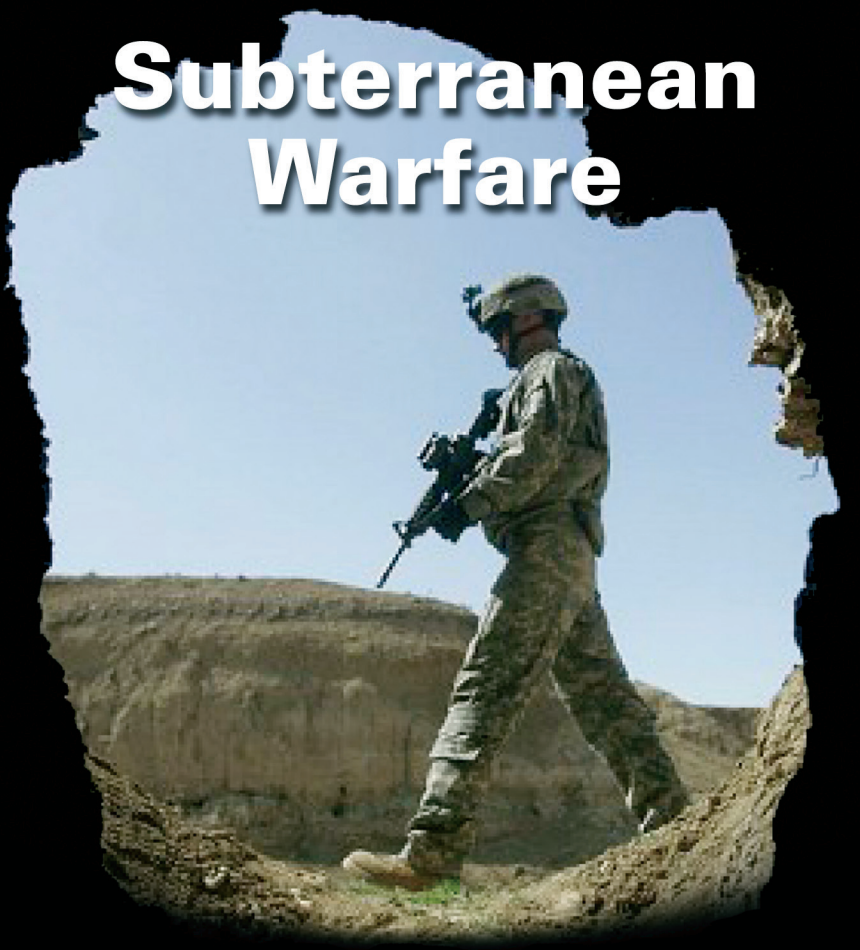
HANDBOOK

December 2009

Subterranean Warfare



U.S. Army Asymmetric Warfare Group

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The U.S. Army's Asymmetric Warfare Group (AWG) has compiled the information contained in this handbook for soldiers preparing for combat in subterranean systems and underground structures. This information is the result of observations made by soldiers and operational specialists conducting operations primarily in Afghanistan and Iraq as well as information obtained from historical sources, law enforcement agencies, search and rescue organizations, and technology experts. Although much of the information in this handbook relates to Operations Iraqi and Enduring Freedom, the concepts contained herein are applicable to subterranean operations wherever they occur.

The operational environment found in subterranean systems presents a soldier with unique challenges that compound the difficulties already faced by those in combat. Underground operations place soldiers in environments of total darkness, cramped spaces, and limited communications—made all the more difficult by potential environmental risks, such as flooding, suffocation, and cave-ins. The intention of this handbook is to complement existing Army doctrine by providing relevant information to support individual soldiers and small units conducting operations within subterranean systems and underground structures. Leaders also may find this guide helpful in prioritizing training tasks during the pre-deployment phase for upcoming operations, which may entail combat in subterranean environments.

INTRODUCTION

When a military force owns terrain, has air superiority, or possesses significant intelligence, surveillance, and reconnaissance (ISR) advantages, subterranean systems and underground structures may afford the opposing force a medium in which to continue the fight and maintain the initiative against their militarily more powerful opponent. The military uses of subterranean systems, such as tunnels, caves, and aquifers, are numerous and may include the following:

- Maneuver routes after losing freedom of maneuverability above ground
- Secure communications, especially in urban environments, through land lines or runners
- Concealed locations to rest and for storage, medical treatment facilities, and command nodes
- A means to deliver weapons, such as explosives and raid teams, to targets
- Lines of communication and resupply
- Surveillance
- Smuggling as a means to generate funding for future operations

This handbook consists of four chapters. Chapter 1 begins with a description of the types of subterranean systems and underground structures typically associated with military operations. Then Chapter 2 proceeds with a few historical examples of subterranean warfare. The handbook continues with a discussion in Chapter 3 of procedures and considerations for the conduct of subterranean warfare. Finally, Chapter 4 deals with an overview of some of the hazards, medical considerations, and rescue techniques associated with subterranean operations.

CHAPTER 1:
TYPES OF SUBTERRANEAN SYSTEMS

Subterranean systems may occur naturally or be manmade. For the purposes of this guide, **subterranean systems** are categorized as tunnels or caves. Within the tunnel category, a subcategory of underground manmade aquifers is further delineated. **Underground structures** are manmade construction inside of a subterranean system. For example, an underground command node or warehouse (the underground structure) can exist inside of or be connected to a tunnel or cave (the subterranean system). What may be normally legitimate, civilian subterranean systems are frequently co-opted for military or criminal uses. For example, when constructing tunnels, insurgent forces often will tap into pre-existing water and sewer tunnels in order to rapidly extend their lines of communication. Tunnels, aquifers, and caves are further described below.

Tunnels

A **tunnel** is a horizontal passageway located underground. Tunnels most typically are built for mining, public works, and transportation. Mining tunnels are used to access and extract minerals, ores, and other deposits from the earth. Public works tunnels are built to carry things such as water, sewage, and power and communications wires between places. Transportation tunnels are used to deliver people and materials between places. For the purposes of this guide, unless otherwise noted, the term tunnels will be used to refer to transportation tunnels used for military purposes.

Examples of tunnels include those built for drug smuggling on the U.S. border with Mexico, for weapons smuggling into Gaza along the Israeli–Egyptian border, for tunneling under prisons in Iraq, and in the demilitarized zone (DMZ) along the border between North and South Korea.

Underground Aquifers

Although technically a form of tunnel, the size and sheer number of **aquifers** in Afghanistan—known as *karez* or *qanats*—represent distinct challenges to conducting military operations there. Karez are used to deliver water from mountain slopes to villages in the valley below through gravitation. The karez is built by digging a tunnel from the destination (e.g., farm fields or a village well) to the water source. Along the path of the tunnel, vertical shafts are dug for maintenance access and wells (see Figure 1). When flying overhead of areas with karez systems, well openings are a common sight.

Karez systems in Afghanistan have existed for hundreds of years, and it is estimated there are as many as 6,000 karez in Afghanistan. Karez can measure from a few kilometers to tens of kilometers in length. The longest known karez is 70 kilometers long. Typical karez depths range from 20 to 50 meters but can be as deep as 200 meters.

