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**NAVAL
POSTGRADUATE
SCHOOL**

MONTEREY, CALIFORNIA

THESIS

**THE ENEMY BELOW: PREPARING GROUND FORCES
FOR SUBTERRANEAN WARFARE**

by

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December 2013

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13. ABSTRACT (maximum 200 words) This capstone project analyses subterranean threats in the contemporary operational environment. It identifies the doctrinal gap in the U.S. military regarding operations within tunnels, urban and natural cavities, and other underground facilities, and outlines the changes necessary to prepare ground forces to operate in these complex environments. This paper reviews historical cases spanning back over half a millennium, proposes a new typological classification system, and investigates the subterranean environment in terms of the United States Army doctrine, organization, training, matériel, leadership and education, personnel, and facilities process. Additionally, it provides analysis geared toward countering subterranean threats through indirect means to include: incendiary weapons, cyber-based attacks, and military information support operations. The capstone finds that: 1) Current U.S. military doctrine does not properly prepare units for operations in subterranean environments; 2) Future conflicts will require general purpose forces to deal with subterranean threats; and 3) Understanding the use of indirect approaches is critical in the conduct of subterranean operations. This research leads to the recommendation that the Training and Doctrine Command Intelligence Support Activity recognize "subterranean" as an operational environment. Additionally, this capstone provides guidance to commanders and staffs to assist in pre-mission training even before the doctrinal gap is filled.				
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**THE ENEMY BELOW: PREPARING GROUND FORCES FOR SUBTERRANEAN
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ABSTRACT

This capstone project analyses subterranean threats in the contemporary operational environment. It identifies the doctrinal gap in the U.S. military regarding operations within tunnels, urban and natural cavities, and other underground facilities, and outlines the changes necessary to prepare ground forces to operate in these complex environments. This paper reviews historical cases spanning back over half a millennium, proposes a new typological classification system, and investigates the subterranean environment in terms of the United States Army doctrine, organization, training, matériel, leadership and education, personnel, and facilities process. Additionally, it provides analysis geared toward countering subterranean threats through indirect means to include: incendiary weapons, cyber-based attacks, and military information support operations. The capstone finds that: 1) Current U.S. military doctrine does not properly prepare units for operations in subterranean environments; 2) Future conflicts will require general purpose forces to deal with subterranean threats; and 3) Understanding the use of indirect approaches is critical in the conduct of subterranean operations. This research leads to the recommendation that the Training and Doctrine Command Intelligence Support Activity recognize “subterranean” as an operational environment. Additionally, this capstone provides guidance to commanders and staffs to assist in pre-mission training even before the doctrinal gap is filled.

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LIST OF ACRONYMS AND ABBREVIATIONS

AWG	Asymmetric Warfare Group
AO	area of operation
BG	brigadier general
C ³ I	command, control, communications, and intelligence
CARVER	criticality, accessibility, recuperability, vulnerability, effect and recognizability
CBRN	chemical, biological, radiological, and nuclear
COE	contemporary operational environment
CONUS	Continental U.S.
CORE Lab	common operational research environment
COTS	commercial-off-the-shelf
CSA	Confederate States of America
CTC	combat training center
DIA	Defense Intelligence Agency
DOTMLPF	doctrine, organization, training, matériel, leadership and education, personnel, and facilities
DTRA	Defense Threat Reduction Agency
DUG	deep underground facility
ENVG	enhanced night vision goggle
FDNY	New York Fire Department
FEAF	U.S. Far East Air Force
FOE	future operational environment
GPF	general purpose forces
GWOT	Global War on Terrorism
HDBT	hardened deeply buried target
HTRAC	Hard Target Research and Analysis Center
HUMINT	human intelligence
IAEA	International Atomic Energy Agency
IED	improvised explosive devices
IMINT	imagery intelligence

IPOE	intelligence preparation of the operational environment
IR	infra-red
ISR	intelligence, surveillance, and reconnaissance
JTTR	joint tunnel testing range
LOS	line of sight
LTC	lieutenant colonel
LTG	lieutenant general
MASINT	measurement and signature intelligence
METT-TC	mission, enemy, time, terrain, troops available, and civilian considerations
MG	major general
MILDEC	military deception
MISO	military information support operations
MIST	military information support teams
MOPP	mission oriented protective Posture
MUTC	Muscatatuck Urban Training Center
MWD	military working dogs
NBC	nuclear, biological, or chemical
OIL	observations, insights, and lessons
OCO	overseas contingency operations
OPFOR	opposing forces
OPSEC	operational security
PLC	program logic control
POL	petroleum, oil, and lubricants
PPE	personal protective equipment
RF	radio frequency
SCBA	self-contained breathing apparatus
SMU	special mission unit
SOF	Special Operations Forces
SPV	single point of vulnerability
SWG	Subterranean Working Group
TBM	tunnel-boring machine

TCO	trans-national criminal organization
TRADOC	U.S Army Training and Doctrine Command
TRISA	training and doctrine command intelligence support activity
TTP	tactics, techniques and procedures
UFAC	Underground Facility Analysis Center
UGF	underground facility
UGS	shallow underground facility
USSOCOM	U.S. Special Operations Command
VC	Viet Cong
VEO	violent extremist organization
WSMR	White Sands Missile Range
WMD	weapons of mass destruction
WSMR	White Sands Missile Range
WWI	World War I
WWII	World War II

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EXECUTIVE SUMMARY

The Subterranean Working Group (SWG) Capstone represents a combined effort with the Naval Postgraduate School Defense Analysis Department and the Asymmetric Warfare Group (AWG). The result of this effort is an analysis of subterranean threats in the contemporary operational environment (COE) and a description of what actions must be taken to prepare ground forces to operate underground. More importantly, this project has created a subterranean lexicon which ranges from the most rudimentary tunnels to deeply buried hardened facilities. With this lexicon, the Subterranean Working Group has created a tool that can assist commanders in planning and executing subterranean operations. Proliferation of subterranean structures continues unabated among those with hostile intentions, including rogue states and criminal, insurgent, and terrorist networks. The most modern underground facilities, incorporate design features that make them essentially impervious to air or missile attack. Currently, ground-assault options are limited to small special operations forces (SOF) contingents. This research suggests that general purpose forces (GPF) solutions may prove necessary to meet these threats.

The Military Problem

The current courses of action for defeating subterranean threats are insufficient. Techniques, tactics, and procedures (TTP) for U.S. forces encountering urban and natural cavities and tunnels are developed ad hoc. However, such responses lack efficiency and require soldiers to assume unnecessary risks. These risks cannot be effectively mitigated unless U.S. forces have conducted training in subterranean operations. The current course of action for the defeat of underground facilities (UGF) is the use of earth-penetrating munitions and, possibly, tactical nuclear weapons. However, deep penetrating munitions will not destroy some reinforced UGF and the use of nuclear weapons is simply not politically or morally feasible. Thus, ground forces must be prepared to conduct operations in a subterranean environment.

Doctrinal Gap

The Department of Defense provides training, doctrinal, organizational and matériel support to U.S. forces conducting operations in jungle, mountainous, and urban environments. However, few resources address the subterranean threat. The Asymmetric Warfare Group (AWG) has published a handbook for subterranean warfare that focuses on the tactical level in terms of tactics, techniques, and procedures (TTP) and safety considerations. This capstone seeks to provide an analysis of historical cases ranging from the fall of Constantinople in the 15th century to the modern era, proposes a new typological classification system, and investigates the subterranean environment in terms of the United States Department of Defense doctrine, organization, training, matériel, leadership and education, personnel, facilities, (DOTMLPF) process.

Typology

To create a subterranean typology and classification the Subterranean Working Group (SWG) conducted case studies of:

- The Siege of Constantinople (1453)
- The Siege of Petersburg during the American Civil War (1864)
- The Mining of Messines Ridge during WWI (1917)
- The Battle of Okinawa during WWII (1945)
- Vietnam War Tunnel Warfare (1966)

Additionally, the SWG participated in fieldwork facilitated by NPS, AWG, the Defense Intelligence Agency (DIA), the Underground Facility Analysis Center (UFAC) Fire Department New York, and the Colorado School of Mines at the following locations:

- Edgar Experimental Mine, CO
- Long Island Rail Road East Side Access Grand Central Station, New York City, NY
- Cu Chi, Long Phoc, and Vinh Moc tunnels, Vietnam
- White Sands Missile Range (WSMR), NM
- Manzano Mountain Underground Facility, Kirkland AFB, NM
- Raven Rock Military Complex, PA
- Iron Mountain Data Storage Facility, PA

With an information gathered from the case studies and fieldwork, the SWG was able to create a typology that encompasses all forms of subterranean environments (see Figure 1):

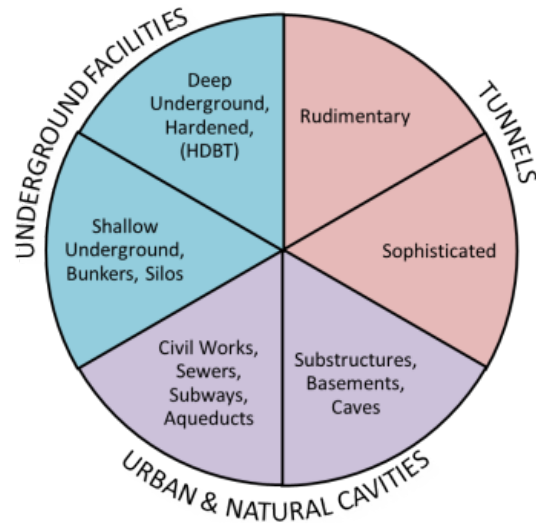


Figure 1. Subterranean Typology

A classification methodology was also created that will enable ground elements and military planners to understand what information is critical to underground operations. The coding system and graphical symbol proposed will enable commanders and staffs to plan subterranean operations effectively within their areas of operation.

Subterranean Targeting Attributes

Within subterranean physical structures, targeting attributes have been identified to assist commanders and staff in identifying intelligence and operational gaps. The fact that the tool can be applied to all case studies and current subterranean threats shows the flexibility of this typology and classification methodology. This system recognizes the multitude of subterranean systems. It also permits leaders at the strategic, operational, and tactical level to use the same planning tool with the same terminology mitigating confusion at all levels of the fight. By understanding the types of subterranean

environments and identifying targeting attributes, leaders and planners will be made aware of the multiple challenges that could be faced underground. These targeting attributes are represented in Figure 2.

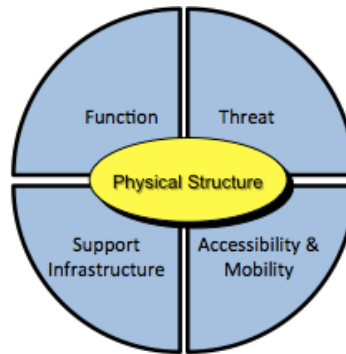


Figure 2. Subterranean Targeting Attributes

Incendiary Weapons, Cyber-Based Attacks, and Military Information Support Operations

This capstone also provides examples in countering subterranean threats with non-traditional means including incendiary weapons, cyber-based attacks, and military information support operations (MISO).

The case studies show that incendiary weapons have been effective in the tunnels and underground facilities (UGFs) of Constantinople, Turkey; Okinawa, Japan; and Vietnam. Incendiary weapons are a simple, cost effective means of combating underground threats and cause immediate psychological and physical damage. Due to the irresponsible use of incendiary weapons in the past, a normative taboo has formed against this effective enabler. This capstone explains how the taboo is hindering U.S. forces conducting operations against subterranean threats. Ground forces conducting underground operations should receive proper training on the effects of incendiary weapons, when they should be used, and how they should be used.

A cyber-based attack, as shown in the Stuxnet incident, is a valid option against UGFs. This form of attack limits exposure and risk to ground forces. Cyber-based attacks have mitigated other underground threats in the past. Given the lack of training in

and doctrine for subterranean operations, electronic warfare should be further explored and incorporated to fill this gap.

Military information support operations (MISO) have historically been successful against subterranean threats. Psychological operations can be applied to all types of underground environments. If shown to be viable, MISO can influence the audience through themes, messages, and actions such as contaminated air supply, structure collapse, food/supply shortage, fire/smoke inhalation, flooding, tunnel remediation, social media, and local populace engagement. Military information support operations (MISO) can assist U.S. forces in shaping the information environment in order to persuade, change, or influence the behaviors of those associated with a subterranean threat.

Conclusion

This capstone finds that:

- Current U.S. military doctrine does not properly prepare units for operations in a subterranean environment
- Future conflicts will require GPF to deal with subterranean threats
- Understanding the use of indirect approaches is critical when conducting subterranean operations.

This research leads to the recommendation that the U.S. Army Training and Doctrine Command Intelligence Support Activity (TRISA) recognize “subterranean” as an operational environment. Additionally, this capstone provides guidance to commanders and staffs to assist in pre-mission training until the doctrinal gap is filled. In recent conflicts, wherever U.S. forces have overwhelming combat power, their adversaries strive to force fighting on a primitive level. The subterranean environment offers enemies a cost-effective safe haven for protecting themselves and their sensitive equipment. By empowering ground forces with the proper understanding, training, and personal protective equipment (PPE) to operate underground, the overall risk to our forces is lowered and our ability to operate in asymmetric environments is increased.

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I. INTRODUCTION

A. BACKGROUND

Historic and current intelligence shows both a persistent and an immediate subterranean threat to the U.S. and its allies. However, little has been done in terms of official doctrine for operations within subterranean environments. Furthermore, there has been little research conducted to increase the survivability of forces when operating in these complex environments. As seen in the past, the use of subterranean environments provides a cheap and effective form of maneuver, concealment, and protection. Historical examples of subterranean warfare include: the Siege of Petersburg, Virginia during the American Civil War; the Battle of Messines during World War I; multiple tunnel, cave, and trench battles in Okinawa, Japan during World War II; and the Cu Chi Tunnels in Vietnam. Subterranean warfare has played a significant role in each of these conflicts. In the contemporary operational environment (COE), subterranean warfare is used by non-state actors in Israel, Afghanistan, and in countries of Central America, to circumvent international borders, defeat force protection barriers, and move without detection despite advanced intelligence, surveillance, and reconnaissance (ISR) systems. Subterranean systems are also used by many state actors. These systems range from subway transportation to military underground facilities (UGFs) housing strategic level infrastructure and sensitive munitions.

Even though large amounts of national resources and intelligence collection are invested in munitions with the purpose of penetrating and destroying subterranean systems, limitations on their use requires a reassessment of the methods used to prepare Special Operations Forces (SOF) and general purpose forces (GPF) to operate in the subterranean domain. Historical analysis has shown that adversaries in the future operational environment (FOE) will likely use subterranean systems to protect personnel and equipment and that they may include weapons of mass destruction (WMD). In order to fill the operational gap, U.S. ground forces must be prepared to operate within subterranean environments.

B. DESCRIBING THE PROBLEM

The purpose of this project is to conduct an analysis of subterranean threats in the COE, and describe the changes necessary to prepare ground forces to operate in this unique environment. Subterranean warfare has significantly impacted warfare in the past and will continue to do so in the future. Historical cases studies will illustrate a trend in the use of subterranean environments in warfare and illuminate subterranean warfare as a problem set that cannot be avoided by ground forces in the COE and FOE.

This project seeks to explore a doctrinal gap in the U.S. military regarding operations within underground tunnels and deeply buried hardened facilities. Despite the fact that the U.S. military has fought in subterranean environments since prior to the American Civil War, currently no military doctrine exists that identifies “subterranean” as a unique operational environment, apart from being subsumed as a minor component of the urban environment. However, the U.S. ground forces organized, trained, and equipped for urban environments are not prepared for the unique challenges of underground engagements. Increasingly, more adversaries are turning to the underground in order to minimize U.S. air power and ISR effectiveness. The purpose of this capstone project is to create awareness of this complex problem-set in order for the U.S. Army Training and Doctrine Command (TRADOC) intelligence support activity to recognize “subterranean” as a unique operational environment.

C. SCOPE OF RESEARCH

The primary scope of this research is to define subterranean as an operational environment. Present U.S. Army doctrine designates urban, mountain, desert and jungle as unique environments, while subterranean has not been given such a distinction. As a consequence, any semblance of doctrine relating to subterranean warfare is fragmented across many publications. An analysis of military history can illustrate a pattern of subterranean warfare during some of the most significant military conflicts and can show it emerging with renewed importance today. The group’s research assumes that when ground forces encounter subterranean environments, commanders will direct soldiers to secure, clear, defeat or destroy the underground site. Not doing so could provide the

enemy a safe haven and potentially enable the enemy to operate rear of friendly lines. Such an advantage acquired by the enemy cannot be discounted if a military force is to achieve success. Through understanding historical patterns more fully, and by placing such historical analysis in a sound theoretical framework, contemporary military leaders will be able to anticipate and plan for the subterranean problem-set.

This project focuses on subterranean operations in three areas of emphasis: typological classification, empirical case studies, and a doctrine, organization, training, matériel, leadership and education, personnel, and facilities (DOTMLPF) analysis. These tasks were chosen according to the following logic. First, the task of creating a typology is an effort to create the relevant conceptual space for the problem. This typology is an improvement on existing efforts as it centers on the operationally relevant aspects of subterranean structures, threats, and conditions. Second, the empirical case studies have been chosen to refine the typology and deduce additional factors or aspects of subterranean operations that may have been omitted from previous studies. Finally, investigation of the DOTMLPF implications of the analysis serves to ground the theoretical and historical aspects of the work firmly in the service of current and future operations.

D. RESEARCH QUESTIONS

How should U.S. ground forces prepare to deal with the increasing use of subterranean environments by state and non-state actors within the contemporary operational environment?

Following the end of the Cold War, enemies of the U.S. have recognized that they must counter military and technological might with unconventional tactics. In order to counter U.S. air and space dominance, and the technical capabilities of ISR, today's opponents are reverting to the underground.

Non-state actors such as trans-national criminal organizations (TCOs), and violent extremist organizations (VEOs), have made significant use of rudimentary tunnels to

move men, weapons, and equipment across international borders. Subverting a nation's ability to control its borders directly holds sovereignty at risk and creates irregular challenges for defense forces.

State actors attempting to conceal and protect military capabilities are doing so by placing them underground, and in some cases, beyond the projected capabilities of kinetic air strikes. Weapons of mass destruction (WMD) have long been used as a deterrent against state aggression. The international community seems to have accepted the status quo on current proliferation and regularly engages in efforts to reduce stockpiles and counter any further acquisitions. States that feel an unequal balance in deterrence capability, however, can choose to undermine counter-proliferation efforts by building storage and production facilities deep underground where detection, surveillance, and destruction are difficult.

This project is designed to address the anticipated challenges faced by ground forces as they prepare to engage in subterranean environments where threats are provided protection from air or missile attack. The project will establish a common typology of subterranean uses by military and paramilitary forces in order to address unique challenges. Pertinent historical cases of subterranean warfare will be explored with reference to the necessity of preparing for this style of combat. Current military doctrine will be analyzed to evaluate the sufficiency of planning and guidelines as they relate to subterranean environments. Recommendations will be made for changes in the way current ground forces organize, train, and equip for combat where subterranean environments are expected to be encountered. Finally, the project will address the use of incendiary weapons and information dominance operations as unique methods that may be used with significant effects against subterranean targets.

II. METHODOLOGY

A. LITERATURE REVIEW

An array of thought exists regarding subterranean environments on best practices for mitigating the underground threat. The principle contributing organizations upon which this capstone focused include academia, the Department of Homeland Security, and the Department of Defense. Despite differing methodologies and purposes, the following positions were consistent among all literature referred to.

1. Doctrinal Void for General Purpose Forces

The Defense Intelligence Agency's *Lexicon of Hardened Structure Definitions and Terms* is a comprehensive and useful document. The target audience for countering subterranean threats however is limited to the U.S. kinetic air strike community. Likewise, the doctrine-producing arm for the U.S. Army (TRADOC) is also limited to a minimal solution utilizing ground forces. Aside from being abbreviated in its planning nature, the content within FM 90-8 *Counter guerrilla Operations*, FM 90-10 *Urban Operations*, and FM 90-10-1 *An Infantryman's Guide to Combat in Built-Up Areas* is fundamentally out of date in regards to today's COE.

2. Historical Trajectory of Subterranean Threats

Past adversaries, in conventional, irregular, and total war have used underground structures for various activities that have grown in complexity over time. The group researched five hand-selected case studies that not only followed this trend, but also incorporated the full spectrum of the typology seen today. The proliferation of the underground phenomenon was explored in chronological order, starting with subterranean warfare at Constantinople in 1453, followed by the siege of Petersburg in the American Civil War and the Flanders Campaign in the First World War, the battle of Okinawa in the Second World War, and finishing with the Tunnels of Cu Chi in the Vietnam conflict. Research shows this trend of underground threats seems to be growing in the present operational environment.

3. Non-standard Approaches Have Value

Non-standard approaches such as the use of fire and smoke have had immense value towards combating subterranean threats for centuries. The battle of Constantinople was among the first recorded subterranean warfare events that captured the value of fire and smoke in a confined environment when the Ottomans used it against the Byzantines. Centuries later such approaches proved useful yet again, this time for Soviet forces in their fight against the Mujahedeen, annotated in *Underground Combat, Stereophonic Blasting, Tunnel Rats, and the Soviet-Afghan War* and AWG's *Subterranean Warfare Handbook*. While fire and smoke remain relevant today, newer indirect approaches such as cyber-based attacks and MISO are also impacting the battlefield.

B. ARGUMENTS

1. Current U.S. Military Doctrine Does Not Properly Prepare Units for Operations in Subterranean Environments

Currently, the U.S. military does not possess adequate doctrine addressing effective operation in a subterranean environment. All current field manuals and/or joint publications address the subterranean environment as an additional factor, such as sewers and basements, to consider while operating in an urban environment. The subterranean environment that exists as part of the urban operational environment does not adequately encompass the level of planning needed when considering all the possible subterranean threats used by today's adversaries. From a mission planning perspective, much of the tactical considerations regarding the subterranean environment are scattered across several manuals. Some major subterranean concerns that are not addressed in current manuals are: command and control, communications, movement techniques, navigation, vulnerabilities of a tunnel above/below ground and environmental factors that hinder soldiers underground. These factors will be a primary focus for current U.S. adversaries that are increasing their use of underground facilities.

Current and historical doctrine does address rudimentary tunnels and urban cavities. However, it does not consider structures that are larger, deeper, more complex and reinforced. Military planning considerations need to be updated to address the

current threat as well as to update technological advances and capabilities that should increase the survivability of U.S. troops. Failure to do so will jeopardize future operations and the lives of soldiers forced to operate underground.

2. Future Conflicts Will Require General Purpose Forces to Deal With Subterranean Threats

The global proliferation of underground tunnels and facilities has grown far beyond the capabilities of air power and special mission units (SMUs) to effectively succeed alone. This is especially true, given the small percentage of the SMU community trained in the complexities associated with UGFs and Counter-WMD scenarios. This is not to say that a GPF unit could not clear an underground structure today. It has been learned from more than 11 years of fighting the Global War on Terrorism (GWOT), and Overseas Contingency Operations (OCO), that units have encountered and achieved much success utilizing varying techniques and procedures against underground enemies. As early as the American Civil War, GPF units used intrinsic capabilities when encountering such structures based on individual soldier backgrounds and experiences. Unfortunately, following the Vietnam conflict, observations, insights, and lessons (OIL) regarding subterranean warfare were not effectively captured or recorded for future generations. All GPF units need to be provided with education and training, in the form of a more comprehensive Army doctrine and training publication, which defines subterranean as its own operational environment. This is not to say that GPF units need to restructure their missions or organizations since the COE has seen enemy forces continuing to seek subterranean environments as a means to limit U.S. kinetic capabilities and ISR platforms. The SMUs simply do not have the manpower to engage every subterranean threat. In order to discourage the proliferation of subterranean threats, unilateral capabilities and preparedness within GPF and SOF must be increased.

3. Understanding the Use of Indirect Approaches is Critical in the Conduct of Subterranean Operations

In some situations, the risk of ground forces entering a subterranean system may be too great. Indirect approaches like incendiary weapons, cyber-based attacks, and MISO can assist in lowering risk and possibly defeating a subterranean threat. A better understanding of these topics could provide commanders and staffs with a variety of options for “prepping” an underground target.

Historically, incendiary weapons have been effective against underground enemy positions. Specifically, during the Siege of Constantinople in 1453, in World War II, and the Vietnam War, these weapons were documented as having positive results. There are no national or international laws that prevent U.S. forces from using incendiary weapons against confirmed enemy forces and facilities. However, due to irresponsible use during previous wars and conflicts, leaders are hesitant to move past the normative taboos that accompany incendiary weapons. Considering the extreme danger and complexity of operating underground, the use of incendiary weapons should be reconsidered. Once deemed necessary by decision makers, incendiary weapons employed in a subterranean environment are lethal. Extreme heat compromises the structural integrity of a facility and can cause collapse. Fire may also cause catastrophic damage to the infrastructure of a facility as well by impacting ventilation, power, and water. Bi-products of incendiary weapons, smoke and particulates, also can incapacitate or kill enemy occupants within the subterranean facility. Though not all subterranean operations will require the use of incendiary weapons, understanding their uses and effectiveness underground is critical in the conduct of subterranean operations.

Cyber-based attacks have also proven effective against subterranean threats. The Stuxnet virus was used in Natanz, Iran is one example that proves the valid applicability of cyber-based attacks. Open-source reports have stated that the physical damage done to the underground centrifuges set the nuclear program back approximately three years. An understanding of how cyber-based attacks can be used against subterranean targets is

crucial to combating such a threat. Due to the lack of subterranean doctrine and limited underground training, the employment of electronic warfare should be researched in order to be incorporated and fill this gap.

Military support operations are another capability that can shift the offense/defense balance. Where cyber-based attacks may only be used against subterranean systems with modern infrastructure, MISO is flexible enough to be used against both primitive and modern underground threats. These operations can be used to influence the behavior of personnel contributing to and operating within a subterranean complex. This capstone will explore a multitude of themes, messages, and actions to support this argument.

In his book, *Spec Ops Case Studies in Special Operations Warfare: Theory and Practice*, Commander of U.S. Special Operations Command (USSOCOM), Admiral William McRaven stated that relative superiority is the condition that exists when a smaller force gains a decisive advantage over a larger or well-defended enemy.¹ In the subterranean environment, the defending force has an intrinsic advantage over the attacking force. Understanding the use of indirect approaches is critical for U.S. forces to achieve the required degree of relative superiority in the conduct of subterranean operations.

C. TYPOLOGY

1. Defining the Typology

The purpose of a typological classification of subterranean environments is to evaluate what aspects are most important to the ground force commander. This involves identifying the defining attributes of subterranean structures used by both state and non-state actors and laying out the variation of, and permutations among these dimensions. A subterranean lexicon, that spans the scale from the most rudimentary tunnels to deeply buried hardened facilities, is useful for developing an understanding of vulnerabilities commanders can use prior to engaging in the subterranean environment.

¹ William H. McRaven. *Spec Ops Case Studies in Special Operations Warfare: Theory and Practice* (Monterey, CA: Presidio Press, 1996).

An explanatory typology is a multidimensional conceptual classification based on observations that allows the description of a subterranean environment likely to be encountered by ground forces. This typology acknowledges the complexity of the subterranean operational environment and seeks to consolidate the number of possible types and heterogeneity of such types into categories that may affect the operational posture of ground forces.² Using a classificatory function, empirical case studies can be inserted into this typology and evaluated as to a particular category. In addition, typological attributes can be used to create a common graphical control measure or symbol that enables commanders to quickly determine resources required to defeat threats within identified subterranean areas. The attributes associated with the subterranean environment are numerous and different audiences have different information requirements. Geologists, for example, concern themselves with types of soil and rock, weapons developers want to know the depth and construction characteristics, and intelligence analysts want to know everything else. For the ground force commander who is directed to commit lives into these unknown spaces, information requirements are more intimate. Pragmatic compression will allow linking of the many different types of underground structures into categories with similar attributes where expansion would not better serve the ground force commander.³ At this stage of research, it is important to lay out the entire breadth of the typological property space. The purpose of this style of typology, therefore, is to begin the process of evaluating what attributes constitute a particular type of underground structure, providing the commander with the knowledge of what to expect based on known characteristics.

2. Typological Attributes

The property-space of the subterranean operational environment is framed by attributes which can be measured in order to build a constructed typology. These attributes are given operational definitions and assist in building an index from which

² Kenneth D. Bailey, "Constructing Monothetic and Polythetic Typologies by the Heuristic Method," *The Sociological Quarterly* (Midwest Sociological Society), 14, no. 3 (Summer, 1973):291, last accessed August 10, 2013, <http://www.jstor.org/stable/4105680>.

³ John C. McKinney, "Typification, Typologies, and Sociological Theory," *Social Forces* 48, no. 1 (September 1969): 3, last accessed August 10, 2013, <http://jstor.org/stable/2575463>.

particular subterranean structures can be coded.⁴ The Defense Intelligence Agency (DIA) maintains a coding or categorization system of hardened structures based on physical characteristics.⁵ One drawback of this system is its limitation to hardened structures, and its use of structural elements or characteristics that would affect the behavior of earth penetrating munitions. A typology of the subterranean operational environment must consider a wider spectrum of subterranean structures and must relate to intelligence requirements of the ground forces likely to enter these areas. The subterranean typology presented here is based on five attributes: *function*, *infrastructure*, *mobility*, *threat*, and *accessibility*.

The *function* attribute is used to describe the purpose of the particular subterranean target area. Understanding the function attribute provides the commander with insight into resources required to achieve a functional defeat. Ground forces do not typically have the resources to achieve a structural defeat of a subterranean target area, thus focus should remain on functional defeat. Functions within the subterranean environment include: command, control, communications, and intelligence (C³I), production, storage, and conveyance.

The *infrastructure* attribute is used to describe the support systems tied to a particular subterranean target area. Understanding the infrastructure attribute provides the commander with insight into a potential single point of vulnerability (SPV). Identifying support infrastructure may provide the ground force commander with the opportunity to achieve a functional defeat without directly targeting or entering the subterranean environment. The criticality, accessibility, recuperability, vulnerability, effect and recognizability (CARVER) matrix, a target analysis tool used by special operations forces (SOF), can be used to evaluate infrastructure elements in terms of the most efficient application of combat power. Subterranean infrastructure includes: ventilation, power supply, water supply, waste discharge, transportation, and communications.

⁴ Ibid.

⁵ Defense Intelligence Agency, *Lexicon of Hardened Structure Definitions and Terms* (UNCLAS/FOUO), Washington, DC: Defense Intelligence Agency, 2011, 85.

The *mobility* within a subterranean passage typically coincides with the largest item that can be conveyed through or housed within the functional workspace. Mobility within the subterranean environment in terms of the maneuverability of ground forces will ultimately determine the tactics employed. The specific assessment of mobility refers to the dimensions of the access portal or entrance, as well as that of the entrance tunnel or adit. The mobility attributes are defined as restricted, semi-restricted, permissive, and unrestricted. Restricted adits are characterized by their confined space that permits only the single file movement of persons in a prostrated or less than fully upright posture. Semi-restricted adits allow for the fully upright movement of persons in single file. Permissive adits allow for the fully upright movement of persons in columns of two. Unrestricted adits are large enough to support upright movement of more than a two-person column and may even support the movement of vehicles.



