MCRP 12-10A.2

Winter Mountain Leader's Guide to Mountain Warfare

U.S. Marine Corps

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UNITED STATES MARINE CORPS

11 May 2026

FOREWORD

Marine Corps Reference Publication (MCRP) 12-10A.2, *Winter Mountain Leader's Guide to Mountain Warfare*, is a reference for winter mountain leaders to use during operations in snow-covered terrain or a cold-weather environment. It contains tactics, techniques, and procedures for snowshoe and ski mobility instruction and skills, movement techniques, firing positions, avalanche hazard assessment and mitigation, ice reconnaissance, and crossing frozen waterways. It also covers snow tracking and deception, ski-borne patrolling considerations, and over-the-snow vehicle employment. This publication is to be used in conjunction with the Marine Corps Tactical Publication 12-10A, *Mountain Warfare*; Marine Corps Tactical Publication 12-10E, *Arctic and Extreme Cold Weather Operations*; MCRP 12-10A.1, *Small-Unit Leader's Guide to Mountain Warfare*; and MCRP 12-10A.3, *Mountain Leader's Guide to Mountain Warfare Operations*.

Winter mountain leaders are the subject matter experts in mountain warfare tactics, techniques, and procedures, such as over-the-snow mobility and avalanche hazard assessment; they act as an advisor to the commander, and they can conduct pre-environmental and mobility training for their units.

This publication supersedes MCRP 12-10A.2, *Mountain Leader's Guide to Winter Operations*, dated 11 July 2013, erratum dated 2 May 2016, and change 1 dated 4 April 2018.

Reviewed and approved this date.

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CHAPTER 1.
OPERATING IN AVALANCHE-PRONE TERRAIN

Because entire units can be killed in an avalanche, units must have accurate and timely information and the ability to analyze tracks to determine size, direction, and proficiency of enemy units. These factors directly affect the commander's decision-making process. Through careful route selection, preparation, and decision making, leaders can reduce risk when traversing avalanche-prone terrain. Leaders must understand that it is possible to travel at times of high snow instability by choosing safe routes; similarly, it is possible to be caught in an avalanche when the snow is stable because of poor route selection and stability evaluation.

A snow avalanche occurs when a mass of snow, ice, and incorporated debris slide down a slope at high speed. Avalanche formation is a complex interaction among terrain, snowpack, and meteorological conditions, and it is difficult to predict. Avalanche-prone terrain includes areas with significant amounts of snow and unstable temperatures, or where there is evidence of existing slides. To reduce the risk of causing an avalanche, leaders use the following three categories (see Figure 1-1) in their decision-making process:

- Slope Angle. Avalanche-prone slopes angles range from 25 to 60 degrees. The most common slope angle for avalanches is approximately 38 degrees. See Chapter 6 of Marine Corps Reference Publication (MCRP) 12-10A.1, *Small-Unit Leader's Guide to Mountain Warfare*, for detailed information on slope angle and aspect.
- Slope Aspect. What direction is the slope facing? Are there natural terrain anchors present? Are there signs of wind loading and previous avalanches?
- Snowpack. Weather, old snow, new snow, temperature (warming and cooling), and rounding or faceting of snow crystals.

Extreme avalanche situations occur when all three categories are present.

DATA COLLECTION AND ANALYSIS

Before operating in snow-covered mountains, Marines must assess the potential avalanche threat using the intelligence preparation of the battlespace process. Leaders assist in this process by analyzing local maps, slope angles, and slope aspects; gathering seasonal patterns; and conducting field data collection. Unit mountain leaders should collect and analyze pertinent data, which includes avalanche trigger recognition, signs of instability and stability, slope angles, and the data from observation and decision-making checklists and field-testing methods.

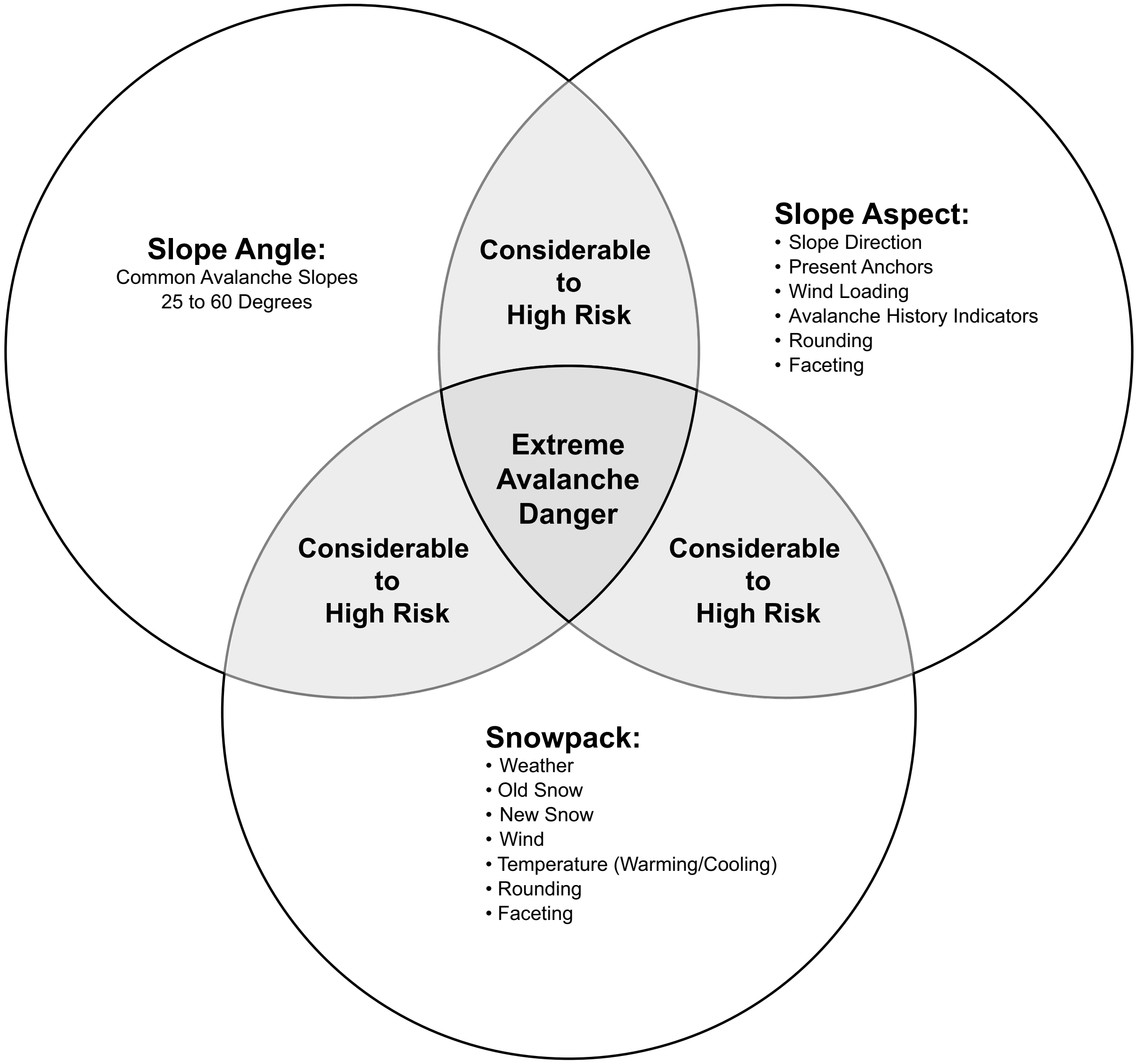


Figure 1-1. Avalanche Mitigation Categories.

Avalanche Triggers

An avalanche trigger is a disturbance that initiates an avalanche. Avalanches are triggered by either an increase in stress on the snowpack (such as added weight) or a decrease in snowpack strength (such as when meltwater weakens an interface). Small stresses, such as a brief snow shower, can trigger a snow slide, as can a large amount of stress, such as an explosive.

There are two types of triggers—natural and artificial (man-made). The most common cause of natural avalanches is loading due to snowfall or wind deposition. Excessive warming can also trigger avalanches, typically by causing melted snow to move through the snowpack and weaken bonds (i.e., causes instability). Natural triggers include a falling cornice, sloughing snow, or stress change due to changes in the snowpack, rock falls, earthquakes, and other avalanches. Artificial triggers include skiers, explosives, sonic boom, etc.

Signs of Instability and Stability

To prevent Marines from triggering an avalanche, the unit mountain leader must continually evaluate the snow's stability. An avalanche-hazard evaluation is based on a systematic decision-making process that uses visual and auditory natural signs to determine snowpack's stability. Instability indicators include the following:

- Recent avalanche activity on similar slopes and small avalanches under foot.
- Booming or whumping, which is the audible collapse of the snow layers (typically a faceted layer).
- Visible cracks shooting out from underfoot that indicate severe tension in the snowpack.
- Sloughing debris is small-scale evidence of avalanche activity occurring. Material sliding down can leave several signs—a visible path, ripples upslope, or an accumulation pile.
- Sunballing, which is caused by rapid rewarming, creates visible lines left by snowballs rolling down the slope.
- Excessive snowfall—more than 1 inch per hour for 24 hours or more.
- Heavy rain that warms and destroys the snowpack.
- Significant wind-loading, causing leeward slopes to become overloaded.
- Long, cold, clear, calm period followed by heavy precipitation or wind-loading.
- Rapid temperature rise to near or above freezing after a long, cold period.
- Prolonged periods of above freezing temperatures (more than 24 hours).
- Temperatures remaining at or below 25 °F, which slows the settlement and strengthening process and enables unstable snow conditions to persist longer.

Stability signs include the following:

- Snow cones or settlement cones, which form around trees and other obstacles, indicate that the snow around the object is settling.
- Creep and glide. Creep is the internal deformation of the snowpack; glide is slippage of the snow layer relative to the ground as depicted in Figure 1-2. Evidence of these two properties on the snowpack includes a ripple effect at the bottom of a slope, indicating that the snow is gaining equilibrium and strength through this settlement process.
- Absence of wind during storms, which is indicated by snow accumulation in the trees during and just after the storm, indicates a greater likelihood of snowpack stability
- Snow temperatures remaining between 25 °F and 32 °F. This rapidly settles the snow and causes snow to become denser and stronger due to rounding.

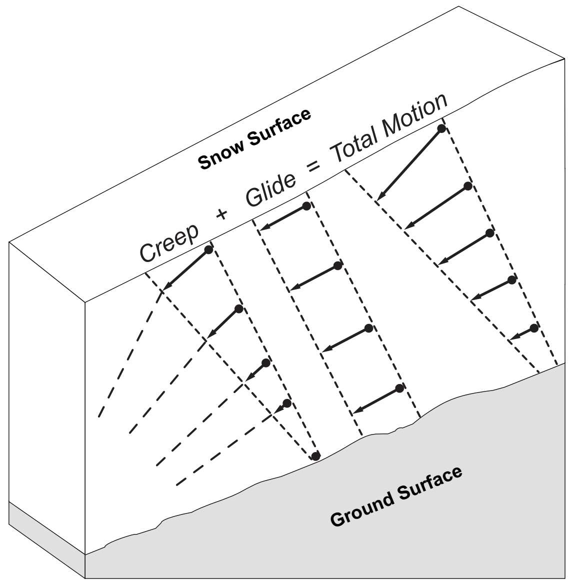


Figure 1-2. Creep and Glide.

Avalanche Checklists

The avalanche checklist consists of two different tools: the avalanche decision-making checklist, which rates hazards from low to extreme and determines hazards by GO/NO GO levels (see Appendix A), and the avalanche data-observation checklist (see Appendix B), which provides detailed information on weather and snowpack assessment and avalanche activity to inform the avalanche decision-making checklist. Leaders should use both checklists for the most accurate avalanche-hazard assessment. Mountain leaders determine the GO/NO GO hazard level based on the tactical situation. See MCRP 12-10A.1 for information on how commanders can reduce the risk of causing an avalanche.

Determining Slope Angle

Slope angle is critical when determining the possibility that a given slope will become an avalanche. Marines can use an inclinometer or protractor to determine a slope's angle.

Inclinometer Method. Inclinometers (also known as clinometers) are designed to measure a slope's approximate angle in degrees. It measures the slope's angles and an object's elevation and depression. This measurement is either given an angular measurement (degrees, minutes, seconds, etc.) or as a percentage with reference to a level zero plane. Inclinometers can be a part of a compass or a separate piece of equipment. To use an inclinometer, Marines—

- Place a ski pole on a slope oriented parallel to the slope's angle or fall line, ensuring that the pole is flush with the surface.
- Place the inclinometer on the ski pole. The inclinometer's dial indicates the slope's angle.

NOTE: Some smartphones have an application for inclinometers.

A compass without a clinometer bubble can be used to measure vertical angles. By aligning the compass' edge to the slope, users can estimate angles. To use a compass as an inclinometer, an individual—

- Sets the compass to east.
- Points the compass up the slope.
- Rotates the dial until it is vertical.
- Reads the slope angle.

Marines should subtract the recorded slope angle from 90 degrees; the result is the slope's angle. The difference between the slope angle and 90 is the approximated slope angle. For example, if the dial reads 60 degrees, the slope angle is 30 degrees. A compass with an inclinometer can measure the slope range from 0–90°. Figure 1-3 depicts how to use a lensatic compass with a clinometer to determine the slope angle.

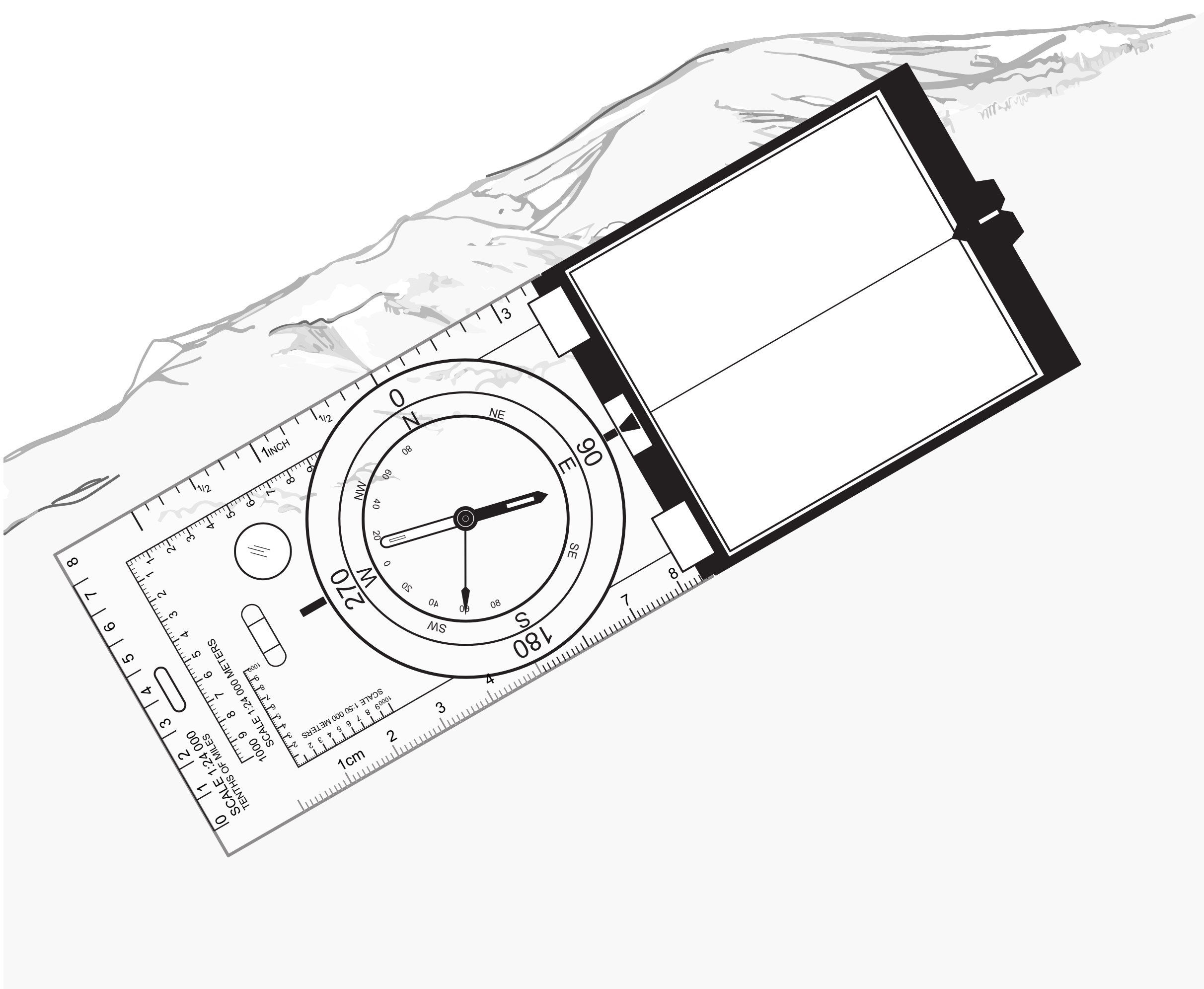


Figure 1-3. Lensatic Compass with a Clinometer.

Protractor Method. To use a standard-issued protractor to determine slope, the user adds a 12-inch string to the protractor's center, placing a weight on the end of the string. To use the protractor method, Marines—

- Dig a small hole into a slope.
- Place a ski pole on the slope oriented parallel to the slope's angle or fall line, ensuring that the pole is flush with the surface and aligned over the hole.
- Place the protractor on the ski pole with 0 degrees down and 90 degrees facing down the slope.
- Read the azimuth degree scale where the string intersects the protector; the number indicates the slope's angle (see Figure 1-4).

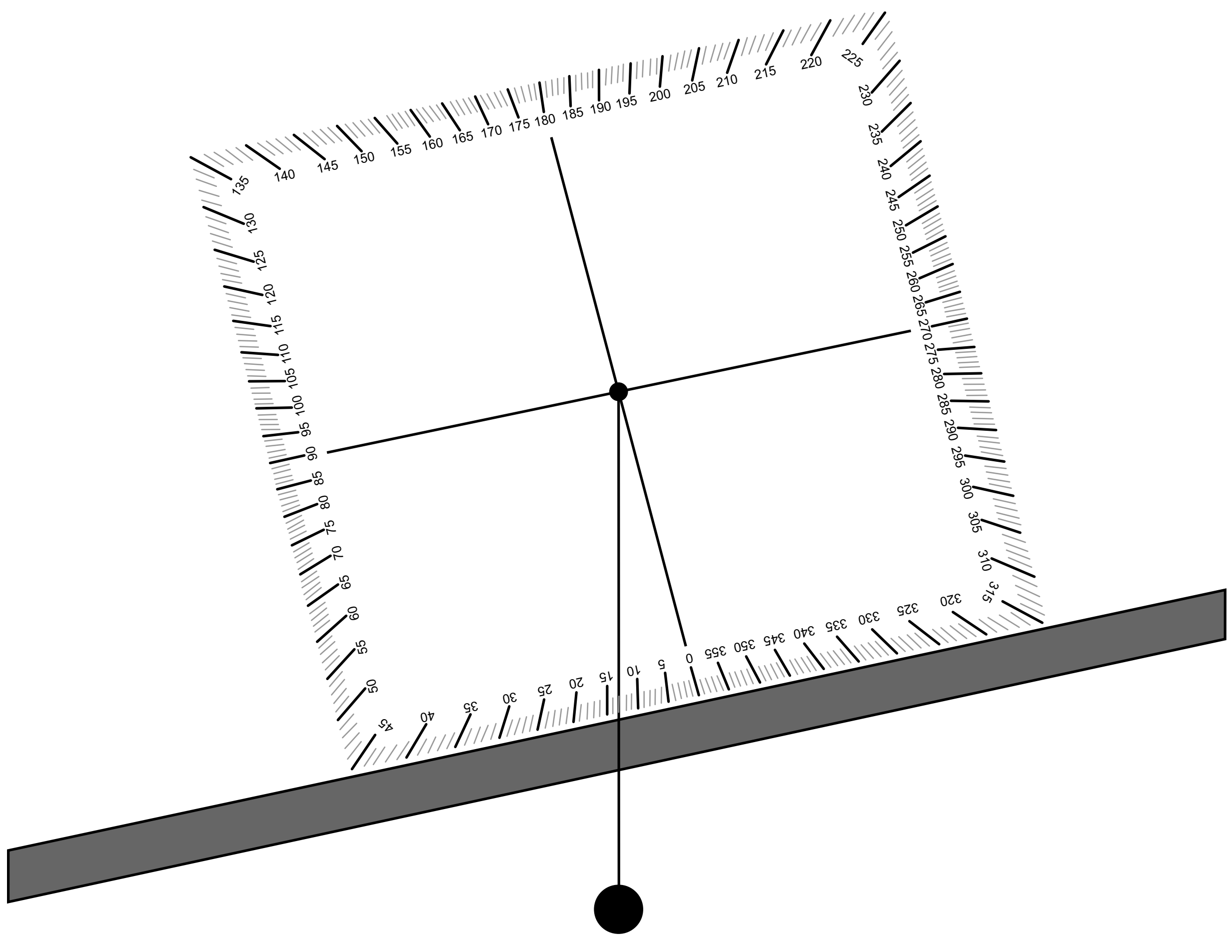


Figure 1-4. Protractor Method.

Field-Expedient Stability Tests

To determine a slope's stability, a unit mountain leader must gather all available information about the snowpack, which typically requires using multiple field tests and observation methods. Unit mountain leaders should conduct field-expedient stability tests on short slopes to minimize the risk of triggering an avalanche. Small, steep slopes can provide a Marine with valuable information. To test the slope's stability, a Marine jumps from the top of the hill onto the slope noting any changes in the snow layers' stability. The following sections describes field-expedient stability tests that Marines can use to gather snow stability information.

Test Skiing. Test skiing is a stability test where a skier adds stress to the snow by standing, jumping, or kicking. The skier can immediately observe the depth and type of snow layers that fail. To test snow stability a skier traverses uphill and then jumps below the uphill ski track, observing any snow break. Breakage indicates that the snow might be unstable.

Ski Pole Test. The ski pole test determines the snow's depth and potential slab distribution (see Figure 1-5). Marines should conduct this test while traveling. To perform the ski pole test—

- Hold the ski pole at a 90-degree angle to the snow's surface.
- Gently push the pole into the snowpack.
- Feel for the layers' relative hardness and the thickness.

Marines should be alert for well-consolidated layers that feel harder than underlying softer, weaker layers. Softer snow layers typically indicate the snow is unstable.

If the basket of the ski pole interferes with probing, the handle of the ski pole can be used to probe instead. A limitation of the ski pole test is that weak layers may be too thin to detect. Additionally, this test does not detect how well the layers are bonded together.

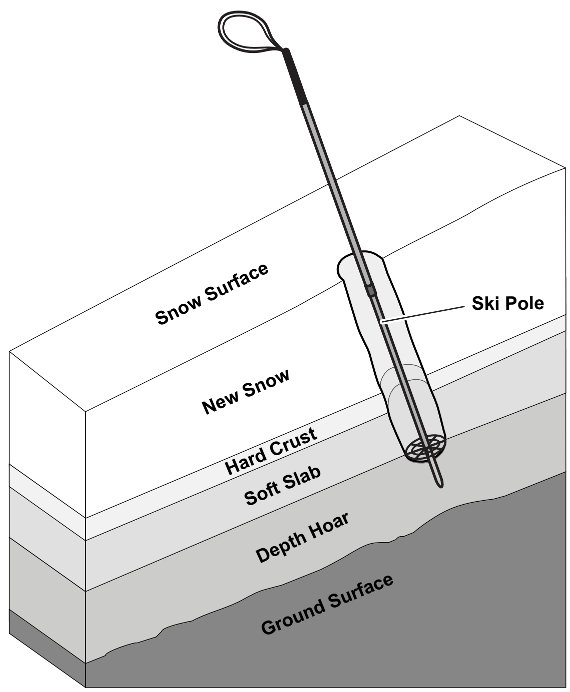


Figure 1-5. Ski Pole Test.

Shear Tests. Marines use the shear test to locate weak layers and interfaces. Although there are various shear tests, Marines primarily use the rutschblock-shear test, shovel- and ski-shear test, and the shred-block test.

<u>*Rustchblock-Shear Test*</u>. To construct a rutschblock, Marines—

- Select a site on a slope with the same slope angle and aspect as the slope the unit intends to cross.
- Dig a pit approximately one ski length wide and at least 5 feet (1.5 m) deep.
- Dig two narrow trenches from the ends of the pit, extending uphill to the about the length of a ski pole, ensuring that each trench's depth matches the depth of the pit.
- Use a snow saw or a knotted length of cordage and cut the back of the wall to isolate the snow block (see Figure 1-6).
- Ski to the side of the test site and carefully approach the upper cut of the rectangular block diagonally from above. Once the skis are perpendicular to the cut on the uphill side, gently move on to the block. Stability is determined at the point when the block fails (see Table 1-1).

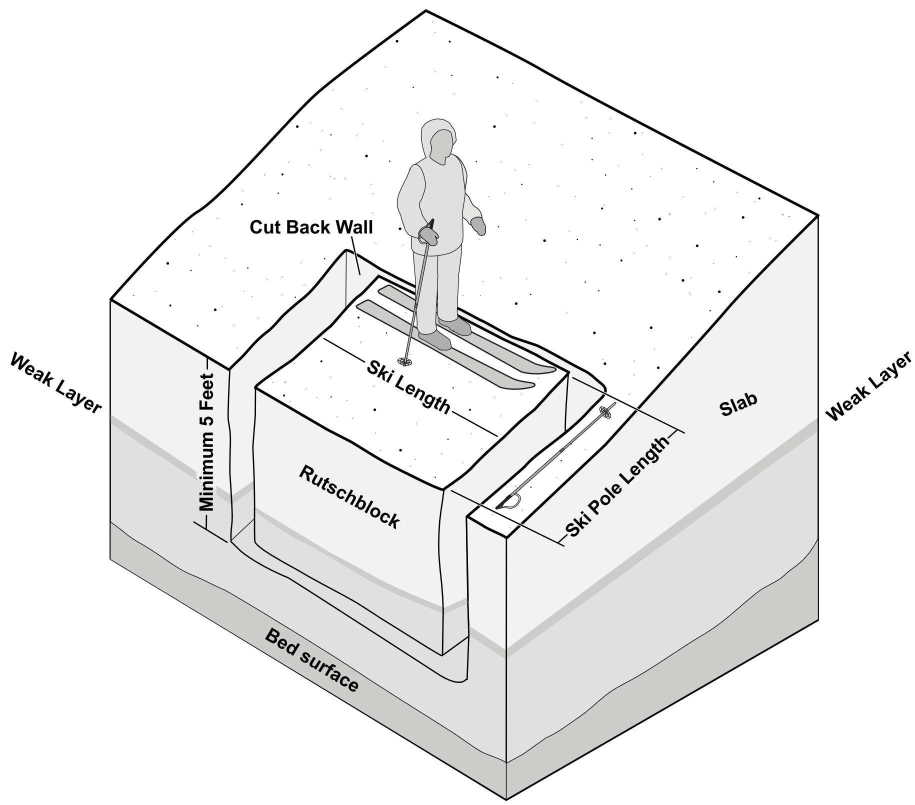


Figure 1-6. Rutschblock Test.

Table 1-1. Rutschblock Test and Stability Levels.

Reaction	Result
Fails while excavating test site	Extremely unstable
Fails while approaching test site	Extremely unstable
Fails while standing on shear block	Extremely unstable
Fails while flexing knees	Unstable
Fails with one jump while wearing skis	Unstable
Fails after repeated jumps with skis on	Relatively stable
Doesn't fail after repeated jumps with skis off	Stable

Shovel- and Ski-Shear Test. Marines conduct the shovel and ski shear test, which requires minimal digging, to determine where the snow is weak or unstable. To construct a shear pit—

- Isolate a column in the uphill pit wall by cutting away the sides with a shovel or ski. The width of this column and the depth cut into the pit should be approximately 12 inches (30.5 cm). The column must be both vertical and smooth (see Figure 1-7).
- Insert a shovel or ski behind the column and exert steady pressure while pushing downward. Look for weak layers separating (see Figure 1-8).

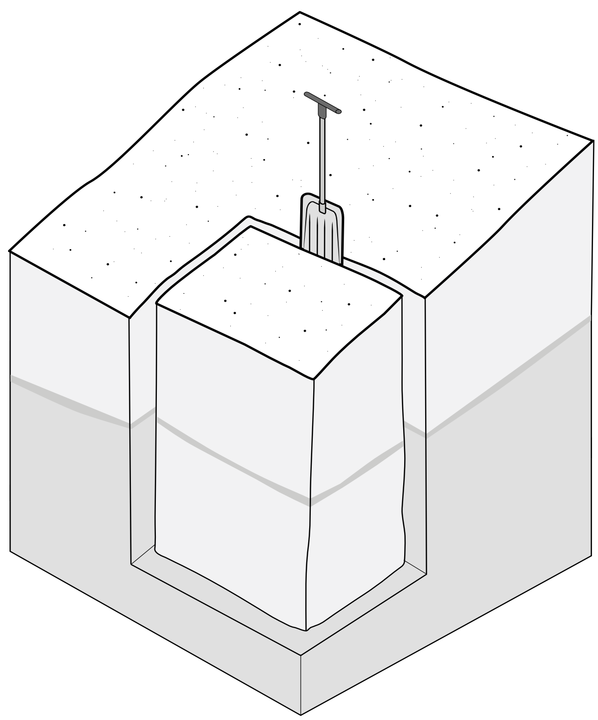


Figure 1-7. Shovel-Shear Test.

