February 2006

Blast Protection for UXO Operations Including Demining

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were indicated by the rats (87 percent), while other items scored less frequently (fragments = 53 percent, bullets = 33 percent).

With the exception of Sargon, all rats scored relatively well (mean = 63.3 percent) with very few false positive indications (mean = 0.8 indications per 100 square metres) for the major markings S+B and 1.6 for all markings S+B+s+b). It should be noted that many of the false positive indications given by different rats were clustered, which might indicate an explosive-contaminated spot.

Although the individual success score might seem low, the overall score on the C, D and E boxes (those containing mines) was 100 percent after three rats evaluated a box (see Figure 5).

Figure 5: Mean success score of the sequence of three rats that tested the five boxes. 

The mean time for a rat to inspect a box was 32 minutes/100 square metres (120 square yards), so when a box was inspected by three rats, this was done in 96 minutes. When we include handling and exchanging animals, the total average time to evaluate one 100-square-metre box (120 square yards) was about 116 minutes.

Conclusions

The test area was a very dense minefield with 20 mines within an area of less than 30 square metres (36 square yards). Besides the mines, the area was highly contaminated with all kinds of war materials (bullets, detonator pins, mine fragments, etc.), which were also often indicated by the animals, especially the detonator pins. After these rats evaluated a box, all mines present in that box were scored.

The construction of risk maps based on the indications of the animals seems to be a very useful tool as 95 percent of the mines were found in the highest calculated risk area and the other mine in the second highest risk area. Using this method, more than a very useful tool as 95 percent of the mines were found in the highest calculated risk area and the other mine in the second highest risk area. Using this method, more than 30 square metres (36 square yards). Besides the mines, the area was highly contaminated with all kinds of war materials (bullets, detonator pins, mine fragments, etc.), which were also often indicated by the animals, especially the detonator pins. After these rats evaluated a box, all mines present in that box were scored.

Table 3: Success scores and number of false positive indications of the rats in the five test boxes.

<table>
<thead>
<tr>
<th>Boxes tested (area)</th>
<th>Success score</th>
<th>False positives S+B/100m²</th>
<th>False positives S+B+s+b/100m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johan A – C – E (265sq m)</td>
<td>9/16 = 56.3%</td>
<td>0.75%</td>
<td>0.75%</td>
</tr>
<tr>
<td>Julie B – C – D – E (362.5sq m)</td>
<td>15/20 = 75.0%</td>
<td>0.28%</td>
<td>3.00%</td>
</tr>
<tr>
<td>Josse B – C – E (262.5sq m)</td>
<td>10/16 = 62.5%</td>
<td>1.14%</td>
<td>1.53%</td>
</tr>
<tr>
<td>Gilgamesh A (65sq m)</td>
<td>No mines</td>
<td>0.00%</td>
<td>1.54%</td>
</tr>
<tr>
<td>Lothar A – D (165sq m)</td>
<td>4/4 = 100%</td>
<td>2.42%</td>
<td>3.64%</td>
</tr>
<tr>
<td>Respect B (67.5sq m)</td>
<td>No mines</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Sargon D (100sq m)</td>
<td>0/4 = 0.0%</td>
<td>0.00%</td>
<td>1.00%</td>
</tr>
</tbody>
</table>

Mines, UXO and improvised explosive devices are explosive hazards that have proliferated for many decades. In a post-conflict scenario, these are sometimes known collectively as explosive remnants of war.1 While global initiatives have limited the spread of certain types of devices (especially anti-personnel mines), a considerable problem still exists and will continue for many years to come.

Even where loss of life is avoided, remediation activities such as soil and water decontamination and the replacement of habitation and infrastructure are subjected to unnecessary risk, delay and additional costs due to the presence (suspected or actual) of ERW.

Technologies for the detection of explosive blast hazards are numerous and range from rakes to multi-spectral sensor arrays on autonomous vehicles. Technologies for the protection of structures, materiel and personnel from blast are considerably less numerous. For such technologies to be attractive they must be simple-to-use, quick-to-deploy and fulfill several key functions:

- Serve as a means to mitigate the blast from a single explosive hazard or site
- Provide blast mitigation for a storage area for explosive hazards
- Protect material, buildings and their occupants in areas close to the site of the explosive hazard or an explosive hazard storage area

In order to fulfill these functions, any workable solution must have the following essential characteristics:

- Flexibility and ease of use
- Low cost
- High, scalable performance
- Low density
- Very low environmental impact
- Longevity

Here, we show that BlastWrap™ performs exceptionally well against these parameters.

BlastWrap Introduction

BlastWrap is a genetic blast-mitigation technology product based on a combination of a compressible mineral and a flame-quenching salt.2 This mixture is commonly used as a protective core within a semi-continuous panel made from two layers of formed thermoplastic comprising a uniform array of sealed compartments. The result is an adaptable and robust blast-mitigating wrapping constructed from lightweight, inexpensive materials (see Figure 1).