Figure 1. Restricted⁶

⁶ Kahili Hamra, *The Guardian* [image] <http://www.theguardian.com/world/2009/feb/10/gaza-tunnels-israel>.



Figure 2. Semi Restricted⁷



Figure 3. Permissive⁸

⁷ “IDF Fighters Go Underground for Subterranean Warfare Training,” [image], July 26, 2013, Defence Talk, <http://www.defencetalk.com/idf-fighters-go-underground-for-subterranean-warfare-training-48577/>.

⁸ “Tunnel Warfare” [image], 3 Nation Airsoft, accessed December 12 2013, <http://www.3nationsairsoft.com/page11.htm>.



Figure 4. Unrestricted⁹

The *threat* attribute characterizes the potential risk to forces entering the subterranean environment. This threat attribute may also factor into the size, composition, weapons posture, and special equipment needed to effectively operate in a particular subterranean environment. Threat characteristics within subterranean environments include environmental, personnel, and matériel. Environmental hazards include: naturally occurring gasses that affect air quality; dangerous insects, arachnids, reptiles, and other wildlife; unstable ground control; stagnant water that may release deadly gases such as hydrogen sulfide or deep water that could create a drowning hazard. Personnel hazards account for the presence of potentially hostile persons within the subterranean structure. These could include armed defense forces or non-combatants that may become hostile once encountered. Matériel hazards include those hazards artificially introduced into the environment. These can include: explosives, booby traps, and improvised explosive devices (IEDs); nuclear, biological, or chemical (NBC) storage or production equipment; fuel and other petroleum, oil, and lubricants (POL); as well as other man-made implements.

⁹ Aeroflight [image], accessed December 12, 2013, http://www.aeroflight.co.uk/waf/albania/af/pics/F-6%208-25%20CLOFTING%20IMG_0539%202.jpg.

Hardness classifications related to the subterranean environment have typically been spoken in terms of the effects of kinetic weapons. For the soldier this definition of hardened, which relates to the structural design, geology, and topography, has little use. For purposes better suited to ground force operations the attribute title of *accessibility* will be used. In order for soldiers to hold the subterranean environment which is at risk they must first be capable of gaining access to critical components. Accessibility relates to the capabilities required to breach portal entrances, gain access to critical support infrastructure, and reduce obstacles between portals and functional workspaces. An accessibility level I structure is one which requires few, none, or only simple tools used in mechanical breaching to gain access, such as a Halligan tool, grappling hooks, sledge hammers, or bolt cutters. An accessibility level II structure may contain hatches or doors that require explosive or ballistic breaching techniques. An accessibility level III structure may contain blast doors, steel gates, or security doors that require dynamic breaching including advanced cutting and extrication tools. An accessibility level IV hardened structure may be beyond the capabilities of the individual soldier and may require heavy engineer equipment or kinetic munitions to reduce exterior obstacles.

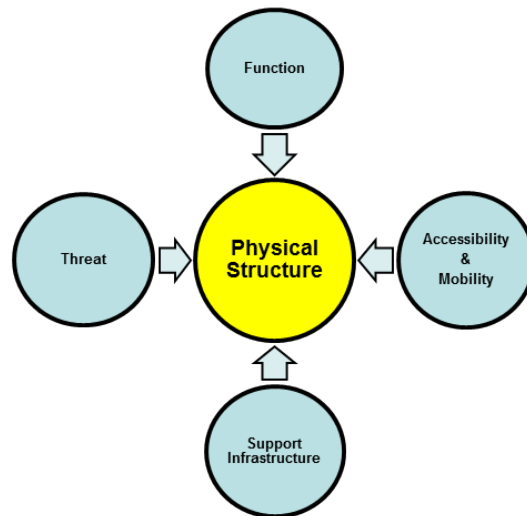


Figure 5. Subterranean Targeting Attributes

3. Categorizing Subterranean Structures

Different names are given to a wide spectrum of subterranean structures. Subterranean structures can range from a small pipe-sized cavity, used to hydraulically pass illicit material, to hardened, deeply buried targets (HDBTs) located hundreds of meters below the surface and used to store or produce WMD. The goal of this paper is to compress the characteristics of the many types of structures into a pragmatic taxonomy, enabling commanders to better understand the complexities within the subterranean operational environment. With respect to ground force operations, subterranean structures can be characterized into three primary categories with each category having two sub-categories. The three primary categories are (i) *tunnels*, (ii) *urban and natural cavities*, and (iii) *underground facilities* (UGFs). Tunnels are broken down into rudimentary and sophisticated. Urban and natural cavities are broken down into substructures (i.e., basements and caves) and civil works (i.e., sewers, subways, aqueducts). The UGFs are broken down into shallow underground facilities (UGS), and deep underground facilities (DUG).

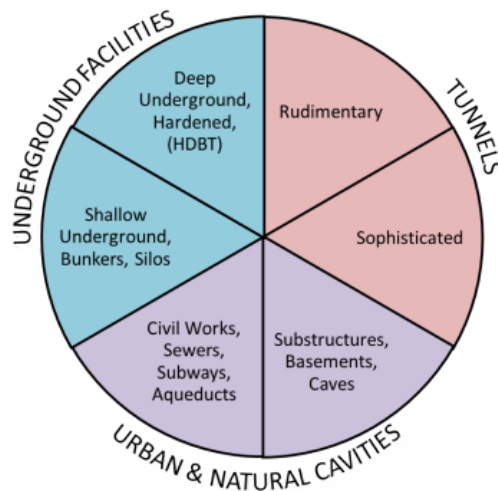


Figure 6. Subterranean Categorization

Tunnels are generally used as a means to move people and items between two or more locations. Non-state actors typically use both rudimentary and sophisticated tunnels to move personnel, supplies, and equipment without detection. Subterranean movement that circumvents state borders often supports smuggling or black market economies, as well as facilitates insurgent activities. Access portals are generally not hardened and adits can be vertical, leading down to an operationally desired depth, or horizontal, into the side of existing terrain. Although state actors have historically used rudimentary tunnels in subterranean siege warfare, today's nation states use technology and financial resources to build sophisticated tunnels to establish lasting means of conveyance or storage. Tunnels can be connected to form a complex subterranean network with multiple access portals and increased infrastructure; a higher degree of sophistication which earns the classification of UGF.

Rudimentary tunnels are typically hand-dug using mechanical and/or general purpose tools. The tunnel walls are bare and have limited or no support features or shoring to prevent structural collapse. Infrastructure is rarely installed. Instead, these tunnels rely on natural air flow for ventilation and structurally designed water removal. Such tunnels are both labor and time intensive to dig. However, they are relatively cheap and are often found in areas where a large labor force is available. In terms of typology, rudimentary tunnels generally function as storage or conveyance, have limited infrastructure, are restricted to semi-restricted in mobility, and have level I accessibility. These tunnels are generally only occupied at times when movement of persons or goods is taking place. Due to the small size and level of sophistication, contact with hostile elements is unlikely, and any resistance would be to facilitate escape. Likely threats include environmental hazards, as well as matériel hazards near access portals.

Sophisticated tunnels are typically dug using mechanical tools or larger heavy equipment. Equipment must rely on air compressors or electricity for power, unless significant ventilation is available to support the use of combustion engines. A noticeable characteristic in sophisticated tunnels is the effort placed in the shoring up of access portals and walls. The use of concrete-like material or masonry and timber to line the walls indicates a deliberate effort to maintain a lasting subterranean passage. These

tunnels are more expensive to build; however, greater distances can be achieved with that added financial investment. Sophisticated tunnels routinely have ventilation conduits and are tied to existing power supplies. Ground water removal is also either structurally engineered or drainage lines and pumps are installed. The size of sophisticated tunnels can range from semi-permissive to unrestricted. Umbilical infrastructure will likely be vulnerable and portals will likely have a level I accessibility. Because of the amount of financial investment in the construction of sophisticated tunnels, they are most likely used for conveyance of persons and goods that offer returns on the investment. Environmental hazards are still a consideration; however, they are less likely with increased levels of support infrastructure. Personnel encountered may be more prepared to engage in hostilities to protect the structure, but the small narrow passages would not support any sustained resistance. In order to protect the structure, matériel hazards such as IEDs or booby traps would likely be placed near portals to deny access.

Urban and natural cavities earn their own category particularly based on the characteristic that most have dual usage; the original structure can be adapted for military purposes. Special considerations must be taken into account with dual use facilities due the impact they may have on civilian populations. Urban and natural cavities cover a wide variety of structures, and the focus is on potential impacts on the civilian population. As such, the size of these cavities can range from restricted to unrestricted. Urban and natural cavities are not hardened in terms of special construction material or design. These subterranean spaces gain additional protection from existing above ground structures and naturally occurring overburden. In terms of accessibility, these adapted structures would likely be rated as a level I or II. The subcategories of urban and natural cavities are substructures and civil works.

Substructures consist of basements and similar subterranean spaces that are attached to an above ground structure. These basement facilities may be accessed from within the above ground structure, but may also have exterior access points and umbilical infrastructure. Spaces such as caves and caverns are naturally occurring subterranean substructures that can be adapted for military purposes. Above ground structures typically support any infrastructure such as power, environmental and life-support

systems, communications, and transportation supplied to these places. Adapted substructures can be expected to function as C³I, storage, and potentially as conveyance. Threats within urban cavities are likely to be personnel and matériel, often with added environmental threats within natural cavities.

Civil works such as sewers, subways, electrical and exhaust tunnels, and aqueducts, all support habitability in a growing urban population. Although these structures are primarily used to support a civilian population, both state and non-state actors can use these same structures to facilitate clandestine movement of high value personnel and equipment, and storage of weapons and illicit matériel. Civil work subterranean structures may be significantly large and have multiple ingress and egress points. Although these structures may appear similar to sophisticated tunnels, or have an infrastructure similar to a UGF, the significant collateral damage considerations make these structures unique in terms of how ground forces can hold threats in these areas at risk. Similar to tunnels, these areas are likely to be unoccupied unless movement activity is taking place. Caution should be used when entering civil work structures due to increased environmental hazards of water, gases, and electrical conduits.

The UGFs are characterized by their purpose-built design and construction to resist destruction by conventional and nuclear munitions. The DIA's Underground Facility Analysis Center (UFAC) and the Defense Threat Reduction Agency's (DTRA) Hard Target Research and Analysis Center (HTRAC) work in concert to identify and characterize UGF's around the world. Along with direct observations made at continental U.S. (CONUS) based operational UGFs, and research done on Cold War Era UGFs, DIA's *Lexicon of Hardened Structure Definitions and Terms* provides most of the needed understanding of what constitutes a UGF. The primary difference between a UGS and a DUG is the level of overburden between the ground surface and the UGF mission space. The DIA distinguishes DUGs as having 20 meters or more of overburden between the mission space and the ground surface.¹⁰ Anything less would be considered a shallow UGF or UGS. For the soldier, the particular depth of a UGF is of less concern

¹⁰ Ibid., 15.

than the physical characteristics which may present a functional defeat option or access vulnerability.

The DIA identifies four types of shallow underground hardened structures: shallow underground bunker, basement bunker, missile silo, and tunnel.¹¹ Again, the DIA's focus on the term "hardened" deals with military-purposed or adapted civil structures designed and constructed to resist the effects of kinetic munitions.¹² For research purposes, these types are compressed into the single category of shallow underground facility or UGS. Additionally, UGSs include any subterranean structures that are military purposed, or have the potential to be adapted for military purpose, with less than 20 meters of overburden and not having dual usage with a civilian population. It is also the level of sophistication in construction and design that distinguishes UGSs and other UGFs from the other categories. The amount of infrastructure that supports the UGS is increased due to the need to sustain life or maintain a particular environment for special matériel. For this reason the function of UGSs are typically C³I or storage. It is also likely that the level of accessibility is increased to protect personnel and equipment or to contain blasts within. Accessibility levels of II or greater should be expected. The function of UGSs also lends itself to larger size structures with mobility ranging from permissive to unrestricted. Due to the level of sophistication in construction, environmental hazards are less likely unless purposely introduced. Personnel and matériel hazards are more likely due to the direct correlation with function.

Deep underground facilities (DUGs) are purposely built or adapted facilities, used by governments to protect and house strategic level information, personnel, equipment, or production. Also, they may function as part of a national level C³I system. Designed to sustain conventional weapon penetration, and resist air-blast and ground shock from nuclear weapon effects, these structures are built using advanced tunneling methods, often using a tunnel-boring machine (TBM).¹³ Caves and mines can also be adapted for strategic usage. In less developed countries, converted mines can create an ideal

11 Ibid., 8.

12 Ibid., 2.

13 Ibid.,15.

opportunity for the construction of a DUG. The sizes of these structures are typically very large and mobility would be considered permissive to unrestricted. These facilities are designed to be tied to surface infrastructure; however, they maintain enough critical internal infrastructure, such as water and fuel reservoirs, power generation, air filtration systems, and food rations, to sustain operations from anywhere from 60–90 days in a “buttoned-up” posture. Some facilities may boast longer sustainment capabilities; however, human psychological factors are likely more of a limiting factor, particularly if under siege. The entrances to DUG facilities can be either horizontally or vertically dug to reach the desired depth of operational workspace.¹⁴ These entrances are typically well hardened to resist kinetic munitions and will likely require accessibility level III or IV breaching methods. Additionally, interior spaces may require additional level III breaching methods. Because of the sustainability mechanisms and life support systems, merely collapsing access portals may not be sufficient to achieve a functional defeat. Facilities may contain excavation implements to remove rubble and repair portals. Threats found within these facilities are likely to be personnel and matériel related.

Using this typology and classification methodology to describe the subterranean operational environment will assist ground forces in mission preparation and intelligence analysts in understanding what information is critical before commanders commit lives into these unknown spaces. The coding system, along with the graphical symbol, illustrated below, allows commanders and planners to use a common reference to quickly identify and communicate the disposition of subterranean threats within their areas of operations.

¹⁴ Ibid.,16–17.

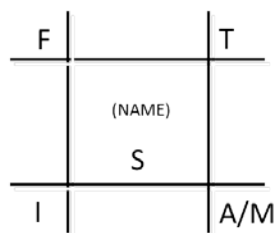
Table 1. Subterranean Operational Environment Typological Coding System

Classification			Typological Attributes			
Tunnel	Code	Description	Element	Code	Description	
Tunnel	TUNR	Tunnel, Rudimentary	Function	C3I	Command, Control, Comms, and Intel	
	TUNS	Tunnel, Sophisticated		PROD	Production	
Urban/Natural Cavity	SUBS	Substructure, Basement, Cave		STOR	Storage	
	CWKS	Civil Works, Sewers, Subways, Aqueducts		MOVE	Movement/Conveyance	
Underground Facility	UGS	Shallow Underground, Bunkers, Silos		Infrastructure	T	Transportation
	DUG	Deep Underground, Hardened (HDBT)			V	Ventilation
					P	Power
					W	Water
					D	Discharge
					C	Communications
			Mobility		R	Restricted Movement
				S	Semi-restricted Movement	
				P	Permissive Movement	
				U	Unrestricted Movement	
			Accessibility	I	Level I - basic mechanical tool breach	
				II	Level II - explosive or ballistic breach	
				III	Level III - advance cutting/dynamic breach	
				IV	Level IV - heavy engineer equip/munitions	
			Threat	E	Environmental, respirators required	
				P	Personnel, ballistic protection/restraints	
				M	Materiel, barrier protection required	

Graphic Control Measure Symbol adaptable to ADRP 1-02

- Area Symbols
 - Movement and Maneuver
 - Defensive Areas

Subterranean Area



Field	Field Type	Description
S	Structure Classification	Abbreviated code that designates typological classification
F	Function	Abbreviated code that designates the primary operational function
T	Threat	Letters that identify most likely threat
I	Infrastructure	Letters that identify known support infrastructure
A	Accessibility	Number that designates assessed level of breach hardness
M	Mobility	Letter that designates assessed size of drifts which may determine movement techniques

Figure 7. Subterranean Area Graphical Symbol

D. CASE STUDY LOGIC AND SELECTION

The case studies selected for use in this project have been chosen because of their historical significance and impact on military forces operating underground. The case studies span over half a millennium of military conflict. In each highlighted case, the aggressor or the defender determined that the ability to maneuver conventionally was severely restricted and the best remaining option was subterranean. The case studies have served to assess and refine the typological space in reference to a military's subterranean efforts. They also allow for the development of DOTMLPF implications from broad but relevant perspectives.

In 1453, during the siege of Constantinople, the Ottoman Turks reached a decision point. After three weeks of inconclusive frontal assaults and artillery barrages, the Byzantines showed no sign of capitulation. The Turks only seeming option was to dig under the city walls to break the stalemate. Even though this Turkish underground approach was defeated, massive Byzantine resources were expended to counter the threat. The action severely degraded the city's defenses, causing the eventual fall of Constantinople. This case set a precedent for armies to employ an underground solution when maneuver is not an option. The subterranean operations that occurred during the siege of Constantinople are the earliest documented examples that could be found, and it is from this point in history that the use of a distinct form of subterranean warfare can be traced. The motives that influenced combatants to seek the subterranean environment have not changed in hundreds of years and the rudimentary methods pioneered in this case can still be seen today. Although technology has often driven advances in warfare, the techniques used in tunnel detection and counter-tunneling at Constantinople continued to be used through the first World War.

The siege of Petersburg during the American Civil War in 1864 provides an example of a subterranean approach during what can be called "the first modern war." The Union Army laid siege to a strongly held Confederate defensive position in Petersburg, Virginia. In order to break the stalemate, the Union looked to an underground solution. Former miners, who were now Union soldiers, tunneled underneath Confederate lines in order to breach the defensive positions. Union miners

detonated a large amount of explosives under the Confederate trenches, creating a huge crater. Union troops rushing into the massive crater were trapped. Confederates counterattacked and easily dispatched the Union troops trapped inside. This action was a catastrophe for the Union Army and extended the siege for another eight months. Regardless of the tactical error, the cunning behind the design of this particular tunnel should not escape analysis. The employment of soldiers with previous training in underground mining proved critical to the subterranean operation. The efforts to mask the presence of a single ventilation shaft displayed understanding of the vulnerabilities associated with such support structures as well as efforts against detection through deception. Having specially trained or adapted soldiers and understanding the art of deception are both essential elements to subterranean operations today.

The Petersburg tunneling technique was used with much greater success in 1917, during World War I at the Battle of Messines Ridge. In this incident, the British devised a more elaborate plan to detonate explosives under German trenches. Nineteen tunnels were exploded, instantly killing 10,000 Germans enabling the British to capture the ridge. For the first time in World War I, a strong defense incurred more casualties than the attacking force. This example illustrates how subterranean operations can be successful if incorporated into a combined arms strategy. This case study relates the frightening realities of subterranean combat where miner-soldiers sometimes were engaged in hand-to-hand combat with counter-miners. The psychological factors associated with living underground for nine months or more required specially trained soldiers or those experienced in mining. In order to avoid detection and destruction by bombardment, miners found themselves going to new depths, increasing levels of sophistication in their operations, and incorporating new technology to sustain life.

In 1945, during World War II, the Battle of Okinawa became the last stand for the Japanese prior to a possible U.S. invasion of the home islands. This case displays an army's adaptation to underground tactics in order to inflict massive U.S. casualties. The Japanese on Okinawa transitioned their efforts into a defensive strategy that utilized underground bunker systems connected by mutually supporting tunnels, effectively becoming a UGS. The Japanese also took advantage of the terrain, which made Okinawa

the bloodiest and most costly single battle for the U.S. in World War II. Choosing not to commit forces underground, American soldiers made effective use of specialized weapons such as flamethrowers and shotguns. Capitalizing on vulnerabilities, motor oil was poured down ventilation shafts to spread and sustain fire and smoke. The effective use of incendiary weapons as an alternative to committing forces underground, contributes to making this a valuable case study.

During the Vietnam War, the Viet Cong constructed a vast subterranean tunnel network that was intended as a staging area for the Tet Offensive of 1968. This case illustrates the benefit of an irregular force remaining concealed underground and the difficulties with efforts to find them. For the first time, the U.S. began to form specially trained units to enter tunnels to interdict and clear Viet Cong hiding inside. This case exemplifies the tactics, techniques and procedures that can be effectively utilized in countering rudimentary tunnels. It also shows the psychological effects on soldiers operating in a subterranean environment.

In every case, the pattern of human behavior, seeking an advantage by going underground, is apparent. The employment of tunnels, when the ability to maneuver above ground has been eliminated, becomes the overarching theme in each case. The studies also serve to reveal different aspects of deception, concealment, stealth, incendiary weapons, explosives, detection, and other forms of combat in a subterranean environment. Attention given to these historical examples will allow the military to better prepare for future underground conflict.

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III. CASE STUDIES

A. THE SIEGE OF CONSTANTINOPLE (1453)

1. Introduction

Since Roman times, tunnel warfare has been utilized as a means for armies to gain a tactical advantage in battle. One of the earliest and most notable uses of subterranean operations was employed in 1453 during the siege of Constantinople by the Ottoman Turks. This battle provides an early indicator of how armies, when faced with adversity above ground, will seek to gain a tactical advantage underground. The battle incorporated a tunneling operation by Ottoman invaders to breach city walls while Byzantine defenders struggled to counter it. The battle remains a pertinent historical example by demonstrating an army's natural tendency to go underground. As modern technology continues to drive conflict underground, the Siege of Constantinople becomes more relevant to modern warfare than ever before.

This historical example reveals an early subterranean encounter that incorporated a variety of offensive and defensive tunneling tactics. The battle exemplifies the difficulties in tunnel construction, exposure to detection, deception and combat in the confines of a tunnel. The use of fire as a weapon by both sides also reveals its psychological and operational effectiveness underground. The extensive amount of resources and manpower required to attack underground, compared to the resources required to defend against, was a significant factor for success. In the case of Constantinople, the Ottoman Turks' resource allocation became the deciding factor that shifted subterranean efforts back to the direct mass frontal assault, resulting in victory.

2. Background

The siege of Constantinople was the great enterprise of Ottoman Sultan Mehmed II. His goal was to capture the capital of the Byzantine Empire which was the last remnant of Rome. The Byzantine emperor Constantine XI made the firm assertion that the city of Constantinople would hold out to the last man if invaded. He believed that it was the religious duty of every Christian to show no fear in the face of their Muslim

enemies. To lose such a city would be a blow to Christendom and allow Muslims the opportunity to invade Europe; the city of Constantinople had to make a stand.¹⁵

When an attack on the city became imminent, Constantine rapidly mobilized the city to prepare defensive measures. The Ottoman Turks had a professional army of 80,000 which included a coalition of many countries that were loyal to the Sultan.¹⁶ Constantinople could muster only an army of 7,000 to defend itself. One defensive measure was a large chain manufactured in order to block the mouth the city's harbor. The chain was so large that it was supported on the water by floating wooden barges. Constantine's intent was to keep the harbor open to the possible arrival of foreign assistance but to also block Turkish ships. Additionally, the walls of the city were reinforced to form two layers of security which were comprised of an inner and outer wall. A moat was dug between the two walls with towers at every 50-60 yards.¹⁷ This provided the city a formidable defense which would allow the Byzantines to hold out until external support arrived from Rome.

The Sultan attempted to strangle the city by sea as well as land operations. One of the first actions taken by the Turks was a blockade of the city by 126 Turkish ships off the coast of Constantinople. Due to Constantine's defensive measures of the massive chain, Turkish ships were unable to enter the harbor. The Sultan understood the city's walls had been reinforced and were formidable enough to render typical artillery of the time obsolete. A new weapon was developed by the Turks to solve this problem. The Sultan commissioned a German engineer to forge massive cannon called "The Basilic." The Basilic was 27 feet long and was able to hurl a 600 pound stone ball over a mile. The Basilic was so large that it was accompanied by a crew of 60 oxen and 400 men.¹⁸ Initially, the Turks assumed this new weapon would be all that was necessary to breach the outer walls of Constantinople.

¹⁵ Paul Davis, *100 Decisive Battles from Ancient Times to the Present* (Oxford, England: Oxford University Press, 1999), 165.

¹⁶ Roger Crowley, *The Last Great Siege, 1453* (New York: Bloomsbury House, 2005), 95.

¹⁷ Crowley, 79-86.

¹⁸ Davis, 165.

In April of 1453, the Sultan's troops positioned themselves to begin bombarding the city walls. The Basilic's fire was focused at the middle section of the outer wall on the inland side of the city. Due to the limited size of the Byzantine army, Constantine only had enough troops to occupy the outer defensive wall of the city. Initially, as the Basilic fired on the outer wall, massive damage was inflicted which caused the Sultan to assume it was only a matter of time before the walls could be breached (see Figure 10). However, due to the inaccuracy of the cannon and its extremely slow rate of fire (three hours to reload); the Byzantines were able to repair the walls after each shot.¹⁹ These factors severely limited the effectiveness of the Basilic and strengthened the resolve of the Byzantines.



Figure 8. Siege of Constantinople²⁰

After several unsuccessful frontal assaults compounded by the ineffectiveness of the Basilic, the Sultan formulated a less direct strategy to break the stalemate. In May, the Sultan ordered his Serbian sappers to find a way to weaken or breach the city's walls. Turkish officer Zagan Pasha was placed in command of the sappers and devised a plan to

¹⁹ Franz Babinger, *Mehmed the Conqueror and His Time* (Princeton, NJ: Princeton University Press, 1992), 80–81.

²⁰ "Ottoman Superguns" [image], accessed December 12, 2013, Weapons and Hardware, <http://weaponsandwarfare.com/?m=201005&paged=3>.

use a series of tunnels to weaken and/or breach the outer walls.²¹ However, the Turkish sappers did not anticipate the difficulties and dynamic problem sets that would come with such an unconventional subterranean approach.

3. Subterranean

Pasha and his men immediately began construction of the first Turkish tunnel, in full view of the defenders, just beyond the range of Byzantine weapons. Around the clock digging by the Turkish sappers revealed large amounts of spoilage (excess earth from the tunnel) that was being removed. Due to the amount of spoilage, the Byzantine defenders knew that it was only a matter of time before the Turks would reach the city walls. As the Byzantine defenders continued to observe Pasha's efforts, it became crucial to devise a plan to counter this new underground threat.

Constantine dispatched all available engineers from his ranks to form a specialized Byzantine underground detachment. He placed in command a Scottish engineer officer named Johannes Grant.²² Grant immediately went to work instructing his men to dig counter tunnels to interdict the Turkish underground approach. The counter tunnel direction was determined by simply estimating the line of sight from the city wall to the Turkish tunnel entrance. As the Turkish tunnel construction progressed, wooden beams were placed every two feet along the tunnel. The beams were intended to reinforce the tunnels and protect the sappers from collapse.

As the Byzantine defenders came into contact with sappers underground on the night of May 16, intense hand to hand combat ensued. Initially, the Byzantines were able to inflict massive casualties upon the Turks and blocked the Turkish approach. As the intense fighting within the tunnel progressed, Greek fire and water were introduced into the struggle. As the Byzantines poured Greek fire and/or water into the tunnels, the terrified Turks were overwhelmed by fear, causing them to flee from the tunnels.²³ The

²¹ Babinger, 86.

²² Ibid.

²³ Davis, 167.

Byzantine engineers were then able to block the tunnels with brick and earth. A citizen of Constantinople named Tetaldi described this event in his diary by writing:

There were many men who knew how to mine all sorts of metals from the earth. Their captains led them, with cleverness and cunning, and they began to dig to bring down and destroy the walls. But the Christians from within the city dug a counter-mine, met the Turks at some point, and killed them with smoke; they lost their lives underground with the stench of corpses. Our side even drowned them with water and prevented them from accomplishing their task.²⁴

Greek fire created such fear for Turkish sappers that deception was used to conceal the direction of the tunnels and the breach point under the wall (see Figure 11). The Turkish sappers conducted this deception by intentionally making no attempt to conceal the entrance of a newly constructed tunnel leaving it in full view of the Byzantines. However, the Turkish intent was to encourage the Byzantines to assume the tunnel would follow a straight line to the wall. Instead, the sappers would construct the tunnel at an oblique angle to the wall which would make tunnel detection difficult for the Byzantine defenders.²⁵ Once the Turkish sappers reached the wall undetected, piles of logs were set on fire under the wall. It was the intent of the sappers to weaken the structure of the wall to the point of collapse. This action by the Turkish sappers, to weaken the city walls in support of bombardment by the Basilic, was only moderately successful. The walls were never reduced enough to enable a breach that could be exploited by Turkish troops above ground.

²⁴ Marios Philippides and Walter Hanak, *The Siege and Fall of Constantinople in 1453* (Surrey, England: Ashgate Publishing Limited, 2011), 509.

²⁵ Crowley, 170.



Figure 9. Ancient use of Greek fire²⁶

Pasha then decided the sappers had to focus on making a breach point under the walls that could accommodate a large assault force. This was accomplished by sappers constructing multiple tunnels at oblique angles in preparation for a final assault on the city. At this point, Grant was faced with the problem of detecting multiple Turkish tunnels while simultaneously having to interdict each effectively. A young Byzantine engineer came up with a technique of using barrels of water to detect new tunnels. The Byzantines would simply place barrels of water at close intervals along the inside of the city wall.²⁷ The barrels were monitored for disturbances in the water that indicated vibrations from Turkish underground digging. This method became very successful for the Byzantines and incurred additional casualties for the Turkish sappers. The tunnels were again bricked up and filled with earth. This caused the sappers to take even more care with tunnel construction in order to limit the amount of vibration and made tunnel detection difficult for the Byzantines, but not impossible. The defenders continued to hastily interdict Turkish tunnels but Grant was determined to enhance Byzantine counter-tunnel methods.

An opportunity arose at one of the interdicted tunnels, resulting in the Byzantine capture of two Turkish sapper officers. The two officers were submitted to severe torture and interrogation and revealed additional tunnels under construction. After sufficient

²⁶ “The Vatican and Islam” [image], accessed December 12, 2013, <http://www.reformation.org/vatican-and-islam.html>.

²⁷ Crowley, 171.

intelligence was obtained, the two Turkish officers were beheaded and their heads displayed on the city walls as a message to the Turks.²⁸ This enraged the Turks, but new tunnel construction continued. As Turkish tunnels continued to be compromised, the Sultan came to the realization that the number of casualties underground was far too costly with too little chance of success. With tunnel efforts thwarted by the Byzantines at every turn, Turkish underground efforts became futile and the Sultan abandoned the operation.