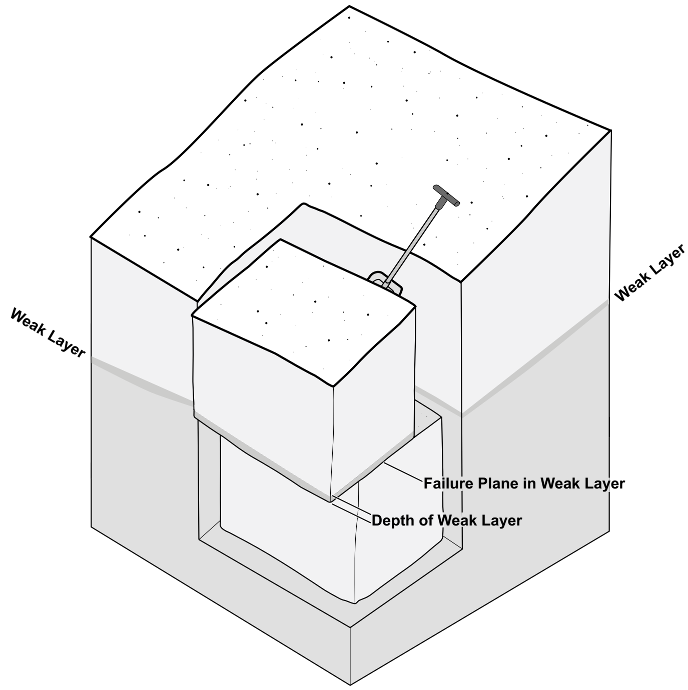


Figure 1-8. Weak Layer Giving in a Shovel-Shear Test.

<u>*Shred-Block Test*</u>. The shred-block test is like the rutschblock test, but it uses snowshoes instead of skis. To perform this test dig the shred block (see Figure 1-9). The shred block dimensions are approximately 5.75 feet (1.75 meters) wide (across the fall line), 5 feet (1.5 meters) on each side (up the fall line), and up to 5 feet (1.5 meters) deep (deeper than the suspected failure layer). Dimensions vary depending on the method Marines use to cut the sides of the block.

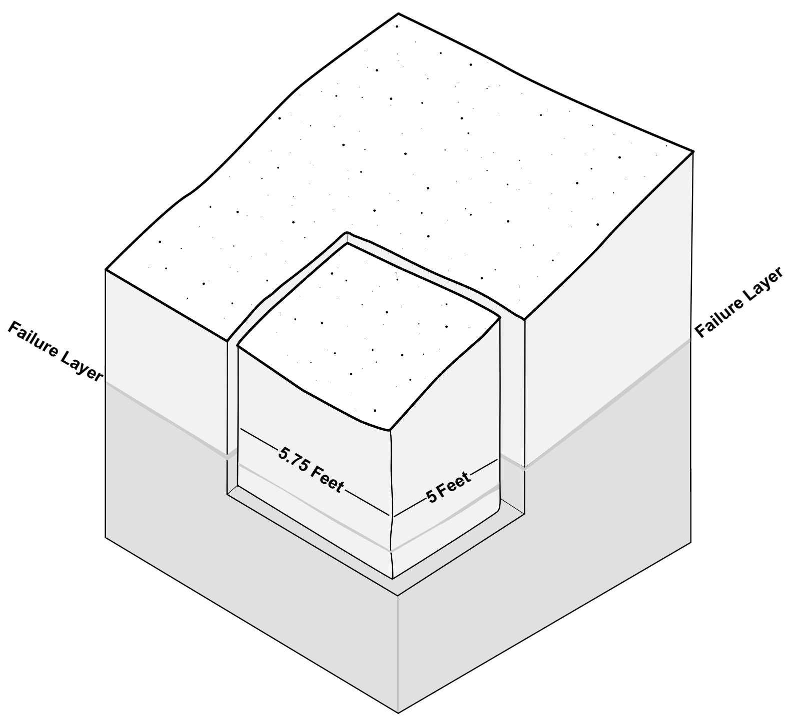


Figure 1-9. Shred Block Using Snowshoes.

NOTE: Conduct the test in the same manner as the rutschblock test, wearing snowshoes instead of skis.

Snow-Pit Analysis. Snow-pit analysis is a method of analyzing the snowpack for instabilities by identifying weak layers. Unit mountain leaders make basic observations when conducting a snow-pit analysis. To construct the snow pit—

- Choose a snow pit location with conditions similar to those that the Marines will be operating on, including factors such as elevation, snow condition, slope angle, and slope aspect.
- Dig a pit 5 feet deep and wide enough to work in. Be careful not to disturb the snow surface surrounding the uphill portion of the pit.
- Smooth off the uphill pit wall and adjacent (side) wall using a shovel. Ideally, the wall that is adjacent to the wall being tested should be shaded, particularly when conducting a hardness or temperature gradient test. The walls must be smooth and vertical, and the snow above the uphill wall must remain undisturbed.

Marines can use the following tests to identify various layers in the snow pit:

- Stratigraphy Test. Using a whiskbroom, paint brush, hat, or mitten, lightly brush the sidewall of the pit with even strokes that are parallel to the snow surface. The raised or ridged surfaces indicate the harder, stronger layers that might be slabs or sliding surfaces. The indented surfaces reveal softer, weaker layers.
- Resistance Test. Insert a straight edge into the top of the sidewall and run it down the wall (see Figure 1-10), noting the relative resistance between hard and soft layers. This test can corroborate and expand upon the information gained from the stratigraphy test.

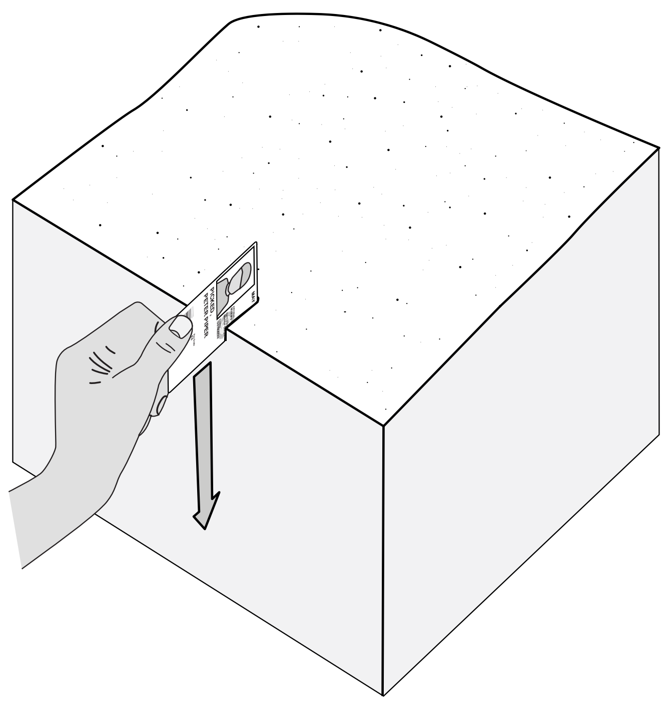


Figure 1-10. Resistance Test.

- Hardness Test. Marines use the hardness test to gauge the relative strength of each snow layer by gently pushing an object (hand, knife, etc.) into the pit wall, applying approximately 2 pounds of force (roughly the amount of pressure applied to one's nose till it starts to hurt). Marines conduct the hardness test using Table 1-2. If a knife cannot penetrate the layer, it is considered ice.

Table 1-2. Hardness Test.

Item	Hardness Level	Durability
Fist	Very soft	Snow can be broken with a fist.
Four Fingers	Soft	Snow cannot be broken with a fist but can be broken with four fingers held together with an open palm.
One Finger	Medium	Snow cannot be broken with the four fingers held together with an open palm but can be broken with one finger.
Pencil	Hard	Snow cannot be broken with one finger but can be broken with a thin pointed wooden object such as a pencil.
Knife	Very hard	Snow cannot be broken with a pencil but can be broken with a sharp metal object such as a knife.

Extended-Column Test. The extended-column test involves isolating a vertical column 35 inches (89 cm) wide in the cross-slope dimension and 12 inches (30 cm) deep in the upslope dimension to expose potential weak layers (Figure 1-11). However, the depth should not exceed 51 inches (130 cm) since the loading steps rarely affect deeper layers. To conduct the test, one end of the column is dynamically loaded using the loading steps of the compression test, which is when the tester taps a shovel with a gloved hand ten times articulating from the wrist, ten times articulating from the elbow and then ten times articulating from the shoulder. The observer notes the number of taps required to initiate a fracture in the weak layer below the shovel and whether the fracture propagates through the weak layer across the entire column. Results are categorized by the number of taps required to cause a failure:

- Very easy (0 taps) is when failure occurs during isolating and cutting the column.
- Easy (1-10 taps) is when failure occurs during wrist taps and indicates high instability.
- Moderate (11-20 taps) is when failure occurs during elbow taps.
- Hard (21-30 taps) is when failure occurs during shoulder taps, indicating higher stability.

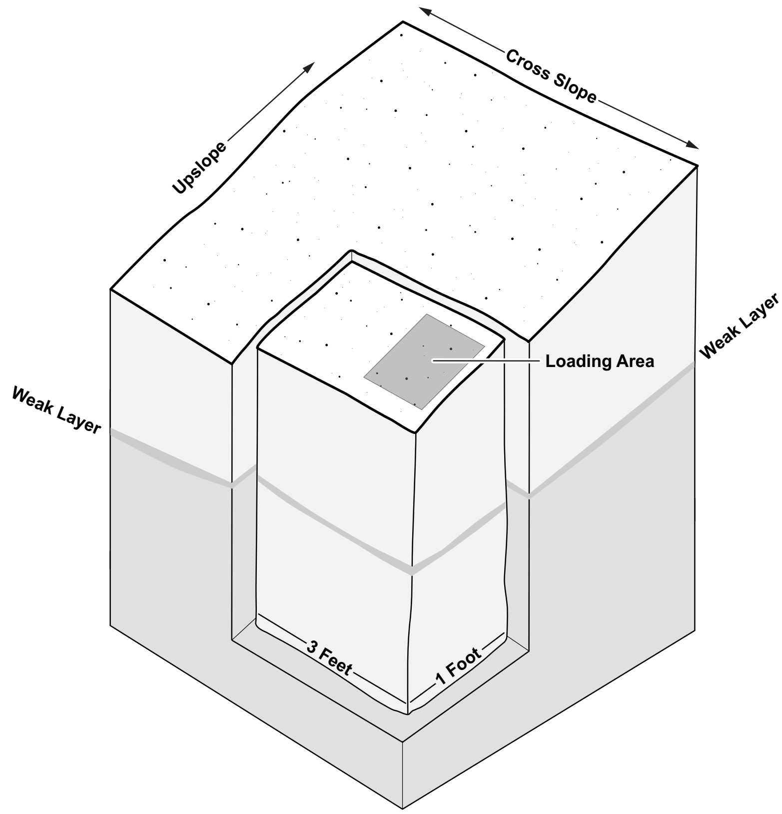


Figure 1-11. Extended-Column Test.

AVALANCHE TRANSCEIVERS

Units determine when to use avalanche transceivers (Figure 1-12) based on the tactical situation, adversary capabilities, and availability. A two-part rescue system (RECCO System) is also an option. However, this system requires rescuers to have both an active detector and passive reflectors. During training, Marines should—

- Use avalanche transceivers.
- Use civilian avalanche rescue and awareness materials.
- Conduct thorough route selection and planning.
- Study weather forecasts to reduce risk and speed recovery efforts.

Transceivers (rescue beacons) are electronic devices that can transmit and receive radio signals. Leaders must ensure that all unit members carry transceivers that are compatible with each other. The following sections provide general information on various avalanche transceivers used in the civilian market.

NOTE: The 457-kilohertz radio frequency is now standard, but some units might still use the 2.275-kilohertz frequency.

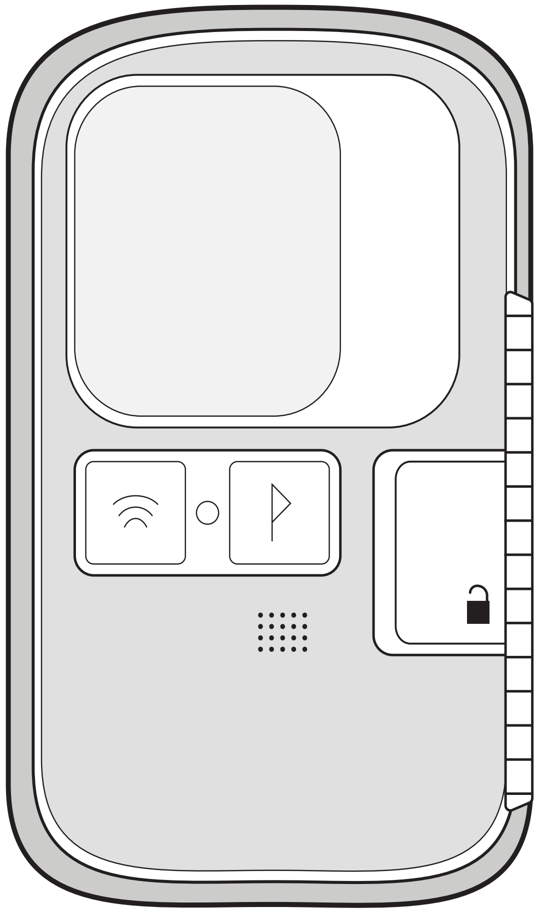


Figure 1-12. Avalanche Transceiver.

Nomenclature and Functions

Although specific models might have additional features, the following features are common to most transceivers:

- Transmit Mode. All avalanche transceivers have a transmit mode (Figure 1-13), which sends out a continuous signal (usually on the 457 kHz frequency) that can be detected by other transceivers.
- Search/Receive Mode. This mode allows the transceiver to receive signals (Figure 1-13) from other transceivers in the event of an avalanche. It is used to locate buried individuals.
- Frequency. Most modern transceivers operate on the standard 457 kHz frequency, ensuring compatibility between devices regardless of the manufacturer.
- Range. The effective range of the transceiver, usually measured in meters, defines how far the device can detect another transceiver's signal. Although this can vary between models, all transceivers have a specified range within which they can effectively operate.
- Direction Indicator. When in search mode, transceivers usually display directional arrows or visual indicators to guide the user toward the buried signal.
- Distance Indicator. As you approach the signal, the transceiver typically shows the distance to the buried transceiver, allowing for more precise location.

- Multiple Burial Detection. Most modern transceivers are equipped with the ability to detect multiple signals if more than one person is buried. This feature may include marking or flagging functionality to help manage multiple rescues.
- Battery Life Indicator. Transceivers typically have a battery life indicator, which shows the remaining power level, ensuring the device has sufficient charge for operation.
- User Interface. All transceivers have some form of display and controls (such as buttons or switches) to switch between modes and interpret data.

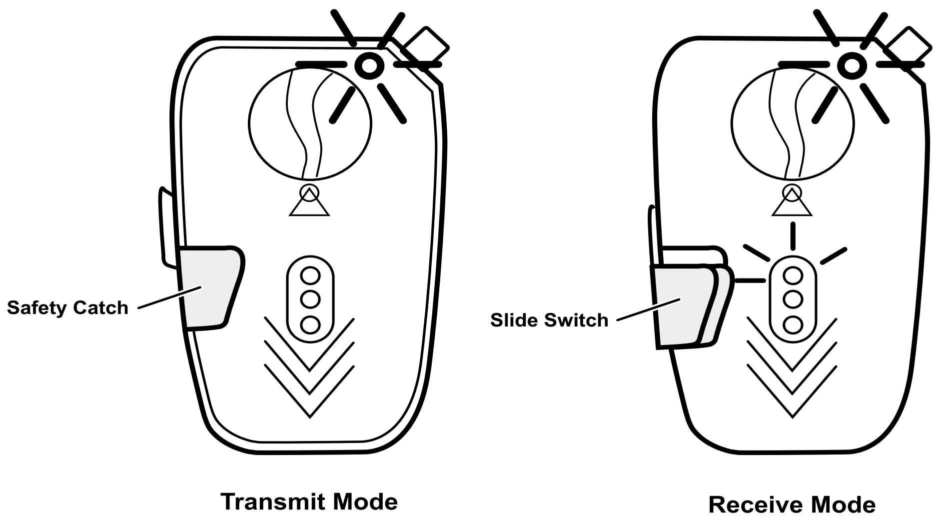


Figure 1-13. Transceiver in Transmit and Receive Modes.

Wearing the Transceiver

When wearing and operating the transceiver, Marines should adhere to the manufacturer's specific guidelines and instructions; this ensures the device functions properly and reliably, thereby increasing safety and effectiveness in avalanche situations. Marines should only switch off the transceiver during the patrol base routine.

> NOTE: The transceiver should always be worn under outer clothing (such as the vapor barrier) and as close to the body as possible, using the transceiver carrying system, and display facing inwards.

Marines should ensure the transceiver is in transmit mode. This step is crucial to confirm that the device is functioning correctly and transmitting in case of an emergency.

Transceiver Operating Test

Before deploying from a safe area, patrol leaders must check the transceivers to ensure that all transceivers are operable:

- The patrol leader sets the transceiver to the transmit mode while all other patrol members set theirs to the receive mode.
- The patrol leader walks to a point where the patrol member's transceivers no longer pick up the signal ensuring that all patrol member's transceivers are receiving, and the patrol leader's transceiver is transmitting.

- The patrol leader switches the transceiver back to receive mode while all patrol members set their transceivers to transmit mode and then walk past the patrol leader.
- The patrol leader should ensure each patrol member's transceiver is transmitting properly.
- After checking each member, the patrol leader sets the transceiver back to transmit mode.

Bracketing Search Method

The bracketing search method is a fast and accurate search method. To conduct this search—

- Record the last point where the victim was seen. If there is further danger of avalanches, post an avalanche guard who should be prepared to switch back to transmit mode.
- Set all transceivers to receive mode to prevent any misleading transmissions from other transceivers.
- Turn the range dial to its highest range setting and increase the volume.
- Deploy searchers at a maximum of 20 meters apart in the last seen area and move down the slope (see Figure 1-14).

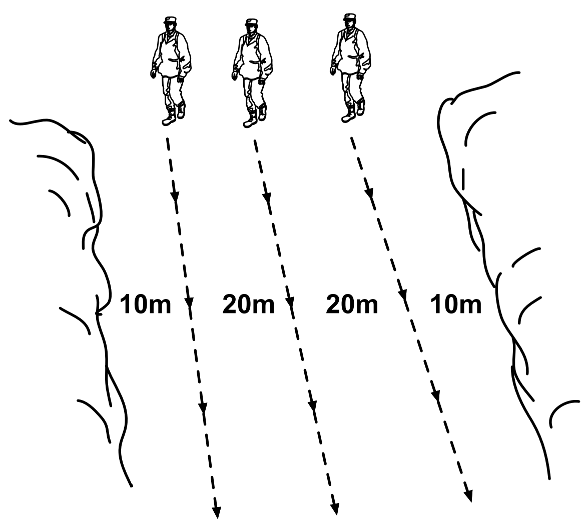


Figure 1-14. Conducting a Bracketing Search.

- Slowly rotate the transceiver 120 degrees from side to side to determine direction of the strongest signal. See Figure 1-15.
- Mark the spot where the first signal was received and proceed in a straight line. The signal will get stronger then weaker.
- Mark the weakest point.
- Find the midpoint between the two weak points and mark this spot. Turn the range dial and volume down so that the signal is low.
- Proceed in a direction 90 degrees to the first line. In one direction, the signal will get weaker; in the opposite direction the signal will get stronger. Move in the direction of the stronger signal.

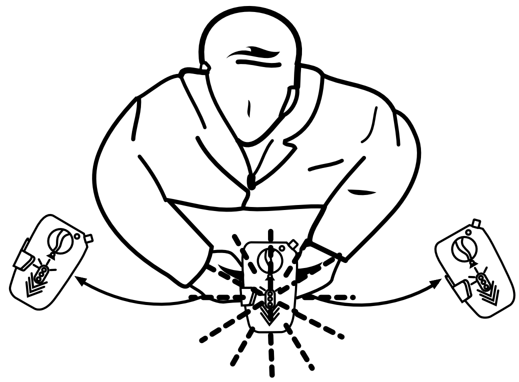


Figure 1-15. Rotating the Transceiver.

- Continue past the strong signal until it becomes weaker and mark this weak spot. Turn the range dial and volume down each time a new line of travel is taken.
- Repeat this process until the exact location is found and begin probing or digging (see Figure 1-16).

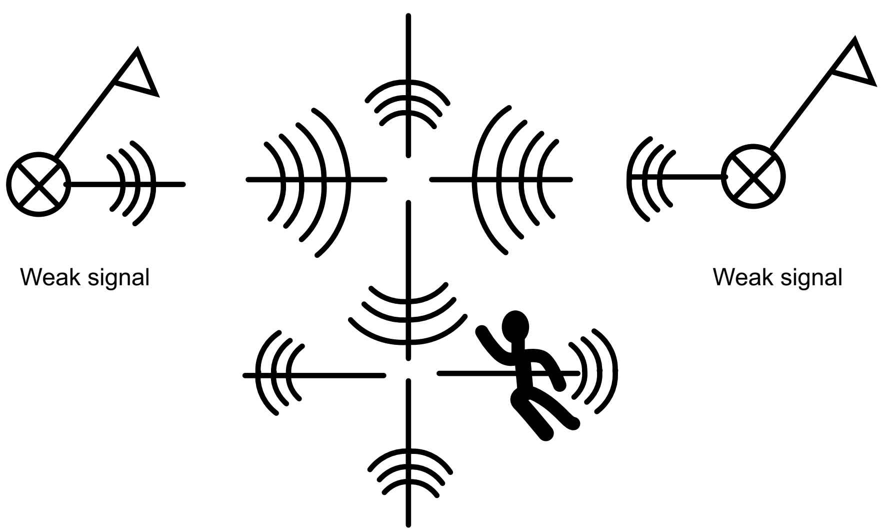


Figure 1-16. Pinpointing Location.

After the search and recovery is completed, all transceivers must be set back to transmit mode. See MCRP 12-10A.1 for information on organizing a company-sized avalanche search.

CHAPTER 2.
TRACKING IN SNOW-COVERED TERRAIN

In snow-covered terrain, Marines can use tracks in the snow to determine a unit's size, direction of travel, and an estimated time of travel (when discovered early in the day). However, as time passes and the environmental factors affect the tracks, making these determinations becomes increasingly more challenging. Conversely, counter-tracking is a skill Marines use in snow-covered terrain to prevent compromise or to deceive the enemy. Terms unique to tracking include—

- Transference. Transference is the removal of material from one area to another. This can occur when walking along a muddy stream bank and then crossing a log or transiting to snow-covered ground and then crossing a road that is cleared of snow; the mud left on the log or snow left on the road is considered transference.
- Compression. Compression refers to the flattening of the soil or snowpack caused by the weight of the body pressing down or leveling of snow, soil, sand, stones, twigs, or leaves. Compression is more likely to occur in frozen, hard, dry, or sandy conditions where there is no moisture to hold a clear and lasting imprint.
- Disturbance. Disturbance includes unnatural patterns, which are common in snow-covered environments. Examples include—
  - Shoveling Snow. The initial tossed snow is transference but once it melts, it disturbs the top layer of the snowpack, leaving an unnatural pattern.
  - Forward Movement. All forward movement by people or animals will kick snow forward. Initially, the tossed snow is transference, but it becomes disturbance once the snow has melted.
- Sign. A sign is any disturbance of the natural condition that reveals the presence or passage of animals, persons, or other objects. Examples include snow that has been dislodged from vegetation or man-made structures (e.g., fences), stones that have been knocked out of their original position, overturned leaves showing a darker underside, sand deposited on rocks, drag marks, displaced twigs, or scuff marks on trees.
- Spoor. Spoor is the track or trail of a human or animal, revealing its size, shape, type, and pattern. The term 'spoor' is generally interchangeable with track, and it can refer to either aerial or ground tracks. See Appendix C for an example of a spoor and tracking template.

DETERMINING A TRACK'S AGE

Marines must be able to determine a track's age. Each geographic area and its associated climate affect how tracks age. The following factors contribute to track deterioration:

- Weather. Includes snow, rain, fog, melt-freeze cycles, and dew.
- Sun. Factors include latitude, cloud cover, slope aspect, and angle to the sun.
- Wind. Includes wind strength and direction. On the mountain's windward side, wind erodes tracks; on the mountain's leeward side, wind buries tracks.

- Surface Content. The rate of deterioration changes depending on whether the surface is hard, sandy, firm, moist soil, or covered with frozen, hard, or loose snow.
- Track Erosion. Snow track erosion depends on the amount of sunlight and temperature to which the track has been exposed (see Table 2-1).

Table 2-1. Track Erosion Timetable.

Time	Track Erosion
Minutes to 1 hour	Transference is noticed around the outer edges on top of the snowpack. Track edges are sharp and clean.
1 to 3 hours	Transferred snow has melted, leaving small pockmarks on top of the snow. Track edges are slightly rounded.
4 to 24 hours	Pockmarks on top of snowpack have disappeared. Track edges are rounded, inside track walls are firm.
24 to 27 hours	Top layer of snowpack is angling down toward the track. Track is beginning to fill in and will have an "S" curve.

TRACKING

Tracking is a critical skill when operating in mountainous terrain. Marines should use the following techniques and procedures for effective tracking:

- Track early in the morning or late in the afternoon because the height of the sun on the horizon casts longer shadows, allowing for greater contrast on the edges of the spoor.
- When observing a spoor, trackers should position themselves between the spoor and the sun.
- Trackers should not move past the last sign until the next sign is found, a technique known as "sign cutting."
- Once the initial track is found, trackers must document and sketch it for future reference. This sketch helps prevent Marines from following the wrong track later.

Direction

Forward movement that displaces snow forward is a type of transference and disturbance referred to as "fluffing." Fluffing is the key to successful tracking. As snow begins to melt, it leaves pockmarks on the level snowpack (see Figure 2-1). Walking backwards in snowshoes still causes fluffing.

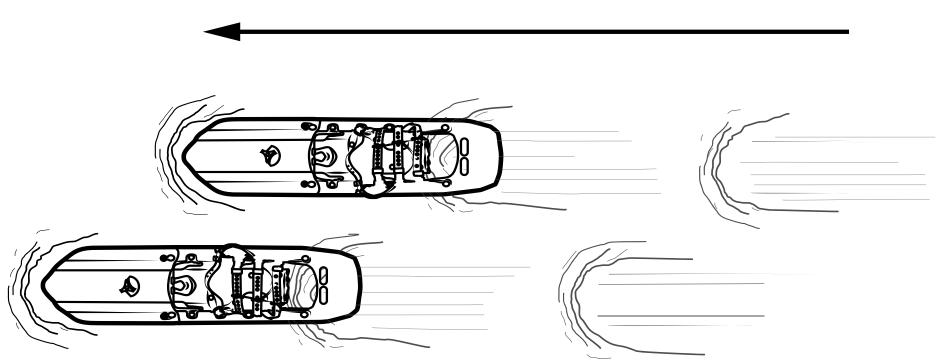


Figure 2-1. Fluffing.

Marines can also track skiers and determine their direction of travel. As the ski pole is planted and the ski moves forward, the ski pole basket angles forward, digging into the snow and leaving an indent on the forward edge, indicating direction of travel. The tip of the ski pole also contacts the snow before the pole is planted, creating a line pointing away from the direction of travel (see Figure 2-2).

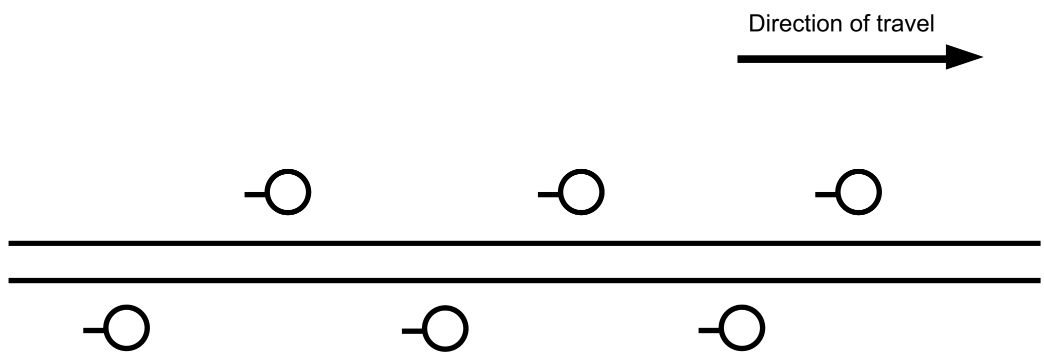


Figure 2-2. Skiing Direction.

Determining the direction of travel with snowmobiles and tracked vehicles is more challenging. However, the tracks created by these vehicles compress the snow inside the track, forming plates. These plates are critical for identifying the direction of travel. At ground level, most plates typically face the direction of travel (see Figure 2-3).

