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IEDS AND URBAN CLEARANCE VARIABLES IN MOSUL:

DEFINING COMPLEX ENVIRONMENTS

by Mark Wilkinson, Ph.D. [United Nations Mine Action Service]

Al-Maedan, west Mosul, May 2018.
All images courtesy of UNMAS Iraq.

More than any other post-conflict environment in Iraq, the complexity of west Mosul and its improvised explosive device (IED) threat challenges our fundamental perceptions and definitions of mine action. From here, 400 km north of Baghdad in the al-Maedan District on the west side of the Tigris River, ISIS ran its caliphate and made its ill-fated last stand against attacking Iraqi Security Forces (ISF).

Context. Clearance operations began in east Mosul even as the battle in west Mosul drew to a close. Nearly two years later, the al-Maedan District in west Mosul remains in ruins, heavily contaminated by explosive hazards (EH), and has served as a virtual laboratory for real time study of EH clearance in a *complex*, urban environment, which begs the question: what makes it complex?¹ In a word, context. This influences render-safe procedures (RSPs) as determined by pre-event, event, and post-event phases, along with their respective physical and political factors.

Reality. Why post-event and not-post conflict? Because the conflict continues. Even as UNMAS Iraq operators and others undertake ostensibly humanitarian clearance tasks,

they remain under ISIS threat, subject to last-minute mission changes based on daily intelligence reports. Sometimes clearance personnel are targeted because they are perceived as part of an opposing, active military force by the very populations they serve.

Objective. According to current U.N. intelligence estimates, between 20,000 and 30,000 ISIS insurgents remain in Iraq.² Their tactics may have changed, but their intent remains the same: regain control of territory actively through guerilla tactics and intimidation; and passively through their deployed IEDs. Until cleared, these IEDs contribute to “destabilization” insofar as they deny access to and repair of infrastructure and the rehabilitation of homes.³

Outcome. When viewed from an outcome perspective, IEDs are less explosive remnants of war (ERW) and more “passive attack” weapons, part of a strategy that is both defensive and offensive at the same time. So long as IEDs remain in place, and thereby stall repair of infrastructure and important cultural assets—such as mosques and churches—they ultimately lead to a political outcome. Despite strong evidence of progress and the on-going recovery in east Mosul and

elsewhere, returnees living with threats and 1.8 million internally displaced persons (IDPs), mostly living in camps, blame the government for their plight. Those not already benefiting from progress to date are dissatisfied and vulnerable to ISIS propaganda.⁴

Factors. RSPs as a function of tactics, type, design, and location and/or placement of IED types depend upon context. Therefore, to understand EH clearance in west Mosul, the community needs to understand the adversaries: their objectives, strategy, tactics, weapons of choice, and how these were used over time. The al-Maedan District of west Mosul serves as a kind of “time capsule” wherein operators can differentiate the three phases already mentioned: pre-event, event, and post-event. Clearance operations to date document the following as contributing factors to complex urban environments for EH clearance:

PRE-EVENT FACTORS

- **Design.** IEDs cleared from sites in Mosul to date can be characterized by range and level of technical complexity suggesting extremely competent and capable design and manufacturing facilities.⁵
- **Detonation.** ISIS manufactured timed, victim-operated, command-initiated devices to support conventional combat tactics and to enhance combat effectiveness or delay/harass opposing forces.

EVENT FACTORS

- **Distribution.** ISIS deployed thousands of IEDs targeting combatants during the 2017 battle to liberate Mosul; these contaminate the remains of completely- or nearly-destroyed buildings and massive amounts of debris estimated at more than 7 million tons.
- **Density.** ISIS relied on IEDs to defend its forces as they withdrew to tighter defensive perimeters in west Mosul; mapping the geography of fighting is a strong indicator useful in directing post-event survey and assessment of EH types and amounts.

POST-EVENT FACTORS

- **Dimension.** More than any other factor, victim-operated IEDs (VOIEDs) hidden in walls, air conditioning units, or under garments hanging on pegs add a third dimension to urban environment clearance, further complicated by narrow streets, piles of debris, and the restricting maneuverability of mechanical assets.
- **Biologic.** Nearly two years after the battle for west Mosul, operators still find deceased victims wearing

suicide belts by the hundreds, which pose both explosive and biologic threats as well as the need for protection and coordination of the return of the remains.

- **Security.** ISIS continues to use VOIEDs as booby-traps to deny access to ostensibly liberated areas by indiscriminately targeting noncombatants as part of an on-going guerilla campaign that includes the harassment, abduction, and murder of the local population. Meanwhile, clearance teams remain targets for both IED and small arms attacks.