4. Effects

Due to the extensive resources required to counter Turkish tunnels, the remaining Byzantine defenses along the city wall were degraded. Eventually, the Sultan made the decision to focus his remaining resources in a massive frontal assault on the city's northwest corner, which had been severely damaged by the Basilic (see figure 12).²⁹ This proved to be more than the Byzantine defenders could handle; the outer wall was breached and an intense battle occurred within the city's inner walls. As the Byzantines continued to lose ground, the Turks penetrated deeper into the city. The battle finally ended when Constantine killed himself as the Turkish invaders were on the steps of the city cathedral, Saint Sophia. The Byzantine Empire expired with the fall of Constantinople.

²⁸ Steven Runciman, *The Fall of Constantinople 1453* (Cambridge, UK: Cambridge University Press, 1990), 108.

²⁹ Crowley, 217.



Figure 10. Final assault of the walls of Constantinople³⁰

5. DOTMLPF Application

By examining the applicability to today's operations in subterranean warfare, Turkish and Byzantine subterranean operations can be analyzed in terms of doctrine, organization, training, matériel, leadership, personnel, and facilities (DOTMLPF):

- Doctrine—Doctrine did not exist in support of either side. Many Turkish and Byzantine sappers were educated in engineering disciplines. The subterranean capabilities relied mostly on non-military experiences.
- Organization—Byzantines and Turks did not establish a permanent underground capability in their ranks. Nor did they retain their sappers after the success.
- Training—Training for subterranean warfare most likely did not exist. The siege utilized those with mining experience.
- Leadership—Zagan Pasha's leadership was a driving force for the Turks but Johannes Grant's improvisation was vital for the Byzantine defense. Grant's encouragement and openness of new and innovation ideas from his men was the key to his underground success.
- Matériel—Flexibility to improvise and cannibalize resources enabled the Turks to reach the city walls and enabled the Byzantines to counter it.
- Personnel—It appears to be a coincidence that both sides had access to former miners willing to engage in subterranean warfare.

³⁰ Marion James, "Sultan Mehmet II Conquest of Istanbul" [image], accessed December 12, 2013, <http://www.todayszaman.com/news-241864-siege-poison-plots-and-the-fall-of-constantinople.html>.

- Facilities—Facilities for subterranean warfare consisted of actual time spent in private and commercial mines during time served in non-military professions.

6. Conclusion

Even though the subterranean battle beneath the walls of Constantinople was not the final determining factor in the conflict, it did influence the Turks to alter their plan of attack. The Turks determined the city's remaining defenses were neglected, due to the resource-intensive counter-tunneling. Additionally, despite successful counter-tunneling efforts, morale within the city also began to plummet when the defenders received word that no reinforcements would arrive from Rome. Mehmed knew the city's defenses were at its weakest point. The Turks resumed the frontal attack, which resulted in the fall of the city. The operation exemplifies how underground warfare can be used in both the offense and the defense. It is the first significant case of subterranean warfare as a breach, use of counter tunnels, fire as a weapon, tunnel detection and concealment. The amount of underground expertise needed by skilled combat troops demonstrated the need for specialized units and training needed to conduct underground warfare. Finally, the case showed how underground operations could work in tandem with activities aboveground, opening new lines of operation and relieving pressure by expanding the scope of the battle space. To dismiss an underground threat could alter the tactical situation above ground and become disastrous in battle. These same underground lessons can still be applied in today's modern warfare.

B. SIEGE OF PETERSBURG DURING AMERICAN CIVIL WAR (1864)

1. Introduction

During the American Civil War, advances in small arms and artillery resulted in devastating casualties on both sides. This case study examines the use of the subterranean operations during the siege of Petersburg by Union forces. The case is another example of the trend to go underground to expand the scope of the battle space. The Petersburg operation showcases specific subterranean tactics of tunnel construction, concealment, deception, and the utilization of an explosive breach. These examples and their implications are relevant to today's threats.

The “Battle of the Crater,” as it became known, took place on July 30, 1864, during the siege of Petersburg, Virginia, between the United States (Union forces) and Confederate States of America (CSA). Under the command of Lieutenant General (LTG) Ulysses S. Grant, Major General (MG) George Meade’s forces waged a nearly month-long struggle against entrenched, fortified, and well-armed Confederate forces. An assault, facilitated by underground sappers was conducted on entrenched Confederates and resulted in devastating casualties for the Union; thus, subterranean warfare might be mistakenly disregarded as counterproductive. To the contrary, the Union debacle was not due to the employment or logic behind an explosive tunnel, but more importantly to the leadership and tactical exploitation of the breach itself. Without proper tactical coordination of troops above and below ground, as part of an overall attack plan, momentum gained was squandered resulting in unnecessary casualties.

2. Background

In the days leading up to the battle, General Meade’s force had been in a deadlock with Confederates; General Grant was eager for suggestions. One idea came from Lieutenant Colonel (LTC) Henry Pleasants who had been a mining engineer in Pennsylvania. Pleasants proposed digging a mineshaft that would extend beyond the Union breastworks and terminate under Confederate entrenchments.³¹ At the end of the shaft, explosives would be emplaced and detonated, killing the defenders above. The resulting crater would enable a breach point through which Union forces could penetrate.

The target would be an area known as Elliott’s Salient in the middle of the Confederate First Corps line. This section was a fortified position that was defended by South Carolina troops. The position was also occupied by several artillery pieces that were integrated into established Confederate entrenchments. An explosive breach at the Salient was intended to neutralize its firepower while simultaneously providing a gap in the Confederate defensive line that could be exploited. Thus, it was hoped that the Confederate defenses at Petersburg would crumble leaving the Confederate capital of

³¹ Jim Corrigan, *The 48th Pennsylvania in the Battle of the Crater: A Regiment of Coal Miners Who Tunneled Under the Enemy* (New York: McFarland & Company Inc, 2006), 21–22.

Richmond vulnerable.³² Additionally, five railroads converged in Petersburg providing a life line of supplies to the Confederate Army. Without Petersburg, the Confederacy itself might fall.³³

Lieutenant Colonel Pleasants's plan offered an opportunity to break the stalemate. It was reluctantly approved by Grant, even though he did not consider the action to be of strategic value. However, Grant believed a tunneling operation would at least keep his troops occupied during the siege. Due to Grant's attitude, subordinate commanders also did not see the urgency in the endeavor resulting in minimal resources allocated in terms of personnel or equipment. In the end, the tactical gain from this operation would enable the capture of key terrain, known as Cemetery Hill, while killing a significant number of Confederates.

3. Subterranean

During the Civil War, an operational tunnel was known by the French term "sap." The term referred to a trench or tunnel that was dug beneath enemy fortifications. The intent was to render the ground underneath the enemy's defensive position unstable, either through the use of fire or explosives to effectively produce a penetrable breach. The structure was usually a rudimentary tunnel dug with hand tools with basic support structures for shoring. The size was limited to the space needed to move a small number of men and equipment. A restricted size also aided in the speed of construction and the effectiveness of fire or explosives.

Pleasant's plan called for a 500 foot shaft to be dug under Elliott's Salient. The mission was estimated to take twelve days and use 12,000 pounds of explosive powder.³⁴ General Grant remained skeptical due to his prior failed attempts with tunnels at Vicksburg. During the siege at Vicksburg, 36 former Union coal miners tried to detonate 2,200 pounds of gun powder under Confederate entrenchments. However, the 3rd

³² Corrigan, 24.

³³ David J. Eicher, *The Longest Night: A Military History of the Civil War* (New York: Simon & Schuster, 2001), 687.

³⁴ Corrigan, 22.

Louisiana Regiment discovered the mining and countered it by digging secondary trenches. The ensuing Union fiasco became known as the battle of the “Death Hole.”³⁵

Pleasants commanded the 48th Pennsylvania Regiment, of which almost 100 were miners from the Schuylkill County, a Pennsylvania coal region. The regiment had earned a distinguished combat record, and like most, its soldiers would do almost anything to end the war.³⁶ Thus, a force with previous civilian miner experience was utilized. Approximately 100 ex-miners from the regiment dug around the clock in two and a half hour shifts. Without any special equipment, they improvised crate-made wheelbarrows and used cracker boxes for hauling dirt (see figure 13). Understanding the need for operational security (OPSEC), they hauled the dirt into the woods and covered it with underbrush at night.³⁷ Pleasants gave testimony before the Committee on the Conduct of the War in which he said, “I got pieces of hickory and nailed on the boxes in which we received our crackers, and then iron-clad them with hoops taken from old pork and beef barrels.” Additionally, in his statement he noted that General Meade and Grant’s chief engineer regarded the effort as nonsense; that a mine that length had never been built in military operations; that the men would likely be suffocated or crushed by earth or the enemy would discover their intentions, and countermine. He stated that, despite his request, he could get no supply of lumber for shoring and had to cannibalize wagons, an old bridge, and even raided a rebel saw-mill. Without the proper hand tools, Pleasants’ men used blacksmiths to straighten and flatten common army picks and axes. Pleasants knew that the most important calculation would be the distance mined. If the distance fell short or long the explosion would have little effect. A surveying tool, called a theodolite, was procured to measure distance and azimuth to the enemy defenses.³⁸

³⁵ Ibid, 28.

³⁶ Ibid, 30.

³⁷ Ibid, 33.

³⁸ William H. Powell, *Battles & Leaders of the Civil War*, vol. 4 (New York: The Century Company, 1987), 545–546.



Figure 11. Entrance to Union Mine (Petersburg 1865)³⁹

Digging through the sand and thick clay, the 400-man regiment averaged nearly 40 feet per day. At about 250 feet, they hit heavy clay. Pleasants directed the shaft to continue at an incline toward the Confederate lines. The incline enabled ease of water drainage without congestion. Pleasants also designed an ingenious air-exchange system to provide ventilation. A single ventilation shaft was constructed vertically, well behind Union lines, to prevent observation. At the base of the shaft, a canvas partition was installed and a fire was kept continuously burning. The heat forced stale-air, from inside the mine, up the shaft while creating a vacuum of fresh air from the tunnel entrance. To conceal the smoke from the shaft, General Burnside ordered round the clock campfires along Union lines to mask the tunnel fire.

Having begun on June 25, the main shaft reached the Confederate lines on July 17. The mine was then extended into a 75-foot gallery running parallel to Confederate

³⁹ Mark Engi, "Free Republic" [image], accessed December 12, 2013, <http://www.freerepublic.com/focus/f-vetscor/1194430/posts>.

lines. The tunnel complex was now T-shaped. The main shaft ran 511 feet long and more than 50 feet below the surface (see Figure 14). The tunnel was narrow at three feet by four and a half foot high, large enough for two miners to work side by side (see Figure 15). Inclining upward, the 75-foot perpendicular galleries sat just 20 feet below the Confederate positions.

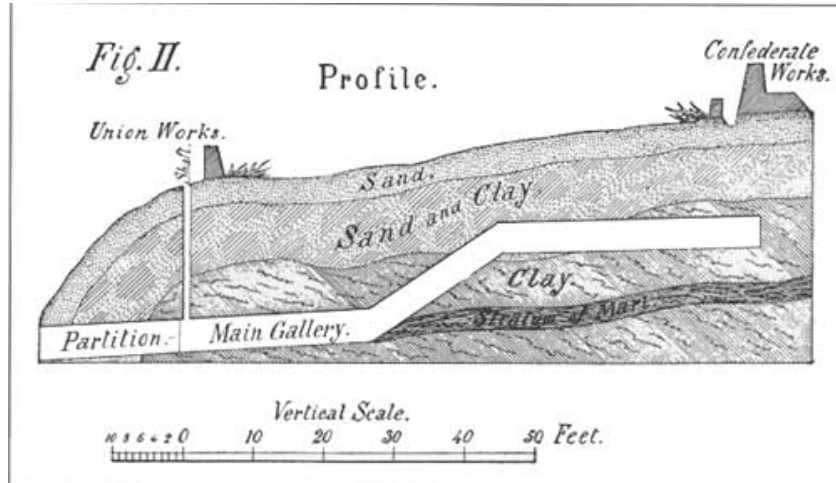


Figure 12. Petersburg Tunnel diagram⁴⁰

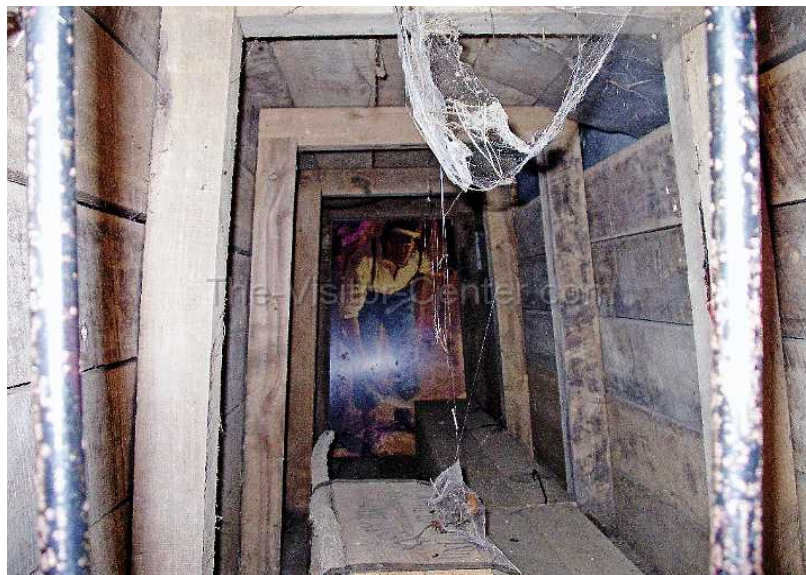


Figure 13. Inside the Union tunnel at Petersburg⁴¹

⁴⁰ Daniel Ingham, “Archives of Maryland: Biographical Series” [image], accessed December 12, 2012, <http://msa.maryland.gov/megafile/msa/speccol/sc3500/sc3520/009200/009241/html/09241bio.html>.

General speculation and gossip along the CSA lines suggested a Union mining operation. The lack of visible aggression towards the Elliott's Salient section led to suspicions by the Army of Northern Virginia 1st Corps artillery chief General Edward P. Alexander. No visible ventilation shafts forward of Union lines suggested a lack of mining efforts to most of the Confederate defenders. Confederate Commander Robert E. Lee was skeptical. However, to be safe, Lee tasked Captain Thomas H. Douglas to begin countermining, to be sure. Lee's skepticism was also fueled by an observation from a British journalist who stated that the British had attempted a similar tunnel of the same length in India. However, the length of that tunnel caused a failure due to lack of air.

Captain Hugh Douglas, a Confederate engineer officer, organized 90 men to being two separate shafts at opposite ends of Elliott's Salient. The shafts would extend toward the Union lines, and be angled toward each other. The countermining was slow and lacked good intelligence. Douglas's men worked twelve hours shifts and usually halted their digging to listen for Union digging. The men of F Company, 1st Confederate Engineers, lacked mining experience, and their shafts were dug between fourteen and eighteen feet deep. Only one shaft extended far enough, but still overshot the 25-foot deep Union shaft.

After three Confederate deserters were questioned, LTC Pleasants quickly realized Confederate countermining was being conducted. Consequently, the Union's 48th Regiment immediately halted digging. Pleasants personally crawled into the tunnel and remained quiet for over half an hour, in order to confirm or deny any Confederate digging. Upon his hearing nothing, Union operations resumed and LTC Pleasants expressed urgency finish the mine as soon as possible. The Confederates could not detect any sounds of digging and soon ceased their countermining efforts in fear of possible cave-ins.

⁴¹ "Petersburg Battlefield the Crater" [image], accessed December 12, 2013, <http://www.the-visitor-center.com/pages/Petersburg-Battlefield-The-Crater/slides/Petersburg-Battlefield-The-Crater-014.htm>.

4. Effects

After Union miners reached their limit of advance, 8,000 pounds of gunpowder were emplaced and tamped with earth. On July 28, a single fuse was spliced multiple times to reach the entrance to the mine; 12,000 pounds of explosive powder were emplaced at the end of the mine and primed (see Figure 16). The mine was set to explode in the early morning hours of July 30. After the initial attempt to detonate the explosive failed, two brave members of the 48th Regiment crawled inside to repair the fuse. After relighting of the 60-minute fuse, the mine finally erupted in a massive explosion. The resulting crater was 170 feet long, 120 feet wide and at least 30 feet deep (see Figure 17). The blast instantly killed 278 Confederate soldiers. The surviving Confederate defenders were dazed, confused and scrambled to consolidate and reorganize. While the shock of the blast was a success, Union troops failed take advantage of the opportunity quickly. For more than fifteen minutes, not a single shot was fired by Union troops. The delay enabled Confederates, led by Brigadier General (BG) William Mahone, to quickly seal the breach. (see Figure 15). Meanwhile, as Union troops attempted an assault through the blast site, they became trapped inside the massive crater. Confederates easily slaughtered Union troops as they continued to flow into the depression.



Figure 14. Charcoal sketch: Col. Pleasants supervising emplacement of explosives⁴²

⁴² Alfred Rudolph, "Petersburg Crater Sketch LOC" [image], *Wikipedia*, accessed November 7, 2013, http://en.wikipedia.org/wiki/File:Petersburg_crater_sketch_LOC.jpg.



Figure 15. Confederate Reinforcement of the Breach⁴³

The Union assault was a complete and devastating failure and the Siege at Petersburg continued for another eight months. Even though the Union subterranean successes were squandered, this event was significant. It displayed how a force with subterranean capability can overcome adversity in an unforgiving environment to achieve a tactical surprise. Another significant factor to this event was that Union miners were given the latitude to design the tunnel themselves, indicating a “bottom up planning” technique. Union commanders understood that those closest to the enemy can have a better understanding of what is required. Given the qualities of this unique operation, it is easy to see why subterranean warfare is a special skill set that can achieve tactical results.

5. Application of DOTMLPF

Lieutenant Colonel Pleasants’ operations can be analyzed in terms of DOTMLPF:

- Doctrine—Doctrine did not exist in to support LTC Pleasants initiative. Though many West Point officers were educated in engineering disciplines, subterranean capabilities relied mostly on non-military mining experience.

⁴³ Mark Engi, “Free Republic” [image], accessed November 7, 2013, <http://www.freerepublic.com/focus/f-vetscor/1194430/posts>.

- Organization—Union Forces during the Civil War did not establish a permanent underground capability in their ranks.
- Training—Training for subterranean warfare most likely did not exist. Petersburg incorporated soldiers with pre-existing mining experience.
- Leadership—Pleasants' leadership and improvisation was vital. Without his understanding of the capabilities and limitation of tunneling, the subterranean approach would have never materialized.
- Material—The flexibility to improvise and cannibalize resources enabled Union miners to dig nearly 40 feet per day.
- Personnel—It was pure happenstance that the 48th Regiment consisted of ex-miners from Pennsylvania who were willing to engage in subterranean warfare.
- Facilities—Facilities for subterranean warfare consisted of actual time spent in private and commercial mines during time served in non-military professions.

6. Conclusion

The siege of Petersburg, Virginia offers a glimpse into one of the earliest uses of subterranean operations by America forces. However, the trend to dig underground still exists. Even today rudimentary cross-border tunnels are seen throughout the world. It would not be implausible for an insurgent to infiltrate a country or a military facility, via a tunnel, with a weapon of mass destruction. Such a happening would be devastating.

Several lessons can be drawn from the Petersburg example and applied to modern tactical considerations. Rudimentary construction can be seen in any modern day smuggling tunnel used by criminals or insurgent groups. Concealment is also essential to preventing an adversary from discovering a subterranean effort. Even with today's advances in measurement and signature intelligence (MASINT) and persistent intelligence, surveillance, reconnaissance (ISR), tunnel detection is severely limited. Ventilation is also a critical necessity and significant vulnerability. Today, mechanical air ventilation conduits are common in most rudimentary tunnels and underground facilities. Knowledge and exploitation of these characteristics can provide modern militaries the means to counter an enemy's use of the subterranean environment.

C. THE MINING OF MESSINES RIDGE DURING WORLD WAR I (1917)

“Gentlemen, we may not make history tomorrow, but we shall certainly change the geography.”

Sir Herbert Plumer, 2nd Army Commander⁴⁴

1. Introduction

The Western Front was caught in a quagmire; by 1916, Germany and a European alliance had been entrenched in static positions for two years. Both sides were unwilling to yield ground, but the need for a breakthrough grew more prevalent each day if victory were to be achieved. The war had already seen hundreds of thousands of men die and pressured military commanders to conceive a strategy that might end the war quickly. Sir Herbert Plumer, Commander of the British 2nd Army, proposed that in order to defeat the Germans, Allied forces needed to utilize clandestine subterranean methods. An underground approach along the Western Front, more specifically at Messines Ridge, was devised to provide a tactical advantage to the British.

Messines Ridge was a prominent natural stronghold that had been previously captured by the Germans in 1914.⁴⁵ Messines was located to the southeast of Ypres, Belgium and its significance was that it acted as a natural obstacle for the Germans. For the British, clearing Germans from the ridge would open a route towards Roulers, a key German distribution point of matériel and troops.⁴⁶ From the start of the stalemate, Messines Ridge had been the scene of persistent harassment for Allied Forces. The Germans occupied the high ground with fortified entrenchments (machine guns and artillery) that made any allied assault futile. The British pinned down in the trenches and receiving casualties, required drastic measures. Sir Herbert Plumer devised an alternative course of action for the British to break the stalemate.

⁴⁴ Michael Duffy, “The Battle of Messines,” last accessed March 20, 2013, <http://www.firstworldwar.com/battles/messines.htm>.

⁴⁵ Ibid.

⁴⁶ Peter Barton, *Beneath Flanders Fields: The Tunnellers’ War, 1914–1918* (Staplehurst, England: Spellmount Press, 2005), 164.

2. Background

Plumer knew every inch of Messines, having fought there since 1914. To break the stalemate, Plumer recommended going underground to disrupt the German defensive position. At an Allied commander's conference in England, Plumer revealed an operational concept to dig multiple mine shafts, fifteen feet under German entrenchments, nested within a massive above-ground assault. However, tunnels at that depth could be easily discovered by German countermine efforts, even though they were not susceptible to artillery bombardment. Plumer discussed the problem with the British Expeditionary Force geologist. A solution was required that could achieve relative stealth in terms of preventing German detection while maintaining structural integrity. The sand and clay layers of Messines were analyzed at varying depths for capacity to dig, mine, and handle explosives. After some debate, an agreement was reached. The heavy clay found between 80–120 feet subsurface was the most optimal for the operation. This would be the layer Allied Forces would use to punch through to achieve surprise.

In preparing for the operation, Plumer had authorized the laying of 22 mine shafts underneath German lines all along the ten kilometer natural ridge. The plan was to detonate all 22 tunnels at zero hour on June 7, 1917.⁴⁷ The attack would then be followed by infantry assaults against a presumably dazed and confused German defense. This unique operation was the largest underground attack ever attempted.

Initially, allied countries such as England, New Zealand, Canada, and Australia heavily recruited civilian miners and tunnellers to join the war effort. With civilian subterranean experience, a typical engineer soldier could utilize geological and metallurgical capability never before seen in combat. From Australia alone, over 4,800 miners/tunnellers were recruited and sent to a makeshift basic training camp in Sydney. In England, "clay kickers" were recruited due to their vast experience developing aqueducts and underground cisterns in Manchester and London. Naturally, the dire need for mining skills meant some recruitment standards were overlooked. Some recruits were

⁴⁷ Duffy, "The Battle of Messines."

well into their late 60s, and others had disciplinary problems. Ex-miners assigned to other branches were reassigned to engineer tunneling units. In all, about 20,000 miners were assembled in Belgium.

3. Subterranean

Despite being professionals at home, these men still needed to be educated on the military aspects of tunneling. For instance, a “listener” was trained to detect enemy digging utilizing the most rudimentary methods. The listener would drive a stick in the ground and place the other end between his teeth. The listener would feel for vibrations, informing him if enemy countermines were occurring underground. Listening posts also contained medical stethoscopes, which became another method of detection. If any digging was detected, all work ceased, even if the sound was later identified as coming from rats. Strings, attached to bells hundreds of feet apart, lined tunnel ceilings in order to relay warnings from the listener to other miners. Lastly, every listener had a caged canary nearby. The canary’s small lungs were more susceptible to carbon monoxide and dioxide than a human’s. A dead canary, or one in distress, was a tell-tale sign that the tunnel should be evacuated.

Construction of the tunnels proved rigorous for the laborers. A typical miner rotational schedule encompassed four days in and four days out. As Plumer’s target date of June 7 loomed closer, the rotations were changed to six days in and two days out.⁴⁸ Tunneling became a 24-hour operation with a typical shift being around twelve hours. The living conditions underground were nearly intolerable due to the increased exposure to lice, bugs, and rats. One miner described it, “If you cut your hand, it was a criminal offense not to go and be injected against tetanus. Jaundice, boils and tetanus were rife.”⁴⁹ In addition, at 80 to 120 feet below ground, water became a constant hazard and miners were consistently operating in roughly one foot of water under poor lighting that affected them mentally and physically. The military aspect of tunneling was a traumatic experience for most. Many miners turned to alcohol as a means to cope with their

⁴⁸ Barton, *Beneath Flanders Fields: The Tunnellers’ War, 1914–1918*, 182.

⁴⁹ *Ibid.*, 168.

problems and alcoholism became the largest problem warranting punitive action amongst tunneling units. Any spare time was used to write loved ones back home and fill sand bags with excess tunnel spoilage.

One of the biggest fears every miner faced was an underground encounter with the enemy. Before the war, miners did not even consider the possibility of running into another shaft resulting in a fight to the death. However, in wartime, this became a real threat. Typically, when one tunnel collapsed into another, fighting was a claustrophobic brawl, with little room to maneuver. A miner would use anything at his disposal to defeat his adversary, including picks, shovels and knives. Side arms were seldom used. The sound of a pistol could give away a miner's position and compromise the entire operation. Another fear was being buried alive. One Australian miner, William Bedson, faced just that outcome when German countermining efforts blew a charge to collapse the tunnel in which he was located. After the collapse, Bedson was entombed for six days, surrounded by his dead friends.⁵⁰

For the regular infantry unit, knowing that a tunneling company was assigned or attached to them was not an appealing thought. Not only were artillery shells and gas attacks a concern, now soldiers felt they had to also worry about an attack from below as well. The Germans routinely conducted fly-overs of Allied positions. Detection of mountainous heaps of spoilage alerted Germans to Allied tunneling efforts. However, in reference to countermines, the Germans were deceived and did not know the Allies were typically digging at least five to ten feet deeper than their own tunnels.

German counter-mining efforts routinely intercepted Allied digging efforts between 50–60 feet below surface. The Germans developed geophones to measure seismic activity and direction. To counter this, Allied miners deliberately made as much noise as possible, at odd locations and depths, to distract attention from an operational mine that was much deeper. The Allies continued devising creative deception techniques over a year-long period. One deception technique involved a system of pulleys attached to two mining picks inside a false or inactive tunnel. Under the pulley system, a British

⁵⁰ Ibid., 175.

soldier would pull a rope, from above ground, which would cause the picks to strike steel spikes leaning against a tunnel wall at an alternate location. The sound was enough to resonate onto German geophones to conceal an actual operational tunnel under construction. Miners would then move the contraption forward to replicate a digging rate of progress. The deception worked and left the Germans completely unaware of British underground preparations for a massive assault.

Plumer's plan was coming to fruition. Like most great concepts, his was simple and easily understood multiple echelons below. The entire operation was essentially broken down into three phases. Phase One was the prolonged deception operation. This phase took the form of multiple mass feint attacks later on. Phase Two was to dig underneath the German position along Messines Ridge and lay 1,000,000 pounds of explosives. The explosives would be distributed throughout tunnel pockets called galleries (see Figure 18). Following the detonation, Phase Three encompassed the infantry retaking the ridge against presumably dazed German defenders. The infantry would be supported by close air bombardments of high explosives and mustard gas. The end state was the capture of Messines Ridge.

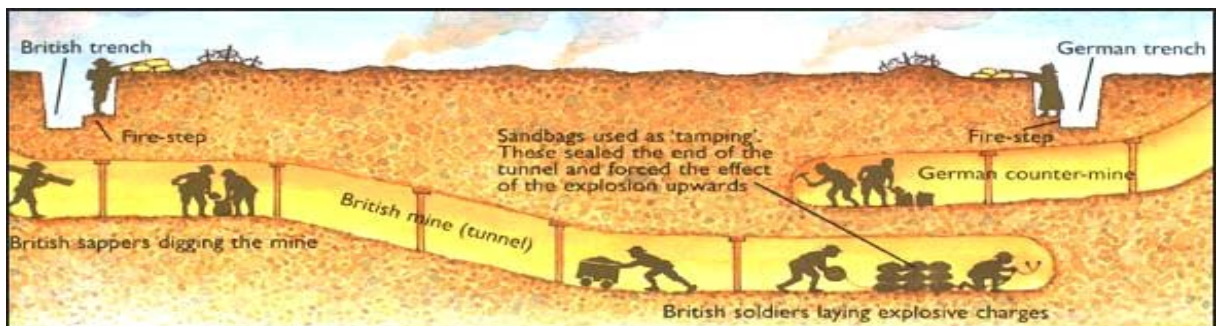


Figure 16. British tunnel diagram⁵¹

In order to exploit this tactical underground advantage, the galleries were dug measuring three-by-six feet. After completion of each gallery, a mine was laid in place

⁵¹ "Father & the Somme" [image], accessed November 10, 2013, <http://www.aaia.com.au/pedro/ww1/trench.html>.

containing charges of ammonal up to 95,000 pounds.⁵² The charge was composed of ammonium nitrate and aluminum powder. The gallery's surrounding presented both advantages and disadvantages. On the positive side, the heavy clay muffled any noise at that depth and Allied miners could operate in full secrecy without worry of detection. Another advantage was that being underground minimized artillery bombardments from above. There was also little chance of the galleries being compromised due to the clay. However, moisture was another problem. The miners took every precaution to ensure the preservation of their explosives. Then, Plumer's timeline was delayed due to focus being shifted to the Battle of Somme and this delay caused some concern about some of the charges which had been laid six months previously.

In the days leading up to day zero, heavy and light artillery had been expanded on the Allied front lines. Over 2,300 guns were lined up wheel to wheel with no effort to hide their positions. An additional 300 heavy mortars were also brought forth. The Germans on Messines Ridge included four divisions with two more divisions on reserve. For two weeks, artillery shells pounded food and water supplies, key roads, and supply dumps. Mustard gas shells were also fired in an effort to force the Germans to don gas masks and lose sleep. On two occasions the artillery fires were doubled in total output to deceive the Germans into believing a massive attack had commenced. In reality, it was to desensitize them before the actual assault. The bombardment was effective and by early June almost half of all German howitzers on the ridge were out of action.

