish the mission can also be hindered by the inherent difficulty of mountain operations. Marines should reference MCTP 3-40D, *General Engineering*, for additional information regarding general engineering in all environments.

ORGANIZATION

Only through an in-depth IPB, a thorough ISR plan, and an in-depth analysis can units overcome the difficulties associated with mountain operations; moreover, Marine Corps engineers execute a thorough engineer battlefield assessment. There is no formula for success in the mountains, as every valley over the next ridge line will present new challenges that require new solutions. But through analysis, effective task organization, and allocating resources, Marine Corps engineers can adapt to those challenges.

Task Organization

Mobility in the mountainous environment is extremely limited, requiring extensive shaping activities. The sheer number of hours required to move earth movement provide construction for mobility in offensive operations requires a focused effort from all engineer elements. The inherent separation of areas of responsibility for the different engineer elements based on subordinate command element mission-essential tasks within units can result in a separation of resources to support varying requirements with varying priorities. To maximize the allocation of engineer resources to the highest priority tasks and to prevent low productivity from any engineer element, commanders must be prepared to detach all horizontal construction engineer elements from subordinate commands and combine them to create a separate element.

Joint Engineer Support Elements

The difficulties presented by the mountainous environment can only be effectively mitigated by the combined effort of all engineer elements in the area of operations. The Marine Corps has limited heavy engineering assets with which to accomplish complex large-scale engineering missions, making liaison or providing an LNO with joint elements, is vital to the procurement of critical engineering capabilities and support that may be organic to the other Services.

Naval Construction Force. Joint Publication 3-34, *Joint Engineer Operations*, describes the basis for naval construction force support to the operational forces (MCTP 3-34D, *Seabee Operations in the Marine Air-Ground Task Force*). In addition to or coincident with component missions specified by the commander, the Navy provides general engineering support to MAGTFs. This support consists of naval construction force units under the operational control of a MAGTF. These naval construction force units are necessary to reinforce and augment the MAGTF's limited engineering capability. They are integral to the MAGTF organization and ensure that CSS tasks are delivered immediately and effectively.

Rapid Engineer Deployable Heavy Operational Repair Squadron Engineer. The rapid engineer deployable heavy operational repair squadron engineer (known as RED HORSE) is a US Air Force unit with the mission of assessing, planning, and establishing contingency facilities and infrastructure to support contingency operations and combat missions.

Prime Base Engineer Emergency Force. The mission of prime base engineer emergency force is to provide civil engineer support for the beddown of personnel and aircraft. In other words, the emergency force provides utilities and civil engineer support to improve and maintain existing infrastructure to support air and space expeditionary task-force operations.

Mobility. During mountain operations in limited mobility, it is critical that units maintain security and control of available road and transportation networks, including securing key bridges, fords, crossing sites, intersections, and other vulnerable choke points. These locations must be protected against enemy air, obstacle, and ground threats; however, commanders must carefully balance their available combat power between protecting their freedom of mobility and allocating forces to critical, close combat operations. Effective risk analysis and decisions are essential. Route clearance operations, patrols, traffic control points, and other security operations aid commanders in securing routes. During offensive operations, commanders may need to commit forces to seize key terrain and routes that afford their forces greater mobility and tactical options against the enemy. Engineer support in front of convoys and combat formations is often necessary to clear and reduce obstacles, such as washouts, craters, mines, landslides, avalanches, and snow and ice in colder mountainous regions. Reducing obstacles is more difficult in mountainous areas because of reduced maneuver space, lack of heavy equipment, and an increased competition for engineer support. Mine-fields should be breached, since bypassing properly sited obstacles is often impossible.

Gap Crossing

Stream and river crossing operations are difficult and often must be accomplished quickly. Bridging operations in mountainous terrain are usually limited to spanning short gaps and reinforcing existing bridges by using prefabricated materials and fixed spans from floating bridge equipment. Nonstandard bridging techniques might be necessary, as well as fording techniques where possible. During the spring and early summer months, snow melt can cause previously passable gap crossings to become untenable. Alternate routes must be identified to ensure mobility.

Limited Assembly and Construction Area. The narrow road systems and the limited curve radius typically found in mountainous environments (potential locations for gap crossings) are severely limited, and crossing locations might be located further from the objective. Setting up staging areas, equipment parks, and assembly areas may not be possible near the gap crossing location because of limited open space in the gap's vicinity. These factors influence using the medium-girder bridge and the improved-ribbon bridge. Properly conducted engineer reconnaissance and IPBs identifies the best locations for gap crossings.

Dry Gaps. Areas that have been identified as dry gaps during the initial engineer reconnaissance can become wet gaps overnight. The same could happen with wet gaps becoming dry gaps in the summer. Using available intelligence and geospatial and historical climatological averages, engineers must identify historical high-water marks during the reconnaissance to predict the potential rise in water level during the wet seasons.

Nonstandard Bridging. The mountainous terrain often hinders employing the standard Marine Corps bridging assets, so engineer elements must be prepared to use nonstandard bridging techniques, such as rope, cable, or suspension bridges, to ensure mobility to mounted and dismounted maneuver forces.

Ice Crossing. During cold weather operations, frozen waterways, such as lakes, streams, or rivers, can be used by friendly forces for mounted or dismounted movement depending on the ice's thickness and condition MCRP 12-10A.4 for more information.

Counter-Improvised Explosive Device and Mine Operations

In a mountainous environment, the terrain favors the enemy using mines and IEDs as stand-alone weapons and in initiating ambushes. In the mountains, using mechanical mine plows and rollers or other standard route clearance vehicles is frequently impossible because the mountains lack roads and trails and those that do exist have a low classification.

Commanders should employ mounted and dismounted counter-radio-controlled IED electromagnetic warfare systems to the greatest extent possible to counter radio-controlled and detonated IEDs. When on foot patrol, breaching or bypassing mines and IEDs might be required. Robots or demolitions use is often required and preferred. Commanders must exercise extreme caution when employing demolitions near snow- and rock-covered slopes because they can cause dangerous rockslides, avalanches, and secondary fragmentation.

Countermine tasks in mountainous environments are also affected by the temperature. Marines should refer to MCRP 12-10A.4 for further information. Mines placed in snow cover can be plowed away to clear a route. Detonation and breaching can be more difficult due to freezing temperatures, frozen ground, and snow-cover concealment. See MCTP 3-34B, *Combined Arms Countermobility Operations*.

Snow-Laid Mines. Enemy forces can easily emplace antipersonnel and antivehicle mines and IEDs in snowy terrain. However, if the mines become covered by a couple feet of snow and the snow pack hardens, the mines become ineffective until the snow melts. Snowy or inclement weather conditions on routes routinely used by pedestrians or vehicles can negatively impact the effectiveness of route clearance equipment. Leaders must ensure they leverage all doctrinal and technological TTP advantages to develop an effective route clearance strategy that assures mobility in all ground cover. This situation presents the possibility that routinely used paths or routes during the winter may contain mines beneath the snow pack. All snow-covered routes considered cleared during the winter must be cleared again once snow begins to melt.

Route Sweep Formations. During fair weather mountain operations, tactical mobility teams can be task-organized and employed in front of convoys or combat formations to perform contiguous and/or combat route clearance operations, and limited route repair and nonexplosive obstacle removal, such as rocks, snow, and downed trees. Unlike with formations in other terrain, route clearance formations in the mountains push the flanks up the hillside to fulfill the role of mountain pickets and overwatch and to uncover potential radio-controlled IED triggermen. In many cases, flanks on one side of the formation can be removed if the slope drops off in a steep decline.

Metal Detectors. Dismounted engineers with mine and metal detectors remain a requirement on the current battlefield to perform sweeps to deny the enemy the intended effects of using mine or IED warfare. Commanders must understand the physical and psychological toll that performing dismounted sweep operations takes on Marines operating in a mountainous environment. Marines of all other military occupational specialties (MOSs) must be cross trained on the use of metal detectors.

Technological Considerations. Extreme cold weather, snow, and highly mineralized soils found in the mountains can have adverse effects on mine and metal detectors. Leaders must conduct pre-operational checks and testing in a secure area prior to deploying detection teams. Counter-IED technology, such as robotic platforms that use LOS remote control interfaces, must also receive pre-operational checks prior to deployment in adverse terrain and snow-packed conditions. Mine detection systems, whether vehicle mounted or handheld, that use ground-penetrating radar technology can be adversely affected by snow- and water-covered surfaces. The counter-radio-controlled IED electromagnetic warfare systems that use LOS may be hindered by mountainous terrain and weather effects.

Engineer Reconnaissance

In preparation for operations, the development of the engineer battlefield assessment, including IPB, mobility, and combined obstacles and ambush sites overlays, could be the most important task that the MAGTF can perform in the mountains. Accurate and detailed reports provide all maneuver element commanders with critical information necessary for proper operational planning.

Engineer reconnaissance holds greater significance in a mountainous environment to ensure supporting engineers are properly task-organized with specialized equipment for quickly overcoming natural and reinforced obstacles. Engineer reconnaissance teams assess the resources required for clearing obstacles on precipitous slopes, constructing crossing sites at fast-moving streams and rivers, improving and repairing roads, erecting fortifications, and establishing barriers during defensive operations. Since the restrictive terrain promotes the widespread employment of point obstacles, engineer elements should be integrated into all mountain reconnaissance operations.

In some regions, maps might be unsuitable for tactical planning because of inaccuracies, limited detail, and inadequate coverage. In these areas, engineer reconnaissance should precede, but not delay, operations. Because rugged mountainous terrain makes ground reconnaissance time consuming and dangerous, a combination of ground and aerial or overhead platforms should be used for the engineer reconnaissance effort. Terrain, vegetation, and soil composition data, combined with aerial photographs and multispectral imagery, allow engineer terrain intelligence teams to provide detailed information that may be unavailable from other sources.

Route Selection. Waterways, such as rivers and lakes, can be obstacles during the spring and summer months but can become trafficable and an asset during the winter months. Using all intelligence available through map, ground, and air reconnaissance is a necessary part of route selection. Route selection criteria varies by season. Road networks, regardless of the season, are required to sustain efforts.

Engineer Ground Reconnaissance. Engineer reconnaissance includes observation of soil, snow cover, vegetation, ground water, surface water, ice thickness, road surface conditions, and sources of local construction materials as well as the conditions of alternate routes. The purpose of this reconnaissance is to verify all information previously collected; check all possible routes for natural and man-made obstacles, such as avalanche debris, mines, and ice obstacles; and select the best site or route to accomplish the mission.

Snow and Ice. As much data and information regarding snowfall and ice growth as possible should be collected in the area of operations. Both are equally important and can be used as an advantage or can become a disadvantage to friendly forces. As snow accumulates, it reduces the mobility of both man and machine. Heavy snow accumulation can result in avalanches, so engineers must be aware of the slope angles and aspects that favor avalanches in their area of operations. This awareness enables the commander to use the following forces of nature to advantage:

- Fresh water freezes at 32 °F and saltwater freezes at 28 °F.
- Ice is relatively strong and has a varying degree of toughness and high bearing power.
- As temperatures drop, the strength increases rapidly from the freezing point to about 0 °F.
- From this temperature, the strength of ice stays fairly constant despite lowering temperatures.

More information is available in MCRP 12-10A.4.

COUNTERMOBILITY

Obstacles

Natural obstacles include deep defiles, cliffs, rivers, landslides, avalanches, crevices, and scree slopes, as well as the physical terrain of the mountains themselves. An obstacle's effect varies with different forces. Commanders must evaluate the terrain from the enemy and friendly force perspective. They must look specifically at the degree to which obstacles restrict operations and at the ability of each force to exploit the tactical opportunities that exist when obstacles are employed. Man-made obstacles used with restrictive terrain and observed indirect fire are extremely effective in the mountains; however, their construction is very costly in terms of time, materiel, transportation assets, and labor. Commanders must know the location, extent, and strength of obstacles so that they can be incorporated into their scheme of maneuver. Commanders should allot more time for personnel to construct obstacles in cold weather due to the restriction of additional clothing and equipment. When developing barrier obstacle plans, they must consider what effect changes in weather will have on the plan. For example, if temperatures increase significantly, many areas that were solid ground may become untrafficable, such as rivers and lakes. Conversely, if temperatures fall, causing rivers and lakes to freeze, these areas may become new avenues of approach for the enemy. Consequently, these areas should be covered by a combination of observation and direct and indirect fire weapons, to include demolitions.

The engineer should use the natural obstacles that the environment offers. Icy slopes and fallen trees can disrupt and channel troop movements. Leeward slopes with heavy deposits of snow can be rigged with explosives to catch enemy forces in the avalanche runout zone. Barbed wire and concertina are still effective on snow. It is easy to create effective obstructions in mountains by cratering roads, fully or partially destroying bridges, or inducing rock slides and avalanches. Units can emplace antitank minefields (family of scatterable mines) effectively to canalize the enemy, deny terrain, or support defensive positions. Commanders should remember that clearing or reducing these same obstacles may be extremely difficult and a hindrance to future operations. Using reserve and situational obstacles, lanes and gaps, and plans to rapidly reduce friendly obstacles must be an integral part of all defensive operations. Commanders should consider obstacles and minefields when developing courses of action that hinge on speed of movement or a particular avenue of approach.

Mines

Personnel should refer to MCTP 3-34B for information regarding the employment of mines in cold weather considerations.

Avalanches

Avalanches occur in nature when snow loads exceed the snow pack’s strength structure. Marines can apply artificial loads, such as explosive detonations, to the snow pack to artificially trigger an avalanche. Artificial avalanche triggers allow engineers to cause avalanches at a specific time when it is safe or most advantageous for friendly forces to hinder an enemy force’s movement. Engineer’s apply stress to a snow pack’s instability by using demolition charges or artillery air munitions. Explosives do not provide the same stress load onto the snow pack as other control trigger mechanisms, but they could be ideal for some snow pack conditions. The range of terrain types as well as the operational requirements calls for various delivery methods to optimize the effectiveness of the explosives. The explosives delivery methods employed in a control area are chosen based on the general terrain, snow pack, effectiveness, operational necessity and potential for noncombatant casualties, and destruction to civilian property and infrastructure.

To mitigate an avalanche or rock slide threat to friendly forces, noncombatants, and destruction of civilian property and infrastructure, the MAGTF has several methods to artificially trigger the slide when it is safe. Engineers can place demolition charges on the snow pack or use indirect fire or direct fire with explosive projectiles. Indirect fire allows the MAGTF to control the timing of the slide, ensuring safe distance from friendly forces. Effective planning selects a trigger time close enough to offensive operations that time is available to clear routes, yet not allow the threat potential to rebuild. For example, in stabilization activities, planners must mitigate the avalanche threat regularly for all LOCs. Small patrols in unfamiliar areas should carry mortar systems to mitigate avalanche threat on any suspicious slopes that they might encounter. For additional information on avalanches, see MCRP 12-10A.1.

SURVIVABILITY POSITIONS

The ability to dig survivability positions into a slope increases the amount of usable terrain, increases survivability of the positions, and saves on time and money for force protection. Engineer units should task-organize and deploy with the proper resources to cut into the hillsides so survivability positions can be placed into the mountain rather than built on top of them. These activities require Marines to use heavy equipment and demolitions.

Choosing Site Location

When planning to establish a fixed site, the position and angle of the enemy's fire serves a significant role in choosing the site location. Whoever maintains the high ground has a fire and cover advantage, so defensive positions should be elevated. Placing fixed sites on peaks or ridges should be avoided because it makes the site vulnerable to fire from 360 degrees. Ideally, sites should be located on the military crest of the reverse slope with observation posts on the military crest of the forward slope and surrounding key terrain. As time permits, positions should be camouflaged and concealed, and deceptive (dummy) positions established.

Overhead Cover

Mountains often present the enemy with the opportunity to shoot at the friendly base from an elevated position, so most rounds impact the structure tops. Overhead cover should be heavily reinforced and maintained, requiring increased structural support in load bearing walls and roof supports.

Forward Operating Base Site Selection

The trend for most forward operating bases (FOBs) is to locate them where it is convenient for logistics, command and control, and mobility, which is most likely next to a local MSR. In the mountains, MSRs tend to follow river valleys. Such routes present an issue when the river valley floods in the spring and washes out the entire MSR and parts of the local population center. Bases must be established high enough off the flood plain to avoid being damaged by the spring snow melt and should have a local MSR that is also clear from the flood plain.

Snow Removal and Drainage

Construction in high altitude areas must be planned with space for snow removal. A location must be identified for storing snow piles and these locations must have adequate drainage to remove the snow melt from the site.

GENERAL ENGINEERING

General engineering involves activities that identify, design, construct, lease, and provide facilities. Characterized by high standards of design, planning, and construction, general engineering in mountainous terrain must be carefully considered due to extreme temperatures, altitudes, and terrain difficulty. If feasible, construction should be undertaken when little or no frost is on the ground; often, if the permafrost is too thick, it can make it impossible to dig. Construction operations in mountainous terrain are extremely time consuming, and are complicated by the lack of local material, heavy equipment operation difficulties, and enemy defensive activities. Because of the uneven terrain, surveyors must be employed to help ensure the construction project's structural integrity. Local materials, if available, should be used for construction to help with stabilization activities and to alleviate the strain on overburdened transportation and aviation assets.

Horizontal Construction

The most noticeable challenge in the mountains is the lack of road networks and railroads. Both are practically nonexistent, making road construction a major operation. Heavy equipment and combat engineer operators exposed to the mountain's elements become rapidly fatigued and require regular relief after short periods. Continuous operations, except for short, periodic stops for operator checks and minimum equipment maintenance, prevent equipment from freezing. Cross-country movement of units without engineer support is extremely difficult.

Roads. For the most part, creating new road systems in mountainous regions is impractical because of the large amount of rock excavation required. Further, in winter months, rock excavation can be nearly impossible using only heavy equipment. Therefore, roadwork is generally limited to the existing roads and trails, which often require extensive construction, improvement, maintenance, and repair to withstand the increased military traffic and severe weather conditions. In certain mountainous areas, materials can be difficult to obtain locally, and it could be impossible to make full use of conventional heavy engineer equipment for road and bridge construction or repair. In such cases, many engineers are required, and units must rely heavily on manual labor, light equipment, and demolitions.

Secondary Roads. Secondary roads and trails should be improved to accommodate wheeled and tracked vehicles and, eventually, heavier vehicles. Secondary road selection depends on necessity and the speed with which the routes can be put into service. Abnormal gradients on roads might be necessary to ensure that construction keeps pace with tactical operations. Side hill cuts are the rule, and the same contour line is followed to avoid excessive fills or bridging. When terrain permits, turnouts should be constructed to mitigate traffic congestion on single-lane roads or trails. Drainage requirements must be considered in detail because of the effects of abnormally steep slopes, damaging thaws, and heavy rains.

Landing Zones. Engineers must be prepared to consider LZs for aviation assets. Drainage is an important factor in selecting an airfield site and planning the construction. Engineers should be aware of the following features related to drainage to ensure a successful LZ design:

- Sites should be selected in areas where cuts or the placement of base-course fills will not intercept or block obvious existing natural drainage ways.
- Areas with fine-textured, frost-susceptible soils should be avoided.
- Soil stabilization and dust abatement must be understood.
- An LZ should usually be on the windward side of mountain ridges or peaks to ensure a reasonably smooth air flow; however, in forward areas, concealment from the enemy observation is a more important factor in selecting a site. These sites should be well clear of structures and vegetation, which are vulnerable to helicopter rotor downwash, particularly in confined spaces.

- An LZ should be as level as possible and may not be on a slope exceeding 7 degrees in most situations. Aircrews that experience difficulty landing due to extreme slope angles in LZs may request to reposition to a less drastic slope angle for operations. On slopes greater than 7 degrees, a helicopter cannot land; however, if rotors are clear of obstructions, they may be able to load and unload in a low hover.
- Snow-covered LZs can be effectively marked with colored dye, timber "letters," or smoke, but they should be camouflaged with more snow when not in use.

In soft snow, a suitable reference point, such as a vehicle, should be available to the pilot to avoid the pilot's becoming disoriented in recirculating snow during descent. Stamping snow to form LZs is dangerous because compacted snow forms a crust when frozen, which, when the powerful downdraft of large helicopters breaks it up, creates a foreign-object damage hazard. As with soft snow, some form of reference point is desirable and, if time permits, the area should be damped with water or other dust abatement material. Helicopter-blown sand or ice is a hazard to Marines and weapons, particularly optics. Furthermore, downwash in freezing conditions can cause frostbite to exposed skin.

An LZ should be relatively clear of fine dirt or sand, which often develops on spaces frequently trafficked by personnel and heavy vehicles. Fine, soft dirt can become deep on a relatively flat LZ and can cause brownout conditions for landing and departing aircraft. This situation can become even more dangerous with the addition of confined approach and departure paths due to surrounding steep terrain. When possible, LZs should have an adequate system in place to reduce dust prior to aircraft arriving. Crushed rock, matting pads, heavy sprays of water, glue or grease-based dust abatement products, and commercial products approved by aviation leadership are all viable methods for preventing pilot disorientation in whiteout and brownout conditions.

Vertical Construction

Field construction time and engineer work difficulties are magnified in mountain operations. Environmental characteristics that complicate engineer tasks are permafrost, extreme and rapid changes in temperature, wind, moisture, snow, ice storms, and flooding. Although standard construction principles remain the same in mountainous environments, some considerations must be given to construction during heavy snowfall periods.

The standard pitch of the roof (4:12 pitch [4 inches of rise over 12 inches of run]) is sufficient for snow to slide off; however, corrugated steel must be used atop plywood to allow the snow to slide off more freely. Ceilings must be sealed to prevent leaking.

For wood frame construction, all material design requirements for structures without a snow load should be increased to the next standard material size. For example, a building with 2-inch by 4-inch studs without a snow load should be designed with 2-inch by 6-inch studs for use in an environment with a snow load. If material of a greater size is not available, on-center spacing for studs and trusses can be decreased to accommodate the increased weight due to snow load.

Utilities

Electrical and water equipment have associated winter kits. It is imperative that these winter kits are deployed with the gear to enable the gear to work under extremely cold conditions. Further considerations must be given to the altitude change for equipment output. Also, when emplacing utility equipment, the operator must ensure that the equipment is on level terrain (not to exceed a 15 percent gradient) and on insulating material to keep it from freezing to the ground.

Tactical Electrical. Generator sets can start and operate at temperatures as low as -25 °F without a winterization kit. With a winterization kit, generators can operate at temperatures as low as -50 °F and can be stored in temperatures no colder than -60 °F. It is recommended that winterization kits be installed prior to deployment. Generators must be allowed to rise to normal operating temperature before applying a load to reduce the possibility of engine damage. When the ambient temperature is lower than -25 °F, most engines require preheating before they are started. The engine type determines the method used. The two basic types of cooling systems used on power-generating equipment are air cooled and liquid cooled. A blowtorch is used to preheat most air-cooled engines. Most liquid-cooled engines are equipped with a preheater in their winterization kits. The respective generator’s technical manual for preheating and cold weather operating instructions is a good reference.

Special care must be taken when emplacing and using field wiring harness kits. Typically, in extreme weather conditions, a lower thickness of American Wire Gauge is needed. If temperatures drop to below -32 °F, a 12-gauge wire will not be able to withstand the weather. Wires will become brittle and need to be covered with thermal protectors. At the same time, if wire is buried, it needs to be below the permafrost layer, which can be up to 3 feet (1 meter) in some areas, or the gauge needs to be low enough to be able to withstand the extreme temperatures.

Generator sets are rated based on sea-level. The rating of the set may decrease as the altitude increases. Information about operating equipment at high altitudes is usually printed on the data plate. The kilowatt rating may be reduced at high altitudes, depending on the type of engine used to drive the generator. Refer to the appropriate technical manual for information for each model of generator set. As a general rule, a generator will lose 3.5 percent of its power for every 300 meters (1,000 feet) over 1,219 meters (4,000 feet) that it ascends.

Cold weather maintenance must be performed on all electrical systems. In all generators, the antifreeze solution must be able to protect the equipment at the lowest temperature expected. Also, the batteries will need to be fully charged to prevent freezing. In some cases, ice fog, which is caused by engine exhaust in very cold climates (-25 °F and below), may occur. To eliminate ice fog, a tube should be placed on the exhaust pipes and covered with a tarpaulin to diffuse the exhaust in the snow. Lastly, prior to operating the equipment, ice, snow, moisture, and other foreign material should be removed from the generator set.

Potable Water. Major water supply sources, in order of efficiency and economy, are—

- Drawing water from under rivers or lakes.
- Melting ice or snow.
- Drilling wells.

More information on water usage requirements is listed in Chapter 6.

The Tactical Water Purification System can operate down to 32 °F without the winterization kit and down to -25 °F with it; however, heated shelters are often necessary for operating water purification equipment to prevent the inner pipes from freezing when not purifying water. When temperatures go below 32 °F, water purification personnel can have difficulty operating and maintaining their equipment. Constant winterizing and use of the water heaters can prevent freezing. Winterizing, however, is not always feasible. Often in winter the water must be pumped from beneath an ice layer. To prevent freezing, it might be necessary to preheat the water during operations and keep it heated until it is issued, which can require additional heaters.

The water site selection can be tricky in mountainous terrain. The water site needs to be on high porous ground, reasonably level, and well drained to prevent water from impeding resupply operations. During the winter in cold regions, reconnaissance teams can use ice augers to determine ice thickness on a potential water source. The team should also measure the water depth under the ice at several spots because the depth varies in shallow streams and rivers. Once a site has been selected, shaped charges are better than hand tools for cutting holes through thick ice to prepare a water hole. Water distribution systems must be maintained. In very cold weather, it can be necessary to periodically drain the raw water pump and the raw water hoses and bring them into a warm shelter, so they do not freeze. Frazil ice is the slushy ice that forms as the water travels in turbulent unfrozen river sections. If frazil ice is present at the water supply hole, the ice filter should be used to keep the frazil ice from being sucked into the raw water pump and freezing.

Higher altitudes require adjustments in planning factors (see Chapter 6). For example, the water treatment chemicals react differently at extremely low temperatures: at 32 °F, chlorine requires twice as much contact time to properly disinfect water. It is recommended that individual Marines carry individual water purification systems and supplementary iodine tablets to purify water for personal consumption. Further information on potable water in cold weather and mountain water operations is found in MCRP 12-10A.4.

Fuel. Mountain operations make fuel storage and distribution challenging for Marines. Cold weather operations require increased testing, recirculation, equipment maintenance, and using fuel because of extended equipment operation requirements. Ground operations can increase the individual vehicle's fuel consumption rate by 30 to 40 percent, requiring more fuel filtration and distribution. Depending on the temperature, adding icing inhibitors to fuel can be necessary. Diesel fuel reaches its freezing point and begins to gel at around 15 °F; whereas jet fuel has a much lower freezing point at about -51 °F. Fuel additives are available to decrease fuel gelling. (Military Detail [MIL-DTL] Specification 85470B, Inhibitor, Icing, Fuel System, High Flash, North Atlantic Treaty Organization Code Number S-1745). Although fuels do not completely freeze; they will be the same temperature as the air. To prevent frostbite, fuel handlers must always wear gloves designed for handling petroleum products when working with fuels.

Heavy Equipment

Engineer equipment use in mountainous environments does not change dramatically from its use in other regions; however, there are considerations that must be made when planning engineer equipment operations, as depicted in the following paragraphs.

Hard Starting. Diesel engines, used on all engineer equipment, can be prone to hard starting. Some are equipped with engine block heaters to help alleviate this problem. Commanders must plan for increased fuel consumption if vehicles are to remain running during extreme cold to counter cold sink.

Tire Chains. When conducting heavy equipment operations in snow, tire chains increases mobility and makes material handling operations safer.

Snow Removal. Front end loaders and road graders make excellent snow removal tools, but road edges, especially drainage ditches, should be marked to avoid accidents. When removing snow, operators must not break through the soil permafrost layer, as it will create muddy conditions. Bulldozers do not make good snow removal tools for FOB operations. The amount of mechanical damage to the ground surface generally outweighs the reduced time for removal. Commanders must weigh the use of bulldozers for snow removal outside the FOB against the damage to road surfaces that can be caused. They must exercise extreme caution when ordering heavy equipment operations in deep snow or ice, because tracked and wheeled vehicles are prone to sliding on ice. Rollover potential increases when operating on uneven snow packs; operators must be cautious of varying snow pack and snow stability.

Excavation and Earthmoving. Mountain soil conditions are prohibitive to excavation and earthmoving operations due to the amount of subsurface rock. During extreme cold weather conditions, excavation and earthmoving operations will be additionally hindered by the permafrost layer. If excavation and earthmoving operations are to take place, commanders must plan for increased time and equipment repair parts, especially cutting edges, cutting blades, and hydraulic systems.

Underground Construction and Confined Spaces

Mountains often reveal natural and man-made cave complexes that make convenient weapon caches and rally points. The threat of earthquakes and other perils associated with confined spaces make underground areas extremely dangerous. As a result, they should be avoided unless necessary. Man-made caves and underground shafts should be avoided at all costs; if suspected caches of weapons or if enemy forces are suspected of occupying man-made underground spaces, an attempt should be made to coerce the enemy to come out of the cave before destroying it using demolitions. Units deploying to any terrain that supports underground spaces should equip their maneuver elements with gas detectors that can identify oxygen and carbon monoxide levels.

CHAPTER 6.
LOGISTICS AND SUSTAINMENT

PLANNING CONSIDERATIONS

Planning considerations for logistics and sustainment begin with a logistics support concept. Other considerations include cross-training and interoperability, waste management, accountability, security, aviation support, and seasonal challenges.

Logistic Support Concept

Due to the time increase associated with moving at high altitude, logistic support should be forward positioned and as close to the supported unit as possible. The FOBs would likely be supported by intermediate staging bases and main supply hubs. During Operation ENDURING FREEDOM (OEF), for example, Jalalabad Airfield in Afghanistan was established so supplies could be positioned forward of the main supply hubs at Bagram Airfield and Kandahar Airfield.

Distributed Operations in Operation ENDURING FREEDOM

During OEF, many battalion, regiment, and brigade areas of operations were extraordinarily large. For example, while deployed to Regional Command East, the area of operations for 1st Battalion, 3d Marines was approximately the size of Maryland. The battalion dispersed into six, company-sized FOBs, which were separated by as much as a 4- to 6-hour drive. Squads and platoons conducted operations outside the FOBs for up to a week at a time. At times, resupply was sporadic, so each forward-based element required considerable self-sustainment, which was facilitated by logistic support teams assigned to each FOB.

—Marine Corps Center for Lessons Learned Report

Logistic Support Elements. In mountain operations, logistic units can be task-organized and attached to combat units to support widely dispersed forces. Infantry battalions operating in mountainous areas can disperse into company- or platoon-sized elements that operate from FOBs and combat outposts (COPs). Each support element should include personnel, such as winter-trained mountain leaders, who have expertise in route planning and movement techniques. Logistic support elements can provide container delivery system (CDS) recovery, sling operations, helicopter LZ coordination, convoy escort, health services, motor transport, material handling, supply, maintenance, vehicle recovery, and field feeding. In addition to these multi-Service functions, the Marine Corps also requires their logistical elements to fulfill detainee operations, embarkation, and general engineering functions.

Intermediate Staging Bases. Operating farther back in intermediate staging bases (ISBs), logisticians employ convoys and aerial drops to deliver critical and sensitive materials and supplies. Logistic organizations at an ISB should assume that key support personnel would be on duty 24 hours a day, seven days a week. The following minimum tasks should be located at an ISB: Class I, III, V, and VIII commodity oversight; mortuary affairs; parachute rigging; sustainment; electronic maintenance; and transportation movement coordination.

Liaison Officers. Supported units should maintain an LNO at the logistic operations center. Additionally, Service LNOs should be maintained with the theater of operation support organizations and other higher level joint commands. They are needed when re-supplying along ring routes to ensure that supplies being distributed to units operating in the mountains are properly prioritized.

Logistic Cross-Training

During mountain activities when units often operate outside of the range of immediate external support, personnel will likely need to be cross trained in many functional areas, including logistics. The institution of combat lifesaver training for nonmedical personnel is one example of successful implementation of this concept. Potential areas for logistical skills cross-training include CASEVAC, utilities, maintenance, food service, and air delivery recovery. For example, in an environment where IED attacks are prevalent, vehicle recovery crews may need to conduct firefighting, CASEVAC, search and recovery of human remains, and sanitization of blast sites and equipment. More information on mortuary affairs is available in MCRP 3-40G.3 *Multi-Service Tactics, Techniques, and Procedures for Mortuary Affairs in Theaters of Operations*.

Interoperability

Joint operations in mountainous terrain require interoperability among the Services. For example, when 1st Battalion, 3d Marines was deployed in the mountains of Afghanistan, logistical support for the battalion (except for Marine Corps-unique items) came from the Army. Units operating in the mountains might be required to rely on other Service, coalition, and/or host-nation support for extended periods. Support between adjacent units from different Services or country origin is frequently necessary during mountain operations. Logistics service providers should be prepared to affect cross-Servicing agreements to procure sustainment from adjacent units from different Services to mitigate periods of unreliable sustainment. The MAGTF must have a plan to coordinate multiple contingency contracting actions.