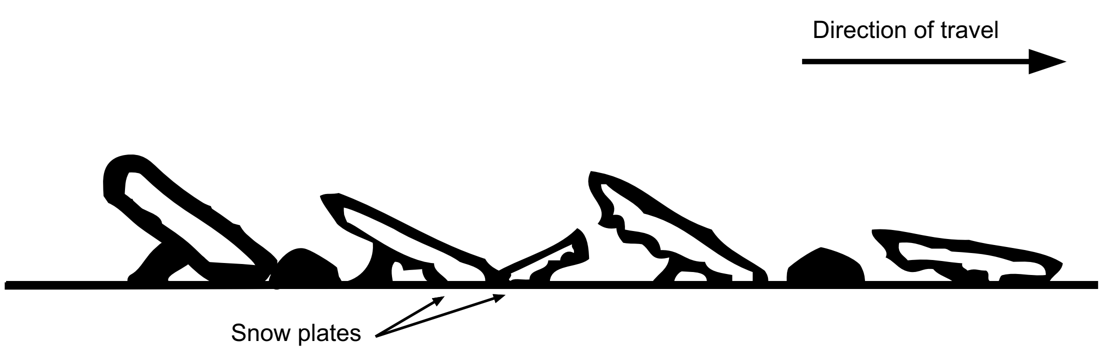


Figure 2-3. Determining Tracked Vehicle Direction.

Tracking Teams

Tracking is a secondary or implied task for combat and security patrols near the patrol base. All tracking teams must document and sketch the initial track. Tracking teams can—

- Locate team members if they become separated.
- Use radios to provide a verbal account of track observation.

The disadvantages of using tracking teams include the following:

- They are typically slower than using dogs (snowpack dependent).
- Observation is limited during limited-visibility conditions.

Formations. Tracking teams can use the following formations:

- "Y" Formation. The Y formation (see Figure 2-4) is the basis for all other formations and immediate action drills. It is best used in open country, where the distance between trackers depends on visual contact with the controller and varies according to terrain and vegetation conditions.
- Half "Y" Formation. The half Y formation (see Figure 2-5) is used when ground or vegetation conditions prevent the flank tracker from keeping pace with the follow-up tracker.
- Single-File Formation. The single-file formation (see Figure 2-6) is used when the terrain or vegetation prevents both flank trackers from maintaining the pace of the tracker. It is generally used in thick brush conditions where visibility is restricted.
- Extended-Line Formation. The extended-line formation (see Figure 2-7) is used when there is little vegetation to restrict visibility, and the spoor is difficult to see. Using three trackers helps Marines quickly track the enemy and maintains the unit's momentum.

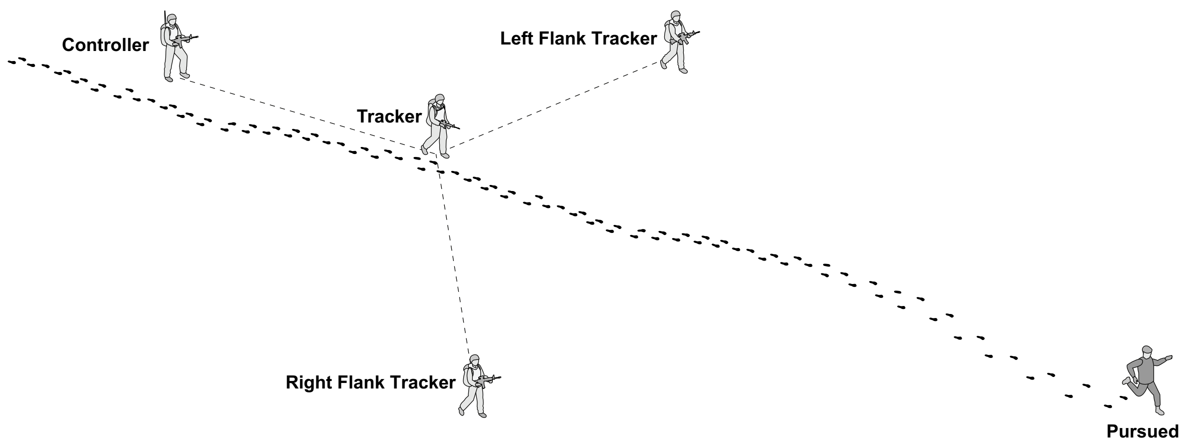


Figure 2-4. "Y" Formation.

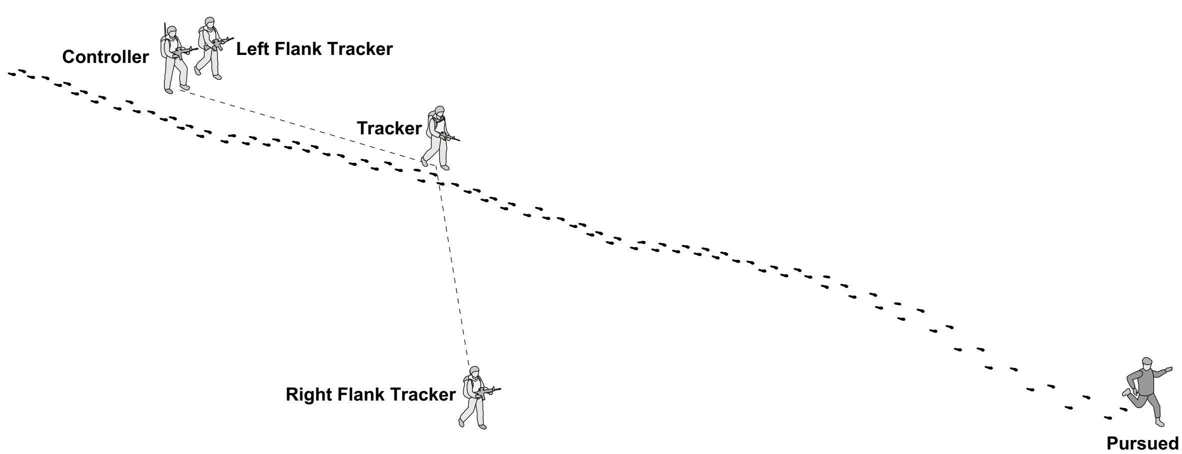


Figure 2-5. Half "Y" Formation.

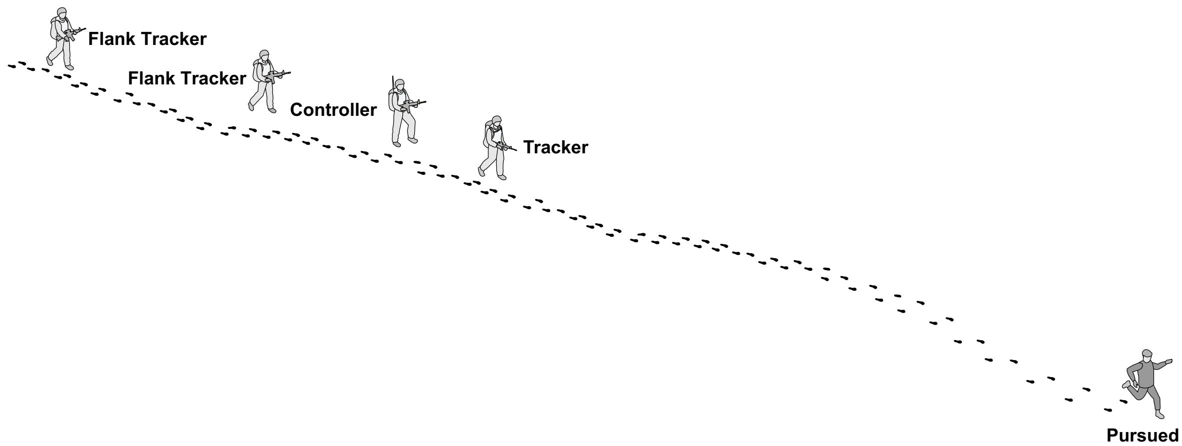


Figure 2-6. Single-File Formation.

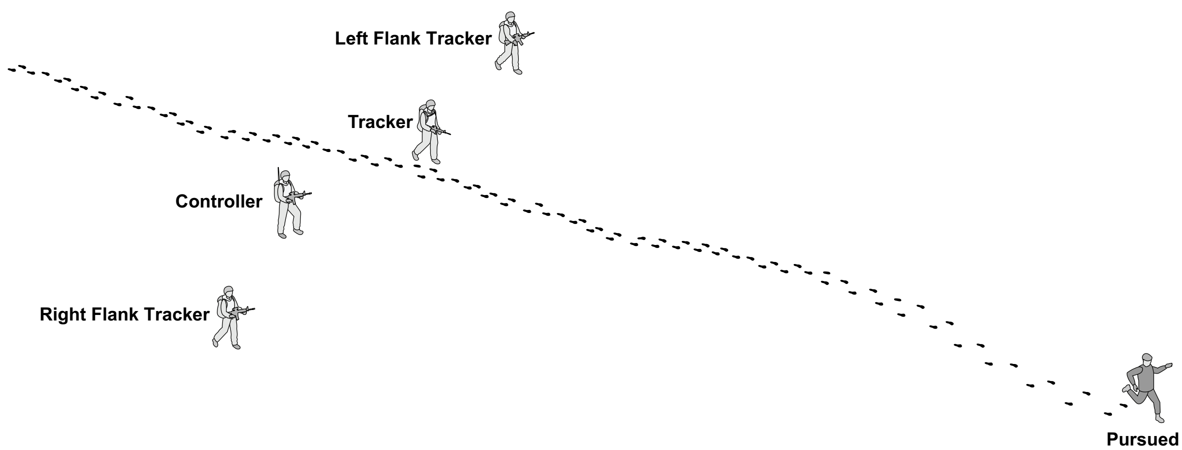


Figure 2-7. Extended Line Formation.

Sign Cutting

Sign cutting is the process of two tracking teams crisscrossing in arcs to intersect a track and using visual clues to determine an enemy unit's composition, direction, and potentially the activity the enemy is conducting. Marines conduct sign cutting using the following steps:

1. The initial team that finds the track remains at the location until another tracking team finds the same track farther ahead on the trail.
2. The last track is marked for future reference.
3. The initial team then assumes responsibility for tracking until they find another track.

Teams can cover increased distances by sign cutting and leap frogging.

Lost Spoor and Track Procedures

If a tracking team operating alone loses a track, they should use the following lost spoor and track procedures:

- Search the most likely lines of advance.
- If this is not successful, conduct a 360-degree search pattern, starting behind the controller.
- If still unsuccessful, widen the 360-degree search pattern and search again.
- If the track remains lost, proceed with an extended line search from the last known track.

ANTITRACKING TECHNIQUES

There are three methods that the enemy can use to track Marines:

- Direct observation.
- Detection equipment, such as thermal imaging, day and night optics, acoustic detectors and sensors, or direction-finding equipment for radios.
- Search teams, which can be military, civilian, or trained trackers. These can be augmented by employing dogs and using equipment.

Marines employ various antitracking techniques depending on time and terrain, and more than one technique can be used simultaneously. The following are antitracking techniques:

- Brushing out tracks.
- Using hard, stony ground.
- Abruptly changing direction.
- Traveling on well-used paths to hide or destroy spoor.
- Confusing the start point or track by creating multiple tracks in various directions.
- Crossing or moving in streams, lakes, or waterways.
- Carefully placing footfalls on the ground, leaving little heel or toe dig.

Units can use the following techniques to reduce or hide tracks:

- Splitting up into break-away groups so not all tracks can be followed.
- Using ground, water, or air transportation, which creates gaps in the track. This technique can be used during various legs of a movement.

When Marines are being tracked, they should put as much distance as possible between themselves and the tracker. Marines should increase this distance by using antitracking and or spoor-reducing techniques.

CHAPTER 3.
ICE RECONNAISSANCE

Conducting ice reconnaissance before crossing a frozen waterway is necessary to determine the ice's load-bearing capacity (i.e., what equipment can cross, how many people can cross, and the required dispersion to mitigate risk). Therefore, Marines must determine the ice's thickness at the crossing point and periodically along the route.

RECONNAISSANCE

Prior to cutting the ice, Marines should check for—

- Mines.
- Ice obstacles.
- Demolitions and explosives (standard or improvised) under the ice.
- Chemical, biological, radiological, and nuclear hazards.

Marines should collect the following information during reconnaissance:

- Ice type, thickness, formation, and quality.
- Snow thickness on the ice.
- Snow thickness on the banks.
- Ice attachment to the banks (i.e., does it hang over the water?).
- Slope angle.
- Riverbank composition.
- Water width and depth.
- Current speed and the slowest current area.
- Ice's weight-bearing capacity.
- Potential ice growth based on weather patterns.
- Best routes for main and secondary crossing sites.
- Requirements to make the crossing site suitable.
- Natural materials available for reinforcement.

TOOLS AND SPECIAL EQUIPMENT REQUIRED

Marines use the following tools and special equipment to conduct ice reconnaissance:

- Ice measuring rod.
- Ice auger or axe bar.
- Chisel or spud.
- Ice saw.
- Weighted depth cord.
- Chemical, biological, radiological, and nuclear detectors.
- Probes.
- Mine detectors (improvised explosive detector dogs, if available).
- Belay rope (always belay the Marine conducting the ice reconnaissance).
- Thermite grenades.
- Axe.
- Ski poles or staff.
- Demolitions.

ICE CLASSIFICATION

Ice is classified in three general types—saltwater ice, freshwater ice, and land ice.

Saltwater Ice

Saltwater ice, also known as sea ice, is weaker than freshwater ice. Saltwater ice begins as crystals within the layer of salt water affected by convection. These crystals give saltwater ice an oily or opaque appearance. Sea ice that is older than one year is much stronger than young sea ice. Young sea ice must be at least 1.66 times thicker than old sea ice to carry the same load. Saltwater ice is classified as pack ice and fast ice.

Pack Ice. Pack ice is formed on the open sea, remains packed together, and is shaped by currents and winds. When pieces of ice break off from the pack, they are called drift ice. Pack ice seldom grows thicker than 5 to 7 feet in the first year, although it has been measured at 12 feet thick in the polar basin where pack ice is perennial. Telescoping and piling of ice floes can create ice thicknesses up to 125 feet around the edges of the pack. Although the pack ice's interior is solid, it is usually not smooth enough for airstrips without some grading. Currents and winds constantly fracture pack ice, leaving lanes or leads of open water. When the leads freeze, they provide sites of smooth ice, which make suitable airstrip locations. These airstrip sites must be double the usual length for a fully loaded aircraft to take off.

Fast Ice. Fast ice is sea ice that is anchored to the coastline, the sea floor, or grounded icebergs. This prevents it from drifting with ocean currents. It typically forms in shallow coastal areas, bays, or lagoons and can remain stable throughout the winter. The portion of fast ice that is attached to the shore is called the ice foot. Fast ice might be attached to the ice foot or separated from it by a crack. Fast ice rises and falls with the tide, but the ice foot remains fast to the shore. The more irregular the shoreline and the more islands in the area, the wider the fast ice will be. Fast ice provides better movement routes and emergency landing fields than pack ice.

Freshwater Ice

Freshwater ice begins to form on lakes and rivers three to five weeks after the daily temperature drops to 32 °F; however, Marines should be aware that the rate of formation varies due to temperature, sun exposure, etc. Freshwater ice has less defects and is stronger than sea ice.

Lakes generally freeze with a smooth surface and, as the ice thickens, no crystalline structures are visible. The surface retains its smooth, dry, polished appearance. Lake ice is generally weak in areas with streams, inlets, springs, or outlets. Decaying vegetation can slow ice formation and cause weak ice by releasing air bubbles that become visible in the ice. These bubbles are trapped and visible within the ice.

Ice that forms on wide, slow-moving rivers typically has the same smooth appearance as lake ice. However, warm temperatures and wind can create a rough surface that remains rough throughout the winter; this ice is filled with air bubbles. In water with a temperature below 32 °F, ice forms fine, spicular, sharp, and pointed crystals in loose, spongy masses known as frazil ice or slush ice. Frazil ice floats upward and becomes thick under ice sheets, eventually becoming an integral part of the river ice.

Fresh water typically does not freeze to a thickness greater than 8 feet in a single season. In lakes, the ice depth by late winter usually ranges from 3.5 to 6 feet, depending on temperatures.

Land Ice

Land ice forms on the ground's surface or on solid objects. As with any movement on ice, Marines should use crampons or other traction devices to move across land ice.

ICE FORMATION

There are four types of ice formations found on inland rivers and lakes—blue ice, chandelier ice, rotten ice, and unsupported ice.

Blue Ice

Blue ice is typically the strongest type of ice and can appear light blue or green in shallow areas or black over deep water. In some cases, where the water depth is less than 3 feet, the ice is clear, and the bottom of the lake or river is visible. Cracks in the ice might be visible but are not a sign of weakness when they are in the same direction as the current. These cracks are caused when ice contracts during extreme cold; there should be no air bubbles present within the ice.

Chandelier Ice

Chandelier ice usually forms in the spring when water permeates or melts through the remaining ice to reach the water below. It also forms when water covers the surface of the ice due to surface melting or an upstream breakup, which floods the surface. The ice then appears as a series of icicles, resembling a chandelier. Inconsistent horizontal strength limits the ice's cohesion. This ice is dangerous to cross even when it is 5 to 6 inches thick.

Rotten Ice

Rotten ice is melting or compromised ice that has lost or is becoming unstable. It can have a honeycomb appearance and can be encountered at any time; however, it is typically encountered during a thaw or incomplete freezing. In winter, bogs, rotting vegetation, and sewers can cause rotten ice, which appears dull and chalky in color and is brittle. Rotten ice should not be used for crossing sites.

Unsupported Ice

Unsupported ice forms when there is space between the ice and water. This type of ice is a common hazard in areas where the water table has fallen due to tidal action or upstream of power dams, where spillway release changes occur. Marines can detect unsupported ice by cutting a hole in the ice. If the water rises less than three-quarters up the side of the hole or does not rise at all, then the ice is unsupported and should not be crossed.

ICE FORMATION RATES

When determining whether a crossing site can support movement, Marines must consider ice strength and the factors that affect ice formation.

Ice strength depends on—

- Ice structure.
- Water purity.
- Freezing process.
- Freezing and thawing cycles.
- Crystal orientation.
- Temperature.
- Ice thickness.
- Snow cover.
- Water current.
- Underside support.
- Age.

The following factors speed up ice formation:

- Low, stable temperatures.
- High wind-chill factor.

- No snow cover.
- No current.

The following factors slow down ice formation:

- Fluctuating temperature.
- Fast current.
- Snow cover.
- Salt water or other impurities.

MOVEMENT OVER ICE ROUTES

Ice routes are generally useful for navigation; conversely, canalized movement along a linear danger area might provide an adversary opportunities to target friendly forces. Traction control devices are recommended; these help individuals maintain mobility and can aid in rescue efforts should a team member fall through the ice. Detailed reconnaissance is required before attempting to move on ice routes. When moving on ice routes, units should treat them as an open area and stay close to the shore to help conceal troops and tracks. Overflow is when water flows onto the ice, affecting the types of ice encountered and potential routes. The following are general rules for selecting routes on ice:

- Outside bends of rivers generally have thinner ice due to the faster current.
- Lake edges generally have thicker ice because water freezes from the outside to the inside and from the top to the bottom.
- Inlets, outlets, converging channels, and tributaries are areas prone to thin ice.
- The ice in the middle of lakes and rivers tends to be thinner; the downwind side of lakes tends to have thicker ice.
- Vapor coming off the snow's surface indicates open water. Isolated patches of frost forming on trees adjacent to waterways indicate that there may be open water nearby, and the ice around that area may be thin.
- "Frost flowers" form when water vapor condenses on ice or snow usually from exposed water. When an open lead (i.e., long, linear crack, fissure, or channel of open water) freezes over, these flowers form on the ice. This ice is thin but might be able to support a load of snow, concealing its presence. When traveling along water routes, units should avoid any depressions in the snow and listen for hollow sounds or flowing water.
- As winter progresses, water levels under the ice begins to drop. This sometimes leaves an air space where the ice is no longer supported by water and might collapse. Marines should check for hollow sounds and the sound of flowing water.

WARNING: Failure to conduct a thorough reconnaissance of a route over ice can lead to loss of life and equipment.

Table 3-1 outlines the ice depth thickness required for different modes of travel and the required distance between individuals.

Table 3-1. Approximate Individual Short-Term or Moving Load Capacity of Solid, Clear, Freshwater Ice.

Load	One-Time Only Use	Normal Repeated Use	Distance Between Individuals
Individual on snowshoes or skis	1.5 inches (4 centimeters)	2 inches (5 centimeters)	17 feet (5 meters)
Individual on foot	3 inches (8 centimeters)	4 inches (11 centimeters)	17 feet (5 meters)

A general rule for armored vehicles is that 16 inches of ice supported by water (waterborne ice) supports 16 tons, and each additional inch supports one additional ton. This rule does not apply to ice thicknesses under 16 inches. For example, 3 inches of ice does not support three tons. If the water level has dropped under the ice, it cannot support heavy loads. See Table 3-2 for the recommended load capacity for solid, clear, and freshwater ice.

Table 3-2. Approximate Vehicle Short-Term or Moving Load Capacity of Solid, Clear, Freshwater Ice.

Vehicle weight	Required ice thickness* (inches = 4√vehicle weight)		Distance between vehicles (about 100 x thickness)	
(tons)	(inches)	(centimeters)	(feet)	(meters)
0.1 (200lbs)	2	5	17	5
1	4	11	34	11
2	6	15	48	15
3	7	18	58	18
4	8	21	67	21
6	10	25	82	25
8	12	29	95	29
10	13	33	106	33
20	18	46	149	46
40	26	65	211	65
60	31	79	260	79
80	36	91	300	91
100	40	102	335	102

NOTES
*To ensure safe movement of single vehicles crossing freshwater (lake or river) ice at temperatures below 32 °F, the formula $P = h^2/16$ or $h=4\sqrt{P}$ can be used as a rough guide (P is in tons and h is in inches of solid, clear, freshwater ice). When moving two loads on the ice, the safe distance between loads is about 100 times the ice thickness at the required minimum thickness. When the two loads differ in weight, planners choose the spacing shown for the larger load. At ice thickness greater than the required minimum, this spacing can be reduced.

**In temperatures above 14 º F, add 25 percent to all required ice thicknesses.

For additional information about crossing frozen waterways, refer to MCRP 12-10A.1.

DETERMINING ICE THICKNESS

Marines can use Gold's Formula to determine the required ice thickness or the weight-bearing capacity of a frozen body of water for landing zones. Gold's Formula:

$$H=\sqrt{(W/A)} \text{ or } W=A*H^2$$

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 (this correlates to risk and safety). The A-value can be used as a safety factor (S) when determining the weight-bearing capacity of ice for a known H-value or when determining the required ice thickness for a known W-value. The average flexural strength of ice is 150 psi, which results in S=1 (very low risk) when used as the A-value in Gold's Formula.

Table 3-3 provides several A-values and their associated levels of risk, as well as the required ice thicknesses for various aircraft weights at various levels of risk. Marines can use this table as a risk assessment tool to derive safety margins for any vehicle if the gross weight is known. Refer to Marine Corps Tactical Publication (MCTP) 12-10A, *Mountain Warfare,* for more information about Gold's formula.

Table 3-3. Landing Zone Ice Thickness for Frozen Bodies of Water

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

Table 3-3. Landing Zone Ice Thickness for Frozen Bodies of Water (Continued).

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

Associated risk when estimating flexural strength of ice

Risk Level	Flexural Strength (A) in psi
Very Low Risk	50 psi
Low Risk	75 psi
Tolerable Risk	100 psi
Medium Risk	150 psi
High Risk	200 psi
Extremely High Risk	250 psi

See Table 3-4 for ice safety information.

Table 3-4. Ice Safety Table.

Item Loaded	Weight in Tons	Ice Thickness Needed in Inches (centimeters)	Distance Apart Needed in Feet (meters)
Individual on snowshoes or skis	0.1	2 (5)	15 (5)
Individual on foot	0.1	4 (11)	15 (5)
SUSV or cold-weather all-terrain vehicle	7.5	13 (33)	89 (27)

ICE-CROSSING SITE SELECTION

Marines should select ice-crossing sites where the stream is broad and straight, the bank is relatively low or has a gentle slope, and the crossing area is easy to prepare. Sites should also have an even riverbed; well-defined channels, and a water flow that is reasonably deep with a low, uniform velocity. These conditions create strong, thick ice that is suitable for constructing ice bridges. Observations have shown that where a primary current curves at a 90-degree angle, and a secondary current enters perpendicular to or into the primary current, the entire water movement in that area slows. This results in freezing from bank to bank, which makes the ice capable of supporting troops on snowshoes or skis. Specific site selection considerations include the following:

- Designate the proposed route, approaches, exits, and sounding holes with bags, ice blocks, snow piles, stakes, or tape.
- Determine the water obstacle's width.
- Determine whether any dams are upstream.
- Determine tidal rise and drop for bays and the duration of high tide.
- Cut and drill holes through the ice every 3 to 5 meters by the banks and every 10 meters in the channel.
- Sketch the river's profile.
- Determine alternate routes.

Immediately adjacent to the shore, the ice is thin, weak, and more likely to develop cracks than ice in the center of a frozen stream. It is generally safer to maintain a route near the shore if the ice rests on the river bottom.

When water flows under a large ice area, the ice in contact with the current is subject to greater temperature variations; therefore, it is thinner than the ice in adjacent areas away from the current.

When determining site selection for ice-crossing, Marines should consider the following:

- Shallow water ice is usually thinner than deep-water ice.
- Good, quality ice is clear and without bubbles and cracks. In a body of water containing both clear and cloudy ice, the clear ice is usually thinner than the cloudy ice.
- Muskeg lakes (i.e., bogs) contain a great deal of vegetation that, when decomposing, delays freezing and results in weak ice.
- Flooded snow, when frozen, produces slush ice, which is white and can contain air bubbles (also called snow ice or white ice). Slush ice has a load-carrying capacity approximately 25 percent less than blue ice.
- Snow cover can insulate thin ice and prevent the formation of clear, blue ice. Marines might have to remove snow to maintain a crossing site.
- Unsupported ice, or ice that is not waterborne, is weak. This typically occurs in reservoirs and lakes with run-offs or hydro-electric dams. In some countries, such as Norway, many rivers and lakes are controlled by flood gates and may be opened by home guard units upon attack.
- During extremely cold weather (i.e., below 0 °F), cracks in the ice can be enlarged by heavy traffic.
- In spring, the main body of ice can be traveled over (if water is on the ice surface) only for a limited time. Potholes require extra caution.
- A reinforced ice crossing site should be located downstream of the summer crossing site to minimize the danger of damage to the bridging equipment during the thaw.

Fording

Broad flood plains with sandbars and shifting water produce weak or unsupported ice with open water areas and difficult working conditions. Such locations typically require a combination of an ice crossing, conventional floating bridges, and winter fording. Fording streams in the winter should be avoided because of the difficulties encountered in the crossing and the effects of water on personnel and equipment. More information on water crossings can be found in MCRP 12-10A.1.

ICE BREACHING FOR COUNTERMOBILITY

Explosives or supporting arms might be required to breach ice. For example, Marines might use this method to—

- Prevent the enemy from using a frozen river or lake as an avenue of approach, landing zone, or main supply route. Marines must continually use supporting arms to break the ice as it refreezes.

- Protect a defensive position on a lake or river line by preplanning fires on the ice and positioning machine guns for grazing fire over the ice.
- Ambush troops, vehicles, or helicopters using a frozen body of water (by grazing fire or preplanned supporting arms).

Ice Breaching Party

The ice breaching party is organized into three teams—reconnaissance, demolition, and initiator.

Reconnaissance Team. The reconnaissance team conducts an ice reconnaissance to select the breaching site and to determine demolition requirements. It reports this information to the demolition team. The reconnaissance team goes before the demolition team to chop, drill, saw, or blast holes in the ice. Chopping can be done with an ice axe, pickaxe, or spud bar. When chopping through the ice, darker water is visible before breaking through. The hole is then cleared out to its desired diameter before the hole fills up with water. Drilling is done with small, tamped charges placed on the surface of the ice in a partially excavated hole. The holes should be large enough for the main charges to pass through. After the reconnaissance team prepares the holes, they move off the ice.

Demolition Team. The demolition team prepares the charges in a concealed position on a single detonating cord chain or with each charge individually prepared for electric detonation. After the reconnaissance team moves off the ice, the demolition team brings the charges onto the ice by sled and places one charge by each hole. A team member remains with each charge and suspends the charge through the hole, using a stake to bridge the hole and hold the charge in place. The demolition team then moves off the ice. The following factors should be noted when using explosives in cold weather:

- In subzero temperatures, plastic explosives (e.g., C-4) can become brittle. If the explosives need to be molded, charges should be prepared in a warming tent. Trinitrotoluene (TNT) demolition blocks are a suitable alternative to plastic explosives because TNT is more water resistant and freeze proof; TNT, however, cannot be molded.
- Detonating cord, time fuze, and firing wire can become brittle in the cold and might not function as expected. Carefully ensure that all kinks or bends are removed. Keep the detonating cord, time fuze, and firing wire as warm as possible by placing it between the Marines' warming layers whenever possible.
- Electric detonation using a series circuit is an alternative method to using detonating cord in extreme cold weather. This method should be applied to small gaps and widths.