Lethality. If these factors can be measured as variables, then the UNMAS experience and data compiled from the west Mosul clearance operations provides a baseline for formative thinking related to a proposed *lethality index*, first to measure complex environments and, second, to help optimize clearance skillsets and levels appropriate for still-to-be-defined new doctrine and standards currently lacking in the humanitarian mine action community.

Progression. After liberation in October 2017, most UNMAS clearance teams assigned both explosive ordnance disposal (EOD) and IED experts to focus on emergency, first-responder-type tasks. Where it was safe to do so, UNMAS used these emergency tasks to focus on areas of the city most affected by fighting to safely remove the most obvious EH hazards consistent with U.N. stabilization and humanitarian initiatives.

Volume. As of 30 January 2019, UNMAS operators had conducted 3,564 conventional EOD tasks and rendered safe a range of conventional threats, including mortars, rockets, projectiles, grenades, and 21 air-dropped munitions and guided missiles. While small arms and pyrotechnics clearly do not represent the same level of hazard to local populations as other types of conventional ordnance, in order to eliminate the subsequent reuse by ISIS, they cannot be ignored. As of 30 January 2019, UNMAS operators had removed and rendered safe for disposal a grand total of 651,039 threats of all types.^{6,7}

Categories. As of 30 January 2019, UNMAS operators had completed 1,092 IED tasks in Mosul alone, and rendered safe and removed 25,302 IEDs of all types (including component parts such as main charges or switches alone), ranging in sophistication from simple and crude devices to technically sophisticated and innovative based on their delivery method.⁷ While IEDs normally are classified as a function of their means of initiation (time, victim-operated, or command-initiated), this classification does not facilitate a broader analysis of IED contamination in Mosul. In simple terms, ISIS developed IEDs to reflect three categories of operational requirements:



ISIS 210 mm and 120 mm mortar bombs. Note the quality control stickers on the tail sections of the 120 mm mortar bombs (center left).

1. To support conventional combat with improvised substitutes for commercial military munitions and ordnance.
2. To enhance combat effectiveness through the integration of improvised weapons into existing force structures.
3. To delay and harass advancing ISF.

Manufacture. ISIS achieved a level, scale, and quality of arms manufacturing—including IEDs—equivalent to conventional arms manufacturers. For example, ISIS manufactured 120 mm mortar bombs to tolerances that—at least at a superficial examination—are all but indistinguishable from weapons commercially-manufactured to military specifications and standards. ISIS 120 mm mortar bombs were recovered containing high-explosive (HE) and chemical fills such as mustard gas. Many unfired bombs were recovered with quality-assurance labels attached illustrating what was a technically-advanced manufacturing and acceptance process. A total of 343 ISIS-manufactured mortars were recovered, including the larger 210 mm variants, with most being rendered safe and recovered for subsequent disposal.

Fuzes. ISIS also developed a range of fuzes. Like their mortars, these show remarkable consistency based on their simple but effective action mechanisms. All improvised fuzes

recovered by UNMAS operators have been point detonating, manufactured from machined aluminum or plastic, often with simple creep springs retaining strikers into modified nonelectrical detonators. Evidence gathered from west Mosul shows that several variants of ISIS fuzes have been used on ordnance ranging from mortars to air-delivered munitions and rockets.

Modifications. ISIS also modified other common conventional munitions, including the ubiquitous 40 mm grenade found in several modified forms. The most common variation replaces a factory fitted fuze with fully improvised point detonating variants; or a second, common modification to the existing fuze allows use of the munition as an air-dropped grenade from drones, or simply thrown by hand.

Air-dropped Munitions.

The ISIS air-delivered aerial munition (ADIM) is yet another variant of the modified 40 mm grenade-type weapon, designed to be paired with the existing range of ISIS fuzes and attached to a plastic body. Explosive fills encountered have included HE, ammonium nitrate-based explosives, and modified 23 mm high-explosive incendiary projectiles for use as hand-thrown and drone-dropped weapons.



Typical ISIS improvised point detonating fuzes (IDPF).

Suicide Belts. UNMAS operators recovered and rendered safe 1,142 suicide belts and vests in west Mosul, many still strapped to the remains of ISIS fighters. These weapons also show remarkably consistent design, utilizing UZRGM-type fuzes (both homemade and military) directly attached by detonating cord taped around HE, normally with added ball-bearing type fragmentation. These devices are almost always recovered in military-style webbing belts and pouches. Clearly a weapon of last resort for the fighter wearing them, logically they would be self-initiated when either being overrun by ISF or while storming fortified positions.

