



SUBTERRANEAN OPERATIONS:

ISRAELI DEFENSE FORCE LESSONS FROM GAZA

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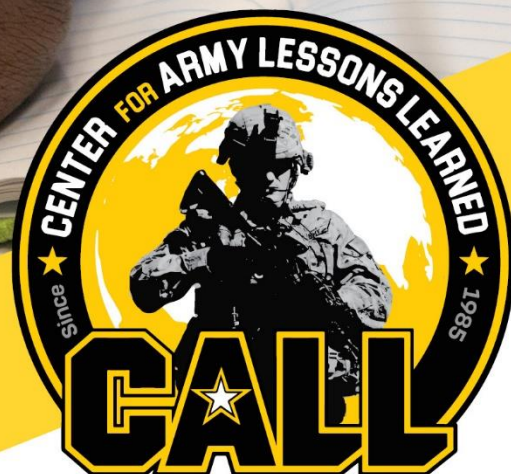
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Introduction

The 7 October 2023 surprise attack by Hamas against Israel, involved a multifaceted assault utilizing rockets, drones, and ground incursions, marking a significant escalation in the ongoing Israeli-Palestinian conflict.

The Israeli Defense Force (IDF) responded by initiating Operation Swords of Iron and engaged in intense combat operations within the Gaza Strip to destroy Hamas' military capabilities. A defining characteristic of the fighting was the extensive Hamas tunnel system which presents a unique and formidable challenge, forcing the IDF to adapt and innovate in its approach to urban warfare.

While the U.S. Army may not currently face a subterranean threat precisely mirroring the scale and complexity of the IDF's experience in Gaza, the potential for adversaries to utilize underground infrastructure to negate U.S. military advantages is a growing concern. Understanding how to counter this tactic becomes increasingly vital as potential adversaries seek to mitigate the capabilities of a superior force.

This paper will explore the IDF's experience confronting the subterranean threat in Gaza, analyzing the tactics, techniques, and procedures (TTPs) employed, as well as the equipment utilized. Ultimately, this analysis provides actionable recommendations for the U.S. Army, drawing lessons from the ongoing conflict to enhance preparedness for potential underground warfare scenarios and bolster overall operational effectiveness.

Overview

The existence of tunnels in Gaza was well known by the Israelis from past experience. The IDF established the Yahalom unit in 1995 as a special operations force of the Combat Engineering Corps responsible for counter-tunnel operations. In pursuit of its mission, Yahalom developed advanced tactics, techniques, and equipment for detecting, mapping, searching, and neutralizing tunnels.¹ This unique organization has played a critical role in countering Hamas' underground network.

Combat operations in Operation Swords of Iron revealed the tunnel network was even more extensive than originally thought and has been referred to by the Israelis as the "Gaza Metro". Reports have indicated 350-450 miles of tunnels with 5,700 shafts within Gaza.² The tunnels are integrated into the civilian infrastructure, making them difficult to detect and target as shown in Figure 1. This also hampered the IDF's ability to destroy the tunnels through air-dropped munitions or explosives without extensive damage to buildings and infrastructure in areas densely occupied by civilians.

¹ Epstein, Jake. *When Israel needs to fight Hamas in its tunnels, it turns to an elite band of commandos called the Yahalom unit*. Business Insider. November 2023. <https://www.businessinsider.com/israel-uses-yahalom-unit-when-it-needs-to-fight-underground-2023-11>. Accessed 25 March 2025.

² *Israel Unearths More of a Subterranean Fortress Under Gaza*. New York Times, 16 January 2024, <https://www.nytimes.com/2024/01/16/us/politics/israel-gaza-tunnels.html>. Accessed 25 March 2025.

Hamas designed the tunnel network with integrated electricity, ventilation, and communication systems, enabling fighters to operate within them for extended periods. This underground network provides capabilities analogous to those roads provide a military force. Tunnels support offensive operations, facilitating the movement of units to conduct ambushes or launch rockets. They also support defensive operations, allowing Hamas to counter Israel Defense Forces (IDF) ground movements or disengage from superior forces. Logistical tunnels enable the movement and storage of supplies across the battlefield, while dedicated command and control tunnels house Hamas leadership facilities. Additionally, cross-border tunnels serve as smuggling routes for goods, weapons, and ammunition into Gaza from neighboring countries.