  WARNING: Electrical firing systems should be used only as a last resort, as the risk of accidental detonation due to static electricity is exponentially greater in a cold weather environment and is further exacerbated by the presence of snow.

- While snow reduces the effectiveness of the charge, using a pattern charge on ice can still be effective.
- Working with explosives and accessories requires feel and tactility. Because of cold temperatures, preparing explosive charges takes twice as long as usual. Marines should enter a warming tent every 30 minutes.
- Wearing contact gloves can increase the duration outside the warming tent.

- If temperatures remain between -4 and 14 °F, a blown hole in ice will refreeze and again be passable for personnel in 4 days, light vehicles in 14 days, and heavier tracked vehicles in 6 weeks.
- Leaders can calculate the required amount of explosives using the ice-breaching formula:

$$W = 1.4 \times T^3 \text{ (to third power)}$$

$$D = 0.6 \times T$$

$$R = 6.56 \times W^{1/3} \text{ (to 1/3 power or the cube root)}$$

D = depth of charge

R = radius of crater

T = ice thickness

W = pounds TNT (weight of charge)

When the water is more than 8 feet deep, the demolition team should suspend charges 4 feet under the ice. If the water is less than 8 feet deep, charges are suspended halfway between the ice and the bottom. The charges might have to be weighted in river currents to keep them stationary at the proper depth. The charges should be set up on a continuous detonation cord trunk line with each charge being wrapped with detonating cord and taped. This preparation increases the likelihood of detonation and quick assembly as each charge is measured for proper separation. The charges are suspended from the detonating cord by wrapping the cord around the stake bridging each ice hole. Therefore, the length between charges should be the separation distance, plus twice the suspended distance, plus 2 feet for wrapping the charge and the stake (see Figure 3-1).

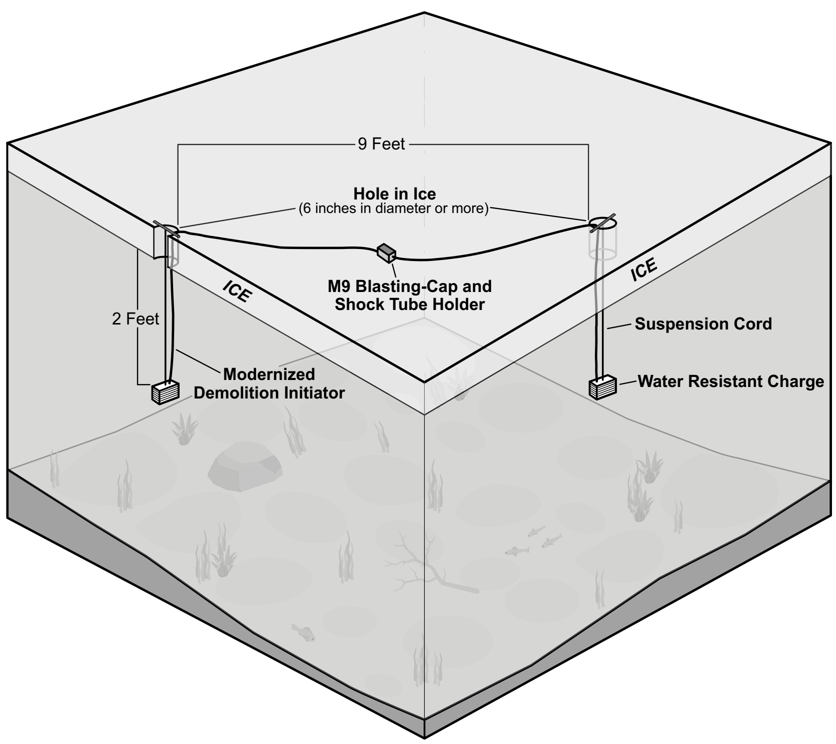


Figure 3-1. Method of Placing Charges in Ice.

Initiator Team. The initiator team follows the reconnaissance and demolition team, checks the charges, and initiates the charges when using nonelectric blasting. The time fuze should be long enough so that the initiator team can clear the ice before detonation. When detonation is time-sensitive or must be executed on command, use shock tube whenever possible; electrical systems in cold weather environments have an increased risk of accidental detonation due to static electricity. The initiator team completes the firing circuit; however, the charges must be inspected every four hours when detonation is time-sensitive or is on command at a future time.

Water Obstacle Maintenance

In cold weather, water obstacles begin to refreeze soon after breaching. Refreezing can be delayed by removing the shattered blocks of ice from the water or pushing them under the downstream ice. The open water can then be covered with a tarpaulin or plastic to insulate it and prevent ice formation.

When examining the obstacle after breaching, Marines should avoid large cracks, which may have opened nearby.

Ice Ambushes

Ice ambush sites typically need to be breeched without disturbing the snow cover. This can be done by employing the following technique:

- Remove a section of ice one meter in diameter near the bank.
- Cut saplings and trim the branches, ensuring that the number of saplings will prevent the current from moving the explosives.
- Attach explosives to these saplings and connect the detonator cord.
- Slide saplings through the hole in the ice with their explosives attached.
- Secure the end of one sapling to the front of the next sapling until the length of ice to be blown up is covered. The charges will be kept afloat and flush against the ice because of the saplings' buoyancy.
- Blow the charge from the bank, as required.

CHAPTER 4.
MILITARY SKI EQUIPMENT

Skis can provide flotation and glide over the snow and are a more efficient and faster means of moving over snow-covered terrain. To achieve proficiency on skis, Marines require approximately three to four weeks of concentrated ski training. Skiing can enhance a unit's ability to conduct mountain activities across the intelligence, maneuver, and force protection warfighting functions. However, snowshoes are recommended because they are easier to use and require minimal training and maintenance. The preponderance of the force is snowshoe mobile with only reconnaissance and surveillance elements or designated units as ski-mobile.

Marines will encounter various ski systems when training with allies and joint services; however, Marines primarily use the Military Ski System (MSS), which is designed to give the novice skier over-the-snow mobility with minimal training. The MSS (Figure 4-1) provides Marines with additional mobility for operating on snow in mountains, as well as in open and forested areas. The MSS provides Marines with the capability to conduct cross-country missions in forward-deployed, cold-weather environments. The MSS has scales to provide traction on slopes up to 15 degrees. Due to the combat load weight and MCCWIK for cold weather environments, Marines can switch to snowshoes when ascending or descending steeper terrain (i.e., level I and II). See MCTP 12-10A for more information on the levels of terrain.

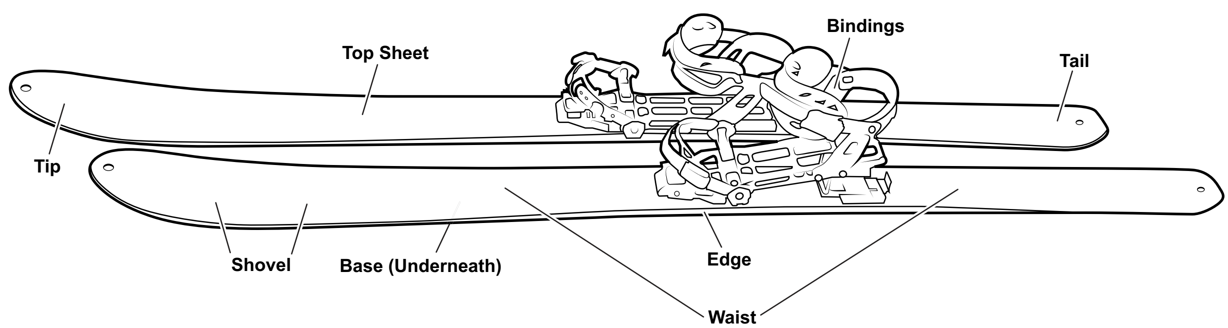


Figure 4-1. Military Ski System.

The MSS uses a universal binding system that is compatible with the vapor barrier or any issued cold-weather boot.

These skis vary in length from 162, 169, and 171 centimeters and are issued depending on the skier's weight; see Table 4-1 for ski recommendations.

Table 4-1. Military Ski System Sizing.

Ski Model and Size	Waist (Skis)	Ski Weight	Surface Area	Recommended Skier Weight (without gear)*
Intrepid 9.7: 162 cm/64 in	97 mm /3.8 in	**6.5 lbs**	1,661 cm^2 /257.5 sq in	150-200lbs
Intrepid 9.7: 169 cm/66 in	97 mm / 3.8 in	6.9 lbs	1,740 cm^2 /269.7 sq in	180-220lbs
Intrepid 10.1: 171 cm/67 in	101 mm / 3.9 in	7.0 lbs	1,825 cm^2 / 282.8 sq in	210-260lbs
NOTE *The overlap in skier weights by length of ski is intentional and allows for additional factors such as height and skier ability				

NOMENCLATURE OF A MILITARY SKI

The following are the common parts of a ski (see Figures 4-2):

- Tip. The tip is the forward point of the ski. The MSS has holes in the ski tips to drag, bundle skis, or improvise a litter.
- Shovel. The shovel is the upturned portion at the front of the ski that helps push aside the snow as the ski moves forward; it provides flotation on snow by keeping the ski on the surface of the snow.
- Waist. The waist is the middle third portion of the ski.
- Tail. The tail is the rear of the ski. It has a notch in the center for attaching climbing skins.
- Base. The base is the bottom of the ski. The MSS uses a fish-scale or scalloped structure in the primary kick zone (fore and aft of underfoot). The structure is designed to glide with little friction on the forward direction and provide the skier with grip to prevent sliding backwards and aid forward movements on modest grades (10 to 15 degrees). This feature aids novice skiers in forward progress and limits the need to transition to skins in varied terrain.
- Edges. The edges are the metal rails on the sides of the ski; used to grip snow during a turn.
- Side Cut. The side cut is the difference in width at the shovel, waist, and tail, or the difference in width measurements from tip to tail. The side cut makes it easier for skiers to turn when they apply pressure on the ski at an angle to the snow surface.
- Camber. The camber is the bow or concave arch in the center portion of the skis. It is often referred to as the wax pocket. When a Marine puts weight on the ski, the bow flattens. The amount of weight needed to flatten the bow depends on the skier's weight and ability. There are three camber types across military skis:
    - Single Camber. The single camber is soft so that more of the ski is in contact with the snow, making steering easier and providing greater control. A single camber ski is best suited for downhill skiing but will perform as a cross-country ski. Single camber skis, (also known as alpine camber), distribute the weight more evenly over the entire running surface of the ski. It also allows a rebound effect from turn to turn. When flexed (that is when you are standing on them), alpine cambered skis should form a smooth arc with no wax pocket. The military has generally selected a ski with single camber to a camber and a half.
    - Double Camber. The "stiffness" in the camber of the ski and pronounced arch with a high central section (also known as Nordic camber). A double camber ski will require more force

to flatten out, causing steering to be more difficult, but the stiffer ski will have a better gliding and kick wax pocket. Double camber skis are suited for groomed trail cross-country use only and are only marginally effective for downhill use and better suited for rolling terrain. The only double camber skis are classic cross-country racing skis, which are not appropriate for the backcountry and due to limited surface area, may not provide effective flotation due to combat load. Nordic and cross-country skis often have a groove down the center base of the ski. This groove allows the skier to track in a straight line.

- Camber and a Half. This is a design compromise, offering a balance between single and double camber. It has an arched, stiff center like a Nordic camber, but the transition between the grip zone and the glide zones is less pronounced than on a true double camber ski. A camber and a half creates an arched and stiff section in the center of the ski. This forms a center wax "pocket." A soft wax is applied to this area of the ski. This forms an area that will grip the snow, thus giving an individual traction and allowing that individual to move forward; or they may have scales for gripping the snow. This type is ideal for general-purpose, backcountry movement within variable terrain (some flat sections, some downhill turns, some climbing). It provides better turning ability than a full double camber ski while still offering sufficient grip for climbing and efficient kick-and-glide on moderate terrain. The less aggressive camber allows it to handle soft, unpacked snow better than a stiff, pure double camber ski.

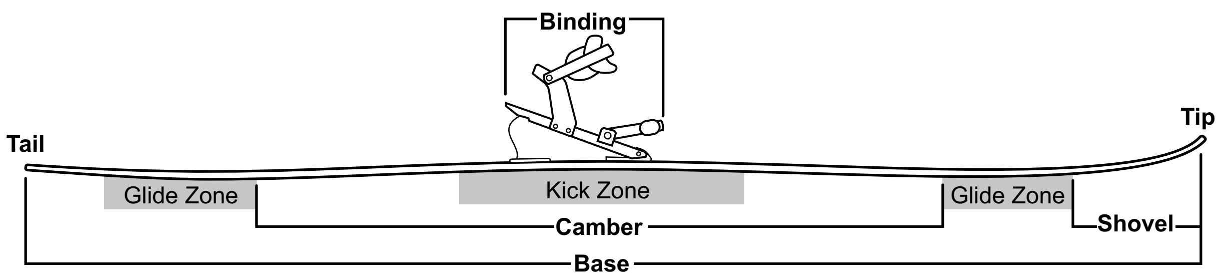


Figure 4-2. Ski Nomenclature.

- Top sheet. The top sheet is the portion of ski that covers the core. The MSS is painted white for camouflage.
- Core. The core is the wood or plastic material layered between the top sheet and base of the ski that provides the load bearing capacity.
- Binding. The binding holds the boot to the ski. It is designed for quick entry and exit. The MSS uses a universal binding to accommodate vapor barrier and other cold-weather boots. The MSS binding accommodates size 6 narrow through a size 15 wide boot. Marines training in large scale exercises with NATO allies may encounter the NATO 120 binding. It is an all-metal binding, consisting of a cable clamp, toe plate, and a cable. The binding features a riser bar (televator) that mitigates fatigue on sustained climbs, movement is limited, and control is maintained through the travel limitation kit (550 cord or cable). Other bindings that Marines might use include the 75 mm telemark or alpine touring.
- Tracking Groove. The tracking groove (also called a ski gimmel) is a U-shaped cut going from just below the tip down to the tail. It is designed to help the ski run over the snow in a straight line. Without the groove, the ski tends to wobble or move from side to side.

- Kick Zone. The kick-zone area is located within the camber and is where the kick wax is applied for grip. The kick zone varies based on a Marine's weight and ability and the terrain. Typically, the zone begins 6 inches before the binding and extends to 6 inches beyond the binding.
- Glide Zone. The glide-zone area remains in contact with the snow surface. The glide zone runs from the ends of the kick zone to the respective ends of the ski.
- Metal Edge. The metal edge can be offset or flush with the running surfaces of the ski and is essential for mountaineering skis.
- Side Wall. The side wall protects the ski's core from warping due to water damage.
- Flex. There are three types of flex—
  - Tip Flex. Soft tips follow the terrain by easily flowing over bumps, dips, and irregularities in the snow. If the tip is too soft, the ski tends to wander and become difficult to control in turns. Moderate tip flex is more desirable for backcountry touring and mountain skiing, providing better flotation in powder and adequate control when turning.
  - Tail Flex. Tail flex is similar to tip flex in its response to snow and turning. If it is too soft, the ski might wash out or not hold an edge while turning.
  - Torsion Flex. Torsion flex is the twisting action from side to side that a ski experiences while in a turn or track. A touring or mountain ski has a torsionally stiffer tip, which gives the ski more holding power and better edge control when turning.

  NOTE: Edge control is the action of adjusting the edge angle and edge pressure of the ski.

SKI BINDINGS

The universal binding on the MSS (see Figure 4-3), which weighs approximately 2.24 lbs, has—

- Adjustable toe wings and heel cups. The bottom of the heel cup has spacers that are placed either inboard or outboard depending on the boot's width.
- An alloy riser bar.
- Stainless steel mounting hardware.
- A heel slide lock:
  - The locked-down position is used for downhill skiing.
  - The unlocked position frees the heel for cross country movement or climbing.

The MSS bindings include the following:

- Axle cap.
- Toe strap and adjustment band.
- Toe lug wings.
- Ankle strap and adjustment band.
- Binding main adjustment track.

- Heel base plate and heel slider lock.
- Ankle heel adjustment cup and bracket.
- Travel Limitation Kit. It uses 550 cord, which provides pull-back tension when cross-country skiing.

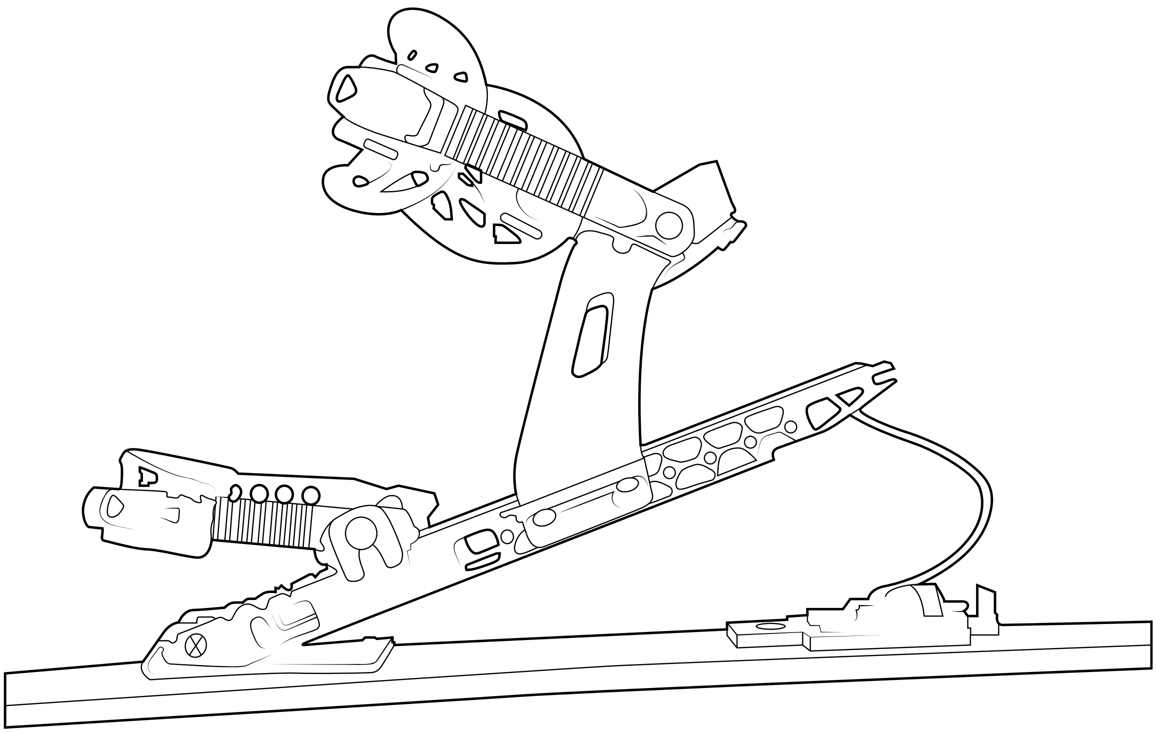


Figure 4-3. Military Ski System Binding.

Technical Manual 4451-20/1, *Operator and Field Maintenance Manual for Consolidated Storage Program Serviceability Standard for Infantry Combat Equipment*, provides more details on care, maintenance, binding sizing, etc.

The NATO 120 ski binding (Figure 4-4) is also used by allies with the NATO ski and can be fitted to various boots, including the vapor barrier boot, box-toed boot, and ski-march boot (used by some NATO countries). Alpine touring bindings and boots may be encountered as well. All systems enable cross country movement and varying capabilities for moving in Class I and Class II terrain.

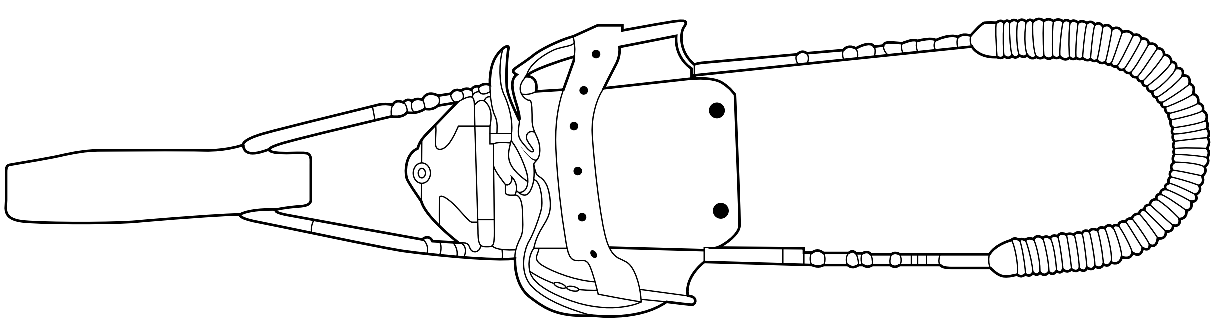


Figure 4-4. NATO 120 Ski Binding.

The following are parts of the NATO 120 ski binding:

- Toe Plate. The toe plate has a wing nut fastener, locking lever, and two adjustable toe plates. A toe strap is used across each toe plate to hold the boot down.
- Cable Clamp. The cable clamp at the front of the binding and is designed to tension the cable around the boot. The cable clamp also has a retractable nut, which allows for two full sizes of adjustment of a cable to a boot.
- Cable. The cable is a plastic coated cable with a coil spring that fits behind the back of the heel. The cables come in four sizes and have a different colored band representing the size rating of that cable. Table 4-2 contains the band color and corresponding boot size.

Table 4-2. Cable Sizing Chart.

Band Color	Cable Size	Boot Size
Blue	Extra large	12 to 14
Black	Large	10 to 12
Green and Yellow	Medium	8 to 10
Red	Smal	6 to 8

NOTE: Blue band cables must be ordered separately; all other cables included with the binding assembly.

Skiers must adjust the various parts of the binding:

- Toe Plate. Every Marine needs to adjust the toe plate by—
  - Loosening the wing nut and lift the locking lever.
  - Placing the toe of the boot behind the wing nut, ensuring that the heel of the boot is centered on the ski.
  - Aligning the toe plates against the welt of the boot and push the locking lever back down into its original position.
  - Tightening the wing nut until no movement can be felt from the toe plate.
- Cable Clamp. These clamps provide the proper tension and must be secured down. Individuals can make minor adjustments to the tension by unscrewing or tightening the nut. Once the cable is clamped down, there should be no lateral movement of the boot.
- Cable. Choosing the correct cable length for the specific boot size and appropriately adjusting the cable clamp ensures proper performance.

MILITARY SKI POLES

Ski poles aid the skier's movement and balance. There are two types of ski poles: adjustable and nonadjustable. An adjustable ski pole weighs approximately one-half pound, while a nonadjustable pole weighs about one pound. To adjust a ski pole, the skier should place the point of the pole on the ground and ensure the handgrip fits snugly in the individual's armpit. For downhill skiing, skiers should adjust the pole to have their elbow at a 90-degree angle while holding the ski pole for balance and maneuver. For cross-country skiing, skiers should lengthen poles to chest height so they can plant and drive the ski pole.

Ski poles have the following parts (see Figure 4-5):

- Wrist Straps. The wrist strap should be adjusted to support the wrist for pushing while cross-country skiing. Once adjusted, they should not be cut as different gloves or mittens will require readjustment.
- Handgrip. The handgrip is made of a hard plastic.
- Shaft. The shaft is made from a single hollow aluminum piece for non-adjustable poles, and several hollow aluminum pieces with associated clamps for the adjustable poles.
- Basket. The basket is located near the bottom end of the pole. This basket allows the pole to remain above the snow's surface during pole plants.
- Point. The point is located at the end of the pole and is also known as a ferrule. The point pierces the snow surface during pole plants.

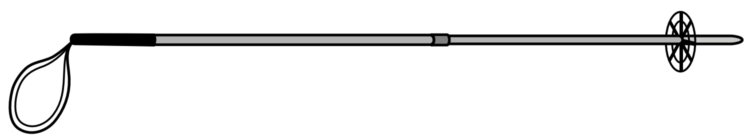


Figure 4-5. Military Ski Pole.

MILITARY SKI CARE AND MAINTENANCE

Serviceability checks, proper ski care, and ski maintenance are required to maintain ski equipment.

Serviceability Checks

Marines must check the following items for serviceability:

- Delamination. Delamination occurs when the plastic coating separates from the ski, causing water damage to the inner core. Marines should frequently check skis for nicks and gouges in the coating.
- Ski Base. The ski base should be flat and smooth. Marines should check for possible gouges and cuts, which might impede the ski's ability to glide and create problems with the wax. Any gouges or cuts should be filled to prevent an unstable ski.
- Ski Edges. If the ski edge is separated from the ski, movement becomes difficult, particularly when turning or edging.
- Bindings. Marines should check all metal parts for stress fractures and missing parts, and for the MSS any cracked or broken plastic pieces. For the NATO 120 binding, ensure that the cable is not missing large sections of the plastic coating or that the coil spring is not over stretched.
- Detuning. Detuning is a process of dulling the edges. If the skis are new, the metal edges are sharp. Detuning the tips and tails approximately 6 inches on both sides helps prevent skiers from "catching an edge" where this stops the ski's motion, while the skier's body continues

down the slope, as if someone took their legs out (most often resulting in a crash). This is done with a standard file moving from the tip toward the tail.

Ski Care

Marines should care for military skis in the following ways:

- Heat. Skis should not be placed next to direct heat because the bottom of the ski could melt. Skis should not be attached too close to the exhaust pipes on tracked vehicles.
- Snow and Ice. Snow and ice should be removed from the skis before staging overnight.
- Waxes. Remove all kick wax before staging skis overnight.
- Staging Skis. Placing the tails of the skis straight into the snow may damage the tails if a hidden object, such as a rock or tree stump, is struck. During breaks, skis should be positioned with their bases facing the sun. This can be achieved by arranging the ski poles in an inverted "V" formation. Insert the shovels of the skis into the wrist straps, then separate the tails. This base-up setup helps maintain the grip wax, keeping it pliable.

Ski Maintenance

The base and edges of skis become damaged after use. The skier should use glide wax to protect the ski's base and to maximize the skier's speed.

Metal edge tuning can be difficult when the ski's metal edge is dulled or pitted. The edges should be sharpened as needed, except in the shovel and tail area. These two areas should be detuned (dulled) for maximum turning efficiency. To tune, hold the file parallel and lengthwise against the side of the edge, filing from the tip to tail, and keeping the file at a 90-degree angle to the base. Avoid excessive filing. The first 6 inches of the tip and the last 3 inches of the tail should be slightly detuned.

SKI WAXING

Two types of wax can be applied to the base of skis to prevent slipping, increase momentum, and maintain glide. Kick (also referred to as grip) wax enables skis to grip the snow and glide wax enables them to glide on snow. As the snow conditions and temperature change, the wax required also changes. The scales on the MSS reduce the need for wax.

Each wax has a range of ideal snow conditions. The type of snow (e.g., powder or slush) and the temperature affect the wax chosen and how it is applied (see Table 4-3). For kick wax the Marine Corps uses a two-wax system, which is part of the Marine Corps Cold Weather Infantry Kit (MCCWIK). Kick wax, as with climbing skins, can be used with the NATO ski system. The scales on the MSS do not typically require kick wax.

Table 4-3. Two-Wax System.

Kick Wax	Snow Temperature	Usage
Blue	5 to 32 °F	A wide range wax for snow.
Red	32 °F and above	Ideal for conditions around freezing and slightly warmer.

Wax and Its Effects on Snow

Applying wax to the ski's base provides a surface to which snow can adhere. When the skier's weight is on one ski, snow crystals are embedded in the wax, holding the ski firm while the skier pushes off. As the ski begins to slide forward, a thin layer of water—resulting from friction between the ski's base and the snow—causes the ski to glide until it stops and downward pressure is reapplied.

Applying Ski Waxes

Kick waxes provide optimum gliding and gripping characteristics for various snow conditions and temperatures. Because waxes vary among manufacturers, no wax should be prescribed; each wax container should specify the weather conditions in which wax performance is best. To provide a proper grip, skiers can use varying amounts, combinations, and application methods. When applying kick wax, skiers should—

- Wax in the temperature being skied.
- Ensure the ski is dry.
- Ensure the wax is corked (cork is used to rub in and smooth out wax after application) in from tip to tail.
- Apply the wax in layers or pattern for grip and then corked the wax.
- Start with a harder (colder) wax. Do not apply a harder wax on top of a softer (warmer) wax.

When applying ski wax, skiers should consider the following:

- Several thin layers work better than one thick layer.
- During movement, carry wax in an inside pocket to keep it warm.
- Do not put newly waxed skis on the snow until the wax has cooled to the air temperature. If the lead group has a specific wax applied for the starting conditions, the trailing group might want to use a warmer or colder wax due to track conditions left by the lead group.
- Marines should test the waxing job and rewax if necessary. Marines must ski several hundred feet for the wax to properly function.

Wax Kit

The MCCWIK wax kit is designed for NATO skis that were predecessors to the MSS and includes two kick waxes (the two-wax system), a cork, and a scraper.

CLIMBING SKINS

Climbing skins are made from synthetic fur called mohair. These mohair strips attach to the bottom of the skis, which allow the skier to slide forward but not back. Skins are used for ascending moderate to steep terrain or pulling sleds and may be issued with the MCCWIK.

> NOTE: Climbing skins are used with NATO skis. The MSS has scales and does not typically require climbing skins; however, commercial climbing skins can be cut to use with the MSS.