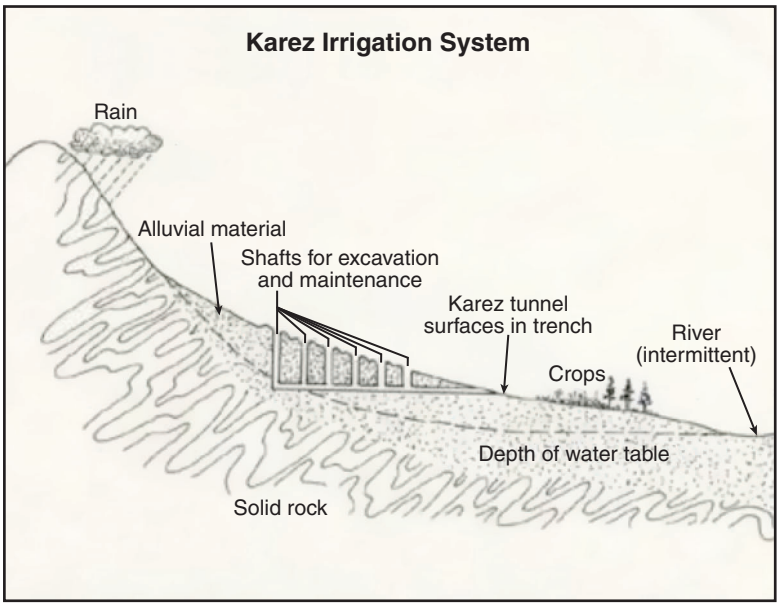

Figure 1. Adapted from the Food and Agricultural Organization of the United Nations, www.fao.org.

The karez systems in Afghanistan have legitimate uses (e.g., irrigation and cold storage); however, karez also present anti-Afghan Forces (AAF) with a means to cache weapons and materials, infiltrate and exfiltrate the battlefield, and move fighters and supplies.

Caves

A **cave** may occur naturally or be manmade. It is generally a horizontal, underground cavity. Caves referred to in this guide will be large enough for a human to enter and conduct a military function, such as storing arms and materials, command and control, or medical treatment. Individual fighting, bunkers, and hide positions will not be considered caves for the purposes of this handbook.

CHAPTER 2:
HISTORY OF SUBTERRANEAN WARFARE

Subterranean systems and underground structures have been used throughout history for military purposes. In this chapter, a few examples are cited to illustrate recent historical examples of the use of subterranean systems and underground structures by military forces to achieve asymmetric advantages against their opponents.

Viet Nam War (Iron Triangle)

During the Viet Nam War, the People's Army of Viet Nam (PAVN) and the Viet Cong[1] used tunnels extensively to conceal themselves from superior U.S. firepower, protect critical facilities, and cache weapons and supplies. Among the most significant of the many tunnel complexes built by the Viet Cong were the ones located in the area known as the Iron Triangle.[2]

The United States conducted multiple operations against Viet Cong insurgents in the Iron Triangle, including Operations Cedar Falls (January–February 1967) and Junction City (February–March 1967). The purpose of these operations was to destroy Viet Cong bases in this region—between Saigon, South Viet Nam's capital, and Cambodia to the west—and to separate the insurgents from their civilian base of support in the area. Although the U.S. military knew of the Viet Cong use of tunnels, they were unaware of the full extent of the tunnel complexes located in the Iron Triangle until after the start of Operation Cedar Falls.

On the first day of the operation, the U.S. 25th Infantry Division (ID) and South Vietnamese army forces seized the village of

[1] The People's Liberation Armed Forces, more popularly known as the Viet Cong, an insurgent force, was the military arm of the People's National Liberation Front.

[2] The tunnels in the vicinity of the Iron Triangle often are referred to as the Cu Chi Tunnels. Cu Chi was a base camp used by the 25th ID that was located near the Iron Triangle and used in support of U.S. operations against Vietnamese insurgents.

Ben Suc, which was considered a logistics base for the insurgents in the Iron Triangle. Above ground, Ben Suc appeared to be a typical village; however, U.S. and South Vietnamese forces soon discovered that beneath the surface of the village was an extensive underground complex with chambers for supplies, document storage, medical treatment, and the manufacture of mines, uniforms, and booby traps.[3]

A systematic site exploitation of all the insurgents' underground facilities in the Iron Triangle was considered too dangerous, so most of the sites were destroyed by engineers after cursory explorations. Still the documents recovered from the tunnels did provide valuable intelligence, including detailed accounts of insurgent activity in the area for the previous 5 years, lists of U.S. and South Vietnamese call signs and frequencies, and names of South Vietnamese officers who were providing information to the Viet Cong.[4]

As Operations Cedar Falls and Junction City progressed, U.S. forces recognized the need to conduct more thorough exploitation of the subterranean systems built by the Viet Cong, so they began using volunteers known as "tunnel rats" to go underground (Figure 2). The tunnel rats entered the tunnels to identify Viet Cong locations, kill insurgents, and emplace explosives to destroy underground structures.

A tunnel rat's equipment was minimal: knife, flashlight, and pistol. Initially, tunnel rats received little or no training; however, training programs eventually were established within divisions and, while limited, tunnel exploration kits were developed by the Army. Additionally, units developed their own kits, which typically consisted of 100 feet of rope, body armor, grappling

[3] MacGarrigle, G. L., *Taking the Offensive, October 1966–October 1967, The U.S. Army in Viet Nam*, Center of Military History, U.S. Army (Washington, DC), 1998.

[4] MacGarrigle (1998), pp. 110–111.

Figure 2. Tunnel rat engineering team exploring a Viet Cong tunnel.

hooks, gas masks,[5] TA-1/PT sound-powered telephones, work gloves, knee pads, earplugs, flashlights, and a half-mile spool of communications wire.[6]

Over time, divisional training programs were developed to prepare the tunnel rats for their arduous assignment. Eventually, tunnel rats also worked with insurgent defectors, known as Kit Carson

[5] U.S. forces were authorized to use CS gas, a riot control agent, throughout much of the war. Although gas masks protected the tunnel rats from the CS gas, the masks offered no protection against carbon monoxide and lack of oxygen.

[6] Rottman, G., *Viet Cong and NVA Tunnels and Fortifications of the Viet Nam*, Osprey Publishing (New York, NY), 2006.

Scouts, who better understood the layout of the tunnels, were able to anticipate booby trap locations, and sometimes could coax insurgents from their hiding positions.[7]

Viet Cong use of the subterranean systems persisted until the end of the war. Besides enhancing the effectiveness and survivability of PAVN and Viet Cong forces, the tunnels also served as an important symbol of the insurgents' tenacity and endurance in the face of American power.[8]

Soviet War with Afghanistan

During the Soviet–Afghan War (1979–1989), the Soviets conducted numerous operations against Mujahedeen fighters operating from karez systems. Afghan Mujahedeen and the civilian populace used karez systems for shelter from the Soviet occupiers to protect themselves from attack, indirect fire, and aerial-delivered munitions. Although the Soviets did not typically conduct large-scale operations against the tunnels, they did on occasion conduct cordon search operations using both Soviet and Afghan communist forces.[9] Soviet preparations for conducting subterranean operations against Mujahedeen included the establishment of schools for Soviet engineers and Afghan Special Forces soldiers.[10]

The Soviet army developed a variety of techniques for subterranean warfare, including ways to destroy karez using stereophonic blasting, which is summarized below:

- To separate civilians who might be in hiding from the Mujahedeen, the Soviets would first attempt to call out civilians through voice commands. While staying clear

[7] Mangold, T., and Penycate, J., *The Tunnels of Cu Chi*, Random House (New York, NY), 1985.