Sustainment Challenges

Logistic planners must accept that the environment’s time and distance would at least double. In some areas, terrain is so restrictive that only air or foot movement is possible. Three kilometers (2 miles) on the map can require nearly 10 kilometers (6 miles) of foot movement due to trail switchbacks, high elevation, and weather. Taking shortcuts and unnecessary risks typically delays movement and compromises the safety of logistic efforts.

When operating in remote mountainous areas, units must be prepared for extended periods without resupply. They may need to maintain two to three times the anticipated supplies or adopt innovative methods to overcome shortfalls. In mountain operations, units should plan for 10 to 20 percent loss of supplies for the following reasons:

- Damage often occurs during air delivery.
- Host-nation trucks can easily get damaged while traversing rough roads over long distances.
- Pack animals carrying supplies over treacherous mountain trails can become lost.

- With less space for storing supplies, they are more susceptible to enemy indirect fire.
- Packaged supplies can easily break open or become buried under snowstorms and avalanches.
- Caches can be lost, stolen, or destroyed by weather and animals.
- Pilferage is common.

Units operating in mountainous terrain may need to rely on innovative and unorthodox methods of logistic support. For example, units might need to make use of captured enemy supplies and equipment. They might need to rely on locals who know the terrain or "piggyback" on a coalition partner's assets. Army and Marine maintenance personnel may be tasked to repair host-nation military or civilian equipment. Hidden supply caches may need to be created.

Supporting Marine Corps Embedded Training Teams in Operation ENDURING FREEDOM

To provide logistical support for the Marine Corps' embedded training teams (ETTs) in Afghanistan, [Marine Forces Central Command [MARFORCENTCOM] established a memorandum of agreement with the Army. The only supplies and equipment MARFORCENTCOM provided to the ETTs were Marine Corps-specific Class II (clothing and individual equipment) and Class VII (major end items). Class II support often required phone calls to Kuwait, Bahrain, Tampa, and an ETT's home station. Class VII resupply, such as battle-damaged vehicle replacement, was handled by [MARFORCENTCOM] in Kuwait, which worked the theater of operation transportation network to transport replacement items to Bagram Airfield. From Bagram Airfield, delivery waited until opportune lift on the ring route was available. Alternatively, ETTs would road-march items if a convoy was available. Host-nation trucks were employed at times, but the trucks lacked security and pilferage rates were high. By mid-2008, [MARFORCENTCOM] had established a liaison team of six Marines at Bagram Airfield, headed by a field grade supply officer, to coordinate with the 101st and 82d Airborne Division staffs. This team supported seven ETTs (comprising 150 personnel) throughout Regional Command-East.

—Marine Corps Center for Lessons Learned Report

Waste Management

Considerations must also be made regarding waste management operations, including solid waste or trash, human waste, medical waste, food waste, and hazardous material disposal, and the impact it can have on the fitness of the mountain force and the local nationals. If not included in the planning process, waste management could rapidly become a serious problem. Waste attracts animals that could carry diseases, such as mosquitos, or pose a physical threat, such as bears. More information can be found in MCRP 3-40B.7, W*aste Management for Deployed Forces*; MCTP 3-40A, *Health Service Support Operations*; MCRP 3-40G.1, *Marine Corps Field Feeding Program*; and ATP 4-02.55, *Army Health System Support Planning*.

Supplies and Equipment Accountability

In mountain operations, supplies and equipment accountability can be extremely difficult because equipment comes from numerous sources. Units and equipment spread out across multiple remote FOBs makes accountability a challenge. Supply personnel must be aware of unit movements, changeovers in unit leadership, and equipment transfer between FOBs. Units should follow current regulations and command policies and procedures for equipment accountability.

Route Security

In mountain operations, the enemy targets logistic units and seeks to interdict resupply operations. Enemy units infiltrate and seize key terrain that dominates supply routes to disrupt and isolate units from logistical support. In mountain operations, there is no rear area. Logistical units operating outside of friendly confines must maintain a combat-oriented mindset, such as vehicle-mounted resupply units that conduct combat patrols instead of convoy operations.

A combination of patrolling and air reconnaissance is the best means for providing route security. Observation posts on dominant terrain along supply routes are also essential for early warning of enemy infiltration into rear areas. Checkpoints between bases should be established to increase route security and enable trucks to deliver supplies without enemy interference. Patrols must be continuously alert for ambush, and they must be skilled at locating and identifying mines; moreover, immediate action drills must be emphasized in training. Route clearance must be conducted at irregular intervals to verify the status of roads and prevent enemy infiltration. For example, the route clearing process in OEF was, first, for a route clearance request to be submitted, and then for the combat logistic patrol to attempt to travel the route shortly after the route was cleared. Experience showed, however, that the route clearance package may not occur on a certain date and at a certain time. Finally, movement of supplies at night may reduce vulnerability to enemy attack, but night marches present other hazards due to the difficult terrain and require daylight reconnaissance, careful route preparations, and guides.

Resupply in Operation Enduring Freedom for 2d Battalion, 3d Marines

The 2d Battalion, 3d Marines faced severe logistic challenges during OEF. In their area of operations in Afghanistan’s northeastern mountains, resupply of basic supplies, vehicle maintenance, and medical evacuation were challenging. Helicopter support was limited due to the enemy’s antiair capabilities and the severe relief, so helicopter resupply was usually infeasible. The primary methods of resupply were through CDS airdrops or through tactical or contracted civilian vehicles. For CDS airdrops, the request process and coordination with both the Army support cell at Bagram Airfield and Air Force planners involved a great deal of refinement and practice. Procedures for coordinating communications, signaling, and final clearance were detailed and strictly adhered to. Once supplies were on the ground, severe elevation changes and switchback mountain trails made the movement of supplies extremely challenging and usually required either a host-nation truck or pack mules. Additionally, when a CDS drop landed well off target, the supplies were sometimes looted by local villagers before the Marines could reach them. Often, the recovery of supplies required too much energy and resources to make retrieving them worth the effort.

—Marine Corps Center for Lessons Learned Report

Aviation Support

Climate variations and frequent and sudden weather changes preclude continuous aviation support, particularly during the winter when mountain passes are regularly impassable because of low ceilings and poor visibility. Rapid weather changes often do not allow aircraft to reach casualties; therefore, alternative evacuation modes must be planned in this environment.

The reduced hours of daylight consistent with mountain arctic or subarctic winter operations can dictate a greater need for artificial lighting, or a greater reliance on night-vision devices, as the tactical situation permits. Additional lighting must be planned for in the logistic concept of operations. For example, sufficient lighting equipment must be available to furnish adequate lighting for maintenance services.

Conversely, the extended daylight during summer requires different operational adjustments.

Winterization

Equipment and facilities may need to be winterized in mountain operations. For example, heated buildings, shelters, or tents with wood flooring are require maintenance in cold weather. Some maintenance activities conducted with bare hands require warm tents to work in and warm water to remove petroleum, oils, and lubricants (POLs). Cold weather additives for POLs are required for equipment to run efficiently. Hoses and water containers must be insulated. Winterization can be a significant undertaking that requires extensive advance planning in preparing facilities and equipment. Material and equipment need to be ordered before the winterization date. Units might have to negotiate contracts with host-nation providers for facilities, generators, and other winterization-related items and services. Delays in delivery of long lead-time items, such as lumber, may require extending winterization target dates. Competing construction projects can stress engineer and logistical assets. These challenges highlight an important point: staff responsibilities must be synchronized so that winterization is viewed as a force-wide mission, not just a task for engineers.

SUPPLY

Logistics and sustainment require the consideration of several types of supplies. Chief among those types are personal nourishment, protection, and equipment items.

Food and Water (Class I)

Mountain operations, particularly in extremely cold weather, increase Class I item consumption and energy requirements by as much as 50 percent. The average person’s caloric need can increase to 6,000 or more calories per day. Despite the greater caloric requirement, high altitude reduces the appetite, which can reduce morale and fighting capabilities and make Marines more susceptible to mountain-related illnesses. For example, some personnel conducting dismounted operations during OEF lost 20 to 40 pounds during deployment and at least one was evacuated because of malnutrition and severe (60 pound) weight loss. Refer to Appendix A for risks related to dehydration.

The standard meal, ready to eat (MRE) contains insufficient calories and nutrition for mountain operations; whereas, the meal, cold weather (MCW) ration is more suitable for the environment, if sufficient water is available. If possible, fresh fruit and vegetables should be provided as well. The MCW ration contains approximately 1,540-calorie menu bags with a main meal that is dehydrated to prevent freezing during extreme cold weather operations. Water is needed to rehydrate the main meal prior to consumption, which leads to increased water consumption rates. At high altitudes with extreme cold, an individual needs to consume three menu bags per day. Each case contains 12 meal bags, weighs approximately 15 pounds, and measures approximately 1.02 cubic feet.

The MRE ration can also be used for high altitude and cold climates; however, the MREs include components that contain liquid that can freeze during extreme cold weather operations if these items are not kept warm, such as by carrying them inside the clothing. Each MRE contains 1,250 calories. At high altitudes, an individual would need to consume more than the standard three MREs per day to meet energy demands. Each case contains 12 meals, weighs approximately 22 pounds, and measures 1.02 cubic feet.

The first strike ration (FSR) can be a better option for Marines to use in high altitudes where temperatures typically remain above freezing. The FSR has been used by units operating at high altitude up to about 2,438 to 3,048 meters (8,000 to 10,000 feet) without issue. The FSR does not contain an individual heater and some items, if frozen, are not palatable. The FSR includes liquid-containing components that can freeze during extreme cold weather operations if not kept warm, such as by carrying them inside the clothing. The FSR contains 2,850 calories in one ration. It is meant to be used in mobile and combat-intensive scenarios where Marines eat on the move or out of their hand. At high altitudes, eating small, frequent meals and consuming more fluids is advised. The FSR contains more fluid beverage bases to increase water consumption and easy-to-eat snacks. The FSR is meant to be used for three days or fewer at a time due to the limited menu and caloric content. To meet increased calorie needs while operating at high altitude, the FSR needs supplemental items, such as fruit, vegetables, and milk, or the addition of one MRE to increase calories and menu variety. When compared with three MREs, the one-day FSR subsistence weighs 50 percent less and takes up half the space. The FSR is similar in weight to three MCWs but does not require rehydration.

The modular operational ration enhancement (referred to as MORE) was developed to augment daily operational rations with additional components tailored to particular environments. There are two types of modular operational ration enhancements, one targets high altitude and cold weather, while the other is intended for hot weather operations. Marines in extreme environments, such as cold weather, high altitude, or elevated temperature, require extra calories beyond the standard operational rations in order to combat weight loss and decreased physical and cognitive abilities. The modular operational ration enhancement provides the correct amount of extra calories for the environment with the right balance of fat, carbohydrate, and protein. The modular operational ration enhancement augments the MRE or FSR with additional calories and nutrients and is not a replacement for the MRE or FSR. The modular operation ration enhancement container lacks a main meal but contains approximately 1,100 calories of snack items intended to supplement a feed plan of MREs and MCWs. Each case contains 24 snacks, weighs approximately 29 pounds, and measures 0.99 cubic feet.

Units that employ pack animals must account for their feed as well. For planning purposes, pack animals require two percent of their body weight in dry weight of feed per day, although an individual animal’s needs vary. As the temperature drops below freezing, animals require an additional one percent of feed for each degree of temperature change.

Water requirements—its production, resupply, storage, and consumption—are often the most significant logistical challenge to extended mountain operations. Leaders should enforce an increase in water consumption for two days prior to an operation. When operating at high altitude, it can be difficult to pack enough water to sustain a unit for more than a day. Marines equipped with lightweight water purification equipment and squad stoves will be able to easily deal with the issues of procuring water. Water filtration systems are available at the platoon and individual level. Dismounted patrols should plan for daily water resupply, if possible. In low mountains, leaders should plan on each Marine consuming 4 quarts of water per day when stationary and up to 8 quarts per day when moving. In high mountains, planners should increase these water-planning factors by about 2 quarts per individual.

In high mountains, where subfreezing temperatures persist year-round, water can be extremely difficult to find unless Marines are equipped with a stove to melt snow or ice. Logistic planners and operators should explore multiple water delivery methods to ensure water needs are being met. For example, natural water sources could reduce the logistic burden. Water sterilization is necessary even if mountain water appears clear. Individuals must take regionally appropriate prophylaxis medications as an additional precaution against food and waterborne illnesses. If clean snow is available, it can be melted for drinking and heated or sterilized using small squad stoves and cook sets. Clean snow is defined as snow that is undisturbed and fresh snowfall that is uncontaminated by animal waste or debris. As each gallon of water weighs approximately 8 pounds, carrying a small water filter or pump or stove and cook set for extended operation can be a weight saver, despite the added weight of fuel for the stove. Each Marine requires approximately 6 ounces of stove fuel per day to boil water and prepare food.

Measures, such as placing canteens or other personal water storage containers inside clothing where they can be warmed by body heat, should be taken to protect water containers from freezing in cold weather. Plastic water cans can break if filled at extreme temperatures; when in use, cans should be kept partially full and turned upside down.

Beyond individual consumption requirements, water is used for personal hygiene, vehicle maintenance, medical care, and pack animals; however, priorities must be set for consuming and conserving water. For example, in the mountains, it may be necessary to omit cleaning the exterior of vehicles, except for windows and undercarriages.

Clothing, Individual Equipment, and Tents (Class II)

In cold weather, preferred clothing consists of loose-fitting layers and insulated, polypropylene clothing that does not allow perspiration to accumulate close to the body. Fleece caps and jackets offer warmth without weight or bulk. Marines will require multiple sets of contact gloves, work gloves, and insulated gloves and mittens to ensure fingers are kept warm and dry. Cold weather boots must also be issued in a mountain or cold weather environment. While personnel are in static positions, they should stand on insulating material if over-boots are not available. Insulating material can be a pine bough or a flat piece of wood. If personnel use improper or worn clothing for even a short time, the chance of developing cold-related injuries increases significantly. Clothing should be fire retardant, if possible, although fire retardant clothing might not be available due to the transition away from producing non-fire-retardant clothing. The rugged terrain increases the chances Marines will need to replace lost or damaged individual clothing and equipment. Boots, jackets, and gloves will wear out quickly. In operational planning, sufficient clothing overages should be considered, and clothing stocks should be built up prior to deployment.

In cold weather, special equipment requirements include snowshoes, boot crampons, avalanche cord, ski wax, candles, axes, shovels, matches, 100 percent ultraviolet protection glacier glasses, sunscreen, special fuel containers, tire chains, and winterization kits. A more comprehensive list can be found in MCRP 12-10A.1, *Small Unit Leader's Guide to Mountain Warfare*.

Prefabricated, synthetic dome tents are useful in cold, mountainous environments. Tents must be easy to carry and assemble at high elevations and easily retrievable from deep snow. Tents must also be able to withstand the snow weight and be equipped with winterization kits, such as roll out flooring and insulation. At a minimum, leaders should plan for sufficient tentage to support command and control, health services support, maintenance, supply, food service, and hygiene.

In cold weather, tent heaters and stoves in billeting and storage areas are recommended. Marines require heated tents for storing some supplies. Refrigerator boxes can be turned off and used to keep supplies warm. Some units may prefer to use multifuel backpacker stoves; however, at high elevations, multifuel cook stoves operate at a lower efficiency.

In cold weather, all batteries provide less power, so battery quantity increases and charging batteries often is required. Cold weather batteries are recommended, if available. Dry batteries must be stored at temperatures above 10 °F and be warmed gradually, either with body or vehicle heat, before use. In subzero weather, additional battery chargers must be on hand to meet heavy requirements for battery maintenance. Battery stocks should be replenished often; planners must pay particular attention to items with unique proprietary batteries. Also, personnel must avoid relying on Service-specific items that require batteries not carried by the theater-level sustainment organization. In warm weather where solar energy conditions permit, leaders should plan for employing renewable energy harvesting systems, such as portable solar panel-based technologies, as an alternative to carrying excessive batteries. Regardless of weather conditions, commanders must implement an effective battery disposal plan for unserviceable battery items.

Petroleum, Oils, and Lubricants (Class III)

In steep-sloped mountains, vehicle fuel consumption can increase by 30 to 40 percent. As vehicles ascend, oxygen levels are reduced, and the engine efficiency drops. On average, vehicles lose 20 to 25 percent of their rated carrying capacity; however, overall fuel consumption for the unit could decrease because of lower vehicle movement. When units rely heavily on aviation assets for resupply and movement, aviation fuel requirements increase. Units that operate in cold weather need to plan for multiple fuel use and storage. Fuel points must supply units with refined or white gasoline that is specifically produced for pressurized stoves, and personal or squad stoves require special fuels. Special fuels could also be needed if using host-nation equipment. Some fuels additives might be needed to prevent freezing and gelling. In arctic conditions, fuel spilled on flesh can cause instant frostbite if the proper gloves are not worn.

Multi-viscosity oil (15W-40) is recommended for most vehicles in cold weather. Use of 15W-40 precludes a need for frequent oil changes in an environment with a great variance in temperature. Vehicles should be changed to multi-viscosity oil before embarkation. In sustained extreme cold conditions, 10W oil is required.

Cold weather mountain operations might require arctic engine oil, a synthetic SW-20 lubricant used for temperatures -65 F and below. Arctic engine oil is approved for engines, power steering systems, hydraulic systems, and manual and automatic transmissions. For all weapon systems, lubricant, arctic weather should be used below -10 °F.

When units are widely dispersed, FOBs might be able to store only a limited quantity of fuel, which can limit operations when circumstances prevent timely resupply. More lightweight, portable fuel storage containers could be needed. Up to twice the typical l number of fuel cans may be required if transporting fuel to vehicles, rather than bringing vehicles to the refueling point. Multiple 5-gallon cans, nozzles, and 1-quart fuel bottles must be available. When vehicles; generators; and petroleum, oils, and lubricants containers are brought into warm storage from the cold, fuel tanks and containers should be filled at least three-quarters full to prevent condensation. Some classes of supply will require heated tents for storage during certain times of year or above certain altitudes. Authorized fuel planners should plan for proper transport, distribution, and storage of such fuels as JP8, packaged white gas, or K1 and gauge fuel distribution according to anticipated demand and environmental conditions.

Other Supplies

Other supplies required for logistics and sustainment include ammunition, major end items, and medical supplies. Spare parts and supplies for nonmilitary programs should also be considered.

Ammunition (Class V). Planners should expect an increase in indirect fire ammunition consumption because of dead space, deep snow, and other mountainous terrain effects. Preparing ammunition dumps is more difficult because of freezing and mud. Special storage for ammunition is not required, but it should be stored in its original containers. Ammunition will usually be transported by air from intermediate support bases to forward deployed units.

Personal Demand Items (Class VI). The availability of personal demand items (e.g., sundry packages, personal health, comfort, and post exchange items) is closely tied to troop morale in mountainous operating environments. Care must be taken to avoid stocking Class VI items that have the potential to freeze in cold weather or deteriorate in excessively hot weather.

Major End Items (Class VII). Resupply of major battle-damaged end items is a significant challenge in mountain operations. Moving deadlined equipment can clog narrow supply routes. There will be an increased demand for power generators, heaters, and for rough terrain loaders with snow removal capability. Forward-based units desiring to travel light may not be able to stock many spare end items. When equipment is destroyed or damaged beyond repair, the only course of action might be to wait for redistribution.

Medical Supplies (Class VIII Including Medical Repair Parts). High consumption rates for medical supplies should be anticipated. Solid medications and storage areas, such as warming tents, vehicles, and containers, are required for storing liquid medications and packed red blood cells or fresh whole blood that has been collected and processed on an emergency basis in theater. Perishable materials must be packaged and marked for special handling. Procedures must be established and followed for special handling requirements for Class VIII material from embarkation to its final destination. There will also be an increased requirement for lip balm, cough syrup, and decongestants. More information is presented in this chapter under Medical Support Considerations.

Repair Parts (Class IX). The increased stress on vehicle parts and adverse effects of cold weather can force a unit to increase its Class IX block by up to 300 percent. Repair parts blocks for motor transport and engineering equipment should be increased, particularly for parts that are susceptible to cold temperatures, such as starters, generators, alternators, and glow plugs. There will be an increased reliance on secondary repairable, component repairs, and selective component exchanges. As with other items, obtaining parts for specialized equipment can take a long time during mountain operations.

Material to Support Nonmilitary Programs (Class X). In mountain operations, the same protective measures and commodities necessary to protect friendly forces are also needed for enemy prisoners of war, indigenous inhabitants, and refugees. Commanders should expedite detained personnel quickly to the rear, closer to such security areas as those sponsored by the host nation, a nongovernmental organization, or the Joint Force Command. Considerable effort and expenditure may be necessary to provide for native inhabitants and refugees taken into custody. Secure storage, transportation, accounting, and delivery of humanitarian supplies must be planned. Supply distribution to the local populace can affect mission accomplishment just as significantly as supporting lethal mountain operations.

VEHICLE AND EQUIPMENT OPERATOR CONSIDERATIONS

In high mountain operations, equipment must be prepared for cold weather prior to arriving in the theater of operation. Most vehicles are designed to operate in temperate climates and must undergo winterization to function properly in the cold. Cold weather kits are necessary for every vehicle and should minimally include tire chains for all wheels, tire chain repair kit, deicer, non-freeze windshield wiper fluid, scrapers, tow bars or straps, extra chock blocks, and plastic or canvas to cover windshields to reduce buildup of ice or frost. The following paragraphs discuss broad principles that apply to all vehicles. For information on specific pieces of equipment, the user should refer to the applicable technical manual.

Vehicle Loading

When loading materiel in any vehicle for delivery to an area of operations, items of low priority should be loaded first. Those high-priority items required first at the destination should be loaded last. Experience has shown that this principle is particularly important in mountain operations. A vehicle load standing operating procedure should be established to ensure that recovery equipment, first aid materials, and battle-damage assessment and repair equipment are placed on top or immediately accessible. In light of the reduced vehicle carrying capacity in mountain operations, personal items must be kept to a minimum and road and bridge limitations must be considered.

Vehicle Operation

Vehicle operation is more difficult in the rough terrain and colder temperatures associated with mountain operations. Driver training is critical, particularly at night. Also, training is required in rough terrain and fording. Ground guides should be used when navigating sharp bends and turns and especially when pulling to the side of the road. Braking distance is generally doubled and increases with the amount of weight being carried.

Every vehicle should have a complete, serviceable chain set for all wheels. Because chains break frequently, chain repair kits should also be carried. All licensed operators should know how to properly put chains on their vehicles. Additional chains are required for trailers and towed artillery pieces. Chock blocks should be used instead of emergency brakes when parking since emergency brakes can easily freeze when set. Air tanks should be drained when parking a vehicle to prevent condensation from freezing.

All operators must be aware of the dangers that drainage ditches and soft shoulders present in most areas where heavy snowfall is expected. These areas are used to help drainage and can become easy traps for vehicles that stray too close to the side of the road. Although snow stakes are good indications of where the road is, they can often lead drivers too close to the side of the road and into a ditch. Whenever parking in cold, wet conditions, Marines should park on some kind of dunnage, such as tree branches, wood, or MRE boxes to prevent tires from freezing to the ground. If tires become frozen to the ground, antifreeze or fuel may have to be used to free them. Marines must park where a vehicle's engine and NATO jump-starting field plug can be easily accessed or set for tow. Special consideration must be given to keeping engines warm and out of the weather or started regularly—at least every 3 to 4 hours. Vehicles should be run for at least 10 minutes or until the typical operating temperature is reached with the air cocks open to prevent them from freezing. The valves should be closed sequentially once the vehicle is shut down, but never all at the same time. A rotating system must be established when a vehicle is used to start another before it is shut down. Vehicles must be operated continuously when the temperature is at or below -25 °F. Personnel must not be allowed to sleep under or in vehicles and must remain vigilant for vehicle deficiencies that might expose personnel to carbon monoxide poisoning.

Personnel must be trained to recover vehicles themselves in mountainous terrain because a wrecker may be unable to reach the recovery site. Training for mountain operations should include vehicle recovery missions that use real-world scenarios, such as simulated IED- or mine-damaged vehicles with different l catastrophic destruction levels and teach recovery assets evaluation and selection as well as conducting the actual recovery mission.

Vehicle Rollover

A primary cause of death and serious injury in mountain operations is vehicular rollover accidents. Rollover drills must be rehearsed using egress trainers, if available, and equipment must be tied down in vehicles.

Vehicle Recovery

Mountainous terrain is hard on vehicles and when a vehicle breaks down, recovery is also difficult. Recovery capabilities will be adversely affected by heavy snow, extensive muskeg (bog-like) areas, unpredictable or extreme weather, and a limited road network. When these conditions occur, recovery alternatives include attempting to fix the vehicle with a contact team, towing it to a vehicle collection point, extracting it by heavy lift aviation asset, or destroying it in place. More information can be found in MCRP 3-40E.1, *Recovery and Battle Damage Assessment and Repair (BDAR)*.

Recovery and on-site repair by forward contact teams is preferred, if possible. In recovery operations, lightweight tow bars are useful, but can become a liability if used improperly. A minimum of two tow bars should be carried in every combat patrol. Vehicles with winches are essential. Unit vehicles can generally accomplish towing; however, wreckers or tank retrievers, if available, are more appropriate since chains and cables can easily break loose and allow the disabled vehicle to slide.

VEHICLE MAINTENANCE

In mountain operations, vehicle maintenance is inherently difficult because units are almost invariably forced to drive heavily laden vehicles over uneven terrain. Road networks in the mountains are unforgiving on motorized equipment. Rocks, dust, shifts from desert heat to arctic cold, and dramatic gradient changes can take a significant toll on military motorized equipment. Overall, maintenance failures can exceed losses due to combat.

Maintenance Personnel

Additional mechanics will likely be needed to support dispersed operations in the mountains. At least one mechanic should be at every FOB (however, two or three are preferred). Having the ability to drop an engine at a distant FOB is an immeasurable combat multiplier. By teaching operators the next level of maintenance (supervised by a company mechanic), units can free up the mechanics for larger, more complicated jobs. Although enemy ambushes on main and alternate supply routes can inflict high numbers of casualties, mechanics should be assigned to combat logistics patrols and convoys with maintenance and recovery assets. General support maintenance sections need to be reinforced with extra mechanics. In the mountains, companies should have access to individual operator-, crew-, and field-level maintenance capability. Battalions should have individual operator-, crew-, field-, and sustainment-level maintenance capability. Further clarification on the levels of maintenance can be found in MCTP 3-40E, *Maintenance Operations*.

Preventive Maintenance and Repair

Preventive maintenance is crucial in mountainous terrain and cold weather: vehicle operators must be well-trained in maintenance and driving techniques and have suitable cleaning solvents and lubricants available for the weather and terrain. Units may have to adjust the preventive maintenance checks and services process to focus on items that are most susceptible to breaking in the mountains, such as brakes, alternator brackets, and fluid levels. For vehicles operating in rough terrain, the maintenance service interval can be reduced. For example, during OEF, the maintenance interval for up-armored high mobility multipurpose wheeled vehicles operating in the mountains was reduced from 6,000 miles to 3,000 miles.

Field Maintenance

In mountain operations, leaders must balance operating tempo with sufficient time for proper maintenance. The ability to maintain vehicles directly correlates to a unit's ability to conduct operations. Commanders should consider alternating between motorized operations and heliborne and/or foot-mobile operations to allow vehicle maintenance teams time to make repairs. They should also set aside at least one day for maintenance each week. Heavy field maintenance is not always possible at forward-deployed locations, some items are evacuated back to larger, more capable logistics hubs.

The increased weight of sandbags, bolt-on armor, and other counter-IED protective measures on vehicles will stress the shocks, springs, and struts, leading to a dramatic increase in damaged pitman arms, tie-rods, and half-shafts. Commanders must make appropriate risk management decisions since counter-IED safety measures also increase the risk to operators and crew due to rollover. This threat is multiplied in mountainous terrain.

Proper maintenance on springs and shocks on vehicles is critical to reduce front-end failure. Torque wrench tightening of all bolts on the suspension is regularly needed. Because transmissions break down due to the added weight and dramatic gradient changes, training on transmission troubleshooting should be provided to all maintenance teams.

Cold weather has a significant effect on vehicle maintenance operations as well. For more information, see TM 4-33.31, *Cold Weather Maintenance Operations*.

DISTRIBUTION AND TRANSPORTATION

Conventional distribution methods are a challenge in the mountains, so redundant methods of distribution must be planned. Distribution consists of a combination of methods: airdrops, assault support, tactical vehicles, pack mules, and porters. Since ground transportation is preferred for distributing food, water, fuel, and construction material, units should be task-organized with additional motorized assets, specifically trucks. Such organization reserves more rotary and fixed-wing assets for higher-value supplies, such as ammunition, major end items, and medical supplies.

In mountain operations, the biggest distribution challenge is transporting supplies across those last few miles to the FOB. Whereas supplies can be transported hundreds of miles to an ISB within hours or days, it can take as much or longer to move supplies much shorter distances from an ISB to the FOB. At higher altitudes, pack animals are the preferred way to transport supplies. At altitudes where even pack animals cannot go, porters or military personnel must. While prepackaged loads are preferred at higher echelons, loads can be broken up and distributed among people and animals at the lowest echelons.

Ground Distribution

Transportation methods vary in a mountainous or cold weather environment. They include a various vehicles, animals, and human-powered methods.

Military Vehicles. The use of small cargo vehicles with improved cross-country mobility is paramount to sustaining units at high altitudes. In snow, tracked over-the-snow vehicles are invariably required for movement off roads and might also be necessary on roads in icy conditions. All-terrain vehicles and snow mobiles are highly mobile but may be of limited utility because they lack protection against enemy fires or explosive and nonexplosive obstacles.

The medium tactical vehicle replacement (Marine Corps 7-ton truck) and joint light tactical vehicle are useful in mountain operations; however, the vehicle capacity in rough terrain at high altitude can be reduced by half. The Logistics Vehicle System is useful in moderate terrain but has a limited off-road capability in snow and mountainous terrain. Amphibious combat vehicles can be used in fjords, at fords, on plowed roads, and, to a limited extent, in cross-country movement.

Host-Nation Vehicles. Host-nation trucks are a major source of ground distribution in mountain operations. For routine resupply of non-sensitive items, contracting for use of host-nation trucks can be essential to conserving combat power dedicated to the fight. Roads might only be able to support local trucks until engineer efforts widen and improve roads. Host-nation trucks can be configured for dry, refrigerated, and liquid cargo. For example, a fuel bladder can be placed on the host-nation pick-up truck bed or small truck to haul Class III supplies.

Host-nation trucks, however, do have short-comings, such as the following:

- Host-nation drivers might not move into high-risk areas without security, and they might be particular about driving in certain weather conditions.
- Timelines for delivery are unpredictable and drivers will frequently take a circuitous route to their destination to visit family, avoid enemy contact, or make other deliveries.
- Loads are often pilfered.
- Local trucks may not be properly maintained and may require frequent towing.

Movement coordinators for the MAGTF and logistics combat element working with host-nation trucks need to verify that these vehicles are maintained, loaded, fueled, and staffed properly. A good relationship with the host-nation truck provider is essential to optimizing transportation capacity. Additionally, service providers should leverage other Service line haul capacity (consistent with United States Code, Title 10, *Armed Forces*) to meet sustainment gaps for transportation support.

Operation ENDURING FREEDOM: 1st Brigade Combat Team Experience

For the 1/82 Brigade Combat Team in OEF, a combination of CDS drops, pack animals, and rented Hilux trucks (4-wheel drive and pick-up trucks) were used to resupply the task force. Pack animals and Hilux trucks were used in combination. While all MSRs and secondary roads did not extend into the high ground, some secondary roads allowed for Hilux trucks to access the valley floor. Once the trucks traversed the valley floor, the pack animals pushed supplies from the valley floor to high ground with a few escort personnel required. Pack animals and Hilux trucks were rented from local host-nation sources in the area of operations.

—Marine Corps Center for Lessons Learned Report

Pack Animals. Pack animals, such as mules and donkeys, are an essential distribution method in mountainous terrain. For load planning purposes, mules can carry 200 pounds depending on the terrain and altitude. Donkeys, on the other hand, can only carry about 65 pounds. As a rule, pack animals carry up to 25 percent of their body weight. Although mules can travel 20 miles per day under moderate conditions, they may make only 8 to 10 miles per day in severely rugged terrain. Crude or improvised pack equipment, unconditioned animals, and the general lack of knowledge in the elementary principles of animal management and pack transportation tend to make the use of pack transportation difficult, costly, and potentially problematic to mission accomplishment. These animals require care, attention, and training; planners must account for the weight and bulk of food and water required daily, as well as the handlers required.

Animals are conspicuous, vulnerable, and can be noisy. Caring for animals takes time to learn as does preparing and tying on loads. Ad hoc animal transport units can be formed using locally obtained animals, with or without local handlers, and any personnel who have experience with animals. For units planning to operate in mountains, a pack animal training course is recommended. See ATP 3-18.13, *Special Forces Use of Pack Animals*, and MCRP 12-10A.1 for more information.