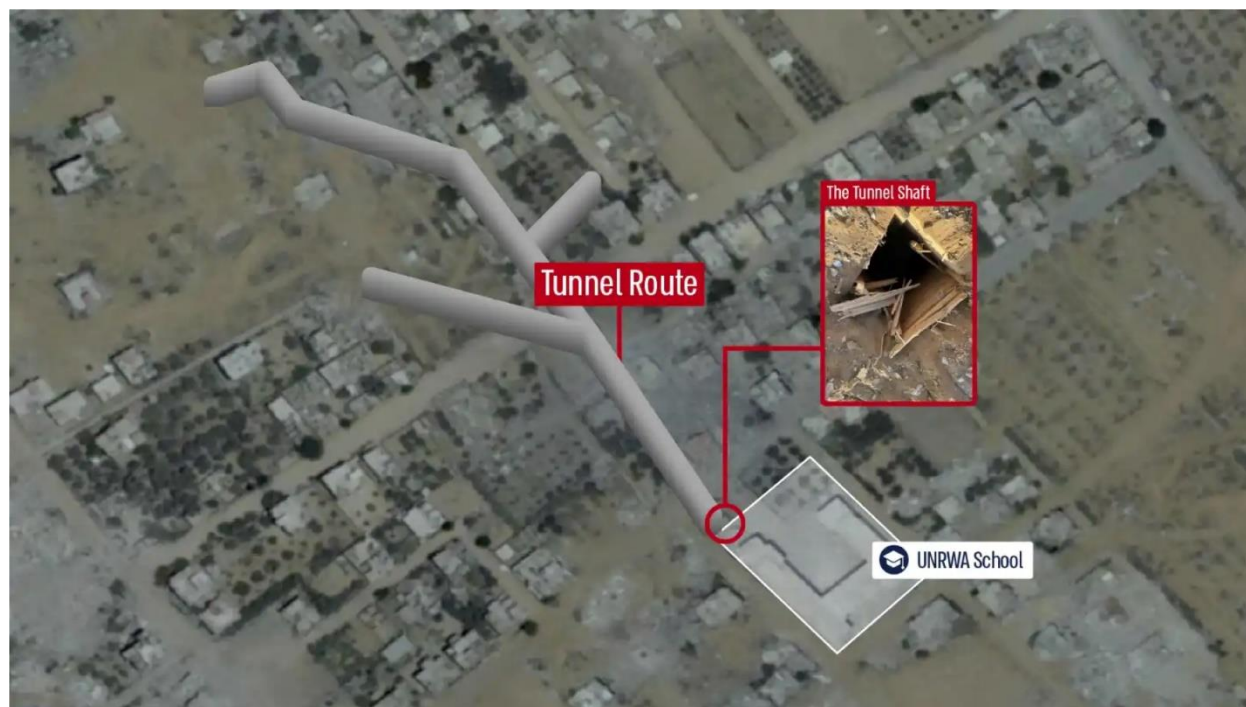


Figure 1. Hamas tunnel route near United Nations Relief and Works Agency School.³

The tunnels in Gaza are not all physically connected though they often have communication links to facilitate coordination between Hamas forces.⁴ The tunnels are roughly organized into serving tactical and strategic purposes. The tactical tunnels are closer to the surface and allow Hamas to move around the battlefield without being observed on the surface. A main channel may have branches with prepositioned arms and ammunition to launch indirect fire attacks or ambush IDF forces. Hamas fighters can also escape to safe areas or reinfiltrate into previously cleared rear areas behind IDF units. The second level of tunnels serve a strategic purpose and are

³ *Tunnel Route Near an UNRWA School*. Israeli Defense Force. 30 June 2024. <https://www.idf.il/en/mini-sites/idf-press-releases-israel-at-war/june-24-pr/tunnel-route-near-an-unrwa-school-discovered-in-rafah/>. Accessed 14 May 2025.

⁴ Watling, Jack and Reynolds, Nick. *Tactical Lessons from Israeli Defense Forces Operations in Gaza 2023*. RUSI Occasional Paper. 11 July 2024. <https://www.rusi.org/explore-our-research/publications/occasional-papers/tactical-lessons-israel-defense-forces-operations-gaza-2023>. Accessed 14 May 2025.

deeper, larger, and better built. These may feature sleeping quarters, command and control centers, and weapons storage facilities.⁵ Figures 2 and 3 depict the Hamas subterranean network from a top view and cross and cross section.

