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# *Covert Tunnel Detection & Subterranean Warfare Industry Overview*



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## 1 Subterranean Warfare

- ❑ Subterranean warfare is an asymmetric answer for the enemies of nation armed forces. Over the past 100 years, subterranean warfare has evolved from a tactic to evade potential enemies into an extremely effective and efficient means to counter the effects of superior power. As the lethality and precision of munitions increase, enemies will be forced deeper and deeper into the earth, possibly presenting overwhelming challenges to military strategists.
- ❑ Lessons learned from past conflicts influence future research and development in tactics, technologies and doctrine that will provide future warfighters the necessary tools to combat the tactics of subterranean warfare in the future.
- ❑ The evolution of subterranean warfare from its origins to the elaborate tunnel complexes of the Korean and Vietnam conflicts to the underground structures in Iraq used during Desert Storm and Gaza.
- ❑ In recent conflicts, wherever U.S. NATO and Israeli 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 military, but also, police forces, first responders, border patrol, and other security organizations.
- ❑ 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.
- ❑ 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 soldier must have the most current and in-depth training necessary for a successful mission in subterranean warfare.
- ❑ Subterranean tunnels have been in use for thousands of years with applications ranging from perimeter infiltration to more modern

applications of drug smuggling. Most historical examples are related to military and security applications, whether it be using a tunnel to build a fire beneath the exterior wall of a castle to facilitate structural failure, or digging a tunnel into enemy territory to execute a behind-the-lines attack.

## 1.1 Key Facts

- ❑ Covert tunnels are growing in number and their sophistication is increasingly astonishing. The boldness of their location, the volume and character of items transported through them, allied with the increasingly sophisticated booby trap protection, have all become a serious threat to security.
- ❑ Subterranean warfare is not new in human history. Tunnels, which have been dug in all periods for various purposes, have usually been the weapon of the weak against the strong and used for concealment.
- ❑ The time required to dig tunnels means that they can be an important tool for local residents against an enemy army unfamiliar with the terrain. Tunnels used for concealment purposes (defensive tunnels) can be distinguished from tunnels used as a route for moving from one place to another. The latter include smuggling tunnels used to smuggle goods past borders (as in the Gaza Strip), escape routes from prisons or detention camps, offensive tunnels to move forces behind enemy lines, and booby-trapped tunnels planted with explosives under enemy facilities .
- ❑ Digging a 1-2 Km tunnel is estimated to take about three months and costs about \$100K. Such tunnels can be concealed so that their openings are inside houses or greenhouses, and can be dug in advance without being used until the crucial time.
- ❑ There have been multiple examples in the last century, including dedicated tunneling companies in World War I that constructed tunnels beneath No Man's Land in Flanders, Belgium, the Cu Chi tunnels in Vietnam in the 1960s, and cross-border tunnels beneath the de-militarized zone (DMZ) in Korea in the 1970s through 1990s. More modern examples include smuggling tunnels along the United States-Mexico border, smuggling tunnels between Egypt and Gaza that circumvent restrictions placed on the import and export of goods from Gaza, and attack tunnels from Gaza into Israel purportedly for carrying out tactical strikes.
- ❑ Currently, covert tunnels have achieved notoriety in Gaza, around Israeli borders, and the US-Mexican and Canadian borders.
- ❑ Covert tunnels and digging nearby any secured infrastructure are a security vulnerability that enables people and contraband to illegally cross a national border and enter and/or attack secured perimeters. These