[8] Mangold and Penycate (1985), p. 271.

[9] Grau, L. W., and Jalali, A. A., "Underground Combat: Stereophonic Blasting, Tunnel Rats and the Soviet Afghan War," *Engineer*, **28**(4), pp. 20–23, November 1998, www.globalsecurity.org/military/library/report/1998/981100-underground.htm.

[10] Grau and Jalali (1998).

Figure 3. Image of Soviet karez operations reprinted from Grau and Jalali (1998).

of the opening, the Soviets next would drop concussion grenades and provide additional warnings for any occupants to surrender before the Soviets destroyed the karez.

- They then would lower a pair of explosives into the karez, one at the bottom of the well shaft and another at the top. When detonated, the top explosive would seal the airway with gasses. The shock wave from the lower charge, detonating a moment later, would slam into the gas blockage above and rush back downward against the sides of the well shaft and the connecting tunnels. The overpressure caused by the twin explosions, the "stereophonic effect," would create a deadly overpressure event for anyone in the well. This same technique could be used against multiple tunnels simultaneously.[11]

Other techniques used by the Soviets included search teams, signal flares to stun those in hiding, incendiary rounds, and ignited petroleum products to kill enemy forces.

[11] A more complete description of this overpressure technique is presented in the Grau and Jalali (1998) article.

U.S.–Mexican Border (Drug Cartels)

Infiltration tunnels do not only exist overseas. More than 100 tunnels, with varying levels of sophistication, have been discovered since 1990 along the U.S. border with Mexico. Figure 4 shows a drug tunnel discovered by Drug Enforcement Agency (DEA) and Immigration and Customs Enforcement (ICE) agents on 26 January 2006. This cement-lined cross-border tunnel linked drug cartel warehouses in Tijuana, Mexico, to Otay Mesa, California. The nearly 1,000-yard tunnel came complete with electricity and ventilation.

Figure 4. Image of cement-lined cross-border drug tunnel between the U.S. and Mexico courtesy of the U.S. Department of Justice, www.usdoj.gov.

Infiltration tunnels built by drug cartels are known to have leveraged U.S. infrastructure tunnels in the past. One technique used by drug cartels is to locate their safe houses near large urban sewer systems that sometimes run into Mexico. A tunnel is then dug connecting the safe house to the sewer system. The cartels then can transport drug shipments from Mexico using the sewer system for concealment to reach the safe house. From there, the shipment can be loaded into transportation vehicles and delivered to follow-on destinations.

Israel (Gaza)

Palestinian militants in Gaza use tunnels for a variety of purposes (Figure 5). Although smuggling operations are probably their best known use of tunnels, they also use tunnels for infiltration, demolition (sabotage), and attacks. One of the most famous attacks was the kidnapping of Corporal (CPL) Gilad Shalit of the Israel Defense Force on 25 June 2006. On that day, Palestinian militants used a tunnel to cross the border from Gaza into Israel and attack CPL Shalit's unit.

In the fight, two Palestinian attackers were killed, but not before they killed two Israeli soldiers, kidnapped CPL Shalit, and escaped with him to Gaza. Since then, Palestinian militant groups have used CPL Shalit's capture for propaganda purposes and to bargain for concessions from the Israeli government. Moreover, the inability of the government of Israel to obtain CPL Shalit's release became a significant political issue in the country. In the end, the refusal of Hamas to release CPL Shalit was one of the justifications Israel used for its decision to invade Gaza in January 2009.

Figure 5. Image of Gaza City tunnel similar to the one used by Palestinians in CPL Shalit's abduction is reprinted with permission of *The Weekly Standard*, where it first appeared on 30 August 2006. For more information visit www.weeklystandard.com.

CHAPTER 3:
SUBTERRANEAN WARFARE PROCEDURES

Subterranean operations may occur as the result of deliberate planning or as a reaction to an immediate threat or opportunity. Similarly, a unit conducting a mission in a subterranean environment might have to rapidly switch between offensive and defensive tasks. This chapter provides information related to the planning, preparation, and execution of subterranean operations.

Planning Considerations

Detailed knowledge of the nature and location of subterranean systems and underground structures is of great importance to personnel planning to conduct operations in these environments. Planning considerations for subterranean operations should include:[12]

- A thorough analysis of the reasons to place troops in a subterranean environment. Subterranean combat is physically and psychologically demanding and must be carefully thought out prior to committing troops.
- A leadership decision as to whether the need to enter subterranean systems or occupy underground structures facilitates mission accomplishment.
- Planning for redundant communications.
- Planning for additional weapons and ammunition that may be required for subterranean operations, such as shotguns, pistols, and distraction devices.
- Planning for and providing support above ground for those elements that are deployed in subterranean areas. Insure that situational awareness is maintained above and below ground.

[12] U.S. Army Field Manual 3-06.11 (FM 3-06.11), *Combined Arms Operations in Urban Terrain, Appendix J: Subterranean Operations*, Headquarters, Department of the Army (Washington, DC), 28 February 2002.

- Consideration of sealing off access routes to underground passages and using smoke to flush out anyone in hiding.

Intelligence Preparation of the Battlefield (IPB)

To provide a complete understanding of the operational environment, IPB for operations should include consideration of subterranean systems and underground structures in the unit's area of interest (AI). In many areas, overhead imagery exists or may be developed to support this analysis. Because tunnels and underground aquifers may extend into areas controlled by insurgents, IPB should develop and routinely reassess physical changes, civil considerations, and cultural and economic significance of subterranean systems in the AI.

Targeting: Find, Fix, Finish, Exploit, Analyze, and Disseminate (F3EAD)

A methodology available to leaders for targeting during subterranean operations is **Find, Fix, Finish, Exploit, Analyze, and Disseminate** (**F3EAD**).[13] The F3EAD process provides leaders with a specialized tool to address targeting challenges within the context of the commander's intent.

F3EAD is an appropriate targeting method to use for civil military operations, information operations, and political, economic, and social programs. Because subterranean operations frequently include a mix of targets assigned to lethal and non-lethal assets, F3EAD provides a solid framework within which to deliver kinetic and non-kinetic effects to accomplish a unit's immediate mission set, while setting the conditions necessary for future success. A quick explanation of F3EAD as it applies to subterranean operations follows.

[13] U.S. Army Field Manual 3-60 (FM 3-60), *Targeting (Draft), Appendix B: F3EAD*, Headquarters, Department of the Army (Washington, DC), 2009.

Find: This step is when the commander establishes priorities for target sets that apply to the tasking of available acquisition assets, information-processing capabilities, and attack means (lethal and non-lethal).

- In subterranean warfare, thought must be given to the means used against the target. For instance, a decision to attack a target within a subterranean system that is connected to public works infrastructure must be considered within the context of the potential impact upon the community caused by collateral damage. For example, an attack on insurgents inside a karez system should take into account the potential disruption to the local economy caused by the event.
- An enemy's ability to remain hidden is paramount to his survival. Subterranean systems provide an insurgent the ability to maintain concealment while keeping close to civilian populations and operational sites. Finding insurgents in subterranean environments requires effective management of available ISR assets and persistent, patient observation. In assessing enemy activity in subterranean systems, nodal or link analysis provides a tool through which to understand how the subterranean activity is linked to other enemy activity in the area. For instance, materials found when exploiting underground weapons caches, documents, and sleeping areas may point to follow-on targets.