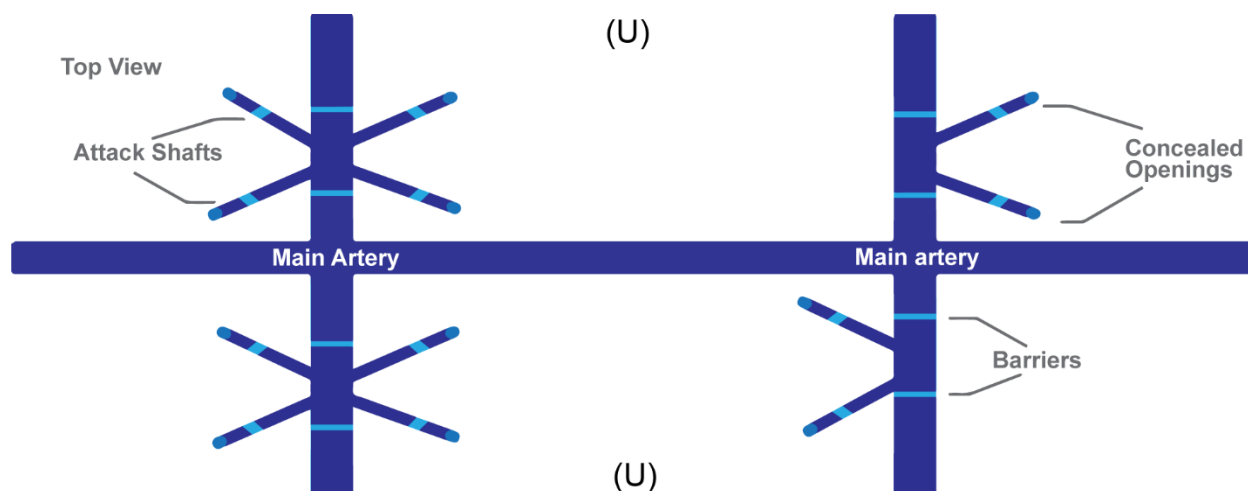


Figure 2. Hamas Subterranean Network Top View.⁶

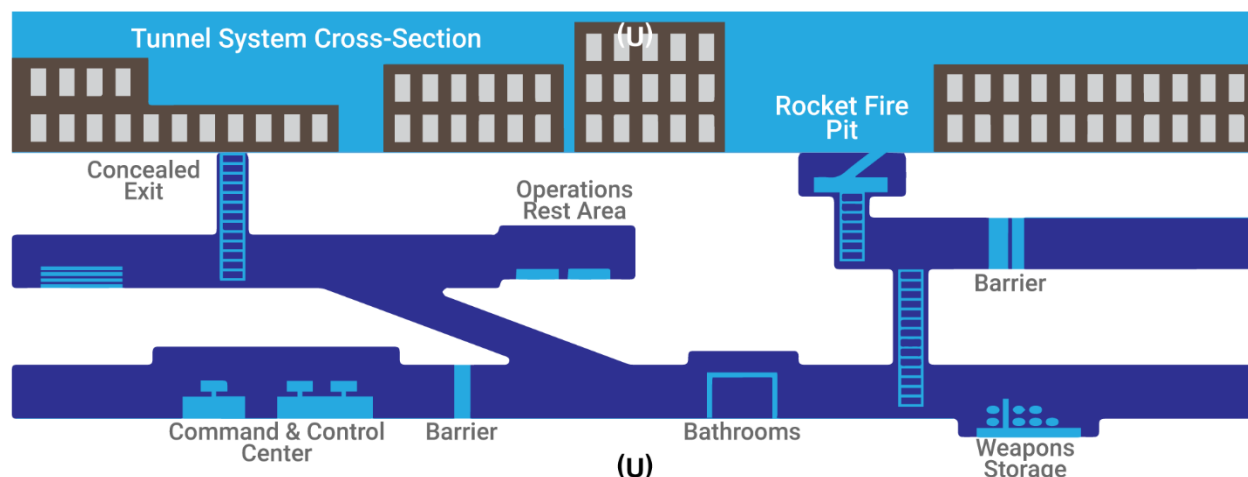


Figure 3. Hamas Subterranean Network Cross Section.⁷

Initially, the IDF considered subterranean operations to primarily be the responsibility of Yahalom. However, the sheer size and complexity of the tunnel network in Gaza has proven to be a central element of the war, challenging the IDF's conventional superiority and necessitating a rapid evolution in subterranean combat strategy.

⁵ Gaza Assessment Task Force, *The October 7 War: Observations, October 2023 - May 2024*, The Jewish Institute for National Security of America, 30 May 2024. https://jinsa.org/jinsa_report/gaza-war-observations-2023-2024/. Accessed 20 May 2025.

⁶ 25-891 Initial Impressions Report: Israel-Hamas War Observations. Center for Army Lessons Learned. This report is available to authorized users only with valid Common Access Cards (CAC).

⁷ Ibid.

“We are engaged in a simultaneous maneuver - fighting both above and below ground, operating with professionalism, with cooperation between special forces, commandos, and the division's combat teams. Hamas terrorists are fleeing. We are striking them and their infrastructure both above and below ground.”

BG Dan Goldfus
Commander of the 98th Division⁸

Fighting in Gaza is multidimensional, with IDF units simultaneously maneuvering in buildings, at ground level, and in tunnels. The IDF must coordinate the actions of conventional and special operations units operating above and below ground, very often across their unit boundaries. This presents challenges to maintaining unity of effort and avoiding fratricide. To help resolve the conventional/special operations forces (SOF) coordination issue, the IDF attached Yahlom and Navy special operations Shayetet 13 detachments directly to conventional maneuver brigades to establish a single command relationship.

Tunnel Detection

Tunnel detection is complicated by the entrances typically being inside civilian structures and hidden from view. The IDF has employed a layered approach to maximize the probability of discovering subterranean activity. This network leverages multiple methods to overcome limitations inherent in single-sensor approaches.

Seismic and Acoustic Sensors

Seismic and acoustic sensor arrays are deployed to detect vibrations associated with excavation, material movement, and personnel activity within tunnel systems. Analysis focuses on differentiating between natural seismic events and human activity signatures.⁹ The sandy soil in Gaza decreases the effectiveness of these sensors but have been more successful in Lebanon where the tunnels are built in rock.

Thermal Imaging

Utilizing both airborne and ground-based thermal imaging systems, the IDF identifies thermal gradients indicative of underground construction or operational activity. This is particularly effective in identifying recently excavated tunnels or those with active ventilation systems.

Ground Penetrating Radar

Ground-penetrating radar (GPR) is utilized to image subsurface structures, providing a non-destructive method for identifying tunnel voids, construction materials, and potential obstacles. Data interpretation requires specialized training to differentiate between legitimate targets and natural geological formations.

⁸ *Combat in Khan Yunis: 98th Brigade Operations Above and Below Ground*. Israeli Defense Force. 29 January 2024. <https://www.idf.il/en/mini-sites/idf-press-releases-israel-at-war/january-24-pr/combat-in-khan-yunis-98th-brigade-operations-above-and-below-ground/>. Accessed 2 July 2025.