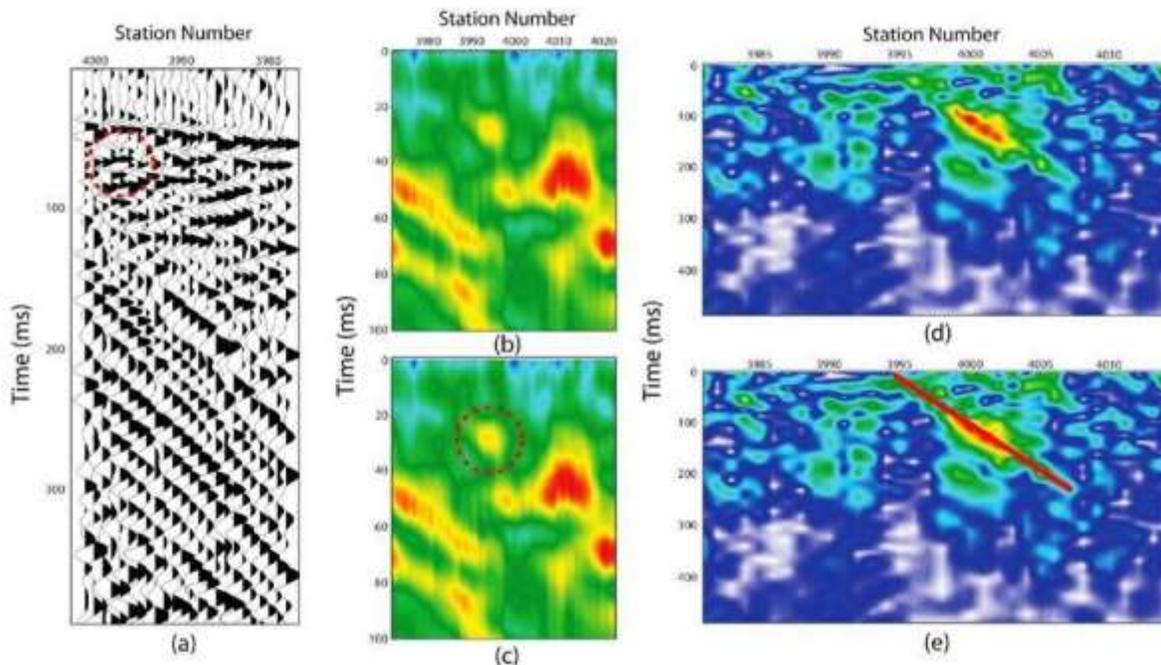
tunnels to-date have been constructed for the purpose of support terrorist activity and crime.

- ❑ There is a lot of attention directed at the problem of detecting cross border tunnels. And for good reason; more than 2500 covert tunnels were found during the last 10 years, which were detected by conventional law enforcement practices once the tunnels were completed. They were discovered through informants or finding the location of a tunnel entrance as a part of an ongoing law enforcement investigation, and by intelligence agencies.
- ❑ Four tunnels have been discovered beneath the DMZ between North Korea and South Korea, between 1974 and 1990 with multiple others suspected to exist. Depths range from approximately 1 m beneath the surface and reinforced with concrete slabs to 350 m deep. These tunnels are blasted through granite using explosives running well into the 4-km wide DMZ and south of the demarcation line.
- ❑ The conflicts in Iraq and Afghanistan have also produced examples of clandestine tunneling; however, the purpose of those has been to escape a secure facility instead of moving illegal drugs or tunneling into a facility. In 2005, a tunnel was discovered at the largest American military prison in Iraq at Camp Bucca that was 4.6m deep and 109m long. The walls of the tunnel were smoothed and cemented with milk while the spoils were spread out over a soccer field used for detainee exercise. Detainees worked five-minute shifts, digging with tools made from tent poles. A similar incident occurred six years later near Kandahar, Afghanistan, in 2011 where a reported 488 Taliban prisoners escaped from the Sarposa prison, which is the largest prison in southern Afghanistan. The tunnel took approximately five months to construct, running over 300m long and 1m wide with electricity and ventilation throughout.

Figure 1 - Afghanistan, Sarposa Prison Escape Tunnel Image



Figure 2 - Seismic Data Collected over a Discovered Tunnel



**Notes:** (a) Is a shot gather with diffraction interpreted to be from the tunnel indicated by the red-dashed circle. (b) and (c) are enhanced diffraction sections with the interpreted tunnel location indicated by the red-dashed circle. (d) and (e) are both surface wave backscatter cross-sections indicating the interpreted signature arising from the tunnel marked by the solid red line.

(Source: U.S. Army Engineer Research & Development Center)

- ❑ But as more and more covert tunnels are being discovered and many others have not yet been found, lots of suggestions have been made regarding a variety of techniques that can be deployed to detect these tunnels directly.
- ❑ Proposed solutions revolve around the application of current technology or the extension of this technology, and include but are not limited to adapt ground-penetrating radar (GPR), the use of seismic sensors, magnetometers, infrared detectors and fused multi-sensors multi-modal systems.
- ❑ In the past, detainees have sometimes resorted to tunnels to escape prisons; a strategy also occasionally employed by the Allies and Axis alike when escaping from prisoner of war camps during World War II.
- ❑ Modern Armies often fought foes that hid in tunnels. In the Vietnam War, the Viet Cong dug into the tunnels early in the war, taking advantage of their cover and using them to surprise American forces in attacks such as the 1968 Tet Offensive. The United States lacked any real means of detecting these tunnels and resorted to bombing them several times during the war. Just as the Viet Cong moved fighters and supplies through their tunnels, the Taliban in Afghanistan use tunnels for the same purposes. The mujahideen fighting the Soviet Union employed Afghan tunnels extensively in the 1980s. These same tunnels have posed challenges since Sept. 11, 2001.
- ❑ People traffickers and drug cartels often use clandestine tunnels to cross the vast U.S.-Mexican border, which runs 3,200 Km