Enhancements. UNMAS operators found and rendered safe numerous IEDs designed to improve the combat effectiveness and firepower of ISIS fighters. Evidence to date shows these weapons fall into one of two categories: improvised/modified rockets and vehicle-delivered explosives. The technical sophistication of many of these IEDs is impressive, both in terms of design and explosive effect. Many improvised rocket designs also integrated chemical weapons (normally low-grade mustard gas) into their warheads.

Launchers. ISIS improvised-rocket designs have been analyzed in detail by a number of organizations, including UNMAS.⁸ In one specific clearance operation alone at the al-Shifa hospital complex in west Mosul, UNMAS operators recovered and rendered safe nearly 100 improvised-rocket launchers along with a large number of used launchers. UNMAS identified and assessed four launcher variants that probably entered service in early 2017. Two of the variants contain PG-7 and PG-9LR, the other two containing PG-9SR and a *thermobaric*-type projectile. In reality, the ISIS designated thermobaric warhead is simply another high-explosive projectile. Launchers share as common design features a hand-grip assembly, a 9-volt direct current (DC) power source, tube diameter, improvised-fin assembly, and internal configurations (projectile or rocket, improvised propelling charge, and counter-mass); however, the sighting system can vary.⁹ While the launchers are intended to be disposable, ISIS instruction sheets recovered by UNMAS operators tell users to retain and return the launchers, presumably for refill. ISIS videos circulating in 2017 showed what appeared to be rockets being loaded into launchers under apparently sterile conditions.¹⁰ Evaluation of these launchers, along with anecdotal evidence of their use in Mosul strongly suggests that these launchers were developed to be integrated into infantry-type fighting in urban environments such as Mosul. The ISIS-designated thermobaric warhead would seem to be specifically designed to attempt to enhance blast effects, particularly when used in buildings.



An ISIS-modified, 40 mm high-explosive, dual purpose grenade, probably intended for hand delivery.



Typical ISIS ADIMs with ISIS-variant point-detonating fuzes attached. Note the driving band of the 23 mm projectile visible through the body of the third ADIM from the left.



A typical ISIS suicide belt recovered in west Mosul. Note the dual UZRGM-type fuzes and the added fragmentation around the pouch-sized main charges.



Four variants of ISIS improvised rockets, all recovered by UNMAS in west Mosul.

Vehicles. UNMAS operators also recovered and rendered safe several vehicle-borne IEDs (VBIEDs) from west Mosul; several others were located in cleared piles of destroyed vehicles placed in scrap heaps by ISF mechanical-handling equipment, e.g., diggers, earthmovers. Other confirmed VBIEDs still remain, as the precarious states of partly-destroyed buildings have prevented access for safe disposal. Again, the design suggests their intended purpose was to enhance combat operations. Variants were rendered safe with both manual (suicide) and remote detonation mechanisms and explosive effects with the aim of inflicting mass casualties (via large explosive payloads) as well as more targeted attacks via concealed improvised explosively-formed penetrator (EFP) type devices.

Switches. ISIS manufactured time-based, command-initiated, and victim-operated devices from its factories in west Mosul, and then deployed these as part of a delay-and-harass defense strategy against any ISF assault.

- **Time-based.** Although UNMAS operators have yet to recover a complete and intact time-based IED, based on timer components recovered and analyzed to date, ISIS likely deployed a limited number of time-based IEDs. Again, analysis of the time-based IED components shows a standard ISIS manufacturing technique: brown-plastic boxes with hot glue-sealed lids form the basis of time switches; written instructions describe how to set time delays of up to 90 minutes. Some variants include electrical “safe-to-arm” switches as well as multiple 9-volt DC batteries wired in both series and parallel,

obviously to match the intended power requirements of the attached circuitry or detonators. Once again, the only confirmed timer components discovered and recovered by UNMAS operators in Iraq have been from west Mosul.¹¹