⁹ Whittaker, Malcom. *A Seismic Victory in Gaza: Mapping the Tunnels of the “Gaza Metro”*. 16 November 2023. https://www.realcleardefense.com/articles/2023/11/16/a_seismic_victory_in_gaza_mapping_the_tunnels_of_the_gaza_metro_993093.html. Accessed 17 June 2025.

Visual Reconnaissance

Visual reconnaissance includes analyzing satellite and aerial photographs for subtle changes in the landscape – disturbed earth, new construction, and ventilation shafts disguised as harmless structures. Soldiers physically search areas, looking for hidden entrances, unusual mounds of earth, or inconsistencies in the terrain. This is extremely dangerous due to potential booby traps and exposure to enemy observation and fire. The sandy soil in Gaza requires the tunnels to be reinforced to prevent collapse. The discovery of prefabricated concrete support panels indicates that a tunnel entrance may be nearby.

Human Intelligence

Human intelligence methods include interrogation of captured fighters and cultivating sources within Gaza who provide information about tunnel entrances, routes, and usage.

Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) are growing capabilities in detecting tunnels. AI algorithms can analyze vast amounts of satellite and aerial imagery to identify indicators of tunnel activity that humans might miss. It can also be used for predictive modeling to determine potential tunnel routes based on historical data and terrain analysis. ML can combine data from multiple sensors (seismic, GPR, thermal, etc.) to create a comprehensive and accurate picture of the underground environment.¹⁰ This capability has been especially valuable due to the vast number of tunnels in Gaza.

Mapping and Investigation

The IDF actions prioritize soldier safety and maximize intelligence gathering when a tunnel is discovered. First, the area around the entrance must be secured to prevent enemy observation and attack. This is an especially dangerous time with stationary forces vulnerable to snipers, indirect fire, and ground attacks. The surrounding area must be searched for vent holes, solar panels, entrances, and sources of water and electricity to help identify the tunnel configuration. Colored smoke can help identify vent holes and other entrances.

Next, explosive ordnance disposal (EOD) teams are used to identify, render safe, and dispose of explosive hazards around the entrances.

Once this is accomplished, an initial assessment conducted by lowering cameras into the entrance. The size, type of construction, and direction of the tunnel is reported to higher headquarters to initiate the mapping and investigation by Yahalom.

Finally, the Yahalom unit conducts a detailed reconnaissance to confirm tunnel layout, collect intelligence, and identify obstacles and booby traps within the tunnel like the ones in Figure 4.

¹⁰ *Inside Israel's AI Factory for War*. DigiAlps Digital Production Studio. <https://digiAlps.com/inside-israels-ai-factory-for-war/>. Accessed 9 April 2025.

The use of military working dogs (MWDs) and unmanned ground vehicles (UGVs) minimize the risk to personnel during the initial entry phase.

UGVs equipped with pan-tilt-zoom (PTZ) cameras, environmental sensors (e.g., gas detectors), and mapping capabilities are used for tunnel assessment. Military working dogs (MWDs) from the IDF Oketz canine unit are specially trained to operate in tunnels. The dogs navigate obstacles and work in low light conditions to rapidly reconnoiter the tunnel, sniff out explosives, and attack Hamas fighters.¹¹

Based on initial reconnaissance, Yahalom teams may then enter the tunnel to conduct a thorough search to look for Israeli hostages, capture Hamas leaders, and/or gather intelligence. The teams are equipped with infrared capable night vision goggles, bulletproof shields, breaching tools, breathing devices, air monitors, and weapons with suppressors to enable their tasks.



Figure 4. IDF soldier guards the entrance to a Hamas tunnel.¹²

¹¹ Spencer, John. *The Dogs of (Urban) War: Lessons from Oketz, the Israel Defense Forces' Canine Unit*, 1 January 2025. Modern War Institute. <https://mwi.westpoint.edu/the-dogs-of-urban-war-lessons-from-oketz-the-israel-defense-forces-specialized-canine-unit/>. Accessed 15 May 2025.

¹² *Locating and Eliminating Underground Tunnel Routes and Rocket Production Facilities*. Israeli Defense Forces. 18 April 2024. <https://www.idf.il/en/mini-sites/idf-press-releases-israel-at-war/april-24-press-releases/locating-and-eliminating-underground-tunnel-routes-and-rocket-production-facilities/>. Accessed 29 April 2025.

Neutralization and Destruction

The method of tunnel neutralization and destruction requires careful planning and assessment to be successful. Critical factors in determining the type and method include the depth of the tunnel, presence of blast doors, soil type, and potential effect on civilian infrastructure.¹³

Physical Collapse

Armored Caterpillar D9 bulldozers or other engineering equipment may be used to physically collapse tunnel sections, rendering them unusable as seen in Figure 5. This method is effective but can be time-consuming and may require extensive earthmoving. Area security must be provided to protect the equipment and operators from enemy attack.



Figure 5. IDF backhoe is used to uncover a tunnel.¹⁴

Polyurethane Foam

To counter the use of Hamas's tunnel network, the injection of rapidly expanding polyurethane foam into tunnel passages is being employed to create impermeable barriers. This technique

¹³ Majd Abuamer. 05 May 2024. *Gaza's Subterranean Warfare: Palestinian Resistance Tunnels vs. Israel's Military Strategy*. Studies in Conflict & Terrorism, DOI: 10.1080/1057610X.2024.2347843.