As Allied units conducted rehearsals in the final days leading to the assault, British planners conducted terrain analysis of the breach points above ground. The miners were also incorporated into the assault as infantry above ground, post-detonation. The final time of execution was not released until June 5. Great measures were taken to conceal the date of the offensive, even from the miners themselves. To the British, it seemed unlikely that the Germans did not know of the deep mines beneath their own entrenchments. The British assumed that captured British prisoners had been forced to reveal tunnel locations. In actuality, not one prisoner of war had revealed any

⁵² Leon Wolff, *In Flanders Fields: The 1917 Campaign* (Alexandria, VA: Viking Press, 1958), 133.

information of the mines to the Germans. By June 5, over 8,000 meters of tunnels had been dug 100 feet below the surface. After eighteen months of mining, the offensive was set for execution. Mining officers met beneath the German entrenchments, on the eve of day zero, for a final champagne toast.

4. Effects

Upon inspection of all 22 underground charges and detonating systems, the officers and men made their way back to their perspective attack positions. The staging of Allied troops was done under the cover of darkness with an emphasis on noise and light discipline in the ranks. The entrenched unsuspecting Germans remained vigilant but did not take any additional measures to mitigate the impending assault.

At 0310 hours on June 7, the miners were given the order to detonate the charges. Nineteen of the 22 mines exploded in unison with massive ground turbulence. Immediately, curious miners peered over their own defenses to catch a glimpse of nineteen red mushroom clouds that now occupied Messines Ridge. Large amounts of earth were hurled 3,000 feet into the air. The concussion of the blast knocked the miners down as they watched. The blast was so loud that Londoners even claimed to hear the explosion. The simultaneous detonation of nineteen mines comprised the loudest man-made explosion until that point. Some British soldiers described the detonations as a pillar of fire across the sky. The trembling of the earth itself could be felt in Lille, a town twelve miles away.

The effect of the mine explosions upon the German defenders was devastating (see Figure 19). Some 10,000 men were instantly killed during the explosion alone⁵³. Within minutes, 80,000 British infantry assaulted through the blast site, capturing over 7,300 dazed and confused Germans prisoners. The operation was a complete success. Surrendering Germans waved handkerchiefs as they wept, grasping the ankles of their

⁵³ Duffy, "The Battle of Messines."

captors.⁵⁴ It was as if the earth swallowed up an entire division of men. Craters hundreds of feet wide and deep took over where fortified trenches once stood and can still be seen to this day (see Figure 20).



Figure 17. View from crater on Hill 60 (6 July 1917)⁵⁵



Figure 18. Messines Present Day Crater⁵⁶

⁵⁴ Wolff, *In Flanders Fields: The 1917 Campaign*, 150.

⁵⁵ “Australians on the Western Front 1914-1918” [image], accessed November 10, 2013, <http://www.wwlwesternfront.gov.au/ploegsteert/zwarte-leen/craters-at-hill-60.php#>.

5. Application of DOTMLPF

By examining the applicability to today's operations in subterranean warfare, World War I subterranean operations can be analyzed in terms of DOTMLPF:

- Doctrine—Doctrine did not exist in support of either side. Many German and Allied miners were educated in engineering disciplines. Subterranean capabilities relied mostly on non-military experiences.
- Organization—The Allies did establish tunneling units for a specific operation. However, those units were later disbanded and absorbed back into the conventional force.
- Training—Training for subterranean warfare most likely did not exist. The tunneling at Messines Ridge incorporated those with civilian mining experience prior to the war.
- Leadership—Plumer's leadership was a driving force for the Allies. German commanders underestimated the underground threat. Without Plumer's intimate knowledge of the Messines Ridge and what was required to defeat it, the endeavor would not have materialized. The British chain of command was receptive to Plumer's plan and properly nested the actions of units above ground to exploit the explosive breach.
- Matériel—the flexibility to improvise and cannibalize resources enabled both sides conceal and/or detect mines. New technology was also developed for tunnel detection (Geophones).
- Personnel—It was mere coincidence that both sides had access to civilian miners willing to engage in subterranean warfare.
- Facilities—Facilities for subterranean warfare consisted of actual time spent in private and commercial mines during time served in non-military professions.

6. Conclusion

The British offensive at Messines Ridge should not have been such a surprise to the Germans. Of the original 22 mines installed for the operation, two did not detonate and one was actually discovered by the Germans prior to the assault. As the Germans destroyed the mine, they assumed it to be a unilateral effort. It was unconceivable to them that there could be 21 more mines just as deep. Some German military commanders had suggested the abandonment of the ridge prior to the blast, but the

⁵⁶ Alertomalibu, *Lochnagar Crater Ovillers* [image] accessed November 12, 2013, http://en.wikipedia.org/wiki/File:Lochnagar_Crater_Ovillers.JPG.

German higher command would not allow it. Such an effort would have made the eighteen months of mining a wasted effort for the British. The German position was firm as noted by an intercepted communiqué from German leadership that read: “These strong-points must not fall even temporarily into the enemy’s hands. They must be held to the last man even if the enemy has cut them off on both sides, and threaten them from the rear.”⁵⁷

The battle for Messines Ridge highlighted, for the first time on the Western Front, that defensive casualties in a major engagement actually exceeded attacking losses. It was a victory literally years in the making. The battle exemplifies the techniques of deception and concealment that were never known to the Germans. The success of the mission can be credited to the unconventional and innovative techniques developed by former civilian miners. The British were also able to organize these soldiers into tunneling units which enabled the creativity needed to construct the tunnels undetected. Allowing the miners to develop their own tactics, technique, and procedures, without interference, was a significant factor that ensured mission success. Nonetheless, the Battle of Messines does highlight how a group of men, with underground skill sets, were brought together for a tactical advantage.

What the Battle of Messines should teach us is how lessons of the past are so quickly forgotten. World War I may have been the greatest allied use of subterranean warfare. However, tunneling efforts were dismissed after World War I because they were deemed too slow and not worth the investment. Today, however, adversaries are turning to the underground in order to counter U.S. kinetic capabilities, avoid surveillance platforms, and as a means to cache weapons. There is currently no U.S. doctrine that identifies subterranean as an operational environment despite the fact that the U.S. has fought in subterranean environments since the Civil War at Petersburg.

⁵⁷ Wolff, *In Flanders Fields: The 1917 Campaign*, 135.

D. THE BATTLE OF OKINAWA (1945)

1. Introduction

The largest amphibious assault in the Pacific campaign was that on the island of Okinawa in 1945 which was larger and more costly than the D-day invasion of Europe. United States' casualties from this conflict not only revealed Japanese resolve, but more importantly, were the deciding factor for President Truman to drop two atomic bombs on Japan. The high cost to U.S. and Japanese forces, during this engagement, was due to an evolution of understanding in how the two militaries could better fight each other through tactical innovations by both sides. One of the most significant of these developments was the Japanese tactic of going underground for protection as well as inflicting maximum casualties on the invaders. Thus, the Japanese adopted underground bunker networks to optimize the effectiveness of their weapon systems and their own survivability. The battle constituted the culmination of both Japanese subterranean techniques for defense, as well as U.S. counter-subterranean assault tactics in the Pacific theater.

Okinawa was intended to be the last stand for the Japanese before the main islands of Japan were vulnerable to invasion. The intent of U.S. forces was to capture the island in order to utilize it as a staging area for a subsequent invasion of Japan, vital to U.S. strategy.⁵⁸ The Japanese viewed the island's operations as a delaying action in order to buy time for the entire civilian population of Japan to mobilize for a U.S. invasion. Japanese military leaders also intended for the battle to inflict enough U.S. casualties to demoralize the U.S. in hopes of a cease fire. It was critical to Japanese strategy, therefore, for the Battle of Okinawa to be one of attrition.

2. Background

Prior to the Battle of Okinawa, three years of combat in the Pacific had evolved into a series of "island hopping" maneuvers.⁵⁹ From the Battle of Guadalcanal in 1942 to the Battle of Iwo Jima in 1945, the U.S. and Japanese forces incessantly refined their tactics, techniques and procedures. The U.S. focused on improving its combined arms

⁵⁸ Bill Sloan, *The Ultimate Battle* (New York: Simon and Schuster, 2007), 12.

⁵⁹ Roehrs and Renzi, *World War II in the Pacific* (2nd ed.), (London: ME Sharpe, 2004), 122.

concept to maximize lethality while seizing islands in the approach to Japan. The Japanese similarly evolved their tactics. The famous Japanese Banzai charge (suicide charge) was being utilized less frequently, but their ability to utilize subterranean bunker complexes began to increase as the war progressed. As the Japanese army continued to lose momentum, due to superior U.S. firepower, it was forced to utilize the only tactical advantage it had left, preparing underground defensive positions.

By 1945, the U.S. still did not have specially trained soldiers and marines to enter underground networks in its ranks. Consequently, U.S. troops rarely entered Japanese tunnels. Instead, to mitigate the underground threat, U.S. troops increased their usage of pinpoint indirect fire, flamethrowers as well as demolition teams.⁶⁰ They used these techniques to neutralize the underground bunkers from above by sealing off or collapsing tunnel entrances, air vents and exits. Those Japanese that survived U.S. flamethrowers, by retreating further underground for safety, were left to suffocate or starve to death unless they surrendered. Many Japanese chose suicide or desperate Banzai charges against U.S. troops waiting at a solitary exit, only to be cut down by U.S. rifles and sub-machine guns.

The Island of Okinawa was populated by 400,000 Japanese civilians and a garrison of 100,000 Japanese soldiers and sailors. The Japanese commander was a calm and well-liked Army General named Mitsuru Ushijima.⁶¹ From the moment Ushijima assumed command of the island, he immediately began to change the Japanese strategy from one of coastal defense to fortifying the interior of the island. In previous battles, the Japanese often gave stiff resistance to a U.S. invasion force, even before the first wave hit the beach. In this battle, Ushijima chose to allow U.S. troops to land on the island unopposed in order to allow an adequate quantity of U.S. targets to enter his kill zone. When U.S. troops were in position, Japanese troops pledged they would fight to the death while trying to inflict as many U.S. casualties as possible. The option to surrender was initially not an option for Ushijima's troops.

⁶⁰ Sloan, 163–164.

⁶¹ Hiromichi Yahara, *The Battle for Okinawa*, (New York: John Wiley and Sons, 1995), 64.

3. Subterranean

Ushijima had formulated his battle plan into two separate defensive strategies. In the North he employed a token Japanese force to keep the U.S. troops occupied and to reduce U.S. troop strength as much as possible. In the South, Ushijima focused the bulk of his combat power into three defensive lines that stretched the entire width of the island (east to west). The three defensive lines were centered on the Shuri line which became the most dynamic of the three. The Shuri line also concealed Ushijima's command and control center that was 160 feet below Shuri Castle (a Japanese Monastery). The command bunker was made up of 1,287 feet of tunnels that encompassed 30 rooms and was impervious to artillery and U.S. air strikes.

Construction of these underground networks was assisted and supported logistically by local civilians.⁶² The bunkers were dug into hillsides that consisted of limestone and coral rock. This factor enabled the complex to maintain strong structural integrity under U.S. bombardment. All three defensive lines consisted of underground bunker systems that were mutually supporting. Each defensive fighting position was concealed, into the hillside, with firing ports that were no more than eighteen inches wide. The firing positions were designed for rifles, machine guns, and anti-tank guns. Each position also had interlocking fields of fire with the position to its left and right flank. Additionally, each firing position was connected to a tunnel network that could bring reinforcements and ammunition at will. The tunnels were also designed with several sharp turns at each tunnel entrance and exit to mitigate the threat from U.S. flamethrowers.⁶³ On the reverse slope of the hill, the Japanese had produced a massive artillery and mortar capability to support each fighting position on the other side of the hill. Ushijima emphasized that every approach be pre-sighted for indirect fire support, while any remaining dead space was heavily mined. Ushijima was intent on producing as many U.S. casualties as possible.

⁶² Yahara, 8.

⁶³ Yahara, 71-72.

United States' troops landed on the island of Okinawa on April 1, 1945 at 08:30 hours. The U.S. invasion force was under the command of Army Lieutenant General Simon Bolivar Buckner. Buckner's invasion force consisted of two Army divisions and two Marine divisions. After a successful amphibious landing on the west central coast of the island, Buckner divided his invasion force by sending the two Marine divisions north and two Army divisions south. His intent was to locate the bulk of the Japanese force and destroy it in a decisive battle.⁶⁴ Buckner had no idea he was playing right into Ushijima's defensive plan.

Within the first six days of the operation, the Marines were able to quickly secure most of their northern objectives with minimal Japanese resistance. The only exception to this occurred on the northwest coast of the island within the Motobu Peninsula.⁶⁵ A small northern Japanese force utilized the wooded and rocky terrain of the peninsula to put up fierce resistance. However, the underground bunker networks were not yet fully known and the Marines assumed the Japanese use of the natural terrain was no different from that of previous engagements. The Marines secured the peninsula on April 8. To the contrary, the soldiers in the south did not have such a swift success.

While the Marines were quickly securing the north, Buckner's two Army divisions began to receive stiff Japanese resistance within 48 hours of their approach south. Soldiers ran directly into Ushijima's outposts of the Japanese first line of defense. Without knowing the location of Ushijima's main effort, soldiers received an introduction to the subterranean threat that would define the battle to come. The initial fighting took place on two fortified ridgelines named the Pinnacle and Cactus Ridge.⁶⁶ The first of Ushijima's defensive lines was surprisingly effective and completely halted the Army advance south. By April 8, the Army was finally able to clear the initial fortified outposts at a cost of over 1,500 U.S. casualties. However, in the process, 4,500 Japanese soldiers

⁶⁴ James Hallas, *Killing Ground on Okinawa* (Westport, CT: Praeger Publishers, 1996), 25–26.

⁶⁵ Hallas, 8.

⁶⁶ Sloan, 85–87.

were killed or captured. Buckner was now convinced that he had located Ushijima's main force and began to reorganize his operations. The Battle of Okinawa had only just begun.

Buckner redirected his two Marine divisions south to reinforce his two Army divisions. As U.S. troops advanced further south, the Marines were positioned on the western flank and the Army on the eastern flank. Buckner's troops then came into contact with Ushijima's primary defense in depth, the Shuri line.⁶⁷ Initial contact occurred on April 11 as Army elements attempted to seize two hills that were connected by a saddle (Kakazu Ridge) forming the eastern half of the Shuri line's defense (see Figures 21). A massive Japanese artillery attack, combined with machine gun fire from fortified defensive positions within the two hills, inflicted severe U.S. casualties. One soldier described it as "running into a beehive of bullets." Eventually, soldiers were able to utilize their combined arms approach by quickly calling for fire from artillery, naval guns offshore and close air support to achieve fire superiority. However, the Japanese defenders simply retreated into the safety of their underground sanctuary to wait for the U.S. bombardment to cease. This allowed U.S. soldiers to retrieve their wounded and move to safer positions. Regardless, the U.S. advance was halted once again and the Japanese had received minimal casualties.

⁶⁷ Sloan, 169-170.



Figure 19. Kakazu Ridge on the Shuri Line⁶⁸

Ushijima and his subordinate commanders were overjoyed with their initial success at Kakazu Ridge. Ushijima began to give into the enthusiasm of his troops to exploit the situation. On the night of April 12, he ordered a counter attack along the entire length of the Shuri line. The assault was, however, a catastrophic loss that resulted in 7,000 Japanese killed.⁶⁹ This event confirmed that Ushijima's original defensive strategy was the only option in the face of U.S. fire superiority. The Japanese would remain on the defensive for the remainder of the battle.

As Ushijima's devastated troops pulled back to the safety of their underground bunkers, the U.S. Army remained stalled. Progress became slow and tedious, which frustrated Buckner as each Japanese fighting position had to be taken one bunker at a time. In order for platoons or squads to move forward, every available asset (machine guns, artillery, naval guns, and close air support) had to be utilized to suppress Japanese positions to the left and right of the target.⁷⁰ United States' firepower had to be synchronized in order for demolition teams and flame throwers to rush forward to neutralize the targets (see Figure 22). Satchel charges were used to collapse tunnel entrances as well as kill Japanese troops within range (see Figure 23). Flamethrowers proved to be invaluable. They were not only used to incinerate enemy soldiers but, more

⁶⁸ "Background to 'The Pacific' Part V: Okinawa" [image], accessed May 17, 2013, <http://padresteve.com/2010/05/17/background-to-%E2%80%9Cthe-pacific%E2%80%9D-part-v-okinawa/>.

⁶⁹ Yahara, 109.

⁷⁰ Sloan, 143.

importantly, to consume all oxygen inside a tunnel in order to suffocate Japanese forces deep within. The process continued until May 13 when tanks were brought forward to capture key terrain that anchored the eastern flank of the Shuri line called Conical Hill. The tanks proved invaluable and were able to seize Conical Hill quickly.



Figure 20. U.S. Marine using a flame thrower to clear bunkers (Okinawa 1945)⁷¹

⁷¹ “Ebay,” accessed Nov 2013, http://www.ebay.com/itm/B-W-Photo-Marine-Using-Flamethrower-Okinawa-WWII-WW2-/350438316629#ht_610wt_1133



Figure 21. Demo Team using satchel charge to destroy bunkers (Okinawa 1945)⁷²

Meanwhile on the western flank, the Marines were also running into a quagmire. The western anchor of the Shuri line, crucial to the Marines, was three small hills. Unknown to the Marines, the three hills were mutually supporting with interlocking fields of fire for the Japanese. The hills were given names of Sugar Loaf, Half Moon and the Horseshoe, which would soon be infamous in Marine Corp history.⁷³ Like the Army, the Marines also utilized U.S. advantages in firepower when approaching these hills. However, in this case, these hills, that had extensive underground bunkers systems posed a serious challenge to the Marines. The Marines quickly realized, to move forward, all three hills had to be suppressed in order to approach one hill. The Japanese fire was so intense that regiments were reduced to company strength and, in some cases, platoons and squads simply ceased to exist. To add to the horrific conditions, monsoon rains began to turn the ground into a muddy tangle of garbage and dead bodies. The decaying

⁷² Robert M. Cusack, *A Demolition Crew from 6th Marin Division Watches Dynamite Charges Explode and Destroy a Japanese Cave* [image], accessed May 17, 2013, <http://en.wikipedia.org/wiki/File:OkinawaMarineCaveDemolition.jpg>.

⁷³ Hallas, 34.

American and Japanese corpses sank into the mud and made the smell intolerable. Any Marine forced to seek cover by lying on the ground could expect to be covered in maggots.⁷⁴

Many times, Marines were able to make it to the crest of these hills, only to be driven off by interlocking fire from other hills. In most cases, due to the concealment of Japanese fighting positions, Marines could not even see the Japanese who were shooting at them.⁷⁵ Once Marines were able to maneuver onto a Japanese fighting position, alternate methods were used to clear the tunnels (see Figure 24). One of the most effective occurred when Marines poured oil into the tunnels and underground bunkers (see Figure 25). A flamethrower then would set the oil ablaze, incinerating any Japanese deep inside. At Sugar Loaf alone, the Marines assaulted the hill eleven times during a twelve-day period and sustained 2,000 casualties. The intense Japanese fire from underground bunkers significantly reduced three regiments before the hill was taken on May 18.

⁷⁴ Hallas, 199.

⁷⁵ Hallas, 204.



Figure 22. Japanese soldier emerges from smoke filled bunker⁷⁶



Figure 23. U.S. troops using smoke to clear bunkers (Okinawa 1945)⁷⁷

⁷⁶ Pacific War Post, “Seeing the Light” [image], Pacific War Museum, accessed December 18, 2013, <http://pacificwarmuseum.blogspot.com/2010/04/okinawa-photos.html>.

⁷⁷ “WWII Photos,” [image], Game Squad, accessed December 18, 2013, <http://forums.gamesquad.com/showthread.php?104031-WW2-Photos/page10>.

Ushijima now had his left and right flanks taken by U.S. troops. As Army and Marine units began to close in on Shuri Castle, Ushijima knew he could hold the Shuri Line no longer. Ushijima gave the command for his surviving troops to displace and move south to their third and final defensive line. At this point, the Japanese Army was losing its command and control structure and organization. As U.S. troops cautiously pursued the Japanese, resistance began to degrade. The Japanese no longer had the troop strength to inflict massive U.S. casualties from mutually supporting fortified positions. The Japanese were reduced to small cells of troops intent on holding out to the death. The battle evolved into a manhunt as U.S. troops cleared Japanese soldiers from bunker to bunker. Once again, surviving Japanese had only two options, commit suicide or surrender. Most chose the former, including Ushijima himself.⁷⁸ Small elements continued to be cleared from their defensive positions until June 22 when hostilities ended.

4. Effects

There is no doubt that the Battle of Okinawa was one of the bloodiest battles of the entire war. However, if U.S. tactics during this time had been reconsidered, U.S. casualties could have been reduced. By marines and soldiers disregarding the option to enter and clear tunnels, they were forced to operate in full view of the Japanese from other fortified positions. This caused unnecessary U.S. casualties and prolonged the operation. If specially trained underground teams could have surgically cleared the complex from within, less manpower might have been placed at risk. To the contrary, if Ushijima would have not ordered a counter attack, which wasted valuable manpower, Japanese troops may have continued their defensive strategy for a longer period of time. This most certainly would have created even more U.S. casualties and enabled a further delay for Japan to prepare for an inevitable invasion of its homeland.

⁷⁸ Yahara, 155.

5. Application of DOTMLPF

By examining applicability to today's operations in subterranean warfare, World War II subterranean operations can be analyzed in terms of DOTMLPF:

- **Doctrine**—Doctrine did not exist in support of either side. However, the Japanese refined their use of underground bunker systems out of necessity. The U.S. tactics were to not enter into Japanese tunnels and to counter them from above ground. Even though neither side established formal doctrine for their evolved tactics, the U.S. (flamethrowers/satchel charges) and Japan (bunker networks) did establish techniques and procedures that were retained at the unit level.
- **Organization**—The U.S. did not establish a tunneling unit due to dependency on firepower and policy to not enter the tunnels. The Japanese utilized their entire force for tunnel construction and operation (untrained).
- **Training**—Training for subterranean warfare most likely did not exist. The Japanese gained experience from prior battles and the U.S. relied on a combined arms approach from above ground.
- **Leadership**—Ushijima's leadership was the driving force to shift the Japanese center of gravity to an underground defense in order to inflict massive U.S. casualties. Buckner did not want to involve his force in an underground fight. Instead, he encouraged his troops to rely heavily on U.S. fire superiority to neutralize bunker networks.
- **Matériel**—Flexibility to improvise and cannibalize resources enabled the Japanese to create bunker systems that were mutually supporting. The U.S. refined the use of flamethrowers and satchel charges in conjunction with fire and maneuver tactics.
- **Personnel**—Neither side had designated subterranean units. Soldiers on both sides developed tactics through trial and error.
- **Facilities**—Facilities for subterranean warfare consisted of prior combat operations that involved subterranean bunker systems.

6. Conclusion

In the end, only 7,000 of the 100,000 Japanese soldiers surrendered. Most were killed in combat or committed suicide. Approximately, one third (150,000) of the civilian population of Okinawa was also killed. The U.S., in total, had approximately 13,000 killed and 38,000 wounded. To President Truman, the prospect of even more U.S. casualties to be expected from another underground threat became an unthinkable

option. It was an indication of what an invasion on the home island of Japan would entail. Measures would have to be taken in order to save American lives, and therefore, Truman thought, using the atomic bomb became the only reasonable option.

Underground bunker systems are even more likely today than ever before, due to the superiority of U.S. airpower. Several lessons can be learned from the Battle of Okinawa and applied to tactical considerations today. One of the most significant is the decision not to enter a bunker system in order to clear it with superior firepower. It is well known that currently most adversaries will certainly seek cover while simultaneously attempting to inflict high numbers of U.S. casualties. The choice to not enter a subterranean system leaves dead space on the flanks and to the rear that can be a threat to U.S. troops; this may result in a prolongation of the mission and unnecessary U.S. lives lost due to not clearing tunnels surgically with troops. On Okinawa, if U.S. troops had cleared tunnels from below ground, an advance could have been more efficient with fewer risks to U.S. soldiers above ground. Thus, the need for U.S. troops to advance while being fired upon by multiple positions would have been mitigated. In other words, the decision to not enter enemy tunnel systems appears to have been detrimental in a combat environment.

E. TUNNEL WARFARE DURING THE VIETNAM WAR (1966)

1. Introduction

One of the most notable subterranean efforts by the United States military was during the Vietnam War. The Viet Cong use of tunnel warfare forced the U.S. military to reevaluate its subterranean tactics, techniques, and procedures. For the first time, the U.S. military decided to no longer avoid entering enemy tunnel systems. An underground capability was needed to breach and clear subterranean safe havens, and thus, a specialized unit of subterranean warriors was formed to operate underground. A new method was established by organizing and training soldiers that were specially selected for their small stature and emotional fortitude; this all-volunteer force

transformed themselves into subterranean specialists. Using only a handgun, knife and flashlight, they trained themselves in tunnel-exploration and tunnel-warfare. They are best known as “Tunnel Rats.”

Unlike past experiences in World War II, when U.S. troops rarely entered a tunnel complex, the Vietnam War presented a new underground problem set that U.S. troops were forced to confront. The Viet Cong (VC) was an insurgent force that preferred not to reveal its position unless it was at a tactical advantage. In order to conceal its safe havens and movements, the VC constructed tunnel complexes that ranged from the rudimentary to sophisticated in construction. These tunnels gave the VC a sense of invulnerability, which boosted their moral. The tunnels were usually located in the rural areas and villages of South Vietnam, which “afforded the VC excellent cover and allowed them to pop-up at any time” while concealing movement to and from combat operations.⁷⁹ In most cases, U.S. troops would rarely see more than a glimpse of the VC during an engagement.

2. Background

The VC utilized hit-and-run techniques that frustrated U.S. troops. This frustration occurred when U.S. troops attempted to pursue VC members, which then culminated in only catching a glimpse of them as they melted away into the jungle. Frequently, U.S. troops would receive sniper fire from a position that was assumed to be hidden in a tree line. After the tree line was searched, no sign of the enemy was present. The U.S. troops could not understand how the VC was able to disappear without a trace. In reality, the VC had utilized a tunnel system to escape and escape out of the area undetected (see Figure 26).

⁷⁹ Allen D. Reece, *A Historical Analysis of Tunnel Warfare and the Contemporary Perspective*, 1998, last accessed March 11, 2013, <http://www.dtic.mil/dtic/tr/fulltext/u2/a339626.pdf>

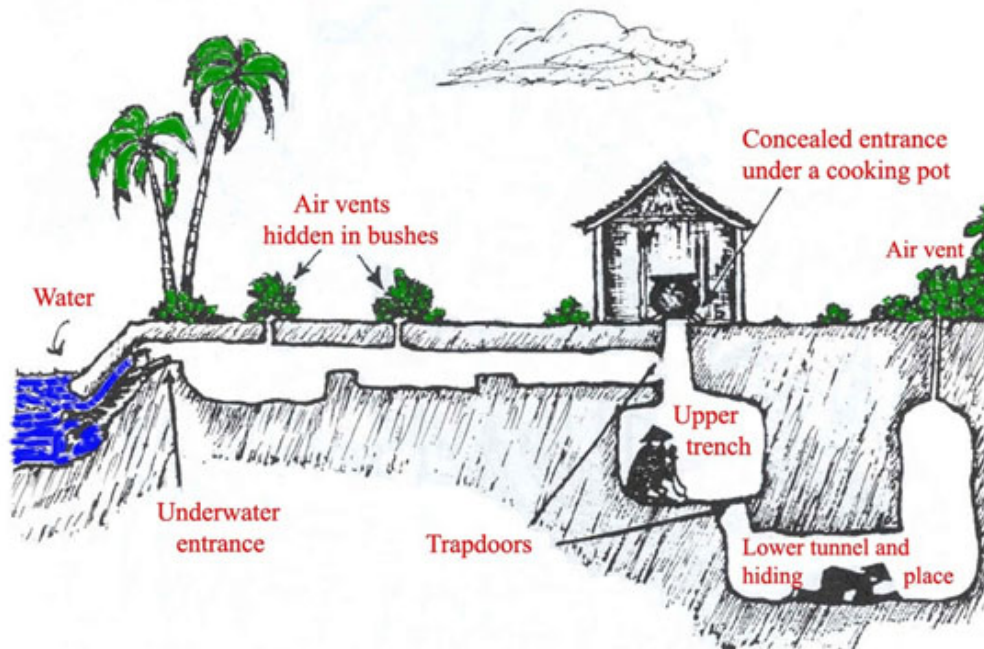


Figure 24. Example of Viet-Cong Tunnel System⁸⁰

After several clearing operations, through VC controlled areas, there were very few considerable engagements that enabled U.S. troops to close with and destroy VC units. This all changed in January, 1966 when the 173rd Airborne (ABN) Division conducted Operation Crimp in a notorious VC stronghold known as the Iron Triangle. During the operation, U.S. troops encountered several booby-traps and bunkers. Australian engineer sappers were called in which were attached to the 173rd ABN. As the Aussie sappers began to clear, they stumbled onto a heavily concealed door that led into a tunnel entrance. An American working dog was called in to investigate. After the dog refused to enter the tunnel entrance, the Aussie sappers stood by unsure of what action to take next. After a brief deliberation, the Aussie sappers entered the tunnel entrance with a flashlight and a bayonet.⁸¹ Once inside, the Aussie sappers were astonished to see the level of sophistication in tunnel construction. The tunnel complex “turned out to be VC

⁸⁰ “Vietnamese Tunnels,” [image], accessed November 17, 2013, About Facts Net, <http://aboutfacts.net/Things8.htm>.

⁸¹ Irrp, “Tunnel Warfare: Vietnam Experience - Six Silent Men,” July 12, 2008, last accessed March 13, 2013, <http://lrrp2.wordpress.com/2008/07/12/tunnel-warfare-vietnam-experience/>

headquarters and one of the biggest intelligence coups in the war to that time.”⁸² It was also the first example of soldiers entering a VC tunnel complex in Vietnam. This complex would be known as the Cu Chi Tunnels.

The Cu Chi tunnel complex was built by the 9th VC Division. The tunnels consisted of hospitals, dormitories and a command and control centers. Unknown to the Australians and the 173rd ABN, the tunnel complex stretched from Saigon to the Ho Chi Minh Trail in Cambodia, which was a distance of roughly 155 miles. It later became a VC staging area for the Tet Offensive in 1968. As Australian and U.S. troops began to discover more of the tunnel complex, numerous intelligence documents were discovered inside. Thus, U.S. commanders were compelled to send even more soldiers into the tunnels. The intent was to recover weapons caches and documents, and engage the VC face to face. These subterranean soldiers were all volunteers and became known to U.S. troops as “Tunnel Rats” and to Australians troops as “Ferrets.” This volunteer cadre was formed out of necessity and expanded the Vietnam War into two operational environments, evolving into operations above and below ground.

As word spread of VC tunnel activity in Cu Chi, the U.S. Army soon realized that attempting to destroy a VC tunnel complex would be inconsequential. If a tunnel was destroyed before it could be exploited, the opportunity to gather vital intelligence on the VC would be lost. Moreover, the tunnel could not be bypassed since it would involve ignoring a threat and would enable the VC to attack from the rear. Thus, there was the realization that a formal unit must be organized to enter and clear every tunnel discovered. United States’ Army infantry units began to informally piece together volunteers to enter this foreign subterranean environment (see Figure 27).