## 1.2 Conclusions

- ❑ Subterranean Warfare, especially the detection of clandestine tunnels & underground structures has proven to be a challenge in itself in ideal conditions. It becomes much more difficult when looking for such subtle signatures in an operational environment where noise sources are plentiful and data acquisition parameters may be compromised due to mission requirements, less than ideal conditions, and the notion that some data, albeit noisy, is better than no data at all.
- ❑ Future Subterranean Warfare technologies and tactics will be based on 3 elements:
  1. Clandestine tunnels & underground structures detection systems will be based on fused Multi-Modal Multi-Sensors hardware, algorithms and architecture.
  2. Proactive “Detect and Kill” Subterranean Warfare, in which remotely controlled subterranean guided robots will search, detect

and combat the opponent tunnels and buried structures. This will open a new era of “Subterranean Warfare” in which a host of spiral ever-changing technologies and tactics will be employed by terrorists, criminals, security and armed forces.

3. Future Asymmetric wars will include future warfighters  
Subterranean Warfare means and tactics

- ❑ Despite the challenges, several technologies are successful in detecting and locating known clandestine tunnels & underground structures that had been previously discovered, as well as a completely unknown target that was subsequently confirmed by excavation and found to be with the interpreted location. Both data sets were processed without any prior knowledge that the clandestine tunnels & underground structures were present or their locations.
- ❑ Tunnel detection has been a problem for years. It's the Holy Grail of geophysics, subterranean detection and warfare. It is a hard problem to solve, finding things in the near subsurface. It is a big challenge, and it has to be a structured program or else it would continue to have a science-fair approach to testing different ineffective technologies continuously.
- ❑ The geology varies widely, ranging from hard rock and very rugged mountainous terrain at high altitudes, to thick sections of loess, to sand dunes and unconsolidated alluvium. Given that the physical properties vary to such a degree, it is no surprise that the detection of clandestine tunnels & underground structures is a challenging task.
- ❑ Geophysical properties are wide-ranging. Seismic velocities can span an order of magnitude from one site to another, and coupled with what can be very complex geology, makes data processing much more complicated. What works at one site may not work at all at another and processing flows must be tuned to each individual site. Further complicating both the data acquisition and processing are the heavily populated urban environments with dense infrastructure and numerous noise sources, such as cars, trucks, motorcycles, tractors, mule-drawn wagons, pedestrians, and the typical noise added by curious onlookers who have never seen a seismic crew or equipment before.
- ❑ Although many technical approaches to tunnel detection have been proposed and tested in the past, the security community has made many efforts to enhance tunnel detection. Most existing capabilities are based on equipment originally designed to detect land mines or identify natural gas and oil deposits; therefore, they are not necessarily suited to specific operational needs.
- ❑ Effective tunnel detection depends on the geophysical characteristics of local soil, which vary immensely.