Porters. Units operating in the mountains may need to hire local porters who have developed endurance and are accustomed to breathing thin air to transport equipment and supplies by foot. Porters are usually employed to move supplies to a certain point prior to handing them over for unit movement to the furthermost dangerous forward positions. The disadvantage of hiring local porters is that they might be reluctant to work too far away from their homes and villages. For force protection and security planning purposes, commanders should provide porters an escort to protect them from enemy fire, indirect fire, and CBRN weapons effects. When calculating the number of porters required for a particular operation, the following factors must be considered:

- Movement distance.
- Terrain, including height above sea level.
- Type of porter available.
- Water availability.
- Size, shape, and load weight.
- Location of an area suitable for offloading supplies.
- Escort availability.

Military Personnel. Any Units may task organize personnel to serve as porters. Any combination of resupply usually includes carrying supplies to forward positions. Marines should be prepared to transport additional supplies and equipment on top of their personal gear. Commanders must develop priorities, accept risk, and require the combat force to carry only the essentials needed for its own support. Any excess equipment and supplies will reduce their personnel's efficiency. Non-essential equipment should be identified, collected, and stored until it is needed. In situations when there are conflicts between ammunition weight and weapon weight, experience has shown that it is better to carry more ammunition and fewer weapons.

Marines should be trained for transporting supplies. Training must emphasize foot marching over difficult terrain with heavy loads and land navigation. Marines should understand the link-up procedures with their supported units. In cold weather, movement should be conducted at a slow pace, depending on the individual's fitness level, to avoid sweating and cold weather injuries.

Cache Network. In mountain operations, direct hand-off of supplies between the supporting and supported units might not be feasible. Restrictive terrain can lengthen supply lines and limit transportation and distribution methods. Establishing a cache network within the battlespace provides flexibility for the resources used for resupply as well as the timing of emplacement and collection. Cache networks are typically used to resupply maneuver elements by positioning supplies and equipment closer to their position. The cache network should be incorporated into the unit's concept of logistics support. Most caches should be recovered according to an established timeline although some should be established as "on-call" resupplies for unexpected requirements.

Caches can be established either ahead of the forward line of own troops (FLOT) or behind it. In a mountainous environment, the FLOT is often difficult to identify due to the dispersion of friendly maneuver forces. When deciding whether to emplace a cache ahead of or behind the FLOT, the survivability of the emplacement team (i.e., porters, platoons carrying gear, pack strings) should be considered. Cache emplacement and recovery teams should be established and rehearsals conducted between them.

When establishing a cache network, units must plan for excess to accommodate for caches that are lost, compromised, or destroyed. Units must consider supply loss and equipment to the environment (i.e., animals, weather). Planners should weigh the options of establishing manned versus unmanned caches.

Manned Caches. Manned caches are those where a small team of Marines maintains visual contact with the cache from a distance. This type of caching is typically used for sensitive materials, such as communications equipment or weapons. Manning caches allow friendly forces to ensure the intended recipient recovers the cache while preventing capturing, destroying, or tampering by the enemy. However, manned caches require personnel and communications equipment to effectively influence the cache network which increases the sustainment burden on the unit.

Unmanned Caches. Most caches within a cache network are unmanned. Unmanned caches are those that are left unattended. This type of caching is recommended for non-sensitive materials such as MREs, fuels, or ammunition. They do not have the security of manned caches, but do not require personnel or equipment to maintain them. Unmanned caches are riskier than manned caches because they are more likely to be lost, captured, destroyed, or tampered with by the enemy without friendly forces' knowledge.

River Distribution

Marines can analyze terrain to determine if resupply by river is possible. Boats, ferries, and rafts can be employed up, down, or across rivers.

Air Distribution

In mountain operations, aviation assets should be maximized to deliver supplies directly to units. Assault support aircraft conducts aerial delivery and can resupply using parachute drops, free-fall drops (known as speedballs), external transport, or internal transport.

Weather Considerations. Inclement weather is a significant threat to aerial resupply. The operating environment must be permissive from the point of origin to the point of delivery to accomplish the mission. Fog, cloud cover, sudden storms, icing, and unpredictable air currents can quickly shut down air support. Temperature and density altitude can restrict aircraft's ability to carry loads and high mountain weather conditions frequently shut down flying for days.

Altitude Considerations. Higher elevations also decrease overall aircraft lift capacity and aircrew physiological performance. In addition to reduced lift capacity, aircrew operating unpressurized aircraft without supplemental oxygen above 10,000 feet (3,048 meters) have service specific directives that limit the amount of time spent operating above 10,000 feet. For example, Marine Corps aircrew are limited to one hour of flight above 10,000 feet without the use of supplemental oxygen. The aircrew determines loading and altitude restrictions.

Terrain and Route Considerations. Mountain terrain can also interfere with air-to-ground and air-to-air communication. Mountainous terrain can interfere with communication, but satellite communications (SATCOM) and friendly force tracking have increasingly added to the capacity for aircrews and ground forces to communicate. Environmental conditions or the terrain might force Aircrew to follow the terrain features of the mountains, adding predictability to their approaches and increasing the risk to the crew. Aircrews choose the routes best suited for their missions and might opt for high-altitude operations in areas of relatively low antiaircraft artillery or man-portable air defense system threat.

Army rotary-wing assets can carry heavier loads and travel to higher elevations than their Marine Corps counterparts and are considerations during joint operations.

Ring Routes. In some cases, air transportation using a ring route might be the only way to move supplies among various outlying bases in an area of operations. During combat operations, one ring route of regular scheduled rotary-wing assets may depart from a large, centrally located airfield, which may be the primary means to deliver Class V items, personnel, and mail, particularly to FOBs. Supplies using ring routes must be prioritized by receiving unit logisticians with caution to prevent backlogs. Ring route flight schedules often change because of weather, sometimes being delayed by a week or more. Distribution planners must submit air mission requests to ensure aircraft are scheduled. Ring deliveries are determined by schedule and sequence.

Container Delivery System Drops. In mountain operations, air distribution by CDS is frequently used, but is a challenging and manpower-intensive operation. Using CDS involves detailed drop zone coordination. When using CDS, planners should expect significant load attrition due to breakage or the load landing in inaccessible terrain or trees (the Marine Corps considers that one-third loss is a good planning factor), even with seasoned crews. Sleds are useful in recovering CDS in a snow-covered environment. Material handling equipment might be required at the drop zones and LZs. In all cases, aircrews advise supported ground units to determine limitations.

Low-Cost Low-Altitude Delivery System. The low-cost low-altitude delivery system can be used in mountain operations and has been a very successful asset when high risks prevent ground resupply options. These systems have the following characteristics:

- Looks visually similar to CDS.
- The typical load is 500 pounds or less when using one parachute, but up to three parachutes can be used for heavier loads.
- Each parachute system is a low-cost consumable item.

Speedball Technique. Speedballs are a field-expedient technique for conducting aerial resupply; the process consists of aircrew dropping free-fall cargo out of a slow moving or hovering aircraft. Because speedballs do not have parachutes to slow their descent, it is best to use the speedball technique to resupply non-sensitive items such as clothing, batteries, rations, or properly packed small arms ammunition. It is not recommended to use the speedball technique for sensitive items such as radios and explosive ammunition. Additionally, it is best for the aircrew to release the speedballs from as low an altitude and as slow a speed as possible to reduce the damage to the supplies and to increase accuracy. There is no defined size or weight limit for speedballs, but in general the size and weight should be limited to what a single person can lift or push. Due to their ability to fly at slower speeds and ability to hover, helicopters and tiltrotors are the ideal platform for the speedball technique and can drop speedballs with relatively high accuracy into locations that are not suitable for other methods of air delivery such as external sling loads or air drops.

Container Distribution System Operations in Operation ENDURING FREEDOM

During OEF, CDS drops were conducted by C-130s originating out of Bagram Airfield. Each drop consisted of up to 12 bundles of supplies that would support two rifle companies for two days with Class I and batteries. To arrange a drop, the receiving unit submitted a joint mission request to air mobility division (AMD) tactics at Bagram through the brigade administration and logistic operations center. The receiving unit would submit an eight-digit grid location along with imagery of each drop zone to AMD. The receiving unit selected at least three drop zones to account for both enemy activity and rugged terrain that hindered movements. The AMD reviewed each proposed drop zone and either approved it or requested that the unit move the location to an area that AMD felt was more suitable for a successful drop. Ultimately, AMD would maintain final approval and the brigade administration and logistic operations center would conduct direct coordination with AMD and the aircrews. Intense planning for accurate drops was a must. Due to the extreme nature of the terrain, a delivery that is only about 200 meters (650 feet) from the intended location might result in the loss of more than half the bundles or a recovery time of several hours.

—Marine Corps Center for Lessons Learned Report

MEDICAL SUPPORT CONSIDERATIONS

In a cold, mountainous environment, personal hygiene can be more difficult to maintain due to limited water and the inconvenience of bathing. The potential for infectious diseases to spread is increased by condensed living spaces that many individuals share. Field hygiene and sanitation must be emphasized. Personnel should also use sunscreen and sunglasses to prevent severe sunburn, which are possible at high altitude or in snow-covered environments.

For small unit operations with widely dispersed forces, personnel must be well-trained in combat lifesaver and CASEVAC procedures, including the following:

- Self and buddy aid, advanced first aid, and field sanitation.
- The self-application of tourniquets or pressure bandages to control bleeding that could be life threatening.
- The use and capabilities of the CASEVAC bag and pole-less litter, including combat lifesaver and higher levels of first-responder care.
- Transmitting a 9-line medical evacuation (MEDEVAC) request and setup of a helicopter LZ.

Each squad (but preferably each fire team) should have at least one trained combat lifesaver to augment the squad's corpsman or combat medic. Also, MEDEVAC crew chiefs should be combat lifesavers to assist, if time and the mission allow, during flight operations. Corpsmen should be EMT [emergency medical technician] qualified. Given the distances involved, en route patient care is vital. Corpsmen should have live tissue training, such as that offered in the civilian Operational and Emergency Medical Skills course. Medical providers should be trained in diagnosing and treating low orthopedic and low back injuries. Corpsmen trained in providing spinal and muscular manipulation can apply these skills to prevent back injuries.

Medical personnel have unique training requirements for mountain operations. Hoist operations should be a planning consideration for medical units operating in mountainous areas. Prior to deployment, units should receive training on how to hoist or drop patients. They should be familiar with high, steep angle rescue and the equipment used in hoist operations, preferably using air platforms in rugged terrain. All medical personnel must be trained prior to deployment on air CASEVAC and equipment used in hoist operations, preferably using air platforms in rugged terrain. Mountain operations require evacuation teams, preferably Level II mountaineers (see Chapter 10), who have the capability to reach, stabilize, and evacuate casualties in the steepest terrain. All personnel should be trained to conduct less technical, steep-slope evacuations.

Casualty Collection and Evacuation

Casualty evacuation is the movement of casualties aboard non-medical vehicles or aircraft. Casualties transported in this manner may not receive proper enroute medical care or be transported to the appropriate medical treatment facility to address the patient's medical condition. When possible, non-medical vehicles should have a combat medic or combat lifesaver on board. On non-medical aircraft, sufficient space might not be available to permit a caregiver to accompany the casualties; moreover, the type of enroute monitoring, medical care, or first aid provided might also be limited. Casualty evacuation should only be used in extreme emergencies or when the MEDEVAC system is overwhelmed.

Mountain operations present numerous challenges for casualty collection and evacuation. Leaders should consider the following when planning mountain operations:

- Difficulty associated with accessing casualties in rugged terrain.
- The increased need for technical mountaineering skills for CASEVAC.
- Proximity of expert medical help.
- Longer periods of wait time for CASEVACs.
- Prior to evacuation, injured and immobilized patients are at the greatest risk of cold-weather injury and must be well insulated during transport.
- Evacuating the wounded from mountainous areas usually requires more medical personnel and litter bearers than do flat terrain evacuations.
- Tough, physical casualty handling should be conducted in every training event.

Each unit should have a detailed CASEVAC plan that is repeatedly rehearsed. Each FOB must have ground evacuation assets and a dedicated security element. The security element should be on call and familiar with primary and alternate routes to higher roles of care (roles 2 and 3). Commanders must clearly consider what levels of risk they are prepared to accept to air evacuate patients using non-medical aircraft.

Medical Evacuation

A MEDEVAC is performed by dedicated, standardized MEDEVAC platforms (ground and air ambulance platforms), with medical professionals who provide the timely, efficient movement and enroute care of the wounded, injured, or ill persons from the battlefield or other locations to the supporting medical treatment facilities. Air MEDEVAC of seriously wounded personnel is the preferred method in mountain operations. Positioning aviation assets forward on the battlefield is critical to supporting such operations; however, during periods of decreased visibility and high winds, these assets may not be able to fly or land in extreme mountainous terrain. Hoist operations are inherently dangerous and can result in fatalities if preventive measures are not considered. Personnel need training prior to deployment on MEDEVAC procedures and the equipment used in hoist operations.

ACCLIMATIZATION

Regardless of an individual's standard of physical fitness, all personnel must acclimate to the environment to be effective and to prevent associated altitude injuries. Acclimatization achieves maximum physical and mental performance and minimizes the threat of altitude-related illness. Mountain warfare training is not a substitute for the acclimatization process, but it does provide personnel with an appreciation for the challenges of surviving and fighting in a mountainous environment.

Acclimatization is required before undertaking extensive military operations. Even the most physically fit Marines experience physiological and psychological degradation when they are thrust into high elevations. Time must be allocated for acclimating, conditioning, and training. There is not a shortcut for the acclimatization process and any attempt to trim or bypass the process can result in injuries. Leaders should build physical fitness plans that will help prepare personnel for operations at altitude.

For most Marines at high (2,438 to 3,962 meters [8,000 to 13,000 feet]) to very high (3,962 to 5,486 meters [13,000 to 18,000 feet]) altitudes, 70 to 80 percent of the respiratory component of acclimatization occurs in 7 to 10 days, and 80 to 90 percent of overall acclimatization is generally accomplished within 2 weeks to a month. Maximum acclimatization can take months to years. Acclimatization cannot be accelerated; some Marines acclimate more rapidly than others and a few might not acclimate at all. There is no reliable way to identify those who cannot acclimate except by their experience during previous altitude exposures. When brought to lower altitudes, personnel can lose their acclimatization in a matter of days.

To acclimate Marines in high mountains, unit leaders use one of two methods: staged ascent or graded ascent. In a staged ascent, Marines ascend to a moderate altitude (2,438 to 3,962 meters [8,000 to 13,000 feet]) and remain there for 4 days or more to acclimate before ascending higher. When possible, Marines should make several stops during the ascent to allow acclimatization to increase. A graded ascent limits the daily altitude gain to allow partial acclimatization. The altitude at which Marines sleep is critical to acclimatization—work high, sleep low is a rule of thumb (e.g., sleep 1,000 feet lower than the working elevation.) Once they have ascended to 2,438 meters (8,000 feet), Marines should gain no more than 300 meters (984 feet) of sleeping altitude each day. This process significantly reduces high-altitude illnesses. A combination of staged ascent and graded ascent is the safest and most effective method to prevent high-altitude illnesses.

CHAPTER 7.
AVIATION

Marine aviation's basic functions do not change when operating in complex and compartmentalized terrain, high altitude, cold temperatures, and all-weather conditions. However, there are unique considerations and limitations associated with some of these functions when operating in these conditions, all of which are inherent to mountainous environments. Many limitations can be minimized or mitigated through understanding the planning and training considerations for the aviation combat element (ACE).

Aviation operations require additional time, planning, equipment, and personnel to operate successfully in this environment. The ACE must strive to complete the mission in all weather conditions and all environments. Mountain weather conditions that can limit or ground some aviation assets are clouds, fog, heavy rain, high winds, and whiteout. Icing presents a problem to aircraft that do not have anti-icing equipment. Aircraft with anti-icing equipment are capable of safe instrument flight into clouds or visible moisture when the temperature is below freezing; however, their ability to influence and support the ground scheme of maneuver would be limited. The weather and environment can also greatly affect ground maintenance. The operational area's climate history should be studied to determine the probable frequency and duration of weather conditions that could limit or preclude flight operations and the support ground units can expect from them.

Aviation units should be deployed to best support the troops on the ground. Unlike many other environments, mountainous environments require the MAGTF commander, ground task force commander, or joint task force commander to use dispersed operations to effectively support their ground troops. The objective is to have aviation forces available to the dispersed units for planning and execution on short notice, so they can quickly react to intelligence and support ongoing ground operations. Dispersed operations impart increased risks for the ACE commanders as it is more difficult to provide supply or resupply, a full echeloned maintenance capability, fuel, forward deployed ordnance, command and control, and security when aviation units are not centrally located with these support functions. For the ground commander, this environment imposes difficulties in surface transportation, which creates an increased demand for aviation support. The delicate balance among such factors requires the Services to carefully plan and understand aviation capabilities.

ANTIAIR WARFARE

Planning Considerations

Severely compartmentalized terrain presents several unique challenges to ground-based air defense assets. Among these challenges are communications, mobility, logistics, cueing, and tactical employment.

Communications. Mountainous terrain severely precludes Marines from using very high frequency (VHF) radio assets except in short-range, LOS situations. The nature of low-altitude air defense (LAAD) or short-range air defense unit employment is such that the tactical dispersion of surface-to-air missile teams, sections, platoons, and batteries will render VHF communications unreliable. Solutions that can be fielded within the battalion include SATCOM assets and high-frequency (HF) radio assets. In addition to organic communications assets, LAAD or short-range air defense planners should explore the nonorganic communications support possibilities, such as using an airborne communications relay, if such assets are operating within the area of operations.

Mobility. Because typical air defense operations are motorized, mountainous terrain limits team mobility. Foot-mobile, LAAD teams can carry a few missiles and batteries and a limited amount of communications equipment, food, and water. It is difficult for a dismounted LAAD unit to execute sustained operations. Options for the LAAD planner to consider include inserting helicopter or tiltrotor teams if the assets are available or dispersing dismounted teams from a rally point or points that are accessible by vehicle. The most constricting terrain might require using pack mules.

Logistics. Mobility constraints affect not only the air defense teams, but also their logistic support. Planners anticipate that the ability for vehicles to support resupply efforts can be limited so they should explore using helicopters, airdrops, and pack mules to sustain the force. Creative resupply options include using gas station or tailgate logistics or a combination of the two, based on METT-T and space and logistics should be considered.

Cueing and Tactical Deployment. Compartmentalized terrain impacts air defense unit's employment and the ability to receive electronic early warning and cueing from ground-based radar assets. The terrain can limit what ground-based radar can see and can limit communications with the identification and engagement authority, extending the amount of time to gain approval authority to prosecute a threat (kill chain). Air defense planners should attempt to decentralize identification and engagement authority to the lowest level possible given rules of engagement and mission constraints. Planners should coordinate with airborne early warning platforms to maximize the amount of cueing that teams can receive.

Unique Capabilities and Limitations of Marine Corps LAAD

The current air defense weapon within the Marine Corps LAAD battalion is the Stinger missile, a shoulder-fired, fire-and-forget missile. Although early warning and cueing from ground-based or airborne radar can help the gunner locate a potential threat quickly, the Stinger does not depend on cueing to fire, which makes it a very effective and highly mobile weapon platform. One disadvantage the LAAD team faces in the mountains is the enemy's ability to use terrain masking or background clutter, which challenges the gunner's ability to acquire and engage the target. Additionally, down-angle shots against aircraft that have background clutter may reduce the probability of a successful engagement.

When tactically employing a LAAD unit in mountainous terrain, general support missions are preferred over direct support missions. Direct support missions, such as air defense of a maneuvering infantry unit, will likely lead to teams employed in locations with limited fields of fire and reduce the time available for gunners to engage enemy aircraft. However, some missions, such as air assault missions, are effective direct support missions in the mountains because they are generally isolated and provide mobility to the teams being inserted. General support missions, on the other hand, allow the LAAD unit to maximize the advantages of the terrain and minimize the disadvantages. Planners should seek to employ the units based on terrain and likely enemy avenues of approach. High vantage points with excellent visibility and fields of fire abound in the mountains; hence, teams can be placed to provide overlapping, mutually supporting fire over likely enemy avenues of approach within the unit's area of operations. Planners should keep in mind that employing mutually supporting fire would likely require teams to locate in remote, austere locations, increasing the need for security to protect them from ground attack and their logistical footprint.

Suppression of Enemy Air Defenses and Air-to-Air Planning Considerations

Aircraft performance could be degraded when attacking surface-to-air threats in high altitude environments, since height above target can affect fuzing and ordnance delivery. Geometry of attack and weather are also considerations in this environment. Mountains may impede radar coverage and increase difficulties in detecting air-to-air threats and ground controlled intercepts. Thorough IPB can map these blind zones and limit these effects.

Training Considerations

When preparing to operate in mountainous environments, air defense units need to focus their training efforts specifically on the area of operations. Every effort should be made to conduct mountain warfare training, to include pre-environmental training, survival, first aid, rope skills, climbing, mountain communications, and animal packing. Depending on the area of operations, cold weather mountain training, to include over the snow mobility, can also be appropriate.

AIR RECONNAISSANCE

While some aircraft have air reconnaissance as their primary mission, all aircraft, regardless of type or mission, can provide valuable intelligence and conduct air reconnaissance as a secondary or concurrent mission. Reconnaissance is most successful if ground and aviation units communicate and exchange information. Prior coordination and participation in mission planning can alert pilots to look for critical intelligence information that is helpful to the maneuver forces. It is also important that ground personnel or LNOs participate in mission debriefs whenever possible to extract critical information about the enemy terrain or weather and to ensure this information is passed to the units who need it.

Aircraft specifically designed for the reconnaissance mission may be available to ground forces, providing real-time information to the ground force commander. Thermal imaging, forward- looking infrared, and day-time television recording provide commanders and Marines with an accurate depiction of what aircrews are seeing and how it may affect their operations. The most widely used air reconnaissance platforms in mountain operations are rotary-wing aviation and UASs.

Attack Reconnaissance Helicopter Operations

Rotary-wing aircraft is used to conduct reconnaissance operations, which enables the ground forces to have additional maneuver and effect. Rotary-wing assets can be either planned, such as an air mission request, or unplanned, such as an established quick reaction force. These platforms can also provide mobile and stationary security coverage for ground forces during operations as a screening force, providing ground forces with reaction time and maneuver space on the battlefield.

Given the compartmentalized nature of mountainous terrain, the ACE could choose to divide attack reconnaissance aircraft and lift and cargo helicopters into smaller maneuver elements that are part of an aviation task force to provide the ground force commander with a range of aviation support options.

Unmanned Aircraft Systems

Leaders can increase the reconnaissance capability of forces in the mountains by employing UAS. These aircraft are generally assigned the following tasks in all environments:

- Conduct air reconnaissance.
- Analyze and synthesize information.
- Control indirect fire.
- Conduct terminal guidance operations.

Planners must make some special considerations in mountainous environments regarding UAS planning, hub-and-spoke techniques, and fires integration, which are discussed in the following subparagraphs. See Table 7-1 for unmanned aircraft group categories.

Table 7-1. Unmanned Aircraft Group Categories.

<table>
<tr><th>Unmanned
Aircraft Category</th><th>Maximum Gross
Takeoff Weight (pounds)</th><th>Normal Operating
Altitude (feet)</th><th>Speed (knots
indicated airspeed)</th></tr>
<tr><td>Group 1</td><td>0-20</td><td>< 1,200 AGL</td><td>< 100</td></tr>
<tr><td>Group 2</td><td>21-155</td><td>< 3,500 AGL</td><td rowspan="2">< 250</td></tr>
<tr><td>Group 3</td><td>56-1,320</td><td rowspan="2"><18,000 MSL</td></tr>
<tr><td>Group 4</td><td rowspan="2">> 1,320</td><td rowspan="2">Any airspeed</td></tr>
<tr><td>Group 5</td><td>> 18,000 MSL</td></tr>
<tr><td colspan="4">LEGEND
MSL mean sea level UA unmanned aircraft</td></tr>
</table>

Unmanned Aircraft System Planning Considerations, Capabilities, and Limitations in Mountains. Terminal guidance provides electromagnetic, mechanical, voice, or visual communication to approaching aircraft and weapons regarding a specific target location (not to be confused with terminal attack control). Additionally, deployed unmanned aircraft squadrons could also be tasked to conduct radio retransmission for a supported unit. Radio retransmission allows the UAS crew to communicate with ground forces using the aircraft. The UAS may also be configured to be used only by the supported ground element to overcome environmental limitations in the mountains for internal unit communication.

Mountain operations using UASs are affected by several unique planning considerations. More information on UAS considerations can be found in MCRP 3-20.5, *Unmanned Aircraft System Operations*. The following are the most important UAS considerations in a mountainous environment:

- Altitude, air density, and temperature.
- Aircraft icing at the operating flight altitude. Icing is often more prominent at higher mountain elevations.
- Communication restraints are caused by mountainous terrain and LOS constraints between the unmanned aircraft and the controlling station.
- High winds typical of mountainous terrain are often channeled through valleys and mountain passes. Smaller unmanned aircraft are generally more affected by severe weather than their manned counterparts. High winds, turbulence, and wind shear will negatively affect the flight profile of unmanned aircraft. It can cause the aircraft to make wider turns, rapidly change altitude, cause erratic flight, or cause a departure from the controlled flight.
- Climb and descent rates of most types of unmanned aircraft are affected by the higher elevations. Planners must account for longer launch and recovery times for their aircraft, particularly when supporting the acquisition of time-sensitive targets.

Due to the higher elevation, the recommended unmanned aircraft flight profile may not be the most efficient for its payload depending on type, model, and series.

Rotary- and fixed-wing aircrews, UAS operators, and command and control operators or controllers must be extra vigilant when integrating unmanned aircraft into the airspace control plan due to the restrictive flight environment and numerous obstacles and hazards to flight in mountainous terrain. Congested airspace surrounding FOB airfields and canalizing terrain can cause flight paths to encroach and can cause mid-air collisions. Aircrews must be provided with current UAS restricted operations zone information as they check in with individual units upon crossing unit boundaries. Constant attentiveness to airspace tasking orders, airspace control measures, immediate restricted operations zones, and civilian helicopter and fixed-wing aircraft traffic can prevent catastrophic consequences.

Marine Corps “Hub and Spoke” Techniques. The UAS scheme of maneuver in mountainous environment is dictated by the terrain and inherent LOS limitations. Hub-and- spoke, or handoff control which can extend a single UAS coverage area, can be used in this environment. For example, crews for a medium-sized tactical UAS can launch and recover from a central launch-and-recovery location (hub) and electronically pass control of the unmanned aircraft and its payload to other UAS control locations (spokes) near the desired operational area. The hub retains responsibility for mission tasking and unmanned aircraft maintenance. The spoke, or receiving control station, is responsible for mission execution and tactical employment according to the supported unit's requirements, which allows units to overcome UAS LOS limitations presented by high terrain, great distances, or large areas of responsibility, such as those encountered in Afghanistan. A single, centrally located UAS unit can service several areas of operations simultaneously, depending on availability of personnel and equipment.

For Marine Corps personnel, positioning spokes with operators and a ground control station at or near the supported commander's command post can enhance the responsiveness of the intelligence production process. Spokes could be located with COPs or with various fires and maneuver units. Hub and spoke operations depend on effective coordination between personnel at the hub and those at the spokes to conduct the handoff of unmanned aircraft. The UAS units must rely on timing and procedural control or employ radios, landlines, and secure local area networks to communicate between the hub and outlying spokes during unmanned aircraft hand-offs (see Figure 7-1).

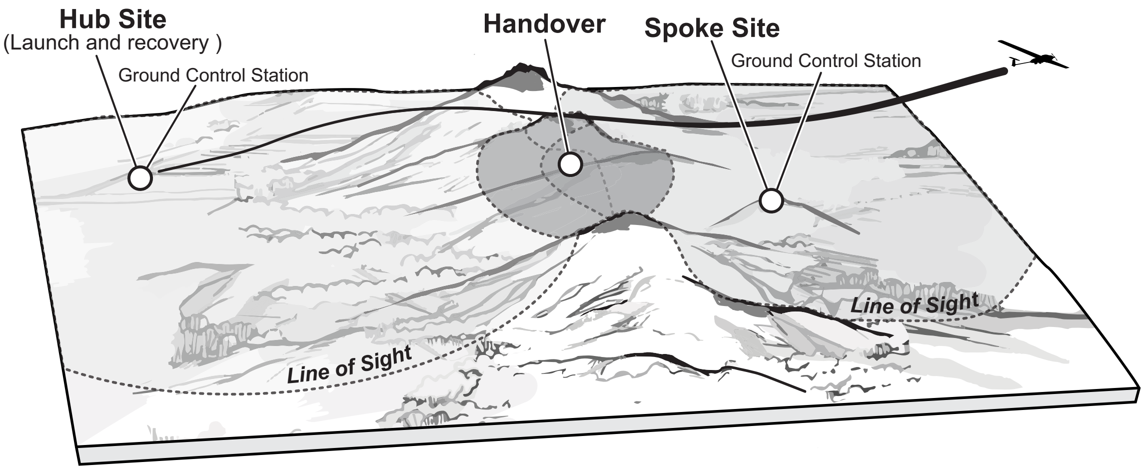

Figure 7-1. Hub and Spoke Concept.

Fires Integration. Planners for UASs must stress their systems capabilities in integrating fires (aviation and surface-to-surface) within the objective area. Movement within mountainous terrain is difficult and time consuming; however, UASs can assist forward observers, rotary-wing aircrews, and forward air controllers (FACs) in observing targets and calling for artillery fire, to include Excalibur and HIMARS [High Mobility Artillery Rocket System] fires from a remote location instead of from an observer near the target area. Commanders of UASs are qualified to conduct a call for fire; they can use the ground control station's video display to locate targets and request fires from the fire support system by radio or some other digital means. Those unmanned aircraft equipped with a laser target designator can deliver precision fires by designating the locations of the target for laser-guided weapons, while some larger unmanned aircraft carry their own weapons. The UAS video can be fed directly to the fire support coordinator, joint fires observer, air officer, FAC or joint terminal attack controller (JTAC), or attack reconnaissance helicopter aircrew through numerous digital methods. For example, Marines use the One System Remote Video Terminal or Remote Optical Video Enhanced Receiver. Marine unmanned aerial vehicle squadron combat operations centers can be physically located with the fire support coordination center, while the UAS control station can be located forward with the supported unit's combat operations center as a spoke.

Coordination between armed helicopter aircrews or armed UAS controllers can enable a cooperative engagement between the two systems, during which UASs enabled with armament or a laser designator can fire or designate reconnaissance aircraft for attack. Such engagements require direct communication between the UAS observer and/or controller and the aircrews. This method can also be known as manned and unmanned teaming, which helps to overcome some of the LOS limitations, ensures the information gets to the people who need it most, and shortens the sensor to shooter loop. As with any system, units must train in similar environments to ones they will operate in so that they can become proficient in unmanned aircraft systems.

ASSAULT SUPPORT

Mountain operations lessen troop capacity, combat radius, endurance, and payload. These same limitations apply to all rotary-wing and assault support aircraft in the joint inventory.

Air Delivery

Mountainous terrain imposes unique requirements on usable LZ terrain to deliver supplies in support of ground forces. Due to higher slope angles, confining terrain, variable mountain winds, and limited avenues of ingress and egress, use of externally delivered or air-dropped supplies might be required instead of internally delivered cargo offloaded in the LZ. Helicopter and tiltrotor external delivery requires the helicopter/tiltrotor support teams (HSTs), to hook up external loads for transport. Due to the dispersed nature of mountain operations, additional personnel should be trained in these skills so they can be available to the receiving units as well. Planners should consider operating aircraft and HSTs out of multiple dispersed locations and using forward arming and refueling points (FARPs) to mitigate the weather and terrain effects on the available support.

Higher elevations and higher temperatures negatively affect the lift capability of assault support aircraft. Due consideration should be given to the location of the PZ and drop zone, the weight of the load(s) to be inserted or extracted, and the time required to transit to and from the location. More assault support aircraft is required to deliver supplies in the mountains than elsewhere in light of higher altitude effects on aircraft performance; moreover, if more assets are not available, then more sorties will be required to accomplish the same tasking.

While external air deliveries place supplies and logistics in a precise drop location, air delivery by air-drop loads allows assault support assets to remain in flight during the drop, which, in most cases, allows a larger and/or heavier load to be delivered and decreases the aircraft's vulnerability to fires during the delivery process. Precise coordination between air delivery aircraft and supported ground assets is required to ensure that dropped loads fall in the correct locations. Due to the variable nature of mountain winds and the confining nature of terrain, air drops might spread over a larger area, into inaccessible terrain or trees; this is not the preferred method when a high level of precision is required.

Combat Search and Rescue and Tactical Recovery of Aircraft and Personnel

Both combat search and rescue and tactical recovery of aircraft and personnel missions require pre-established criteria for the launch of assets. These missions involve a coordinated effort among several organizations, all of which are challenged by the mountainous terrain, dispersed forces, and weather. Such challenges include communications, isolated personnel detection, lift, and time on station (TOS) helicopters capabilities used to conduct the rescue or recovery.