Fix: Once the criterion is met to warrant action, a commander makes a decision whether or not to launch the finish force.

- The decision process should be supported by intelligence. At echelons below the Brigade Combat Team (BCT), this intelligence analysis frequently is undertaken by intelligence support teams formed from internal personnel assets with sufficient knowledge of targets, unit standard operating procedures (SOPs),

sensor assets, and the status of data collection to support the commander.[14]

- In analyzing a target, personnel conducting intelligence preparation should attempt to learn as much information as possible about the site itself. In urban areas, maps may be available of subways systems, underground sewage and storm drains, and tunnels. In less developed areas, local nationals frequently are the best source of information related to local subterranean systems and underground structure.

Finish: For success, targets frequently require rapid action.

- Units must have a trained assault force ready to launch on very short notice (Figure 6). Intelligence should provide the assault force indications of when a target is expected to be at a predicted location and for how

Figure 6. Image from U.S. Department of Defense, Defend America, www.defendamerica.mil. (U.S. Army photo by Sgt. Gregory Heath, 4th Public Affairs Detachment.)

[14] For additional information on how to build an effective intelligence cell at the company/team level, see Asymmetric Warfare Group, *Tactical Reference Guide: Company Intelligence Support Team (CoIST)*, Asymmetric Warfare Group (Fort Meade, MD), May 2008.

long. Rehearsals, training on specialized equipment, and well-developed SOPs are extremely important for subterranean operations because there may not be time available for elaborate preparations and planning.

- Additionally, units must be prepared to encounter snipers or ambush teams on routes leading to subterranean systems. Rehearsals should include planned actions on the approach and egress routes of subterranean systems.

Exploit: Once a target in a subterranean system is engaged, the target site must be exploited.

- Tactical site exploitation is a methodical, detailed collection process to gather potential intelligence. As with the finish force, effective site exploitation requires prior planning to include SOPs, search plans, prepared site-exploitation kits, and question plans.[15] For some targets, the exploitation step is the most important because information gathered at the site may become actionable intelligence for higher-priority targets.
- Target and document exploitation are critical to the F3EAD process. Underground structures may hold information in the form of documents, cell phones, or computers that are stored there by the enemy because the place is considered safer than carrying the items on their persons. Likewise, ordnance and ordnance markings discovered at cache sites may help to reveal sources of material support to insurgents. Through this information, the enemy's overall network can be brought into focus.
- Tactical questioning (TQ): When suspected insurgents are detained or local nationals are present at subterranean sites, TQ provides a method for gathering

[15] For additional tactics, techniques, and procedures (TTPs) on tactical site exploitation, see Asymmetric Warfare Group, *Tactical Pocket Reference: Tactical Site Exploitation*, Asymmetric Warfare Group (Fort Meade, MD), October 2008.

information from people using an expedited interview process. Soldiers can use TQ to gain and exploit time-sensitive information for follow-on missions, which can be especially important when subterranean operations identify evidence of insurgent activity in the system.[16]

Note: TQ is always an interview; it is not an interrogation.

- Materials, items of equipment, and documents collected during tactical site exploitation also may be of use as evidence to ensure continued detention of captured insurgents. In this sense, actionable intelligence also is actionable evidence, which can be presented by the law enforcement and legal counsel to host nation authorities. The continued detention and eventual prosecution of captured insurgents prevents their return to the battlefield and thereby enhances the commander's rule-of-law counterinsurgency efforts.

Analyze: In the analysis step, information obtained from the site is examined, evaluated, and turned into actionable intelligence. Some information may be immediately actionable, whereas other information may require further analysis and corroboration.

Disseminate: While straightforward, the disseminate step can be time consuming. Nevertheless, it is critically important that everyone who needs to know learns information discovered about exploited targets.

- With subterranean systems, it is especially important to provide information about changes in enemy TTPs (e.g., security, booby traps, and observation techniques) to help prepare other units for what they can expect to face in combat.

[16] For additional TTPs on TQ, see Asymmetric Warfare Group, *Tactical Pocket Reference: Tactical Questioning*, Asymmetric Warfare Group (Fort Meade, MD), October 2008.

- Observations related to engineering and construction are likewise important. Underground construction requires a degree of sophistication and training. As such, observations about construction techniques can reveal relevant information about the site, who built it, and how the enemy is being supported.

Movement

Movement techniques during subterranean operations will vary based on METT-TC (Mission, Enemy, Terrain and weather, Troops available, Time available, and Civilian considerations). Regardless of the organization, movement in subterranean systems must be organized and conducted to provide stealth, dispersion, and security.

The below description provides an instructive method for leaders to review when developing SOPs and planning movement through subterranean systems, such as tunnels and underground aquifers.[17] The example illustrates how the patrol is organized to provide front and rear security, maintain communications with other elements, gain contact with the smallest force possible, and position the leader to provide effect command and control.

- **Team Organization:** The squad leader organizes his squad into two fire teams for movement (A and B Teams). One fire team leads with the rifleman as the point man, tasked with security to the front. The A-team leader moves directly behind the point man, controlling movement. Behind the team leader is the M249 gunner, ready to move forward and provide suppressive automatic fire if required. The squad leader moves directly behind the M249 gunner and records data. The team grenadier follows the squad leader and is the pace man during movement. Following the grenadier is the rifleman of the other team; he is responsible for rear security and for rolling out the

[17] U.S. Army FM 3-06.11.

"tag line."[18] The team leader, M249 gunner, and grenadier remain at the point of entry as a security post. They are responsible for detecting enemy and serving as the communications link between the squad leader and his higher headquarters. (See Figure 7 for diagram.)

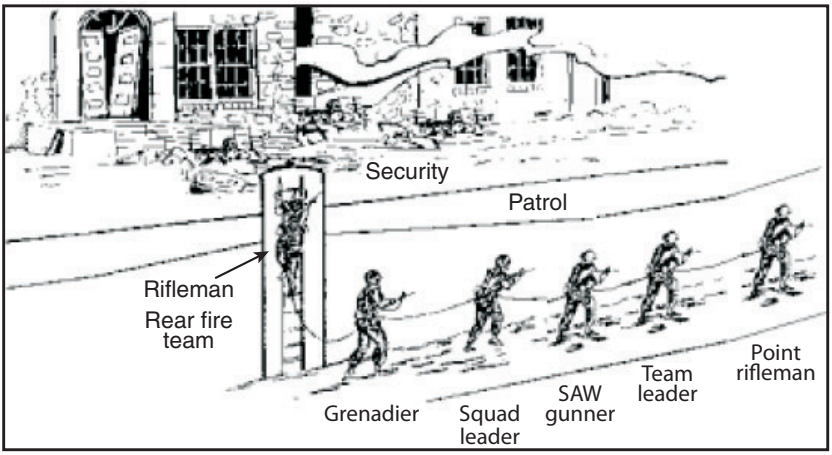

Figure 7. Team organization diagram.

- **Initial Entry:** Once the squad is organized and equipped, it moves to the entrance of the tunnel. The point man descends into the tunnel (with safety line attached) and determines whether the air is safe to breathe and movement is restricted. Unless the squad leader knows the air is safe, the point man should remain in the tunnel 10 minutes before the rest of the squad follows. If the point man becomes ill or is exposed to danger, he can be retrieved by use of the safety rope.