⁸² Allen D. Reece, *A Historical Analysis of Tunnel Warfare and the Contemporary Perspective*, 1998, last accessed March 11, 2013, <http://www.dtic.mil/dtic/tr/fulltext/u2/a339626.pdf>.



Figure 25. Tunnel Rat Unit Patch⁸³

3. Subterranean

One of the first attempts to formalize such a unit of “Tunnel Rats” was by a chemical officer from the 1st Infantry Division, CPT Herbert Thornton. In selecting volunteers “Thornton sought a special breed of soldier. He had to have an even temperament, an inquisitive mind, a lot of common sense (in order to know what to touch and what not to), and to be exceptionally brave.”⁸⁴ Most of Thornton’s men were small in stature. They were intended to squeeze through tight trap doors and crawl along the narrow passages with relative ease. Volunteers soon became part of standard operating procedure for most infantry units.

Due to the operational tempo of infantry units in combat, there was not much time for formal training for most Tunnel Rat units. Thus, a new Tunnel Rat recruit would be forced to learn from a more experienced Tunnel Rat, or through direct experience. A Tunnel Rat soon realized that entering into a tunnel entrance was a terrifying experience. New techniques had to be developed in order to enter a tunnel entrance while maintaining security. Before entering a tunnel, each Tunnel Rat would strip off any excess clothing and/or equipment. This would allow the Tunnel Rat ease of movement underground. Equipment was kept to a minimum, usually just a flashlight, bayonet, pistol and spare

⁸³ Command Post, “Tunnel Rat Patch” [image], accessed November 17, 2013, Army Surplus World, <http://www.armysurplusworld.com/product.asp?ProductID=27485>.

⁸⁴ Irrp, “Tunnel Warfare: Vietnam Experience—Six Silent Men”, last accessed March 13, 2013, <http://lrrp2.wordpress.com/2008/07/12/tunnel-warfare-vietnam-experience/>

ammunition. Sometimes a mask was carried if gas had been utilized prior (see Figure 28 and 29). Eventually, the U.S. Army developed tunnel exploration kits that consisted of a “headlamp, communication system (utilizing a wire and bone microphone), and a .38 caliber revolver with silencer and aiming light. These innovative kits rarely made it to the troops in the field conducting combats operations.”⁸⁵ Thus, Tunnel Rats were more often reliant on a flashlight, 1911 pistol (.45 caliber automatic) and a bayonet (see Figure 30). Most Tunnel Rat units would operate in two to three man teams in order to support each other in case of enemy contact.



Figure 26. Australian and U.S. troops utilizing a blower to clear tunnel at Cu Chi⁸⁶

⁸⁵ Army Concept Team in Vietnam, *Evaluation of Tunnel Exploration Kit*, 1967 last accessed March 13, 2013, <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=AD0804859&Location=U2&doc=GetTRDoc.pdf>

⁸⁶ “Viet Cong Tunnels,” [image], accessed November 17, 2013, Australia and the Vietnam War, <http://vietnam-war.commemoration.gov.au/combat/viet-cong-tunnels.php>.



Figure 27. Tunnel Rat entering a tunnel wearing a gas mask⁸⁷



Figure 28. Clearing tunnel with .45 caliber pistol and flashlight (Cu Chi 1967)⁸⁸

⁸⁷ “Vietnam War, Tunnel Warfare,” [image], accessed November 17, 2013, Warchapter.com, http://www.warchapter.com/Vietnam_war_Tunnels.html.

⁸⁸ Robert C. Lafoon, “SGT Ronald A. Payne Tunnel Rat Vietnam” [image], accessed December 12, 2013, *Wikimedia*, http://commons.wikimedia.org/wiki/File:Sgt._Ronald_A._Payne_Tunnel_Rat-Vietnam_War,_1-24-1967.png.

One of the most difficult tasks for the troops above ground was tunnel detection. The VC was able to camouflage tunnel entrances so effectively that a U.S. soldier would have to stomp his foot on the door of a VC tunnel entrance to locate it. Eventually, some of the indicators for tunnel detection were clumps of bamboo that afforded a terrain advantage. Even though an entrance was camouflaged, a very distinct trail could be seen leading through the bamboo. This trail would inevitably end in the area of the tunnel entrance. Also, air shafts could be detected by looking for bamboo stalks stuck in the ground meant to look like the surrounding bamboo. These air shafts usually could be seen by detecting a stalk that had been cut.⁸⁹

Once a tunnel entrance had been detected, a Tunnel Rat would enter a narrow tunnel entrance head first, while his teammates would lower him into the tunnel by holding his ankles (see Figure 31). This allowed the lead Tunnel Rat to have his M1911 pistol in one hand and his flashlight in the other to engage enemy personnel (see Figure 32). Once inside, the lead Tunnel Rat would also utilize his bayonet to probe for mines or booby traps. As a team would progress further into a tunnel, the lead man would continue to probe with a bayonet while the number two man would assist in pulling security while simultaneously checking for trip wires on the ceiling of the tunnel. Some accounts describe how the VC would hang poisonous snakes (bamboo viper, or krait) from the ceilings in a tunnel as a booby trap. This created a psychological effect on U.S. Tunnel Rats that only the most resolute could overcome. For some, the mental factor was a far biggest obstacle:

...imagine yourself worrying that your heart is beating too loud, is there enough air, where is the trip wire, where are the snakes, will the pistol work, how fast can I crawl backwards and I hope the VC is moving away from me?⁹⁰

These were the thoughts that could sometimes overwhelm a Tunnel Rat.

⁸⁹ Military Assistance Command, Vietnam, *Techniques for Detecting, Neutralizing and Destroying Enemy Tunnels*, 1969, last accessed March 13, 2013, <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=AD0683375&Location=U2&doc=GetTRDoc.pdf>

⁹⁰ Fred Meurer (former Tunnel Rat commander), interview with Josh Bowes (author) August 12, 2013



Figure 29. Tunnel Rat entering a tunnel head first⁹¹



Figure 30. Tunnel Rat inspecting entrance before entering tunnel⁹²

A typical VC tunnel was constructed with several 60 and 120 degree turns. This would deny Tunnels Rats the ability to fire down a tunnel more that 10–20 yards. It

⁹¹ “The Vietnam War Tunnel Rats,” [image], in *Cherries: A Vietnam War Novel*, accessed December 12, 2013, <http://cherrieswriter.wordpress.com/2012/08/04/the-vietnam-war-tunnel-rats-guest-blog/>.

⁹² “Vietnamese Army Including the Viet Cong,” [image], accessed November 17, 2013, http://vietnamresearch.com/nvavc/vc_nva.html.

would also provide cover for VC in order to ambush a Tunnel Rat as he approached. If enemy contact was made in the tunnel, a Tunnel Rat learned to fire his pistol reflexively, without taking careful aim, due to the close proximity. After the engagement, a Tunnel Rat quickly conducted a magazine change regardless if his pistol was empty or not. This was due to the VC knowing how many rounds an M1911 pistol would fire until it was empty and in need of a magazine change. This delay would provide the VC an opportunity to engage a Tunnel Rat unopposed.

It was well known to conventional forces above ground that Tunnel Rats would experience a very physically and mentally demanding task underground. It could also push a Tunnel Rat's emotional state to his breaking point. Operating in a confined pitch-black environment, while crawling for hours looking for a heavily armed enemy, who have the advantage, would cause most soldiers to mentally break down. According to *Tunnel Warfare*, "Occasionally, under the strain, a Tunnel Rat's nerves would break and he'd be dragged from the tunnel screaming and crying. Once this happened he would never be allowed down a tunnel again."⁹³ Only the strongest were allowed to continue.

Some infantry units developed tear gas generators to utilize in conjunction with their Tunnel Rats. In order to mitigate these efforts, the VC constructed water traps underground. A water trap was an obstacle that was intended to seal off a tunnel from gas. In order to clear a water trap, a person entering the tunnel would need to submerge under the water to clear the obstacle, in order to continue through the tunnel to the other side. As a Tunnel Rat would clear a water trap and rise out of the pitch black water, he was completely defenseless. A VC soldier could easily be waiting on the other side of the water trap in ambush. The thought of an AK-47 waiting as they raised heads out of the water, was more that some Tunnel Rats could take. The 25th Infantry Division had a standing rule for its Tunnel Rats. If a Tunnel Rat cleared more than three water obstacles in one day, he was relieved by a teammate and was not allowed to continue for the next 24 hours.

⁹³ Irrp, "Tunnel Warfare: Vietnam Experience—Six Silent Men," 2008, last accessed March 13, 2013, <http://lrrp2.wordpress.com/2008/07/12/tunnel-warfare-vietnam-experience/>

Most Tunnel Rats would describe the experience by saying, “the feeling you get, crawling into a tunnel, knowing that someone or something is trying to kill you, can never be fully understood or explained. At the time, we thought we were invincible.”⁹⁴ Another fear factor for a Tunnel Rat was not only what could happen underground but also what could happen above ground as they came out at a different tunnel entrance. The sight of a small man, stripped of a uniform, covered in dirt, would surely be mistaken for a VC and shot by a fellow U.S. soldier. The Tunnel Rats developed signals, such as simply whistling “Dixie” before he exited a tunnel to alert any fellow U.S. soldiers.

4. Effects

This underground occupation transformed the Tunnel Rats into a position of respect and reverence by conventional troops. Most soldiers saw Tunnel Rats in their units as “brave but crazy” to volunteer for such a job. As for the Tunnel Rats, there were various reasons to continue in such an occupation. Some enjoyed the admiration from their fellow soldiers, others were attached to the adrenaline “high” of facing death underground and living to tell the tale. Regardless, these men were conducting a new type of subterranean warfare that had not been experienced in prior historical U.S. conflicts. The U.S. military had not established training or doctrine to draw reference from. It was simply developed in combat, out of necessity and with great success.

Once a tunnel complex was clear of VC, a ground force commander would make the decision to destroy the tunnel and U.S. Army engineers would be called in. The Tunnel Rats would then assist the engineers in destroying a tunnel complex in order to deny it from being used again by the VC.⁹⁵ The demolition process would initiate with a Tunnel Rat having to re-enter the tunnel to place explosive charges. The explosives were placed at intervals throughout the tunnel. Each satchel charge was set in a descending order in reference to the time fuses. This would enable the charges to detonate

⁹⁴ Fred Meurer (former Tunnel Rat commander), interview with Josh Bowes (author) August 12, 2013

⁹⁵ “Tunnel Destruction pt1-2 1969 US Army Training Film Vietnam War” YouTube video, posted by “Jeff Quitney,” December 18, 2013, <http://www.youtube.com/watch?v=EeNP-aUT0sY>

simultaneously while allowing the Tunnel Rat time to get to a safe distance away. After total destruction of the tunnel, Tunnel Rats would consolidate, reorganize and move to the next tunnel complex to start the process again.

5. Application of DOTMLPF

By examining the applicability to today's operations in subterranean warfare, U.S. subterranean operations in Vietnam can be analyzed in terms of DOTMLPF:

- **Doctrine**—Doctrine did not exist in support of either side. The U.S. began to refine subterranean tactics, techniques and procedure that remained at the unit level. However, the U.S. military did not develop subterranean lessons learned into doctrine. The VC refined their underground techniques and procedures but retained lessons learned at the unit level.
- **Organization**—The U.S. established tunneling units that specialized in clearance and destruction of VC tunnel networks. The VC utilized their entire force for tunnel construction and operation (untrained).
- **Training**—Training for Tunnel Rats was not conducted in a formalized setting. Each new Tunnel Rat depended on learning from more experienced members, within the unit, and on-the-job training. The VC were untrained and refined their techniques from prior engagements prior.
- **Leadership**—CPT Herbert Thornton's initiative was the catalyst that encouraged the development of subterranean units throughout the U.S. military in Vietnam. The VC chain of command encouraged underground operations because of the inability to maneuver in daylight due to U.S. aircraft. This tactic was adopted out of necessity.
- **Matériel**—Out of necessity, Tunnel Rats used tools that were already in the inventory (.45 caliber pistol and a flashlight). The development of tunneling kits was also prevalent. However, new equipment seldom made it out to troops in the field, and those that did were regarded as useless and cumbersome. The flexibility to improvise and cannibalize resources enabled the VC to create vast tunnel networks undetected.
- **Personnel**—Tunnel Rats volunteered and were selected at the unit level. However, those units were reabsorbed back into the regular force after the war and valuable subterranean experience was lost.
- **Facilities**—Facilities for subterranean warfare consisted of combat operations that were ongoing at the time.

F. CONCLUSION

The tunnel networks during the Vietnam War presented an extensive dangerous combat environment for U.S. troops. “By the end of 1970, 4,800 tunnels had been discovered by the United States and allied forces.”⁹⁶ Viet Cong tunnels were able to delay and/or stop U.S. infantry units with a profound disruption to combat operations. With no choice but to clear newly discovered tunnels, the U.S. Army depended on the specialized skill set of the Tunnel Rats. Without such a specialized force, U.S. troops would have most certainly incurred far more casualties and achieved far less success. In future conflicts, much can be learned from references to tactics, techniques and procedures that were established by the Tunnel Rats. Not to learn from that experience would constitute a lost opportunity for U.S. military efforts.

During the Vietnam War, the utilization of uniquely skilled subterranean soldiers, organized into distinct units, was a huge leap forward in underground warfare. It marked the creation and the disappearance of subterranean doctrine in a combat environment. Subterranean lessons learned began to be disseminated through the ranks from which other Tunnel Rat units could benefit. However, valuable subterranean tactics, techniques and procedures were never established into formal military doctrine. Most of the lesson learned were filed away into unit store rooms or lost over time.

Rudimentary tunnel systems as experienced during the Vietnam War are not unique to that conflict; it is an underground pattern that continues today. The U.S. must not ignore lessons from the past or current threats that are seeking advantages underground. North Korea, Iran, transnational criminal organizations, and violent extremist organizations are all known to conduct tunneling activities. Much like airborne forces are designed to conduct a vertical envelopment, subterranean forces may offer the strategic surprise of envelopment from below.

⁹⁶ Allen D. Reece, *A Historical Analysis of Tunnel Warfare and the Contemporary Perspective*, 1998, last accessed March 11, 2013, <http://www.dtic.mil/dtic/tr/fulltext/u2/a339626.pdf>

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IV. CASE STUDY COMPARISON AND ANALYSIS

A. TREND COMPARISON

There are several trends that are apparent in warfare. Even though the case studies that have been presented span many centuries of warfare, there are several elements that are common to all. The most significant tendency is for militaries to seek a subterranean advantage when the ability to maneuver has been reduced. In all five case studies, maneuver was disrupted by either a stalemate at the tactical level, or an insurgency that was forced underground for protection at the operational level. All scenarios have also indicated how the subterranean option became logical, to employ, when no other means of maneuver was possible. A clear understanding of these subterranean trends will be invaluable to future conflict.

During the siege of Constantinople, the Ottoman Turks were unable to maneuver in order to defeat the Byzantines inside the city walls. The Turks chose to employ rudimentary tunnels under the walls to breach the cities' defenses. During the siege of Petersburg, the Union army was at a stalemate due to the formidable Confederate entrenchments around the city. The Union army also chose to utilize a rudimentary tunnel under the Confederate defensive line to emplace an explosive breach. During World War I, the Allies were also at a stalemate with German forces at Messines Ridge. To break the quagmire, 22 tunnels were dug in order to detonate simultaneous explosive breaches that were nested with massive Allied assault. In Okinawa during World War II, the Japanese chose to construct mutually supporting underground bunker systems. By going underground, the Japanese minimized their vulnerabilities while maneuvering from one defensive position to another. In South Vietnam, the Viet Cong were also forced to seek an underground solution to mitigate being detected by U.S. aircraft or ground troop. The human instinct to go underground, when maneuver is disrupted, is a key factor in every case study. It is also an indicator of what an adversary will be inclined to pursue when faced with in similar circumstances.

In terms of significant commonalities, there are also factors that have been repeated in the past that will provide awareness for the future. In the case studies of the Byzantines and World War I, both involved tunneling and counter tunneling. The ability of an attacker to approach a defensive line undetected is problematic for either side. In both cases, counter tunnels were dug to interdict an attacker's approach which demonstrates a defender's ability to detect and locate an attacker's tunnel. Finally, both case studies involve intensive hand-to-hand combat that occurred when contact was made underground.

The concealment of tunnels is also a repeated. The Turks purposely dug tunnels at oblique angles, from the walls of Constantinople, to conceal their approach. In Petersburg, Union miners made an effort to conceal their ventilation system between siege lines. The use of a fire in the tunnel, for air circulation, was concealed by keeping multiple Union campfires burning to produce smoke which concealed the air/exhaust vent. In Vietnam, the Viet Cong created numerous methods to conceal tunnel entrances, airshafts and exits in plain sight by utilizing what was natural to the landscape.

The superiority of U.S. firepower has also been a factor causing adversaries to seek the subterranean environment for protection and/or concealment. In Okinawa, the Japanese were forced to modify above ground operations into subterranean tactics for protection while inflicting massive U.S. casualties. In the Vietnam War, the Viet Cong were also forced to go underground for protection in the face of superior U.S. firepower. However, VC tunnels were utilized as clandestine safe havens instead of fortified positions. The Okinawa case study also illustrates how the decision for U.S. troops not to enter Japanese subterranean bunkers became instrumental in causing high U.S. casualties.

To the contrary, the Vietnam case study validates the effectiveness of specialized U.S. troops to enter tunnel systems to mitigate the VC threat from their rear. The shift in U.S. tactics became the catalyst for the development of subterranean tactics, techniques and procedures that remain relevant today. This U.S. underground surgical approach also resulted in minimal U.S. casualties. In addition, during World War I, the Allies were also

very successful in the construction of 22 tunnels that required dynamic subterranean skill sets. The formation of underground units greatly contributed to the overall Allied success at Messines Ridge.

B. DOTMLPF ANALYSIS OF CASE TRENDS

Given the factors from all five historical case studies, it is easy to see why subterranean warfare is a trend that continues today. Some broader conclusions from the cases of subterranean operations can be drawn through the application to DOTMLPF:

- **Doctrine**—Doctrine did not exist in any of the case studies presented. However, the refinement of subterranean tactics, techniques and procedure remained at the unit level in all five case studies. The U.S. military failed to establish these subterranean lessons into doctrine; the majority of the lessons it learned were poorly documented, limited to the participating unit, and not widely distributed throughout the U.S. military.
- **Organization**—The formation of specialized underground units did not occur until World War I when the Allies temporally organized ex-miners, from their ranks, into tunneling companies. The U.S. formation of Tunnel Rat units refined the organization into a semi-permanent element that was utilized throughout the war but afterwards disbanded.
- **Training**—Formalized training for subterranean units did not exist in any of the case studies presented. The majority of the case studies relied heavily on the experience and expertise of former miners within their ranks. In Vietnam, the U.S. military did not provide standardized training to inexperienced soldiers when assigned to Tunnel Rat units. As a result, inexperienced Tunnel Rats relied heavily on the lessons learned from more experienced members within the unit. The high operational tempo of Tunnel Rat units forced new arrivals to learn by means of on the job training during combat operations.
- **Matériel**—Out of necessity, in all five case studies, underground soldiers were forced to utilize organic resources to construct or clear tunnels. Most utilized weapons and equipment that were already in their inventories, in a subterranean environment. For example, in Okinawa, flame throwers were instrumental in clearing tunnels from above ground. In Vietnam, Tunnel Rats simply relied on their senses, a .45 caliber pistol, and an elbow flashlight when entering a tunnel.
- **Leadership**—The success or failure of all five case studies can be credited by the leadership of commanders that had a clear and definitive understanding of the subterranean environment. Not understanding the capabilities and limitations of underground warfare can be catastrophic to U.S. forces operating underground.

- Personnel—In all five case studies, the majority of organizations relied on former miners that were already acclimated to a subterranean environment. In Vietnam, due to lack of miner experience, Tunnel Rats were an all-volunteer force. Most volunteers were small in stature and could easily traverse through restrictive rudimentary tunnels. However, once a Tunnel Rat displayed any mental adversity (an emotional breakdown) to operating underground, he was never allowed into another tunnel and was sent back to the regular force.
- Facilities—Training facilities, for subterranean warfare, consisted of combat operations that were on-going at the time (on the job training).

V. RECOMMENDATIONS AND CONCLUSIONS

A. ANALYSIS BY DOTMLPF FOR CURRENT U.S. LAND FORCES

1. Doctrine

The extent of subterranean warfare doctrine within the U.S. Army is found within the following current publications: FM 3-06 *Urban Operations*, ATTP 3-06.11 *Combined Arms Operations in Urban Terrain*, ATTP 3-21.50 *Infantry Small-Unit Mountain Operations*, and FM 3-34.170 *Engineer Reconnaissance*. Historical doctrinal publications such as FM 90-8 *Counter guerrilla Operations*, and FM 90-101-1 *An Infantryman's Guide to Urban Combat* also contain fragments of subterranean doctrine. The U.S. Army's Asymmetric Warfare Group (AWG) combines a majority of this doctrine into a single publication titled, *AWG Subterranean Handbook*. The limitations of these current publications is the lack of consideration beyond tunnels and urban and natural cavities, and the limited detail to which other DOTMLPF factors and operational considerations are discussed. The subterranean environment, as described by this capstone's established typology, spans environments ranging from the most rudimentary tunnels to deep underground facilities; the totality of which current doctrine fails to address. Today's military forces, regardless of location or geographic orientation, must concern themselves with the preparedness to engage in subterranean operations. This section of the analysis seeks to identify gaps in current publications and highlight the need for a more comprehensive doctrine.

In order to develop a comprehensive doctrine on subterranean warfare, TRADOC should consolidate information currently scattered across doctrinal areas. Information found in FM 3-34.170 on tunnel uses, detection, reconnaissance, and destruction is valuable to any unit conducting subterranean operations; however, it is unlikely to be sought after outside of the career engineer field. Similarly, the information found in other publications is of value to more than their specifically illustrated environments. Once consolidated, planning considerations, threats, and challenges associated with subterranean environments can be expanded to include the full scope of the subterranean

typology. Integrating the identified subterranean attributes can assist leaders in focusing intelligence collection and can aid in determining resource allocation. Finally, alternate approaches should be discussed to provide commanders with options other than committing forces underground.

a. Planning Considerations

Commanders and planners should have detailed knowledge of the types and general locations of subterranean systems and structures within their planned operational areas. The need to plan a subterranean operation may result from a directed mission or in response to an immediate threat or intelligence opportunity. Subterranean operations may occur across the full spectrum of combat and rules of engagement. Mission, enemy, time, terrain, troops available, and civilian considerations (METT-TC) will often change. The commander's decision to commit soldiers into a subterranean environment must be thoroughly analyzed.⁹⁷

Existing methodologies dealing with intelligence preparation of the operational environment (IPOE) can assist in providing the best operational picture, and should include known or suspected subterranean systems or structures within the area of operation (AO). A Subsurface Area Overlay, such as that discussed in FM 3-06, applies not only to other environments beyond urban, but should be expanded to incorporate assessment of engagement factors described within the subterranean typology and illustrated using the subterranean graphical symbol. In many areas, imagery intelligence (IMINT) exists or may be requested to support analysis. Also, measurement and signature intelligence (MASINT) platforms can be leveraged to provide closer analysis of known underground structures. Multi-spectrum imagery may be able to detect surface anomalies that could indicate subsurface vents, intakes, or portals. Tunnels and existing underground infrastructure may extend into areas controlled by insurgents and even

⁹⁷ U.S. Army Asymmetric Warfare Group, *Subterranean Warfare Handbook* (Fort Meade, MD: Headquarters, U.S. Army Asymmetric Warfare Group, 2009), 3-1.

among different parts of the population. The IPOE process is a cycle and should be continually evaluated to assess changes in the environment and how these systems impact culture and economic conditions in the AO.⁹⁸

Conducting a thorough terrain analysis can reveal locations of subterranean activity. Any areas that employ access control measures such as fences or walls could be undermined. International borders, in particular, are targets for subterranean operations; this may be done in order to capitalize on the illicit transportation of smuggled goods and persons. Areas of high topographical relief changes such as mountains and canyons should be analyzed for indicators of subterranean activity. Roads or trails that seem to end abruptly or lead to nowhere may illuminate a transportation network supporting subterranean activity. Roads, power and other utility lines must go somewhere. Following these structures on imagery to places where they seemingly disappear can reveal an underground facility. Unexplainable or isolated surface structures such as power transformers not near population centers, or buildings that radiate excessive amounts of heat may indicate infrastructure support to a UGF. Keeping this in mind, some surface structures may serve as decoys or deception mechanisms to disguise the extent or layout of subterranean areas. Cut-and-cover facilities may be more difficult to detect, but can be exposed by human behavior. Small isolated buildings that have more vehicles parked outside than would reasonably be expected could indicate a vertical shaft access portal. It is important to conduct surveillance of these areas to identify suspicious anomalies.

In order to identify and document all known vulnerabilities, a micro-terrain analysis should be conducted of any suspected subterranean site to include any site occupied by friendly forces for an extended period of time. These site surveys are important to IPOE in order to visualize where infrastructure and vulnerabilities may exist. Surface infrastructure and existing buried infrastructure that can be used to circumvent force protection measures must be identified. Planners should plot site information on a map using imagery and identify the most likely areas from which the enemy can tunnel.

⁹⁸ Ibid., 3-2.

Understanding the surrounding local infrastructure is critical to force protection. Intelligence should be gained on what residences or businesses have been recently purchase or rented. Distances from perimeter protection to surface infrastructure and residences or businesses should be identified.

Entering a subterranean structure should be a deliberately planned operation. Once a subterranean structure is identified, the area should be isolated and surface structures cleared before entering. Maneuvering forces above ground and below ground simultaneously should be avoided. Above ground personnel need to be prepared to provide support to personnel deployed in subterranean environments. Subterranean teams have a difficult task to provide situational awareness to above ground elements. Current doctrine that discusses the organization and techniques for Cordon and Search Operations can be applied. Tactics described in current doctrine, including clearing hallways and establishing above ground cordon and security, are all applicable. However, the tactics in tunnel destruction described in FM 3-34.170 by “firing one or two magazines from a rifle into the tunnel entrance” prior to conducting a loudspeaker call-out would not only be counterproductive, but likely a useless waste of ammunition. Additionally, there are much more effective ways to breach access portals than placing a grenade on portal covers.⁹⁹ This method of destruction seems to be adapted from battle drill five, “Knockout a Bunker.” If the friendly element is not engaged from the subterranean structure, clearing and site exploitation prior to destruction or access denial of the site would be a greater use of resources.

b. Threats

The environmental hazards of subterranean operations include flooding, cave-ins, and suffocation. Air quality, degraded by smoke, gas, or airborne debris is a primary concern. Soldiers will also face psychological challenges brought on by claustrophobic spaces, limited visibility, and disorientation. Lack of ambient light will challenge night vision devices, and communication signals may be difficult to maintain in

⁹⁹ Department of the Army, Headquarters Department of the Army, FM 3-34.170/MCWP 3-17.4, *Engineer Reconnaissance* (Washington, DC: Headquarters, Department of the Army, 2008), 4-23.

a range of underground depths. The risk of booby traps and unexploded ordinance will further increase the risk to force and degrade speed of movement.¹⁰⁰

An enemy that is prepared to use the subterranean environment can force the fight on two levels and extend resources beyond more than just street-level fighting, thus challenging traditional battle planning strategy. Subterranean passages provide the enemy with covered and concealed routes into and through built-up areas. This enables the enemy to launch attacks along roads that lead into the city while infiltrating a force behind established perimeters. Document ATTP 3-06.11, section VII Subterranean Operations, discusses the advantages and disadvantages associated with the role of attacker and defender. What is important to realize in the COE is that the role of attacker and defender changes often. These roles become so blurred that the only clear reality is that the enemy, whether attacking or defending, has the advantage in the subterranean environment. Only intelligence, planning, and preparation can lessen this advantage.

Underground passageways provide tight fields of fire that force troops to advance in dangerous, funnel-like formation. Obstacles placed at tunnel intersections set up excellent ambush sites and turn subterranean passages into deadly mazes. The enemy can easily gain the element of surprise through selection of ambush positions and withdrawal routes. The enemy's familiarity with the subterranean systems will facilitate its use for ready-made lines of communication, movement of supplies and supply caches, and evacuation of casualties.

c. Challenges

Soldiers who find themselves within the subterranean operational environment will be faced, not only with the unique challenges of being underground, but will find these challenges compounded by effects of above ground combat.¹⁰¹ The placement of underground facilities in populated areas near schools, hospitals, religious buildings, and other civilian infrastructure makes detection and elimination of these facilities difficult. Military planners must be able to conduct subterranean operations

¹⁰⁰ U.S. Army Asymmetric Warfare Group, *Subterranean Warfare Handbook*, iii.

¹⁰¹ *Ibid.*

with consideration not only for the operational safety of soldiers and mission accomplishment, but also with concern for civilian casualties and collateral damage.

Traditional equipment found within today's military is not designed for subterranean combat. Load carrying equipment and body armor is too bulky to be worn inside restrictive subterranean environments. Shedding this equipment becomes an operational necessity and an additional risk for commanders to consider. Night vision devices are really light amplification devices and in environments where there is no ambient light, or with smoke, these devices are useless without the use of supplemental Infra-Red (IR) lighting. Rifles may be too long to be effectively wielded in restrictive environments. Pistols have shown to be of greater use, yet few soldiers are issued a secondary weapon. The sound amplification caused by confined spaces in subterranean environments causes increased risk to soldiers' hearing during the firing of weapons or use of explosives. Radio communications systems typically operate along line-of-sight (LOS) and are limited in their ability to transmit or receive through terrain. Maintaining communications with surface elements is difficult without "bread-crumbling" personnel throughout the subterranean system. Air quality is a significant risk to forces in a subterranean environment, thus portable air monitors would need to be acquired. Many solutions exist or are being developed to provide enhanced capability and mitigate risks in subterranean environments. Unfortunately, this equipment is not widely fielded because the subterranean problem-set has not presented itself to enough forces to justify the cost. Training with the equipment that units have, adapting it to any potential problem-set, and understanding its limitations becomes the priority.

d. Indicators and Detection of Subterranean Activity

The detection of tunnels and the identification of tunneling activity are key skills in eliminating an enemy's ability to build and use underground facilities. While innovations in tunnel detection technology offer promising long-term strategy, technology cannot be the sole solution. Technology can assist in subterranean activity detection and is utilized on the U.S./Mexico border and other locations globally. Although a number of detection technologies exist, no single piece of equipment,

currently available, is sufficiently accurate for routine subterranean detection. Inherent difficulty exists, in part, because of the varying sizes and depths of tunnels in diverse geological conditions. Currently, subterranean detection technology is in use by the U.S. military only in Afghanistan. Because the technology is not widely used, it is important for soldiers to know the indicators of subterranean activity to assist in non-technical detection. Situational awareness is critical.