Personnel recovery is defined as “the sum of military, diplomatic, and civil efforts to prepare for and execute the recovery and reintegration of isolated personnel. Also called PR. See also combat search and rescue; evasion; personnel; recovery; search and rescue (Department of Defense (DoD) Dictionary). The weather effects r on isolated personnel and their ability to endure the conditions until recovery forces can locate, authenticate, and recover them should be analyzed. Pilots and crews must be trained to survive in harsh conditions, and survival kits should be prepared. High mountain winds and limited LZs can inhibit the recovery forces’ ability to land close to the isolated personnel and aircraft, further delaying the recovery effort and limiting the TOS available for supporting aircraft. The aircraft’s inability to land close to isolated personnel due to terrain can be mitigated by using a hoist capable aircraft equipped with a rescue basket or forest or jungle penetrator. Lastly, weather can affect recovery aircraft responsiveness and impede the recovery force from reaching isolated personnel should the supporting assets be operating from dispersed locations or conducting operations spanning impassable mountainous terrain that has been closed by weather.

Terrain hampers communication between the rescued individuals and the forces trying to locate them because of LOS communication restrictions, so planners should consider using over-the-horizon communications capabilities. Aerial relays, SATCOM, and other techniques can be employed by communications planners to locate and communicate with aerial and downed personnel. Detailed information on the planning and execution of tactical aircraft and personnel recovery can be found in JP 3-50, *Personnel Recovery* and MCRP 3-05.3 *Multi-Service Tactics, Techniques, and Procedures for Personnel Recovery*.

Medical, Casualty, and Air Evacuations

As with any mountainous-terrain assault, planners must consider LZ terrain and the required TOS and lift capability to determine whether aircraft can support medical, casualty, or any air evacuation.

Rescuers to use the fastest aircraft available to deliver patients to appropriate medical facilities as quickly as possible unless they must evacuate numerous personnel. If larger force extraction is required, heavy lift assault support assets at higher altitude often can move forces to safety. In offensive operations conducted over complex terrain, weather conditions can hamper medical transport, increasing risk and decreasing critically injured patients’ chances of survival. Where terrain or vegetation might not allow aircraft to land close to the casualty, consider evacuation using a hoist capable aircraft to mitigate the risks. Planners might have to disperse aircraft to positions closer to the Fleet Marine Forces or establish medical care facilities farther forward to cut down the travel time. Planners should consider using intermediate shuttle LZs to facilitate hasty extractions. In a snow-covered environment, it is recommended that ground force personnel use the Ahkio Huddle Technique to expedite loading the patient onto the aircraft and to protect the patient from exposure to windchill and flying debris to include snow and ice.

Combat Assault Transport

High-altitude assault operations can be restricted by the canalizing terrain and mountain weather effects. At higher elevations, zone size, slope, and suitability for large-scale assault support landings must be tempered with the desire to rapidly build combat power up in the LZ. Assault support aircraft planners require detailed analysis of the LZ suitability, the forecasted weather, the anticipated loads (passengers and cargo), and the requirements for transit and loiter in the objective area. Commanders must recognize that timely support depends on aircraft availability, mission technique (dispersion typically works best at higher altitudes) and the location of supporting assets. Cold weather, mountainous terrain, and dispersed operations can hamper security, maintenance, and logistic support. Further information regarding the planning for and execution of air assaults is found in MCTP 3-20E, *Assault Support*.

Airborne Command and Control

Weather permitting, commanders should consider the use of organic and joint airborne command and control capabilities to mitigate the effects of limited LOS communications in mountainous terrain. Rotary-wing platforms, such as the Marine UH-1Y, enable the commander to use LOS communications with aviation and ground forces and to land directly in an LZ to build situational awareness or communicate directly with forces on the ground.

The Marine Corps' organic airborne command and control platforms are the KC-130, MV-22, and UH-1Y. The KC-130 and MV-22 can offer commanders VHF, ultrahigh frequency (UHF), SATCOM, and network-on-the-move (NOTM) communications capabilities along with significant time on station and interior space. The UH-1 offers commanders VHF and UHF communications capabilities and, along with the MV-22, the ability to land close to ground forces. In addition, there are numerous other joint airborne command and control capabilities that can increase situational awareness and mitigate terrain effects. Commanders and their staffs should request the use of these assets through joint tactical airstrike request procedures to augment their own capabilities and mitigate the weather and terrain effects in the mountains.

Battlefield Illumination

To maintain situational awareness for Marines being transported, assault support assets should plan for battlefield illumination in a mountainous environment. Although conducting low light operations, battlefield illumination helps mitigate the effects of brownout and white-out landings. In low-light environments, proper planning regarding the objective area geometry and coordinating assets to employ battlefield illumination will enhance the capability of assault support assets. Consideration must be made for light degradation. East-west orientated mountain ranges are shadowed by the sun and moon, which creates low-light conditions on reverse slopes. Though battlefield illumination does not turn low light into high light, planners should consider employing overt and covert illumination in a theater of operation. Battlefield illumination should be requested in advance and made available to conduct such operations.

Landing Zone Considerations

Special considerations must be made when evaluating and choosing an LZ for operations in mountainous terrain. The high-altitude effects on assault support aircraft include decreased hover power, decreased forward airspeed limits, susceptibility to blade stall, vortex ring state, and decreased maneuverability. Planners, working with aviation leadership familiar with the area of operations, should evaluate landing sites, considering LZ size and mission suitability. Aviation requirements for altitude, prevailing winds or weather, and safe approach and departure paths can further limit the selection of certain LZ and PZ sites, but aviators endeavor to meet the needs of ground forces within those limitations. Together, ground forces and aviators should select LZs that will be used as part of routine air movements, such as FOBs and COPs. These sites should be well marked and, if available, lighted by either visible or infrared position lights. Portable systems can be acquired through military supply and can decrease the overall risk associated with confined or low-light LZ operations, particularly when aircrews may be operating under night vision systems. Landing zones that will be used only once for assault operations should be carefully chosen with input from the aircrews that will be performing the air assault.

Further considerations include the height and size of obstacles, slope, suitability, topography, wind direction, demarcation line, turbulence, null areas, escape or departure routes, drop-off, wave off, elevation, density altitude, and power available versus power required. As assault support performance decreases, the transition period becomes more critical, approaches must be shallower, and transitions must be gradual. As the obstacle's height increases, larger LZs are required to facilitate appropriate approach angles and speeds, and aviation planners should be consulted to ensure that the LZ meets their approach criteria. Additionally, planners must consider the number of aircraft that are required to land to support operations. Although prevailing winds should be a key factor for landing direction, terrain produces local wind effects that could also be dangerous during landing or take-off from the LZ. Further guidance on effective air assault mission planning and LZ and PZ selection criteria can be found in MCTP 3-20E, FM 3-99, *Airborne and Air Assault Operations*, and in FM 3-21.38, *Pathfinder Operations*.

Landing Zones on Frozen Bodies of Water

In a mountainous terrain where suitable LZs are limited, frozen bodies of water such as lakes and rivers can be used as LZs. Frozen bodies of water have several characteristics that make them ideal locations for landing aircraft, chief of which are that they are flat and generally free of vertical obstacles. This enables a larger number of assault support aircraft to land simultaneously, allowing for a more rapid build-up of combat power. The danger of using frozen bodies of water as LZs is the risk of breaking through the ice if the ice is not thick enough or of high enough quality to bear the load of the aircraft. To mitigate the breakthrough risk, it is important to conduct an ice reconnaissance to determine the ice quality and thickness and whether there is a void between the ice and water below it. If the ice is compromised or there is a void under the ice, then the ice is not a suitable landing zone. Additionally, pilots can mitigate the risk of breakthrough by slowly reducing power once in contact with the ice to allow the aircraft's weight to gradually settle onto the ice in a controlled manner, allowing the aircrew to detect breaks before they become catastrophic.

To determine the required ice thickness or weight bearing capacity of a frozen body of water, commanders and planners should use Gold's formula:

Gold's formula: $H= \sqrt{(W/A)}$ or $W=A*H2$

H = thickness of the ice in inches
W = gross weight of the aircraft in pounds
A = flexural strength of the ice in pounds per square inch

In Gold's formula the most important variable is the A-value which can be used as a safety factor, expressed as SF, when determining the ice's weight bearing capacity for a known H-value or for determining the required ice thickness for a known W-value. The average flexural strength of ice is 150 psi which results in SF=1 when it is used as the A-value in Gold's Formula. Depending on the level of risk that commanders are willing to accept, there are several A-values that can be used which correspond to an associated level of risk.

Table 7-2 provides commanders and staffs with a risk assessment tool comprising the several A-values and their associated levels of risk, as well as the required ice thicknesses for a range of gross aircraft weights at various levels of risk.

Table 7-2. Risk Assessment Tool When Determining Required Ice Thickness for Using Frozen Bodies of Water as Landing Zones.

Aircraft Weight (1,000s lbs)	Very Low Risk (A=50 psi), SF=1	Low Risk (A=75 psi), SF=2	Tolerable Risk (A=100 psi), SF=1.5	Medium Risk (A=150 psi), SF=1	High Risk (A=200 psi), SF=0.75	Extreme Risk (A=250 psi), SF=0.6
12.00	15.49	12.65	10.95	8.94	7.75	6.93
13.00	16.12	13.17	11.40	9.31	8.06	7.21
14.00	16.73	13.66	11.83	9.66	8.37	7.48
15.00	17.32	14.14	12.25	10.00	8.66	7.75
16.00	17.89	14.61	12.65	10.33	8.94	8.00
17.00	18.44	15.06	13.04	10.65	9.22	8.25
18.00	18.97	15.49	13.42	10.95	9.49	8.49
19.00	19.49	15.92	13.78	11.25	9.75	8.72
20.00	20.00	16.33	14.14	11.55	10.00	8.94
25.00	22.36	18.26	15.81	12.91	11.18	10.00
30.00	24.49	20.00	17.32	14.14	12.25	10.95
35.00	26.46	21.60	18.71	15.28	13.23	11.83
40.00	28.28	23.09	20.00	16.33	14.14	12.65
45.00	30.00	24.49	21.21	17.32	15.00	13.42
50.00	31.62	25.82	22.36	18.26	15.81	14.14
55.00	33.17	27.08	23.45	19.15	16.58	14.83
60.00	34.64	28.28	24.49	20.00	17.32	15.49
65.00	36.06	29.44	25.50	20.82	18.03	16.12
70.00	37.42	30.55	26.46	21.60	18.71	16.73

Snow-Covered Terrain

Brownout and whiteout conditions can cause spatial disorientation. Winter operations in mountains bring recurring snowfalls that are characterized by deep, dry, powder-like snow, particularly in very high elevations. Viable whiteout mitigation plans are mandatory in these conditions. The procedures for landing in snow-covered terrain are similar to desert landing approaches and should be briefed before execution. Aircrews should assist to facilitate the pilots' referenced landings. Wave off cues should be briefed to ensure a safe, controlled approach into a high altitude, snow-covered landing. The aircrew should consider terrain beneath the snow's surface to ensure safe touchdown. Landing points should be marked on the landing site with an object that contrasts with the snow as a reference for depth perception. If time and threat conditions permit, the ground force should make efforts to prepare a snow-covered LZ by compacting the surface snow with snowshoes, skis, vehicles, etc., to minimize whiteout conditions. The ground force can also use avalanche probes to reconnoiter beneath the snow's surface to determine if hazardous obstacles that could damage an aircraft, such as large rocks or tree stumps, are buried just beneath the surface. In areas of deep, powdery snow, it is recommended that the ground force use the Ahkio Huddle Technique to facilitate faster loading and unloading of the aircraft. In PZs, the Ahkio Huddle is also an excellent way to mark the LZ. MCRP 12-10A.1, *Small Unit Leader's Guide to Mountain Warfare* has detailed procedures on how to use the Ahkio Huddle Technique.

Air-Ground Integration and Training Considerations

Overall, mountainous terrain does not adversely affect the way assault support aircraft conduct basic training to support operations; however, commanders should focus training on preflight planning in high altitudes with an emphasis on fuel planning, weight and power available, and blade stall considerations. Mountain flying requires paying close attention to aircraft and engine performance throughout mission planning; however, landing and takeoff differ little from the confined area landing training that is accomplished regularly as part of unit workups. Crews must understand their aircraft capabilities, particularly density altitude and its effects on performance.

When possible, aircrews should train with their supported ground unit prior to deployment, ensuring a thorough understanding of ground force TTP and operations. Such training allows ground forces to become familiar with various aircraft employment methods and aircrews to understand how they can be employed during combat operations. Aviation forces support ground operations.

MARINE CORPS-SPECIFIC CONTROL OF AIRCRAFT AND MISSILES

The following paragraphs focus on Marine Corps command and control of aircraft and missiles. Although the following paragraphs center on Marine aviation command and control organizations, the principles are applicable to all aviation command and control organizations.

Marine Air Command and Control System Considerations

The MAGTF's command and control is provided by the Marine air command and control system (MACCS). In mountainous environments, MACCS units will be geographically separated by great distances to support the commander. For example, Marine mobile air traffic teams can be pushed out to austere sites to provide tower control to transiting aircraft. Liaison teams might need to be pushed out to the GCE to provide situational awareness about aircraft transiting to and from its area of operations. The terrain compels the MACCS to rely on numerous agencies and possibly on joint and coalition units to facilitate control of the MAGTF's airspace. Airborne extensions of MACCS, such as tactical air controller (airborne) and assault support controller (airborne), could be necessary; moreover, MACCS planners must consider gaps in coverage because of limited TOS. Aircraft and any special hardware required for the mission must also be anticipated prior to the execution of any missions. If the MACCS requires airborne extensions, its exact role and responsibilities should be proliferated by the Marine tactical air command center (Marine TACC) to the rest of the MACCS to ensure that all MACCS agencies and their extensions have well-defined command relationships and proper delegations of authority. Figure 7-2 shows how the MACCS would deploy to support aviation operations.

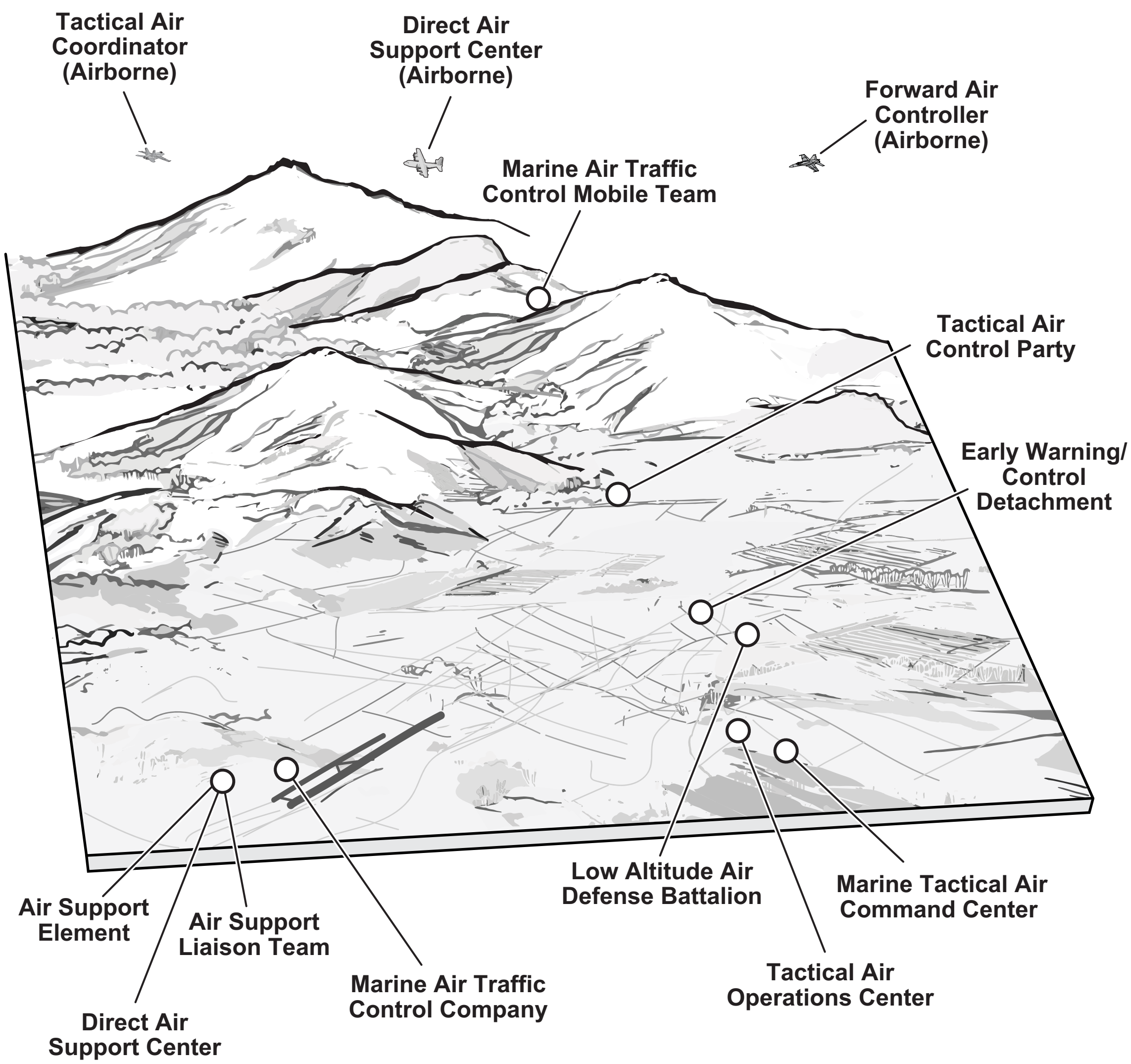

Figure 7-2. Marine Aviation Command and Control.

Changes to Standard Organization. Every MACCS agency is task-organized to support the MAGTF at all levels; however, in mountain operations, many MACCS agencies can support the MAGTF at much lower levels than they are usually tasked to support. This situation could create additional manpower requirements that must be considered during the planning process. In decentralized combat operations in a mountainous environment, MACCS agencies can support individual companies or battalions, that will likely not be the senior GCE component. As the main effort shifts, the MACCS units will need to be flexible in their support. Marine air traffic control mobile teams may have to displace to provide air traffic control services to austere sights as required by the GCE. Another example could be direct air support center (DASC) or UAS liaisons pushed down to a company or battalion level to ensure those units can request manned or unmanned air support.

Delegation of authority is a key consideration for MACCS agencies during dispersed operations. Once established, this command relationship must be proliferated and maintained throughout the MAGTF, so the Marine TACC acts as the only MACCS agency that exercises command. For example, an air support element that conducts the same mission as the DASC might have its own airspace but still be subordinate to the DASC; it could work directly for the Marine TACC and be adjacent to the DASC. The established relationship must be agreed upon prior to the execution of operations.

Additional Equipment and Personnel. Additional SATCOM gear and dedicated net requirements must be planned for. Additionally, HF communications are necessary to communicate with other MACCS agencies and GCE command and control nodes. Multichannel communications may not be able to support data connectivity due to LOS constraints; therefore, HF and SATCOM must be used to achieve data functionality. Since all MACCS units could face additional personnel requirements in the event of dispersed operations, they can task small unit leaders as direct liaisons to GCE and other ACE units, depending on the level of support the GCE requires. Personnel qualifications can vary and could require additional training with the units they are supporting prior to deployment. Also, due to the additional SATCOM and HF single-channel communications requirements, personnel who are sent to austere sites must understand the operation of these types of communications. Security at these austere sites will also be a factor.

Training Considerations. The MACCS units should continue to train to their output standards regardless of the operational environment; however, it is imperative that commanders provide their intent and updated mission-essential tasks that can better suit operations in a mountainous environment. The MACCS agencies should also include training on current beyond-LOS capabilities because of the communication constraints in a mountainous environment. Wing communication Marines would likely be required to set up relay sites within the compartmentalized terrain to provide LOS communications. These Marines should train to this task at the appropriate venue.

Tactical Air Operations Center Considerations

The tactical air operations center (TAOC) provides surveillance, traffic, and positive radar control services to the MAGTF. Employment of the TAOC, a task-organized early warning and control (EW/C) site, or an early warning site in mountainous terrain presents certain limitations. Radar systems are used to detect and control aircraft along the LOS. Mountainous terrain limits LOS to ground-based radar, which limits the radar’s ability to identify, acquire, and track aircraft; positively control them; or cue other air defense resources to a threat. To mitigate limited ground-based radar coverage, planners might consider augmenting it with an airborne radar platform, such as the E-3 AWACS [Airborne Warning and Control System] or E-2 Hawkeye, using data links to share the air picture.

Further limitations exist with radio communication. Most aircraft controlled by a TAOC or EW/C site use UHF radios, which also have LOS limitations. Aircraft can be controlled procedurally if SATCOM or radio relay is available. See MCTP 3-20F, *Control of Aircraft and Missiles*.

Mountains provide challenges to logistic operations and terrain presents issues with employing and supporting TAOC and EW/C sites. These sites have a large logistic resupply requirement that must be transported by vehicle, a method that can be severely limited on unimproved roads. All TAOC equipment, radar equipment, and operations modules require level ground, which is not typically found in compartmentalized terrain, so staffs must plan to have engineers available during set up.

In air-to-air operations, positive identification and control is required to successfully support fighter aircraft engagement against airborne threats. A TAOC or EW/C site employed in mountainous terrain would not likely be able to execute this mission set, so an airborne radar and controlling agency would be required to take these missions.

Overcoming mountainous terrain for the TAOC and EW/C site would require smaller, more mobile, self-sustaining ground-based systems that can employ multiple radar systems over the terrain to cover gaps. SATCOM would use data links currently available in these sites to fuse the air picture.

Joint and Coalition Theater Command and Control Architecture

Joint and coalition command and control architecture centers on the theater air-ground system. Each Service and coalition member has its own unique contribution to this system—the MAGTF has the MACCS. The roles and responsibilities of each Service and its respective agencies will vary; however, the senior agency is typically the air operations center. The air operations center may be joint or coalition, depending on the type of operational environment. More information on joint and coalition command and control architecture is available in JP 3-30, Joint Air Operations. The joint theater command and control architecture does not significantly change for operations in mountainous environments.

ELECTROMAGNETIC WARFARE

Electromagnetic warfare-equipped aviation units conduct tactical jamming to prevent, delay, or disrupt the enemy's ability to use early warning, acquisition, fire or missile control, counterbattery, and battlefield surveillance systems. Tactical jamming also denies or degrades enemy communications capabilities. For more information on electromagnetic warfare capabilities and employment considerations see MCRP 3-32D.1, *Electronic Warfare*.

Weather and Terrain

Weather and terrain affect aviation operations by limiting its takeoff and landing options. In mountainous terrain, however, it is necessary for electromagnetic warfare planners to study the terrain carefully to determine how it affects the enemy radar coverage, communication capability, and friendly electromagnetic warfare assets. This study begins with the intelligence section's IPB, which should be updated as new information becomes available from ground reports and other sources. For more information on IPB requirements and considerations can be found in MCRP 2-10B.1, *Intelligence Preparation of the Battlespace*.

Time On Station

Aircraft TOS is a significant consideration when planning electromagnetic warfare fires, which include antiradiation missiles and radar and communications jamming, in any environment. In general, airborne electromagnetic attack assets will be tasked by the combined forces air component commander as a theater asset, which can influence the MAGTF commander's priority for this asset. Depending on the aircraft, it can be a combined forces air component commander asset, so it may not be collocated with the MAGTF, which can affect planning or TOS considerations. Airborne electromagnetic attack should be delivered at a critical time against a critical enemy electromagnetic system, such as fire control networks during an enemy attack, air defense systems during friendly offensive air operations, and command and control communications for the control of the movement or commitment of reserves. Although these factors apply in any environment, the dispersed nature of mountain operations complicates them. Air officers need to be familiar with electromagnetic warfare capabilities and work with other staff members to ensure communication links or liaisons provide redundant ways to use these assets properly.

Electromagnetic Attack

Though electromagnetic attack efforts should be preplanned, and they can be conducted in response to the immediate tactical situation. These unplanned operations are difficult for Marines because of the centralized control of the asset and the communications challenges associated with mountain operations. Commanders should not rely on electromagnetic attack support in the mountains unless they are the main effort and they have put a great deal of planning effort into ensuring that changes at the tactical level will not affect other operations. If commanders choose to use electromagnetic jamming, they must carefully weigh the operational requirement against the rules of engagement, the effects on friendly systems, and the loss of enemy information otherwise gained by SIGINT and electromagnetic warfare support. Degradation of some friendly communications may have to be accepted to effectively employ jamming. Mountain operations can work to an advantage in that mountains can help electromagnetic warfare units target one area while shielding friendly forces on the other side of the mountain from the effects of the electromagnetic warfare attack. Thorough IPB that incorporates the enemy electromagnetic order of battle (EOB) is critical to success. For more information about amplitude modulation control authority and propagation effects of airborne electromagnetic attack see MCRP 3-32D.1.

Electromagnetic Warfare Support

Intelligence supports electromagnetic warfare by making accurate EOB and threat characteristics information available to accurately program electromagnetic warfare support equipment. Alternatively, electromagnetic warfare support passes intelligence through electromagnetic warfare support systems that collect information. That information can then be rapidly disseminated as a threat warning or be passed to intelligence production and analysis elements for further processing. Electromagnetic warfare support provides immediate threat recognition and is an information source for immediate decisions involving electromagnetic attack. To best meet immediate tactical requirements, electromagnetic warfare support information used in immediate threat recognition is rapidly disseminated without in-depth processing.

The technical control and analysis center supports the MAGTF through semiautomated SIGINT processing, analysis, reporting, and electromagnetic warfare support. The system correlates the mission data with other sources of electromagnetic intelligence, electromagnetic warfare support, and EOB and threat characteristics information to support the MAGTF during operations afloat and at FOBs. These efforts produce a comprehensive EOB, which provides intelligence and situational awareness information critical to the Marine Corps, joint, and coalition mission planning. The challenge that the mountains pose to this system is how to push information to the many dispersed units that may need it. The Marines from the technical control analysis center must aggressively push this information to all elements of the MAGTF and it is the responsibility of the subordinate elements to ensure they plan for redundant means to disseminate this information down to the tactical units that need it. This situation also applies to joint assets.

Electromagnetic Protection

Electromagnetic protection is the subdivision of electromagnetic warfare and involves actions taken to protect personnel, facilities, and equipment from any effects of friendly or enemy use of the electromagnetic spectrum that degrade, neutralize, or destroy friendly combat capability. Examples include spectrum management, electromagnetic hardening, emission control, and use of wartime reserve modes. There are no special considerations for mountain operations; however, units should use mountains to shield them from the enemy's electromagnetic warfare capability and should consider the EOB and battlefield geometry when establishing communication sites and command posts whenever possible.

Training Considerations

Mountainous terrain has limited effect on electromagnetic warfare activities. As such, commanders should focus training on the mission skills that support the Marine Corps tasks for aviation. Electromagnetic warfare and training should be tailored to the expected threat in the area of interest, whether traditional or nontraditional, rather than the expected terrain. Commanders must consider the terrain effects and the other METT-T elements in developing their training plans.

OFFENSIVE AIR SUPPORT

Planning Considerations

Although TTP for most offensive air support platforms remains the same in high mountains, some platforms, particularly rotary-wing aircraft, have altitude restrictions and can experience the following limitations:

- All Marine Corps rotary-wing aircraft are restricted to less than 3,048 meters (10,000 feet) pressure altitude due to lack of supplemental oxygen systems and pressurized cabins.
- According to Army Regulation 95-1, *Flight Regulations*, Army rotary-wing aircraft that are unpressurized may operate to:
  - 3,048 meters (10,000 feet) for up to 1 hour, after which oxygen is needed.
  - 3,650 meters (12,000 feet) for up to 30 minutes, after which oxygen is needed.
  - 4,267 meters (14,000 feet) and above, oxygen must be used.

The LOS challenges associated with communications in a mountainous environment also applies to the terminal control of attack aircraft. Having an understanding of communications paths is essential to provide timely, effective fires in rugged mountains. Using other radio relay and digital CAS platforms can greatly enhance communication between the JTAC, FAC, and attacking aircraft.

Ordnance Versus Fuel

The more ordnance an aircraft carries, the less fuel can be carried, decreasing TOS. The TOS required by the commander may affect weapons load out and selection. While higher elevations may benefit fixed-wing aircraft fuel burn and TOS, they negatively affect rotary-wing operations. The thinner air at higher elevations affects rotary-wing power management and can limit the ability to hover in certain conditions, necessitating rolling takeoffs or landings on large, improved surfaces and shallower than normal approach and departure paths.

Foward Operating Base and Forward Arming and Refueling Point Locations

The FARPs' locations in higher altitudes can affect how much fuel or ordnance an aircraft can reload. An aircraft that arms and fuels at lower elevations provides a different capability than an aircraft arming and fueling at a higher elevation. Planners must be aware that loading up with the same amount of ordnance and fuel might not be possible, which is a significant planning factor when developing supportability timelines as it affects TOS for all CAS and rotary-wing aircraft. These issues should also be considered when planning FOB and FARP locations. Prior coordination with the ACE enables ground forces to extract information about FARP capabilities and limitations prior to FARP emplacement at various FOBs and the required support package needed. Further information on FARP planning and FARP operations is found in MCTP 3-20B, *Aviation Ground Support*. Aviation III and V platoons might have limited equipment and personnel and can often exceed their operating capacity if too many FARPs are emplaced with few personnel staffing them. Ground forces may have to assist FARP operations to maintain continuous and close aviation support for certain periods of time.

Ordnance Selection

Target type, composition, location, risk estimate distance, and collateral damage estimates drive ordnance selection. Terrain also influences ordnance fuzing and explosive effects. Planners must understand how to employ certain aerial weapons in mountainous and snow-covered terrain and the capabilities and limitations of attack aircraft. The terrain and the mission requirements directly influence the munitions selected and the fuzing used. When employing laser-guided weapons, lower-than-typical cloud layers and heavy mountain fog can have a negative effect on the ability to laser designate a specific target. Depending on whether the target is in a cave, on the side of a mountain, or in the middle of a valley, the laser energy effects should be planned. Risk estimate distances can be reduced by the effects of surrounding terrain, allowing planners to use larger munitions near friendly forces—a significant advantage in compartmentalized terrain.

Reduced Power Available

During operations at high altitude, rotary-wing aircraft can experience significantly different flight characteristics than at sea level. The most significant among these differences is a limitation of power available due to the general aerodynamics of rotor systems. Whether these limitations are felt in less lift, reduced tail rotor authority, the inability to recover quickly from a dive, or the reduced ordnance and fuel combinations available to planners, the challenges are significant and must be accurately and continually planned for. Planners must update supported units on what they can expect during different times of year and in different environmental conditions of heat, humidity, and altitude.

Geometry of Fires

The GCE scheme of maneuver, enemy position, environment, and terrain are all factors when determining attack geometry; however, special attention must be paid to CAS in mountainous terrain, which becomes more significant when integrating fires in a combined arms scenario. Reverse slope, terrain features, weapon type, aircraft type, and attack profiles are all factors for consideration while employing fires. The terrain can restrict the marking platform, the terminal controller, and attacking aircraft's sight to the target. The enemy has a significant advantage in the mountains because they can use terrain to effectively counterattack CAS aircraft.

Weather

Weather conditions in the mountains can have the same effect on aviation assets as they do in flat terrain. Overreliance on aviation assets may render a force susceptible to the uncertainties of weather. Winds, cloud deck, visibility, pressure, and temperature must be considered because they can affect the type of supporting CAS aircraft and ordnance employed. Conditions will also affect the accuracy of certain weapon systems as well as the delivery profile of the attacking aircraft. Knowing capabilities of CAS aircraft will help to successfully prosecute targets despite a deteriorating weather condition. Differences in the way CAS aircraft are affected must be understood by planners: fixed-wing aircraft may be unable to see the target or use specific weapons due to quickly materializing cloud layers, while rotary-wing aircraft may not have the ability to climb high enough to safely avoid mountainous terrain due to altitude limitations and lack of supplemental oxygen.

Deep Air Support

Deep air support is not considerably affected by this environment. However, the following limitations created by weather patterns and winds must be considered.

Training Considerations

Training requirements are outlined in aircrafts' training and readiness manuals and Marines should rely on these to accomplish the full mission spectrum, to include offensive air support. Continual training and skill refinement is necessary to overcome the difficulties associated with aviation activities in a mountainous and high-altitude environment, which requires units to achieve and maintain a high degree of aircrew proficiency.

Aviation Ground Support

Planning Considerations

An effective aviation ground support deployment capability enables the ACE to establish and maintain a viable expeditionary force. The Marine wing support squadron must be capable of deploying under a various conditions and configurations. Considerations for fixed-wing aircraft should be made when operating in a mountainous environment. Typical runway lengths of 2,438 to 3,048 meters (8,000 to 10,000 feet) can be reduced by adding arresting gear and reducing fuel and ordnance loads.

Forward Arming and Refueling Points

The FARP provides the fuel and ordnance necessary for highly mobile and flexible helicopter, tilt-rotor, and fixed-wing operations. The FARP size varies with the mission and the number of aircraft to be serviced. Usually, FARPs are temporary, transitory facilities established for a specific mission and duration. The scope of flight operations in the FARP area should include individual aircraft or aircraft sections or divisions requiring ordnance and refueling. The LZ location and size the remain the same for mountainous and cold environments; however, weather considerations influence FARP activities. Deep snow could cause an aircraft landing gear to sink, greatly reducing the rotor ground clearance and increasing the hazards to personnel operating in and around the FARP.