[18] **Tag Lines:** Tag lines are flexible handholds used to guide individuals along a route that aid in navigation and movement when operating in confined spaces such as buildings, tunnel systems, and caverns with limited visibility, where sense of direction can be lost. Lines can be rope, string, cable, or wire. An effective material for tag lines is communication wire because in addition to working as a tag line, it also can be used as a means of communicating with elements above ground.

Note: When entering a crawlspace, if your head and chest will fit, usually the rest of your body will. If you must remove your helmet to enter a crawl space, it is not large enough for you to enter.

- **Movement Techniques:** When the squad is moving through the tunnel, the point man moves about 10 meters in front of the team leader. Other squad members maintain 5-meter intervals. If water in the tunnel is flowing faster than 2.5 meters per second, or if the sewer contains slippery obstacles, those intervals should be increased to allow for squad members to react if one man slips. If using a safety rope, all squad members should remain tied in so that they can be retrieved from danger. The rear security man marks the route with the tag line so the other troops can find the squad.

  Note: The path of ricochets tends to follow close to the surface that they strike. Movement in subterranean areas with hard surfaces, such as stone, concrete, or steel, may require personnel to stand slightly away from walls.

- **Approach:** The enemy may defend the entrance to subterranean systems with mines, ambushes, or snipers. One of the best historical examples of this was the Battle of Okinawa in World War II where the Japanese army built an extensive underground cave system, which was occupied by more than 100,000 personnel. The Japanese defended the openings to these caves with an interlocking network of trenches and fortified machine gun emplacements.
- When fighting irregular forces, the defensive preparations of subterranean systems will not match the scope and sophistication of the Japanese defense of Okinawa; however, the dangers are the same. Soldiers should use observation, reconnaissance, and, when

possible, information obtained by local inhabitants to develop a clear understanding of any preparations the enemy may have made.[19]

Booby Traps

When approaching and moving through subterranean systems, care must be taken to avoid booby traps. Enemy forces will frequently deploy booby traps near openings and junctions. The types of booby traps vary significantly based of geography, availability of materials, and the technical sophistication of the enemy force. Some booby traps will be little more than alarm devices to warn the enemy of the presence of intruders.

Examples of booby traps include:

- Nail boards and sharpened stakes
- Improvised explosive devises rigged to trip wires
- Rock drops and pits

Techniques for detecting and avoiding booby traps are as follows:

- Infrared (IR) designators, such as the AN/PEQ-2 Target Pointer/Illuminator/Aiming Light, used with night-vision goggles (NVG) can make trip wires sparkle to identify possible booby traps. The "sparkle" is the glint seen in the NVG lenses when the IR illuminator crosses the wire surface.
- Another technique to identify trip wires when moving without light is to use a trip-wire feeler using a long pole, a string, and a weight (Figure 8).
- Standing water in tunnels provides excellent camouflage for anti-personnel mines and booby traps scattered on likely routes. Soldiers should avoid walking in water, if possible.

[19] For additional information, see Asymmetric Warfare Group, *Tactical Pocket Reference: Sniper Awareness and Counter-Sniper Tips*, Asymmetric Warfare Group (Fort Meade, MD), May 2008.

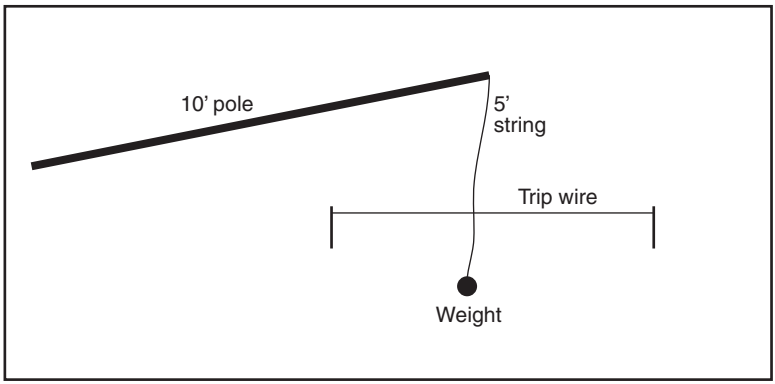

Figure 8. Diagram of a trip-wire feeler.

Climbing Skills

Operations in subterranean environments frequently require movement in areas with steep vertical climbs and drops. In these situations, the ability to use skills and equipment associated with mountain climbing can prove invaluable. This is especially true when conducting medical evacuations. The AWG's *Mountain Warfare Handbook* provides detailed information on the skills and equipment required for accomplishing these tasks.[20]

Shooting

The fundamentals of marksmanship must be followed in subterranean warfare. Because of their linear nature, it is difficult to bring weapons online to mass fire against targets. Fire discipline is absolutely essential in this environment because friendly personnel frequently will be between personnel at the rear of the formation and the enemy.

Planning and preparation for subterranean operations must require training and cross-training in all weapons planned for the mission.

[20] Asymmetric Warfare Group, *Mountain Warfare Handbook*, Asymmetric Warfare Group (Fort Meade, MD), November 2008.

The precepts of effective marksmanship—steady position, aim, breathing, trigger control, and follow through—must be taught, trained, practiced, and mastered.

- **Steady Position:** Fighting in a confined space with corners and low overhead requires soldiers who can fight from various positions other than the prone. Soldiers must train to achieve steady firing positions from alternative stances and to be able to effectively use their weapons' sling in order to provide stability when firing from asymmetric positions.
- **Aiming:** Good site pictures with consideration to angle and range are required. Soldiers must be aware of their aim point when engaging targets at extremely close range and adjust their aim accordingly. Moreover, angular deviations will require soldiers to incorporate angled firing techniques into their shooting skills. In subterranean operations, soldiers should anticipate short-range engagements.
- **Breathing:** Physical fitness and a soldier's ability to recover his breathing to manageable levels is imperative to enhancing good shooting techniques—*Control Your Breathing*.
- **Trigger Control:** Physical exertion and mental anguish during the fight can lead soldiers to disregard this fundamental. Soldiers must overcome the effects of stress and fatigue and accurately engage targets with the minimum number of rounds necessary—*Trigger Squeeze*.
- **Follow-Through:** Assess the target effect, make adjustments, and reset the trigger.

Communications

Communications in subterranean systems and underground structures is a significant challenge. Radio communications may

not be possible and using the global positioning system (GPS) may be denied. When planning subterranean operations, units should not assume radio communications will work the same as they do above ground. Some planning considerations for communications in subterranean environments follow:

Radio Communications

- Subterranean environments frequently prevent the use of radio communications. The reasons for this are many but include radio signal attenuation (loss of signal strength) caused by the effect of tunnels, corridors, levels, and walls on the radio signal. Even when a signal is present, the operational range may be short. It also means patrols operating underground may be unable to talk to anyone above ground or even among one another.
- In addition, the composition of the structure, walls, and objects within subterranean systems can create multipath signal conditions that impair high-frequency signal reception. Moreover, in mobile operations, units may be unable to optimally position/orient antennas. As a consequence of these factors, the comparative communications advantage U.S. forces typically enjoy over enemy forces may be reduced in subterranean operations.
- Methods do exist to mitigate the impact of subterranean terrain on radio communications. For instance, placing a radio operator at the opening of a well and another at the bottom of the well can provide a means for subsurface elements to maintain contact with above-ground elements. When using this technique in tunnels, thought must be given to synchronizing the movement of the above-ground radio operator with the team below, i.e., the above-ground link should not be moving at the same time as the below-ground team is moving.
- Existing wiring and metal construction (e.g., pipes and railings) sometimes can be leveraged to provide communications connectivity between the surface

and subsurface. All the same, subterranean operations, especially those in primitive environs, will likely have a serious negative impact on radio communications.