Many of the indicators of subterranean activity require persistent surveillance, routine patrols, and human intelligence (HUMINT) reports. Personnel should be suspicious of mounds of loose or disturbed soil and/or dirt scattered within close proximity to residences, businesses, or water sources. Soil that is a different color from the surrounding soil can indicate that it has been displaced.

During searches, all wires should be traced to determine both the power source and what is being powered. Large amounts of wire are needed for communication lines and to power lights, fans, and digging equipment.

Holes in the ground or pipes sticking out of the ground can be used to provide ventilation to a subterranean structure. Hoses, metal piping, or PVC piping can be used to provide air to a tunnel, or to move water out. Water is also needed to keep dust down to a minimum during construction. As with wire, it is important to trace a hose, beginning to end, to determine its source and what is being watered.

Increased truck/vehicle activity in a residential or commercial area may also provide an alert to the movement of loads of dirt from underground construction sites. Particular attention should be given to dirt-laden trucks departing structures when there is no other discernible construction activity.

Groups of people who enter an establishment and do not depart in a reasonable time may be suspect. Also, people with muddy clothes or shoes in a dry climate provide clues. Large quantities of empty barrels or rice/flour/fertilizer bags may be present to remove soil. These items may contain dirt residue. Digging hand tools, buckets and headlamps found in the absence of a construction site may also be reasons to investigate further.

e. Alternate Approaches

The United States Army describes the mission of infantry as “to close with the enemy by means of fire and maneuver in order to destroy or capture him, or to repel his assault with fire, close combat, and counterattack. The Infantry will engage the enemy with combined arms in all operational environments to bring about his defeat.”¹⁰² This may not be the best way to proceed when dealing with subterranean operations. Placing troops in a subterranean environment must be carefully thought out. Commanders must determine the driving force requiring ground forces to enter a subterranean environment. Personnel recovery, securing a high value target, or weapon of mass destruction may be that mission which requires the commitment of ground forces into the underground.

Commanders may consider alternative approaches to committing forces underground. One such alternative is called the Tactical Callout. This technique can be used to assist in removing personnel from a tunnel or underground facility prior to committing soldiers to a subterranean environment. A tactical callout is a non-lethal approach to getting a target out of a building or village. The tactical callout gives the assault force the opportunity to cordon off the intended target area and gives the enemy an opportunity to walk out or surrender without duress or injury.¹⁰³ It provides maximum force protection especially when the intended target is low priority or there is no immediate threat to U.S. forces or no chance of the target(s) fleeing. It is important to know the location of tunnel exits or escape hatches so that they can be secured. In addition, a tactical callout helps facilitate the information operations’ plan to further provide leads to future targets.

Commanders might consider the use of a siege in an underground situation. Siege warfare has been a tactic used since ancient times. It was used when a city or fortress was too difficult to overtake and casualty count would be high. Effective

¹⁰² Headquarters, Department of the Army, *Field Manual 3-21.8, The Infantry Rifle Platoon and Squad* (Washington, DC: Headquarters, Department of the Army, 2008).

¹⁰³ Headquarters, Department of the Army, *Field Manual 3-24.2, Tactics in Counterinsurgency*, (Washington, DC: Headquarters, Department of the Army, 2009).

sieges involve surrounding the target and blocking the reinforcement, re-supply, or escape of troops. This could be coupled with locating and sealing off entrances/exits, cutting off power, attacking ventilation, and other life support mechanisms. Unfortunately, a commander may not have the undetermined amount of time required for a siege to be effective and all exits may not have been secured.

Robotic technology is another resource that is of value in working in subterranean environments. Robots are particularly suitable for performing reconnaissance, breaching, and/or recovery operations. They are extremely mobile, can negotiate stairs or obstacles, can be outfitted with day/night cameras, various grippers, and even saws mounted on double-jointed arms. During a tactical call-out, robots can be mounted with a speaker to relay commands and can also be mounted with a weapon system.

The subterranean environment can be extremely hazardous, with the presence of both natural and man-made obstacles. When available, robots should be utilized for exploration of tunnels before personnel enter. Once deployed, robots can safely detect such hazards as enemy personnel, booby traps, animals (snakes/insects), and if equipped with a gas meter, oxygen and hazardous gas levels. Robots have different capabilities depending on the robot's category, power source, weight, size, and mobility configuration. Radio frequency (RF) robots operate on line-of-sight, so as the robot advances in a tunnel or takes a turn, the signal may degrade or be lost. The particular mission set and tunnel configuration will dictate the best robot to utilize, should choices be available.

Military working dogs (MWD) are quite popular with ground forces and bring a unique combat multiplier to the battlefield. A dog can be used prior to sending a team into a subterranean structure, or can be used in conjunction with a clearing team. Some dogs are trained to detect explosives and can prevent the triggering of booby traps. Dogs are notorious for instilling fear in the opposition and can assist in locating personnel. When planning operations, these advantages should be weighed against the military working dog's potential vulnerability to drowning or lack of air, disorientation

from an enclosed environment, unusual sounds, and susceptibility to booby traps. Dogs need to be screened and trained to identify which can operate in a subterranean environment.

2. Organization

The current organizational structures of Army maneuver forces are adequate for dealing with subterranean threats. Light infantry, reconnaissance, combat engineers, and Special Forces are particularly adaptable to this type of warfare. Although historical examples have shown the utility of specially organized subterranean units, these elements were formed during wartime in order to meet immediate threats. Today's military should anticipate future conflicts and recognize the value of having widely skilled and adaptable forces for any operational environment, to include subterranean.

In terms of task organization for any given subterranean operation, every situation will be different and the extent of subterranean environments is difficult to assess from the surface. Rudimentary tunnels may only require a two or three man clearing team, while large underground facilities could require a battalion-level operation. Tactical leaders can be expected to assess operational requirements and utilize the fundamental task organization of assault, support, and security elements. The key to success is having available the right enabler(s) such as a NBC reconnaissance team, MWD handler, EOD technician, tactical MISO team, demolition team, and specialized SSE teams. In a perfect world, all these enablers should be readily available in support of subterranean operations; however, units must strive to attain even the most basic internal capabilities within each of these areas.

United States military forces are highly adaptable. When given the task to conduct operations in subterranean environments no hesitation is likely to be found. However, commanders must understand that this environment is indeed unique and other DOTMLPF elements should be considered in order to mitigate risks and provide the best possible conditions for success. The Army should develop skilled individuals across organizations that allow for an increased knowledge base and enhanced overall capability.

3. Training

Realistic training is the decisive aspect of DOTMLPF that will determine success in subterranean operations. The high operational tempo since 2001, and ever-increasing demand for technological solutions, has found many units training with and employing new equipment while engaged in combat operations. Combat is not the first place soldiers should be exposed to operating underground. As units conduct collective training prior to combat, they must be exposed to the challenges of subterranean operations.

Although many urban training areas have underground tunnels, many units are not comfortable in their use, or mark them as “off limits” for risk mitigation. Not since the Vietnam War has the Army had formalized training on operations against tunnels. Today, many soldiers that encounter caves, aqueducts, or tunnels in Afghanistan simply venture into these spaces without proper planning and equipment.

Training for the complexities of the subterranean environment begins with fundamental skills that can be practiced in any environment. Training that includes confined spaces with no ambient light can identify personnel that are best suited for subterranean operations. Climbing techniques, obstacle courses, trench clearing, room clearing, and movement techniques in hallways are all fundamental skills that can apply to subterranean environments.

In addition to training on operational techniques, training on specialty equipment is essential to the development of a specialized subterranean capability. Soldiers preparing for subterranean operations should be comfortable with the use of various types of breaching equipment, respiration devices, and robotic vehicles that can greatly increase survivability. Soldiers can easily adapt these devices into any training scenario, and familiarity with them will increase survivability across the range of operational environments.

4. Matériel

Through the U.S. Army’s acquisition processes and rapid fielding initiatives, new technologies and current equipment upgrades have flooded today’s battlefield. There are

many current pieces of soldier equipment that can enhance capabilities during subterranean operations; however, much of this gear is not widely distributed beyond the SOF community. Other equipment that has been found to be essential for subterranean operations is available on the civilian commercial market. Available commercial-off-the-shelf (COTS) items that can be adapted for military uses in subterranean environments are currently in use by the fire and rescue, commercial mining, industrial safety, and recreational climbing communities.

a. Air Quality

A significant risk to soldiers in subterranean environments is air quality. In urban environments and commercial mines, dangerous gases can be odorless, and can quickly incapacitate, or can ignite to create explosions. Lethal particulates are by-products of mechanical and dynamic breaching tools used by personnel attempting to gain access to subterranean facilities. Any unit entering a subterranean environment should carry an air quality meter, an example seen in Figure 33, to ensure necessary levels of oxygen exist, and alert to the presence of harmful gases. Miner safety courses, such as those taught by Colorado School of Mines, can educate soldiers on appropriate levels of oxygen, lethal types of particulates and gasses, and how to determine the appropriate types of air quality meters.



Figure 31. MX6 iBrid on miner¹⁰⁴

¹⁰⁴ Industrial Scientific, “IBRID MX6” [image], accessed December 13, 2013, <http://www.indsci.com/products/multi-gas-detectors/mx6/#overview>.

b. Optics/Visibility

Although the use of night vision devices is essential in subterranean operations, these devices are severely degraded without the presence of ambient light. Due to the natural characteristics of the underground environment, there is no ambient light without the assistance of man-made devices. Units employing night vision devices underground must possess light with infrared (IR) capabilities. The latest night vision device is the AN/PSQ-20 Enhanced Night Vision Goggle (ENVG) which has enhanced capability in low-light situations and fuses thermal imaging (see Figure 34). The AN/PSQ-20 has three operational modes: image intensifier only, thermal only, and image intensifier/ thermal fused. The capability to use thermal optics greatly increases visibility when operating in no light or smoke conditions. However, due to the limited fielding of items like the AN/PSQ-20 within GPF, soldiers should employ the use of IR filters or covers on tactical flashlights until the requirement can be filled. Every soldier entering a subterranean environment should carry a weapon, helmet, and hand portable lights with IR filters. The use of white lights should be avoided unless an area is secured.



Figure 32. View of soldier using AN/PSQ-20¹⁰⁵

When used in combination with night vision devices, IR laser aiming/targeting devices such as the AN/PEQ-4 or LA-5/PEQ can be used to “sparkle”

¹⁰⁵Defense Update, “PSQ-20” [image], accessed December 18, 2013, <http://defense-update.com/wp-content/uploads/2011/10/psq-20.jpg>.

tripwires or illuminate areas. Sparkling tripwires occurs when the IR light is reflected off metal or monofilament wire. Although laser devices are typically mounted on rifles, they can be hand carried when operating in a restricted tunnel.

c. Chemical, Biological, Radiological, and Nuclear

Soldiers in subterranean environments should carry chemical detection paper such as the M8 or M9 papers when there is the potential for chemical, biological, radiological, or nuclear (CBRN) exposure. However, the M8 and M9 papers only detect liquid nerve and blister agents. If the potential for WMD exists, additional chemical, biological, radiological, and nuclear (CBRN) detectors, alarms, and mission oriented protective posture (MOPP) equipment must be readily available. Although the presence of WMD is not limited to the size of the environment, there is greater likelihood this type of threat would be seen in larger UGFs. If this type of threat is suspected or discovered, the area should be isolated and SMU with CBRN reconnaissance capabilities employed.

d. Hearing Protection

The amplification of sound waves in confined subterranean environments demands the need for enhanced hearing protection and sound limiting devices. Tactical electronic hearing protectors that limit decibel levels and use microphones to enhance hearing are excellent devices underground operations. Specifically, the style of headsets that completely covers the ears, such as those shown in Figure 35, would be ideal for subterranean operations. Some tactical electronic hearing protectors have communications connectors to allow radio communication directly through them. Due to the increased sound amplification and decibel levels of gunfire and explosives, dual hearing protection, combining earplugs with hearing protectors, should be considered.

Weapon suppressors, for both rifle and pistol, should be used underground. The overpressure exerted by firing weapons underground results in excessive amounts of dust and debris to cloud the air. This not only impairs visibility, but also degrades air quality. The use of a suppressor will reduce the decibel level of weapons fired as well as reduce the flash signature, making it harder for the enemy to effectively return fire. Weapon

suppressors are not readily available outside of SOF. Their utility goes beyond their use in the subterranean environment and fielding should be expanded to GPF.



Figure 33. Peltor Comtac II Electronic Headset¹⁰⁶

e. Breaching Equipment

Subterranean areas in urban environments and particularly UGFs may require the use of advanced breaching tools. Cutting devices such as “quickie-saws,” thermo-baric “broco” torches, hydraulic spreaders, and other power tools may be required. It is important to keep in mind how the use of these devices can degrade the air quality and may require the use of a respirator or self-contained breathing apparatus (SCBA). The exhaust of gas-power tools may also choke out the tool’s intake in confined spaces and render it inoperable. Training with these mechanical breaching tools must be conducted so that operators can master the challenges associated with these devices in confined spaces.

f. Incendiary Weapons

Incendiary weapons have proven effective in the past in combating underground threats. Though the M2 flamethrower (see Figure 36) is no longer in the U.S. military’s inventory, it would be an excellent addition to GPF currently conducting

¹⁰⁶ Optics Planet, “Peltor Comtac II Electronic Headset 21db Hearing Protection” [image], accessed December 18, 2013, <http://www.opticsplanet.com/peltor-comtac-ii-electronic-headsets-military-green-mt15h69fb-47.html>.

subterranean operations. The AWG should be tasked to conduct research on the employment of flamethrowers by U.S. forces within subterranean environments. Incendiary weapons that are currently in the U.S. military's inventory such as the AN/M14 incendiary grenade and the M15 white phosphorus grenade should be tested in subterranean training sites for possible TTPs.



Figure 34. Soldier demonstrates flamethrower¹⁰⁷

g. Remote Controlled Robotics

The use of remote controlled robotics was previously discussed in alternate approaches. Tactical robots are either RF operated or controlled by means of an electronic tether. This tether is usually made up of a single fiber optic wire or multiple wires covered by a protective shroud. Regardless of operation, robots in subterranean environments should be tethered in order to retrieve them in case of a loss in communication or if they become stuck on an obstacle. The communications tether should not be used as a retrieval tether due to the risk of damaging the wiring. Type III nylon, commonly referred to as 550-cord, is an effective tether and can be easily tied to most robots. Tactical robots are designed for a multitude of environments and have various mobility platforms, optics, tool and sensor attachments, and even weapon attachments. The utility of a robot operating in advance of soldiers in a subterranean

¹⁰⁷ "Flamethrowers," [image], accessed December 12,, 2103, Homemade Defense, <http://homemadedefense.blogspot.com/2010/05/flamethrowers.html>.

environment cannot be overstated. However, operators must understand that obstacles such as debris and water in subterranean environments can significantly degrade the effective use of robots. Soldiers should use them to clear entry points, corners, and other dead space (see Figure 37). As technology advances, the effective use of robots will increase, improving the survivability of soldiers.



Figure 35. Soldier uses a robot to detect booby traps in an Afghanistan cave¹⁰⁸

h. Air blowers

Ventilation is crucial in subterranean environments. As previously discussed, poor air quality can endanger the lives of U.S. forces and render mechanical breaching tools inoperable. Air blowers can be used as a hasty means to ventilate a subterranean structure. Technical rescue and miner rescue teams have historically employed air blowers such as the one shown in Figure 38 to ventilate confined spaces.

¹⁰⁸“Can Human-Robot Bonding Affect Mission Performance?,” [image], accessed December 18, 2013, Military 1, <http://www.military1.com/products/military-technology/military-robots/article/406317-can-human-robot-bonding-affect-mission-performance>.



Figure 36. Technical rescue team using portable air-blower¹⁰⁹

Blowers can also be used against enemy forces occupying a subterranean environment. For example, during the Vietnam War, engineer and chemical troops used a portable blower, called the M106 Mity Mite, to flush enemy forces out of tunnels by forcing smoke into the entrance. At the same time, additional entrances were exposed by smoke exiting the ground.¹¹⁰

5. Leadership and Education

Tactical leaders and operational planners must be prepared to adapt to any operational environment. In order to prepare ground forces for subterranean operations, scenarios involving tunnels, urban and natural cavities, and underground facilities should be incorporated into training exercises both in force generating schools and unit level training.

Leaders must be creative and seek opportunities to learn about the subterranean domain. Courses taught by civilian institutions on underground mining, confined space search and rescue, along with government agencies that specialize in intelligence collection and analysis of underground facilities can be just the beginning to gaining a high degree of preparedness for subterranean operations. Due to the lack of emphasis on

¹⁰⁹ Image taken by author during field research.

¹¹⁰ Rottman, Gordon L. *Viet Cong and NVA Tunnels and Fortifications of the Vietnam War*. Oxford: Osprey Publishing, 2006.

training in the subterranean environment, leaders are only limited by their imagination and the unit's willingness to resource training, not the availability of facilities.

6. Personnel

The operational environment underground is a dynamic problem set that is mentally and physically demanding. Conventional techniques above-ground are impacted by additional mental and physical stresses when conducted below ground. A former Tunnel Rat commander in Vietnam describes several discriminating factors that should be addressed in order to identify soldier with a natural capacity to operate in a subterranean environment.

It is not the intent of this project to create an organization that specializes in underground operations. However, historic data can be pulled from training programs similar to the Tunnel Rats of Vietnam to prepare leaders for what to expect. Leaders must expose their forces to types of subterranean environments to observe which soldiers can endure the physical and mental stress associated with tunnel, urban and natural cavities, and UGFs. For example, U.S. forces are administered swim tests in order for leaders to identify strong and weak swimmers. This is not to say that those identified as weak swimmers will not conduct water crossings or bypass water hazards, but actions are taken to mitigate harm to the soldier. If a soldier shows symptoms of claustrophobia in confined spaces then he should be employed in other ways, such as providing security at the opening of the underground structure. Several hundred meters into a tunnel during combat operations should not be the first time a leader identifies a soldier as claustrophobic. In addition to claustrophobia, Tunnel Rats were assessed for physical stature, physical endurance, mental aptitude, and comfort in confined spaces. These personal attributes are applicable today and across the range of subterranean typology.

7. Facilities

United States Army installations do contain facilities that address some of the underground structures presented in this project; however, they fall short of the full range identified within the typological space. Today's fiscal environment requires creative training solutions and home station opportunities. The following are training facility

environments the SWG experienced through field research that represents the range of subterranean typology. Characteristics of these training areas can also be developed into existing home station training areas.

a. Tunnel Training

The tunnel is the easiest type of subterranean environment to replicate for training. The CTCs and the majority of urban training sites have both rudimentary and sophisticated tunnels that can be used by U.S. forces. In addition to the CTCs, the Muscatatuck Urban Training Center (MUTC), Butlerville, Indiana, offers over one mile of searchable tunnels in which a unit might conduct training. Operated by the Indiana National Guard, the tunnels range from rudimentary to sophisticated, and can be modified to include opposing forces (OPFOR), weapons caches, or any number of other situations. The Joint Tunnel Testing Range (JTTR), at Yuma Proving Grounds is a recently opened underground tunnel facility designed to replicate the low-tech tunnels found along the U.S.-Mexico border, and those in Southwest Asia. This training area was specifically chosen for the soil and dry ground composition that resembles what is currently seen in Afghanistan. In addition to military facilities, access to civil underground structures should be researched to provide variety to underground training. Coordination with local communities could assist in facilitating an enduring training relationship.

b. Urban & Natural Cavity Training

Similar to tunnel training areas, many CTCs and urban training areas contain opportunities for leaders to replicate urban cavity training. Additionally, civil underground facilities such as subway systems and building sub-structures may be utilized through memorandums of agreement. Locations that support training within natural cavities also exist at CTCs (see Figure 39); however, these areas may have restrictions that prevent employment of devices such as pyrotechnics and weapon simulators. In addition to replicating combat effects, exercise control and safety procedures may be constrained by the natural complexities of subterranean environments. Complicating training factors include degraded radio communications and visibility.



Figure 37. Cave locations at the National Training Center, Fort Irwin, CA¹¹¹

c. Underground Facility Training

White Sands Missile Range (WSMR) offered an excellent opportunity for training in a shallow underground missile silo/bunker environment, and was recently host to 2013’s Network Evaluation Integration 14.1 and 14.2 distributive test events, which were meant to identify capability gaps in the force. Within the event was a subterranean assessment hosted by the AWG for soldiers assigned to Company B, 1st Battalion, 6th Infantry Regiment, 2nd Brigade Combat Team, 1st Armored Division. The AWG operational advisors utilized the WSMR facilities to replicate a series of complex and unpredictable subterranean environments and situations to build soldier confidence (see Figure 40).

The majority of the techniques employed in UGFs are similar to those employed in above ground urban environments. Therefore, training should focus on the understanding of vulnerabilities associated with UGFs. The target audience for this type

¹¹¹ Brant Hoskins, Todd Heintzelman, and Melvin Cuffee, “National Training Center Offers New Training Opportunities” [image], *Army Chemical Review* (Jul–Dec 2005), 23.

of training should be tactical leaders and planners and should capitalize on existing opportunities offered by the DIA's UFAC.



Figure 38. Soldiers move through an UGF during NIE 14.1¹¹²

d. Other Training Opportunities

In the conduct of field research for this project, it was discovered that most installations with maneuver units have trench complexes that can be modified to replicate rudimentary tunnels. The AWG has devised effective means for conducting subterranean training. One concept being proposed essentially modifies a unit's subterranean training plan to address any of the three outlined typologies. An installation could possibly procure shipping containers from the Defense Reutilization and Marketing Office (DRMO), and create underground training environments by emplacing them underground.

¹¹² Sonise Lumbaca, "AWG Subterranean Risk Reduction Exercise Prepares Soldiers for NIE 14.1," [image] The Army Homepage, accessed November 25, 2013, http://www.army.mil/article/111831/AWG_Subterranean_Risk_Reduction_Exercise_prepares_soldiers_for_NIE_14_1/.

B. AREAS FOR CONTINUED RESEARCH

This project serves as a platform for future development of subterranean warfare awareness and operational proficiency within the U.S. Army and across the Department of Defense. The project alone cannot possibly encompass the totality of research that should be sought in order to enhance the understanding and operational capability of ground forces within the subterranean operational environment. This research was conducted concurrently with the AWG's initiative on subterranean warfare, and select units are presently being exposed to the challenges that this research highlights. Through the research and analysis of the subterranean warfare problem set, several topics have presented themselves for potential future exploration.

In order for the dynamics of subterranean warfare to become inherent within unit level collective training, research should be conducted to evaluate how this unique environment could be incorporated into the force generation elements of the U.S. Army. Courses such as basic training, officer basic courses, and tactical leader courses such as the Sapper Leaders Course and Ranger School could potentially develop programs of instruction (POI) of TTPs when operating in the subterranean environment. Part of this future research should be on the development and analysis of specific tasks essential to subterranean operations. Potentially a course unique to subterranean warfare could be developed maximizing individual skill development in techniques for both differing subterranean categories and specialty equipment use training.

Additional research and analysis could be conducted on the procurement and sustainment of specialty matériel solutions. Equipment that enhances survivability, such as SCBA, rebreathers, respirators, and other PPE not currently widely available in maneuver units might be considered for rapid fielding. Equipment identified as COTS may require unique training by industry subject matter experts at additional cost.

In order to conduct operations against subterranean threats, such locations must first be found. Throughout this research it was apparent that although many attempts at technological solutions for detection, mapping, and characterization have been pursued, all have fallen short in real-world defense applications. An examination of current and

emerging technologies could be valuable to many different government agencies, potentially spurring the development of new capabilities.

C. CONCLUSION

The authors believe that this capstone provides sufficient support to confirm original arguments:

- Current U.S. military doctrine does not properly prepare units for operations in subterranean environments.
- Future conflicts will require GPF to deal with subterranean threats.
- Understanding the use of incendiary weapons is critical in the conduct of subterranean operations.

1. Case Studies

Support of arguments has been based on the examination of five case studies that show multiple forms of subterranean environments, uses, and techniques. These case studies cover over half a millennium, ranging from a single battle to an entire campaign. The main “take-away” from the case studies is that subterranean warfare has been a persistent aspect of warfare throughout history. It has evolved from siege warfare, to conveyance of forces, to cross-border smuggling, and to storage of WMD. This illustrates that, though considered primitive, it will always have an application in modern warfare. Recent warfare has not been traditional siege warfare. Maneuver forces have found tunnels used by the enemy and tried to exploit them for intelligence value as well as deny their further use to the enemy. The enabling effects of the subterranean environment for enemy forces can be seen today in Israel, Afghanistan, Central America, Syria, and on the Korean Peninsula. The predominant theme throughout the case studies is that of complexity. The case studies show that the underground option is always taken when one side has the technological advantage; a primitive tactic to defeat a modern military.

2. Typology

The recommended typology and classification methodology provided in this capstone will allow ground elements and military planners to understand what

information is critical before leaders commit forces. The coding system and graphical symbol provided will enable commanders and staffs the ability to use a template to quickly describe and communicate the subterranean threat in their areas of interest and operations.

In defining the typology, attributes most relevant and significant for planning considerations have been identified. By merging the efforts of the DIA, U.S. Customs and Border Protection, and the Asymmetric Warfare Group, the authors have created a lexicon that can be applied by any element conducting operations in a subterranean environment.

As demonstrated below, the recommended typology and classification can be applied to the selected empirical case studies:

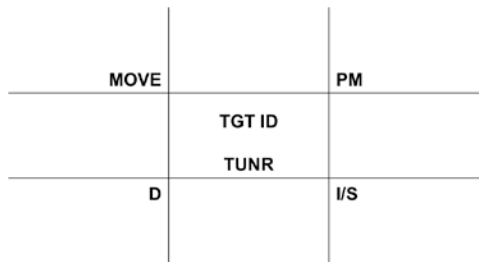


Figure 39. Siege of Constantinople

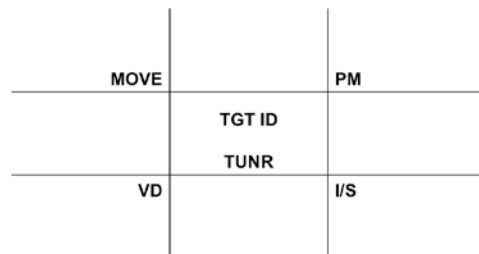


Figure 40. Petersburg (American Civil War)

MOVE		PM
	TGT ID TUNS	
D		I/S

Figure 41. Messines (WWI)

C3I		P
	TGT ID UGS	
V		I/P

Figure 42. Okinawa (WWII)

MOVE		EPM
	TGT ID UGS	
V		I/R

Figure 43. Cu Chi Tunnels (Vietnam War)

Additionally, this typology and classification can be applied to current subterranean threats for allied forces:

MOVE		EP
	TGT ID TUNR	
TVP		I/R

Figure 44. Gaza, Israel

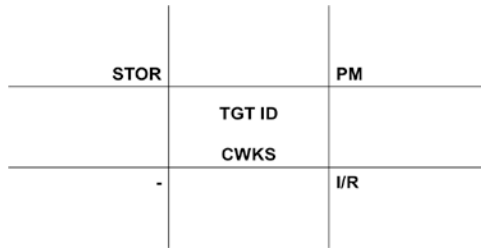


Figure 45. A Karez tunnel in Afghanistan

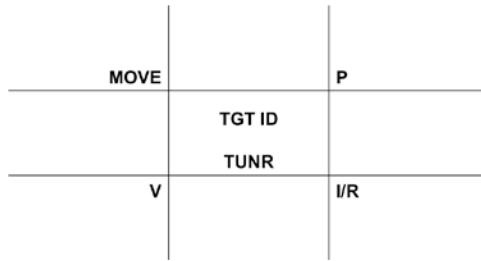


Figure 46. Cross-border tunnels in Central America

These examples show the flexibility of the proposed typology and classification which recognizes the widely varying uses for a subterranean system. It also affords a leader the ability to control the collection process for planning operations in this complex environment. By simply “plugging” the information into the graphic, commanders and staffs are forced to acknowledge the multiple challenges that could be faced underground.

3. DOTMLPF

This research shows that when ground forces encounter a subterranean environment, leaders will commit forces into that underground site. Not doing so provides enemy forces with a safe haven to conduct operations providing them with a military advantage.

Most units that have encountered subterranean threats in the COE have limited formal training, and have had to learn on the job. Subterranean pre-mission training should be included for deploying forces that are likely to encounter underground threats. As shown in the DOTMLPF analysis, most Combat Training Centers (CTCs) have rudimentary tunnel networks. At a minimum, this provides leaders the opportunity to expose their soldiers to the psychological impacts of being in a confined space.

The AWG has developed a *Subterranean Warfare Handbook* that provides relevant information to units conducting operations within subterranean systems and underground structures and facilities. Though a tactical application, it is a large step in the right direction and will assist leaders in prioritizing training tasks during a pre-deployment phase for upcoming operations.

4. Incendiary Weapons, Cyber-based Attacks, and MISO:

This project has also provided possible non-traditional approaches to countering subterranean threats including the use of incendiary weapons, cyber-based attacks, and MISO (see Appendix A). Considering the dangers associated with subterranean operations, non-traditional approaches must be considered in terms of either defeating the subterranean threat or mitigating some of the risks to ground forces. These approaches provide the U.S. military with other options to countering such threats, other than airstrikes and committing ground forces.

The paper's case studies have shown that incendiary weapons such as flamethrowers and napalm have proved effective in the tunnels and UGFs of Constantinople, Okinawa, and Vietnam. Incendiary weapons are a simple, cost-effective means of combating subterranean threats and have immediate psychological and physical effects.

In some cases there may be a subterranean threat that cannot be engaged due to an overwhelming risk. This research shows that although incendiary weapons would be the appropriate choice in such a scenario, leaders will not authorize their use due to a normative taboo. Soldiers should not take unnecessary risks when there is a capability that could reduce or eliminate those risks. This capstone has addressed this taboo and recommends that U.S. forces be properly trained on the effects of incendiary weapons, when they should be used, and how they should be used.

Cyber-based attacks, as described in the Stuxnet incident, are a valid option against UGFs. As with incendiary weapons, cyber-based attacks limit the exposure and risks to ground forces and have proven effective against underground threats in the past

(see Appendix A). Due to the lack of training and doctrine for subterranean environments, electronic warfare should be further explored and incorporated to fill this gap.

Military information support operations (MISO) are another historically proven indirect approach toward subterranean warfare (see Appendix A). The advantage of MISO over cyber-based attacks is its flexibility to be applied to all types of underground environments (underground facilities, urban/natural cavities, and tunnels). If proven credible, MISO can influence the audience through themes, messages, and actions such as contaminated air supply, structure collapse, food/supply shortages, fire/smoke inhalation, flooding, tunnel remediation, social media, and the local populace. These operations can enable U.S. forces to shape the information battle-space in order to persuade, change, or influence the behaviors of those associated with the subterranean threat.