There are several hazards to consider during aircraft arming and refueling activities in a mountainous environment with snow. A major concern is eliminating ignition sources and controlling vapor generation. Static electricity is a primary ignition source. Deep snow retards the grounding of aircraft, which could generate enough static electricity to ignite fuel vapors. Ordnance storage is also a concern. Terrain should be used when possible, to satisfy the safe storage of explosives and quantity distance separation requirements. An aviator must certify the FARP using a FARP checklist (MCRP 3-20A.1, *Coalition Forward Arming and Refueling Point [FARP] Interoperability Pamphlet*) prior to the FARP being available for refuel and rearm.

Forward Operating Base Locations

Airfield size, approach and departure paths, and security for the forward aviation sites are the same for any operations. If an airfield that can be used by the ACE does not already exist, there are various options available to the ACE to build one. Unimproved surfaces can be engineered for safe, continuous flight operations. Varying types of expeditionary airfield systems provide fully portable options that range from individual AM-2 landing pads to a full 8,000-foot runway with taxiways and parking areas. These systems can include tactical air traffic services packages that provide airfield control and radar guidance as needed. For Marine Corps units, assets, and equipment required to build an airfield can require support from all MAGTF elements if needs exceed the capabilities of a Marine wing support squadron. When deployed, these services allow for a safe, all-weather launch and recovery capability.

Aviation Logistic Support In A Mountainous Environment

Planning Considerations

As with all air operations, planning for mountain warfare should be no different regarding its aviation logistical support process. Aviation logistic success is based on having a centralized location for the distribution or repair of components for its supported dispersed units. These concepts are set forth in MCTP 3-20B. More maintenance support personnel may be necessary, depending on the number of dispersed units in the area of operations, the size of the area of operations, and number of aircraft at each dispersed site. Also, since a limited number of intermediate-level Marine aviation logistics squadron (MALS) Marines are located at a dispersed site, more supplies, equipment, and personnel (all requiring support) are necessary. With the current Marine aviation logistics support program and maritime prepositioning ships, a MALS can support any type of aircraft composition for the MAGTF ACE. Major planning considerations for these dispersed operations include the following:

- Determine whether intermediate and higher maintenance and equipment levels are available.
- Intermediate-level technicians (National Defense Industries).
- Inspections cycles.
- Ground support equipment.
- Calibration.
- Survey equipment.
- Cold weather effects on equipment.

The following problems result from the increased maintenance and continuous operation of equipment at low temperatures and higher altitudes:

- Oils thicken at low temperatures and impair starting and operating for most equipment. Covers for aircraft equipment should be used to protect it from the elements. When possible, aircraft should be removed from the elements and maintenance should be conducted in temporary hangar structures.
- Maintenance time factors may increase in areas of extreme cold.
- Aircraft mechanics are hampered by heavy winter clothing and gloves. When the tactical situation permits, shelters or warming tents should be provided for personnel performing maintenance. Proper clothing is necessary for all personnel and survival kits tailored to the environment must be carried on all flights.
- Equipment preventive maintenance is more critical in cold weather environments associated with mountain operations than elsewhere.
- Parts availability and differing levels of maintenance will vary based on location and distance from the aircraft wing.
- Units may go through far more consumables because equipment and vehicles may have to be started often or run continuously to mitigate the effects of extreme cold weather. Resupply must be planned.

Material Storage and Handling Considerations

Cold weather and snow have significant effects on supplies. Personnel operating in these conditions must undergo special storage and handling training to work effectively.

Snow Fall and Snow Cover's Effects on Supply Operations. Major snowfall and snow cover can significantly reduce a unit's logistic mobility in improved and unimproved road surfaces when using vehicles not designed or equipped to operate in snowy conditions. Most MALS vehicles are commercially acquired, two-wheel drive, subcompact utility all-terrain vehicles or flatbed commercial trucks that are not well-suited for severe weather operations. Tactical vehicles must be assigned or available to transport material, equipment, or personnel. Snow tires, chains, and tow chains should be available and used as needed. Twelve inches of snow usually stops movement of two-wheeled commercial vehicles; 36 inches usually stops all-wheeled vehicle movement. All-wheel or 4-wheel drive vehicles with low ground pressures are best for moving over snow-covered or muddy terrain.

Extreme Cold's Effects on Material and Equipment. Extreme cold can significantly slow material handling and maintenance activities by numbing exposed skin, such as the face and hands. Activities that usually require only minutes in temperate weather can take hours in extreme cold. Movement by foot or vehicle over snowy and icy surfaces is slower and poses a high injury risk to personnel and damage to equipment. Subfreezing temperatures result in freezing water in water tanks, waterlines, and equipment exposed to snow and water penetration. Because water expands when frozen and metals and plastics become brittle in subzero temperatures, standing water in equipment can freeze and damage parts in close areas that have no room to expand. Additionally, metals contract at lower temperatures and expand at higher temperatures. Consideration must be given to guard components and equipment against improper clearances that can lead to binding or excessive loosening when exposed to subfreezing temperatures.

Commanders and logisticians must make every effort to winterize vehicles and equipment with cold weather lubricants and antifreeze liquids. Keep equipment free of snow and water to prevent ice forming; this is accomplished by keeping equipment running or placing impermeable covers on it when in storage or not in use. Material handling and storage personnel should be provided with suitable head gear and gloves to minimize the severe cold weather effects.

Cold's Effects on Metals. Metals become brittle and fail in severe cold temperatures. Storage, handling, and use of equipment containing dissimilar metals that are bolted together or are in constant friction are most at risk for failure during transporting and handling, or when placed into operation following long exposure periods to subfreezing temperatures. In cold weather, special care should be taken to protect equipment from excessive shock; mechanical components should be allowed to gradually warm up before being started.

Effects on Rubber and Plastics from Extreme Cold. Rubber and plastic gradually stiffen but retain much of their elasticity until reaching extreme cold temperatures, usually below -20 °F, at which rubber loses its elasticity and becomes brittle. For example, fuel hoses can crack when crystal forms from cold weather exposure or can break if bent while frozen. Aircraft tires become rigid in cold weather, causing flat spots on parts that come in contact with the ground. In severe cold temperatures, sidewalls become brittle and crack. Every effort should be made to minimize the length of time that material constructed primarily from rubber and plastic is exposed to extreme cold temperatures.

Training Considerations

Maintenance and logistical personnel must train for cold-weather environments and plan for additional requirements before deploying to mountainous regions. The most effective training program for Marines includes hands-on and real time environmental and survival training for the individual Marine followed by supporting actual aircraft in the environment to which they will deploy. Marines must understand all the factors affecting the aircraft, tools, equipment, vehicles, support gear, and themselves to keep airplanes flying. The MALS Marines will likely be responsible for their own force protection and security when operating in remote regions while supporting aviation operations. Marines' training for this mission should include fire team and squad tactics and an understanding of quick-reaction forces and supporting fires from higher headquarters. Communications equipment, weapons, and ammunition tailored to the operating area will be required.

To be effective in mountain warfare, the MAGTF must understand the limitations mountain environments impose on the fighting ground force and aviation elements. While the terrain, altitude, and weather shape certain operations, the basic tenets of military aviation support the Marine mission regardless of location. The skills and knowledge of ACE operators ensures the successful integration between ACE units that support the MAGTF commander's mission. Since successful planning can mitigate effects of high altitude and extreme weather, ACE planners should be used extensively to ensure that support for the Marine is being sourced appropriately.

CHAPTER 8.
FIRES

Combat operations in mountainous areas are characterized by many of the same challenges found in cold regions—rugged, compartmented terrain with steep slopes and treacherous mobility; however, mountain weather can range from extremely cold temperatures with ice and snow in winter to extremely hot temperatures in some areas during the summer. Extreme terrain and weather can pose significant problems and are important to planning considerations for maneuver and fire support operations. In many cases, the terrain favors the defender who tries to control the heights, so offensive operations are usually battles for this key terrain or the choke points they control in the valleys. Consequently, dismounted infantry and airmobile operations are most suitable for this type of terrain, particularly if they are properly supported by fires. For example, it is important to position mortars and artillery in defilade to increase their survivability; yet, such terrain is often subject to snow slides, rock slides, and avalanches, which can fall on their positions with devastating results. Intelligence estimates should identify defilade positions that pose the least amount of risk of such hazards.

These same types of positions are sought by enemy units, which is why observed indirect fires are so crucial to success in this environment. Indirect fires can impede the enemy's mobility or destroy positions, giving maneuver elements time to close with and destroy the enemy. Although the basic tactical principles for artillery remain valid in mountains, they are subject to the terrain and weather limitations. Unless otherwise noted, the principles outlined in this chapter apply to mortars as well as artillery.

ORGANIZATION FOR ARTILLERY

To mitigate some of the limitations in the mountains and to better support isolated maneuver units, the artillery battery can be broken down into smaller platoons than what is called for in the unit's table of organization and equipment (TO&E). This organization does allow support of maneuver units across vast distances, but it strains its personnel and equipment (e.g., fire direction center [FDC], logistics, communications). Despite these constraints, these smaller gun platoons can operate independent of the battery, while retaining the capability to mass fires as a battery depending on the distance via a battery operations center construct. Platoons can also operate from FOBs or COPs in support of missions, but ammunition could be limited due to logistic requirements.

Although using smaller gun platoons can effectively support the commander in a dispersed environment, such dispersal complicates the ability to mass fires, lead, and sustain each platoon. The commander must depend on officers and noncommissioned officers (NCOs) who can operate independently, sometimes performing duties above their TO&E rank structure. The requirement for specialized logistics, security, communications, computers, and vehicles for each platoon position can require a significant increase in personnel, exceeding a battery's authorized TO&E. As a result, proper staffing based on pre-deployment mission planning is essential.

The artillery battalions' structure dictates how they can be divided into two or three-gun platoons. To meet this challenge, units may have to either cross-train personnel and request additional equipment or operate with reduced personnel within the FDCs and divert communications and computers from other sections.

MOVEMENT AND POSITIONING

Reconnaissance, Selection, and Occupation of a Position

The reconnaissance, selection, and occupation of a position are critical to mission accomplishment. Because of the mountains' rugged terrain and reduced mobility Marines often rely on field artillery fire support; however, positioning employing field artillery systems may be severely hampered by the extreme difficulties of ground mobility. The battery leadership must analyze the routes to be used by the unit assets and the time and distance required to make the move. Having the ability to move one firing platoon while keeping a second platoon fire capable is critical to platoon-based operations in support of dispersed maneuver units. Moving the battery over long, difficult routes requires well planned, coordinated movement orders, and unit standing operating procedures (see MCRP 3-10E3, Tactics, Techniques, and Procedures for the Field Artillery Cannon Battery). Clearing near and intervening crests is always a factor in selecting firing positions.

Movement

Weather affects visibility (e.g., fog, haze) and trafficability (e.g., ice, rain-softened ground). Ground movement of field artillery is often limited to traveling on the existing road and trail networks and positioning in their immediate vicinity. Air movement of towed field artillery is possible with fixed- or rotary-wing aircraft; therefore, gun crews should be proficient using equipment-rigging techniques and air assault procedures and should possess ample sling-load equipment. Field artillery emplaced by helicopter usually requires continued airlift for subsequent displacement and ammunition resupply and often necessitates substantial engineer support.

Air Movement

Towed field artillery can require forward displacement of gun sections by helicopter to provide forward troops the necessary support. Additionally, this provision requires Marine Corps HSTs to facilitate a battery's firing capability using air movement operations.

Position Selection

Usually, field artillery is employed far enough to the rear to take advantage of increased angles of fall. Flat areas, such as dry riverbeds, villages or towns, and farmland, can usually accommodate firing units; however, these positions present problems in the mountains for the following reasons:

- Dry riverbeds are hazardous because of the danger of flash flooding.
- Towns and villages usually have adequate flat areas, such as parks, schoolyards, and playing fields, but they are relatively scarce and often easily targeted by the enemy.

- Farmland is often difficult to negotiate from spring to fall. In the winter, if the ground is frozen, farmland can provide good firing positions; however, frozen ground can cause difficulty in emplacing spades, base plates, and trails.

Consequently, good artillery positions that have been selected for cover, flash defilade, and accessibility to road nets and LZs are difficult to find, and their relative scarcity makes it easier for the enemy to target probable locations. Commanders must ensure that positions on dominant terrain provide adequate defilade. Positions on commanding terrain are preferable to low ground positions because there are—

- Fewer missions requiring high-angle fires.
- Less dead space in the target area.
- Less exposure to small arms fire from surrounding heights.
- Less chance of being struck by rock slides or avalanches.

Some weapons can be moved forward to provide long-range interdiction fires or, in extreme cases, direct fires to engage a road-bound enemy in mountain passes or along valley floors. Rugged terrain, higher angles of fire, and reduced ranges, can make it necessary to displace artillery more frequently in mountains than on level terrain to provide continuous support. Additionally, even when maneuver units are not dispersed, artillery commanders can be forced to employ field artillery in a decentralized manner or disperse it in multiple locations in the same general area because of the limited space for gun positions. Security must be provided for each gun location.

Multiple Launch Rocket System M270A1 and High Mobility Artillery Rocket System M142 Position Considerations

Although mountains can mask all types of firing units, they present special challenges and limitations to rocket-fired munitions. Dead space is the area that is masked behind a crest and cannot be attacked by rockets from particular firing positions. Masks are terrain features that have enough altitude to potentially interfere with rocket or missile trajectory. There are two categories of masks—immediate and downrange. Immediate masks are within 1,981 meters (6,500 feet) of a launcher firing point and are measured and input to the launcher fire control system by individual section chiefs. Downrange masks are beyond 1,981 meters (6,500 feet) and are measured and input into the advanced field artillery tactical data system's fire direction system by the platoon leader or battery operations officer in accordance with unit operating procedures.

Downrange masks are measured and applied using crest clearance tables and automated downrange mask checks. The M270A1- and M142-equipped units in mountainous terrain must be familiar with these tables, which allow leaders to establish minimum planning ranges beyond a crest for launchers in a specific firing area. Proper use of these tables ensures rockets will clear the crest and not detonate prematurely. It will also help to identify the dead space that must be covered by other indirect fire weapons, such as mortars, or by aviation or direct fire weapons placed behind the intervening slopes.

ACQUISITION AND OBSERVATION

Radar Considerations

Because of high-angle fire requirements, radar can be effective against enemy indirect fire systems if properly emplaced; however, terrain masking can diminish the radar's LOS and degrade its effectiveness if it is not properly emplaced. Sites should be selected on prominent terrain to obtain the lowest possible screening crest, but it is often difficult to obtain a low and consistent screening crest in mountainous terrain. Too low a screening crest drives the search beam into the ground; too high a screening crest allows the enemy to fire under the beam and avoid detection.

In mountainous terrain, selecting general position areas to take full advantage of the radar range and capabilities is difficult. Helicopter assists are often required to move radar teams to optimal locations. Very often the positions that provide the best LOS for acquisition provide the least concealment and survivability, so proper camouflage techniques are critical for survival. Additionally, the heavy rain and snow often found in the mountains can degrade radar capabilities by decreasing the probability of location. See MCRP 3-10E.7, *Tactics, Techniques, and Procedures for Field Artillery Target Acquisition*, for additional information on positioning radar assets.

When positioning weapons-locating radar systems, commanders should consider the following:

- Although time consuming to create, visibility diagrams are extremely useful in determining the probability of acquiring targets within the radar's search sectors.
- To limit search areas, radar activity should focus on terrain that can be occupied by artillery and mortars.
- Accurate survey control is essential because of the extreme elevation variations in mountainous terrain. Helicopters may be useful in performing survey by use of the Position and Azimuth Determining System. If possible, digital radar maps may be used to minimize the time required for height correction of the weapon system. Digital maps allow the fire-finder systems to initially locate weapon systems to within 250 meters (820 feet), which enables the radar operator to make only few visual elevation adjustments to accurately locate the weapon system.
- Prediction is computed at the radar's elevation; therefore, excessive errors in the prediction can be expected.
- Radar teams in the same area that face one another and radiate at the same time can cause interference and emissions burnout, resulting in equipment failure. If radar systems must face one another to accomplish the mission, commanders must coordinate with each other to ensure that they do not radiate at the same time.
- Computing track volume may become a critical task in determining the radar's effectiveness for a proposed position.
- Units will need to rely more on shelling reports to determine enemy firing locations, so pre-deployment training must ensure all units meet minimum standards for this skill.

Observer Considerations

High-angle fire is used for firing into or out of deep defilade, such as that found in heavily wooded, mountainous, and urban areas. It is also used to fire over high terrain features near friendly troops. The observer may request high-angle fire based on terrain analysis in the target area. The fire direction officer may also order high-angle fire based on a terrain analysis from the firing unit position to the target area. The primary characteristic of high-angle fire is that an increase in elevation causes a decrease in range.

Because high-angle fire involves large quadrant elevations and long flight times, it will not be as responsive as low-angle fire to meet the immediate needs of a maneuver force. In addition, trajectories can be more vulnerable to enemy detection. The long flight time and the steep terrain make it difficult for the observer to identify their rounds. Corrections can change dramatically from round to round because spotting rounds often become lost in defilade positions. To help the observer, FDC personnel announce the time of flight in the message to observer and SPLASH, 5 seconds before the impact of each round (see MCRP 3-10E.4, *Tactics, Techniques and Procedures for the Field Artillery Manual Cannon Gunnery*).

> **NOTE:** SPLASH is a proword transmitted to the observer 5 seconds before the estimated impact of a volley or round of artillery, mortar, or naval gunfire.

To prevent friendly fire, noncombatant casualties, and destroying civilian property and infrastructure, field artillery fires in mountains will be observed, particularly close support and defensive fires. Unobserved fires are generally more unreliable in mountains because of unreliable maps, rapidly changing meteorological conditions and elevation changes. A good FDC can overcome some weather challenges and high-angle fires through training and by capturing timely and accurate meteorological data.

Elevated points, such as crests and trees, are often used for observation posts. Landmarks and prominent terrain features should be avoided as these are probably targeted. When selecting an observation post, the observer must consider the characteristics of forward slope (e.g., military crest) versus reverse slope positioning.

Advantages of the forward slope position include the following:

- The view of the front and flanks is better.
- Fires impacting on the topographic crest will not neutralize the position.
- The hillside provides background, which aids in concealment.

Disadvantages of the forward slope position include the following:

- Difficulty in occupying during daytime without disclosing the position.
- Radio communications can be difficult and require remoting radios to the reverse slope.
- Cover from direct fire may not be available.

The advantages of a reverse slope position include the following:

- It can be occupied in daylight.
- Greater freedom of movement is possible.

- Communications installation, maintenance, and concealment are easier.
- Protection from direct fire is available.

Disadvantages of the reverse slope position include the following:

- The field of view to the front is limited.
- Enemy fire adjusted onto the topographic crest may neutralize the observation post.

Low clouds or fog might require moving the observation post to preplanned emplacements at lower elevations. Observers must be prepared to perform assault climbing to reach the most advantageous observation site. Commanders can use aerial observers or UASs to detect long-range targets and complement forward observers by adjusting fires beyond terrain masks, in deep defilade, and on reverse slopes. Commanders might also consider using long-range telescopic cameras for observing; however, in extremely high mountains, air observers might be confined to valleys and lower altitudes due to altitude limitations on various aircraft. Observing fires in mountains is difficult because the area being observed is three dimensional relative to other types of terrain. As such, the observer could encounter increased difficulties in determining accurate target location (to include altitude). Additionally, subsequent corrections can appear more exaggerated, particularly as angle T increases. In most cases, increased accuracy comes with experience and training gained from operating in mountains before deployments.

Use of Laser Range Finders and Laser Designators for Laser-Guided Munitions

Using laser range finders and laser-guided weapons in the mountains requires increased emphasis on training and observation techniques. Laser target ranging and designation systems help to overcome difficulties in range estimation by providing accurate directional distance and vertical angle information for use in locating enemy targets; however, when using a laser designator, an observer should consider LOS with the target and cloud height. While laser-guided munitions (e.g., artillery, mortar, or air delivered) self-correct in flight, the ability to correct the trajectory is based upon the seeker head acquiring the target in sufficient time to make the correction. Cloud ceilings that are too low will not allow laser-guided munitions enough time to lock on and maneuver to the target. Global Positioning System (GPS)-aided munitions can overcome this limitation as they do not rely on reflected laser energy.

SURVEY AND METEOROLOGY

Survey in Mountains

Survey operations are always critical and those in mountainous environments are no exception; however, there could be times in the mountains when conducting typical survey activities are not possible due to the terrain, electrical interference, limited equipment, or equipment failure. When these hindrances occur, units can use the trigonometric functions to compute a traverse method or the triangulation methods that are explained in MCRP 3-10E.6, *TTPs For Marine Artillery Sensor Operations*. The triangulation method is ideally suited for rough mountainous terrain when other methods are impractical. It employs oblique triangular figures and enables the surveyor to cross obstacles and long distances. Although this method is time consuming and requires careful planning and extensive reconnaissance, it is effective and can help ensure accurate fires, even in the mountains.

Global Positioning System Limitations and Considerations

Global Positioning System receivers rely on electronic LOS with satellites. Initially, they search and select satellites that are 10 degrees or more above the true horizon. Mountains, mountain forests, or deep canyons can mask the signal. If usable satellites cannot be detected, operators might have to move to higher ground to get better LOS to the satellites and use more traditional techniques to survey firing positions. Global Position System receivers must be protected. Marines can protect GPS receivers by carrying them inside their clothing or in a heated vehicle and using an auxiliary antenna system.

Meteorological Message Space and Time Validity

The accuracy of a meteorological message could decrease as the distance and time from the meteorological sounding site increases. Local topography has a pronounced effect on the distance that meteorological data can be reasonably extended. In mountainous terrain, distinct wind and temperature variations occur over short distances. Usually, meteorological messages for artillery are considered valid up to 20 kilometers (about 12 miles) from the balloon release point; however, the validity distance decreases proportionally with the roughness of the terrain. As a result, meteorological messages for artillery are only considered valid up to 10 kilometers (about 6 miles) from the balloon release point in mountainous terrain, which can lead to increased targeting errors and should be considered when firing near friendly or civilian positions in mountains.

TARGETING

Because of the decentralized nature of mountain operations, there might be fewer targets warranting massed fires than in open terrain; however, narrow defiles used as routes of supply, advance, or withdrawal by the enemy are potentially high- payoff targets for interdiction fires or large massed fires. Large snow and rock masses above enemy positions and along MSRs are also good targets because they can be converted into highly destructive rockslides and avalanches to deny the enemy the use of roads and trails and destroy elements in defilade. In the mountains, suppression of enemy air defenses takes on added importance because of the increased dependence on all types of aircraft. Commanders and their staffs should carefully review MCTP 3-10F, *Fire Support Coordination in the Ground Combat Element,* to understand the targeting methodology. Such knowledge and that of the capabilities and limitations of target acquisition and attack systems in a mountainous environment is crucial to the synchronization of all available combat power. To provide accurate and timely delivery of artillery fires in mountainous terrain, commanders must consider the following:

- High elevation angles and increased flight time for rounds to impact.
- Targets on reverse slopes, which are more difficult to engage than targets on flat ground or rising slopes and require more ammunition for the same coverage.
- Dead space unreachable by artillery fires.
- Intervening crests that require detailed map analysis.

When the five requirements for accurate predicted fire (i.e., target location and size, firing unit location, weapons and ammunition information, meteorological information, and computational procedures) are not achievable, registration on numerous checkpoints becomes essential because of the elevation variances (see MCRP 3-10E.4 for more detailed information).

MUNITIONS

Terrain and weather also affect the units using field artillery munitions. When evaluating the use of lethal or nonlethal fires, commanders must carefully weigh the operational requirements against the rules of engagement. Considerations for high explosive munitions, smoke and obscurants, high-angle fire, and thermobaric weapon employment in a mountain environment is outlined in the following paragraphs.

High Explosive Munitions

High explosive munitions include point-detonating fuzes, variable or electronic time fuzes, mechanical time super quick (MTSQ) fuzes, and mechanical time-only fuzes.

Impact fuze, high explosive shells are very effective on rocky ground, scattering stones, and splintering rocks, which themselves become missiles. However, deep snow that is often found in high mountains during the winter months reduces their bursting radius, making them approximately 40 percent less effective. Also, the rugged terrain can provide added protection for defending forces; therefore, larger quantities of high explosives might be required to achieve the same desired effects against enemy defensive positions than in other types of terrain.

Variable time or electronic time fuzes should be used in deep snow conditions and are particularly effective against troops on reverse slopes. The MTSQ fuzes are typically not used in high-angle, high explosive fire due to an increased height of burst probable error. There are some older MTSQ fuzes (M564 and M548) that could prematurely detonate when fired during times of precipitation. Base ejection rounds (such as illumination) using mechanical time-only fuzes are less affected by height of burst probable errors than are high explosive rounds fuzed with MTSQ fuzes. For example, if a high explosive projectile armed with a variable time fuze and set with a time less than the minimum safe time is to be fired over marshy or wet terrain, water, ice, or snow, then the average height of burst will increase. The vertical clearance must be significantly increased (for more information see MCRP 3-10E.4 and MCRP 3-10E.3).

Smoke and Obscurants

Smoke operations in mountainous areas are challenging due to the terrain and wind. Insufficient roads enhance the military value of existing roads, mountain valleys, and passes and add importance to the high ground that dominates the other terrain. Planners can use smoke and flame systems to deny the enemy observation of friendly positions, supply routes, and entrenchments and degrade their ability to cross through tight, high passes to engage friendly forces with direct and indirect fires. Commanders should use white phosphorous cautiously in snow cover. White phosphorous pieces can burn for up to four days if covered by snow as it ignites only after being exposed to air. Thermally induced slope winds that occur throughout the day and night and units can experience difficulty when establishing or maintaining smoke operations. Units must continue to study and observe wind currents, eddies, and turbulence in mountainous terrain. Forward observers who understand these local weather patterns can skillfully exploit them and enhance smoke operations rather than have them deterred by the weather. Employing smoke screens could be of limited use due to enemy air observation, to include UASs, and observation by enemy forces located on high ground.

High-Angle Fire

High-angle trajectory, often required in mountainous environments, has two inherent characteristics that affect munitions selection—a steep angle of fall and a large height of burst probable error for MTSQ fuzes. The steep angle of fall means the projectile is almost vertical as it approaches the ground. When the high explosive projectile bursts, the side spray contains most of the fragmentation. Since the projectile is nearly vertical, side spray occurs in various directions and is nearly parallel to the ground; hence, high explosive shells with quick fuzes or variable-time fuzes are very effective when fired at high angles. Conversely, large probable error in height of burst makes using mechanical-time fuzes impractical in high-angle fire.

Thermobaric Weapons

Thermobaric weapons are useful in mountainous environments due to their destructive capability when employed against tunnels, caves, and isolated terrain compartments. The shock wave and overpressure created by these weapons can cause casualties in confined spaces. This effect is ideal if units are tasked with clearing confined areas, such as caves. Thermobaric weapons have been used in the cave networks of Afghanistan with positive results. In the past, clearing cave networks has caused numerous casualties, so commanders and their staffs should consider these weapons for this type of mission. These weapons are restricted because of their destructive capabilities, and they require extensive planning time for acquiring release authority from higher echelons.

MORTARS

Mortars are essential during mountain operations. Their high angle of fire and high rate of fire are suited to supporting dispersed forces. Mortars can deliver fires on reverse slopes, into dead space, and over intermediate crests. Like field artillery, rock fragments caused by the mortar round impacts can cause additional casualties or damage. Suitable mortar firing positions can still be a challenge to find but are often easier to find than artillery positions. By design, mortars must be emplaced closer to the supported unit than artillery because of their limited maximum range.

Mortars come in three different configurations— 60 mm, 81 mm, or 120 mm (US Army). The 60 mm mortars are light and portable enough to be carried on dismounted movements. They provide smaller units with an organic fires capability when conducting independent operations and can be used to pin down an enemy to escape from an ambush, to maneuver on, or to allow time for other firing assets to acquire the target. Although it is possible to carry 81 mm and 120 mm mortars on dismounted movements, it is not desirable to do so in rugged mountainous terrain. The weight increase from 81 mm and 120 mm mortar rounds severely hampers already slow movement in the mountainous environment. Planners must consider that small units could also be forced to sacrifice carrying other heavier items, such as Javelins, AT4s, additional ammunition for crew-served weapons, and fewer mortar rounds if they carry larger mortar systems. If possible, larger mortar systems should be placed at COPs or FOBs for use, which is often the only way to ensure there are tactically significant quantities of ammunition available.

During movement to contact or other offensive activities, larger mortars should be transported along valley roads and trails to provide continuous fire support coverage to the lighter dismounted units in the higher rugged terrain. Continuous coverage can be achieved by splitting units into sections and conducting bounding techniques to ensure at least one section is always ready to fire. See MCTP 3-01D, *Tactical Employment of Mortars*, for additional information on employing mortars in mountainous environments.

AIR SUPPORT

Because the terrain compels the enemy to concentrate forces along roads, valleys, reverse slopes, and deep defilades, CAS is very effective; however, the terrain restricts the attack direction of the CAS strikes. The enemy also conducts an IPB to determine the likely direction of the CAS strikes and will weight air defenses along those routes. The fire support officer must aggressively identify the enemy air-defense systems and target them to enhance the chances the CAS assets survive.

Air interdiction and CAS operations can be effective in mountains as enemy mobility is also restricted by terrain. The forward air controllers (airborne) (FAC [A]) and CAS pilots can be used as valuable information sources and can find and designate targets that is masked from direct-ground observation. Vehicles and personnel are particularly vulnerable to effective air attack when moving along narrow mountain roads. Precision-guided munitions, such as laser-guided bombs, can quickly destroy bridges and tunnels and, under proper conditions, cause landslides and avalanches that close routes or collapse on stationary and advancing enemy forces. Precision-guided munitions and fuel-air explosives can also destroy or neutralize well-protected point targets, such as cave entrances and enemy forces in defilade.

Low ceilings, fog, and storms common to mountain regions can degrade air support operations. Despite these challenges, GPS-capable aircraft and air-delivered weapons can negate many of the previous limitations caused by weather. Terrain canalizes low-altitude air avenues of approach, which limits ingress and egress routes and available attack options and increases aircraft vulnerability to enemy air defense systems. Potential targets can hide in the crevices of cliffs, the niches of mountain slopes, and on gorge floors; hence, pilots may be able to detect the enemy only at short distances, requiring pilots to swing around for a second run on the target and giving the enemy more time to disperse and seek better cover. Additionally, accuracy may be degraded due to the need for pilots to divert more of their attention to flying while executing their attack.

Planning considerations for CAS and close combat attack are discussed in MCRP 3-31.6, *JFIRE Multi-Service Tactics, Techniques, and Procedures for the Joint Application of Firepower*. While CAS is a joint concept, close combat attack is used exclusively by the Army and is defined as a coordinated attack against targets that are in close proximity to friendly forces.

Although CAS and close combat attack are similar, there are differences to explore. The first is the two manners in which support is requested: CAS is requested in a standardized 9-line format, while close combat attack is reported according to a 5-line format. Second, close combat attack enables aircrews, having received the brief from ground forces, to retain the freedom to maneuver as needed to engage targets. Third, due to enhanced situational awareness from aircrews, positive terminal control from the ground forces or certified controllers are not required. Those intending to employ either method should consider the joint nature of the contemporary operational environment. In mountainous terrain, the use of a close combat attack enables ground forces to provide information on the engagement to Army attack reconnaissance helicopters without limiting the direction of engagement, which allows aircrews to use the canalizing terrain and select more advantageous attack methods to destroy enemy targets.

In addition, CAS is requested by using FACs or JTAC. Both are certified Service members who, from a forward position, direct the action of combat aircraft engaged in CAS and other offensive air operations. A FAC(A) is a specifically trained and qualified aviation officer who exercises control from the air of aircraft and indirect fires engaged in CAS of ground troops. According to MCRP 3-31.6, a certified and qualified JTAC or FAC(A) is recognized throughout the DoD as capable and authorized to perform terminal attack control.

A joint fires observer is a certified and qualified Service member who can request, adjust, and control surface-to-surface fires; provide targeting information in support of type II and type III CAS terminal attack controls; and perform autonomous terminal guidance operations per MCRP 3-31.6 and JP 3-09.3, *Close Air Support*. Although not as highly trained as a JTAC, FAC, or FAC(A), more individuals can be trained as a joint fires observer. The joint fires observer adds a warfighting capability but does not circumvent or nullify the need for a qualified JTAC, FAC, or FAC(A) during CAS operations. With JTACs, joint fires observers assist ground commanders with the timely synchronization and responsive execution of joint fires and effects at the tactical level.