Telephone Communications

- Landline phones are an option, but they can affect mobility and are less flexible in employment than radio communications are.[21]

GPS

- Because subterranean systems prevent unobstructed views of the skies, GPS will not work. Compasses do work underground; however, their performance may be impacted when used underground in areas with high concentrations of mineral deposits.

Equipment

The individual equipment kit for soldiers conducting subterranean operations should be tailored to meet the requirements of the mission. **Suggested equipment for soldiers conducting subterranean operations** is as follows:

- Slick body armor (pouches removed or streamlined; long-sleeved shirt)
- Harness or rappel seat
- NVG
- AN/PEQ-2 (wire sparkling)
- Small first aid bleeder kit
- Eye protection clear
- Head lamp
- Two handheld lights
- Extra batteries

[21] Tunnel rats in the Viet Nam war did on occasion use landline communications. (Rottman, 2006).

- Pistol with mounted light and IR cover (police technique)
- Gloves, surgical masks, and knee pads
- Pen flares
- Chemical lights, visible (10)
- Chemical lights, IR (2)
- Smoke grenade (*not* HC white)
- Pencil and graph paper (for cave mapping)
- Mirror (can be used to reflect light from the surface down shafts in order to explore for/observe the presence of enemy activity)
- Hearing protection [Combat Arms earplugs, National Stock Number (NSN): 6515-01-466-2710]
- Mountaineering equipment (to include 2 each locking carabineer, 1 each 14-foot sling, and 1 each 20-foot section of tubular nylon)
- Other items: whistle (for rescue use), entrenching tools, and pepper spray (to chase away dangerous animals without noise)

At the **team level and higher, additional equipment** recommendations include:

- Shotgun with mounted barrel gun light, three pieces of cleaning rod, #9 shot [slugs or 00-Buck may detonate unexploded ordnance (UXO)]
- Pistol barrel taped with light
- Chemical lights, visible (10)
- Radio
- Handheld metal detector/titanium mine probe/map and FalconView controlled image base (CIB) imagery of working area
- Mountaineering equipment (to include 1 each 9- to 20-mm rope, 1 each SKED® system, and 1 each 30-foot sling per squad)

The amount of ambient light present may impact the **effectiveness of NVG** in subterranean systems.

- IR light sources, such as the AN/PEQ-2 IR designator and IR chemical lights may be required.
- The AN/PSQ-20 enhanced NVG, now in limited fielding, significantly enhances soldiers' ability to see in extremely low-light environs, such as caves and tunnels, by using an IR intensifier in combination with a forward-looking IR.

In some situations, **white light** might be the preferred method for illumination in a subterranean environment. As such, units should practice operational procedures for switching between NVG and flashlight illumination, regardless of color, to ensure that they can switch efficiently in an operational environment.

The advantages of using **military working dogs** in subterranean systems include their ability to detect explosives and drugs as well as to instill fear in others. When planning operations, these advantages should be weighed against the military working dogs' potential vulnerability to drowning and susceptibility to booby traps.

Training

Preparing for subterranean operations requires education, training, and practice. Soldiers need to master skills associated with new equipment, adapt current procedures, and become confident with conducting operations in a new environment, both as an individual and as a member of a team. The United States' experience in the Viet Nam War (where Army divisions established training programs for tunnel rats) and the Soviets' experience during their war in Afghanistan (where they developed training curricula and schools for Soviet engineers and Afghan Special Forces) both reflect the importance of effective training programs to prepare soldiers for subterranean warfare.

- In order to develop the problem-solving capability and the ability to apply subterranean warfare skills in the-ater, training and education should be outcome based. Outcome-Based Training and Education (OBTE)[22] is a philosophy of training and education that focuses on the development of the individual in relation to their mission. Applied to subterranean warfare preparation, OBTE develops:
  - Mastery of skills required for subterranean warfare.
  - The ability to merge these skills and apply them in the subterranean operational environment.
  - Knowledge of how to merge subterranean warfare skills with other mastered skills.
- Major installations and the Combined Training Centers have Military Operations in Urban Terrain (MOUT) sites with underground networks where subterranean warfare techniques can be practiced, refined, and drilled. In addition, many municipalities' emergency response organizations have fire houses or like facilities that units without access to a MOUT site may use to train on skills needed to operate in a confined space.
- Training events also may identify soldiers who are prone to claustrophobia when placed in confined subterranean systems. Claustrophobia is the fear of having no escape when in a closed environment. The symptoms of a panic attack commonly last 30 minutes but sometimes can continue for hours.
- Sometimes people without a history of claustrophobia will experience panic attacks in subterranean situations. A person who otherwise may not have trouble in confined spaces may experience a panic attack

[22] Asymmetric Warfare Group, *Outcome-Based Training and Education (OBTE) Integration Workshop—Summary*, Asymmetric Warfare Group (Fort Meade, MD), July 2009.

after reaching a certain depth, distance, or time underground. Because most underground operations are conducted by small teams, the evacuation of even one person could compromise a mission's chance of success. Rehearsals should be conducted under the most realistic conditions possible to identify soldiers who exhibit symptoms of claustrophobia in order to minimize the risk of having to conduct an evacuation during an operation.

During the Viet Nam War, the 25th ID established a tunnel rat school at Cu Chi Base Camp. The school maintained a 500-foot underground tunnel system complete with false walls, dead ends, and booby traps.[23] In addition to developing the skills needed to conduct underground operations, the school and its underground tunnel system also worked to identify those soldiers who would be ill-suited for underground operations.

[23] Mangold and Penycate (1985), p. 139

CHAPTER 4:
HAZARDS, TREATMENT, AND RESCUE

Whether entering a subterranean system in a permissive or non-permissive environment, there are hazards present underground that can expose personnel to risks that are immediately dangerous to life and health.

Structural Considerations

Soil is very heavy. A cubic foot of soil weighs approximately 100 pounds, and a cubic yard can weigh as much as 2,700 pounds. In a collapse, the human body is not strong enough to support these loads. As such, before entering a subterranean system, and throughout the operation, personnel should be alert for problems with the structural integrity of the system. This is especially true in combat situations where explosions or fire may have undermined the support structure. Indicators of structural problems may include:

- Newly formed cracks in the soil near openings
- Loose rocks or dislodged construction materials overhead
- Damaged, cracked, and dislodged shoring
- Indications of fire damage to the support structure
- Moisture lines indicating a break in the soil

When a structural hazard is identified, it should be communicated to everyone on the team. Mark it and avoid it, if possible, or remove it. When shoring is required, it should be done by a trained structural specialist who will know how to transmit or redirect collapse loads to stable ground or structurally stable elements of the system by using proper engineering techniques and shoring materials.