¹⁴ Soldiers Expose and Destroy Underground Military Compound on Gaza's Coast. Israeli Defense Force. 4 January 2024. <https://www.idf.il/en/mini-sites/idf-press-releases-israel-at-war/january-24-pr/soldiers-expose-and-destroy-underground-military-compound-on-gaza-s-coast>. Accessed 29 April 2025.

offers a relatively quick and precise method of obstruction, minimizing collateral damage compared to traditional demolition methods. However, the effectiveness of this approach is dependent on the structural integrity of the tunnels themselves; compromised or heavily damaged tunnels may allow the foam to escape, reducing its blocking capability. Further considerations include the volume of foam required to effectively seal a tunnel segment and the potential for Hamas to circumvent barriers through alternative routes or by rebuilding obstructed sections. This method is part of a broader effort to degrade Hamas's subterranean infrastructure and deny them a key operational advantage.¹⁵

Bunker-Buster Munitions

Bunker-buster munitions, such as the GBU-28, may be employed against heavily fortified tunnel sections. Precise targeting and collateral damage assessment is critical to avoiding civilian casualties and unnecessary damage to the urban infrastructure.

Controlled Explosive Charges

Yahalom engineers utilize controlled explosive charges to collapse or breach tunnel sections, requiring meticulous planning and execution. The type of soil is a critical factor. Tunnels in Gaza are in sandy soil where those in Lebanon are in rock. Each requires different explosives and methods to obtain the desired effect.

Flooding Tunnels

Previous attempts to flood tunnels with seawater proved largely ineffective due to the porous nature of the local soil, the presence of blast doors, and strategically placed drainage systems. The time and amount of water required to achieve saturation was deemed impractical, leading to this method being largely discontinued.

U.S. Army Implications

Subterranean operations have been a historical part of warfare for centuries as armies have used them to gain advantage over their adversary. Two of the main factors increasing the potential of underground warfare in large scale combat operations (LSCO) are the rising urbanization of the world's population and the use of uncrewed aerial systems driving forces underground to escape detection and attack. This section covers the implications for the U.S. Army on the IDF's experience in Gaza and potential changes to U.S. Army doctrine, organization, and training.

Expanding Likelihood of Urban Combat

The likelihood of future large-scale combat operations occurring in urban areas is increasing, with the United Nations projecting that 68 percent of the world population will live in cities by

¹⁵ Tiwari, Pushkar. *Sponge Bombs": Israel's New Secret Weapon to Block Hamas Tunnels*. NDTV World. 23 October 2023. <https://www.ndtv.com/world-news/sponge-bombs-israels-new-secret-weapon-to-block-hamas-tunnels-4518837>. Accessed 29 April 2025.

2050.¹⁶ The urban environment typically includes subterranean structures such as sewers, subways, basements, and parking garages which requires a military force to clear and hold to successfully defeat the enemy.

“An increasingly urban operational environment means large scale combat operations (LSCO) will include dense urban warfare in environments with challenging warfighting conditions.”

TRADOC Pamphlet 525-40

*The Operational Environment 2024-2034*¹⁷

During the 2022 Russian campaign to seize Mariupol, Ukraine, a significant subterranean complex presented a major challenge to invading forces. The Azovstal Steel and Iron Works, one of the last areas to fall, contained a deep network of tunnels and rooms originally constructed during the Cold War to shelter workers from nuclear attacks. This hardened infrastructure proved impervious to artillery and air bombardment. Remnants of the Ukrainian 36th Marine Brigade held out for almost three months against a Russian force estimated to be five to eight times larger.¹⁸ The situation was further complicated by the presence of many civilians seeking refuge from the fighting above. Rather than attempt a costly and likely bloody assault into the vast underground network, Russian forces opted for a siege. The Ukrainian soldiers and civilians eventually surrendered due to critical shortages of food, water, and ammunition. Had the Ukrainians proactively fortified the underground complex with sufficient supplies and defensive measures; the situation could have been significantly more difficult for the Russian forces.

Proliferation of Uncrewed Systems

The proliferation of uncrewed aerial systems (UAS) has driven the need to move important headquarters and facilities underground to avoid detection and attack, as seen in the current Russia-Ukraine war and the 2020 conflict between Armenia and Azerbaijan

UAS have been used extensively in the Russia-Ukraine war to identify and target military positions from the air. This has made surface positions highly vulnerable, prompting military forces to seek the protection of subterranean environments, often in cities. By moving critical infrastructure and equipment underground, units can shield themselves from aerial surveillance and precision strikes, thereby enhancing their survivability and operational effectiveness.

An example of failing to protect a military force from the UAS threat was seen in 2020 during fighting between Armenia and Azerbaijan over the contested Nagorno-Karabakh region. The two countries had faced off against each other since 1994 along a line of contact which included an extensive system of trenches and artillery firing positions. After years of stalemate, Azerbaijan employed UAS in 2020 to identify and attack Armenian forces easily seen from the air and

¹⁶United Nations. *68% of the World Population Projected to Live in Urban Areas by 2050*. Department of Economic and Social Affairs. <https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un>. 25 April 2025.