NAVAL SURFACE FIRES

As demonstrated in the Pacific Campaign of World War II, naval surface fires can be employed in mountainous terrain; however, the opportunity to use such fires is limited. The issues of trajectory and intervening crests along the gun-target line often make its employment difficult in mountainous terrain. Conventional naval-surface fires typically have a low angle of fire and a flat trajectory. Though the position of the naval vessel in relation to the target determines the gun-target line and the accessibility of the target by conventional naval surface fires, operational-level planners should not forget the capability that naval-launched, precision-guided munitions can bring to the battlefield. Cruise missiles launched from naval vessels can engage targets deep inland with devastating accuracy and are not subject to the same limitations as conventional naval fires.

NONLETHAL FIRES

Nonlethal fires are an important part of any arsenal and can be effective across the range of military operations in mountainous environments. As with lethal fires, the desired effects of nonlethal fires can be limited by the terrain due to mobility restrictions and the fact that physical geographic features can create sub-environments where the same nonlethal fires may have entirely different effects. Marines must be creative and use other nonlethal capabilities when interaction with the local populace is hindered by terrain or weather.

Information Activities

Information activities are defined as the integration, coordination, and synchronization of all actions taken in the information environment to affect a target audience's behavior in order to create an operational advantage for the commander. In many cases, traditional information-related capabilities, such as print and broadcast media, is less effective in the execution of information activities because many mountain communities have low literacy rates and do not have access to modern communication technologies. Personnel who engage in information activities can overcome such challenges by offering low technology solutions, such as the distribution of hand-cranked radios.

Deception

Deception is a capability in the form of a planning process that focuses actions to deliberately mislead adversary military decision-makers (or target audiences) as to friendly military capabilities, intentions, and operations with the intent of enticing or inciting a specific behavior in the battlespace that will provide the commander or MAGTF an operational advantage. One example is using mock radar systems in addition to the actual radar system. This deception prevents the enemy from knowing the actual location of friendly radar systems and, most importantly, from knowing the direction of radar observation. See MCRP 12-10A.1 and MCRP 12-10A.3 for deception considerations for planning, command and control, and maneuver in a mountainous or cold weather environment.

FIRE SUPPORT COORDINATION MEASURES

The information contained in MCRP 3-31.6 is applicable to any environment; however, the mountains often require changes to standing operating procedures. The Marine Corps usually conducts fire support coordination at the battalion level and higher. The distances and dispersed nature of the fight in mountainous environments often requires smaller units to control and clear fires within their areas of operations and companies to receive some of the same equipment and personnel that is usually only found in battalion and larger organizations. Recommended methods to achieve this organization are to—

- Establish clear boundaries and simple direct fire control measures.
- Establish appropriate fire support coordination measures.
- Recommend appropriate airspace coordinating measures.

ARTILLERY LOGISTICS

Artillery requires a substantial logistic effort to supply and sustain itself on the battlefield. Mountainous terrain requires that artillery perform many high-angle missions and missions using propellant charges at maximum capability. Such artillery use causes premature howitzer failure or and an increased maintenance effort to remain mission capable. In a mountainous environment, logistic support becomes very difficult and requires unique solutions due to the terrain limitations.

Helium and nitrogen management is vital in mountainous terrain. Helium is used by meteorological teams to gather updated weather data for firing units. Meteorological support can only extend up to 10 kilometers (about 6 miles) from the release point in mountainous terrain. To provide accurate meteorological support throughout the battlefield, the meteorological teams and their helium must be positioned and frequently resupplied in numerous locations across vast distances. As a result, logistical resupply of helium becomes more important and more difficult in mountainous terrain. Similarly, nitrogen resupply is essential in maintaining firing capability among artillery units. The amount of nitrogen used in howitzer recoil systems, how much is on hand in a given country, where it is located, and how to transport it to the area of operations are all logistical considerations when managing artillery operations in this environment.

Energy management and ammunition management are also other important issues of consideration for the artillery community in mountain operations. Many of these issues are covered in detail in Chapter 6 of this publication or in MCRP 12-10A.4 for the cold weather effects on artillery ammunition.

Fires are one of the strongest enablers for commanders and planners in mountainous environments. Commanders who use lethal fires effectively can compensate for the long ranges and large amount of dead space that is found in mountainous environments. If necessary, commanders can, break down batteries from their traditional modified TO&E with proper preparation and training. There will be a heavy reliance on air support. Commanders and planners should train all personnel on CAS procedures and, if possible, train unit personnel to become joint fires observers. Effective nonlethal fires and information activities builds good will with the public and facilitates operations of all types in the mountainous environment.

CHAPTER 9.
COMMUNICATIONS

PLANNING CONSIDERATIONS

The MAGTFs are rarely employed independently; they are likely operating within a larger force or coalition. Every effort should be made to maintain the integrity of these organizations to maximize their inherent synergies, such as their robust joint, interoperable communication network that enables operational adaptability of command and control system capabilities. The mountainous environment poses unique challenges when trying to employ communications equipment. The following are communications planning considerations:

- Widely distributed units, such as companies and platoons, require the same communications capabilities and decision-making authorities typically found at battalion or higher levels.
- Units must develop core communications competencies with various communications equipment and systems down to the lowest echelons of command possible.
- Commands must develop the leadership and decision-making skills of junior leaders.
- Command and control architectures require redundancy and must account for the operational environment effects.
- Installation time of communication nodes in mountainous areas can double, depending on the terrain and the weather conditions.
- Command and control plans for communications nodes should accommodate expansion as more equipment and personnel arrive and more capability is required.
- The communications priority should be single-channel radio (SCR) and SATCOM, since they will be the primary command and control links for headquarters.

REQUIREMENTS IDENTIFICATION

Each organization has its own unique requirements for command and control. The mission, area of operations, terrain, and weather dictates the radio nets, local area networks, and special purpose systems required. Expeditionary units coming from the sea initially relies heavily on long haul, narrow-band communications until command and control transitions ashore. Once ashore, networks expand as more units and capabilities are added. Units expand their command and control network from one that relies on tactical radios to one that consists of a combination of radios and local area networks. A fully implemented command and control architecture integrates four different types of communications and information networks known as the tactical data network. Communications planning requirements include the following:

- Identify critical communications nodes and support requirements based on mission analysis.
- Identify requirements for each node (power, electronics, network connections, data, equipment, and personnel).

- Determine equipment capabilities and limitations, given terrain and weather.
- Develop plans to mitigate the terrain and weather effects.
- Develop various communication courses of action to support the concept of operations and provide for redundant capabilities by combining them, if required.
- Estimate timelines for installing communications networks, including timelines for different insertion techniques in the event weather or terrain preclude the primary option.
- Submit satellite access, ground access, frequency, equipment, and personnel augmentation requests to higher and supporting headquarters and agencies as soon as possible.
- Inform the commander about courses of action that are not feasible without assigning additional personnel or equipment.
- Identify shortfalls and aspects of warfighting functions that cannot be supported from a command and control perspective.

COMMUNICATIONS SYSTEMS COMPARISON

Eleven methods of communications are available for use. The following paragraphs and Table 9-1, discuss the advantages and limitations of each.

Single-Channel Radio

The SCR equipment includes radios that operate in the UHF tactical satellite (TACSAT), UHF, HF, and VHF bands that can provide secure voice and limited data communications capability (transfer rates are limited by bandwidth constraints).

Retransmission of tactical communications is one of the most effective means of mitigating the deficiencies of VHF and UHF communications. As a result, retransmission requires focused and detailed planning. The following are planning considerations for employing retransmission teams:

- Survivability of retransmission teams relies on operations security, the proper use of cover and concealment, light and noise discipline, and planned mutual support due to their exposure to enemy and environmental threats.
- Teams should be emplaced at night and just before operations to help protect them from compromise and attack.
- Logistical requirements, such as batteries, food, water, and all relevant classes of supply, should be anticipated.
- Mobile retransmission sites should be identified, reconnoitered, and validated prior to execution of operations when the operational environment allows it.
- Airborne retransmission and relay of critical nets help to overcome many challenges associated with ground retransmission; however, they can only be relied upon for short-duration missions (some UASs can provide extended periods of coverage).
- Specially configured rotary- and fixed-wing aircraft can serve as robust command and control platforms.
- Conduct terrain analysis of purposed scheme of maneuver to ensure retransmission site provides decision advantage to commander’s vice slow operational tempo..

Table 9-1. Communications System Comparison.

Communications Systems	Advantages	Disadvantages
HF	HF radios support long-range communications.	Work best when stationary. Require more training than VHF or UHF. Affected by terrain masking.
VHF	Single-channel ground and airborne radio systems are highly capable tactical radios due to their built-in communications security and electromagnetic countermeasures capabilities.	Greatly affected by terrain masking. Limited to near LOS employment. A LOS study will maximize the potential of VHF communications.
UHF	Not restricted to LOS and can bend somewhat over mountain tops.	Absorbed by intervening terrain.
TACSAT	Some are small and lightweight. Flexible and reliable.	Geosynchronous satellite can be masked by mountainous terrain. More susceptible to electromagnetic warfare and interference. Limited number of assigned satellites.
DTCS	Small and lightweight. Most are flexible and reliable. DTCS radios provide position location. Can send preformatted text messages. Nongeosynchronous, low orbiting satellites are not masked by mountainous or urban terrain.	Limited data transfer. More susceptible to electromagnetic warfare and interference.
BFT	Transmits position location by geosynchronous satellite. Provides a reliable data communications link for sending preformatted and free text messages. Satellite based, making it an ideal system for the mountains.	Must have LOS to the geosynchronous satellite. Vehicle mounted.
MUX	Small and lightweight, broadband MUXs use frequencies in the UHF and SHF bands.	More logistical and operating requirements than SCR systems. Communications between MUX communications nodes will not be possible if there is intervening terrain between the nodes.

High Frequency

Though HF communications support long-range communications, they work best when stationary and require more training than VHF or UHF radios. High frequency radios, such as the AN/PRC-160, TRC-209, or vehicle-mounted MRC-148 and VRC-104, use third general automatic link establishment. They are a suitable stationary alternative to TACSAT radios, but often take longer to set up and are not as effective on the move. When using HF, field expedient antennas employ in Near Vertical Incident Skywaves configurations mitigate the effects of terrain masking on HF systems.

Very High Frequency

The VHF radios are greatly affected by terrain masking and are limited to LOS employment in mountainous terrain. A LOS study should be conducted as part of the IPB to maximize the potential of VHF communications. This LOS study will help to determine positioning requirements, relay requirements, and antenna farm positioning. The most widely employed VHF tactical radio is the SINCGARS [single- channel ground and airborne radio system] family of radios.

Ultra High Frequency

The UHF signals are absorbed by intervening terrain and are another form of LOS communications; however, UHF signals are not restricted to LOS and can bend somewhat over mountain tops. During the Soviet War in Afghanistan, the Soviets noticed the following:

- They could communicate using UHF radios out to 100 kilometers (about 60 miles) if the transmitting and receiving stations were on high ground and any intervening terrain was midway and no higher than 198 meters (650 feet) above the stations.
- Taller mountains and multiple peaks interfered with UHF communications.
- A single, closer (yet lower) peak cut transmissions to 20 to 22 kilometers (12 to 14 miles) and that was only if the mountain crest was narrow and both stations were aimed at the sharp peak.
- UHF communications distance was cut to 10 to 12 kilometers (6 to 7 miles) if the intervening peak rose to 100 meters (328 feet) higher than the stations.
- If there were a series of 200- to 400-meter (650 to 1,300 feet) peaks between stations and if both stations were far enough away from the mountain bases and used whip antennae, transmission distance was cut to 9 to 10 kilometers (5.5 to 6 miles).
- Large, domed mountains cut UHF transmissions to 5 to 6 kilometers (between 3 and 4 miles), while cut-up rugged mountainous terrain further limited transmissions to 4 to 5 kilometers (about 2.5 to 3 miles).
- UHF communications were frequently lost while moving along mountain roads or in the “silent zone” on the far side of mountains.

These communications ranges involved knife edge diffraction, also known as obstacle gain diffraction. This method of establishing communication has typically been applied within the Marine Corps to high power, directional systems, such as the AN/TRC-170. The low power, omnidirectional UHF systems employed by Marines are not likely to experience such types of radio links. Measures to improve UHF communications in the mountains include the following:

- Select communications sites that have a narrow single mountain crest between them. Aim the transmissions at the highest peak. Keep the sites away from the mountain base.
- Deploy radios away from the mountain base to a distance at least equal to the distance of the slope between the base and mountain crest.
- Deploy radios to commanding heights to improve their LOS to the top of the intervening mountain.
- Deploy radios where they can communicate over a single mountain rather than a series of peaks and defiles.
- When confronted with a large, domed mountain, Marines can deploy the radios away from mountain’s base and on high ground.

Tactical Satellite Radio

Marines use the TACSAT, also known as SATCOM, radio in the mountains. It combines mobility, flexibility, and ease of operation with unlimited range. The PRC-117G, PRC-117F, PRC-148, PRC-152, VRC-110, and VRC-111 are all capable of transmitting SATCOM, UHF, and VHF voice or data, and are suitable for base or mobile communications in the mountains. Though flexible and reliable in the mountains, TACSAT radios are more susceptible to electromagnetic warfare and interference, channels are usually limited, and the radios have limited capability to support data transfer. The mobile user objective system offers an on-the-move, SATCOM capability. The mobile user objective system increases the unit's operational tempo but is still susceptible to terrain effects on SATCOM.

Commercial Satellite Terminals

Commercial satellite terminals with appropriate communications security modules can be used to provide reliable worldwide voice and data communications. These devices provide a first-in, redundant, and amplifying capability to TACSAT or SCR.

Special Purpose Systems

Special purpose communications systems support specific functions, such as position location, navigation, and intelligence dissemination. There are many types of special purpose systems in the Marine Corps inventory and many more are available when operating as part of a joint task force. Marines must be able to employ these systems to leverage the significant capabilities they represent. For example, the Distributed Tactical Communications System (DTCS) is an extension of "netted iridium," push-to-talk communications capability. The DTCS can provide over-the-horizon, on-the-move, beyond-LOS netted voice and data communications over the Iridium network.

Multichannel Radios

Broadband multichannel radios (MUXs) use frequencies in the UHF and SHF [super high frequency]. The demands of operating along these frequency bands as well as performing multiplexing functions require complex and relatively large pieces of equipment. The MUX systems, therefore, have considerably more logistical and operating requirements than SCR systems. In addition, they have a requirement to transmit and receive a tightly focused beam of radio energy, which is not practical for units on the move. For sustained operations in mountains, ground relay stations or "RIPER" nets can be established to relay large amounts of data. Planners should consider the following MUX characteristics:

- MUX equipment is limited to LOS and, in some cases, a very low takeoff angle.
- Compartmentalized, mountainous terrain will require more nodes and larger packages.
- Communications between MUX communications nodes will not be possible if there is intervening terrain between the nodes.
- MUX repeater sites can enable command and control in the mountains. Repeaters need to be placed near or on the top of ridges or peaks.
- Wind speeds on top of ridges and peaks often exceed the operational tolerances of MUX antennas, requiring the antennas be taken down during inclement weather.
- Satellite terminals, such as the Support Wide Area Network system and the Secure Mobile Anti-Jam Reliable Tactical Terminal, along with older systems, such as the TSC-85 and TSC-93, provide a method of switched connectivity in addition to MUX that often makes them preferred over MUX in a mountainous environment.

Blue Force Tracking

Blue force tracking (BFT) provides a reliable data communications link for sending preformatted and free text messages. Because BFT uses satellites rather than ground radio relays, it is an ideal system for mountainous environments, such as in Afghanistan. Unlike the enhanced position location reporting system which is limited by the LOS, BFT provides continuous coverage despite the terrain and number of users in the battlespace. It provides a near real-time feed to the common operational picture and is a highly reliable means of text communication between dispersed units.

Cell Phones

The proliferation and common use of cell phones may provide opportunities to exploit operational security issues, particularly as relay towers and usage expand in the future.

CHAPTER 10.
TRAINING CONSIDERATIONS

Fighting on steep slopes and at an altitude dramatically alters such things as marksmanship and movement techniques and, unless planners understand and compensate for these differences, these changes can render units that are considered well-trained at sea level into a liability in the mountains. Therefore, Marine Corps units should focus on basic individual skills and on collective training in a mountainous environment to overcome the challenges that this environment presents. Although the specialized technical skills that are highlighted in Army and Marine Corps doctrine (e.g., TC 3-97.61, MCRP 12-10A.2, and MCRP 12-10A.3) are useful, these specialized skill sets will only be needed by a few troops, such as mountain leaders and assault climbers, within each unit. Information is provided in this chapter on all mountain warfare training in the DoD for understanding in joint mountain operations.

The high interaction and interoperability between the Army and Marine Corps in the operational environment adds importance to establishing common training standards and programs. Currently, the Marine Corps is the only Service with a standardized training list that addresses individual and collective tasks needed in the mountains. The Marine Corps' mountain warfare training curriculum is based on Navy/Marine Corps Departmental Publication (NAVMC) 3500.70B, *Mountain Warfare Operations Training and Readiness Manual*, that focuses on the following fundamentals:

- Employ specialized mountain or cold weather clothing and equipment.
- Survive in a mountain or cold weather environment.
- Mitigate the effects the mountain or cold weather environment exerts on operations.

Individual and collective unit mountain and/or cold weather training is essential prior to conducting operations in these environments. Commanders should make every effort to maximize the training capabilities of the Marine Corps Mountain Warfare Training Center (MCMWTC) to enhance the units' warfighting capability in these challenging environments.

MILITARY MOUNTAINEERING SKILL SETS

The Army and Marine Corps recognize three levels of military mountaineering skill sets. Table 10-1 highlights the method the Army's Northern Warfare Training Center (NWTC) and Army Mountain Warfare School use to train Soldiers for mountainous environments and build the requisite skill sets in units so an institutional memory can be maintained.

Level I: Basic Mountaineer (Army)

The basic mountaineer is a graduate of the basic mountaineering course. They must learn the fundamental traveling and climbing skills necessary to move safely and efficiently in mountainous terrain. Basic mountaineers should be comfortable functioning in this environment and, qualified mountain leaders or assault climbers, can supervise and assist in the rigging and using basic rope installations. On technically difficult terrain, a basic mountaineer should be capable of performing duties as the “follower” or “second” on a roped climbing team and should be well trained in using all basic rope systems. They may provide limited assistance to personnel unskilled in mountaineering techniques. Particularly adept individuals may be selected to be members of special purpose teams led and supervised by mountain leaders or assault climbers/ advanced mountaineers. At a minimum, basic mountaineers should possess the following mountain-specific knowledge and skills:

- Characteristics of the mountainous environment (summer and winter).
- Mountaineering safety.
- Individual cold weather clothing and equipment use, care, and packing.
- Basic mountaineering equipment care and use.
- Mountain bivouac techniques.
- Mountain communications.
- Mountain travel and walking techniques.
- Hazard recognition and route selection.
- Mountain navigation.
- Basic CASEVAC.
- Rope management and knots.
- Natural anchors.
- Familiarization with artificial anchors.
- Belay and rappel techniques.
- Fixed ropes (lanes) usage.
- Rock climbing fundamentals.
- Rope bridges and lowering systems.
- Individual movement on snow and ice.
- Mountain stream crossings (to include water survival techniques).
- First aid for mountain illnesses and injuries.

NOTE: Army Special Operations Forces Mountaineering Operations Training Task in United States Army, Special Operations Command (USASOC) Regulation 350-12, Special Operations Forces Mountaineering, refers to Level I as being highest in the USASOC. The USASOC levels of training are reversed compared with conventional units.

NOTE: Level I-qualified personnel should be identified and prepared to serve as assistant instructors to train unqualified personnel in basic mountaineering skills. All high-risk training must be conducted under the supervision of qualified level II or III personnel.

Level II: Assault Climber (Marine Corps)/Advanced Mountaineer (Army)

Assault climbers and/or advanced mountaineers are responsible for the rigging, inspection, use, and operation of all basic rope systems. They are trained in additional rope management, knot tying, belay, rappel techniques, and the use of specialized mountaineering equipment. Assault climbers and advanced mountaineers are capable of rigging complex, multipoint anchors, and high angle raising and lowering systems. Level II qualification is required to supervise all high-risk training associated with Level I. At a minimum, assault climbers should possess the following additional knowledge and skills:

- Using specialized mountaineering equipment.
- Performing multipitch climbing on rock.
- Leading on class 4 and 5 terrains.
- Conducting multipitch rappelling.
- Establishing and operating hauling systems.
- Establishing fixed ropes with or without intermediate anchors.
- Moving on moderate-angle snow.
- Establishing evacuation systems and performing high-angle rescue.

Level III: Mountain Leader (Marine Corps) and Master Mountaineer (Army)

Mountain leaders have all the skills of the assault climber and have extensive practical experience in a various mountainous environments in winter and summer conditions. Level III mountaineers must have well developed hazard evaluation and safe route-finding skills over varied mountainous terrain. Mountain leaders are best qualified to advise commanders on all aspects of mountain operations, particularly the preparation and leadership required to move units over technically difficult, hazardous, or exposed terrain. The mountain leader is the highest level of qualification and is the principal trainer for conducting mountain operations. A Level III qualified mountain leader is required to supervise all high-risk training associated with level II. Instructor experience at a military mountain warfare training center or as a member of a special operations force's mountain team is critical to acquiring Level III qualification.

Additional Knowledge and Skills

At a minimum, mountain leaders should possess the following additional knowledge and skills:

- Preparing route, movement, bivouac, and operational risk management.
- Recognizing and evaluating peculiar terrain, weather, and hazards.
- Performing avalanche hazard evaluation and mitigation.
- Organizing and leading avalanche rescue operations.
- Planning and awareness of roped movement techniques on steep snow and ice.
- Awareness of glacier travel and crevasse rescue.
- Conducting ski instruction.
- Planning and conducting skiborne patrols in class 3 and 4 terrain.
- Using winter shelters and survival techniques.
- Conducting multipitch climbing on mixed terrain (rock, snow, and ice).

- Leading units over technically difficult, hazardous, or exposed terrain in winter and summer conditions.
- Advising commanders and staff during planning on mountain warfare considerations across all warfighting functions.

Table 10-1. Recommended Individual Military Mountaineering Training Strategy.

Training Focus	Combat Effects of the Environment		Leverage Environment Against Enemy	
Training Level	Base – Orientation	Level I – Basic	Level II – Advanced	Level III - Master
Course Title and Qualification	Mountain Warfare Orientation Course (No qualification)	Basic Military Mountaineer (SQI)	Advanced Mountaineer (Assault Climber)	Mountain Leader (Certified Mountaineering Instructor)
Target Audience	All unit personnel	1-2 per platoon	2 per battalion	1 per brigade
Individual Capability	• Basic mobility skills • Basic understanding of the fundamentals for operating in a mountainous region	• Basic technical skills • Trains Soldiers and leaders in basic mobility skills • Assists in planning mountain operations	• Advanced technical skills • Advises the battalion commander • Unit trainer and planner of mountain sustainment training and operations	• Advanced technical skills and experience • Advisor to the brigade commander • Unit trainer and planner of mountain sustainment training and operations
Training Time	4-5 days	14 days	15 days	2+ years
Training Provider	• AMWS NWTC Unit Military Mountaineer	• AMWS • NWTC	• AMWS • NWTC • MCMWTC	• Fully qualified current or former Military Mountaineering Instructor
Unit Operational Capability	Basic: Marines, planners, leaders trained capability built and applied		Advanced: Advanced technical skills capability built and applied	
LEGEND AMWS Army Mountain Warfare School MCMWTC Marine Corps Mountain Warfare Training Center NWTC Northern Warfare Training Center SQI Special Qualification Identifier				

MARINE CORPS MOUNTAIN WARFARE TRAINING CENTER

Training at MCMWTC should be conducted prior to deploying to a mountainous and/or cold weather operational environment. Training should replicate the high altitude, mountainous, and cold weather conditions associated with the operational environment. At the MCMWTC, training is conducted at both the individual and unit level. The individual training by formal school courses is considered an integral part of unit training and should be scheduled one to three months before unit training and deployment.

Collective Training

The established collective training exercise is called Mountain Exercise. The mountain exercise trains the Marine Air Ground Task Force (MAGTF), joint force, and allied and partner forces in the technical aspects of operations in a high altitude, mountainous, cold weather environment.

Training is progressive, advancing from individual to collective events during the exercise beginning with pre-environmental training, mobility training, through force-on-force training. The mountain exercise culminates in a field exercise in which new technical skills must be applied to gain tactical advantages. Situations arise when units are deployed to a mountainous area of operations without prior training. The unit should use their mountain leaders to schedule, prepare, organize, and conduct in theater training. This usually takes two to three weeks and is accomplished concurrent with acclimatization.

Units can request mobile training teams from MCMWTC, if they do not have mountain leaders. The suggested training is not meant to be all inclusive; rather, it is a guide that commanders can use to develop a customized mountain warfare training package. The mountain exercise is composed of three stages: Pre-environmental Training, Mobility, and a field exercise. Execution covers 27 training days. Mountain Operations Staff Planning Considerations is a training event for training audience leadership that runs parallel to pre-environmental training and Mobility.

Mountain Operations Staff Planning Considerations. The training event is unit level training done in conjunction with a unit's participation in a mountain exercise. These planners are staff personnel who have been specifically trained in the considerations for planning mountain warfare operations across the warfighting functions and aviation planning using the Marine Corps Planning Process. This training is recommended for battalion level and higher staff planners and is focused across warfighting functions, terrain walks, and planning repetitions.

Stage 1 (Training Days 1-3): Pre-environmental Training. This stage begins with the Welcome Aboard brief and concludes once all pre-environmental training instruction periods are complete on training day three. The purpose of the pre-environmental training is to provide the necessary environmental and individual level training required to survive in the mountainous, high altitude, and cold-weather environment. This stage encompasses environmental considerations, hazards and mitigation, using specialized clothing and equipment, and historical lessons learned. Refresher training prior to any significant change in altitude, topography, or temperature is recommended. Pre-environmental training should occur before a unit deploys to a mountainous environment or on initial arrival, if necessary. It includes individual entry-level training using the 2000-level tasks from NAVMC 3500.70B.

Stage 2 (Training Days 4-19): Mobility Training. This stage begins with insertion to the training areas and concludes with movement to the Lower Base Camp. This training is conducted over 16 days at the operational altitude or climate. The purpose of mobility training is to provide the technical and collective training required to thrive and sustain operations in the mountainous, high altitude, and cold-weather environment. The end-state is that the training audience is proficient enough in the technical skills (e.g., advanced mountain and over-the-snow mobility training, driver training, medical training, and animal packing) that they can employ them in the field exercise. Mobility training progresses from individual to collective skills (3000 to 6000 level events from NAVMC 3500.70B), including company (6000 level) events for the GCE. The Training Audience execution of the MCPP for field exercise overlaps with this stage.

Stage 3 (Training Days 23-29) MAGTF Final Exercise. This stage begins with the training audience rehearsal of concept and ends with withdrawal from the training areas to lower-base camp. The field exercise purpose is to provide a venue for the Service-level training exercise MET assessment, and more specifically, to apply the technical skills learned during mobility during a tactical scenario. The field exercise is the venue for the unit MET assessment. This training is conducted over six days. The final stage is to exercise the entire MAGTF on 6000 to 8000 level tasks from NAVMC 3500.70B. The following exercises test MAGTF dispersed operations in complex, compartmentalized, mountainous terrain that replicates elevations and climates found in the operational environment:

- The command element tests its ability to effectively plan, command, and control the conduct of anticipated dispersed mission profiles across all elements of the MAGTF.
- The GCE tests its ability to shoot, move, and communicate.
- The ACE conducts air missions; aircraft maintenance; logistic support; LZ use at high altitude, on ridgelines, and/or in snow; and the establishment of FARPs.
- The logistics combat element tests its ability to provide CSS to the MAGTF that focuses on units using CASEVAC or MEDEVAC, aerial resupply, and ground resupply over restricted terrain using animals or over-the-snow vehicles.

Individual Training

Individual Marines can be specially trained for one or more of the functions discussed in the following paragraphs.

Mountain Leader (Company-Grade Officers, Staff Noncommissioned Officers, and Noncommissioned Officers). The mountain leaders' current training is divided by season. A completely trained mountain leader has attended the summer and winter mountain leader courses. The summer trained mountain leader is a qualified in rope techniques and an assault climber. A mountain leader is also aware of requirements for alpine movement and glacier travel; alpine training is a progression for mountain warfare instructors and can include training at Mount Shasta. The winter mountain leader is a scout skier and certified as a basic ski instructor. Mountain leaders are skilled in all aspects of warfighting in a mountainous and cold-weather environment. The primary role of the mountain leader is to train, advise, and plan company- and platoon-level dispersed operations in those parts of complex, compartmentalized terrain that would otherwise be inaccessible to the unit commander. Mountain leaders have the knowledge and skills to operate in all types of mountainous terrain and weather conditions (high to very high altitude; wet or dry; extreme cold; rock- or snow-covered slopes to vertical). Recommendations are two per infantry company, two per scout platoon, three per reconnaissance company for a reconnaissance battalion, and two per team for Marine Special Operations Command.

The Mountain Leaders curricula aboard MCMWTC consists of 35 training days that will challenge students in planning, operating, and sustaining units in complex, compartmentalized terrain as well as tactical employment of units in this challenging environment. Students are taught TTP across warfighting functions to serve as leaders and train others in these considerations with their parent unit. This course is designed to provide company grade officers, staff noncommissioned officers and sergeants academic instruction and field application in using specialized mountaineering and cold-weather equipment, mountain warfare TTP, including planning considerations across warfighting functions for offensive and defensive operations in complex, compartmentalized mountainous terrain.

Winter Mountain Leader Course. The scope and outcome of the Winter Mountain Leader course is to develop subject matter experts on the care and how to use mountain and cold-weather equipment, environmental and mobility skills (e.g., horizontal and vertical obstacle negotiation), and small-unit tactics to enable them to train company-sized units to conduct offensive and defensive operations in this environment. The desired end state is a course graduate who would increase a unit's endurance, survivability, mobility, sustainability, and assist unit leaders in planning and advising in this environment. Course graduates (enlisted and officer) receive the Winter mountain leader FMOS.

Summer Mountain Leader Course. The scope and outcomes of the Summer Mountain Leader course is to develop subject matter experts on the care and use of mountain and cold-weather equipment, environmental and mobility skills, and small unit tactics to enable them to train company-sized units to conduct offensive and defensive operations in this environment. The desired end state is a course graduate who will increase a unit's endurance, survivability, mobility, and sustainability and assist unit leaders in planning and advising in this environment. Graduates of this course will receive the Summer mountain leader FMOS.

Summer (course number M24M7A1) and Winter (course number M24M7B1) Mountain Leader course graduates (enlisted and officer) receive the Summer/Winter mountain leader FMOS. Staffs must pull a report of the unit's mountain leaders for the commander to help plan operations.

Mountain leaders learn and develop skills in these areas to include:

- Prepare route, movement, bivouac, and risk management.
- Recognize and evaluate peculiar terrain, weather, and hazards.
- Perform avalanche hazard evaluation and mitigation.
- Organize and lead avalanche rescue operations.
- Plan and supervise roped movement techniques on steep snow and ice.
- Conduct glacier travel and crevasse rescue.
- Conduct ski instruction.
- Plan and conduct ski-borne patrols in class 1 and 2 terrain.
- Winter shelters and survival techniques.
- Conduct multipitch climbing on mixed terrain (rock, snow, and ice)
- Lead units over technically difficult, hazardous, or exposed terrain in winter and summer conditions.
- Advise commanders and staff during planning on mountain warfare considerations across warfighting functions.

Assault Climber. This is a 23-day course that exposes students to rope techniques, climbing, and increasing mobility to supported units in a littoral and or high altitude, compartmentalized mountainous terrain. This course focuses on using rope techniques to negotiate land and water obstacles unique to these environments. The Assault Climber Course is designed to provide students a working knowledge of the TTP used to overcome near vertical-to-vertical obstacles. The skills and methods taught have been developed from the Mountain Warfare Operations Training and Readiness Manual NAVMC 3500.70B.

Scout Skier. This course exposes students to high altitude, compartmentalized mountainous terrain, with an emphasis on over-the-snow mobility, and cold-weather TTP. The Scout Skier Course is a 19-day training course, designed to train individual personnel as subject matter experts on the care and use of cold-weather equipment, environmental and mobility skills, and small-unit tactics to become subject matter experts in winter mountain picketing and skiborne patrolling.

Mountain Medicine. This learning program is designed to educate students to a high standard on technical and medical considerations unique to mountainous environments. The course covers the diagnosis, treatment, prevention of high altitude and cold weather-related illnesses and injuries, technical casualty evacuation techniques, movement, bivouac, and leadership skills in austere environments. The focus of classroom instruction and field mentoring is placed on enhancing the students' medical knowledge base, clinical competence, self-confidence, and individual resourcefulness. This is a 20-day course involving classroom and field instruction including high-risk training in rappelling, hoist operations, and high-angle rescue techniques. The classroom phase lasts one week and focuses on expanding medical understanding of wilderness and environmental medicine topics as well as providing pre-environmental training on techniques and procedures necessary for mountainous operations. The field phase covers the next two weeks and focuses on instructing and employing mountainous, compartmentalized, and high-angle casualty rescue and movement techniques as well as applying the medical knowledge from the classroom phase in a field setting. The course culminates with a final field exercise where students will demonstrate the application of knowledge from the classroom and field phases in various scenarios.