- **Command-initiated devices** deployed by ISIS in west Mosul used both wire and remote-controlled (RC) systems. Evidence from command-wire-type devices rendered safe by UNMAS operators feature relatively short lengths of command wire, suggesting they were used to carefully and accurately target passing ISF foot or vehicle patrols, probably with follow-up small arms action. This further suggests that ISIS planned and executed complex ambushes as ISF advanced into west Mosul. Main charges used in command-wire IEDs feature large EFP and “platter-type designs” to enhance explosive effect, also giving an ability to effectively attack armored vehicles.
- **Remote-control.** UNMAS analysis of three types of devices recovered by UNMAS operators in west Mosul:
 1. **Long Range Cordless Telephone (LRCT).** Relatively few LRCT devices have been recovered, probably due to the fact that they quickly became obsolete as the growing mobile telephone network in Mosul City was utilized for longer range and more reliable communications.
 2. **Dual Tone Modulated Frequency (DTMF)** devices have also been used in relatively small numbers based on evidence to date. These devices require entry of coded numbers into a handset and transmission for activation and thereby provide a high degree of protection against accidental initiation; however, they are highly susceptible to electronic counter measures as well as environmental conditions such as degradation to power sources due to weather and time, much like LRCTs.
 3. **Mobile Telephones** appear to be a default choice for ISIS when integrating remote-control switches into IED designs.

Modifications. Recovered mobile telephones (normally basic, low-cost handsets) were modified in several ways. Internal antennas were replaced and devices have additional power sources and circuitry to initiate attached electrical detonators.

Among the most sophisticated integration of mobile telephones into IEDs is their use as arming mechanisms for passive infrared (PIR) victim-operated devices. These designs were recovered from a range of locations, including buildings



A typical ISIS mechanical timer recovered by UNMAS in west Mosul.



A typical ISIS DTMF recovered by UNMAS in west Mosul.

where they were connected to large numbers of 9-volt DC batteries thus providing an extended life as an active IED. One IED successfully rendered safe by UNMAS contained 22 batteries connected to a Nokia mobile telephone that acted as an arming switch for the PIR sensor.

The dangers in rendering safe any IED containing a PIR switch are considerable. While many recovered devices have contained batteries with insufficient remaining current to initiate the attached detonator, others did not. In these cases, it is likely that other component failure or environmental factors prevented these devices from functioning.

Victim operated. A range of other victim operated devices were rendered safe by UNMAS in west Mosul. In many cases, these are deployed to target personnel and are sometimes used to build anti-handling devices into IEDs. Tripwire-type devices have used clear fishing twine, usually laid across doorways, pathways, or other obvious choke points. One

variant encountered used medical syringes; when force is applied to the attached fishing twine, the switch contained within the syringe is closed, thus completing an electrical circuit and initiating the attached IED. Another used integrated “push-pull” toggle switches with fishing twine. As with the syringes, these toggle switches were recovered from tripwire IEDs and as bulk components. Both of these switches suggest a clear intent on the part of ISIS to target EOD and IEDD personnel in operations following the expected liberation of Mosul.

What is clear from the range of IEDs and associated components recovered from Mosul is that ISIS effectively produced and deployed a wide-ranging and technically-sophisticated IED threat, representing the entire spectrum of time, victim-operated, command-initiated, and projected-IED capabilities.

Three dimensions. What does this mean in terms of applying existing humanitarian mine action (HMA) doctrine to the complex EH situation in Mosul? Or, what makes Mosul different?

First, the EH environment is a three-dimensional problem. EH have been located in sub-surface, surface, and vertical/aerial pockets (walls, ceilings, and improvised air-dropped munitions). The prevalence of metal in the urban environment, in particular reinforcement bar (rebar) in



A Nokia mobile telephone attached to a plastic container with 22 9-volt DC batteries inside (top). Mobile telephones also have been used as arming switches for attached PIR devices (bottom).



An ISIS “push-pull” toggle switch before and after removal of tape.

concrete, makes search activities that rely on metal detection extremely difficult.

Second, where the environment degrades detector capabilities, the combination of visual recognition and experience (i.e., knowing what to look for) become key factors. Safe and efficient clearance depends upon highly-trained search personnel being able to quickly differentiate between innocuous items and those requiring further investigation. Effectively, experience gained from each search contributes to planning for the next, to include deployment of search teams and assets.

Third, threat assessment is usually considered to be an active and dynamic process, but the formulation of a threat assessment in post-event Mosul arguably alters the normal relationship between the assessed intent, capability, and location available to the individual laying the IED.¹² Therefore, the key challenge to any IED render-safe operation is knowing the type of device, its method of initiation, layout, and fabrication.

Reconnaissance. Within a “conventional” setting, threat information can normally be established via questioning of witnesses. However, in west Mosul, local people were often not present in their homes when IEDs were laid,

and many devices were moved as a result of mechanical-handling equipment activity or simply exposed due to environmental changes. This leads to the logical question “What about robots?” No current UNMAS implementing partner uses robots for IEDD support, partly due to the cost of even small robots, partly for operational difficulties in urban settings, and partly due to the limited (nonexplosive) actions that can be safely and effectively delivered from the available platforms.