5. Final Thoughts

In recent conflicts, wherever U.S. forces have overwhelming combat power, adversaries have sought to fight on very primitive levels. Enemies understand the value of hiding themselves and their sensitive equipment underground. Subterranean operations are conducted in the worst environments imaginable. This is not merely a problem set for the U.S. military, but also, police forces, first responders, border patrol, and other security organizations. Therefore, it is the recommendation of this research group that the TRADOC Intelligence Support Activity recognize “subterranean” as an operational environment.

An instruction from the Commander-in Chief for the need of research such as that done with this capstone can be seen below:

In order to credibly deter potential adversaries and to prevent them from achieving their objectives, the United States must maintain its ability to project power in areas which our access and freedom to operate are challenged. In these areas, sophisticated adversaries will use asymmetric capabilities, to include electronic and cyber warfare, ballistic and cruise missiles, advanced air defenses, mining and other methods, to complicate our operational calculus. States such as China and Iran will continue to

pursue asymmetric means to counter our power projection capabilities, while the proliferation of sophisticated weapons and technology will extend to non-state actors as well. Accordingly, the U.S. military will invest as required to ensure its ability to operate effectively in anti-access and area denial environments.¹¹³

By empowering ground forces with the proper understanding, training, and PPE to operate underground, the overall risk to forces is lowered while their ability to operate in an asymmetrical environment is raised. Regardless of the tactics, techniques, and procedures (TTPs) employed, or special equipment developed to conduct subterranean operations, leaders should begin to consider the preparedness of forces to engage threats within this domain. The subterranean environment has been mentioned in narratives of historical military campaigns, and its use is likely to continue as a valuable tactic in future engagements, large and small. Additional analysis and research should be conducted on specific subterranean structures within emergent threat locations. The DIA's UFAC collects classified information for use by weapons developers and airborne attack planning. This information would also be of value to those training facilities that might need to replicate these potential environments and structures as part of troop and mission preparedness.

Military adversaries and unlawful civilians will continue to use subterranean structures and facilities because they are an inexpensive and effective means to provide sanctuary and move personnel and supplies. The U.S. soldier must have the most current and in-depth training necessary for a successful mission in subterranean warfare.

¹¹³ Office of the Secretary of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, DC: Office of the Secretary of Defense, 2012), 4.

APPENDIX A. INFORMATION DOMINANCE

A. MILITARY INFORMATION SUPPORT OPERATIONS AND MILITARY DECEPTION

Military information support operations (MISO), formerly known as “psychological operations,” is another historically proven indirect approach toward subterranean warfare. The advantage of MISO is its ability to target the full typology: tunnels, urban and natural cavities, and underground facilities. Joint Publication 1-02 defines MISO as follows:

Planned operations to convey selected information and indicators to foreign audiences to influence their emotions, motives, objective reasoning, and ultimately behavior of foreign governments, organizations, groups, and individuals. The purpose of military support operations is to induce or reinforce attitudes and behavior formidable to the originator’s objectives.¹¹⁴

Nested within MISO is the ability to conduct military deception or “MILDEC” which can target the full typology of subterranean warfare. Also, from Joint Publication 1-02, MILDEC is defined as: “Those measures designed to mislead the enemy by manipulation, distortion, or falsification of evidence to induce the enemy to react in a manner prejudicial to the enemy’s interest.”¹¹⁵

The authors of this capstone had the ability to conduct site visits on at least one example of each of the subterranean structures that encompass the full typology. Based on those site visits, the proceeding areas were deemed possible points of interest for MISO and MILDEC which can possibly influence a subterranean target audience through themes, messages, and actions.

1. Contaminated Air Supply

Military deception (MILDEC) could be designed to influence combatants to believe that an underground structure’s air supply is compromised. The most courageous

¹¹⁴ Department of Defense, Joint Publication 1-02, *Dictionary of Military and Associated Terms*, (Washington, DC: Government Printing Office, 2011), 234.

¹¹⁵ *Ibid.*, 97.

of personnel in an underground setting cannot avoid the mental stress associated with thoughts of contaminated air. Contaminated air can stem from particulates associated with underground works or can come from above (e.g., chemical agents). Soviet forces were reported to have used such agents against Mujahedeen hiding in karez systems in Afghanistan.

2. Structure Collapse

Also, MILDEC could be designed to influence combatants to believe that an underground structure is in jeopardy of collapsing or will be collapsed by air strike or ground force action. Just recently, 21 entombed German soldiers were discovered by archeologists near the town of Carspach, along what was the Western Front during World War I.¹¹⁶ The men were German counter-miners who were buried alive when an Allied shell collapsed their tunnel. In 2010, a Chilean mining shaft's structure collapsed on its own, trapping 33 miners over 2,000 feet underground for just over two months.

3. Food/Supply Shortages

Designed MILDEC could influence combatants to believe that an underground structure's supply lines are cut off, resulting in looming food and supply shortages. Despite a combatant's best efforts, the human body cannot go more than three days without water or three weeks without food. Messages to this effect can be used to concede surrender from underground structure inhabitants.

4. Fire/Smoke Inhalation

Military deception could be designed to influence combatants to believe that an underground structure's ventilation systems are compromised and fire/smoke inhalation is imminent. Incendiary weapons previously discussed in this capstone have proved their

¹¹⁶ Graham Smith, "The 'Pompeii' of the Western Front: Archaeologists Find the Bodies of 21 Tragic World War One German Soldiers in Perfectly Preserved Trenches," Mail Online, February 10, 2012, accessed November 1, 2013, <http://www.dailymail.co.uk/news/article-2099187/Bodies-21-German-soldiers-buried-alive-WW1-trench-perfectly-preserved-94-years-later.html>.

mettle against subterranean environments in World War II and Vietnam. The ability to vacuum oxygen out of a confined space is what makes the armament so effective and psychologically debilitating to combatants.

5. Flooding

Specific MILDEC could be designed to influence combatants to believe that an underground structure will be flooded. Flooding is a relatively cheap way of functionally defeating an underground system, although only for a limited time. Flooding does not always have to be through water. In February 2013, Egyptian forces turned from water to sewage to flood cross-border tunnels used for smuggling and launching militant attacks.¹¹⁷ Sewage proved the deciding factor in maintaining an underground system inoperable for relatively long periods of time (see Figure 49).



Figure 47. A Palestinian attempts to clean out sewage from a tunnel in Rafah.¹¹⁸

¹¹⁷ Ibrahim Barzak, " Hamas Accuses Egypt of Flooding Gaza Tunnels," Associated Press, February 19, 2013, accessed November 1, 2013, <http://news.yahoo.com/hamas-accuses-egypt-flooding-gaza-tunnels-132142173.html>.

¹¹⁸ Ibrahim Barzak, " Hamas Accuses Egypt of Flooding Gaza Tunnels," [image], accessed November 1, 2013, <http://news.yahoo.com/hamas-accuses-egypt-flooding-gaza-tunnels-132142173.html>.

6. Tunnel Remediation

Further, MILDEC could be designed to influence combatants to believe that an underground structure will be remediated. Tunnel Remediation occurs when a discovered underground structure is filled with cement (see Figure 50). It is costly but achieves complete structure defeat. For fiscal year 2013, the city of Tucson, Arizona spent \$21,088 on 10.5 cubic yards of 3000 PSI concrete to remediate drug tunnels.¹¹⁹ An underground structure can never be used again if it has been properly remediated.

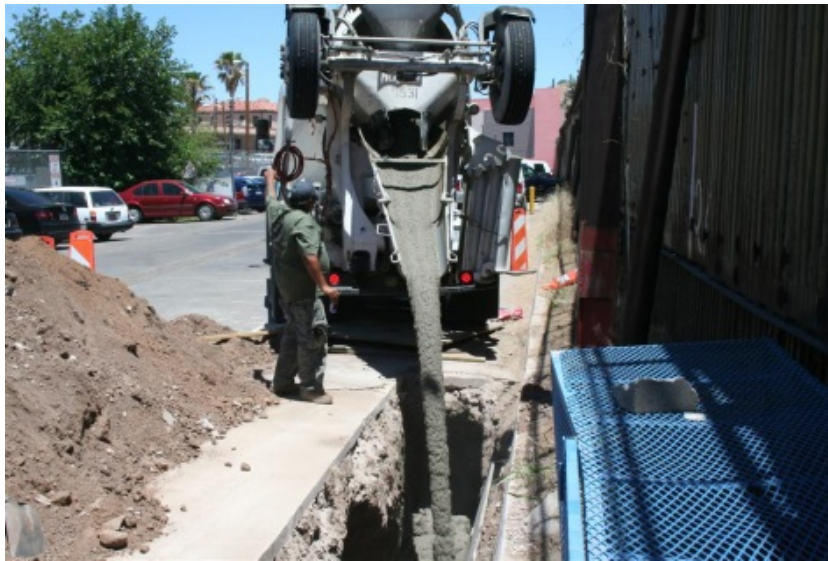


Figure 48. U.S. Customs and Border Protection Agents contract cement trucks to fill a tunnel along the Tucson sector of Nogales.¹²⁰

7. Social Media

The design of MISO could influence combatants to concede surrender from an underground structure through social media. Social media such as Facebook, Twitter, Instagram, and YouTube are this generation's leaflet technology for influencing emotions and behaviors. The Arab Spring in 2012 and 2013 saw the power of the Twitter hashtag mobilize an Army of youth to revolt against the Egyptian government. The combatant

¹¹⁹ U.S. Customs and Border Protection "Mapping the Smuggling Threat" (presented at Virginia Tech Applied Research Corporation, Alexandria, VA, 8 January 2013).

¹²⁰ Ibid.

age males that comprise both non-state and state actors operating underground are avid users of this technology despite some of their safe havens deemed “failed states.” military information support teams (MIST) can also target these mediums to observe patterns of life. The CORE Lab located at the Naval Postgraduate School in Monterey, California was able to map Twitter hashtags posted during the Arab Spring, to map patterns of life and movements of key personnel.¹²¹ Such creative adaptations of technology should be leveraged in order to draw combatants out of underground structures and prevent hostile actions on both sides.

8. Local Populace Interaction

Specific MISO design could influence the local populace surrounding subterranean structures to aid GPF in their location. The local populace will almost always know the location of subterranean structures in the area. They may be involved in one aspect or another (e.g., digging, smuggling, concealing) or have no role at all, but fear retribution for speaking out. The fear – more times than not – comes from a lack of security. Since 2008, over 30 drug smuggling tunnels have been discovered in three main cities along the U.S.-Mexico border in Otay Mesa, Tecate, and Calexico.¹²² An alarming TTP was the use of local businesses and warehouses for tunnel entrances and exits, as well as the use of electric outlets to power underground lighting and ventilation systems (see Figure 51). Professional packing materials were used to simulate normal product distribution, but in reality carried spoilage for removal. The locals found themselves in a dilemma. If they reported the underground works to authorities, they risked retribution from the cartels. If they complied with the cartels, they now provided a safe haven for drug smuggling.

¹²¹ Gregory Wilson, “CORE Lab Introduction” (lecture at Naval Postgraduate School, Monterey, CA, August 15, 2012).

¹²² Joint Task Force North, “Counter Tunnel & Tunnel Detection” (presentation at Virginia Tech Applied Research Corporation, Alexandria, VA, January 8, 2013).



Figure 49. Cartels force local vendors to conceal tunnel entrances and exits

In summary, MISO and MILDEC serve as force multipliers that shape the information environment in order to persuade, change, or influence the behaviors of a target audience. To optimize their value, they must both be integrated early into planning at all levels of war: strategic, operational, and tactical. Effective MISO and MILDEC must also receive adequate intelligence, organization, and evaluation feedback from first-line leaders.

Additionally, products designed for MISO and MILDEC operations must be credible to their audience. The effectiveness of any MISO or MILDEC operation depends on the enemy's perception of what can be lost if there is no compliance. This can best be achieved by those who themselves have experienced an underground environment. While this caveat may seem unrealistic, many of the CTCs have included rudimentary tunnel complexes to their sites. Personnel from MIST must themselves experience the environment if they are going to produce products related to it.

Psychology is a significant factor of life underground that cannot be easily dismissed. Details such as warm colors and pastels, paintings and furniture are often used underground to calm the human subconscious from focusing too much on the idea

of living and working underground. Efforts made to understand this psychology further will enhance MISO and MILDEC operations and increase their probability of success.

B. CYBER AND ELECTRONIC ATTACK

1. Introduction

The purpose of this segment is to shed light on an already proven indirect approach towards achieving defeat of a subterranean complex: cyber-based attacks. There are several thousand cyber intrusions on a daily basis attempting to access an array of systems that range from commerce to government. Domestically, in the last few years, the U.S. has been the victim of countless cyber-attacks. More often than not, these intrusions stem from both nation state and non-state actor sponsorship, but attribution may not always be clear. As the technical skill of attackers increases, the ability to identify the perpetrator's identity decreases.

The following description is of a cyber-attack that not only made domestic and international news headlines, but is currently altering the way cyber activities in both the legal and ethical sense are being considered. Many aspects of the events that unfolded in Natanz, Iran have been and are generally deemed still classified in nature. There were, however, many open lessons learned of which state and non-state actors have taken notice, reevaluating internal cybernetic infrastructure intended to protect interests above and below ground. The most important lesson remains that underground facilities, specifically HDBTs, capable of withstanding air and ground strikes, must now also contend with cyber-attacks. Stuxnet, as the virus was termed, became the first ever cyber-attack used to cause physical destruction.

2. Stuxnet

What is known about Stuxnet began in June of 2010 when a highly sophisticated computer worm was first detected. Stuxnet was discovered by a Belarus-based security company which traced the worm to an Iranian client after a complaint of a software glitch. Originally the virus was thought to have been designed to steal industry secrets. Stealing industry secrets by means of the web has long been a common practice within

the competitive business world. This worm, however, was acting differently, targeting specific Siemens¹²³ settings, and self-injecting malicious code into the program logic control (PLC).¹²⁴ The code's role was to change existing cybernetic infrastructure.

The significance of the PLC is one that cannot be understated. For Natanz, it was also a major point of vulnerability. A PLC like the one in Figure 52 serves as the operations hub for many machinery and industrial-type systems. Conveyor belts, elevators, and roller coasters are just a few examples that operate by means of a PLC. As Stuxnet self-injected into the Natanz PLC, it cleverly remained undetected. Investigators believe it was purposely built this way to avoid raising alarm; an indicator of the technical expertise of the code's author(s). By all best estimates, the PLC may have intruded well into a year before it was discovered.

Reports on the damage caused by Stuxnet vary due to the sensitive and top-secret nature of nuclear facilities. One source said the damage done to the centrifuges was significant enough to set back the nuclear program for at least three years.¹²⁵ Nuclear centrifuges serve an important role of separating U-235 and U-238, the two isotopes required to power a nuclear plant or make a bomb. By the first account, Stuxnet caused hundreds of centrifuges to essentially spin beyond control, ultimately breaking in the process. A second report had the facility well on its way to recovery only six months after the attack.¹²⁶ United Nations inspectors representing the International Atomic Energy Agency (IAEA) witnessed over 900 centrifuges removed from the underground

¹²³ Siemens is a Europe-based electronics and engineering company.

¹²⁴ Robert McMillan, "Was Stuxnet Built to Attack Iran's Nuclear Program?," *PC World*, September 21, 2010, accessed October 15, 2013, http://www.pcworld.com/article/205827/was_stuxnet_built_to_attack_irans_nuclear_program.html.

¹²⁵ Kim Zetter, "Legal Experts: Stuxnet Attack on Iran Was Illegal 'Act of Force,'" *Wired*, March 25, 2013, accessed October 19, 2013, <http://www.wired.com/threatlevel/2013/03/stuxnet-act-of-force/>.

¹²⁶ Joby Warrick, "Iran's Nuclear Facility Quickly Recovered from Stuxnet Cyberattack," *Washington Post*, February 16, 2011, accessed October 19, 2013, <http://www.washingtonpost.com/wp-dyn/content/article/2011/02/15/AR2011021506501.html>.

facility and replaced with new centrifuges.¹²⁷ Regardless of which explanation is true, Stuxnet achieved what has been previously defined as functional defeat of a subterranean facility.

3. Subterranean Lessons Learned

The underground facility at Natanz was by the definition laid out in this capstone, an HDBT. The point of vulnerability was ultimately its cyber defenses, which lent access to the PLC where the disruption occurred. Today's underground facilities are typically used around the world for uranium mining, processing, enrichment, heavy/light water processing, and C3I structures. Most of these operate cybernetically through a PLC, and vary in cryptic defense. Since Stuxnet, Iran has positioned over 100 academics to work on information security in an effort to prevent future mishaps.¹²⁸

The malware that Stuxnet loaded into Natanz's subterranean facility was aimed specifically to target the Siemens PLC. What can be deduced is that the author(s) of Stuxnet had prior intelligence of the internal infrastructure and built the virus around that knowledge. This validates the point that while cyber-attacks by themselves are extremely potent, when coupled with human intelligence (HUMINT), the probability of success naturally increases.

If the manner in which Iran's subterranean facility was infiltrated appeared simple, it is because deception was achieved on multiple fronts. Though Stuxnet was deliberate and thorough in its attack, it was assumed to be time-consuming to plan and to cost millions to produce. The virus was also tested prior to its infiltration, another key factor when planning cyber weapons.¹²⁹

The authors of Stuxnet may never be identified further than speculated. What is known is that there are only a handful of technical experts worldwide capable of

¹²⁷ Ibid.

¹²⁸ John Arquilla, "Conflict in the Information Age" (lecture at Naval Postgraduate School, Monterey, CA, October 24, 2012).

¹²⁹ 60 Minutes Overtime, "Stuxnet Copycats: Let the Hacking Begin," *CBS News*, March 4, 2012, accessed October 15, 2013, http://www.cbsnews.com/8301-504803_162-57389729-10391709/stuxnet-copycats-let-the-hacking-begin/.

conducting such an attack. Like SOF, hackers are not mass produced. While the U.S. is making strides in building tomorrow's cyber warrior within the Armed Forces, hackers are the key. The U.S. government seems to prosecute rather than cultivate such skills. Anyone can go from enemy to hero. This was the case for the V2 rocket scientists in World War II that joined Allied Forces after leaving the Nazis, in itself a huge strategic narrative victory.

Cyber-attacks may prevent the need for ground forces altogether. However, cyber-attacks can also be coordinated with ground forces. This scenario was almost a reality during the 2007 cyber-attack against Estonia, reportedly at the hands of Russia for retribution when a Red Army statue was removed in the Estonian capital of Tallinn. Troops were mobilized; however, cyber force never reached physical force. To this day, a cyber-attack has yet to be retaliated against by ground forces.

4. Conclusion

Stuxnet is in the past; focus is now shifted to the next cyber-attack. As FBI Director Robert Mueller said, "I do believe that the cyber-threat will equal or surpass the threat from counterterrorism in the foreseeable future."¹³⁰ State actors and non-state actors capable of conducting similar attacks understand that cyber has low entry costs and based on the skill of the "wizard" can be difficult to trace. As for those capable of triggering a "Cybergeddon," "Cyber Pearl Harbor," or a "Cyber 9-11," the number of master hackers, state-sponsored or not, are a limited few. In the U.S., it has been traditional to alienate those whose capabilities could be harnessed for self-defense. A disturbing thought is that some nation states have more Internet users than the U.S. has people.

As stated, no doctrine exists in defining subterranean as its own operational environment. This affects the training and implementation of ground forces in such structures and facilities. Special operations forces have capability, but their capability to

¹³⁰ Ibid.

affect the underground is limited by manpower. Electronic warfare is a proven capacity against underground facilities that must be further explored and incorporated as a normative U.S. arsenal method of engagement.



Figure 50. Former Iranian President Mahmoud Ahmadinejad touring a centrifuge facility.¹³¹



Figure 51. Siemens PLC¹³²

¹³¹“Long War Journal,” [image], accessed October 15, 2013, http://www.longwarjournal.org/threat-matrix/archives/2009/11/uranium_centrifuges_and_uraniu.php.

¹³² “Spanish Alibaba,” [image], accessed October 15, 2013, <http://spanish.alibaba.com/product-free/siemens-plc-cpu-312c-110556357.html>.

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APPENDIX B. APPLICATION OF INCENDIARY WEAPONS

Currently, U.S. forces conducting combat operations are having difficulties defeating enemy personnel in tunnels, urban/natural cavities, and underground facilities. In the past, the effective weapons used against these strongholds were incendiary weapons. Specifically, ground flame weapons (flamethrowers and napalm) were documented as having positive results during World War II, the Korean War, and the Vietnam War. According to the *Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons (Protocol III)*, incendiary weapons are defined as:

Means of any weapons or munitions which is primarily designed to set fire to an object or to cause burn injury to persons through the action of flame, heat, or a combination thereof, produced by a chemical reaction substance delivered on the target.¹³³

There are no national or international laws that prevent U.S. forces from using incendiary weapons against confirmed enemy forces and positions. FM 27-10 *The Law of Land Warfare* states that:

The use of weapons which employ fire, such as tracer ammunition, flamethrower, napalm and other incendiary agents, against targets requiring their use is not in violation of international law. They should not, however, be employed in such way as to cause unnecessary suffering to individuals.¹³⁴

The *Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons* (Protocol III) states the following:

It is prohibited in all circumstances to make the civilian population as such, individual civilians or civilian objects the object of attack by incendiary weapons.

¹³³ International Committee of the Red Cross, "Humanitarian Law: Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons (Protocol III). Weapons Category," October 10, 1980. http://www.icrc.org/web/eng/siteeng0.nsf/iwpList2/Humanitarian_law:Weapons?openDocument.

¹³⁴ Headquarters, Department of the Army, *FM 27-10, The Law of Land Warfare* (Washington, DC: Headquarters, Department of the Army, 1956).

It is prohibited in all circumstances to make any military objective located within a concentration of civilians the object of attack by air-delivered incendiary weapons.

It is further prohibited to make any military objective located within a concentration of civilians the object of attack by means of incendiary weapons other than air-delivered incendiary weapons, except when such military objective is clearly separated from the concentration of civilians and all feasible precautions are taken with a view to limiting the incendiary effects to the military objective and to avoiding, and in any event minimizing, incidental loss of civilian life, injury to civilians and damage to civilian objects.

It is prohibited to make forest or other kinds of plant cover the object of attack by incendiary when such natural elements are used to cover, conceal or camouflage combatants or other military objectives, or are themselves military objectives.¹³⁵

Despite the absence of any legal prohibition, the U.S. military has developed a normative taboo against the use of incendiary weapons. The term “normative taboos” refers to the widespread repulsion against incendiary weapons and the widely held inhibitions on their use.¹³⁶ This normative taboo is hindering military ability to effectively defeat and destroy certain types of subterranean threats in the COE. This normative taboo stems from three catalysts:

- Civilian deaths during World War II, the Korean War, and the Vietnam war
- The perception that incendiary weapons are only used by terrorists
- The negative stigma that incendiary weapons cause the unnecessary suffering of enemy personnel

Section One will provide a historical account of the use of incendiary weapons by U.S. forces during World War II, the Korean War, and the Vietnam War. This section will show how the irresponsible and improper use of such weapons contributed significantly to the current normative taboo against incendiary weapons. The majority of research provided in this section was derived from the International Committee of the Red Cross (ICRC) report, *Weapons that may Cause Unnecessary Suffering or have*

¹³⁵ International Committee of the Red Cross, “Humanitarian Law.”

¹³⁶ Nina., Tannenwald, *The Nuclear Taboo: The United States and the Non-use of Nuclear Weapons Since 1945*. Cambridge: Cambridge University Press, 2005, 435

Indiscriminate Effects, and Dr. Malvern Lumsden's *Incendiary Weapons*. Both readings provided a detailed account of all incendiary weapons used by international military forces from World War I to the end of the Vietnam War. Though the intent of both reports is to provide detailed information on incendiary weapons in order to prevent their use, they do point out when incendiary weapons had successful results.

Section Two will show that the successful use of incendiary weapons by terrorist organizations has contributed more to the normative taboo by branding it as a "weapon used by terrorists." The following three cases where terrorist organizations have successfully used incendiary weapons will be examined:

1. 2004 Beslan School massacre
2. 2011 attack in Mumbai, India
3. 2012 attack on the U.S. Consulate in Benghazi, Libya.

For the Beslan School massacre and bombings in Mumbai the thesis, *Braving the Swarm: Lowering Anticipated Group Bias in Integrated Fire/Police Units Facing Paramilitary Terrorism*, conducted by Fire Department of New York CPT Sean Newman provides sufficient information on the attacks. Captain Newman's argument that terrorist organizations are shifting more towards the use of incendiary weapons and tactics adds credibility to the negativity that can be associated with this normative taboo. Many people believe that the use of incendiary weapons projects an image of terrorism. The *Accountability Review Board Report (unclassified) on Benghazi Embassy Attack*, provided information that showed a terrorist organization's successful use of incendiary weapons and tactics resulted in catastrophic losses.

Section Three addresses the stigma that incendiary weapons cause the unnecessary suffering of enemy personnel. This stigma also drives the normative taboo against incendiary weapons through what Tannenwald refers to as "taboo talk." For example, she mentions lines like "this is simply wrong" and "we just don't do things like this" and how they may help identify a normative taboo.¹³⁷ The International Committee of the Red Cross report, *Weapons that May Cause Unnecessary Suffering or Have Indiscriminate Effects* provides a great deal of data that spans what is called the

¹³⁷ Ibid.,440.

“principle categories of weapon and their effects.” These principle categories consist of: explosive, penetrating, incendiary, nuclear, biological, and chemical.¹³⁸ The report provides an excellent account of what medical risks come with each category, but could not show whether one principle category caused more suffering than the other.

The conclusion will state the need for a paradigm shift away from the normative taboo against incendiary weapons to a responsible acceptance of these enabling capabilities. Finally, the authors of the capstone will recommend how and when incendiary weapons should be employed in order to prevent future taboos.

A. SECTION ONE: CIVILIAN DEATH DURING WORLD WAR II, THE KOREAN WAR, AND THE VIETNAM WAR

In previous wars, the use of incendiary weapons was an obvious choice due to the psychological effect against enemy combatants. *Weapons that May Cause Unnecessary Suffering or Have Indiscriminate Effects*, states “man seems to have an intense inbred fear of fire, and incendiary weapons, particularly those based on scatter-type agents, may unnerve him to an extent that other forms of attack may not.”¹³⁹ Even the *Old Testament: Book of Judges* tells a story of Samson and his use of incendiary weapons when angered by the Philistines. Samson captured 300 foxes, set their tails on fires, and then released them into a cornfield occupied by his enemies.¹⁴⁰ Though incendiary weapons can be traced as far back as the creation of fire, U.S. forces did not start employing incendiary weapons systematically until World War II.

1. World War II

According to Stockholm International Peace Research Institute Member and author of *Incendiary Weapons*, Dr. Malvern Lumsden, the incendiary weapons employed by U.S. forces during World War II were: man-portable flamethrowers, mechanized

¹³⁸ International Committee of the Red Cross, *Weapons that May Cause Unnecessary Suffering or have Indiscriminate Effects* (Geneva: Stockholm International Peace Research Institute, 1973), accessed November 4, 2013, http://www.loc.gov/rr/frd/Military_Law/pdf/RC-Weapons.pdf, 22.

¹³⁹ International Committee of the Red Cross, 58.

¹⁴⁰ American Bible Society. *Old Testament: Book of Judges*. New York, NY: American Bible Society, 1816, 15, 3-6

flamethrowers, and various incendiary bombs dropped by U.S. aircraft.¹⁴¹ The first successful employment of flamethrowers was used by U.S. forces on January 15, 1943 at the battle of Guadalcanal against Japanese forces.¹⁴² The original report states that the flamethrowers were specifically successful “against caves and tunnels.”¹⁴³ Though the flamethrower was employed in both theatres of World War II, it was used more frequently in the Pacific. Lumsden states that this was due to the fact that “the Japanese soldier was said to be less likely to surrender than his German counterpart, who might give up a position when confronted by a flamethrower.”¹⁴⁴

The primary use of incendiary weapons by U.S. forces during World War II was via strategic bombing. The U.S. forces viewed strategic bombings as a means of bringing the war to the center of Germany and its industrial infrastructure. The majority of these bombings were conducted at night and incendiary bombs were used at the beginning of each raid to mark targets for subsequent aircraft actions.¹⁴⁵

Lumsden states “incendiary bombs were used in Asia with much the same rationale as in Europe—as weapons for mass destruction.”¹⁴⁶ The U.S. forces dropped over 650,000 tons of bombs in the Pacific Theatre. Some of these bombing attacks consisted solely of incendiary weapons:

Altogether during WWII, the U.S. Army Air Force dropped about 14,000 tons of napalm bombs, over two-thirds of them the Pacific area. U.S. military experts concluded that napalm bombs were most effective against human targets and in addition had a terrorizing effect, though prisoners of war state that widely dispersed napalm bomb hits had little or no effect on morale.¹⁴⁷

¹⁴¹ Lumsden, Malvern. *Incendiary Weapons*. Stockholm: Stockholm International Peace Research Institute, 1975, 78–79.

¹⁴² Lumsden, *Incendiary Weapons*, 38–39.

¹⁴³ *Ibid*, 39.

¹⁴⁴ *Ibid*, 39.

¹⁴⁵ *Ibid*, 33.

¹⁴⁶ *Ibid*, 36.

¹⁴⁷ *Ibid*, 40.

The philosophy of destroying the enemy's means of production through strategic bombing with incendiary munitions caused a catastrophic number of civilian deaths. General Curtis Lemay was quoted as saying, "I'll tell you what war is about, you've got to kill people, and when you've killed enough they stop fighting."¹⁴⁸ This tragedy stimulated what is now the normative taboo against incendiary weapons. What seemed to be a successful use of flamethrowers was overshadowed by the outlandish civilian death toll caused by incendiary bombing raids.

2. Korea

The Korean War witnessed the transition to napalm bombs via the U.S. Far East Air Force (FEAF). Lumsden states that the FEAF "used a total of 32,557 tons of napalm" during the Korean War.¹⁴⁹ Napalm tactics showed initial success against enemy forces, however, the irresponsible use of this enabler resulted in negative media attention. During the Korean War, U.S. ground forces also used flamethrowers, flame land-mines, and flammable liquids. Due to the negative overshadowing outcomes of incendiary bombings, it is difficult to find data of successful uses, especially regarding incendiary weapons by ground forces. Poor target selection and "cure-all-ism" with bombing raids added fuel to the growing normative taboo against incendiary weapons.

3. Vietnam

The Vietnam War saw the most profligate use of incendiary weapons. The negative media alone might be responsible for the normative taboo against incendiary weapons. Most notably was the Pulitzer price-winning photo of the "Napalm Girl" taken by Nick Ut (see Figure 54). According to Lumsden, of the 6,650,543 tons of munitions dropped by aircraft, 400,000 tons were incendiary bombs.¹⁵⁰ The blast from the atomic bomb dropped in Hiroshima was equivalent to 15,000–20,000 tons of TNT.