¹⁷ TRADOC Pamphlet 525-40 *The Operational Environment 2024-2034*. U.S. Army Training and Doctrine Command. December 2024. <https://adminpubs.tradoc.army.mil/pamphlets/TP525-92.pdf>. Accessed 18 June 2025.

¹⁸ Spencer, John and Collins, Liam. *Twelve months of war in Ukraine have revealed four fundamental lessons on urban warfare*. Modern War Institute. 23 February 2023, <https://mwi.usma.edu/twelve-months-of-war-in-ukraine-have-revealed-four-fundamental-lessons-on-urban-warfare/>. Accessed 15 May 2025.

unprepared to counter the threat. Azerbaijan quickly won a decisive victory and reclaimed much of the disputed territory. Armenia would have fared much better if they had prepared underground defensive positions that shielded their forces from this overwhelming capability.

Doctrine

Army Techniques Publication (ATP) 3-21.51 Subterranean Operations provides commanders and staffs of brigade combat teams with the doctrine that guides Army subterranean operations.¹⁹ The prescribed actions when encountering a subterranean system is to mitigate its effect on operations with tactical mission tasks to “bypass, neutralize, control, and contain, or clear” the site and continue with the original mission.

The time and application of combat power and resources increases with the different missions as shown in Figure 6, Comparison of Mitigation Options. IDF operations in Gaza focus on the contain and clear missions due to the extensive tunnel network being an integral part of the Hamas defensive plan and the need to rescue Israeli hostages.

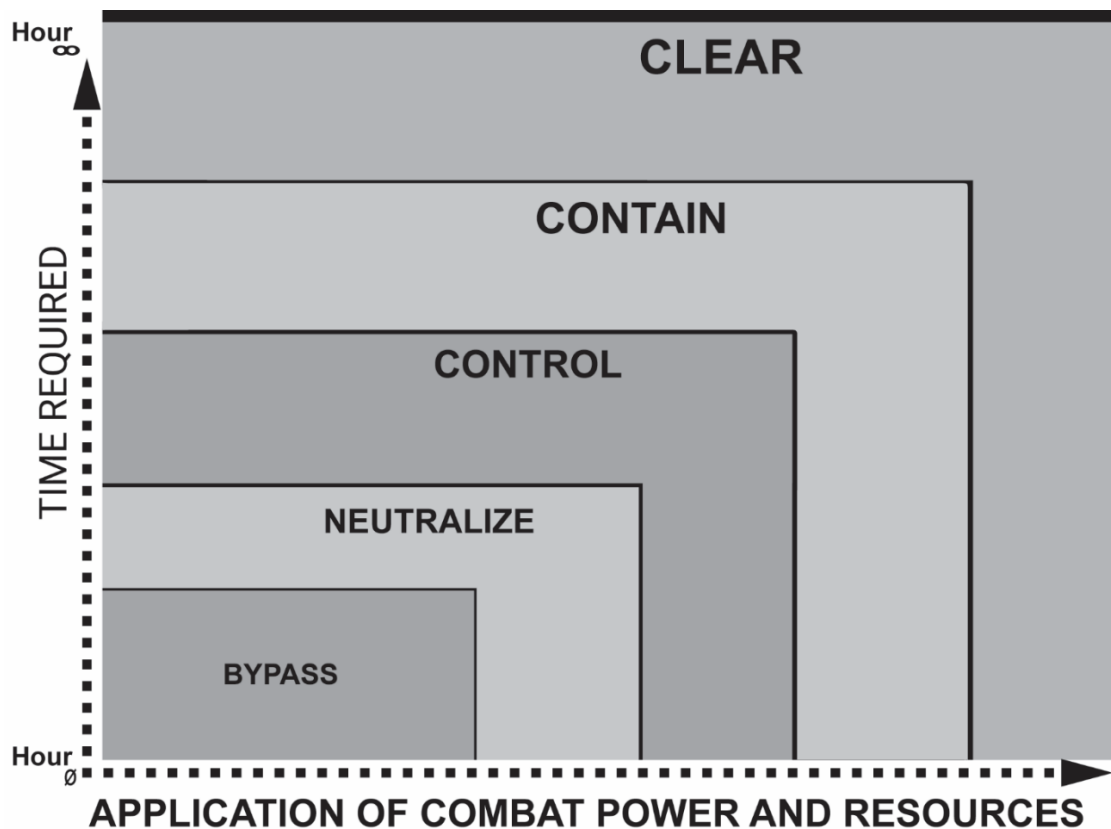


Figure 6. Comparison of Mitigation Options per ATP 3-21.51 Subterranean Operations.²⁰

¹⁹ Army Techniques Publication (ATP) 3-21.51 *Subterranean Operations*. November 2019. https://armypubs.army.mil/ProductMaps/PubForm/Details.aspx?PUB_ID=1008062.

²⁰ Ibid.

Battalions and brigades handle synchronizing above and below ground operations and deciding the mitigation action to implement. Infantry companies are tasked to clear subterranean structures if the decision is made to clear. Detailed information on these tasks can be found in Field Manual 3-90, Tactics.²¹

“... commanders may choose to clear a facility. However, an attack to clear an underground facility, specifically a deep or potentially large subterranean network, requires a deliberate decision.”