Climbing skins (see Figure 4-6) include—

- Skin. A skin has two distinct sides: an adhesive side and a mohair side. The adhesive side is placed against the ski's base. The mohair side is exposed to the snow.
- Heel Clamp. The heel clamp secures the skin to the tail of the ski.
- Toe Clamp. The toe clamp secures the skin to the ski tip. It is typically equipped with a rubber-tensioning device.

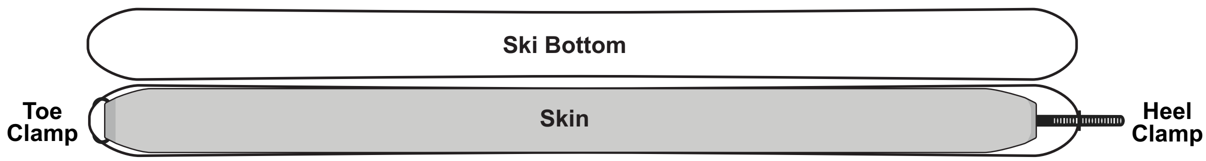


Figure 4-6. Climbing Skin Nomenclature.

The M-buckle located on the toe clamp is held in place by inserting the climbing skin through the buckle and folding it behind itself. To adjust skins, the folded adhesive should be pulled apart. When the skin length is correct it is folded back on itself.

To maintain the adhesive side, Marines should air dry the skins after each use. To store the climbing skins, Marines should find the midpoint and fold the two adhesive sides on themselves, then store the skins in their carrying bag. When in the field, Marines should place the skins (folded at the midpoint) between the sleeping mat and sleeping bag every night; they should not be left on the skis. The warmth reactivates the skin glue for the next use.

CHAPTER 5.
OVER-THE-SNOW MOVEMENT

SKIING

Military skiing can provide flank security and overwatch support for large-unit movements and enable reconnaissance and security elements with an enhanced mobility option. Military skiing increases Marines' mobility, giving them an advantage in combat.

Military skiing entails unit movements under a combat load with MCCWIK or assault load (see MCRP 12-10A.1). Snowshoes can be used when skis are not available although they provide slower rates of movement. When terrain levels and classes, deteriorating conditions, and or group ability negate the relative mobility advantage of skis, mountain leaders should direct the unit to switch to snowshoes.

For Marines to have the ability to successfully maneuver, they must learn to effectively ski and be trained in route selection. Military skiing enhances mobility, giving Marines the ability to move across snow-covered terrain, steep slopes, and through limited or sparse bush- and tree-covered terrain faster and, if adequately trained, with less effort than snowshoes.

Intelligence, surveillance, and reconnaissance personnel, including attachments such as forward air controllers, forward observers, and naval gunfire ground spot team members, should be ski trained. For example, the force reconnaissance company should be highly skilled to accomplish its mission; the air/naval gunfire liaison company should have skills on par with the allied unit to which they are attached; and overwatch personnel (mountain pickets) in larger, conventional units should be proficient scout skiers.

Initial ski instruction should be kept basic to provide a solid foundation and should be conducted on flat, snow-covered surface. Basic techniques of military instruction should be followed: explaining and demonstrating any new terms, such as "fall line" or "snow plow," that may be unfamiliar to students. After describing the basic skill, instructors should demonstrate it from a front, side, and rear view. As Marines progress in their skiing ability, leaders should begin teaching more complex, skills for more challenging terrain.

Skiing is a balance and movement activity that Marines learn through application. Leaders should ensure their Marines have adequate practice time. Skiers must be proficient in all snow and weather conditions. After completing initial instruction, Marines should train with packs, weapons, and equipment in varying environmental conditions and visibility levels.

Mitigating Falls and Injuries

Ski instructors should emphasize terrain and equipment selection as the primary considerations for avoiding injuries. When selecting routes and equipment, leaders should consider the skill level of the least experienced skier. Leaders are responsible for instructing and training their Marines. Marines must wear helmets when skiing.

> NOTE: Casualty evacuations typically require 4 to 12 Marines, which affects the unit's combat strength.

Ski Techniques

The following are common ski techniques:

- Basic athletic stance.
- Telemark position.
- Star turn.
- Controlled fall.
- Recovery from a fall.
- Kick turn.
- Diagonal stride.
- Telemark glide.
- Double poling.
- Sidestep.
- Forward sidestep.
- Herringbone.
- Half herringbone.
- Downhill running.
- Terrain absorption.
- Uphill traverse
- Downhill traverse.
- Uphill diagonal stride.
- Double pole with a kick.
- Wedge (gliding and braking).
- Wedge turn.
- Wedge christie.
- Wedge telemark.
- Stem christie.
- Step turn (in motion).
- Skate turn.
- Basic parallel.
- Dynamic parallel.
- Obstacle crossing.
- Free skiing.

For instructional information on these ski techniques, refer to Appendix F.

SKIJORING

Skijoring is a towing technique that uses vehicles to tow Marines on skis (see Figure 5-1). Units use skijoring to quickly transport Marines over a snow-covered environment; however, it is typically limited to snow-packed roads or trails made by tracked vehicles. Additionally, those being towed must have basic skiing abilities. Skijoring helps Marines conserve energy and can speed a unit's movement. Training for both the skiers and the drives is critical. For more information on skijoring techniques, refer to Appendix F.

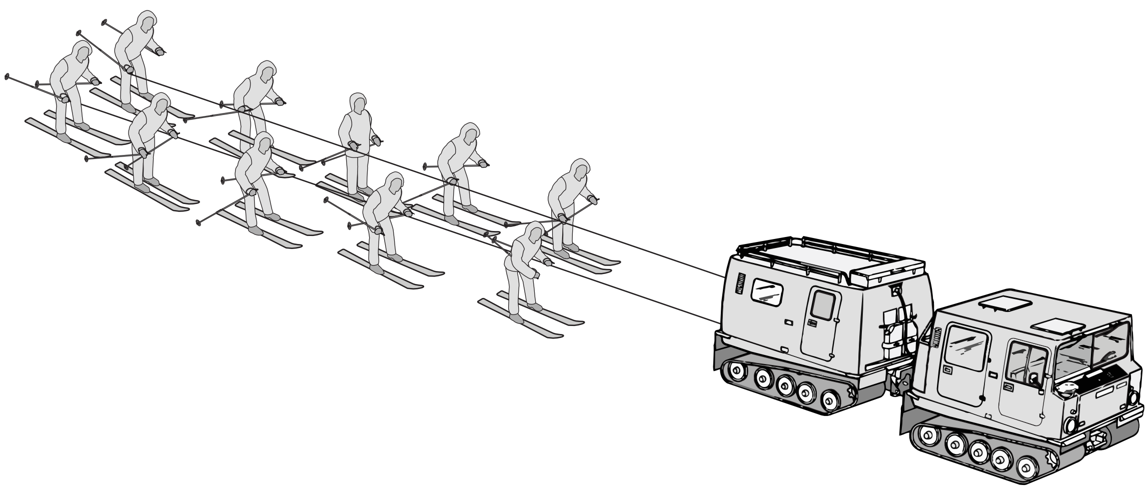


Figure 5-1. Skijoring.

Over-the-Snow Vehicles

Skijoring requires an over-the-snow vehicle with sufficient towing capacity. The vehicle's driver determines the towing capacity, which is based on snow conditions, vehicle type, and the safety rider's field of observation. The vehicle's driver should ensure that the—

- Mirrors for the driver are in correct alignment for best viewing to the rear of the vehicle.
- Vehicle has a functional back-up horn.
- Safety rider is positioned so that they can observe the skiers.

The driver or mountain leader determines the number of skiers that will be skijoring. To prepare for skijoring, the driver or mountain leader—

- Identifies the middle of the towing rope.
- Opens the trailer hitch and place an over-the-object clove hitch into it using the middle of the towing rope, which forms two towing lines behind the vehicle. A clove hitch is the only knot used.
- Tightens down the clove hitch, replaces the top of the trailer hitch, and ensures it is locked down to prevent the rope from slipping out.

For more information about over-the-snow vehicles, refer to Appendix E.

CHAPTER 6. OVER-THE-SNOW CASUALTY EVACUATION

Detailed casualty evacuation (CASEVAC) or medical evacuation is part of the planning process and supports mission accomplishment for the unit. Depending on the injury and the environmental and terrain conditions, moving a casualty from the point of injury to the collection point could require the entire squad and take significant time. Such movement not only endangers the mission but can be deadly for the patient. Therefore, units must conduct detailed planning, which should include preplanned collection points and movement routes, extraction points, alternate transportation options, and availability of appropriate types of litters (equipment). Leaders must ensure the CASEVAC plan is supportable at all levels.

The standard litter for over-the-snow CASEVAC is the MCCWIK fireteam sled; however, larger, older ahkio sleds or litters may be used to facilitate CASEVAC. A flexible litter may be used as well if available and the patient is adequately protected from the elements.

When preparing a CASEVAC, Marines should—

- Place the casualty's sleeping mat or extra clothing inside the sled as insulation and padding.
- Place the casualty's sleeping bag inside the team sled and place them in it.
- Secure the straps across the casualty's chest, knees, and shins. Rescuers can also place skis under the victim to provide C-spine precautions and to help support the legs out of the sled.
- Keep the casualty's head uphill during transport.

Marines should use the mnemonic "A PASS NGG" when conducting CASEVACs:

- **A**pply essential first aid. Apply lifesaving steps, such as splints or pressure bandages.
- **P**rotect the patient from the elements. Provide the casualty with proper insulation from the ground, such as a sleeping bag, field tarpaulin, or bivvy cover, ensuring that they are warm and dry. If there are any natural hazards, such as falling rocks or lightning, the casualty should be moved as quickly as possible, or responders should ensure that they are well protected and helmeted.
- **A**void unnecessary handling of patient.
- **S**elect easiest route. Send scouts ahead, if possible, to break trails.
- **S**et up relay points and a warming station. If the route is long and arduous, set up relay points where a fresh litter team may be waiting or where a system for raising or lowering has been emplaced. These relay points should also provide warming stations with minimum amount of medical personnel to—
  - Permit emergency treatment. Treat for shock, hemorrhage, or other conditions that may arise.
  - Constantly re-evaluate the patient. If the patient develops increased signs of shock or other symptoms during the evacuation, they may be retained at an emergency station until stable.

- **N**ormal litter teams must be augmented in arduous terrain. In a mountainous environment, a minimum of six Marines makes up a normal litter team.
- **G**ive litter teams specific goals. The litter team's job is extremely tiring, both physically and mentally. The litter teams must be given realistic goals.
- **G**ear remains with casualty. Ensure all the patient's gear is kept with them throughout the evacuation.

Additional information on over-the-snow CASEVAC can be found in MCRP 12-10A.1.

CHAPTER 7. WEAPONS CARRIES, FIRING, AND EMPLOYMENT CONSIDERATIONS

Extreme terrain and weather can pose significant challenges that Marines must plan for in both maneuver and fire support activities. In many situations, the terrain favors the defender who controls the high ground. Offensive activities typically include battles for this key terrain, or the chokepoints controlled in the valleys. Consequently, dismounted infantry and air operations are most suitable for this type of terrain, particularly if they are supported by fires. For example, it is important to position mortars and artillery in defilade to increase their chances of surviving. Yet, such terrain is often subject to devastating hazards such as snow slides, rockslides, or avalanches. Therefore, intelligence estimates should identify defilade positions that offer the greatest chance of friendly force survival.

Enemy units might seek to occupy the same types of positions as friendly units, thereby making observation and fires crucial to success in a cold-weather environment. Indirect fires can impede the enemy's mobility or destroy positions, giving maneuver elements time to close with and destroy the enemy. The basic tactical principles for artillery are subject to the limitations imposed by terrain, and weather can affect artillery employment in these environments. See MCTP 12-10A and MCRP 12-10A.1 for fire support and small-arms considerations.

DEEP SNOW EFFECTS

Conducting an assault is affected by deep snow and some form of flotation is needed to help troops move as fast as possible. The best and simplest flotation device is a snowshoe. Snow obscures objects—such as rocks and depressions—that provide cover and concealment, and it slows the assaulting troops' movement, making them a more vulnerable target. Fire superiority can be a problem because cold temperatures can cause malfunctions and because of limited ammunition due to challenges of resupply and limited individual loads. Initially, units must maintain a high volume of fires and then shift to a sustained rate of fire. Commanders should have a battle drill for maintaining fire superiority, such as an odd/even system within the buddy team so that units can maintain fire superiority.

Standard firing positions must be modified in deep snow conditions. Executing a standard drop from a standing position into a prone position would result in a Marine's elbow, face, and rifle being buried in the snow. Firing positions with skis or snowshoes are discussed in MCRP 12-10A.1.

Snowshoes or skis restrict the ability to rotate the body; individuals could have a difficult time shooting with their dominant hand. Regardless, a Marine's movement will be restricted when shooting uphill.

When firing in deep snow, Marines should—

- Sit between the skis for a stable non-moving position.
- Use ski poles for offhand firing as a long-range firing position; otherwise, use a more stable position, such as kneeling or prone. Extra steps to remove the ski poles, cross them, and assume the firing position are time consuming and may not be practical for short range shooting, unless rehearsed.
- Face downhill and sit uphill of one's skis (as in a controlled fall position) or snowshoes if fired on while traversing downhill.
- Face uphill and kneel if traversing and fired upon from the uphill side. On flat or gentle terrain, the kneeling position is sometimes unstable if the skis are not edged into the snow.

RIFLE CARRIES

Carries depend on the sling Marines have; these are generalized and based on the two-point sling but may be modified for other styles of slings. Depending on the glove a Marine is wearing, the trigger guard may need to be opened to access to the trigger.

Carry 1

To use carry 1 (see Figure 7-1), Marines—

- Attach the sling to the rear sling mount and around the front slip ring. The sling goes over the shooter's head. The weapon hangs down the firing side (the right side of a right-handed Marine or the left side of a left-handed Marine).
- Place the magazine pouch and canteen on the belt so that the rifle can be placed along the hip.
- Place the entrenching tool on the opposite side of the rifle when the pack is worn.

Figure 7-1. Carry 1.

The butt of the rifle is behind the shoulder with the pistol grip to the rear so the rifle or pistol grip will not be forced under the armpit if a fall occurs.

Carry 2

To use carry 2 (see Figure 7-2), Marines must—

- Attach the sling to the rear sling mount and around the front slip ring. The sling goes over the shooter's head. The weapon hangs down the firing side (the right side of a right-handed Marine or the left side of a left-handed Marine).
- Carry the rifle diagonally across the front (chest to waist).
- Place the sling around the neck and shooting shoulder.

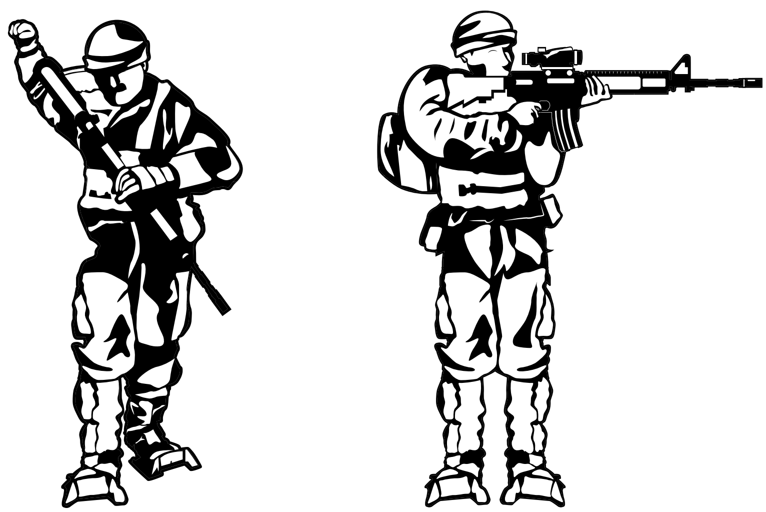


Figure 7-2. Carry 2.

SKI CRAWLS

Moving forward or advancing by sliding, crouching, or with trailing skis, enables Marines to move into firing positions in various snow conditions.

Working Forward on Skis

Marines should use this technique during a meeting engagement or as an immediate action when there is no time to remove their skis. They must—

- Keep poles together flat on the ground at their side.
- Rise from the prone position and support themselves on the non-firing side knee.
- Hold the rifle vertically with the dominant hand and gain more support by leaning with the non-firing hand on the poles.
- Raise the dominant foot, set the ski in the desired direction, and advance in a crouching position while pushing themselves along with the rifle and poles.
- While working forward, keep the rifle in the right hand and the poles in the left. Reverse this positioning for left-handed Marines. (See Figure 7-3.)

Rise from the Prone

Push with Rifle and Poles

Figure 7-3. Working Forward on Skis.

Advancing by Sliding

Marines should use this technique in moderately deep snow that will support them and their equipment. They must—

- Exit the ski bindings; put on snowshoes if designated.
- Place poles on the skis with the handles under the bindings and the baskets over the ski tips.
- Sling the rifle over the shoulder or lay it on the skis in front of themselves. See Figure 7-4.
- When sliding forward in a prone position, place skis close together, lie on their stomach on the bindings, and slide forward by pushing with the hands or toes.

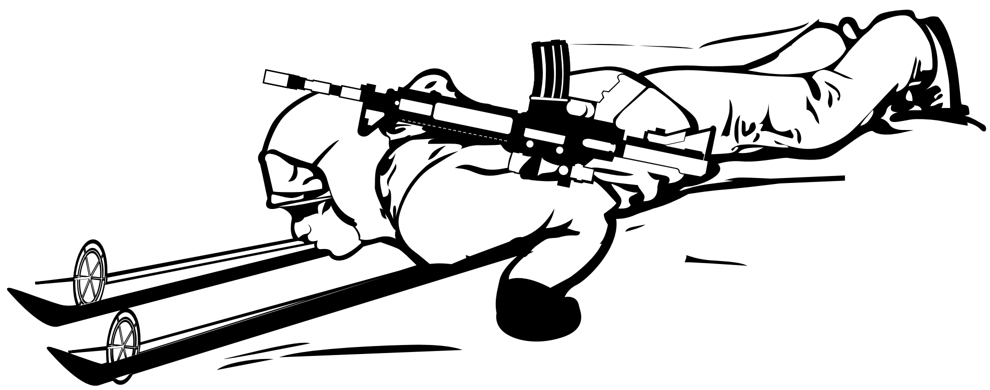


Figure 7-4. Advance by Sliding.

Advancing in a Crouching Form

Marines should use this technique in deep or loose snow by running in a crouched position. They must—

- Sling the rifle horizontally in front, around the neck, or over the back, depending on the situation.
- Place skis parallel on the ground, separated by the width of their body.
- Place pole baskets on the skis, placing the poles under the toe straps.
- Bend low and run, while grasping the bindings and poles together for support. See Figure 7-5.
- Get on elbows and knees and push forward with the knees if the ground and the combat situation do not permit this method of advancing.
- Use their hands to move skis forward one at a time.

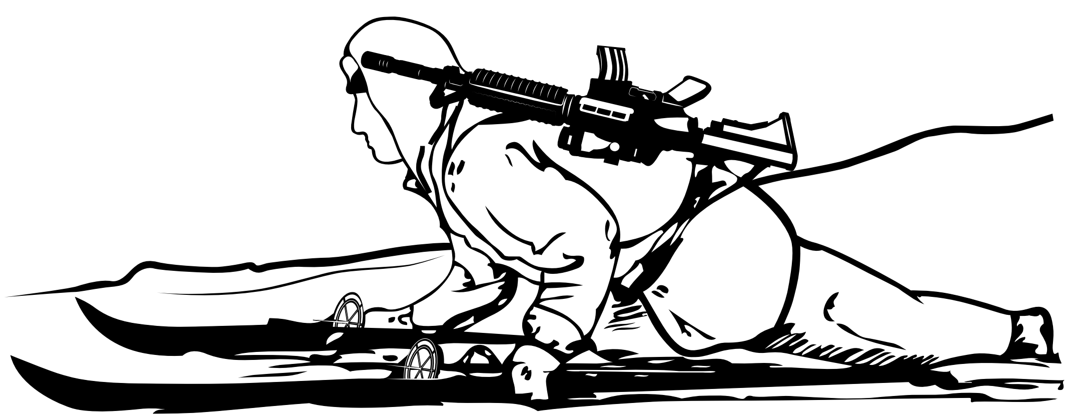


Figure 7-5. Advancing in a Crouching Form.

Advancing with Trailing Skis

Marines should use this technique in shallow snow. They must—

- Trail the skis behind while walking or rushing.
- Attach skis to the waist with a cord through the holes in the ski tips.
- Carry poles in one hand and the rifle in the other or on the back. See Figure 7-6.

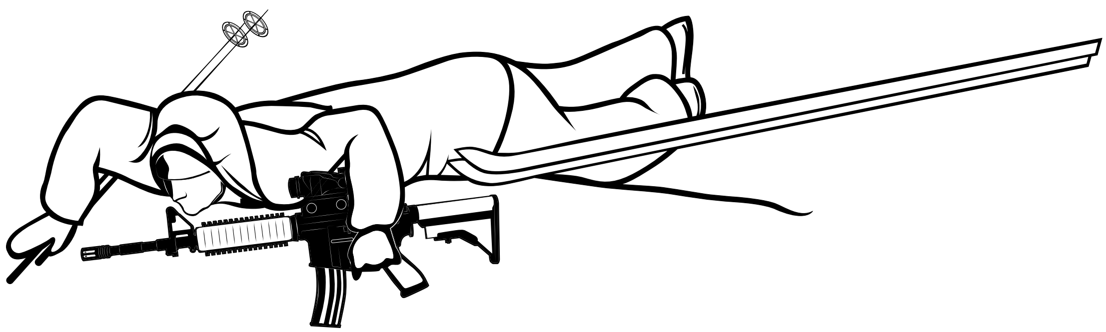


Figure 7-6. Advancing with Trail Skis.

CHAPTER 8. SNOW SHELTERS

BASIC CHARACTERISTICS FOR SHELTERS

All shelters must have six basic characteristics:

- Protection from the elements. The shelter must provide protection from rain, snow, wind, and sun.
- Heat retention. It must have insulation to retain heat and prevent wasting fuel.
- Ventilation. Ventilation must be constructed, particularly when burning fuel for heat, to prevent carbon monoxide accumulation. Ventilation is also needed for carbon dioxide given off when breathing.
- Drying facility. A drying facility must be constructed to dry wet clothes.
- Free from natural hazards. Shelters should not be built in areas where there is a risk of avalanches, rock fall, or where there are dead trees or large limbs that could fall on the shelter.
- Stable. Shelters must be constructed to withstand severe weather.

SNOW SHELTER CONSTRUCTION

When constructing snow shelters Marines should—

- Build for a group's size.
- Improve heat retention with a low silhouette and reduced living area.
- Avoid exposed hilltops, valley floors, moist ground, and avalanche paths.
- Create a thermal shelter by applying snow, if available, to roof and sides of the shelter.
- Build near firewood, water, and a signaling area.
- Determine the time and effort needed to build the shelter.
- Determine if the shelter can protect Marines from the elements.
- Provide concealment from enemy observation.
- Plan escape routes.

SNOW SHELTER TYPES

There are many types of snow shelters, such as—

- Snow wall.
- Snow cave.
- Tree-pit snow shelter.
- Fallen tree bivouac.
- Snow trench.
- Snow coffin.
- A-frame shelter (see MCRP 12-10A.3, *Mountain Leader's Guide to Mountain Warfare Operations*, for more information).

Table 8-1 can be used as a general guideline to determine which shelter to construct.

Table 8-1. Recommended Shelters.

Snow Pack	Snow Depth	Estimated Hours to Construct	Recommended Shelter
Loose	< 2 feet	2	A-frame
Compacted	4-6 feet	2–3	Snow coffin
Compacted	6 feet	3	Snow cave
Iced	Not Applicable	2–3	Snow trench
Not Applicable	Not Applicable	1–2	Fallen tree
Not Applicable	Not Applicable	1–2	Tree-pit
Not Applicable	Not Applicable	0.5	Snow wall

Snow Wall

One or two Marines can quickly construct a snow wall when weather conditions prevent constructing a stable shelter. To construct a snow wall Marines should—

- Determine wind direction.
- Construct a wall of compacted snow in the shape of a horseshoe to shield Marines from the wind. The wall should be at least 3 feet high and as long as the body. Figure 8-1 depicts a snow wall.

A poncho or tarp can be attached to the top of the wall with the other end secured to the ground for added protection. Skis, poles, branches, and equipment can be used to increase stability.

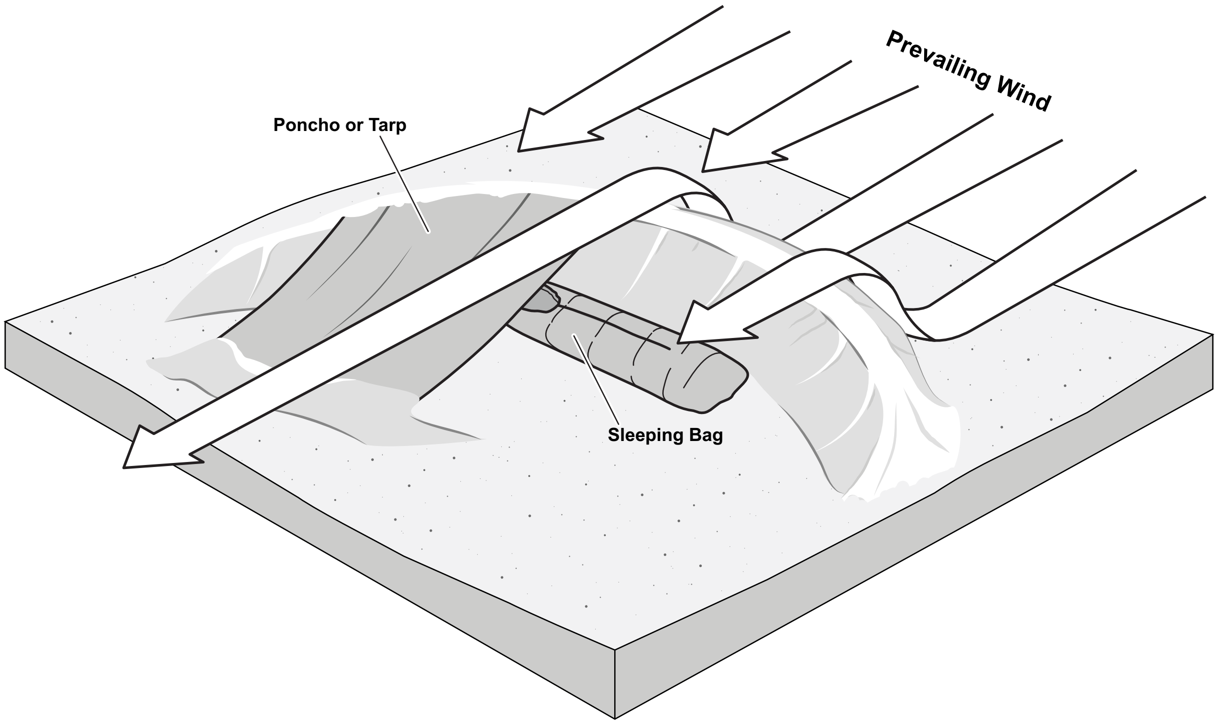


Figure 8-1. Snow Wall.

Snow Cave

A snow cave is used to shelter 1 to 16 Marines for extended durations. A snow cave's base must be 6 feet of well-compacted snow. To construct a snow cave Marines should—

- Dig into the snow until the desired tunnel entrance has been reached.
- Place all excavated snow on top of the shelter for added strength.
- Cut an entrance into the snow approximately 3 feet by 3 feet.
- Continue to dig out the cave while removing excess snow out of the entrance. Shape the roof into a dome. If a bluish color appears through the snow in the roof, stop. There is not enough snow to support the roof.
- Create a cooking or working shelf and a sleeping bench inside the shelter.
- Dig a ventilation hole through the roof at a 45-degree angle above the entrance. A ski pole or branch is left in the hole to mark the hole and allow clearing should the ventilation hole become clogged. A pine bough branch can be placed on the outside of the roof above the hole, to aid in keeping the hole clear during falling snow.
- Avalanche transceivers should be worn while inside a snow cave in case of collapse.

There should always be an arctic sentry in case the cave collapses.

Personnel should wear minimum layers under the protective layer to avoid overheating while digging inside the cave. Once the cave has been dug, the entrance hole must be filled in with a snow block. Loose snow should be packed in between the cracks and allowed to harden for approximately two to three hours, depending on the weather. After the snow has hardened, a small entrance hole can be cut. Packs or a poncho can also be used to block the entrance to the cave. See Figure 8-2.