Air Quality

The air we breathe is a mixture of different gasses. The composition of dry air at sea level is nitrogen (78.08%), oxygen (20.95%), argon (0.93%), carbon dioxide (0.03%), and other gasses (0.01%).[24] Air composition inside subterranean systems can be such that it is dangerous. The reasons for this danger include:

- Lack of ventilation
- Air can pick up other gasses as it passes through a cave
- Settling of dangerous gasses in low areas
- Decomposition of organic matter creating methane
- Particulate matter, such as dust or ash

Bad air in subterranean environments can physically stress personnel and reduce stamina and effectiveness. Soldiers must be alert to symptoms that may indicate lack of oxygen or the presence of carbon dioxide.

> ***Note: Protective masks provide no protection against the absence of oxygen.***

Some of the most common bad air conditions are as follows:

- **Smoke:** Smoke inhalation caused by underground fires in subterranean systems can lead to a variety of hazards, including reduced oxygen levels, thermal injury to upper airways, and chemical injury from inhaling toxic gasses suspended in the smoke.
- **Oxygen:** Too much or too little oxygen both can be problems in subterranean environments. Air overly rich with oxygen creates the risk for an explosion. Oxygen deficiency, however, is more common in a subterranean

[24] Federal Emergency Management Agency (FEMA), *Urban Search and Rescue Response System, Task Force Medical Team Training Manual*, FEMA (Washington, DC), April 2007.

environment. Whenever the atmosphere contains 19.5% oxygen or less, it is considered oxygen deficient (21% is normal). At 17% oxygen levels, personnel may begin panting, and at 15%, personnel will become dizzy and experience headaches. At lower levels, 9% and 6%, personnel will become unconscious and/or die.

- **Carbon Monoxide:** An odorless, colorless, and tasteless gas, carbon monoxide accumulates in low areas and displaces oxygen. Carbon monoxide is the byproduct of fire and will occur naturally in any environment where there is fire. It also is produced by the exhaust from vehicles and generator equipment. It can react with blood to prevent the transfer of oxygen. Symptoms of dangerous levels of carbon monoxide are headaches and dizziness, but high doses can be fatal.
- **Carbon Dioxide:** Carbon dioxide gas also is colorless and odorless. It enters caves and displaces oxygen in a variety of ways. It can be absorbed then released by water as it passes through soil with high concentrations of carbon dioxide, it can be generated as a result of breathing by people or animal life in the cave, or it can settle in areas without ventilation because it is heavier than oxygen. The presence of carbon dioxide is dangerous. Even low levels in the atmosphere (less than 1%) will cause lack of focus, loss of energy, weakness, and anxiety. High levels (concentrations of 10–15%) for only a few minutes will lead to unconsciousness and suffocation, while higher levels will cause death within 1 minute.
- **Hydrogen Sulfide:** Hydrogen sulfide gas is colorless but has the odor of rotten eggs. It reacts with enzymes in the bloodstream to inhibit respiration. High concentrations can shut down a person's lungs. Lower concentrations cause burning of the respiratory tract and burning of the eyes.

- **Methane (natural gas):** Methane is colorless, odorless, and can cause asphyxiation. Methane, which is both flammable and explosive, is produced naturally through the decomposition of organic wastes in low-oxygen environments, such as sewers and tunnel systems.

Adequate ventilation will prevent most gasses associated with bad air from reaching dangerous concentrations. Although mechanical means for ventilating subterranean systems may not be available, measures can be taken to reduce or avoid the risk, such as the following:

- Do not block/cover subterranean openings
- Point vehicle exhausts away from openings
- If working in a confined space, monitor each other for symptoms of exposure to bad air
- Extinguish fires
- Use caution when opening/entering sealed areas

Air monitors that can detect the presence of toxic gasses in the atmosphere exist and are in wide use in industry and by fire and rescue organizations. There are lightweight models that, after training, are relatively simple to operate and maintain. Plans for incorporating air-monitoring equipment into the unit's subterranean warfare SOPs should include procedures for training, maintenance, and calibration.

Unexploded Ordnance (UXO)

Recovery of UXO to the surface is time consuming. Safety must override unnecessary haste or convenience.

- Upon discovery of a cache, security must be maintained, and render-safe procedures should be conducted by qualified explosive ordnance disposal (EOD) personnel. Underground caches should be exploited using standard site-exploitation procedures. Recovery

of munitions will be determined by the onsite commander and EOD personnel.

- When the cache does not contain any exploitable intelligence items, recovery of bulk UXO to the surface may require significant time and effort. Options available are blow in place (BIP) or structural collapse of the cache. If BIP is the method to be used, serious precautions must be taken. Analyze all available information, net explosive weight of the ordnance, location of local nationals, minimum safe distance, risk of sympathetic detonation of undetected UXO, fragmentary hazard from subsurface ground burst, and the potential effect of a blast on the local water supply and water contamination.
- Recovered munitions must be rendered safe and placed in a container for transport to the surface. Team members should move out of the well opening when UXO is being extracted to protect against vertical (drop hazard) impact detonation. Layout and subsequent removal of UXO from the cache should be supervised by EOD personnel. UXO can be removed from the cache with duffle bags, sling nets, sturdy boxes, and backpacks. Site-exploitation procedures should be conducted on the surface to verify that all munitions have been removed, have been accounted for, and have exploitable value.

Medical Considerations

Common injuries caused by explosions and collapse that may be encountered in subterranean systems include fractures/lacerations, multiple traumas, closed head injury, hypothermia, and dehydration. In addition to these injuries, there are injuries common to victims of collapsed structure that are uncommon to routine medical emergency situations, as follows:[25]

[25] FEMA (2007).

- **Dust Impaction Injury:** Collapses and explosions can create huge amounts of dust, which can obstruct airways, especially when victims are dehydrated.
- **Compartment Syndrome:** In compartment syndrome, swelling inside a fascial compartment in the body compresses nerves and blood vessels, impairing the blood supply. Without prompt medical treatment, compartment syndrome may lead to nerve damage and muscle death.
- **Crush Syndrome:** Crush syndrome occurs when a victim has sustained a prolonged compressive force on a muscle mass. When an injured person is trapped by debris or a heavy weight, their tissue becomes compressed. The resulting lack of blood flow causes cells to die, creating toxins. When the weight is removed, the toxins rush into the bloodstream. If untreated, the toxins can cause cardiac arrhythmia, kidney failure, and death. These toxins are why victims who are trapped by debris may appear to be in stable condition but when freed quickly deteriorate and die.
- **Prolonged Untreated Trauma:** Common trauma injuries that have had time to progress result in problems that require adaptations because of the circumstances.

Hearing Loss

Blast waves from weapon discharges and explosions can cause tympanic membrane (TM) perforations (eardrum rupture). This risk is increased in the canalized space of subterranean environments. Although earplugs are effective in reducing the risk of TM rupture, the need to hear quietly spoken instruction or enemy movement is critical. Non-linear hearing protection enables soldiers to hear verbal communications while mitigating the risk of TM perforation from blast waves.

Shown in Figure 9, Combat Arms earplugs are an example of non-linear hearing protection available to soldiers. There also are

Figure 9. Combat Arms earplugs. NSN: 6515-01-466-2710.

more sophisticated products available, albeit at greater cost, that enable radio communications while still providing hearing protection and allowing ambient listening. Some of these systems enable amplification of low-level sounds, such as voice communication, to provide better hearing than the naked ear, while still protecting the eardrums from perforation.