¹⁴⁸ Stephen L. McFarland, *America's Pursuit of Precision Bombing, 1910-1945*, (Tuscaloosa: University of Alabama Press, 1995), 199.

¹⁴⁹ Lumsden, *Incendiary Weapons*, 43.

¹⁵⁰ Lumsden, *Incendiary Weapons*, 52.



Figure 52. Napalm Girl¹⁵¹

The quantities of ground flame weapons procured by U.S. forces were 394 million AN-M14 thermite incendiary grenades and 379 million white phosphorus grenades.¹⁵² The XM-191 was also fielded in 1969 and replaced the flamethrower. This incendiary weapon fired up to four rockets filled with a pyrotechnic fuel that would ignite once it impacted its target. Again, due to the overwhelming number of civilian deaths tied to aerial napalm and incendiary bombing attacks, little data has been reported of the positive effects of ground based incendiary weapons.

Reports began to filter through to the West in the press and other mass media about the use of incendiaries, and in particular napalm, by U.S. troops in Vietnam. The increasing number of these reports contributed to a wave of public concern. This public interest, in turn, led to a number of investigations and it is possible that these were instrumental in the formation of more restrictive rules of engagement.¹⁵³ Negative public opinions stemming from horrific scenes of napalm attacks in Vietnam have contributed greatly to the normative taboo against incendiary weapons. However, instead of learning from mistakes made and correcting how incendiary weapons are used, incendiary weapons have simply been removed from property books.

¹⁵¹ Nick Ut, "Napalm Girl" [image], June 1972, accessed December 18, 2013, www.npr.org/2012/06/03/154234617/napalm-girl-an-iconic-image-of-war-turns-40.

¹⁵² Ibid, 53.

¹⁵³ Ibid, 56.

B. SECTION TWO: WEAPONS USED BY TERRORISTS

Recent successful terrorist attacks that have benefited from the use of incendiary weapons have added to the normative taboo against these weapons. Fire is a simple, cheap, and easily employed weapon for terrorist organizations. The psychological and physical consequences of incendiary weapons used by terrorists are severe. The idea of dying by fire is religiously symbolic, making this technique even more appealing to terrorists.

1. 2004 Beslan School Massacre

On September 1, 2004, a Chechen terrorist organization attacked School Number One in Beslan, North Ossetia (Russia).¹⁵⁴ At the conclusion of the siege, a large fire was started in the gymnasium where most of the hostages were being held.¹⁵⁵ Reports conflict as to whether a terrorist initiated the fire or if a bullet fired from the security force struck an explosive device. Either way, the fire that ensued benefited the terrorists and caused confusion amongst the security forces. The dilemma for the security forces was whether the priority was the fire, the terrorists, or the hostages. Of the 400 people killed during the Beslan School Massacre, 160 were killed by the fire.¹⁵⁶

2. 2008 Attack in Mumbai

In November 2008, members from the terrorist group Lashkar-e-taiba executed a series of attacks in Mumbai, India.¹⁵⁷ The attacks targeted multiple high-profile structures and resulted in almost 200 deaths, with an additional 300 people injured.¹⁵⁸ In addition to body armor and assault rifles, the terrorists used incendiary weapons to delay security forces, create more casualties, and cause damage to buildings. Combining small

¹⁵⁴ Sean S. Newman, *Braving the Swarm: Lowering Anticipated Group Bias in Integrated Fire/police Units Facing Paramilitary Terrorism* (Master's thesis, Naval Postgraduate School, Monterey, CA, 2011). 20.

¹⁵⁵ Ibid, 20.

¹⁵⁶ Ibid, 20.

¹⁵⁷ Ibid, 17.

¹⁵⁸ Ibid, 17

arms fire and incendiary weapons proved to be an effective tactic. Firefighters and security forces were not trained to put out fires during a gunfight and the results were catastrophic.

The most resonating image of the 2008 bombings in Mumbai was one with plumes of smoke and fire pouring out of the symbolic Taj Mahal. Public safety first-responders stood helpless as the civilians trapped inside perished. This horrible scene is an example of how incendiary weapons can contribute to the creation of a normative taboo.

3. 2012 Attack on the U.S. Consulate in Benghazi

On September 11, 2012 members of a terrorist organization attacked the U.S. Consulate in Benghazi, Libya. The event was “a series of attacks, involving arson, small-arms and machine-gun fire, and use of rocket-propelled grenades (RPGs), grenades and mortars, focused on two U.S. facilities.”¹⁵⁹ As the attack progressed, the terrorists used fuel cans from the compound’s generators and set fire to the building where the Ambassador was located. This use of fire resulted in confusion amongst the Ambassador’s security force and ultimately his death from smoke inhalation.

The terrorists attack in Benghazi caused the “deaths of four U.S. government personnel, Ambassador Chris Stevens, Sean Smith, Tyrone Woods, and Glen Doherty; seriously wounded two other U.S. personnel and injured three Libyan contract guards; and resulted in the destruction and abandonment of the U.S. Special Mission compound and Annex.”¹⁶⁰ The terrorists’ use of incendiary weapons in Benghazi adds to the normative taboo against incendiary weapons and is responsible for the loss of life, injuries, and damage to U.S. property.

This normative taboo creates a slippery slope logical fallacy that “terrorists use incendiary weapons. Therefore, if U.S. forces use incendiary weapons then they are also

¹⁵⁹ U.S. Department of State, *Accountability Review Board Report (unclassified) on Benghazi Embassy Attack*, December 2012, Accessed June, 2013, <http://www.state.gov/documents/organization/202446.pdf>, 1.

¹⁶⁰ *Ibid.* 4.

terrorists.” However, like terrorists, U.S. forces also use body armor and assault rifles and that does not make them terrorists. Nor does it make body armor and assault rifles “weapons of terrorists.” If incendiary weapons are employed properly against enemy combatants (in accordance with international law and the Department of the Army FM 27-10) then it is simply another way to achieve victory in combat.

C. SECTION THREE: THE NEGATIVE STIGMA THAT INCENDIARY WEAPONS CAUSE THE UNNECESSARY SUFFERING OF ENEMY PERSONNEL

According to *Weapons that may Cause Unnecessary Suffering or Have Indiscriminate Effects*, there are three components to incendiary weapons. These components are: incendiary agents; munitions for dispensing the agent; and a delivery system for transporting the munitions to the target.¹⁶¹ Due to the ranging vulnerability of targets (i.e., wood, concrete, metal) a variety of incendiary weapons have been developed. An ICRC report categorizes incendiary weapons based on their chemical characteristics: metal, pyrotechnic, pyrophoric, and oil-based.¹⁶² Obviously, the human body suffers horribly from exposure to any category of incendiary weapons.

Incendiary weapons cause deep and excessive burns since they have been engineered to the level required to damage targets that are more durable than the human body.¹⁶³ Lumsden and the ICRC argue that victims of serious burns do not always die immediately. Depending on the quality of accessible medical treatment, size of the burn, and the degree of burn, victims may suffer for “hours, days, or even weeks.”¹⁶⁴ They also argue that “skin does not have the immediate impact of, say a bullet wound in the heart or brain.”¹⁶⁵ This “suffering” from burns contributes to the normative taboo against incendiary weapons.

¹⁶¹ International Committee of the Red Cross, “Humanitarian Law,” 55.

¹⁶² *Ibid*, 56.

¹⁶³ Lumsden, *Incendiary Weapons*, 185.

¹⁶⁴ *Ibid*, 185.

¹⁶⁵ *Ibid*, 185.

This project argues that not all bullets hit the “heart or brain” and not all explosive fragmentations or blasts result in immediate deaths. Many injuries from explosive or penetrating weapons have prolonged physically painful and psychologically damaging effects. In fact, Lumsden states that third degree burns destroy pain receptors and the victim may die without feeling much pain.¹⁶⁶ This is not common with explosive and penetrating weapons that are currently employed by U.S. forces. Unless the explosive or penetrating weapon causes damage to the spinal column, pain is instant and excruciating. In terms of pain, incendiary weapons could be less painful if the burns are deep enough.

An obvious secondary lethal effect from incendiary weapons is the victim breathing in harmful smoke, carbon monoxide, and particulates. According to British and German authorities, carbon monoxide turned out to be a major lethal agent in incendiary attacks on German cities during World War II.¹⁶⁷ The most common cause of death as a result of fire is due to asphyxiation from smoke. In their reports, neither the ICRC nor Lumsden could define how asphyxiation “feels” in terms of pain. Many interviews with fire victims revived by CPR show that though their initial feeling was panic, some experienced a sense of euphoria and calmness before passing out from smoke inhalation. Deaths by fire, explosions, penetration, and drowning have their own types of suffering. None of which is more unnecessarily harmful than the other.

All categories of weapons and their effects cause suffering. However, just like a combatant can be taught to “shoot to wound” or “shoot to kill,” soldiers can also be taught to employ incendiary weapons in a way that would not cause unnecessary suffering. If employed against the proper type of targets, incendiary weapons could prevent the unnecessary loss of U.S. soldiers. The matrix for whether a particular weapon should be employed should not be based on suffering, but on how well it can help win the fight, while not creating human-rights problems.

¹⁶⁶ Ibid, 185.

¹⁶⁷ Ibid, 207.

D. CONCLUSION

In conclusion, the U.S. military has developed a normative taboo against the use of incendiary weapons. This normative taboo is preventing troops from effectively defeating the enemy in certain types of strongholds and fortified positions. These positions include caves, underground tunnels, and subterranean complexes. Given the fact that there are no national or international laws that expressly forbid them, there should be nothing preventing U.S. forces from using incendiary weapons. Decision makers would not expect a soldier to clear a room with his or her knife, or engage a tank 1,000 meters away with a shotgun. With efficient training in proper use and rules of engagement, U.S. forces would benefit from the use of incendiary weapons.

In the past, incendiary weapons have been used irresponsibly during World War II, the Korean War, and the Vietnam War. In each case, the most negative results came primarily from incendiary weapons being used via aircraft. In caves, underground tunnels, and subterranean complexes, incendiary weapons would be employed via man-portable devices. Man-portable devices are easier to control and do not indiscriminately destroy large areas at a time. In World War II, the Korean War, and the Vietnam War, the reports of man-portable devices were positive, especially against “both caves and tunnels.”¹⁶⁸ Any weapon can have a negative result if used incorrectly or irresponsibly. However, U.S. forces should not suffer today due to a normative taboo that has manifested from mistakes in the past.

The fact that terrorists have used incendiary weapons also adds to the normative taboo. Incendiary weapons are cheap, simple, and effective. These characteristics are why terrorists use them, not because incendiary weapons are evil, but because they work. Terrorists have also successfully used social media and networks to plan and execute successful attacks. Does this mean that having a Twitter or Facebook account implies conducting or planning acts of terror? Due to the organizational design of terrorist groups they quickly adopt effective tactics and techniques for recruiting, supporting,

¹⁶⁸ Ibid, 39.

funding, training and executing their operations. Today they may use incendiary weapons; tomorrow they may use cyber terror. Not using a weapon or tactic simply because terrorists use it is unacceptable.

The negative opinion that incendiary weapons cause unnecessary suffering of enemy personnel also contributes to the negative taboo. It would be thoughtless to deny that the potential injuries and deaths from incendiary weapons are horrific. However, this can also be said about deaths and injuries from any type of weapon. The reality is, combatants have to fight each other. The results of these fights are injuries and deaths on both sides of the conflict. The authors of this project agree that means should be taken to prevent unnecessary suffering from incendiary weapons. However, it is not agreed that the way to prevent unnecessary suffering is to not use them. Combat is an unfortunate experience and no real soldier gains pleasure from taking someone's life. Still, this does not mean that U.S. forces should suffer from a normative taboo against a weapon that could save lives.

United States forces should be properly trained on how and when to use incendiary weapons. Leaders who irresponsibly use these weapons and cause the unnecessary suffering or death of civilians should be severely punished. This project recommends that in order to overcome these normative taboos, incendiary weapons should be used in a way that shows their positive effects. For example, they should be employed in an environment where they have been successful in the past (i.e., man-portable devices in tunnels and caves). Simply removing incendiary weapons as an option for U.S. forces does not increase the forces' chances of survivability or success.

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APPENDIX C. ANNOTATED BIBLIOGRAPHY

A. PHYSICAL CHARACTERISTICS STUDIES

In a February 2004 appearance before the Senate Armed Services Committee, Vice Admiral Jacoby, Director of the DIA, stated that more than a dozen foreign military or defense related UGFs were under construction. Several countries with known WMD programs are expanding their use of UGFs in order to protect and conceal equipment and leadership.¹⁶⁹ Both nation states and non-state actors looking to tip the scale of vulnerability have recognized that conducting nefarious activities deep underground is the only way to escape the “unblinking eye” of U.S. ISR, and the kinetic effects of aerial delivered munitions. Before military planners can commit ground forces to subterranean targets, they must be able to clearly distinguish the characteristics of the environment.

1. **Underground Structures of the Cold War: The World Below by Paul Ozorak**

Paul Ozorak’s book, *Underground Structures of the Cold War: The World Below*, is a historical compilation, detailing the use of bunkers and complex underground facilities by more than 60 countries during the Cold War. The book describes the types of underground structures used by countries from Afghanistan to Vietnam. The particular focus is on the threat posed by the use of nuclear weapons and the protection needed to ensure retaliatory capabilities, continuity of governments, and civil defense. Paul Ozorak, a Canadian military historian, allocates a large portion of text to the politics, protocols, defense capabilities, and planning associated with underground nuclear defense structures. As expected, the largest sections are committed to the United States, Russia, Germany, China, and the author’s home, Canada. Many critical characteristics of underground facilities such as depth, sizes of blast doors, ventilation systems, escape hatches, and life support elements are highlighted.

¹⁶⁹ *Statement to the Senate Armed Services, Current and Projected National Security Threats to the United States, Hearing, 109th Cong., (2004) (statement of Jacoby E. Lowell).*

This compilation of research illustrates the global proliferation of underground structures during a very dark and unstable point in history. As technology in the precision and effect of conventional munitions increases, more and more countries, interested in illicit activities, are turning to subterranean environments for cover and concealment of critical infrastructure and defense capabilities. Defense community professionals must understand that even though many of the structures discussed are no longer in use, the use of underground facilities has continued, and the fundamental characteristics of these structures have not changed. Advances in tunneling and construction technology have made newer facilities more concealable and hardened. Rather than building underground facilities under government buildings or in isolated areas, governments choosing to take advantage of aversions to collateral damage, are likely to build illicit underground facilities under traditional “no fire areas,” such as schools, hospitals, religious centers, and cemeteries. As aerial delivered munitions are unlikely to be used in such environments, ground forces must be prepared to enter and clear these types of underground structures.

2. Lexicon of Hardened Structure Definition and Terms, by the Defense Intelligence Agency

The DIA has composed a *Lexicon of Hardened Structure Definition and Terms*, that establishes consistent terminology used by intelligence, operations, and weapon development communities. The focus of this reference is on hardened structures and serves as a guide to understanding the construction of hard and deeply buried targets (HDBTs).¹⁷⁰ Subterranean environments used for military purposes can be both natural and man-made. Understanding the mission of these underground structures is critical and proper identification and typology is the first step in assessing how effects can be applied. Scientists and engineers have studied the subterranean environment in great detail, and a goal of this project is to integrate terminology across disciplines in order to better communicate an understanding of the unique subterranean environment.

¹⁷⁰ Ibid.

3. Classification of the Typologies of Artificial Cavities in the World, by the Speleological Society of Italy.

Classification of the Typologies of Artificial Cavities in the World presents a typological tree of subterranean environments. The Speleological Society of Italy subdivides the subterranean environment, and its work, into seven categories: hydraulic, war, worship, civil settlement works, mines, transit, and other works.¹⁷¹ Each category has further sub-categories. Further analysis could include historical examples of military uses found with each category.

4. [Title Classified Secret] a Thesis by James Papineau at the Naval Postgraduate School

In order to explore the vulnerabilities of subterranean structures, it is important to understand the different types of construction, as well as internal and external support systems. By understanding the vulnerabilities, a classification of hardness can be distinguished to determine critical node targeting by ground forces. A classified thesis by James Papineau in December 1994, outlined the need for this type of analysis. Unclassified elements can be extracted to build upon areas for continued research. Papineau focused on the problem-set of UGFs which are classified by Papineau as tunnel facilities and cut-and-cover types. The DUGs are considered those with 20 or more meters of overburden.¹⁷² Because the amount of overburden is primarily a consideration when discussing kinetic aerial munitions, this is an unnecessary distinction when applying ground forces; UGFs will be sufficient. There are two types of tunneled UGFs, vertical shaft and hillside facilities. Vertical shaft facilities, as the name suggests, are constructed by excavating a vertical shaft to a desired depth and then tunneling out the space required. Hillside facilities are tunneled directly into steep-sided terrain. The use of natural wall material or the installment of artificial walls, roofing and flooring should also be considered in characterization and vulnerability assessments. Papineau's thesis discussed elements commonly found in UGFs, including internal subsystems such as life

¹⁷¹ Carla Galeazzi, "Classification of the Typologies of Artificial Cavities in the World" (presented at International Workshop, Turin, Italy, 18, 19, and 20 May 2012).

¹⁷² James Papineau, [Title classified S] (master's thesis, Naval Postgraduate School, 1994). This document is classified Secret.

support, power, and environmental control. He also discussed surface support elements such as ventilation openings, water supply, waste handling, municipal power, communication connections, and transportation corridors. All of these characteristics will be considered in developing a typology of all military purposed subterranean environments.¹⁷³

Once a clear typology based on potential missions and common characteristics is determined, mission planning considerations and operational guidelines can be improved. Referencing unclassified portions of Papineau's 1994 thesis, U.S. forces can implement principles discussed about UGFs, to all forms of subterranean structures. Papineau discusses the application of the CARVER principle against UGFs. The CARVER principle is a Special Operations target analysis process that considers criteria of criticality, accessibility, recuperability, vulnerability, effect, and recognizability, in order to determine the best attribute of a particular target to attack to achieve the desired effect. Aside from offering a general description of characteristics and vulnerabilities in all UGFs, effects-based planning is also discussed. Structural kills (destruction) versus mission kills (operational disruption) must be decided upon when targeting any underground structure, be it a tunnel, fortification, or facility. Physical damage to ingress/egress route, restricting air intake/exhaust vents, disabling personnel, and causing failure of essential components can all be accomplished without committing ground forces into the subterranean environment. Mission planners must be clear on the exact desired effect of mission of ground forces preparing to operate in the subterranean environment. The characterization and mission of these structures is essential in determining if the use of ground forces is appropriate.¹⁷⁴

B. HISTORICAL PUBLICATIONS

1. The Fall of Constantinople 1453, by Steven Runciman

During the fifteenth century, one of the most consequential struggles during the middle ages took place in the Byzantine Empire during the siege of Constantinople. The

¹⁷³ Ibid.

¹⁷⁴ Ibid.

forces of Ottoman Sultan Mehmed II laid siege to the ancient city of Constantinople. This forced its Christian inhabitants to seek refuge underground. Entire underground cities began to form under Constantinople to mitigate the threat from their Muslim enemies.¹⁷⁵

2. The Battle of the Crater, by Alfred P. James

The tendency for military units to seek defensive positions underground continued to play a significant role in defensive positions through the centuries. This was again demonstrated in 1864 during the American Civil War. Confederate forces were heavily entrenched and fortified around Petersburg, Virginia when Union forces laid siege to the city. These elaborate, in many cases underground confederate defensive positions prompted Union forces to attempt an offensive tunneling campaign by emplacing a large amount of explosives underground to breach confederate lines. Results of the explosion were disastrous and caused a catastrophic loss to union forces during the battle. This required the Union forces to reevaluate their subterranean operations.¹⁷⁶

3. In Flanders Fields: The 1917 Campaign, by Leon Wolff

Subterranean warfare continued to evolve into a simultaneous struggle of offensive and defensive tunneling by the beginning of the 20th century in World War I. This was illustrated in the Battle of the Messines in 1917. German and Allied Forces were locked in a stalemate of trench warfare in Flanders, Belgium along the Messines Ridge. Both sides made valiant efforts to tunnel their way under the defenses of one another to break the stalemate. However, as they tunneled towards each other, they began to interdict their enemy's underground advances by counter-mining tunnels to intercept their foe. Subsequently, several underground engagements occurred and resulted in a new and horrifying aspect of underground warfare for the troops on both

¹⁷⁵ Steven Runciman, *The Fall of Constantinople 1453* (Cambridge, UK: Cambridge University Press, 1965).

¹⁷⁶ Alfred P. James, "The Battle of the Crater," *The Journal of the American Military History Foundation* 2 (1938).

sides.¹⁷⁷ The experiences of the British, Australian, Canadian, and New Zealand contingent caused U.S. forces to approach subterranean defensive positions with caution during World War II.

4. Okinawa: The Last Battle of World War II, by Robert Leckie

Towards the end of World War II, the Japanese Army made a tactical decision to use underground defensive positions throughout the Pacific in order to neutralize U.S. air power and naval gunfire. The U.S. forces in the Pacific were ordered not to enter underground defensive positions occupied by the Japanese. During the Battle of Okinawa in 1945, U.S. forces focused on using incendiary weapons such as flamethrowers to drive out or kill Japanese troops in their underground positions. The mounting casualties and difficulties associated with an invasion of the fortified and entrenched Japanese homeland may have been a contributing factor in the Truman administration's decision to use the first nuclear weapons in warfare, in order to save American lives.¹⁷⁸

5. The Tunnels of Cu Chi, by Tom Mangold

The lessons learned from World War II, also played a role in future U.S. subterranean conflicts. One of the most notable was during the Vietnam War. Instead of attempting to drive North Vietnamese from their subterranean defensive positions, to engage the enemy above ground, U.S. forces adopted a new strategy of entering tunnels to engage the enemy in order to clear a tunnel. This became evident in the Cu Chi tunnels east of Saigon. The tunnel complex became so extensive it caused severe disruption to U.S. forces.¹⁷⁹

¹⁷⁷ Leon Wolff, *In Flanders Fields: The 1917 Campaign* (Alexandria, VA: Viking Press, 1958).

¹⁷⁸ Robert Leckie, *Okinawa: The Last Battle of World War II* (Australia: Penguin Books, 1996).

¹⁷⁹ Tom Mangold, *The Tunnels of Cu Chi* (New York, NY: Random House, 1985).

6. A Historical Analysis of Tunnel Warfare and the Contemporary Perspective, by Major Allen Reece

A monograph by then Major Allen Reece titled, “A Historical Analysis of Tunnel Warfare and the Contemporary Perspective,” examines the use of subterranean combat during the Civil War, World War I, World War II, Korea, and Vietnam. Each of these conflicts can illuminate unique characterizations and operational challenges to specific uses of the subterranean environment. Major Reece’s monograph concludes by assessing that current U.S. doctrine is sufficient to combat the challenges of subterranean warfare.¹⁸⁰ This assessment is challenged by the lack of organizations, training, and equipment found in today’s military, to combat subterranean threats.

7. Underground Combat: Stereophonic Blasting, Tunnel Rats, and the Soviet-Afghan War by Lester W. Grau

The current U.S. FMs also fail to address weaponry and personal protective equipment (PPE). According to Lester W. Grau’s (1998) article, *Underground Combat: Stereophonic Blasting, Tunnel Rats, and the Soviet-Afghan War*, concussion, explosive, thermo-baric, incendiary, fire and smoke tactics and munitions were extremely effective against insurgents in Afghanistan, Pakistan, Iran, and Vietnam.¹⁸¹ These forms of weaponry have been successful in combating tunnel networks in multiple theaters by many military organizations, yet U.S. doctrine has failed to provide what U.S. forces should use when conducting a subterranean operation.

C. DOCTRINAL PUBLICATIONS

1. ATTP 3-06.11 Combined Arms Operations in Urban Terrain

The subterranean environment that exists as part of the urban operational environment does not adequately emphasize the level of planning needed when considering all the possible subterranean threats used by today’s adversaries. The newest 2011 revision, *ATTP 3-06.11 Combined Arms Operations in Urban Terrain*, covers much

¹⁸⁰ Allen D. Reece, “A Historical Analysis of Tunnel Warfare and the Contemporary Perspective” (monograph, School of Advanced Military Studies, Fort Leavenworth, KS, 1997).

¹⁸¹ Lester Grau and Ali Ahmad Jalali, “Underground Combat: Stereophonic Blasting, Tunnel Rats, and the Soviet-Afghan War,” *Engineer* 28, no. 4, (1998): 20–23.

of what the tactical planner or soldier should consider when preparing to enter urban tunnels and basements. On the spectrum of typology, urban subterranean environments are one element, and although many of the same tactical considerations can be applied, understanding the environmental challenges from rudimentary tunnels to underground facilities and everything between is essential.

2. FM 90-8 Counterguerrilla Operations, FM 90-10 Urban Operations, and FM 90-10-1 An Infantryman's Guide to Combat in Built Up Areas

FM 90-8 Counterguerrilla Operations, FM 90-10 Urban Operations, and FM 90-10-1 An Infantryman's Guide to Combat in Built Up Areas, only provide doctrine on subterranean in urban sewage systems and rudimentary tunnels similar to the Cu Chi Tunnels in Vietnam.¹⁸² Subterranean environments can range from rudimentary tunnels like the ones found in Gaza, Israel, to hardened underground facilities like the ones protecting nuclear weaponry for various nation states. The types of underground environments are vast and though there are some similarities, each one will require its own special considerations and techniques.

¹⁸² Department of Defense, *Field Manual, Counterguerrilla Operations* (Washington, DC: Government Printing Office, 1986, 1993, 2003).

GLOSSARY

Accessibility—Relates to the capabilities required to breach portal entrances, gain access to critical support infrastructure, and reduce obstacles between portals and functional workspaces. An *accessibility level I* structure is one which requires little to none or only simple tools used in mechanical breaching to gain access, such as a Halligan tool, grappling hooks, sledge hammers, or bolt cutters. An *accessibility level II* structure may contain hatches or doors that require explosive or ballistic breaching techniques. An *accessibility level III* structure may contain blast doors, steel gates, or security doors that require dynamic breaching including advanced cutting and extrication tools. An *accessibility level IV* hardened structure may be beyond the capabilities of the individual soldier and may require heavy engineer equipment or kinetic munitions to reduce exterior obstacles.

Civil works—Such as sewers, subways, electrical and exhaust tunnels, and aqueducts, all support habitability in a growing urban population. Although these structures are primarily used to support a civilian population, both state and non-state actors can use these same structures to facilitate clandestine movement of high value personnel and equipment, and storage of weapons and illicit matériel.

Environmental hazards—Include naturally occurring gasses that affect air quality; dangerous insects, arachnids, reptiles, and other wildlife; unstable ground control; stagnant water that may release deadly gases such as hydrogen sulfide or deep water that creates a drowning hazard.

Function—Attribute is used to describe the purpose of a particular subterranean target area. Functions within the subterranean environment include *C³I* (Command, Control, Communications, and Intelligence), *production*, *storage*, and *conveyance*.

Hard and deeply buried target (HDBT) —This generic term refers to all types of intentionally hardened targets, either above ground or below ground, that are designed to withstand or minimize kinetic weapon effects. ¹⁸³

Hardened structure—A structure that is intentionally strengthened to provide protection from kinetic weapons effects. This strengthening is in excess of the amount required for normal building design loads. ¹⁸⁴

¹⁸³ Defense Intelligence Agency, *Lexicon of Hardened Structure Definitions and Terms* (UNCLAS/FOUO) (Washington, DC: Defense Intelligence Agency, 2011), 85.

¹⁸⁴ *Ibid.* 85.

Hard structure—Hard structures include those that are intentionally or unintentionally hardened. Hard structures, such as highway or railroad tunnels, certain types of bridges, and some airfield runways, may be inherently hard without special construction because of their normal design.¹⁸⁵

Incendiary weapons—Means of any weapons or munitions which is primarily designed to set fire to an object or to cause burn injury to persons through the action of flame, heat, or a combination thereof, produced by a chemical reaction substance delivered on the target.

Infrastructure—Attribute is used to describe the support systems tied to the particular subterranean target area. Subterranean infrastructure includes ventilation, power supply, water supply, waste discharge, transportation, and communications.

Matériel hazards—Include those hazards artificially introduced into the environment. These can include, explosives, booby traps, and improvised explosive devices (IEDs); nuclear, biological, or chemical (NBC) storage or production equipment; fuel and other petroleum, oil, and lubricants (POL); as well as other man-made implements.

Mobility—Within a subterranean passage typically coincides with the largest item to be conveyed through or housed within the functional workspace. The mobility attributes are defined as *restricted*, *semi-restricted*, *permissive*, and *unrestricted*.

Permissive—Adits that allow for the fully upright movement of persons in columns of two.

Personnel hazards—Account for the presence of potentially hostile persons within the subterranean structure. This could include armed defense forces or non-combatants that may become hostile once encountered.

Restricted—Adits that are characterized by their confined space permitting only the single file movement of persons in a prostrated or less than fully upright posture.

Rudimentary tunnels—Are typically hand dug using mechanical and/or general purpose tools. The walls of these tunnels are bare and have limited to no support features or shoring to prevent structural collapse. Rudimentary tunnels have little to no infrastructure installed and instead rely on natural air flow ventilation and structurally designed water removal.

Semi-restricted—Adits that allow for the fully upright movement of persons in single file.

¹⁸⁵ Ibid.

Sophisticated tunnels—Are typically dug using mechanical tools or larger heavy equipment. Equipment must rely on air compressors or electricity for power, unless significant ventilation is available to support the use of combustion engines. A noticeable characteristic in sophisticated tunnels is the effort placed in shoring up of access portals and walls. The use of concrete-like material or masonry and timber to line the walls indicates a deliberate effort to maintain a lasting subterranean passage.

Substructures—Constitute basements and similar subterranean spaces that are attached to an above ground structure. These basement facilities may be accessed from within the above ground structure, but may also have exterior access points and umbilical infrastructure.

Threat—Attribute characterizes the potential risk to forces entering the subterranean environment. This threat attribute may also factor into the *size*, *composition*, *weapons posture*, and *special equipment* needed to effectively operate in a particular subterranean environment. Threat characteristics within subterranean environments include *environmental*, *personnel*, and *matériel*.

Tunnels—Tunnels are generally used as a means to clandestinely move people and items between two or more locations. Tunnels can be classified into two subcategories, Rudimentary and Sophisticated.

Unrestricted—Adits that are large enough to support upright movement of more than a two person column and may even support the movement of vehicles.

Underground facilities (UGFs) —UGFs are characterized by their purpose-built design and construction to resist destruction by conventional and nuclear munitions. The subcategories of UGFs are Shallow Underground Facilities (UGS) and Deep Underground Facilities (DUGs).¹⁸⁶

Urban and natural cavities—Most have dual usage; meaning the original structure can be adapted for military purpose; cover a wide variety of structures, with the focus being on potential impacts on the civilian population. The subcategories of Urban and Natural Cavities are *Substructures* and *Civil Works*.

¹⁸⁶ Ibid.

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