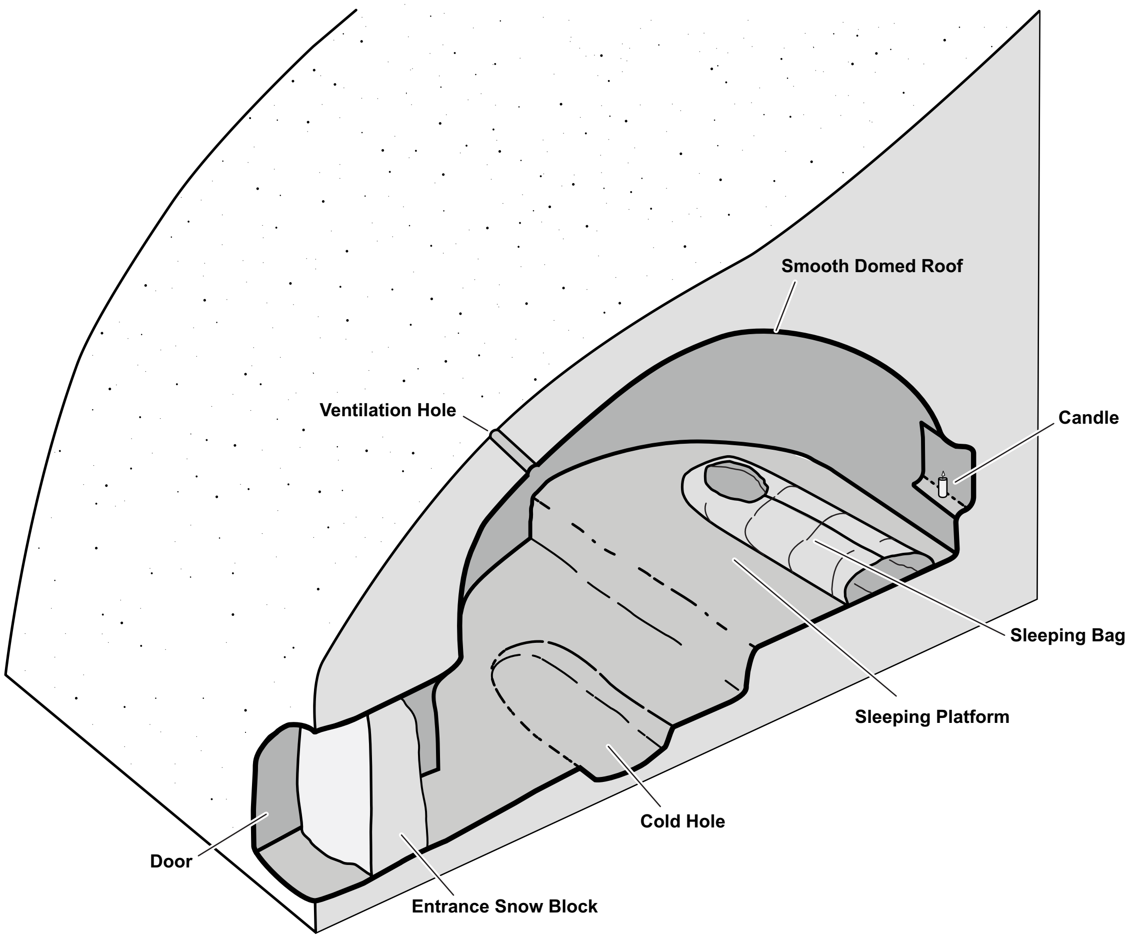


Figure 8-2. Snow Cave.

Snow caves can be heated by a candle, which will raise the inside temperature approximately 2 °F. An Arctic sentry or fire watch must remain posted to reduce the danger of asphyxiation or alert others to assist in rescue in the event of a snow cave collapse. The burning candle can also serve as a preventive measure against oxygen deprivation in the snow cave. If the vent hole or door becomes covered in snow, the burning candle will indicate that there is no fresh air flow into the cave and that the occupants are at risk of asphyxiating. Burning stoves to heat a cave will cause the snow to melt and should be avoided.

Tree-Pit Snow Shelter

A tree-pit snow shelter (see Figure 8-3) is designed for one to three Marines for short durations. It provides excellent overhead cover and concealment and should be used as an observation post. To construct a tree-pit snow shelter Marines should—

- Locate a tree with bushy branches that provides overhead cover.
- Dig out the snow around the tree trunk until reaching the depth and diameter desired or until reaching the ground.
- Find and cut other evergreen boughs. Place them over the top of the pit for additional concealment. Do not use a bough from the tree being used for the shelter.
- Place evergreen boughs in the bottom of the pit for insulation.

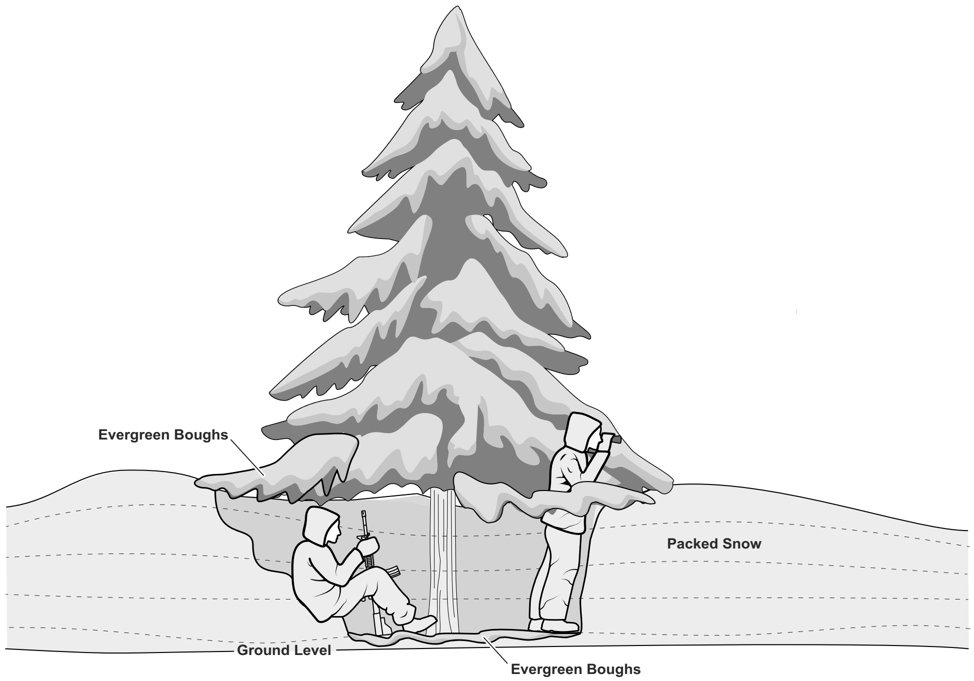


Figure 8-3. Tree-Pit Shelter.

Fallen Tree Bivouac

To construct a fallen tree bivouac Marines should—

- Ensure the tree is stable before constructing.
- Cut away branches on the underside and dig out snow, making it hollow underneath.
- Place additional snow and insulating material on the top and sides of the tree.
- Build a small fire outside of the shelter.

Snow Trench

A snow trench (see Figure 8-4) is a short-term shelter used on hard-packed snow and when trees or other building materials are not available, such as in alpine and glacier environments. Blocks of snow or ice are cut and placed to build this shelter. To construct a snow trench Marines—

- Dig the trench so that the wind blows from the foot side to minimize snow erosion.
- Place a triangular key block vertically at the trench's foot to serve as roof support.
- Cut a notch along the inside wall of the trench. The size and width of this notch depends upon the condition of the snow. Weak snow would require a larger notch.
- Trim the roof blocks at an angle so that the tops meet at a point. The first roof block is a half block in width. This construction keeps the joint lines of the other blocks from meeting and producing a weakness in the roof.
- Inspect the trench daily to avoid a collapse of the roof during a whiteout.

MCRP 3-05.1, *Multi-Service Tactics, Techniques, and Procedures for Survival, Evasion and Recovery*, provides options for snow trench construction with sticks and foliage and covered with snow in lieu of cutting blocks.

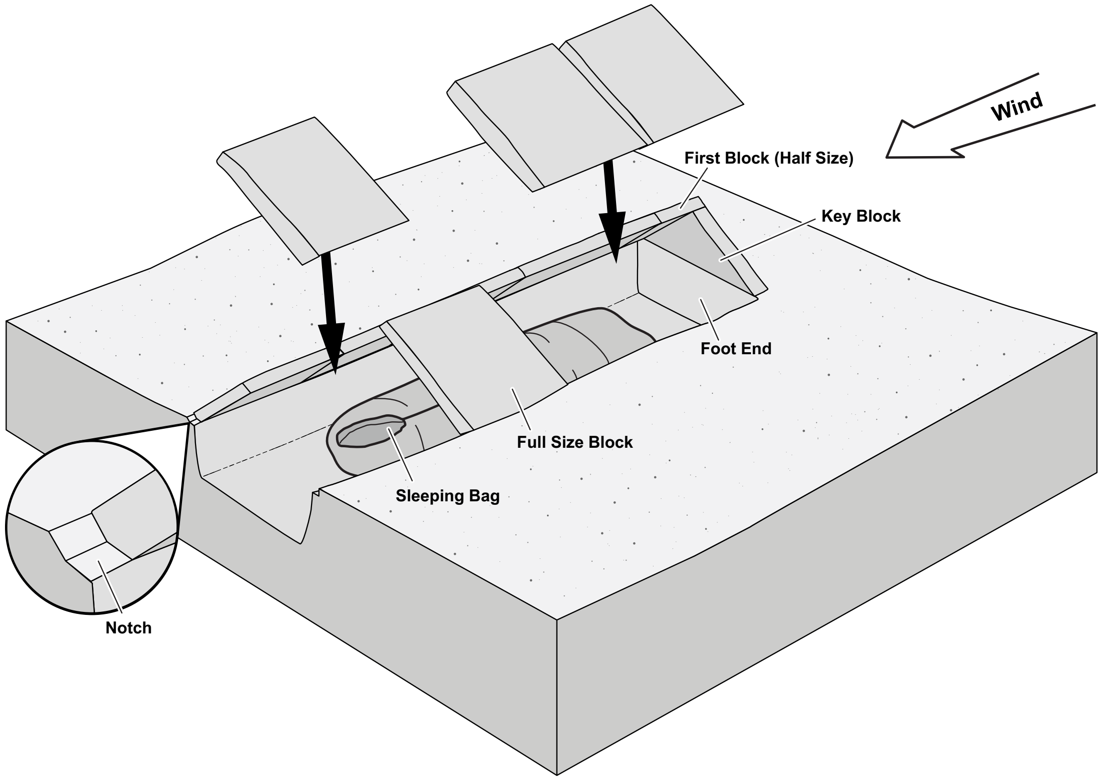


Figure 8-4. Snow Trench.

Snow Coffin

A snow coffin (see Figure 8-5) is built for one to four Marines for extended periods. It is a variation of the snow trench and requires at least 4 feet of compacted snow. To construct a snow coffin—

- Dig a trench into the snow approximately 3 feet wide, 8 to 12 feet long, and 4 feet deep.
- Dig a cold hole into the floor of the trench and create sleeping platforms (coffins) off the sides of the trench.
- Cover the top of the trench for added protection with either an A-frame or poncho or tarp.

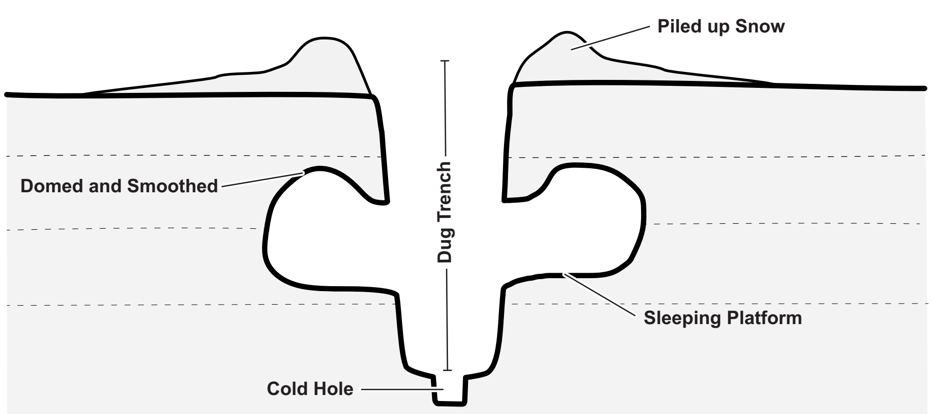


Figure 8-5. Snow Coffin.

APPENDIX A.
AVALANCHE DECISION-MAKING CHECKLIST

Table A-1 represents an avalanche decision-making checklist.

Table A-1. Decision Making Checklist.

Current Danger Rating	Low (Green)	Moderate (Yellow)	Considerable (Orange)	High/Extreme (Red)
Danger Trend/ Forecast	Improving/Steady	Rising Slowly	Rising Rapidly	
Continue? If yes, proceed to avalanche activity data:				
When:	Past	Recent	Current	Current + widespread + your position + human/natural + large
Number:	None/few	Many	Widespread	
Where:	Far away	In area	Your position	
Triggers:	Natural	Human	Human/Natural	
Characteristics:	Small	Medium/slabs	Large	
Continue? If yes, proceed to snowpack data:				
Average depth:	>2.0 m (6.5ft)	0.5–2.0 m (5 - 6.5 ft)	<1.5 m (<5 ft)	
Average strength:	Strong	Moderate	Weak	
Variability from average depth/ strength:	Uniform	Somewhat variable	Highly variable	
Strong over weak layering:	Little/none	Some	Pronounced	
Compression tests (CT) and Rutschblock tests (RB):	CT 30+ RB 7	CT 20–30 RB 5–6	CT 10–20 RB 3–4	CT 0–10 RB 1–2
Danger signs (cracking, whumping):	Few/None Heavy trigger Localized propagation	Isolated Medium trigger Moderate propagation	Widespread Light trigger Wide propagation	
Continue? If yes, proceed to weather data:				
Storm:	None	Snow 1–2 cm/hr (0.4–0.8 in/hr) Winds move little snow in start zone Cool and steady temps	Snow 2–3 cm/hr (0.8-1.2 in/hr) Winds move some snow in start zone Warm temperatures/ rapid temperature rise	Snow 3+ cm/hr + (1.2+ in/hr) Winds move much snow in start zone + Very warm temperatures/ rapid temperature rise
Last NO GO storm ended:	>48 hrs ago	36–48 hrs ago	<36 hrs ago	

Table A-1. Decision Making Checklist (Continued).

Current Danger Rating	Low (Green)	Moderate (Yellow)	Considerable (Orange)	High/Extreme (Red)
New snow (12 hrs):	<15 cm (6 in)	15–30 cm (6-12 in)	>30 cm (12 in)	
Blowing snow:	None	Some recently	Much recently or currently	
Temperature: Solar radiation:	Cold–Cool None–Little	Cool–Warm Some	≥0°/rapid rise strong	
Continue? If yes, proceed to terrain assessment:				
Incline:	<25	25–35	>35	
Wind exposure/ aspect:	Windward	Some cross/lee	Much cross/lee	
Trigger points:	None–Few	Some	Many	
Size/traps:	Small/None–Few	Moderate/some	Large/many	
Other Pertinent Data:				
	GO with normal caution Consider human factors	Consider safer options GO with increased caution Consider human factors	Consider safest options Travel not recommended on specific terrain or certain snowpacks Consider human factors	Travel not recommended Consider human factors
Discussion of decision (terrain/snowpack to avoid, human factors):				
LEGEND CT compression test RB rutschblock test > greater than ≥ greater than or equal to < less than				

APPENDIX B.
AVALANCHE DATA-OBSERVATION CHECKLIST

The Avalanche Data-Observation Checklist is used to provide detailed assessment of weather, snowpack, and avalanche activity to inform Appendix A the Avalanche Decision-Making Checklist to provide accurate avalanche-hazard assessment.

Table B-1. Avalanche Data-Observation Checklist.

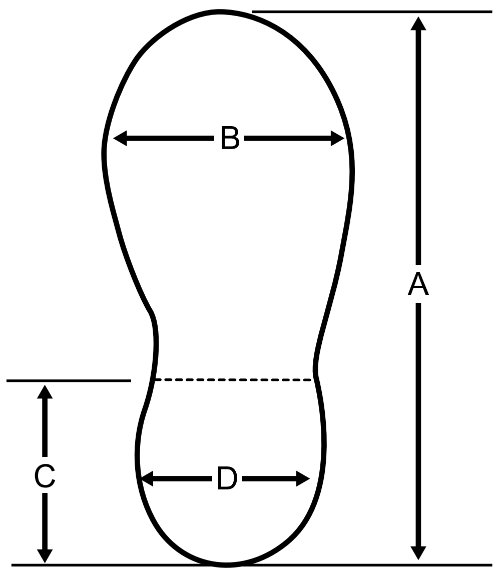
Data Class	Information Category	Observation Made	Red Flag Values	Current Observation
Weather	Precipitation	Type	Rain/heavy wet snow	
		Intensity	> 3 cm (1 in)/hour	
		Accumulation	> 30 cm (12 in)/ 12 hours	
	Wind	Speed	Strong enough to move snow	
		Direction	Moving snow onto or across terrain where Marines will travel	
		Duration	Long	
	Temperature	Current	≥ 0 ºC (32 ºF)	
		Maximum/Minimum	≥ 0 ºC (32 ºF)	
		Trends	Rapid changes (particularly from cold to warm and through the freezing level	
	Solar radiation	Cloud cover	Allowing a lot of radiation to enter. Intensifying radiation.	
		Intensity	Strong	
		Duration	Long	
Snowpack	Snow cover	Height	< 1.5 m (5 ft)	
		Strength	Weak	
		Variability	High	
	Layers	Strength	Strong over weak	
		Temperature	Near or equal to 0 ºC (32 ºF)	
		Grain characteristic	Large, loosely packed, angular	
	Bonding	Strength	Compression test ≤ 20 Rutschblock ≤ 4	
		Plane characteristic	Smooth, clear	

Table B-1. Avalanche Data-Observation Checklist (Continued).

Data Class	Information Category	Observation Made	Red Flag Values	Current Observation
		Failure layer	Large, loosely packed, angular grains	
	Booming or whumping	Initiation	Natural or man-made trigger	
		Propagation	Far (>3 m [10ft])	
		Extent	Widespread	
Avalanche Activity	When	Current	Observed	
		Recent	<24 hours (maritime climate) <48 hours (continental climate)	
		Past	If condition still exists	
	Where	Area	Widespread	
		Slope angle	More than 30 degrees	
		Slope aspect	Facing sun Leeward	
		Slope shape	Concave	
		Terrain traps	Traps exist where avalanches are running	
	What	Natural triggers	All natural triggers	
		Human triggers	All human triggers	
		Other triggers	Remote triggers, artillery, demolition	
	How	Destructive potential	≥Class 2	
		Propagation	Wide fracture lines running far	
		Failure layer	Large, loosely packed, angular grains	
LEGEND > greater than ≥ greater than or equal to < less than ≤ less than or equal to				

APPENDIX C.
SPOOR AND TRACKING TEMPLATE

The following is an example to aid in tracking others in snow-covered and or mountainous terrain if the tactical situation permits.



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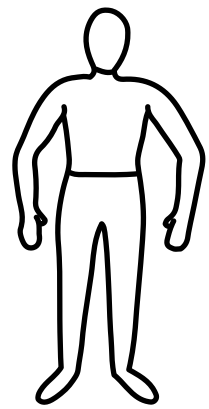

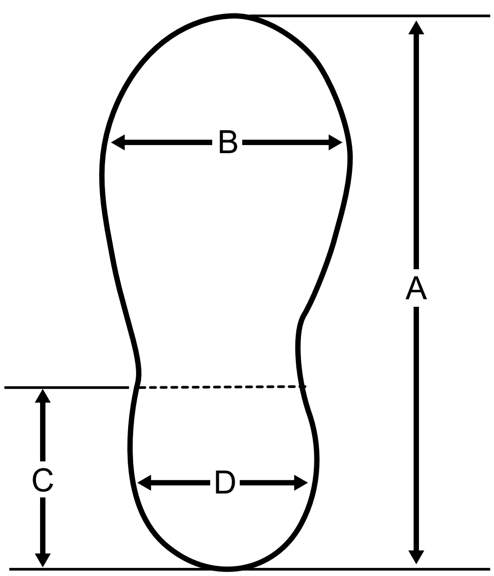

Nickname ________________________
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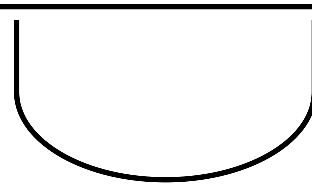

HEEL STRIKE DETAILS

APPENDIX D. COLD-WEATHER TACTICS, TECHNIQUES, AND PROCEDURES

Many of the casualties sustained in mountainous and cold-weather environments result from Marines and Sailors not being physically and mentally prepared for the environment. Leaders should start the training process by identifying the terrain and climatic conditions that the unit expects to encounter throughout the operation. Based on this information, leaders can identify specialized procedures and equipment needs specific to the environments and develop a training plan. Marines that graduate the Mountain Leader, Scout Skier, and Basic Cold Weather Advisor courses can provide this training for their units; they can also recommend the clothing and equipment needed and assist in planning and preparing to mitigate environmental effects on the unit.

The Marine Corps Mountain Warfare Training Center (MCMWTC) is a resource for cold weather and mountain warfare information and training. Marines can access the MCMWTC Formal Schools SharePoint repository at https://usmc.sharepoint-mil.us/sites/TECOM_MCMWTC/SitePages/Formal-Schools.aspx for links to mountain warfare resources; information on clothing, equipment, and doctrine; coursebooks; and available training courses. The lesson files on Sharepoint are intended for MCMWTC course graduates to use with their parent units following graduation. Refer to MCRP 12-10A.1 for more information on available mountain courses.

COLD-WEATHER CLOTHING AND EQUIPMENT

Cold weather clothing and equipment are categorized into the following levels:

- Vapor Transmission, Base Layer:
  - Level 1 (the next-to-skin layer). Flame-resistant lightweight (silk-weight) underwear set or cold-weather mesh baselayer (undershirt and drawer).
  - Level 2. Flame-resistant mid-weight (gridfleece) underwear set.
- Insulating Layer:
  - Level 3. Wind resistant synthetic fleece jacket (windpro fleece jacket).
  - Level 4. Marine Corps combat utility uniform (MCCUU), flame-resistant combat ensemble, and enhanced flame-resistant combat ensemble (mission dependent).
- Protective Layers:
  - Level 5. All-purpose environmental clothing system (also called APECS), inclement weather combat shirt, and lightweight exposure suit.
  - Level 6. Extreme cold-weather parka, trousers, and booties are worn under the all-purpose environmental clothing system in a wet-cold environment or in when in static positions.

The following tables provide information on cold-weather clothing, equipment, subsistence, and training by cold-weather category.

Table D-1. Cold Weather Environment: Wet Cold 39°F to 20°F (4°C to -7°C).

Area of Consideration	Special Requirements and Recommended Actions
Available Personal Clothing and Equipment	• Vapor Transmission, Base Layer (Level 1) • Insulating Level (Levels 3 and 4*) • Protective Layer (Levels 5 and 6**) Other: • Extreme cold-weather mountaineer socks with synthetic liner socks. • Marine Corps combat boots, temperate-weather boots, and intense cold-weather boots. • Lightweight fire-resistant balaclava and neck gaiter, hard face micro-fleece cap. • Intermediate cold weather glove and extreme cold weather mitten gear. • Pocket items (e.g., knife, lip balm, sunscreen, sunglasses, note-taking supplies, emergency ration, flashlight, headlamp). • Arctic necklace (lighter and chap-stick worn around neck). • Assault load per person (combat load per fire team).
Training	• Knowledge of cold weather environmental hazards. • Knowledge of cold weather clothing capabilities and limitations. • Familiarity of clothing and equipment for various cold weather conditions. • Knowledge and skills to prevent, recognize, and treat cold weather injuries. • PET. Classes focus on individual and small unit leadership, environmental safety considerations, principles of use and design of issued clothing and equipment, environmentally specific gear requirements, weather effects, common injuries, and other health considerations. PET is required for all personnel and the BCWA course is recommended for element leaders and above.
Food and Water	• MRE, MCW, CCAR, or FSR. Supplement with MORE, high altitude, cold weather (Type I). • One hot meal daily as mission dictates. Include UGR arctic supplements. • 3.5 to 5 quarts of water per day (cold-weather hydration system complete).
Shelter and Heat	• Three-season sleep system (modular sleep system). • Sleeping mat, wet weather tarpaulin (poncho), and wet weather poncho liner (optional). • Extreme cold-weather tent or 15-person arctic tent (optional).
Additional Control Measures	• Water re-supply plan. • Sanitation plan. • Leader and corpsman daily checks. • No skin camouflage below 32°F. • Check for frostbite twice a day and record findings. • Contact gloves must be worn when working outdoors.

LEGEND

BCWA	basic cold weather advisor	MCW	meal, cold weather
CCAR	close combat assault ration	MORE	modular operational rations enhancement
FSR	first strike ration	MRE	meal, ready-to-eat
MCCUU	Marine Corps combat utility uniform	PET	pre-environmental training
		UGR	unitized group ration

NOTES

*Use of camouflage utilities, particularly the MCCUU, is not recommended during heavy or extended precipitation events. Use Level 1 and 5 with an insulating layer, as needed, when heavy or extended precipitation is expected.

**The extreme cold-weather gear is best suited for bivouac, routine, and sentry activities.

Table D-2. Cold Weather Environment: Dry Cold 19°F to -4°F (-7°C to -21°C).

Area of Consideration	Special Requirements and Recommended Actions
Available Personal Clothing and Equipment	• Vapor Transmission, Base Layer (Level 1) • Insulating Level (Levels 3 and 4*) • Protective Layer (Levels 5 and 6**) **Other:** • Extreme cold weather mountaineer socks with synthetic liner socks. • Intense cold-weather boots; extreme cold-weather vapor barrier boots. • Mid-weight flame-resistant balaclava and neck gaiter, hard face micro-fleece cap, cold weather cap. • Intermediate cold-weather glove and extreme cold-weather mitten gear. • Goggles. • Pocket items. • Arctic necklace. • Assault load per person (combat load per fire team).
Training	• Cold-weather field training for TO/E Units. • Knowledge and skills to prevent, recognize, and treat cold weather injuries. • PET. PET is required for all personnel. • Two winter-mountain leaders per company is recommended. • The BCWA course is recommended for team leaders and above.
Food and Water	• MRE, MCW, CCAR, or FSR. Supplement with modular operational rations enhancement, high altitude, cold weather (Type I). • One hot meal daily as mission dictates. Include UGR arctic supplements when available. • 3.5 to 5 quarts of water per day (cold-weather hydration system complete). • Increase caloric intake.
Shelter and Heat	**Individual:** • Three-season sleep system. At temperatures below 15 °F use the extreme cold-weather bag. • Sleeping mat, wet weather tarpaulin (poncho), and wet weather poncho liner (optional). • Open air bivouac shelter possible***; extreme cold-weather tent or other shelter recommended. **Squad:** • Extreme cold-weather tent per ahkio team (four-person and four-season). • 15-person arctic tent (optional). • SHC-60 stove.
Additional Control Measures	• Mountain leader, BCWA, corpsman CWI checks 2–3 times daily, at minimum, for exposed personnel. • Detailed check once daily. • All Marines and Sailors checked upon entering shelter. • Water re-supply and storage plan (to prevent water from freezing). • Sanitation plan. • Contact gloves must be worn when working outdoors. • Petroleum, oil, and lubricant gloves must be worn when working with fuel. • Consider extreme cold-weather or tent flies for personnel that work away from support base.

LEGEND

BCWA basic cold weather advisor
CCAR close combat assault ration
CWI cold weather injury
FSR first strike ration
MCCUU Marine Corps combat utility uniform
MCW meal, cold weather
MRE meal, ready-to-eat\
PET pre-environmental training
SHC space heater convective
TO/E table of organization equipment
UGR unitized group ration

NOTES

*Use of camouflage utilities, particularly the MCCUU, is not recommended during heavy or extended precipitation events. Use Level 1 and 5 with an insulating layer, as needed, when heavy or extended precipitation is expected.
**The extreme cold-weather gear is best suited for bivouac, routine, and sentry activities.
***Extended duration not recommended because of increased cold-weather injuries; use other shelters when possible.

Table D-3. Cold Weather Environment: Intense Cold -5°F to -25°F (-21°C to -32°C).

Area of consideration	Special Requirements and Recommended Actions
Available Personal Clothing and Equipment	• Vapor Transmission, Base Layer (Levels 1 and 2) • Insulating Level (Levels 3 and 4*) • Protective Layer (Levels 5 and 6**) **Other:** • Extreme cold weather mountaineer socks with synthetic liner socks. • Intense cold weather boots; extreme cold weather vapor barrier boots. • Mid-weight flame-resistant balaclava and neck gaiter, hard face micro-fleece cap, cold weather cap. • Intermediate cold weather glove and extreme cold weather mitten gear. • Spare balaclava, neck gaiter, mitten liners, socks when available. • Goggles. • Pocket items. • Arctic necklace. • Assault load per person (combat load per fire team).
Training	• Cold-weather field training for TO/E Units. • Knowledge and skills to prevent, recognize, and treat cold weather injuries. • PET. PET is required for all personnel. Two winter-mountain leaders per company is recommended. • The BCWA course is recommended for team leaders and above.
Food and Water	• MCW (MREs, CCARs, and FSRs are not preferred). Supplement with modular operational rations enhancement, high altitude, cold weather (Type I). • One hot meal daily as mission dictates. Include UGR arctic supplements when available. • 3.5 to 5 quarts of water per day (cold-weather hydration system complete). Transport bulk water in heated truck. Fill cans with hot water. Water trailer in heated tents. • Increase caloric intake to approximately 4,600, depending on workload.
Shelter and Heat	Individual: • Extreme cold-weather sleeping bag. • Sleeping mat, wet weather tarpaulin (poncho), and wet weather poncho liner (optional). • Open air bivouac shelter for units with previous training***; otherwise use extreme cold-weather tent or other shelter. Squad: • Extreme cold weather tent per ahkio team (four-person and four-season). • 15-person arctic tent (optional). • SHC-60 stove.
Additional Control Measures	• Water re-supply plan and sanitation plan. • Leader and corpsman daily checks. Detailed checks once daily. • All Marines and Sailors checked upon entering shelter. Mountain leader, BCWA, corpsman check for cold-weather injuries every 2 hours. Buddy checks ever hour for exposed personnel. • No skin camouflage below 32 °F. • Frequently rotate shifts for Marines and Sailors in static positions; warming tents or vehicles should be available for personnel. • Four-season shelters for personnel that work away from support base are mandatory. • Mandatory sock change daily.