ATP 3-21.51 Subterranean Operations²²

Collaboration and support from special operations forces, echelons above brigade, and joint, interagency, and multinational partners may be necessary if encountering weapons of mass destruction or if specialized expertise is needed due to the physical structure or purpose of the underground facility.

The IDF experience in Gaza has shown that the subterranean and above ground fight is integrated and difficult to separate into distinct and separate operations. Units must simultaneously conduct combat operations above and below ground while synchronizing efforts in time, space, and purpose with adjacent forces.

In addition, the Hamas tunnels feature portal openings that are camouflaged or concealed within buildings which makes identification and mitigation difficult. The sheer number of portals and their location makes overwatching or destroying them extremely difficult and time-consuming. Units could quickly get bogged down trying to neutralize, control, or contain portals which would require additional forces to maintain the momentum of an operation.

To assist with determining how to mitigate an underground facility, ATP 3-21.51 Subterranean Operations describes three categories of subterranean systems as shown in Figure 7.²³ This is a general guide, and subterranean facilities may span multiple categories. For example, the tactical tunnels in Gaza could be classified as Category 1 Tunnels, Cave, and Natural Cavities in the sophisticated subcategory. However, the supporting amenities/infrastructure trends to be in Category 2 and 3 due to the extensive preparation and effort put into developing the tunnels. In addition, the strategic tunnels could be classified as Category 3 Underground Facilities (Military Purposed).

²¹ Field Manual (FM) 3-90 Tactics. May 2023. https://armypubs.army.mil/epubs/DR_pubs/DR_a/ARN38160-FM_3-90-000-WEB-1.pdf. Accessed 25 April 2025.

²² Army Techniques Publication (ATP) 3-21.51 Subterranean Operations. November 2019. https://armypubs.army.mil/ProductMaps/PubForm/Details.aspx?PUB_ID=1008062. 25 April 2025.

²³ Ibid.

CATEGORIES	Category 1 TUNNELS, CAVES, AND NATURAL CAVITIES		Category 2 URBAN SUBSURFACE SYSTEMS		Category 3 UNDERGROUND FACILITIES (Military Purposed)	
Subcategories	Rudimentary	Sophisticated	Substructures	Civil works	Shallow	Deep
Description	Lack of shoring	Shoring; basic amenities	Basements, parking garages	Subways, sewers, aqueducts	Silos, bunkers (<20 m)	Military bases (>20 m)
Functions	Civil: commercial operations, transportation, and storage enemy: C2, operations, storage, production, protection				C2, operations, storage production, protection	
Supporting Amenities/ Infrastructure	Power cords, small generators, lights, ventilation shafts, small pumps		Electrical power, transportation corridors, life support systems, environmental controls, communications lines *Internal redundancies may exist allowing the facility to operate for extended periods independent from external support			
Common Threats	Personnel, improvised explosive devices, traps, direct fire methods				Military offensive and defensive measures	
Common Hazards	Environmental (poor air quality, dangerous gases, wildlife), materiel (munitions, fuels), structural integrity					
Legend: C2 – command and control, m – meters						

Figure 7. Subterranean Environmental Categories²⁴

ATP 3-21.51 Subterranean Operations provides a base of doctrine that drives how the U.S. Army prepares for underground warfare. Some areas to consider for improvement are:

- Include the use of artificial intelligence and machine learning in detecting and analyzing subterranean networks by incorporating data from multiple sources and sensors.
- Expand the techniques and material that may be used to mitigate the subterranean system by sealing entry portals and ventilation shafts to include rapidly expanding foam, concrete, and physical collapse using engineering equipment.
- Emphasize the planning, preparing, executing, and assessing operations above and below ground must be included in a comprehensive concept of the operation.
- Highlight the need to display the subterranean network into the graphic representation of the operational area to facilitate synchronizing operations.
- Consider adding the scale and scope of the subterranean network to the environmental categories described in ATP 3-21.51 when assessing mitigation options.

Organization

The U.S. Army does not have an equivalent of the IDF's Yahalom that specializes in subterranean combat. However, depending on the complexity, threat, and purpose of the subterranean environment, the mapping, neutralization, and destruction may be conducted by U.S. SOF supported by personnel with special technical expertise. A likely example of this

²⁴ Ibid.

would be Category 3, Underground Facilities, that stores or manufactures weapons of mass destruction or houses a national command center.

Except for these unique circumstances, conventional forces must be prepared to conduct subterranean operations. Clearing an underground system may not be avoided especially if it is integrated into a prepared enemy defense such as in Gaza. The training, personnel, and equipment necessary to clear a facility increases in relation to the complexity and characteristics of the subterranean environment. Units will need to organize their subterranean clearing force supplemented with capabilities from echelons above brigade to overcome prepared enemy underground defenses.

“All BCTs can mitigate underground facilities or subterranean networks to varying degrees with their organic combat power; however, BCTs usually require substantial augmentation to enter, clear, and seize an underground facility.”

ATP 3-21.51 Subterranean Operations²⁵

Commanders should consider forming ad hoc teams with specialized training and equipment to map and clear underground systems based on the mission, time available, and expected subterranean environment. This is similar in concept to the female engagement teams (FETs) established by brigade combat teams (BCTs) in Iraq and Afghanistan to interact with the local women in the villages and towns. The FETs required a deliberate effort to select and train female Soldiers within the brigade to execute this unique mission.