Rescue Operations

Conducting rescue operations in subterranean environments presents challenges that are sometimes different from rescue operations above ground. Although the medical approach to patient treatment remains the same, the operational environment can present circumstances that may be unfamiliar to rescue personnel. These challenges include difficult evacuation routes, administering first aid in confined spaces, and structural and material hazards.

Medical Care Problems: In addition to the medical conditions described previously, medical problems confronting personnel attempting to treat soldiers in subterranean environments include:

- Inherent delays in reaching injured personnel, especially when trapped
- Progression in trauma and medical problems beyond normal caused by delays in evacuation
- Inability to quickly evacuate patients because of their location or because they may be trapped

Medical Objectives: The objectives of medical care in a subterranean environment are as follows.

- Increased survivability by prompt stabilization
- Expedited extraction by providing:
  - Stabilization of vital signs, allowing more time for extraction
  - Immobilization of fractures
  - Pain control
  - Patient cooperation through reassurance
- Knowledge of specialized extrication techniques
- Communication with treatment specialists on anatomic and physiological issues
- Efficient preparation of injured personnel for handover

Vertical Evacuations: SKED® litters (Figure 10) are common equipment in most units and, with some exceptions, have great capabilities. The SKED® litter is effective for packaging a patient

Figure 10. The SKED® Basic Rescue System is designed to provide confined-space, high-angle, or technical rescues and has traditional land-based applications. NSN: 6530-01-260-1222.

for vertical evacuation. In subterranean operations, the vertical evacuation may be from a cliff face in front of a cave or a vertical shaft into a tunnel complex. Because the SKED® litter does not provide cervical-spine immobilization, a backboard should be used with the litter for vertical evacuations.[26]

[26] Asymmetric Warfare Group, *Mountain Warfare Handbook* (2008), pp. 5-12–5-13.

APPENDIX A:
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Note: Please visit the AWG portal through the Army Knowledge Online (AKO) portal at https://awg.army.mil to review all AWG products and to subscribe to the AWG New Product Subscription Service. The system will send you an e-mail to notify you when a new unclassified AWG product is available on the AWG portal.

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5. Click on the type of product you are looking for
6. Click on your required products

APPENDIX B:
ACRONYMS AND ABBREVIATIONS

AAF	Anti-Afghan Forces
AI	Area of Interest
AKO	Army Knowledge Online
AWG	Asymmetric Warfare Group
BCT	Brigade Combat Team
BIP	Blow in Place
CIB	Controlled Image Base
CoIST	Company Intelligence Support Team
CPL	Corporal
DEA	Drug Enforcement Agency
DMZ	Demilitarized Zone
EOD	Explosive Ordnance Disposal
F3EAD	Find, Fix, Finish, Exploit, Analyze, and Disseminate
FM	Field Manual
GPS	Global Positioning System
ICE	Immigration and Customs Enforcement
ID	Infantry Division
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
ISR	Intelligence, Surveillance, and Reconnaissance
METT-TC	Mission, Enemy, Terrain and weather, Troops available, Time available, and Civilian considerations

MOUT	Military Operations in Urban Terrain
NSN	National Stock Number
NVG	Night-Vision Goggles
OBTE	Outcome-Based Training and Education
PAVN	People's Army of Viet Nam
SOP	Standard Operating Procedure
TM	Tympanic Membrane
TQ	Tactical Questioning
TTP	Tactic, Technique, and Procedure
UXO	Unexploded Ordnance

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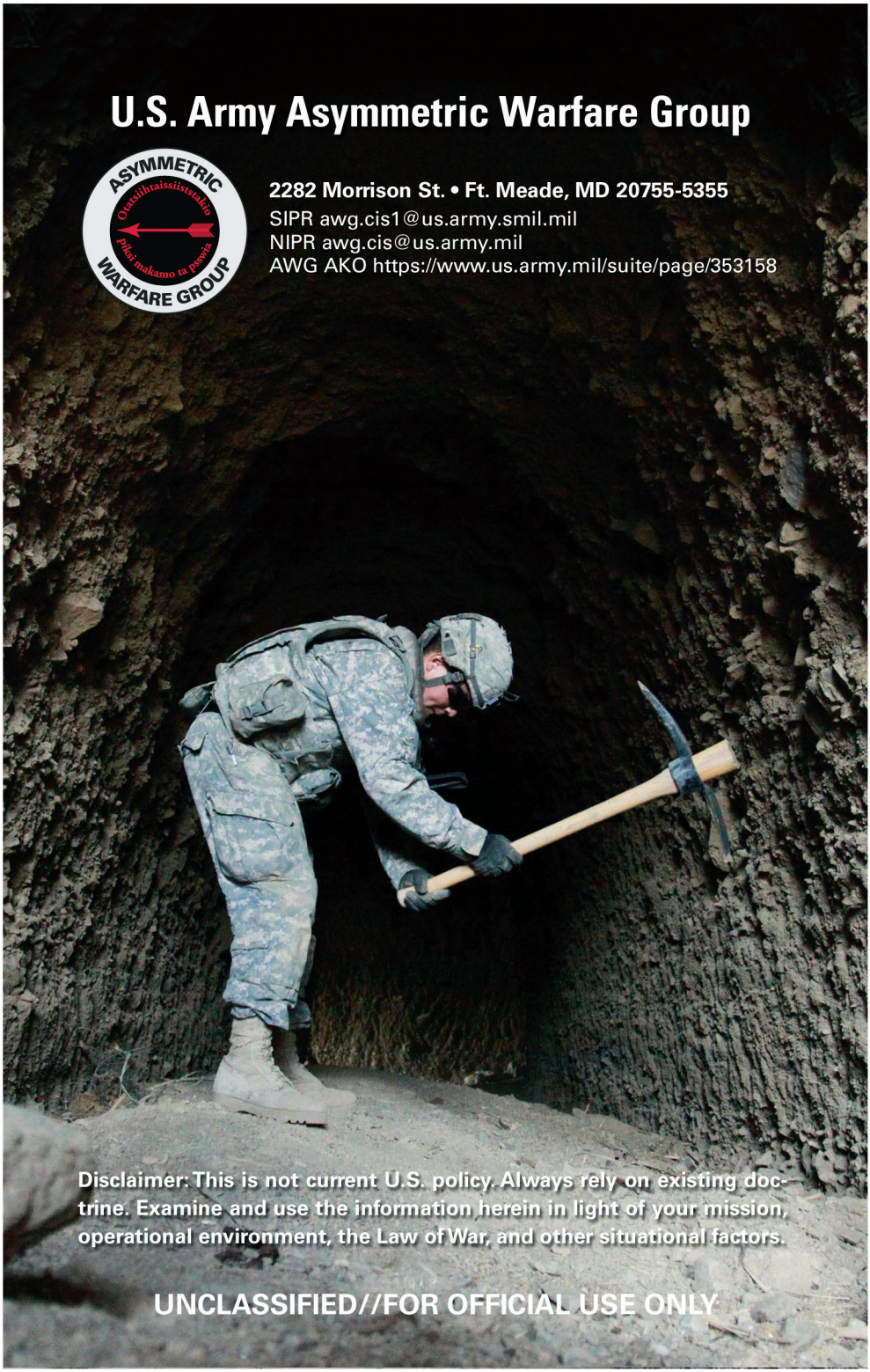

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