LEGEND

BCWA basic cold weather advisor
CCAR close combat assault ration
FSR first strike ration
MCCUU Marine Corps combat utility uniform
MCW meal, cold weather
MRE meal, ready-to-eat
PET pre-environmental training
SHC space heater convective
TO/E table of organization equipment
UGR unitized group ration

NOTES

*Use of camouflage utilities, particularly the MCCUU, is not recommended during heavy or extended precipitation events. Use Level 1 and 5 with an insulating layer, as needed, when heavy or extended precipitation is expected.
**The extreme cold-weather gear is best suited for bivouac, routine, and sentry activities.
*** Extended duration not recommended because of increased cold-weather injuries; use other shelters when possible.

Table D-4. Cold Weather Environment: Extreme Cold -25°F and Below (-32°C and Below).

Area of consideration	Special Requirements and Recommended Actions
Available Personal Clothing and Equipment	• Vapor Transmission, Base Layer (Levels 1 and 2) • Insulating Level (Levels 3 and 4*) • Protective Layer (Levels 5 and 6**) **Other:** • Extreme cold-weather mountaineer socks with synthetic liner socks. • Intense cold-weather boots; extreme cold weather vapor barrier boots. • Mid-weight flame-resistant balaclava and neck gaiter, hard face micro-fleece cap, cold-weather cap. • Intermediate cold-weather glove and extreme cold-weather mitten gear. • Spare balaclava, neck gaiter, mitten liners, socks when available. • Goggles. • Pocket items. • Arctic necklace. • Assault load per person (combat load per fire team).
Training	• Cold-weather field training for TO/E Units. • Knowledge and skills to prevent, recognize, and treat cold-weather injuries. • PET. PET is required for all personnel. • Two winter-mountain leaders per company. • The BCWA course is recommended for team leaders and above.
Food and Water	• MCW (MREs, CCARs, and FSRs are not preferred). Supplement with modular operational rations enhancement, high altitude, cold weather (Type I). • One hot meal daily as mission dictates. Include unitized group ration, arctic supplements when available. • 3.5 to 5 quarts of water per day (cold weather hydration system complete). Transport bulk water in heated truck. Fill cans with hot water. Water trailer in heated tents. • Increase caloric intake to approximately 4,600, depending on workload.
Shelter and Heat	**Individual:** • Extreme cold-weather sleeping bag. • Sleeping mat, wet weather tarpaulin (poncho), and wet weather poncho liner. • Open air or unheated bivouac for units with special training***; otherwise use extreme cold-weather tent or other shelter. **Squad:** • Extreme cold-weather tent. • 15-person arctic tent. • SHC-60 stove.
Additional Control Measures	Implement all control measures used in an intense cold temperature and add the following: • Limit outdoor operations and training. • Detailed checks once daily. Hourly mountain leader, BWCA, corpsman checks for cold-weather injuries. Buddy check every 30-45 minutes for exposed personnel. • Cover all exposed skin. • Static duty not recommend; frequently rotate shifts for Marines in static positions (every 2 to 3 hours). • Daily mandatory sock change.

LEGEND

BCWA	basic cold weather advisor	FSR	first strike ration	MRE	meal, ready-to-eat
CCAR	close combat assault ration	MCCUU	Marine Corps combat utility uniform	PET	pre-environmental training
CWI	cold weather injury	MCW	meal, cold weather	SHC	space heater convective
				TO/E	table of organization equipment

NOTES

*Use of camouflage utilities, particularly the MCCUU, is not recommended during heavy or extended precipitation events. Use Level 1 and 5 with an insulating layer, as needed, when heavy or extended precipitation is expected.

**The extreme cold-weather gear is best suited for bivouac, routine, and sentry activities.

*** Extended duration not recommended because of increased cold-weather injuries; use other shelters when possible.

APPENDIX E.
OVER-THE-SNOW VEHICLES

There is no service program of record for an over-the-snow vehicle; however, prepositioned equipment with allies includes SUSVs. Training at the Marine Corps Mountain Warfare Training Center uses commercial over-the-snow vehicles. Vehicle requirements vary depending on the activity and the terrain. Wheeled vehicles are usually limited to maintained roads (snow-plowed). Chains are frequently required, even with four-wheel drive. Tracked vehicles, light armored vehicles (LAVs), and amphibious combat vehicles (ACVs) are just as limited. Over-the-snow vehicles, such as snowmobiles or SUSVs, are best in this environment but typically availability of these vehicles is limited.

SMALL-UNIT SUPPORT VEHICLE

The SUSV (see Figure E-1) is a tracked vehicle designed for use in marginal terrain, mud, or sand, in a mountain or cold-weather environment. It has two, track-driven cars made of reinforced fiberglass and four interchangeable tracks. The front car carries four passengers and contains the engine, transmission, steering, braking, and transfer system. There are four SUSV variants; however, the maintenance and operating characteristics do not significantly differ among the vehicles. The four variants are—

- Carrier, Cargo: tracked, 1.5 ton, M973A1 (personnel carrier).
- Carrier, Cargo: tracked, 2 ton, M1067 (cargo carrier).
- Carrier, Command post: tracked, 1.5 ton.
- Carrier, Ambulance: tracked, 1.5 ton.

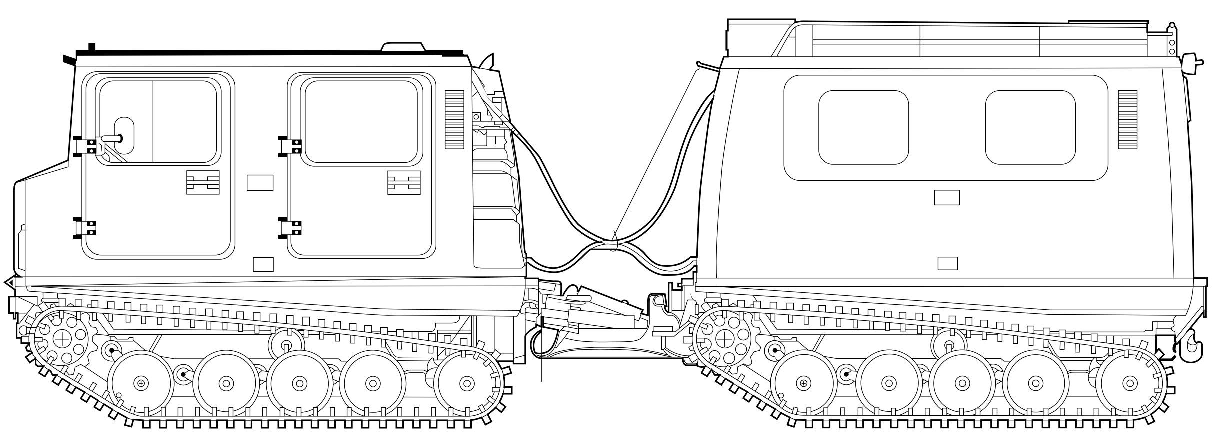

Figure E-1. Small-Unit Support Vehicle.

The SUSV is a versatile vehicle that is used by armed forces throughout the world. Its track system enables it to travel in most terrain or weather conditions. It can traverse a 35-degree slope and climb up to 35 degrees. It can navigate narrow roads usually found in a mountainous environment. Typical uphill speeds vary from 3 to 9 miles per hour, depending on the grade and if towing another vehicle. It is also possible to pull skiers (skijoring) behind the vehicle. The SUSV steering system limitations (see Figure E-2) are as follows:

- Maximum height differential between front and rear wagons 8.7 inches.
- Maximum possible angle between front and rear wagon is 17 degrees.
- Maximum turn angle between the front and rear car is 34 degrees between the front and rear wagons.
- Maximum roll angle between the front and rear wagon is 40 degrees from the horizontal.

The cargo carrier can be adapted to support crew-served weapons team operations. However, because the vehicle is made of reinforced fiberglass, extreme care should be used if the passenger variant is used as a firing platform because a weapon's recoil can damage the vehicle. Also, because the vehicle is made of thin material, it should not be used in a support-by-fire role unless the vehicle is placed in a fortified position.

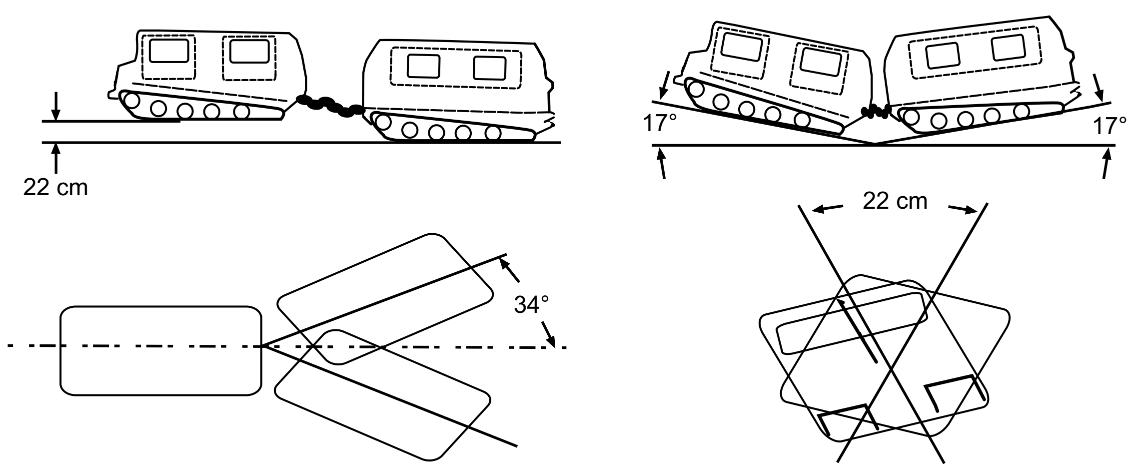

Figure E-2. SUSV Steering System Limitations.

When operating in a mountainous environment, vehicles should be in low gear; the proper way to shift the transfer is with the engine on and the transmission in neutral.

WHEELED VEHICLES

Wheeled vehicles are usually limited to maintained (i.e., snow-plowed) roads. Chains are frequently required, even with four- or all-wheel drive. Tracked vehicles, light armored vehicles, and amphibious combat vehicles are just as limited. However, tires can be deflated to traverse snow-covered terrain. All-wheel drive and differential lock power increases traction but decreases maneuverability.

SNOWMOBILES

A snowmobile—also known as a snow machine, sled, or skimobile—is a land vehicle that can travel over snow and ice. Snowmobile variations enable Marines to use some machines in deep snow or forests; however, Marines typically use them on open terrain, including frozen lakes, or driven on paths or trails. Operators should be aware that if powder snowmobiles are used on trails for too long the sleds will overheat.

The snowmobile's track and ski systems allow it to travel on snow-covered terrain. It can traverse a 35-degree slope and climb up to 35 degrees. It can traverse narrow roads or travel off-road in a mountainous environment. It is also possible to pull skiers (skijoring) behind the vehicle. Typical speeds vary from 40 to 65 miles per hour depending on local regulations, slope grade, snow depth, and whether towing another vehicle or skiers. Because of the snowmobile's maneuverability and speed, it is most often used by scout units or for messenger communications.

APPENDIX F. SKIING AND SKIJORING TECHNIQUES

SKIING TECHNIQUES

Warmup Exercises

Marines should wear minimal layers and ensure adequate ventilation before starting warmup exercises. To warm up the body for skiing, Marines without skis and ski poles should—

- Move the neck, arms, legs, and ankles in circles.
- Jog or march in place to raise the heart rate.
- Jog in place with leg kicks.
- Perform lunges, alternating legs and keeping the back straight.

Using ski poles for balance, Marines should perform the following stretches while standing on skis:

- Knee Lift. Assume the basic athletic stance. Pull the knee up with the arms as high as possible.
- Hamstring Stretch. Place ski tail on snow, stretch toward the toe.
- Quadricep Stretch. Place the tip of the ski behind the skier, lean back, and pull the ski tail forward.
- Groin Stretch. Assume the herringbone position, feet spread. Bend the knees and stretch forward and then sideways.
- Back Bend. Assume the basic athletic stance. Bend backwards.
- Toe Touch. Bend from the waist and touch toes.
- Side Bends. Assume the basic athletic stance. Hold ski poles behind back and bend side to side.
- Trunk Rotation. Assume the basic athletic stance and twist upper torso in both directions.
- Lunges. Deep lunge until the quadriceps stretch.
- Back and Leg Stretch. Bend towards toes, reach between legs, and try to stand.

Basic Athletic Stance

The basic athletic stance is a neutral stance, balancing over the center of the whole foot and both skis evenly weighted. This is the foundation for all ski movement.

Teaching Terrain. Teaching terrain should be flat or nearly flat ground.

Body Position and Mechanics. Marines should keep knees and ankles comfortably flexed, arms loose and relaxed with slightly flexed elbows, the torso relaxed, and the head upright with eyes forward.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate.
- Equate this stance to an athlete in the "ready" position (i.e., a player ready to move in any direction). Tell students to find a balance point over the center of the foot by leaning forward and backward.

Telemark Position

The telemark position is a neutral stance with one foot ahead of the other. This stance is not applicable for alpine touring skis or MSS. This is the basic balance position when moving on skis with the heel-free binding system.

Teaching Terrain. Teaching terrain should be flat or gently sloping ground.

Body Position and Mechanics. Marines should center balance on the front foot and ball of the back foot with weight evenly distributed on each ski. Marines should keep knees and ankles comfortably flexed, arms loose and relaxed with slightly flexed elbows, the torso relaxed, and the head upright with eyes forward.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate standing still.
- Explain that the telemark position provides forward and backward stability when working with the free heel military binding system.
- Show how the basic athletic stance leads into the upper body position of the telemark stance. From the telemark stance, students can move into the telemark glide.
- Correlate with flat ground movement training.

Star Turn

Marines use a star turn to change direction when stationary on a flat surface or to change direction when snow conditions, terrain, skiing ability, or load impedes using other turning skills.

Teaching Terrain. Teaching terrain should be flat ground.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Start with the basic athletic stance.
- Flex the knee to pick up the tip of the ski.
- Move the tip to one side, forming a "V" position with the skis and lower the foot.
- Bring the other ski parallel with the first.
- Repeat.
- Use poles for balance.

This turn requires a high knee lift to raise the tip of the ski out of the snow. Some students may need some time to adjust, particularly in new or loose snow. Use poles for balance.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Turn around the tails.
- Demonstrate a 360-degree turn, keeping the tails of the skis together.
- Point out that the tails of the skis remain close together and on the snow.
- Turn around the tips.
- Demonstrate a 360-degree turn, keeping the tips as the pivot point and moving the tails into an "A" position.

Extra Practice. Skiers should practice executing the turn around the tails without poles and then, executing the turn around the tips without poles. Finally, students should alternate moving tips and then tails without poles. This practice prepares students to move in places where they cannot complete a full turn in one place.

Controlled Fall

Marines use a controlled fall to safely stop after losing control. The skier uses this fall to prevent injury.

Teaching Terrain. Teaching terrain for a static fall (fall while standing still) should be flat ground. For a dynamic fall (fall while moving), it should be a gentle to moderate slope.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Lean toward the slope and sit down, landing on a hip. If the left side of the body is closer to the slope, the skier will land on the left hip. If the right side is closer, the skier will land on the right hip.
- Raise the pole out of the way of the fall.
- Lean back into the slope, allowing hands to trail over the head and the poles to fall.
- Slide to a stop.

Instructional Techniques. The instructor should demonstrate both falls on the appropriate terrain.

Recovery From a Fall

Recovery from a fall is a technique to regain an upright position and return to the basic athletic stance without removing the skis.

Teaching Terrain. Teaching terrain should be flat ground or gentle to moderate slopes.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Evaluate the position on the hill.
- Determine the position in relation to the fall line. The fall line is the most direct route downhill. For example, a ball dropped on a hill will roll down the fall line.

- Place the skis downhill from the body.
- Position the body so that it aligns with the fall line and the skis are at a 90-degree angle to the line.
- Pull the skis up as close to the hips as possible while keeping them perpendicular to the fall line and close together.
- Remove the ski pole straps from the wrists.
- Place the tip of one ski pole through the basket of the other.
- Place the ski pole tips into the snow next to the hip on the uphill side. The hand closer to the snow grasps the poles near the basket. The other hand grasps the ends of the poles.
- Push away from the hill.
- Start straightening the legs. The hand closer to the baskets should work its way up the poles as weight is put on the skis.

Instructional Techniques. Instructors should be aware students may have to remove their packs and other equipment to get up. If in deep snow and the poles sink, leaders should instruct Marines to cross their ski poles so that the baskets are 90 degrees apart, using them as a support base to push away from the hill.

Kick Turn

A kick turn is a stationary turn that moves the skier in the opposite direction (180 degrees) when other techniques are undesirable or ineffective. It is particularly useful on narrow trails or where the snow is deep. It is appropriate for slopes, whether going uphill or downhill.

Teaching Terrain. Teaching terrain should be flat ground or gentle to moderate slopes.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Start in the initial body position with the lower body facing in the direction of movement and the upper body facing downhill. Marines should keep skis parallel. The body weight is on the non-kicking leg. If on a hill, the non-kicking leg is the uphill leg.
- Plant the ski poles above the uphill ski for support. The poles help maintain balance during the turn and support body weight. The poles should remain planted throughout the entire maneuver.
- Kick the downhill ski and leg forward and up.
- Rotate the ski, turning the toe outside, and place the foot down so that the skis are parallel with the downhill ski and facing in the opposite direction.
- Transfer body weight to the ski facing in the new direction (the downhill ski).
- Bring the uphill ski around, placing it parallel to the other ski. Now, both skis face in the new direction.
- Lift the ski pole to follow the moving leg.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Practice ski balance drills.
- Demonstrate the turn on a flat surface and instruct students to practice the turn on flat ground, then demonstrate and have students practice on a slope.
- Emphasize maintaining three points of contact throughout the turn—the two planted poles and one leg.

Diagonal Stride

The diagonal stride, which is based on the telemark position, is the fundamental technique for flat or slightly uphill terrain. The feet glide on the skis; the hands push back on the poles. The term diagonal stride refers to the simultaneous movement of the diagonally opposite arm and leg. The diagonal stride is the most used technique for forward motion in cross-country skiing. It provides rhythm and efficiency.

> NOTE: When using alpine touring skis, there is no "running" movement such as cross country skiing, just walking on skis.

Teaching Terrain. Instructors should start the students on flat terrain. Well-defined tracks deep enough to hold the skis will aid learning. As students progress, the terrain should also increase in difficulty to include mildly rolling tracks or a slight uphill slope.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Keep the head up with the eyes focused down the track.
- Coordinate arm and leg movement like walking.
- Keep arms comfortably flexed at the elbow and wrist when planting the pole. This angle is maintained as power is initially applied to the pole. Power increases until the hand passes the hips, and the arm is extended and straight.
- The tip of the pole should be planted approximately even with and just outside the tip of the lead boot (the opposite foot). On the vertical plane, the pole handle is moved ahead of the baskets. As the pole is planted, the skier exerts downward and backward pressure on the pole, providing a propelling force as the arm extends to the rear. The push action occurs as the knee comes forward. The degree of follow-through varies with speed. As speed increases, more follow-through is needed.
- Skiers plant the ski pole immediately after pushing off with the leg. Pole pressure helps maintain momentum on the gliding ski for as long as possible.
- The poling arm should swing forward near the body when the feet come together to maximize glide before another push-off.
- The skier pushes off to start one ski to glide and then pushes off on the other ski before the first one stops. The motion is like walking, but only the heel rises as the body moves forward. A slow motion at first develops into a more powerful compression of body weight on the push-off ski. A quick explosive push-off is the main source of acceleration.
- Before push-off, the skier is upright. Then, at the moment of push-off, the body leans slightly forward while the leg remains vertical. The knees, ankles, and hips are slightly flexed to tense the muscles prior to the push-off and leg extension. The whole foot pushes down and back,

which causes the wax to grip and creates a stationary platform from which to project forward. At the end of a push-off, the leg is fully extended back. The knee and ankle are extended. The degree of extension is in direct relation to the speed of the skier. The faster skier uses a full extension and the slower skier, less extension. The front or sliding leg supports the body while gliding. As the skier glides, the weight moves from the heel to the ball of the foot, but the knee angle remains constant. The knee and ankle of the front leg are flexed to help with balance and remain flexed for the next push-off.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- The instructor should select kick wax for the students and supervise its application. Students must feel their skis grip to practice this skill.
- Instructors may be unable to provide ski poles of proper length to the students, which may affect the efficiency of pole use.
- Teaching the diagonal stride is like teaching all cross-country skills. Three key areas of instruction are the ability to glide, to pole, and to push off on the ski. Each of these areas should be taught separately, focusing on timing and balance; speed will develop accordingly. Exercises should be used during the lesson to practice these skills and to analyze students' progress.
- Students can experiment with the equipment by moving along the track.

Students should not use poles at the start of the lesson so that they can concentrate on moving the skis and developing a natural arm swing. Instructors should consider the following:

- First, demonstrate an easy push and glide so that the students can see a side view. Tell students to stand in a relaxed, upright position; slide the skis on the snow; swing their arms at their sides; take small strides; try to feel a little glide after each push from the ski; and try to feel the weight on the gliding ski.
- Have the class practice with an easy, slow push and glide. The heel should rise off the ski slightly as the skier pushes. The arms should also swing in time with the legs. As balance and confidence improve, more power comes by pushing harder off the skis. The body leans forward, and the back ski may naturally lift slightly off the snow. Stress a relaxed, upright position since it is restful and quite efficient. When bending forward and using overly bent knees, the skier uses too much energy and load carrying is adversely affected.
- The faster a skier moves, the farther ahead the pole is planted and the closer the pole shaft is to being vertical. When speed slows down, plant the pole farther back to allow immediate pull and push. Faster skiers plant the pole straighter because of increased momentum and because the pole is at a working angle by the time pressure is applied.

Extra Practice. Students can use the following information for extra practice:

- Poor Balance. Students with poor balance or a fear of sliding need more practice time without their poles. The following exercises are helpful for the novice and advanced skier but should be preceded with a demonstration followed by a concise explanation and practice:
- Exaggerated Knee Bend. Stand straight and sink low, bending the knees. Keep the upper body erect and push off on the ski. Then, slide the other ski forward. This skill will be useful when a skier must absorb a bump or dip.

- Exaggerated Arm Movement. Move arms forward in exaggerated motion, then follow through to a high back extension, which can become a timing practice for arms and legs. It also aids flexibility in the shoulder joint. Arms should move straight forward and back without crossing over in front.
- Quick Ski. Take short, shuffling steps while keeping skis on the snow. Bring the arms up to the chest like a jogger. Start the push-off from the whole foot and move the arms in quick succession forward and back. This exercise will also loosen the shoulders. The speed will increase the breathing rate in the warmup stages.
- Weight Transfer. Balance on one ski while it moves and hold a stationary position over the gliding ski. Then, switch and balance on the other ski. This exercise works well on gradual downhills when the position can be held longer.
- Scooter Drill. This drill is effective for emphasizing dynamic weight transfer and push-off. It requires firmly packed snow and a preexisting track. Have students remove one ski. Using both poles, students push off with the foot that has no ski and slide on the ski. Progress from two poles to no poles. Then, introduce using just one pole.
- Using the Poles. Pole use centers on a relaxed, loose arm swing. First, review how to grip the pole. Show how to bring the hand under and up through the strap so it falls around the wrist. Then, grip the strap and handle together. If the strap is adjustable, show how to adjust it so that the hand is close to the top of the handle. Next, plant the pole in the snow at an angle, pointing back to use it immediately to apply pressure. Look for proper technique while students practice pole use. Have students ski slowly and drag the pole basket in the snow when it is brought forward to be planted. Look for a light grip between the thumb and forefinger.

Telemark Glide

A telemark glide is a running or gliding position with the skis parallel and approximately shoulder-width apart. As the skier moves, one ski advances about one-quarter to one-half a ski's length. It enables the skier to absorb changes in snow conditions or terrain and to provide stability from front to rear, skiing across slopes with or without packs.

NOTE: This technique is not applicable for alpine touring skis.

Teaching Terrain. This technique can be taught on any terrain.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Start with the basic athletic stance and advance one ski forward of the other to increase forward and backward stability. The front knee is bent with the foot flat on the ski. The rear heel is lifted off the ski, resulting in ski-boot contact at the ball of the foot.
- Flex the knees and slide one ski forward until the tip of the back ski is approximately halfway between the binding and shovel of the forward ski.
- Position the front knee over the toes of that foot. Bend the knee to form a right angle between the upper and lower leg. Raise the back heel off the ski and support weight on the ball of the back foot.
- Stand relaxed as the skis glide in the snow about shoulder-width apart.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate static drill with change of leading ski.
- Keep both poles planted for balance.
- Practice sinking into the telemark glide position, alternating the leading ski.
- Slide the new leading ski forward when moving from the telemark glide position to the downhill running position. Resist the temptation to let the rear ski move backward.
- Change the lead ski, maintaining the basic telemark position.

Double Poling

Double poling is a method for forward propulsion. Using both poles simultaneously, double poling maintains or increases speed on downhills or as an alternative to other techniques on flat terrain. Double poling is used primarily on downhills.

Teaching Terrain. Teaching terrain should be gradual downhill sections of the trail, but it can be taught on flat sections. If taught on a steep hill, students may be unable to stop, so select a slope to match ability level.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- The arms swing forward and backward together. As the arms swing forward, plant the poles at an angle and apply pressure immediately, keeping a slightly flexed elbow. Compress the larger, stronger abdominal muscles and transmit this power through the slightly flexed arms to the poles. The angle between the upper and lower arm should remain constant during the initial phase of poling to better transmit muscular force to keep the skis gliding. The angle of the pole shaft varies with the speed.
- As pressure is applied to the pole, the hand, forearm, and upper arm together lever on the pole shaft. The arms are slightly flexed. Remember, the arms are not the primary muscle group that produce the power. They are extensions that transfer the power of the major muscle groups of the upper body to the poles.
- As the hands pass the hips, continue to push until the arms, hands, and pole shafts are in a straight line to the rear. At the first extension, release the grip and point the fingers toward the pole basket. This technique shows why a properly adjusted wrist strap is important. The arms then swing forward in a relaxed pendulum motion.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate proper movements in a static position. Then, demonstrate by using the appropriate speed and tempo.
- Have students reach forward with both arms extended and plant both poles at an angle (top of ski pole ahead of tip). Push on the pole until arms are extended straight behind.
- Separate tracks allow individual practice.
- Combine practice with the diagonal stride if terrain favors its use.
- Practice reaching forward to plant the poles. Make a powerful pull, then push off with the poles. Start the poling with the larger, stronger abdominal muscles and continue acceleration with the smaller muscles of the arm and wrist.

Sidestep

A sidestep helps a skier move uphill or downhill along the fall line through narrow, steep sections of a trail or very deep snow where no other technique is possible. Marines should use the sidestep as a restful alternative to other uphill techniques or as a safe way to descend a slope.

Teaching Terrain. Teaching terrain should have moderate slopes with some loose snow for easy edging.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Keep the skis perpendicular to the fall line with edges angled into the hill, just enough to prevent the skis from slipping downhill.
- Keep the body upright, weight over the feet, knees slightly flexed for balance, and head up.
- Move the arms simultaneously or alternately, depending on snow conditions and steepness of the slope. The arms are used mainly for balance and support.
- Be careful not to step on the ski pole baskets.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- First, demonstrate the techniques of a sidestep going in both directions.
- Find a section of open slope with uniform snow and tell students to practice the movements as demonstrated.
- Remind students to practice the angling of the knees.

NOTE: The instructor can have students practice the sidestep on the same slope that will be used for downhill techniques so that it becomes packed and ready for the first run.

Forward Sidestep

The forward sidestep is a combination of the diagonal stride and the sidestep; it is used to quickly traverse up open slopes and wooded areas that are too steep for the diagonal stride. A skier can climb faster using this technique, although it is more strenuous than the uphill traverse. The forward sidestep is secure when the skis stay perpendicular to the fall line, and the inside edges are set.

Teaching Terrain. Open slopes with fresh or loose snow. Fresh snow helps students see their tracks and makes edging easier.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Demonstrate the forward sidestep while showing a traverse and a forward uphill step.
- Poles are used either diagonally or simultaneously with each step depending on slope steepness.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Moderate to steep slopes are ideal as practice terrain. To prevent slipping on steeper slopes, the skis must remain edged and perpendicular to the fall line. In deep snow, this requires a high-stepping motion.

- Have students make their own tracks so that all can practice individually.
- Instruct them to use the kick turn to change direction.