- ❑ If the first precept in providing security is used, we can avoid much of the cost and time associated with evaluating alternatives that may require extreme extension of current technology or development of new technologies. It also allows rapid determination of which of the existing technologies have the greatest probability of success, and a good estimation of the relative time and cost to deploy them.
- ❑ The first precept is threat analysis. Since we are focusing on the threat from border crossing tunnels and we are not concerned with “who” is building them, we can immediately move to characterization of the threat. This can be viewed according to physical parameters (diameter, materials), location (depth, crossing point) and transient properties (construction time and changes in attributes over time).
- ❑ There is a range of materials and sizes that might be necessary to consider; but, it is nearly certain that the physical parameters will differ significantly from the immediate area around the tunnel. The main influence of location is on sensor placement and properties. The “eureka” moment comes from the realization that transient properties are just changing. A second revelation comes with recognition that we do not care if the tunnel builder knows we are searching for their tunnel.
- ❑ While the question arises as to whether we are looking for an existing tunnel, a tunnel under construction or a newly built tunnel, it turns out that we don’t really need to be very concerned about this, as the properties of the tunnel will change as it is being used/built. Furthermore, the properties of the terrain are permanently changed when the tunnel is completed. One noteworthy factor to consider is that tunnel construction is a very slow process, and even its use is a relatively slow process.
- ❑ Consequently, a continuous, overlapped monitoring process that is capable of detecting changes relative to a baseline of characteristics of the area under inspection will detect anomalies. Since the environment is very stable in comparison to the air or ocean, and the variations to be detected are very low in frequency, the background “noise” is comparatively low in the frequency band of interest. Therefore, we can use a combination of passive and active “signatures” as the baseline for comparisons.
- ❑ Probability of Detection PD should be determined or defined for each technology and the subsurface geo-environment.
- ❑ Regardless of which theories are advanced to account for discovery of the Clandestine Tunnels & Underground Structures, an immediate national security concern is determining the probability that smuggling Clandestine Tunnels & Underground Structures will serve as the conduit by which terrorists or their weapons of mass destruction will bypass post-9/11 security procedures.

- ❑ At the core of the national security concern is that it is difficult to separate criminal and terrorist groups who may use the same tunnel, as well as separating Clandestine Tunnels & Underground Structures built and used only by criminals from Clandestine Tunnels & Underground Structures built and used only by terrorists.
- ❑ The discussion includes national security threats posed to a nation by smuggling tunnels controlled by terrorist organizations or cells under the organization's control, in addition to or in concert with individuals with criminal and terrorist intent, among a citizenship that has either supported or become indifferent to tunnel construction. At its core, transnational analysis would be a national intelligence program that follows the post-9/11 model by seeking to fuse foreign intelligence analysis of the threat that Clandestine Tunnels & Underground Structures pose to other governments with the criminal data, criminal intelligence, and criminal investigative analysis regarding tunnels on national borders.
- ❑ It has been said that “be it natural caves, simple hand-dug Clandestine Tunnels & Underground Structures , or very sophisticated hard and deeply buried Under Ground Fortress, it now appears that the underground terrain may very well be the pivotal battlefield of the not so distant future”
- ❑ This prediction has been confirmed in recent reports from the war in Afghanistan in which Taliban use Clandestine Tunnels & Underground Structures to maintain command and control elements as well as to run operations (“Afghan, coalition forces,” 2010) and have used Clandestine Tunnels & Underground Structures to move between a fortress and an escape route (“Al-Qaeda suspects” 2004). When soldiers of the 101st Airborne's 3rd Battalion, 3rd Brigade searched one of Saddam Hussein's underground fortress-and-tunnel systems, they found a 12-room complex inside a cave with white marble floors, 10-foot ceilings and fluorescent lighting.
- ❑ For purposes of transnational analysis, it is understood that the Gaza Strip borders Egypt on the southwest and Israel on the south, east, and north. The terrain is flat to rolling, sand- and dune-covered coastal plain. Geopolitical factors of the Gaza Strip included the Israeli-imposed crossing closures, which became more restrictive after Hamas violently took over the territory in June 2007, and fighting between Hamas and Israel, which resulted in the near-collapse of most of the private sector, extremely high unemployment, and high poverty rates. Shortages of many goods are met through the Hamas-controlled black market tunnel trade that flourishes under the Gaza Strip's border with Egypt.
- ❑ The strength of U.S. security is that there are only two possible borders by which tunnels can subvert transportation security checkpoints. However, the corresponding security weakness is that the Canadian border (excluding Alaska) is approximately 3,987 miles long, while the length of

the United States-Mexico border is approximately 1,933 miles long both of which present significant distances to protect.

- A similarity between individuals who constructed the United States-Canada tunnel in 2005 and individuals involved in the Middle East Clandestine Tunnels & Underground Structures is that the individuals in both hemispheres of the world were bound by specific ethnic groups within the larger population. Specifically, individuals in the United States-Canada tunnel came from the ethnic classification, Fijian East Indian. The importance of identifying, classifying, and understanding ethnicity of individuals who construct Clandestine Tunnels & Underground Structures is critical. Understanding individuals' ethnicity, family connections, and national alliance if any, leads to an understanding of the individuals' worldviews, especially views related to U.S. national security.

**More information can be found at:**

**[Subterranean Warfare \(Tunnels & Underground Structures Detection and Subterranean Robots\) Technologies: Global Market - 2015-2020](#)**