Variables. Findings in Mosul to date suggest a threat environment further complicated by a combination of variables: conceptual, physical, and device-specific. These influence the threat environment but do not conform to any preconceived fixed relationship determined by the design or components of the IED alone. Even then, there seem to be few constants available.¹³

For example, the environment variable may or may not cause degradation. Contrary to the argument that batteries degrade with time such that they no longer contain a charge sufficient to initiate an electrical detonator, evidence suggests in the short term this is not true. Recent tests on the batteries from a recovered RC armed PIR IED in Rawah (west Anbar) show that, despite the device being in place for approximately two years, each 9-volt DC battery in the device contained a full 9 volts of charge. Further, the battery shelf life expiry date was indicated as 2021. Evidence collected from other tests on recovered batteries provided similar data.

Constants. Given there is no clear and proven degradation of battery life as a function of time and/or environmental conditions, and therefore, the lethality of the device cannot be assumed to be reduced over time, the technical complexity of an IED is always a key factor in threat assessment, as well as a key determiner of the subsequent RSP.

Competency. Contrary to normal RSPs that usually would rely on explosive materials, conditions in Mosul call for simple tools such as “j-cutters” used semi-remotely to neutralize IEDs as well as highly-trained IEDD operators with the skills and experience to recognize and render safe threats. For example, devices such as the improvised ISIS 120 mm mortar bombs may contain high-explosive or chemical-agent (mustard gas) fills. Often only subtle details differentiate between threats, which may or may not be safe to move.

Hostility. IED operators work in high-threat environments where render-safe operations expose them to retaliatory attacks. In addition, there is always a possibility that the security situation within a clearance location can deteriorate and the IED operator becomes a target by virtue of the fact that they are clearing IEDs.



A “j-cutter” positioned prior to semi-remotely cutting a single electrical wire connecting a power source to an IED.

Characteristics. For purposes of EH clearance, west Mosul can be characterized as a complex environment based on the following factors:

1. A diverse range of complex IEDs.
2. The quantity of IED threats and other EH threats present.
3. The three-dimensional exposure.
4. Accessibility to clearance sites for threat assessment.
5. Reliance on semi-remote means for neutralization.
6. Extreme consequences of accidental initiation.

Differentiation. The complex threat environment, as with all environments, should drive the selection of personnel, equipment, and training as well as standard operating procedures (SOPs) and operational-review processes.

Experience. The implications of differentiating between simple and complex threat environments in terms of assets to perform adequate, safe, and cost-effective render-safe operations, likely focus on IED operators and their experience regardless of local or international status. Moreover, qualified personnel must be present at task locations at all times to provide oversight of threat assessment and the conduct of search and subsequent RSPs. The economic implications should be as obvious as they are inescapable: the more experienced the operator, the safer and quicker clearance will be, albeit more costly the task. While the competencies for IED operators are discussed and described in IMAS and U.N. standards, the requirements of a complex environment suggest those selected both as international technical advisors as well as local national IED operators should be carefully considered, tested, and evaluated based on demonstrated skills in line with overarching competencies described in IMAS and U.N. standards.^{14,15}

Conclusions. What are the implications for future EH clearance activities in complex urban environments? Facts and analysis support the following conclusions.

1. IED clearance activities should be considered as a function of technical complexity rather than threat assessment.
2. While the perception of threat to an IED operator from a device may decrease over time in the post-event environment, facts suggest devices remain lethal in the long term.
3. The EH context as determined by pre-event, event, and post-event phases and related factors establish a context for threat assessment and appropriate RSPs.
4. Existing HMA doctrine will need to change to reflect this new operating reality. UNMAS is currently linking the development of standard working practices—for example, linking “residential area search and clearance” to both IMAS and implementing partner SOPs based on experience gained during operations to date in both simple and complex environments.
5. The concept of complex environments, compared to the simple environments (see previous article), becomes a key aspect not only for capacity development but recruitment and selection of IEDD operators. Future work plans are now carefully tailoring implementing partner capabilities to match the operational environment.
6. The need for continued research and analysis of ongoing operations should include a lethality index based on the pre-event, event, and post-event phases and related factors identified as a gauge to assess future operations and task difficulty, also important as a basis to establish and report efficiency and cost-effectiveness.

To be continued. ©

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