Herringbone

Marines use the herringbone technique to climb straight uphill. It is faster than the uphill sidestep and more secure on steep terrain than the uphill diagonal stride, but it is generally more tiring.

Teaching Terrain. Moderate to steep slopes. Some loose snow helps show students their tracks.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Initially keep the body's center of gravity between the skis. The head should remain upright, particularly when wearing or pulling heavy equipment.
- Alternate poles or plant both while moving one ski at a time.
- Depending on the steepness of the slope, keep the poles even with or behind the center of gravity.
- When on steep slopes or wearing or pulling heavy equipment, put the hands on the top of the ski poles for extra leverage.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Introduce this skill on flat terrain.
- Demonstrate on a slope that starts gradually and gets steeper.
- Start students on a hill where they can practice the transition from the uphill diagonal stride to the herringbone as the slope steepens.

Half Herringbone

The half herringbone is a technique to ascend moderate slopes where two edged skis are not required, and the terrain precludes other uphill methods. This technique is less strenuous and is faster than the uphill sidestep and the herringbone.

Teaching Terrain. Moderate to steep slopes. Some loose snow helps show students' tracks.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Position skis at a 45-degree angle to one another (one ski in a track, the other angled). Slide the ski that is in the track in the snow. The skier should feel pressure against the tops of the toes as the ski that is angled is picked up. The angled ski is lifted and placed ahead on its inside edge.
- The poles are used as in the diagonal stride. If more stability is needed when carrying heavy loads, the hand can be placed on the top of the ski pole.
- The opposite arm and leg move forward. Plant the poles behind the feet for support.

Instructional Techniques. This technique is best introduced on flat terrain. Instructors should demonstrate on a slope that starts gradually and becomes steeper. Start students at the bottom of the hill.

Downhill Running

When downhill running, the skis are parallel, flat, and directed down the fall line, which is useful when going straight down the hill.

Teaching Terrain. Smooth, gentle downhill terrain with a natural runout. This technique is a good way to challenge those in the class who are ready, while respecting the skier who is not.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Students should assume the basic athletic stance, bend the knees, and move the hands forward in front of the hips. Skiers will have to adjust this position as speed and terrain dictate. The center of gravity will become lower and the knees bend more when speed increases. With the increased knee bend, stability increases and the unevenness in the terrain is absorbed by the knees.
- As speed increases, students should slide one foot slightly ahead of the other (telemark position) to help them maintain balance and increase the forward and backward support. The heels of both feet should remain on the skis.

Instructional Techniques. At the top of the slope, spread the class so that each student makes their own track to the bottom. Be sure to provide an adequately safe runout area at the bottom.

After a demonstration, begin the straight run from a level area. Point skis straight down the fall line and start moving with a double pole push. Class control is important. Do not allow students to start a great downhill dash to the bottom.

Demonstrate that at the end of each straight run the student finishes the runout in the telemark glide position.

Terrain Absorption

Terrain absorption is a technique to maintain balance and stability over irregular terrain by flexing and extending the legs. Absorption includes adjusting the magnitude of pressure or compression by vertical displacements of the body mass through flexing and extending the hips, knees, and ankles.

Teaching Terrain. Irregular terrain, such as dips and bumps, and changing snow conditions, such as ice, slush, packed snow, and powder.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Make sure that the weight is distributed over both feet. Hold hands out in front of the body with the forearms parallel with the ground to increase stability.
- Skis may be either parallel or in the preferred telemark glide position. Use absorption or extension so that the greater absorption occurs at the top of the bump and the greater extension occurs at the bottom of the dip.
- The flexion on the bumps and extension in the dips allow the skier to absorb the force generated by the irregular terrain.

Instructional Techniques. Select tracks with varying terrain and snow conditions, both in ski training and on ski marches. When students learn this skill well enough, have them practice while wearing packs with realistic loads.

Uphill Traverse

The uphill traverse is a technique Marines use to move diagonally across the fall line, gaining elevation while conserving energy.

Teaching Terrain. Open slope of moderate steepness with soft snowpack that allows easy edging.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Angle ski edges into the hill to prevent the skis from slipping downhill.
- Move arms as in the diagonal stride, shortening the uphill arm swing as the slope steepens.

Instructional Techniques. On flat terrain, the instructor should review edging techniques, diagonal stride, kick turn, and the angling of the knees. Explain how the edges keep the ski from sliding downhill. The technique resembles the uphill diagonal stride, but uphill edges of the skis are kept at an angle across the slope.

A properly waxed ski that provides grip is essential. A slipping ski tires the arms because, when the ski slips, the arms must provide support. Have students practice a gradual angle across the slope to build confidence. Instructors should consider the following when teaching this technique:

- When planting the pole, try to keep the uphill arm from rising unnecessarily.
- The hands should stay low and swing forward only high enough to plant the pole and apply pressure.
- Link the traverse with a kick turn to show students how to continue traversing uphill.
- A kick turn on steep slopes is secure because of ski pole support and the body facing downhill.

Downhill Traverse

The downhill traverse is a technique Marines use to move diagonally across the fall line to descend a slope under control and to approach a turn safely by reducing the effective slope of the hill.

Teaching Terrain. On open slopes of moderate steepness with soft or loose snowpack. Since edging is easier in soft snow, powder slopes are ideal.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Practice edging by side slipping to an edge set. To do this, flatten the skis on the snow, slide downhill perpendicular to the slope, then turn the ankles and knees into the hill to set an edge and stop.
- Assume an angled position over the skis. Angling results when the knees and hips move toward the hill and the upper body is centered over the downhill ski.

- Weight the downhill ski with the uphill ski slightly ahead, freeing the hips and allowing the upper body to face downhill with less resistance.

  NOTE: The weight should be distributed approximately 60 percent on the downhill ski and 40 percent on the uphill ski.

- Hold the arms and hands in front of the body about waist high, elbows flexed.
- Keep the pole baskets behind their body.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate this technique by skiing toward and away from the class.
- Explain how it is like the straight run.
- Demonstrate by skiing at an angle across the slope with ankles turned into the hill, edging the skis.
- Make sure students can stop on a gradual runout.

Uphill Diagonal Stride

The uphill diagonal stride is a fundamental Nordic technique for rhythmically ascending gradual to moderate slopes.

Teaching Terrain. Gradual to moderate uphill slopes with well-defined tracks.

Body Position and Mechanics. Timing in the uphill diagonal stride involves the coordination of movement between the arms and the legs. As in walking, the opposite arm and leg work together in a diagonally opposite direction. Marines should consider the following when conducting this technique:

- The hand moves down as the pole is pulled and pushed in a shorter, more vigorous motion.
- The stride length is shortened, and the tempo is increased to maintain momentum with little or no forward glide.
- The angle of the slope requires a definite weight transfer to the forward ski while that foot is pushed slightly ahead of the knee to apply maximum pressure on the gripping ski.
- Push-off is quick and explosive to eliminate time spent on the stopped ski.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Select the proper wax and supervise its application.
- Instruct students to use quicker and shorter movements, like jogging uphill.
- The push comes from the whole foot and ends with an ankle extension. Like the diagonal stride, the legs contribute to the major thrust.
- Keep the legs flexed and hips forward.
- While maintaining the same knee angle during the glide, plant the poles farther back at an angle so that force is immediately applied to keep the gliding ski moving.
- Even though the steepness of the hill will shorten the stride length, students should continue the glide, if possible.
- The distance covered during the poling motion is critical to the overall stride length.

Double Pole with a Kick

Marines use the double pole with a kick technique by pushing off with one leg while using both poles to maintain or increase speed or change pace for recovery. This technique is developed from double poling skills.

Teaching Terrain. Gradual downhill slopes or flat terrain with good tracks.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- The arms swing forward and backward together. As the arms swing forward, plant the poles at an angle and apply pressure immediately while keeping elbows slightly flexed. Compress the larger, stronger abdominal muscles and transmit this power through the slightly flexed arms to the poles. While the arms are slightly flexed, the hand, forearm, and upper arm align with the pole shaft as pressure is applied to the pole.
- Leg movement involves a push-off from one ski with a complete weight transfer to the forward or gliding ski. Make the push-off with the same foot or alternate feet. For a better distribution of the workload, alternate feet. The leg is flexed to supply power in the push-off. The leg then extends. The other leg remains flexed during the glide with weight on the ball of the foot.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Start with double poling.
- Continue double poling, initiating a kick with the same leg.
- Alternate legs on subsequent practice runs.
- Use the scooter drill (see diagonal stride) to emphasize push-off and weight transfer.

Wedge (Gliding and Braking)

The wedge is a technique for downhill running with skis in an "A" (convergent) position while controlling speed, maintaining stability, or providing a way to stop on a downhill run.

Teaching Terrain. Packed, smooth, and gentle slopes that are free of bumps and obstacles.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Assume the basic athletic stance, emphasizing that the head is upright and eyes are forward.
- The arms are slightly flexed and the forearms are parallel to the slope. Arms and hands are forward of the hips about waist high with elbows bent. The pole baskets are behind the skier.
- Spread both ski tips into an "A" position with equal pressure on both skis. The ankles and knees control the slight edging of both skis, relative to the slope.
- In a braking wedge, put pressure on the inside edges by turning the knees and ankles inward. Use pressure, edging, and the width of the wedge to control speed.
- The legs flex more to lower the center of gravity and widen the wedge as speed decreases.
- In the gliding wedge, keep the ankles and knees flexed.

- Keep the skis nearly flat on the snow for momentum. Control the edges with the knees and ankles.
- Slope steepness and snow conditions determine the exact amount of edging needed to maintain forward movement.
- At the same time, maintain the tips a fist's width apart.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate moving from the basic athletic stance to the wedge position on flat terrain.
- On a gentle slope with a safe runout, have the students practice the gliding wedge, holding the position until they stop.
- Progress from the downhill running position to a gliding wedge and back to the downhill running position.
- Alternate positions while moving, emphasizing a sinking and rising motion.
- Practice moving from a gliding wedge to a braking wedge, stopping at a predetermined point.

Wedge Turn

A wedge turn is a technique to control speed and change direction while maintaining an "A" or wedge position.

Teaching Terrain. Moderate, even, smoothly packed slopes. Packed, settled snow or light, shallow powder is best used for this practice.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Assume the basic athletic stance, emphasizing head upright and eyes forward. Arms are slightly flexed with forearms parallel to the slope. Arms and hands are forward of the hips about waist high and elbows are bent. Pole baskets are behind the skier.
- The weight is transferred onto the turning ski (the ski on the outside of the curve) with a greater bend at the knee and ankle and with a slight sideward bend of the upper body over the turning ski.
- To steer, the muscle groups in the upper leg and hip press on the inside forward edge of the weighted ski.
- The edged ski skids a curved path in the snow which results in a gradual turn.
- The outside ski is edged and pressure is applied against it while the inside ski is flat throughout the turn.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate shifting weight from one ski to the other while on flat terrain and in the wedge position.
- Practice a wedge turn in one direction and stop with a braking wedge. Alternate directions on successive runs.
- Practice a downhill traverse, finishing with an uphill wedge.
- Link wedge turns on varying terrain and snow conditions. Link wedge turns on a slalom course using student ski poles for gates.

Wedge Christie

The wedge christie is used to transition from a wedge to a parallel turn.

Teaching Terrain. Well-maintained, easy (green) and intermediate (blue) terrain.

Body Position and Mechanics . The wedge christie is like the wedge turn, but the skis are matched to parallel as the turn progresses. Both skis are steered from a parallel position to a wedge position. As the turn progresses, the outside leg will become more dominant and the inside leg will be turned at a slightly faster rate, causing the skis to match. Steering the inside ski is facilitated by actively rolling the ski off its inside edge to the outside edge (flattening the inside ski). The turn finishes with both skis skidding out of the fall line. Marines should consider the following when practicing this technique:

- Matching of the skis occurs at different points with respect to the fall line, depending on speed, terrain, snow conditions, and competence of the skier.
- Flexing and extending all joints may involve a greater range of motion, and more pronounced weight shift due to increased speed and terrain.
- No pole touch is required; hands and arms are used to balance the torso over feet and legs.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Speed is slightly higher than for wedge turns.
- Demonstrate single turn to one side.
- Link wedge christies on varying terrain and snow conditions.
- Link wedge christies on a slalom course using student ski poles for gates.

Wedge Telemark

A wedge telemark is used to transition from a wedge to a telemark turn (telemark bindings only).

Teaching Terrain. Groomed, easy (green) and intermediate (blue) terrain.

Body Position and Mechanics. The initiation of this turn is like the wedge christie, with the finish of the turn completed by moving into a telemark position. At turn initiation, as the old outside ski edge is released, the new outside leg twists to form a wedge. As the turn progresses, the inside ski is actively steered along with the outside ski moving from wedge to telemark. In a tall telemark stance, the feet are positioned about a boot's length apart and the skis are parallel to each other. Marines should consider the following when practicing this technique:

- Matching of the skis occurs at different points with respect to the fall line depending on speed, terrain, snow conditions, and competence of the skier.
- Flexing and extending all joints may involve a greater range of motion, and more pronounced weight shift due to increased speed and terrain.
- No pole touch is required; hands and arms are used to balance torso over feet and legs.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate and practice the wedge telemark J-turns to a stop.
- Practice to both sides.

- Link wedge telemarks on varying terrain and snow conditions.
- Link wedge telemarks on a slalom course, using student ski poles for gates.

Stem Christie

The stem christie is used to navigate varying conditions while carrying heavy loads.

Teaching Terrain. Intermediate (blue) to advanced (black) terrain, including varying conditions such as bumps, crud, and powder.

Body Position and Mechanics. This turn is like the wedge christie, but it uses a stem move to create the initial wedge position. At turn initiation, while maintaining an edge set on the downhill ski, the new outside ski is stemmed out to form a wedge. Concurrently, a pole swing and tap will direct a movement of the center of mass toward the new turn. As the turn progresses, the outside leg will become more dominant and the inside leg will be turned at a slightly faster rate, causing the skis to match. The turn finishes with both skis skidding out of the fall line.

Depending on conditions, the stemmed ski can be stepped out into a wedge and the inside ski can be stepped into a matched position.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Demonstrate and practice wedge christie J-turns to a stop.
- Practice to both sides.
- Practice stepping the stem out and in to both sides.
- Practice sliding the stem out and in to both sides.
- Demonstrate and practice up stem and down stem.
- Link wedge christies on varying terrain and snow conditions.
- Link wedge christies on a slalom course, using student ski poles for gates.

Step Turn (In Motion)

The step turn is a technique to change direction by stepping the skis divergently ("V") into a new direction. The step turn controls speed, changes direction, or both, and can be used in all snow conditions.

Teaching Terrain. Taught best on moderate downhill terrain.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Assume the basic athletic stance.
- Project the arms and upper body slightly in the direction of the anticipated turn.
- The tip of the inside ski is picked up and placed at a divergent angle to the other ski. The other ski is brought parallel and the process is repeated until the desired change in direction is achieved.
- Both skis are edged to the inside of the turn; the tails are left on the snow.
- Knees and ankles are flexed throughout the turn.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Have students practice static star turns around the tails.
- From a downhill traverse, step turn out of the fall line.
- Instruct students that they should try to have the sensation of pulling up with the toes and pressing down with the heel, much like a star turn.
- Tell students this technique is a moving star turn.

Skate Turn

A skate turn is a dynamic step turn that is accomplished by pushing off an edged, divergent ski. Marines can use this technique to move through a turn while maintaining speed or accelerating.

Teaching Terrain. Flat or downhill terrain, with or without tracks, on hard snow.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Assume the basic athletic stance.
- Arms and upper body are dynamically projected in the direction of the turn.
- Legs are flexed to lower the body over the skis (pre-loading).
- The inside ski is lifted and angled in the direction of the turn. From the weighted ski, the skier pushes off in the new direction, transferring all weight to the inside ski and gliding on it.
- The other ski is brought parallel (matched).
- Repeat this maneuver until the desired new direction is obtained.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Start practicing on flat terrain.
- Move to gentle downhill terrain.
- Encourage students to practice in both directions.
- Instruct students to practice several skating turns to both sides, first with the poles and then without them.

Basic Parallel

A basic parallel is a technique where, at turn initiation, a pole swing and tap can time and direct a movement of the center mass toward a new turn. Marines can use the basic parallel technique to link parallel turns with rhythm and speed control.

Teaching Terrain. Groomed, intermediate (blue) terrain. Speed is faster than for the wedge christie.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- At turn initiation, a pole swing and tap will time and direct a movement of the center mass toward the new turn. Skis are maintained at a hip's width stance. Tipping and twisting movements of both feet and legs occur simultaneously so that the skis are parallel throughout

the turn. Pressure dominance shifts from the former outside ski to the "new" outside ski, while knee and ankle flexion develop as the turn progresses. Accurate blending of skills enhances consistent turns.
- At initiation, a pole swing and tap will time and direct a movement of the center of mass toward the new turn. Edge change (releasing and re-engaging) occurs through tipping versus pushing movements. Turn shape controls speed. Slightly more dynamic turns require increased range of motion. Countering develops as needed but should not be contrived.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Use a short downhill run to parallel J-turn; do each side.
- From a downhill traverse, release edges, steer into the fall line, and then continue steering into a J-turn and set edges.
- Practice a static knee roll left-to-right, back and forth. Then, try narrow radius parallels, using simple knee rotation back and forth, rolling from one set of edges to the other.
- Link turns together with and without pole plants.
- Increase slope angle and vary snow conditions.

Dynamic Parallel

A dynamic parallel is used to make parallel turns in advanced terrain in various conditions.

Teaching Terrain. Intermediate (blue) to advanced (black) terrain in varying conditions, including bumps, crud, and powder. Dynamic parallel turns can be short, medium, or long in radius.

Body Position and Mechanics. This turn is like basic parallel, but uses more external forces generated by speed and ski-snow interaction. It requires more active use of the feet and legs in edging and twisting movements and earlier edge engagement. Dominance of the outside ski also develops earlier than in basic parallel due to increased speed and more active flexing/extending movements. The center of mass is continuously and actively moved into each new turn. Marines should consider the following when practicing this technique:

- Skier increases the range of motion.
- More dynamic skiing requires more speed.
- Increased edging movements maximize use of ski design. Ski design, accompanied by efficient skill blending, is used to carve and shape turns.

Instructional Techniques. Instructors should consider the following when teaching this technique:

- Link turns together with and without pole plants.
- Increase slope angle and vary snow conditions.
- Practice a single ski turn by picking up the inside ski at turn initiation and holding through full radius.
- Practice rapid, linked, short radius turns.
- Practice long, gradual, giant slalom turns.
- Practice hopping parallels for turn initiation; practice hopping turn initiation at the top moguls.
- Progress from hopping to jumping parallels.

Obstacle Crossing

Obstacle crossing is a technique of crossing ditches, fences, fallen trees, streams, and crevasses while on skis, which allows skiers to continue the ski march uninterrupted without removing skis.

Teaching Terrain. As applicable.

Body Position and Mechanics. Marines should consider the following when practicing this technique:

- Assume the basic athletic stance.
- Evaluate skier position. Align the skis parallel to the obstacle.
- Set poles to stabilize the skier's position with one pole placed on the far side of the obstacle. Be sure to allow enough room to place skis in the new position.
- Sidestep the ski closest to the obstacle followed by the other ski.
- Bring the second pole across.
- Be careful and check both sides of the obstacle to see if it can support weight. If this is questionable and if the obstacle is deep or wet, a safety rope must be used.

Instructional Techniques. Instructors should subject students to constructed and natural obstacles in all types of terrain and snow conditions.

Free Skiing

Marines can use free skiing to navigate varied and difficult terrain.

Teaching Terrain. Intermediate (blue) to advanced (black) terrain off-piste (a marked run) with varying conditions.

Body Position and Mechanics. Marines should consider the following conditions when practicing free skiing:

- Bumps (Mogul Skiing):
  - Visualize a trajectory (the line) down the mogul run.
  - Keep the upper body facing down the fall line.
  - Maintain rhythmic fall-line turns.
  - Maintain continuous leg steering.
  - Maintain ski-to-snow contact.
  - Keep hands in continuous motion.
- Steeps (Skiing Steep Terrain):
  - Visualize a trajectory (the line) down the mogul run.
  - Vary turn tempo and shape to control speed.
  - Direct the upper body down the fall line.
  - Steer with the legs.
  - Initiate with a solid pole plant.
  - Manage pressure build-up.

- Ice:
  - Keep ski edges sharp.
  - Align the body laterally to aid balance over edged skis.
  - Keep both skis equally weighted and pressured.
  - Apply pressure over the skis consistently and progressively.
  - Edging movements are key. Edge early or drift early!
  - Exploit ski design.
- Powder (Loose Deep Snow):
  - Develop tolerance for speed in deep snow.
  - Keep the upper body quiet and solid.
  - Equalize pressure over both skis.
  - Keep feet and legs loose and supple.
  - Actively steer skis in and out of turns.
  - Use poles to aid in rhythm and flow.
- Crud and Crust:
  - Keep the upper body facing down the fall line.
  - Maintain rhythmic fall-line turns.
  - Ski aggressively and with a purpose.
  - Use leapers and hop turns.
  - Initiate with a solid pole plant.
- Wet, Heavy Snow:
  - Wax skis to minimize sudden grabbing of the snow.
  - Keep the upper body facing down the fall line.
  - Maintain a centered stance.
  - Maintain rhythmic fall line turns.

Instructional Techniques. Instructors should vary practice in accordance with snow conditions and steepness of the slope.

SKIJORING

Safety Requirements

Safety requirements include the following:

- A skier should never tie into a skijoring rope because it could cause the skier to be dragged over, around, or through obstacles and cause serious injuries.
- The vehicle pulling experienced skiers should not exceed 25 miles per hour. For inexperienced skiers, the rate of speed should not exceed 15 miles per hour.
- Skiers should be spaced at least half a ski's length apart from the tail of the front skier to the tip of the following skier.

- There should always be a safety rider who has visual contact with the skiers and can communicate with the driver. The safety rider should be experienced in skijoring. The safety rider should—
  - Be able to observe all skiers.
  - Be in constant communication with the driver whether by using a whistle, a cord, or another person to relay messages.
  - Give the halt signal for all others to hear in case anyone falls and so the driver knows to halt.
  - Have a signal that everyone knows for stopping, slowing, and accelerating.

Safety Considerations. Marines should consider the following safety factors when skijoring:

- Communication signals between the safety rider and driver must be established as a backup.
- The safety rider must be positioned to view all individuals skijoring, start slowly with a consistent speed, stop gradually, and increase speed down gentle slopes.
- Skiers should unhook before steep slopes. The decision to unhook for downhill grades depends on the skier's ability.
- The driver should avoid sharp turns.
- Limited-visibility conditions might warrant fewer skiers.
- Deep snow may warrant fewer skiers.
- The least experienced skier's ability dictates the vehicle's speed.
- Sleds should be towed separately from skiers for safety (see Figure F-1).
- When turning or going around curves, Marines should ski to the outside of the turn, particularly the rear skiers on the inside rope.
- Leaders should brief drivers on safety considerations, commands, and intended route.

Figure F-1. Towing Sleds.

Skijoring Techniques

Each skier should line up on the outside of the line. The first skiers should be at least one ski length behind the vehicle and where the safety rider can observe them. Skiers should be half a ski's length apart from each other before hooking up to the tow rope (see Figure F-2).

The skiers in the front should hook up to the tow line first, followed by the second set, and so on. To hook up to the tow line, Marines must—

- Place the ski pole handgrips on top of the tow rope.
- Grasp the tow rope in front of the pole.
- Wrap the rope around the ski poles and directly under the handgrips, forming a half hitch.
- Place the ski pole baskets behind the outside armpit to use as a rest (see Figure F-3).
- Shuffle skis when starting to prevent skis from freezing to the ground.
- Keep skis parallel, about shoulder width apart, and knees flexed in the basic ski stance.

The last skiers should ensure they keep the tension on the end of the rope to keep their ski poles in place. If a Marine falls, everyone must let go of the rope and ski outboard to the side. The most experienced skiers should be in the front and back of the rope.

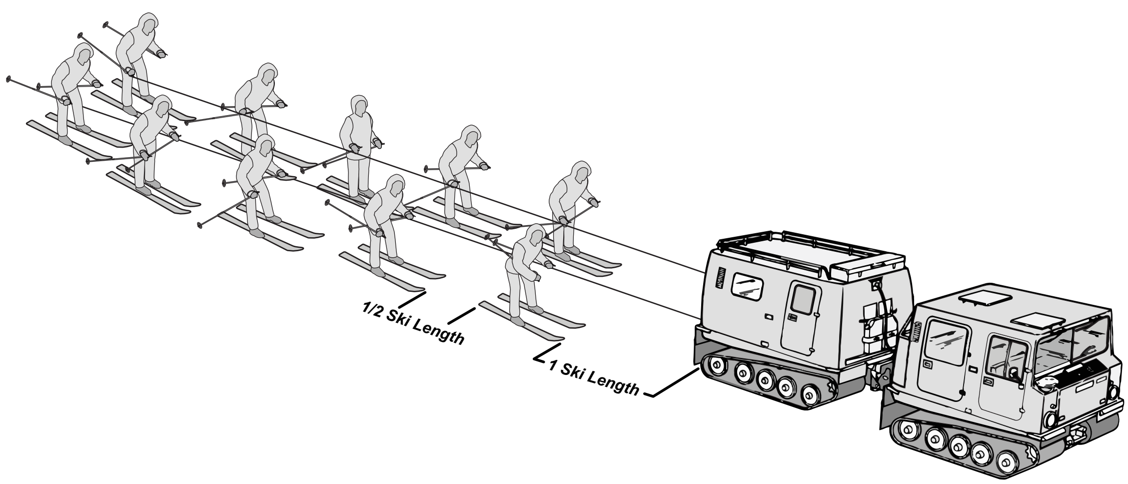

Figure F-2. Skijoring Tow Rope and Skier spacing.

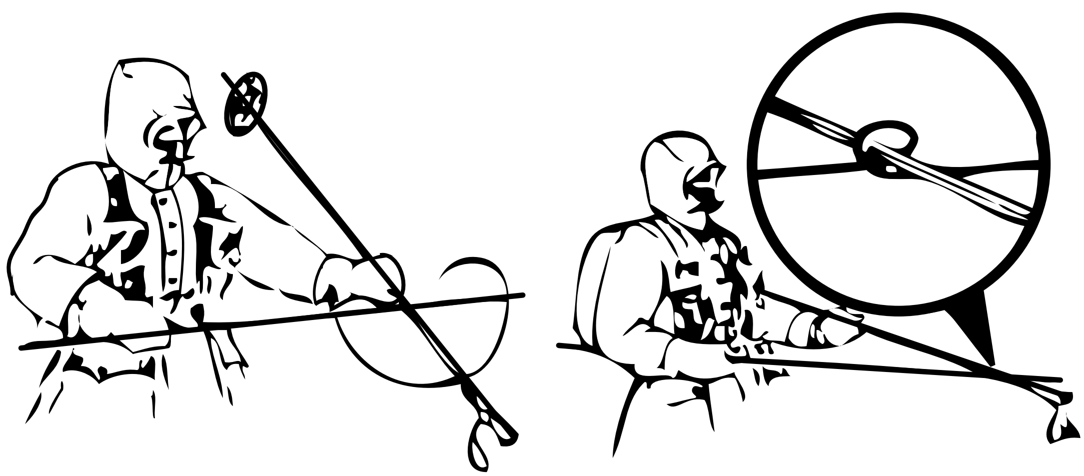

Figure F-3. Hooking Up to Skijoring Line with Ski Poles.

GLOSSARY

Section I. Acronyms and Abbreviations

ACV	amphibious combat vehicle
°C	degree Celsius
CASEVAC	casualty evacuation
CATV	cold weather all-terrain vehicle
CBRN	chemical, biological, radiological, and nuclear
°F	degrees Fahrenheit
LAV	light armored vehicle
LZ	landing zone
MCCWIK	Marine Corps cold weather infantry kit
MCMWTC	Marine Corps Mountain Warfare Training Center
MCRP	Marine Corps reference publication
MCTP	Marine Corps tactical publication
MSS	military ski system
SUSV	small-unit support vehicle
TNT	trinitrotoluene

REFERENCES AND RELATED PUBLICATIONS

NATO Publications

Allied Tactical Publications (ATP)

3.2.1.5 Conduct of Land Tactical Operations in a Cold Weather Environment

Marine Corps Issuances

Marine Corps Tactical Publication (MCTPs)

12-10A Mountain Warfare

12-10E Arctic and Extreme Cold Weather Operations

Marine Corps Reference Publication (MCRPs)

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12-10A.1 Small-Unit Leader’s Guide to Mountain Warfare

12-10A.3 Mountain Leader’s Guide to Mountain Warfare Operations

Technical Manual (TM)

4451-20/1 Operator and Field Maintenance Manual for Consolidated Storage Program Serviceability Standard for Infantry Combat Equipment

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Army Techniques Publication (ATPs)

3-21.50 Infantry Small-Unit Mountain and Cold Weather Operations

3-90.97 Mountain Warfare and Cold Weather Operations

Training Circular (TC)

21-3 Soldier’s Handbook for Individual Operations and Survival in Cold Weather Areas

Training Manual (TM)

4-33.31 Arctic and Cold Weather Maintenance Operations