Figure 1: BlastWrap.
BlastWrap has been used to mitigate against blast in a variety of applications. Military applications have focused on accident prevention in storage and during transport. Work has recently demonstrated the effectiveness of BlastWrap to prevent sympathetic detonation between artillery shells, and work is currently underway to design a BlastWrap retrofit container for large-caliber ammunition. In the oil and gas industries, BlastWrap has been proven to prevent blast damage to oil pipelines. Civil-sectarian applications have focused on developing blast-proof litterbins (such as the BlastGard MTR range of trash receptacles) and on the protection of buildings within Iraq.

BlastWrap’s pedigree is predicated on its appliqué nature, such that existing structures can be transformed into blast-resistant structures via retrofit. Table 1 describes how BlastWrap fares in terms of the essential characteristics listed above.

### Civilian Safety

The development of the MTR litterbin has generated a performance curve for BlastWrap. The data is summarised in Figure 2. It is conceived that such a device might find use in the transport and storage of ERW.

### EOD Safety

A temporary three-man shelter for protection of explosive ordnance disposal personnel has been proposed. This structure is designed to be positioned as near as 100 feet from a 2,000-pound (900-kilogram) device. The shelter has the capability to prevent fragment penetration and eliminate lethal overpressure within the survival area. The possibilities for EOD usage have subsequently been extended (see below).

### Building Protection

Two diverging approaches can be taken when protecting buildings. The most effective is to provide a barrier between the building and the source of the blast. The effect of the blast on the building is minimised. Alternatively, blast mitigation that is light and flexible enough to be used inside the building can be used to reduce the invasiveness of the blast wave. Although this approach is more discreet and controllable, it still leaves the structure vulnerable to damage that may lead to partial or complete collapse of the building, depending on the situation. With this in mind, BlastWrap is considered to be part of a necessarily more complex solution. This type of application has been proposed for use in Iraq to protect buildings associated with infrastructure.

### Munitions Safety

The prevention of sympathetic detonation between artillery shells by BlastWrap suggests a considerable capacity to perform blast-wave energy over very short distances (see Figure 3). This is borne out by the performance taken from the litterbin trials (see Table 2). The reduction in blast-wave energy has two benefits. First, it reduces the range of lethality of the blast. Second, it reduces the likelihood and extent of secondary reactions of nearby explosive devices. Hence, the same function can be used in dividing walls within magazines or other explosives storage areas to reduce sympathetic or secondary reactions, as well as around the periphery of the storage area to reduce the effect to the surrounding area.

### UXO Operations with BlastWrap

The operational view of handling ERW is drawn down into distinct phases, from planning through reconnaissance and identification to render safe and disposal operations. Removal and storage of ERW is also an option. To perform these functions, certain physical processes must be performed:

- Establishment and maintenance of safe areas
- Establishment and maintenance of demolition and/or storage areas
- Provision and maintenance of the associated logistical chain
- Provision and management of the requisite personnel and equipment
- Break-down and close-out procedures

The objective of BlastWrap deployment is to provide a portable blast mitigation solution that is capable of considerable service life and operation in the widest possible operational situations. These might include:

- An ERW location marker that has blast-suppressing properties, particularly useful for managing multiple ERW in close proximity
- A mitigant to minimise the damage to equipment resulting from an explosion during demining
- A blast tent to protect the surroundings during render-safe operations
- A semi-permanent blast shield to protect safe areas and buildings where an explosive event is possible
- A lagging layer to transform a normal building into a safe explosive device storage area
- A sacrificial blast-damping device to the impact of noise and flash associated with the neutralisation of ERW
- Packaging for stored explosive devices

An example is illustrated in Figure 4. This trial is associated with the characterisation of the MTR litterbin. It is conceived that a similar approach can be used to mitigate the effects of an IED on the surrounding areas where there is a damage issue, e.g., in a built-up area, in a multi-story building, in the vicinity of a treasured landmark or building.

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**Table 1: The characteristics of BlastWrap.**

<table>
<thead>
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<th>Essential Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility and ease of use</td>
<td>The core technology is a granular material that can be applied to form any void and so conforms to any shape. The standard product (see Figure 1) can easily create flat and cylindrical barriers.</td>
</tr>
<tr>
<td>Low cost</td>
<td>Raw material costs are quoted as $16 (U.S.) per square foot for a 1-inch-thick layer ($140 per square foot for a 25-mm-thick layer)</td>
</tr>
<tr>
<td>High, scalable performance</td>
<td>Reduction of overpressure of 50 percent or more has been demonstrated. Multiple layers can be used for large explosive devices or storage.</td>
</tr>
<tr>
<td>Low density</td>
<td>A 1-inch (25-mm) layer has an areal density of 0.6 lbs per square feet (3 kilograms per square meter)</td>
</tr>
<tr>
<td>Very low environmental impact</td>
<td>Materials are non-toxic, as are the combustion products.</td>
</tr>
<tr>
<td>Longevity</td>
<td>Will retain performance for more than 20 years.</td>
</tr>
</tbody>
</table>

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**Figure 2: BlastWrap litterbin data summary. Figure by Glen Miles.**

**Figure 3: LM UK INSYS testing of BlastWrap with artillery shells.**

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**Figure 4: Explosive trial of BlastWrap-lined container (courtesy of BlastGard International).**
Editor's Note: Some countries and mine action organizations are urging the use of the term “mine free,” while others are espousing the term “mine safe” or “impact free.” “Mine

credible threat to a community or country.

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