Cold Weather Medicine. This learning program is designed to educate students to a high standard on technical and medical considerations unique to mountainous and cold weather environments. The course covers the diagnosis, treatment, and prevention of high altitude and cold weather-related illnesses and injuries, technical casualty evacuation techniques, movement, bivouac, and leadership skills in high altitude, compartmentalized, and snow-covered terrain. The focus of classroom instruction and field mentoring is placed on enhancing the students' medical knowledge base, clinical competence, self-confidence, and individual resourcefulness. This is a 20-day course involving classroom and field instruction including high-risk training in cold water immersion, hoist operations, and steep earth patient movement techniques. The classroom phase lasts one week and focuses on expanding medical understanding of wilderness and environmental medicine topics with a focus on cold weather injuries and illnesses. The classroom phase also covers pre-environmental training on field techniques and procedures necessary for cold weather operations. The field phase (two weeks) focuses on instructing, sustainment, movement, casualty care and transport in a high altitude/snow-covered environment as well as applying the medical knowledge from the classroom phase in a field setting. The course culminates with a final field exercise where students will demonstrate the application of knowledge from the classroom and field phases.

Animal Packing. Animal Packing is a 16-day learning program designed to provide MAGTF units with a core of Marines who understand and are capable of extending their units culminating point in a mountainous environment by covering the following warfighting functions; maneuver, logistics, force protection, and command and control. Maneuver is oriented on transporting crew served weapons in support of combat operations. Transportation of supplies and equipment will enable sustainment efforts. The command and control warfighting function is oriented on planning, organizing, conducting animal packing, and providing advice to senior commanders and staffs. Force protection is focused on casualty evacuation techniques, animal first aid, and bivouac considerations while employing pack animals.

Over the 16 days, students will move more than 70 kilometers employing a pack string. This course is designed to aid Marine Corps units in alternative methods for transporting crew served weapons, equipment and supplies, and wounded personnel to and from areas inaccessible to mechanized and air mobile transportation. The course subjects include introduction to animal packing, planning, anatomy of pack animals, animal packing techniques, casualty evacuation techniques, animal first aid, and bivouac considerations.

Horsemanship and Animal Packing. Horsemanship and Animal Packing is a 16-day learning program designed to provide units with a skilled core of personnel capable of working with indigenous personnel operating with riding and/or packing animals in a mountainous environment. This learning covers the following warfighting functions; maneuver, logistics, and force protection. Maneuver will cover horsemanship and riding techniques; packing and transporting crew served weapons, equipment and supplies will enable sustainment; transportation of wounded personnel will enable force protection. Students will conduct multiple pack string and mounted/horse-borne operations covering over 115 kilometers.

This course is designed to train small units in operating with indigenous personnel who ride or pack animals. This includes riding horses and packing animals for supporting combat operations (e.g., infiltration, exfiltration, CASEVAC, and moving weapons systems and equipment). The course subjects include animal care, anatomy of working animals, animal packing techniques, casualty evacuation techniques, animal first aid, bivouac/harbor site considerations, and horsemanship techniques.

Summer Mountain Engineer. The Summer Mountain Engineer course is a 24-day Learning Program designed to enhance the skills of combat engineers operating in complex, compartmentalized, subterranean, and mountainous environments. This learning program is designed to provide the combat engineer officer and NCO academic instruction and field practical application in mountain warfare engineering TTP; to include engineer planning considerations for maneuver and force protection warfighting functions for combat operations in complex, compartmentalized, mountainous, and subterranean environments.

Winter Mountain Engineer. The Winter Mountain Engineer course is a 24-day Learning Program designed to enhance the skills of combat engineers operating in complex, compartmentalized, snow-covered, and mountainous environments. This learning program is designed to provide the combat engineer officer and NCO academic instruction and field practical application in mountain warfare engineering TTP to include engineer planning considerations for maneuver and force protection warfighting functions for combat operations in complex, compartmentalized, mountainous, and snow-covered environments.

Basic Cold Weather Advisor.The Basic Cold Weather Advisor course is a 12-day learning program designed to provide MAGTF units with a skilled core of Marines capable of serving as advisors in basic winter operations. The intent of this course is to build enablers across the MAGTF to conduct sustained operations in a cold weather operational environment. This learning program is focused to train military personnel from any MOS, to become basically qualified in winter operations. Graduates can sustain themselves, applying considerations, techniques, sustaining routines and procedures, supervising and advising others to enable effective operations in a cold weather, mountainous, and or snow-covered environments. Graduates can also assist in pre-environment training to their unit. These Marines are capable of teaching and advising their Marines in a cold weather environment and may assist Mountain Leaders in these efforts.

Mountain Communications. The Mountain Communications Course is designed to provide instruction in the unique aspects and challenges of communications in a mountainous environment. Additionally, the course provides students awareness and understanding of command and control challenges, environmental considerations, and mobility in support of MAGTF operations. The desired result is the student graduate who has an enhanced knowledge base and skills that allow them to operate in austere environments while enabling C2 in support of high altitude, cold weather combat operations. This is a 15-day course with subjects inclusive of the use of specific radios in a mountainous environment, antenna types and construction in the mountains, radio wave theory, and retransmission site selection and operations considerations. Graduates can provide mountain communications considerations training for units. Sending students to this course is recommended for units conducting the Mountain Exercise portion of the MAGTF Warfighting Exercise SLTE to enable command and control.

ARMY TRAINING

Northern Warfare Training Center

The Army NWTC is located at Fort Wainwright, Fairbanks, Alaska, and features the—

- Basic Military Mountaineer—15-day course (summer only).
- Assault Climber Course—15 days (summer only, basic is prerequisite).
- Cold Weather Orientation Course—4-day course.
- Cold Weather Leaders Course—13-day course.

Mountain Warfare School

The AMWS is located at Camp Ethan Allen, Jericho, Vermont, and features the—

- Basic Military Mountaineer, Summer—14-day course, five per season.
- Basic Military Mountaineer, Winter—14-day course, three per season.
- Advanced Military Mountaineer Course, Summer—14 days (basic is prerequisite), two per season.
- Advanced Military Mountaineer Course, Winter—14 days (basic is prerequisite), one per season.
- Mountain Marksmen-Sniper (see Army Training Requirements and Resources System for more detail on course schedule and availability).
- Rough Terrain Evacuation (see Army Training Requirements and Resources System for more detail on course schedule and availability).
- Mountain Leader Orientation Course—7 days, three per year.

Special Operations Mountain Warfare Training Center

This training is located at Fort Carson, Colorado Springs, Colorado, and features the—

- Summer Mountain Operator Course—6 weeks.
- Winter Mountain Operator Course—3 weeks.

Navy Sea-Air-Land Team Cold-Weather Maritime Course

The SEAL [sea-air-land] team cold weather training is located at Kodiak, Alaska. It is part of required training covering basic cold weather survival, navigation and/or movements, and cold-water training.

Army National Guard High Altitude Aviation Training Site

The Army National Guard school for high altitude training of rotary-wing pilots is located in Gypsum, Colorado, and is 7 days long. Flying is conducted at elevations ranging from 1,981 to 4,267 meters (6,500 to 14,000 feet).

Coalition Mountain Warfare Training

Coalition countries that are mountainous often have training courses, but few are taught in English. These courses can expand the base of knowledge and experience of Marines, but are not a substitute for standardized Marine Corps mountain warfare training. The language of instruction should be verified prior to training. Coalition exercises in mountainous terrain in Norway and Slovenia are the best means to mutually exchange TTP:

- NATO Centre of Excellence, Cold Weather Operations, Norway.
- NATO Mountain Warfare Centre of Excellence, Slovenia.

Exchange programs exist in mountain warfare that are concentrated on the northern North Atlantic Treaty Organization requirement (British, Dutch, and Norwegian). The experience gained from these programs applies to all mountain warfare environments as well as to interoperability.

Training Charts

Tables 10-2 through 10-5 break down the available instruction by individual, collective, and aviation summer and cold weather training.

Table 10-2. Summer Individual Mountain Training.

Location	Course Name	Duration	Level	Equivalent
MCMWTC, Expeditionary Operations Training Groups at I, II, III MEF	None		I	Basic Mountaineer (summer)
Northern Warfare Training Center	Basic Mountaineer Summer	14 days	I	Marine Corps Pre-Environmental Training, Mobility, Rope Techniques
Army Mountain Warfare School	Basic Mountaineer Summer	14 days	I	Marine Corps Pre-Environmental Training, Mobility, Rope Techniques
MCMWTC, Expeditionary Operations Training Groups at I, II, III MEF	Assault climber	4 weeks	II	USA Assault Climber (summer)
Northern Warfare Training Center	Assault climber	15 days (+Basic Mountaineer Summer)	II	Assault Climber Course
Army Mountain Warfare School	Assault climber, summer (prerequisite is Basic Mountaineer Summer)	14 days (+Basic Mountaineer Summer)	II	Assault Climber Course
MCMWTC	Summer Mountain Leaders Course	6 weeks	III	US Army Basic Mountaineer and Assault Climber (summer)
Special Operations Mountain Warfare Training Center	Summer Mountain Operators Course	6 weeks	II	Assault Climber Course portion of Summer Mountain Leader Course
Special Operations Mountain Warfare Training Center	Winter Mountain Operators Course	3 weeks	III	Alpine and ski training
MCMWTC	Mountain Communications	15 days	S	None
MCMWTC	Animal Packing	16 days	S	None
MCMWTC	Mountain Scout Sniper	21 days	S	None
MCMWTC	Mountain Medicine	21 days	S	None
MCMWTC	Summer Mountain Engineer	24 days	S	None

LEGEND
S supporting (specialized training for a certain MOS or unique skill)
MCMWTC Marine Corps Mountain Warfare Training Center

Table 10-3. Mountain Aviation Training.

Location	Course Name	Duration	Equivalent
High altitude aviation training site	High altitude aviation training	7 days	None

Table 10-4. Cold Weather/Mountain Individual Training.

Location	Course Name	Duration	Level	Equivalent
Army Mountain Warfare School	Basic Mountaineer Winter	14 days	I	Portion of Winter Mountain Leader Course
Army Mountain Warfare School	Assault climber, winter (prerequisite is Basic Mountaineer Winter)	14 days (+ Basic Mountaineer Winter)	II	Portion of Summer Mountain Leader Course
MCMWTC	Winter Mountain Leaders Course	6 weeks	III	Army Mountain Warfare School and Northern Warfare Training Center Basic Mountaineer and Assault Climber (winter)
MCMWTC	Scout Skier	14 days	I	US Army Cold Weather Leaders
Northern Warfare Training Center	Cold Weather Orientation	4 days	I	Pre-Environmental Training
Northern Warfare Training Center	Cold Weather Leaders	13 days	S	Scout skiers, Basic Cold Weather Advisor
MCMWTC	Basic Cold Weather Advisor	12 days	S	Cold Weather Leaders
MCMWTC	Cold Weather Medicine	21 days	S	None
MCMWTC	Winter Mountain Engineer	24 days	S	None
SEAL Team Detachment, Kodiak, AK	SEAL Cold Weather Maritime	28 days	S	Portion of Winter Mountain Leader Course, maritime is unique. *Part of training continuum

LEGEND
S supporting (specialized training for a certain MOS or unique skill)
SEAL sea-air-land MCMWTC Marine Corps Mountain Warfare Training Center

Table 10-5. Marine Corps Mountain Collective Training.

Location	Training Exercise Stage Name	Duration	Equivalent
Marine Corps Mountain Warfare Training Center	Pre-Environmental Training	3 days	None
Marine Corps Mountain Warfare Training Center	Mobility Training	16 days	None
Marine Corps Mountain Warfare Training Center	Final Exercise	7 days	None

APPENDIX A.
ALTITUDE AND ENVIRONMENTAL HAZARDS

High mountain activities are inherently dangerous. They can be unforgiving for those without adequate knowledge, training, and equipment. All personnel must understand that the interaction of environmental conditions with mission responsibilities and individual characteristics can significantly affect the health of Marines. Sound planning and preparation can prevent or reduce an adverse effect. Marines operating in high mountains need time to acclimate. All Marines should be aware of the threats associated with operations in high altitudes and use personal protective measures to minimize disease and nonbattle injuries. Conversely, the enemy is enduring the same environmental challenges and is just as susceptible to these hazards; understanding and identifying this may present an opportunity.

HIGH-ALTITUDE ILLNESSES

Operating in the mountains stresses the human body. To become acclimated, the human body must go through physiological changes that will vary from person to person. Successful acclimatization depends on three factors (see Table A-1):

- The degree of hypoxic stress (altitude).
- The rate of onset of hypoxic stress (ascent rate).
- Individual physiology (genetic differences between individuals).

Table A-1. Altitude Effects.

Altitude	Approximate Elevation	Effects
Low	Sea Level – 1,200 m (4,000 ft)	None
Moderate	1,200–2,400 m (4,000–7,870 ft)	Mild altitude illness and decreased performance may occur
High	2,400–4,000 m (7,870–13,125 ft)	Altitude illness and performance decrements are more common and more acute
Very High	4,000–5,500 m (13,125–18,000 ft)	Altitude illness and decreased performance is the rule
Extreme	5,500 m (18,000 ft) and higher	With acclimatization, humans can function for short periods of time
LEGEND ft feet m meters		

The following paragraphs discuss seven illnesses caused by high altitude.

Acute Mountain Sickness

Acute mountain sickness is caused by ascending too rapidly to high altitude. Symptoms may include headache, nausea, vomiting, fatigue, irritability, insomnia, or dizziness. Symptoms generally appear 4 to 24 hours after ascent to high altitude, reach peak severity in 24 to 48 hours, and subside over 3 to 7 days at the same altitude.

To treat acute mountain sickness, Marines must stop further ascent and descend. Continuing an ascent puts individuals at risk for more severe high-altitude illnesses. Acetazolamide may be used for the prevention of acute mountain sickness. Aspirin, ibuprofen, or acetaminophen may be used to treat headaches and prochlorperazine, promethazine, and Alka-Seltzer may be used to treat nausea. Acetazolamide can also be administered to help speed up the acclimatization process, which, in turn, helps to relieve acute mountain sickness symptoms. Avoid or minimize the use of aspirin, ibuprofen, acetaminophen, or other nonsteroidal anti-inflammatory drugs for an acute mountain sickness headache during combat operations because of their detrimental effect on blood coagulation.

Acute mountain sickness alone does not mean that descent is absolutely necessary. Stopping the ascent to rest and acclimatize to the same altitude will resolve acute mountain sickness in three days or less (in most individuals)—the best option in cases of mild acute mountain sickness. Medical therapy is crucial when descent is not possible. Use of any medication should be discussed with a physician.

Once symptoms have gone away, Marines can resume gradual ascent. Those who continue to show signs of acute mountain sickness must be observed for development of high altitude pulmonary edema or high altitude cerebral edema, which could be fatal.

All troops are susceptible to high altitude illness. A staged or graded ascent, or movement to a lower altitude, can prevent acute mountain sickness. Limited evidence suggests that a high carbohydrate diet, such as whole grains, vegetables, peas and beans, potatoes, fruits, honey, and refined sugar, can also reduce acute mountain sickness symptoms.

High-Altitude Pulmonary Edema

High altitude pulmonary edema occurs when individuals ascend too rapidly to high altitude or ascend too rapidly from a high to a higher altitude. High altitude pulmonary edema usually begins within 24 to 72 hours after rapid ascent to 2,438 meters (8,000 feet) or more. Symptoms include coughing, noisy breathing, wheezing, gurgling in the airway, difficulty breathing when at rest, and deteriorated behavioral status, such as confusion or vivid hallucinations. High altitude pulmonary edema occurs in up to 2 to 15 percent of people brought rapidly to altitudes above 2,438 meters (8,000 feet).

Marines experiencing acute mountain sickness who are not treated and continue to ascend to higher altitudes are at significant risk for high altitude pulmonary edema. If untreated, high altitude pulmonary edema can be fatal within 6 to 12 hours. It is the most common cause of death among altitude-related illnesses. Preventive measures include staged and graded ascent, proper acclimatization, sleeping at the lowest altitude possible, avoiding cold exposure, and avoiding strenuous exertion until acclimated.

Immediate descent is the best treatment for high-altitude pulmonary edema. If available, a hyperbaric chamber, such as the Gamow Bag (a portable hyperbaric chamber weighing 14 pounds), can take a patient from 4,267 to 2,134 meters (14,000 to 7,000 feet) in 4 to 6 hours if evacuation to lower altitudes is not possible. The Gamow Bag is operated by a foot pump, the bag is pressurized to an internal pressure of 2 pounds per square inch.

High-Altitude Cerebral Edema

High-altitude cerebral edema is the most severe illness associated with high altitudes. Individuals with high-altitude cerebral edema frequently have high-altitude pulmonary edema. As with other high-altitude illnesses, hig- altitude cerebral edema is caused by ascending too rapidly without proper acclimatization. Marines experiencing acute mountain sickness should be closely monitored for the development of high-altitude cerebral edema. Marines with acute mountain sickness who continue ascending are considered high risk for high altitude cerebral edema.

In general, high altitude cerebral edema occurs later than acute mountain sickness or high altitude pulmonary edema. If untreated, high altitude cerebral edema can progress to Marines entering a coma in 12 hours and death within 24 hours. In some instances, death has occurred in fewer than 12 hours. The average onset time of symptoms following ascent is 5 days, within a range of 1-to-13 days.

High altitude cerebral edema symptoms often resemble acute mountain sickness (e.g., severe headache, nausea, vomiting, and extreme lethargy); however, a more visible indicator for the onset of high altitude cerebral edema is a swaying upper body, especially when walking. Early behavioral deterioration may include confusion, disorientation, and inability to speak coherently. Marines can appear withdrawn or demonstrate behavior generally associated with fatigue or anxiety.

Preventive measures for high altitude cerebral edema are the same as for acute mountain sickness and high altitude pulmonary edema. Those with symptoms of high altitude cerebral edema should be evacuated immediately. High altitude cerebral edema treatment is immediate descent at first sign of symptoms, such as swaying upper body and change in behavioral status. Decadron and oxygen are used to treat high altitude cerebral edema. If available, a hyperbaric chamber (such as a Gamow Bag) can be used to stabilize patients if evacuation to lower altitudes is not possible, but must NOT be used as a substitute for descent.

Caution

The preferred step in treating any high-altitude illness is to evacuate affected individuals to a lower altitude. Under no circumstances should anyone with severe acute mountain sickness symptoms or suspected high altitude pulmonary edema or high altitude cerebral edema be allowed to continue their ascent.

High-Altitude Systemic Edema

High altitude systemic edema is the swelling of tissue and joint discomfort that can occur due to rapid ascent. Persons with high altitude systemic edema may not exhibit any other symptoms of high-altitude sickness.

High-Altitude Retinal Hemorrhaging

High altitude retinal hemorrhaging only occurs at extremely high altitudes (almost always found above 4,572 meters or 15,000 feet). Signs can only be seen with an ophthalmoscope. Vision can be blurred in severe cases.

Subacute Mountain Sickness

Subacute mountain sickness occurs in some people during prolonged deployments (weeks to months) to elevations above 3,474 meters (11,400 feet). Symptoms include sleep disturbance, loss of appetite, weight loss, and fatigue. This condition reflects a failure to acclimate adequately.

Poor Wound Healing

Poor wound healing may occur at higher elevations and results from lowered immune functions. Injuries, such as burns or cuts, may require descent for effective treatment and healing.

Environmental Threats

The following paragraphs address conditions that are not unique to mountainous environments but commonly occur at high elevations.

Nonbattle Injuries

Exhaustion, dehydration, lower limb orthopedic injuries, lower back injuries, frostbite, diarrhea, malaria, and weight loss are the most common nonbattle-related injuries in the mountains. Hypoxia, an inadequacy in the oxygen reaching the body's tissues, and cold can impair judgment and physical performance, resulting in a greater risk of injury while operating in rugged terrain.

Cold Injuries

Once a Marine has acclimated to altitude, cold injuries are generally the greatest threat. Frequent mountain winds may prove dangerous due to windchill effects. Because hypoxia-induced psychological effects can result in poor judgment and decision-making, a higher incidence of cold injuries should be anticipated. Preventive measures for cold injuries include command emphasis on maintaining nutrition, drinking plenty of fluids, and dressing in layers.

Heat Injuries

Standard heat injuries, such as heat cramps, heat exhaustion, and heat stroke, can occur in the mountains. They occur during movements, especially upslope with heavy loads or at high altitude with heavy loads. Personal protection equipment can restrict evaporation of sweat (body cooling) and also cause heat injuries. Commanders need to balance the load, personal protection equipment, and pace with the altitude and degree of slope.

Injuries Caused by Sunlight

The potential for solar radiation injuries caused by sunlight increases at high altitudes due to higher ultraviolet radiation in the thinner atmosphere and the reflection of light on snow and rock surfaces. Solar radiation injuries will occur with less exposure at high altitude than at low altitude and include sunburn and snow blindness.

Sunburn

Sunburn is more likely to occur on partly cloudy or overcast days when troops are unaware of the threat and fail to take appropriate precautions. Applying sun block (at least 30 SPF [sun protection factor]) to all exposed skin helps to prevent sunburn. Some medications, such as acetazolamide, increase the danger of sunburn.

Snow Blindness

Snow blindness results from ultraviolet light absorption by the external parts of the eyes, such as the eyelids and cornea. Initially, there is no sensation, other than brightness, as a warning that eye damage is occurring. Sunburn-like damage can occur in a matter of hours. Sunglasses or goggles with ultraviolet protection will prevent snow blindness. Sunglasses with side protectors are recommended. If sunglasses are lost or damaged, emergency goggles can be made by cutting slits in dark fabric or tape folded back onto itself.

Treatment for snow blindness includes covering the eyes with a dark cloth if the casualty is not needed to perform the mission. The cloth prevents light from reaching the eyes and it helps to keep the casualty from moving their eyes, which could result in additional pain. A muslin bandage can be folded into a cravat and used to keep the cloth in place or the cravat can be used as a blindfold. Do not put ointment in the eye.

Terrain Injuries

Marines must be aware of the high-altitude dangers, including snow avalanches and rock falls. Poor judgment at high altitude increases the risk of injury. The potential for being struck by lightning is also increased at higher altitudes, especially in areas above the tree line. Protective measures include taking shelter in solid-roofed structures or vehicles; laying in depressions, such as creek beds; and avoiding tall structures or large metal objects.

Carbon Monoxide Poisoning

Carbon monoxide poisoning is a frequent hazard. Heavier than oxygen, carbon monoxide settles in the bottom of tents and enclosures. Tent ventilation should be at the lowest point in the tent to ensure carbon monoxide is able to escape. The following can lead to increased carbon monoxide levels:

- Inefficient fuel combustion.
- Combustion heaters and engines in enclosed, poorly ventilated spaces.
- Cigarette smoking.

Preventive measures include ensuring that Marines do not sleep in vehicles with the engine running, ensuring heaters and stoves work properly, and ensuring tents have adequate ventilation.

Infectious Diseases

Although there is generally a reduced threat of disease at higher elevations, Marines should take precautions to avoid diseases caused by insects, plants, and animals and diseases transmitted person to person.

At moderate to high altitudes, insect-borne disease (from mosquitoes, ticks, and flies) is common. In some areas, malaria-bearing mosquitoes live as high as 1,828 meters (6,000 feet). The threat of diseases transmitted from person to person is increased at higher, cold climates because Marines will spend more time inside tents and huddling to stay warm. Crowding and poor ventilation in tents and other shelters increase dissemination of respiratory infections. The influenza (flu) vaccination is a preventive measure.

HIGH-ALTITUDE OPERATIONAL IMPACTS

The effects of altitude on the mind and body influence operations in several ways, as described in the following paragraphs.

Reduced Physical Performance

Hypobaric hypoxia causes a reduction in physical performance. Personnel cannot maintain the same physical performance at high altitude that they can at low altitude, regardless of their fitness level. Measures to prevent disease and injury include acclimatization, adjusting work rates and load carriage, planning frequent rests during work and exercise, and planning and performing physical training programs at altitude.

Psychological Effects

Altitude exposure can result in changes in vision, taste, mood, and personality. These effects are directly related to altitude and are common above 3,048 meters (10,000 feet). Some effects occur early and are temporary, while others may persist after acclimatization or even for a period of time after descent.

Vision

Vision is generally the sense most affected by altitude exposure. Dark adaptation is significantly reduced, affecting personnel as low as 2,438 meters (7,900 feet) and can affect military operations at high altitude.

Behavioral Effects

Behavioral effects are most noticeable at very high and extreme altitudes, and they include decreased perception, memory, judgment, and attention. To compensate for loss of functional ability, leaders should allow extra time to accomplish tasks.

Alterations in mood and personality traits are common during high altitude exposures. Within hours of ascent, many individuals could experience a euphoria (joy or excitement) that is likely to be accompanied by errors in judgment that may lead to mistakes and accidents. The buddy system during this early exposure time helps to identify Marines who can be more severely affected. Marines can become irritable, quarrelsome, anxious, apathetic, or listless. These mood changes reach a peak after 18 to 24 hours of altitude exposure and typically recede back to Marines' previous state after 48 hours at altitudes up to 4,724 meters (15,400 feet). Building "esprit de corps," and unit cohesion before deployment and reinforcing them during deployment helps minimize mood swings.

Sleep Disturbances

High altitude can have significant effects on ability to sleep. The most prominent effects are frequent periods of apnea (a brief pause in breathing) and fragmented sleep. According to the Army's Technical Bulletin Medical 505, sleep disturbances occur in nearly everyone functioning above 3,048 meters (10,000 feet). Also, reports of "not being able to sleep" and "awake half the night" are common and can also contribute to mood changes and daytime drowsiness. These effects have been reported at elevations as low as 1,524 meters (5,000 feet) and are very common at higher altitudes.

During cold-weather operations eating a snack before bedtime is helpful. Snacking before bedtime helps keep Marines warmer during sleep which prevents shivering and allows for sounder, more restful sleep. Ensuring adequate insulation when sleeping is also important as the body's core temperature decreases naturally during sleep.

Acetazolamide has been found to improve sleep quality at high altitudes and reduce acute mountain sickness and other altitude illnesses. Sleeping pills and other medications that promote sleep or drowsiness should be taken only with medical supervision.

Dehydration

Dehydration is a very common condition at high altitude. Perspiration, vomiting, decreased thirst sensation (hypoxia-induced), calorie deficiency, and increased energy needs due to exertion increase the risk of dehydration. Routine activities and chores performed at high altitudes— even common activities, such as walking—require increased exertion.

Dehydration can increase hot and cold weather injuries, altitude illness, and decreased physical capabilities. Dehydration and high-altitude cerebral edema symptoms are similar.

Marines can prevent dehydration at high altitudes by consuming at least 3 to 4 quarts of water (including water consumed in food) or other noncaffeinated fluids per day and 6 to 8 quarts during cold weather. Individuals can drink various fluids, such as juice or sports drinks, as each is an equally effective aid in rehydration. At high altitudes or cold weather, thirst is not an adequate warning of dehydration. Commanders must monitor Marines to ensure they drink enough fluids and do not become dehydrated. See Technical Bulletin Medical 505, *Altitude Acclimatization and Illness Management*, and 508, *Prevention and Management of Cold-Weather Injuries* for more information.

Nutrition

Poor nutrition contributes to illness or injury, decreased performance, poor morale, and susceptibility to cold injuries. Influences that impact nutrition at high elevations include a dulled taste sensation (making food undesirable), nausea, lack of energy, or lack of motivation to prepare or eat meals. Poor eating habits (lack of fruits and vegetables or eating only a few MRE ration components) and dehydration can also lead to constipation or aggravation of hemorrhoids.

Marines can reduce the effects of poor nutrition at high elevations by increasing their consumption rates. Rations should be supplemented, and frequent snacking encouraged. High carbohydrate snacks are recommended since they are easily carried and require no preparation. Technical Bulletins Medical 505 and 508 also have more information on t proper nutrition and cold-weather injury prevention.

Toxins

Other products that can seriously shape military operations include tobacco, alcohol, and caffeine. Tobacco smoke interferes with oxygen delivery by reducing the blood's oxygen-carrying capacities. Tobacco smoke in close, confined spaces increases the amounts of carbon monoxide. The irritant effect of tobacco smoke may produce a narrowing of airways that interferes with optimal air movement. Smoking can effectively raise the "physiological altitude" as much as several thousand feet. Alcohol impairs judgment and perception, depresses respiration, causes dehydration, and increases susceptibility to cold injury. Caffeine from coffee and other sources may improve physical and mental performance; however, it also causes increased urination (leading to dehydration) and should be consumed in moderation.

APPENDIX B. MOUNTAIN WEATHER DATA

COLD WEATHER CATEGORIES

Cold weather temperature extremes are seasonally associated with most mountainous environments and almost always associated with high altitude. Cold temperatures can have effects on personnel and equipment, it is important for military planners to understand the unique characteristics associated with operating in this type of weather. The Marine Corps divides cold weather temperatures into the four categories shown in Table B-1. The Marine Corps, expeditionary nature its equipment is generally not designed to operate below -25 °F. The climatic definitions outlined in the following paragraphs generally have the same effect on operations.

Table B-1. Marine Corps and Army Temperature Categories.

Marine Corps		Army	
Wet Cold	+39 °F to +20 °F	Wet Cold	+39 °F to +20 °F
Dry Cold:	+19 °F to -4 °F	Dry Cold:	+19 °F to -4 °F
Intense Cold:	-5 °F to -25 °F	Intense Cold:	-5 °F to -25 °F
Extreme Cold:	Below -25 °F	Extreme Cold:	-25 °F to -40°F
		Acute cold	-40 °F and below

Wet Cold

Wet snow and rain often accompany wet cold conditions. This environment is often more dangerous to Marines and equipment than the colder, dry cold environments because the ground becomes slushy and muddy and clothing, and equipment become wet and damp. Because water conducts heat 25 times faster than air, core body temperatures can quickly drop if Marines become wet and the wind is blowing; they can rapidly become casualties due to weather if not properly equipped, trained, and led. Wet cold environments combined with wind can be even more dangerous because of the wind's effect on the body's perceived temperature (see Tables B-2 and B-3). Wet cold conditions can quickly lead to hypothermia, frostbite, and trench foot. Wet cold conditions are not only found in mountainous environments, but also in many other environments during seasonal transition periods. Under wet cold conditions, the ground alternates between freezing and thawing because the temperatures fluctuate above and below the freezing point, which makes planning problematic. For example, areas that are trafficable when frozen could become severely restricted if the ground thaws (for more information see MCRP 12-10A.4).

Table B-2. Windchill Chart.

		Air Temperature (°F)																	
		40	**35**	**30**	**25**	**20**	**15**	**10**	**5**	**0**	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**
Wind Speed (mph)	**5**	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
	10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
	15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
	20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
	25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
	30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
	40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
	45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
	50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95

Wind speed based on measures at 33 feet height. If wind speed measured at ground level multiply by 1.5 to obtain wind speed at 33 feet and then utilize chart.

WCT (°F) = 35.74 + 0.6215T – 35.75(V0.16) + 0.4275T(V0.16)
Where T is temperature (°F) and V is wind speed (mph)

Risk of frostbite (see times on chart below)
GREEN — LITTLE DANGER (frostbite occurs in >2 hours in dry, exposed skin)
YELLOW — INCREASED DANGER (frostbite could occur in 45 minutes or less in dry, exposed skin)
RED — GREAT DANGER (frostbite could occur in 5 minutes or less in dry, exposed skin)

Time to occurrence of frostbite in minutes or hours in the most susceptible 5% of personnel.

Dry Cold

Like wet cold, proper equipment, training, and leadership are critical to successful operations. Though temperatures are colder, the dry cold environment is the easiest of the four cold weather categories in which to survive because of low humidity and constant frozen ground. As a result, people and equipment are not subject to the effects of the thawing and freezing cycle and precipitation is generally in the form of dry snow. Windchill, however, is a complicating factor in this type of cold.

Intense Cold

Intense cold exists from -5 °F to -25 °F and can affect the mind as much as the body. Intense cold has a rapid numbing effect. Simple tasks take longer and require more effort than in warmer temperatures and the work quality degrades as attention to detail diminishes. Clothing becomes bulkier to compensate for the cold, so Marines lose dexterity. Commanders must consider these factors when planning operations and assigning tasks.

Extreme Cold

When temperatures fall below -25 °F, the Marine's survival is paramount. During extreme cold conditions, it is easy for Marines to prioritize physical comfort above all else. Personnel might withdraw into themselves and adopt a cocoon-like existence.

Table B-3. Risk of Frostbite.