The following are recommendations for commanders based on IDF lessons in Gaza:

- The mapping, neutralization, and destruction of underground systems may require task organized teams that include infantry, combat engineers, explosive ordnance demolition (EOD) technicians, intelligence, and military working dog (MWD) teams.
- The psychological effect of working in dark confined spaces, feelings of claustrophobia, disorientation, and isolation coupled with the potential for close combat may cause panic and extreme stress in individuals. Unit leadership should look for volunteers and assess an individual's ability to effectively fight in the subterranean environment.
- A subterranean annex to the unit tactical standard operating procedure should include methods for tracking personnel entering and exiting the underground system, route marking and mapping, and emergency resupply.
- First contact with the enemy should be made with remote operated vehicles or military working dogs to improve situational awareness and limit Soldier vulnerability to enemy action like in Figure 8.²⁶
- The subterranean system should be depicted on maneuver graphics and the common operating picture as it is mapped by the clearing force to facilitate situational awareness

²⁵ Ibid.

²⁶ Aliotta, Jerome. DIVIDS photo. DEVCOM Ground Vehicle Systems Center.
<https://www.dvidshub.net/image/6987734/autonomous-tunnel-exploitation5>.

of units conducting operations above ground. Enemy units may emerge and engage from unanticipated directions then disappear to the safety of the tunnels.

- The use of artificial intelligence and machine learning should be developed to assist with subterranean complex mapping and predicting enemy actions.
- Subterranean clearance teams require specialized equipment to include:
 - infrared capable night vision goggles
 - bullet proof shields
 - breaching tools
 - personal breathing devices
 - air monitors
 - individual weapons with suppressors
 - specialized equipment to evacuate casualties



Figure 8. U.S. Army testing sensor-enabled robotic systems for subterranean operations.²⁷

Training

Training Circular 25-8, Training Ranges provides a basic range design for battalion sized urban operations collective training.²⁸ In addition, subterranean facilities may be added for training up

²⁷ Ibid.

²⁸ Training Circular (TC) 25-8 *Training Ranges*. 2 November 2021. https://armypubs.army.mil/epubs/DR_pubs/DR_d/ARN34143-TC_25-8-000-WEB-1.pdf. This publication is available to authorized users only with valid Common Access Cards (CAC).

to platoon-sized elements in subterranean operations. For example, the urban training facility at Fort Bragg, NC includes a tunnel complex for units to practice underground tactics, techniques, and procedures. The facility is built mostly above ground and features over a kilometer of tunnels of various sizes and dimensions.²⁹ See figure 9 for Subterranean training facility at Fort Bragg, NC.



Figure 9. Subterranean Training Facility at Fort Bragg, NC.³⁰

The following are recommendations for commanders to conduct individual and collective training based on IDF lessons in Gaza:

- Live, virtual, and collective training should include an extensive subterranean network that prepares brigades and battalions to operate simultaneously above and below ground and across unit boundaries.
- Underground system clearance teams must have training on the use of specialty equipment such as self-contained breathing units, air monitors, suppressed weapons, ballistic shields, uncrewed ground vehicles, and breaching tools and techniques.

²⁹ Luther, Adam. *Tunnel rats: Warfighters can now train in subterranean warfare*. Fort Bragg Garrison Public Affairs Office. 1 September 2020. <https://www.dvidshub.net/news/377207/tunnel-rats-warfighters-can-now-train-subterranean-warfare>. Accessed 2 July 2025.

³⁰ Ibid.

- Aid and litter teams must practice the techniques and equipment necessary to move wounded over and around obstacles, through narrow passageways, and hoist stretchers up to entrances.
- Develop and refine tactical standard operating procedures to facilitate mitigating subterranean facilities.
- The subterranean mitigation task of contain may require portals to be neutralized using explosives. If engineers are not available in the quantity needed, then other Soldiers may need to be trained on the calculation and placement of demolitions.
- Based on the mission and time available, commanders should consider forming ad hoc teams from across their formation with the training and equipment to map and clear underground systems.
- The Subterranean Add on Package range provides the ability to train platoons on the tactical tasks of clearing a subterranean facility. Commanders need to explore methods of how to train on simultaneously exercising command and control of the subterranean clearing force and the above ground force.

Conclusion

The U.S. armed forces may not be able to avoid a subterranean fight in the future. Our adversaries have observed the fighting in Gaza and the issues it has caused the IDF. The Russian experience with the Azovstal Steel Works in Ukraine demonstrated how a hardened underground complex can slow, or even stop, the operational tempo of an offense while sufficient resources are brought to bear. In addition, the fighting in Ukraine has also shown that the proliferation of the UAS threat has forced units underground to counter observation and attack from the air.

U.S. forces may encounter extensive underground headquarters and well-prepared defensive positions during large scale combat operations. Units must be prepared to fight underground and defeat enemy forces that look to exploit that asymmetric advantage. The U.S. Army subterranean doctrine should be reviewed and updated as necessary based on the IDF experience in Gaza and the current operational environment. Success in the subterranean fight relies on tactical units with the right personnel, training, and equipment to operate in that environment. Commanders must look for opportunities to prepare their units for this challenging task before being confronted with a complex subterranean facility.



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NO. 25-1031
AUG 2025

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