	Air Temperature (°F)											
Wind Speed (mph)	**10**	**5**	**0**	**-5**	**-10**	**-15**	**-20**	**-25**	**-30**	**-35**	**-40**	**-45**
5	>2h	>2h	>2h	>2h	31	22	17	14	12	11	9	8
10	>2h	>2h	>2h	28	19	15	12	10	9	7	7	6
15	>2h	>2h	33	20	15	12	9	8	7	6	5	4
20	>2h	>2h	23	16	12	9	8	8	6	5	4	4
25	>2h	42	19	13	10	8	7	6	5	4	4	3
30	>2h	28	16	12	9	7	6	5	4	4	3	3
35	>2h	23	14	10	8	6	5	4	4	3	3	2
40	>2h	20	13	9	7	6	5	4	3	3	2	2
45	>2h	18	12	8	7	5	4	4	3	3	2	2
50	>2h	16	11	8	6	5	4	3	3	2	2	2

NOTE: Wet skin significantly decreases the time for frostbite to occur.

LEGEND
> greater than
h hour
mph miles per hour

Leaders must expect and plan for weapons, vehicles, and munitions to fail in this environment. Most military equipment is tested and required to perform only at temperatures above -25 °F. As in other categories, leadership, training, and specialized equipment is critical to operate successfully in this environment.

Acute Cold

Commanders and planners are warned that operations below -40 °F are extremely hazardous. Units must be extensively trained before undertaking an operation in these temperature extremes.

PRECIPITATION CONDITIONS

Mountain precipitation is a result of several factors, the most important being humidity and air flow. It is important for military planners and leaders at all levels to understand the causes of precipitation in mountains and why precipitation rates vary. Precipitation results from cloud formations that, when accompanied by a drop in barometric pressure, are the best indicators of approaching adverse weather. Planners need to understand how clouds form and why precipitation occurs in order to predict mountain weather and its effect on operations. Before understanding clouds, however, a few meteorological concepts must be explained: humidity, air movement, cloud formation, and atmospheric pressure.

Humidity

Humidity is the amount of moisture in the air. The amount of moisture air can hold is proportional to its temperature: the warmer the temperature, the more water the air can hold. Accordingly, cold air holds less moisture than warm air. Air is considered to be at its saturation point when it has 100 percent relative humidity. When air that is saturated is cooled, the moisture is released in various forms, such as clouds, rain, dew, snow, sleet, and fog. The temperature at which this occurs is called the condensation (dew) point. The dew point varies depending on the amount of moisture in the air at the time it begins to cool. Air that contains a lot of moisture, or high humidity, can reach its dew point when the temperature cools to 68 °F. However, in very dry environments, condensation might not occur until the temperature drops to 32 °F.

Air Movement

There are three ways that air can be lifted and cooled beyond its dew point—orographic uplift, convection, and frontal lifting. Mountain environments often experience some or all three, which contributes to the unpredictability of mountain weather.

Orographic Uplift. This phenomenon happens when an air mass is pushed up and over a mass of higher ground, such as a mountain. Due to the increase in altitude, the air cools until it reaches its condensation point. The result is precipitation. This type of lifting and cooling is the most common type in mountainous environments. In large mountainous areas where there are prevailing winds, the side of the mountain facing the wind often experiences high levels of precipitation while the backside of the mountain is drier because the clouds release their moisture before reaching the top and the air warms as it rolls down the opposite side. This weather also occurs even in warm weather mountainous areas. For example, the windward side of the Hawaiian Islands experiences a lot of rain, but the leeward side is comparatively dry and warm.

Convection Effects. Convection is usually a summer effect due to the sun’s heat reradiating from the earth’s surface and causing air currents to push straight up and lift air to its condensation point.

Frontal Lifting. Frontal lifting occurs when two air masses of different temperature and moisture content collide. The resultant phenomena are known as fronts. Since the air masses will not mix, the warmer air is forced aloft; from there it is cooled until it reaches its condensation point.

Cloud Formations

Any time air is cooled below its saturation point, clouds are formed. Marines who can identify and understand how clouds are formed can help predict weather changes, which is important to those who are planning or executing mountain operations. Clouds can be described and classified by height, by appearance, or by the amount of area covered (vertically or horizontally). Meteorologists recognize many different types of clouds. Cirrus, stratus, and cumulus are the most useful to military planners.

Cirrus clouds are formed of ice crystals at very high altitudes (usually 6,096 to 10,668 meters or 20,000 to 35,000 feet) but are thin, feathery clouds at the mid-altitudes. These clouds generally point in the direction of the air movement at their elevation and can provide Marines up to 24 hours warning if bad weather is approaching. Frail, scattered types, such as “mare tails” or dense cirrus layers are a fair-weather sign but is an indicator of precipitation and a front.

Stratus clouds are formed at low and mid altitudes when a layer of moist air is cooled below its saturation point. Stratus clouds lie mostly in horizontal layers or sheets that resist vertical development. The word "stratus" is derived from the Latin word for "layer." A stratus cloud is characteristically uniform and resembles fog. It has a uniform base and a dull, gray appearance. Stratus clouds appear heavy and a fine drizzle or very light snow with fog can occur. Because there is little or no vertical movement in stratus clouds, heavy precipitation does not occur.

Cumulus clouds are formed from rising air currents and are prevalent in unstable air that favors vertical development. These air currents create cumuliform clouds that give them a piled or bunched up appearance, looking like cotton balls. Within the cumulus family there are three different cloud types——

- Cumulus are fair weather clouds, but Marines must observe them for possible growth into towering cumulus and cumulonimbus.
- Towering cumulus clouds are characterized by vertical development. Their vertical lifting is caused by some type of lifting action; for example, during summer afternoons when wind is forced to rise, the mountain slope or the lifting action from a frontal system. The towering cumulus has a puffy, cauliflower-shaped appearance.
- Cumulonimbus clouds are characterized in the same manner as the towering cumulus, forming the familiar thunderhead that thunder-storm activity occurs. These clouds are characterized by violent updrafts that carry the cloud tops to extremely high elevations. Tornadoes, hail, and severe rainstorms happen when cumulonimbus clouds form. At the top of the cloud, a flat anvil-shaped form appears as the thunderstorm begins to dissipate.

Atmospheric Pressure

Besides cloud formations, changes in weather are also indicated by changes in atmospheric (barometric) pressure. Decreasing pressure usually indicates deteriorating weather, although increasing pressure usually indicates improving or good weather.

WIND

Mountains greatly affect the air flow and amplify wind speed. Generally, valley winds on south-facing slopes (north-facing slopes in the southern hemisphere) change direction at different times of the day. When the temperature increases, air rises and is less dense, resulting in gentle winds; however, at night the direction is reversed, and it turns into a down slope wind. Down slope winds are caused by cooling air, which can occasionally be very strong. Wind speeds change as winds flow across mountains. For example, winds traveling down the leeward slope can become especially strong. Examples of these types of very strong winds include the Foehn in the Alps, the Chinook winds in the Rockies, and the Zonda winds in the Andes.

When winds converge through mountain passes and canyons, a funneling effect is created. Because of this, wind may blast with great force on an exposed mountainside or summit. Mountain winds are subject to strong gusts and the force exerted by wind quadruples each time wind speed doubles; that is, wind blowing at 40 knots pushes four times harder than a wind blowing at 20 knots. So, it is important to pay attention not only to prevailing winds in the mountains, but wind gusts as well. Wind combined with cold temperatures creates windchill (see Tables B-2 and B-3), which can cause freezing and frostbite to exposed skin.

LIGHT DATA

Sunrise, sunset, and the amount of usable light available for operations is relative to where personnel are physically located. Light data analysis in the mountains must be specific to the local area to be relevant to operations. See MCRP 12-10A.4 for detailed information on predicting illumination depending on the time of year.

MOUNTAIN WEATHER HAZARDS

Mountains create many natural hazards due to their slope and elevation. The following paragraphs provide information on landslides, avalanches, lightning strikes, flooding, and extreme cold weather. Although there are other numerous hazards, these hazards can cause a catastrophic mission failure. By identifying these hazards, planners and leaders can mitigate these risks through composite risk management.

Landslides and Rockfalls

Landslides are caused when a slope's natural stability is disturbed. Although they are not as common or dangerous as avalanches, they cause approximately two dozen deaths per year in the United States. Sometimes called mudslides, they usually accompany heavy rains or follow droughts, earthquakes, volcanic eruptions, or large explosions. They occur when water rapidly accumulates in the ground and results in a surge of water-saturated rock, earth, and debris. They usually start on steep slopes and have been known to bury entire villages. Rockfalls are not landslides, but they can be dangerous. They usually occur in the springtime when the freeze-thaw action is most prevalent. This action causes boulders and rocks to dislodge and tumble down hills or cliffs. Rockfalls can block routes, injure personnel, and damage vehicles that are traveling beneath them. Engineers should conduct route reconnaissance along steep mountain trails that are cut into cliff sides because these trails are often susceptible to rockfalls. In addition, because many mountain trails are often designed for foot or animal traffic, they can have unstable edges that can give way under heavy vehicle traffic, causing a rockfall or even a landslide of its own.

Avalanches

Avalanches are similar to landslides; however, they occur on snow-covered mountains when the snow's weight exceeds the cohesive forces that hold the snow in place. Like landslides, pre-existing terrain conditions (slope characteristics and no ground cover) and weather (prevailing winds and snow type) combine with a trigger, which is often human activity, to cause avalanches. Military leaders should take advantage of avalanche maps and advice from local inhabitants and be trained to recognize and avoid avalanche danger areas whenever possible.

The following slope characteristics are usually key factors in determining the likelihood of avalanche danger:

- *Slope angle*. Slopes as gentle as 15 degrees have avalanched; however, most avalanches occur on slopes between 30 degrees and 45 degrees. Very few avalanches occur on slopes that are above 60 degrees, because such slopes are too steep to accumulate significant snow amounts.
- *Slope profile*. Dangerous slab avalanches are more likely to occur on convex slopes, but occasionally occur on concave slopes.
- *Slope aspect*. Snow on north-facing slopes is more likely to slide in midwinter while snow on south-facing slopes is most dangerous in the spring and on sunny, warm days. Wind-ward slopes are generally more stable than leeward slopes.
- *Ground cover*. Rough terrain and terrain with more vegetation is more stable than smooth terrain. Avalanches are more likely on grassy slopes or scree because the snow pack does not have any natural anchors to which it can adhere.

The weather is also a significant factor in determining the risk of avalanche in the following ways:

- *Temperature*. In low temperatures, settlement and adhesion occur slowly. Avalanches during extreme cold weather usually occur during or immediately following a storm. When temperature is just below freezing, the snow pack stabilizes quickly. At temperatures above freezing, especially if the temperature rises quickly, the potential for avalanche is high. Storms with a rise in temperature can deposit dry snow early, which bonds poorly with the heavier snow deposited later. As a result, most avalanches occur during the warmer midday.
- *Precipitation*. About 90 percent of avalanches occur during or within 24 hours of a snowstorm. Additionally, the rate at which snow falls is important. High rates of snowfall (2.5 centimeters [1 inch] or more per hour), especially when accompanied by wind, are usually associated with periods of avalanche activity. Rain after a snow fall increases the weight of snow and tends to weaken the snow pack, increasing the likelihood of an avalanche.
- *Wind*. In sustained winds of 15 miles per hour or greater, snow builds up in wind slabs on the leeward side slopes, which is why avalanches are more prone on the leeward slope than the windward slope.

Most victims trigger the avalanche that buries them. Generally, it is the additional weight of personnel or vehicles that triggers an avalanche. In some cases, triggers can be manmade noise or vibrations from vehicles, low-flying helicopters, firing, or explosions.

Extreme Cold Weather

Extreme cold weather can overwhelm forces that are unprepared. See MCRP 12-10A.4 for information on the following unique weather phenomena that can affect military operations in extreme cold environments:

- Ice fog.
- Blizzards.
- Whiteout.
- Grayout.
- Temperature inversion.

Lightning Strikes

Lightning strikes frequently in the mountains due to rapidly changing and often violent weather patterns. Lightning kills approximately 50 people annually in the United States and it is particulary deadly in mountains. Lightning naturally seeks a path to high points and prominent features, so mountain peaks are prime targets. During thunderstorms, personnel should avoid mountain ridges, isolated trees, crests, peaks, and rock needles. Also, because lightning flows around and through objects like water, personnel should avoid gullies, washes, shallow depressions, shallow overhangs.

Flooding

During the seasonal runoff, mountain-fed rivers can become extremely hazardous and rain at high elevations in snow-covered mountains can cause flash flooding. Many dry riverbeds also become hazardous and are at risk to flash flood.

Mountain Weather Effects on Operations

Weather and visibility conditions in the mountainous regions of the world may create unprecedented advantages and disadvantages for combatants. To fight effectively, the commander must acquire accurate weather information about the area of operations. Terrain has a dominant effect on local climate and weather patterns in the mountains. Mountainous areas are subject to frequent and rapid changes of weather, including fog, strong winds, extreme heat, cold, and heavy rain or snow. As a result, many forecasts that describe weather over large areas of terrain are inherently inaccurate. Commanders must be able to develop local, terrain-based forecasts by combining available forecasts with field observations (local temperature, wind, precipitation, cloud patterns, barometric pressure, and surrounding terrain).

Forecasting mountain weather from the field improves accuracy and enhances the ability to exploit opportunities offered by the weather, while minimizing its adverse effects. Table B-4 highlights the effects of weather in the mountains versus in flat terrain. Weather conditions in the mountains will have a significant impact on all military operations (see Tables B-4 through B-12). The impact of weather on specific types of operations is highlighted in MCRP 2-10B.6, *MAGTF Meteorological and Oceanographic Operations*.

Table B-4. Potential Weather Effects.

Weather Condition	Flat to Moderate Terrain Effects	Added Mountain Effects
Sunshine	• Sunburn • Snow blindness • Temperature differences between sun and shade	• Increased sunburn and snow blindness increased risk • Severe, unexpected temperature variations between sun and shade • Avalanches
Wind	• Windchill	• Increased risk and windchill severity • Blowing debris or driven snow causing reduced visibility Avalanches
Rain	• Reduced visibility • Cooler temperatures	• Landslides • Flash floods • Avalanches
Snow	• Cold weather injuries • Reduced mobility and visibility • Snow blindness • Blowing snow	• Increased risk and severity of common effects • Avalanches
Storms	• Rain and snow • Reduced visibility • Lightning	• Extended duration and intensity greatly affecting visibility and mobility • Extremely high winds • Avalanches
Fog	• Reduced mobility/visibility	• Increased frequency and duration
Cloudiness	• Reduced visibility	• Greatly decreased visibility at higher elevations

Table B-5. Weather Effects on Intelligence Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 200 ft	Engagement range
	< 1,000 ft	Aerial observation
Surface visibility at the following wavelengths: 1.06 m, 3–5 m, 8–12 m	< 1 mi	Determination of enemy's ability to conceal actions Location and identification of targets
Wind (surface)	>60 kt	Equipment damage
Precipitation	>0.1 in/h liquid	Audio sensors and radar effectiveness
	>0.5 in/h liquid	Speed of personnel and equipment movement
	>2 in within a 12-h period	Speed of personnel and equipment movement trafficability and storage of equipment
Snow depth and cover	>6 in	Trafficability
Thunderstorms and lightning	Any occurrence within 3 mi	Troop and equipment safety false alarms and false readings
Temperature (surface)	> 122 °F < -58 °F	Emplacement site selection
Temperature (ground)	< 32 °F	Trafficability assessment
Wet bulb globe temperature	> 85 °F	Troop safety
EM propagation	Subrefraction and super refraction	Ducting of radar transmission and returns
Effective illumination	<0.0011 lux	Target acquisition
River stage and current strength	>6-ft depth	Enemy's ability to cross rivers or streams

LEGEND

EM	electromagnetic	ft	feet	h	hour				
in	inch	in/h	inches per hour	kt	knot				
m	meter	mi	mile	>	greater than	<	less than	≤	less than or equal to

Table B-6. Weather Effects on Ground Maneuver Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 1,000 ft	• Concealment and cover from threat surveillance • Tactical air and aerial supply support • Background contact for target acquisition or using thermal devices
Surface visibility at the following wavelengths: 1.06 m, 3–5 m, 8–12 m	TOW < 1,600 m	• System selection
Wind (surface)	> 7 kt	• Smoke operations • Background radar noise
	>20 kt	• Visibility restriction in blowing sand and snow • Soil drying speed • Aerial resupply • Windchill effect on equipment and personnel
	>30 kt	• Accuracy of antitank missiles
	>75 kt	• Antenna failure
	> 125 kt	• Equipment (van) failure
Precipitation	>0.1 in/h liquid	• Soil type (affected by temperature and moisture)
	>2 in within a 12-h period	• Vehicle movement • Site location • River levels • Runoff • Flooding • Delays in resupply • Demolitions • River crossing • Visibility • Target acquisition • Radar effectiveness
Snow depth and cover	>2 in within a 12-h period	• Effectiveness of mines
	>6 in	• Choice of construction materials
	>24 in	• Trafficability
Freeze and thaw depth	< 6 in	• Off-road employment of wheeled and tracked vehicles
Thunderstorms and lightning	Any occurrence within 3 mi	• Munitions safety • Personnel communications equipment safety
Temperature (surface)	≥ 122 °F	• Thermal sights
	> 90 °F	• Lubricants, personnel, and infrared sensors
	> 32 °F	• River crossing sites and off-road movements (affected by melting snow and ice)
	< 32 °F	• Drying of soil • Freeze or thaw depth
	<-50 °F	• Lubricants gel and vehicles become inoperable
	Any change of 50 °F	• Munitions trajectories
Windchill	• ≤ -25 °F 1-min exposure • < -75 °F 1-sec exposure	Time before exposed flesh will suffer frostbite

LEGEND

TOW tube launched, optically tracked, wire guided

ft feet in/h inches per hour > greater than

h hour kt knot ≥ greater than or equal to

in inch mi mile < less than

m meter min minute ≤ less than or equal to

sec second

Table B-7. Weather Effects on Field Artillery Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 600 ft	• Target acquisition • Copperhead performance
Visibility—slant range at the following wavelengths: 1.06 m, 3–5 m, 8–12 m	≤ 100 mi	Target acquisition
Wind—vertical profile	5-kt change/3,280 ft	• UAS operations • Nuclear fallout prediction
Thunderstorms and lightning	Any occurrence within 3 mi	• Safety and storage of munitions
Effective illumination	< 0.0011 lux	• Mission planning for night artillery operations

LEGEND
ft feet   kt knot
m meter   mi mile   > greater than   < less than   ≤ less than or equal to

Table B-8. Weather Effects on Engineer Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 500 ft	• Area of operations and location of facilities • Personnel safety • Aerial reconnaissance • Camouflage needs
Visibility (surface)	≤ 0.25 mi	• Mission planning • Concealment and cover
Wind (surface)	≥13 kt	• Construction and stability of bridges and structures
Precipitation	>0.5 in/h liquid	• Need for mines (reduced) • Loading and offloading operations
Snow depth and cover	>2 in within a 12-h period	• Some areas of operations and locations of facilities • Stability of bridge structures • Types of demolitions to be used and size and charge • Blast from trigger mechanisms (may render mines ineffective)
Freeze and thaw depth	< 6 in	• Trafficability determination
Thunderstorms and lightning	Any occurrence within 1 mi of site	• Equipment and personnel safety • Munitions protection
Temperature (ground)	< -32 °F	• Freeze or thaw depth determination • Construction material • Operations, personnel, and structures (threatened as a result of precipitation at or below 32 °F)
Humidity	>35%	• Comfort, equipment operations, and site selection planning

LEGEND
ft feet ““““““““““““““““““““““> greater than
in inch ““““““““““““““““““““““≥ greater than or equal to
in/h inches per hour ““““““““““< less than
kt knot ≤ less than or equal to
m meter mi mile

Table B-9. Weather Effects on Aviation and Air Assault Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 300 ft (90 m)	• Map-of-the-earth planning and acquisition—rotary wing
	< 300 ft (90 m) flat terrain	• Daylight target acquisition—fixed wing
	≤ 500 ft (150 m) mountainous terrain	• Daylight target acquisition—fixed wing
	≤ 500 ft (150 m) flat terrain	• Night target acquisition—fixed wing
	≤ 1,000 ft (300 m) mountainous terrain	• Night target acquisition—fixed wing
Visibility (surface)	≤ 0.25 mi (400 m)	• Navigation and target acquisition—rotary wing
	≤ 1 mi (1,600 m)	• Landing and takeoff minimums for mission planning
	≤ 3 mi (4,800 m)	• Landing and takeoff minimums for mission planning
Visibility (slant range)	≤ 0.25 mi (400 m)	• Navigation and target acquisition—rotary wing
	≤ 3 mi (4,800 m) mountainous terrain	• Navigation and target acquisition—rotary wing
Wind (surface)	> 30kt	• Mission planning
	> 15-kt gust spread	• Aircraft safety
Wind (aloft)	> 30 kt	• Mission planning—duration
Precipitation	Any freezing	• Rotorblade icing • Aircraft survivability and damage
	> 0.5 in/h liquid	• Target acquisition
Hail	≥ 0.25-in diameter	• Aircraft damage
Snow depth and cover	> 1 in (2.54 cm) powder	• Location of LZ and drop zone; vertigo
Icing	≥ Light (clear/rime)	• Mission planning and safety • Ordnance delivery restrictions—rotary wing
Turbulence	Moderate	• Mission planning • Aircraft survivability
Thunderstorms and lightning	Any occurrence within 3 mi of site	• Refueling and rearming operations
Density altitude: variable with aircraft, weight, power, and temperature	> 6,900 ft	• Flight control, runway limits, takeoff, and landing
Effective illumination	< 0.0011 lux	• Mission planning for night operations

LEGEND

cm centimeter > greater than
ft feet ““““““““““““““““““““““““““““““““≥ greater than or equal to
in inch ““““““““““““““““““““““““““““““““““< less than
in/h inches per hour ≤ less than or equal to
kt knot
m meter mi mile

Table B-10. Weather Effects on Communications and Information Systems.

Element	Critical Value	Impact
Wind (surface)	> 7 kt	• Radar background noise
	> 25 kt	• Safety and stability for installing LOS and troposcatter antennas
	> 69 kt	• Wind damage to main communications antenna—linear pole
	> 78 kt	• Safety and stability of SCR and short-range, wideband radio antennas
Precipitation	Any occurrence of freezing	• Damage to equipment and antennas • Wind tolerances of antennas • Troop safety
	> 0.5 in/h liquid	• Blocking of troposcatter transmission • Radar range (decreased) • Signal for SCR, short-range wideband radio, and LOS communications (attenuated by precipitation)
Thunderstorms and lightning	Any occurrence within 3 mi	• Damage to equipment • Interference with radio signals, especially HF signals
Temperature (vertical gradient or profile)	All significant inversions	• Fading during use of troposcatter equipment
Ionospheric disturbances	Not applicable	• Dictation of most usable frequencies for communications

LEGEND
in inch in/h inches per hour kt knot
mi mile > greater than

Table B-11. Weather Effects on Logistics Operations.

Element	Critical Value	Impact
Snow depth and cover	> 2 in	Trafficability
Freeze and thaw depth	< 6 in	Site and equipment selection; mobility
Thunderstorms and lightning	Any occurrence within 3 mi	Equipment, personnel, and munitions safety
Temperature (surface)	> 122 °F	Storage and required temperature control for movement of medicines
	< -25 °F	Munitions storage
Humidity	> 70%	Storage of selected supplies and munitions

LEGEND
in inch mi miles
> greater than < less than

Table B-12. Weather Effects on Airborne Operations.

Element	Critical Value	Impact
Ceiling—cloud and sky cover	≤ 300 ft (90 m) flat terrain	• Mission planning (day)—jump altitude, aircraft penetration
	≤ 500 ft (150 m) flat terrain	• Mission planning (night)—jump altitude, aircraft penetration
	≤ 500 ft (150 m) mountainous terrain	• Target acquisition (day)
	≤ 1,000 ft (300 m) mountainous terrain	• Target acquisition (night)
	≤ 10,000 ft (3,000 m) mountainous terrain	• Mission planning for LZ or drop zone
Surface visibility at the following visible wavelengths::1.06 m, 3–5 m, 8–12 m	≤ 0.25 mi (400 m)	• Mission planning—infrared sensors, navigation and target acquisition—rotary wing
	≤ 1 mi (1,600 m)	• Day mission planning—minimum takeoff or landing, minimum fixed wing
	≤ 3 mi (4,800 m)	• Night mission planning—minimum takeoff or landing, minimum fixed wing
Wind (surface)	≥ 13 kt	• Troop safety for paradrop operations; limiting value for operations during training
	≥ 15 kt (> 21 kt for C-12 and U-21 aircraft)	• Mission planning and aircraft safety and recovery
	≥ 25 kt (OV-1 aircraft) ≥ 30 kt and/or gust speeds	• Mission planning and aircraft safety and recovery
Wind (aloft)	≥ 40 kt	• Jump point Planning for flight route and duration
Precipitation	Any intensity or type	• Rate of troop fall and target acquisition
Thunderstorms and lightning	Any occurrence	• Aircraft performance; aircraft refueling; reliability of communications systems • Predetonation of certain munitions
Temperature (surface)	< 32 °F (0 °C)	• Ground conditions
Pressure altitude	< 100 ft	• Parachute opening altitude
Density altitude: variable with aircraft, weight, power, and temperature	> 6,900 ft	• Planning Cargo limits
	>	
	>	
LEGEND °C Celsius ft feet kt knot m meter mi mile > greater than ≥ greater than or equal to < less than ≤ less than or equal to		

GLOSSARY

Section I. Abbreviations and Acronyms

°C	degree Celsius
°F	degree Fahrenheit
ACE	aviation combat element
AMD	air mobility division
ATTP	Army tactics, techniques, and procedures
BFT	blue force tracking
CAS	close air support
CASEVAC	casualty evacuation
CBRN	chemical, biological, radiological, nuclear
COP	combat outpost
CSS	combat service support
DASC	direct air support center
DoD	Department of Defense
DTCS	Distributed Tactical Communications System
EOB	electromagnetic order of battle
ETT	embedded training team
EW/C	early warning and control
FAC	forward air controller
FAC(A)	forward air controller (airborne)
FARP	forward arming and refueling point
FDC	fire direction center
FLOT	forward line of own troops
FM	field manual (Army)
FOB	forward operating base
FSR	First Strike Ration

GCE	ground combat element
GPS	Global Positioning System
HF	high frequency
HST	helicopter/tiltrotor support team
HUMINT	human intelligence
IED	improvised explosive device
IPB	intelligence preparation of the battlespace
ISB	intermediate staging base
ISR	intelligence, surveillance, and reconnaissance
JP	joint publication
JTAC	joint terminal attack controller
LAAD	low-altitude air defense
LNO	liaison officer
LOC	line of communications
LOS	line of sight
LZ	landing zone
MACCS	Marine air command and control system
MAGTF	Marine air-ground task force
MALS	Marine aviation logistics squadron
MARFORCENTCOM	Marine Forces, Central Command
MARINE TACC	Marine tactical air command center
MCMWTC	Marine Corps Mountain Warfare Training Center
MCRP	Marine Corps reference publication
MCTP	Marine Corps tactical publication
MCW	meal, cold weather
MCWP	Marine Corps warfighting publication
MEDEVAC	medical evacuation
METT-T	mission, enemy, terrain and weather, troops and support available—time available
mm	millimeter
MOS	military occupational specialty
MRE	meal, ready to eat
MSR	main supply route
MUX	multichannel radio

NAVMC	Navy/Marine Corps departmental publication
NCO	noncommissioned officer
NWTC	Northern Warfare Training Center (Army)
OEF	Operation ENDURING FREEDOM
SATCOM	satellite communications
SCR	single-channel radio
SIGINT	signals intelligence
TACSAT	tactical satellite
TAOC	tactical air operations center
TO&E	table of organization and equipment
TOS	time on station
TTP	tactics, techniques, and procedures
UAS	unmanned aircraft system
UHF	ultrahigh frequency
US	United States
USASOC	United States Army, Special Operations Command
VHF	very high frequency

Section II. Terms

combat service support

The essential capabilities, functions, activities, and tasks necessary to sustain operating forces in theater at all levels of warfare. Also called CSS. (DoD Dictionary)

defensive operations

Operations conducted to defeat an enemy attack, gain time, economize forces, and develop conditions favorable to offensive and stability operations. The three types of defensive maneuver are position, mobile, and retrograde. (USMC Dictionary)

logistics

1. The science of planning and executing the movement and support of forces. 2. All activities required to move and sustain military. (DoD Dictionary)

maneuver

Employment of forces in the operational area, through movement in combination with fires and information, to achieve a position of advantage in respect to the enemy. Maneuver is one of the seven warfighting functions. See also warfighting functions.

offensive operations

Operations conducted to take the initiative from the enemy, gain freedom of action, and generate effects to achieve objectives. The four types of offensive operations are movement to contact, attack, exploitation, and pursuit. (USMC Dictionary)

stabilization activities

Various military missions, tasks, and activities conducted outside the United States in coordination with other instruments of national power to maintain or reestablish a safe and secure environment and provide essential governmental services, emergency infrastructure reconstruction, and humanitarian relief. (DoD Dictionary)

tempo

The relative speed and rhythm of military operations over time with respect to the enemy. (USMC Dictionary)

References and Related Publications

Federal Issuance

United States Code

Title 10	Armed Forces

Joint Issuances

Joint Publications (JPs)

3-09.3	Close Air Support
3-30	Command and Control for Joint Air Operations
3-34	Joint Engineer Operations
3-50	Personnel Recovery

Navy/Marine Corps Departmental Publications (NAVMC)

3500.70X	Mountain Warfare Operations Training and Readiness Manual

Department of Defense Dictionary of Military and Associated Terms

Marine Corps Publications

Marine Corps Warfighting Publication (MCWP)

2-10	Intelligence Operations

Marine Corps Tactical Publications (MCTPs)

2-10A	MAGTF Intelligence Collection
3-01A	Scouting and Patrolling
3-01D	Tactical Employment of Mortars
3-10F	Fire Support Coordination in the Ground Combat Element
3-20B	Aviation Ground Support
3-20E	Assault Support
3-20F	Control of Aircraft and Missiles
3-34A	Combined Arms Mobility
3-34B	Combined Arms Countermobility Operations
3-34D	Seabee Operations in the MAGTF
3-40A	Health Service Support Operations
3-40D	General Engineering
3-40E	Maintenance Operations
10-10C	MAGTF Counter-Improvised Explosive Device Operations

Marine Corps Reference Publications (MCRPs)

2-10A.8 MTTP for Intelligence, Surveillance, and Reconnaissance (ISR) Optimization
2-10B.1 Intelligence Preparation of the Battlespace.
2-10B.4 Geospatial Information and Intelligence
2-10B.6 MAGTF Meteorological and Oceanographic Support
2-10B.7 Company-Level Intelligence Cell
3-05.3 Multi-service Tactics, Techniques, and Procedures for Personnel Recovery
3-10E.3 Tactics, Techniques, and Procedures for the Field Artillery Cannon Battery
3-10E.4 Tactics, Techniques and Procedures for the Field Artillery Manual Cannon Gunnery
3-10E.6 TTPs For Marine Artillery Sensor Operations
3-10E.7 Tactics, Techniques, and Procedures for Field Artillery Target Acquisition
3-20A.1 Coalition Forward Arming and Refueling Point (FARP) Interoperability Pamphlet
3-31.6 Multi-Service Tactics, Techniques, and Procedures for the Joint Application of Firepower
3-32D.1 Electromagnetic Warfare
3-34.3 Engineer Reconnaissance
3-40A.6 Multiservice Tactics, Techniques, and Procedures for Health Service Support in a Chemical, Biological, Radiological, and Nuclear Environment
3-40B.7 Waste Management for Deployed Forces
3-40E.1 Recovery and Battle Damage Assessment and Repair (BDAR)
3-40G.1 Marine Corps Field Feeding Program
10-10E.7 Multi-Service Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Reconnaissance and Surveillance
12-10A.2 Mountain Leader's Guide to Winter Operations
12.10A.4 Cold Region Operations

Marine Corps Training Manuals (TMs)

4-33.31Cold Weather Maintenance Operations

Miscellaneous

Marine Corps Supplement to the DoD Dictionary of Military and Associated Terms

Army Publications

Army Field Manuals (FMs)

2-0	Intelligence
3-21.38	Pathfinder Operations
3-55	Information Collection
3-90	Tactics
3-99	Airborne and Air Assault Operations

Army Regulation (AR)

95-1	Flight Regulations

Army Techniques Publications (ATPs)

2-01	Collection Management.
3-18.13	Special Forces Use of Pack Animals
3-21.50	Infantry Small-Unit Mountain and Cold Weather Operations
4-02.55	Army Health System Support Planning
4-64	Multi-Service Tactics, Techniques, and Procedures for Mortuary Affairs in Theaters of Operations.

Army Tactics, Techniques, and Procedures (ATTP)

3-97.11	Mountain Warfare and Cold Weather Operations

Army Training Circular (TC)

3-97.61	Military Mountaineering

Technical Bulletins Medical

505	Altitude Acclimatization and Illness Management
508	Prevention and Management of Cold-Weather Injuries

Military Detail [MIL-DTL] Specification 85470B, Inhibitor, Icing, Fuel System, High Flash, North Atlantic Treaty Organization Code Number S-1745

Training Circular (TC) 3-97.61, Military Mountaineering and Army Techniques Publication (ATP) 3-21.50, Infantry Small-Unit Mountain and Cold Weather Operations.