INTERPRETING SUBMUNITION FRAGMENTATION MARKS ON HARD SURFACES FOR THE SURVEY OF CLUSTER MUNITION STRIKES

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Submunition fragmentation can produce distinct patterns on hard surfaces that can assist in establishing if a cluster munition has been used. This article will review some of the submunition fragmentation impact patterns seen in current and former conflict zones around the world. It will also underline the risks of misidentifying such patterns and the need to corroborate them with associated evidence such as the submunition fragmentation itself. Trying to accurately identify evidence of cluster munition strikes is an important skill, not just for those surveying contamination for subsequent clearance, but also for journalists and human rights advocates seeking to document instances of cluster munition use.

When a submunition impacts the ground, normally from a high angle, those that function typically spread fragmentation of one form or another. If a submunition impacts a hard surface such as concrete or asphalt, fragmentation can cause distinctive scarring. Different submunitions make differing fragmentation scarring patterns. These patterns are sometimes referred to as craters. If taken in conjunction with corroborating evidence, these may be used as a basis for assessing whether a strike has taken place and if so, dependent on the submunition, possibly what direction it came from. It should be noted that some submunition fragmentation patterns can easily be mistaken for those caused by other munitions such as mortar rounds.

Article 2 of the 2008 *Convention on Cluster Munitions* (CCM) classifies an explosive submunition as "a conventional munition that in order to perform its task is dispersed or released by a cluster munition and is designed to function by detonating an explosive charge prior to, on or after impact." Most mechanically fuzed submunitions function on impact. Currently there is a range of what could be classified as submunitions in use by non-signatories to the CCM. For example, there are spin-stabilized fragmentation submunitions, anti-armor fin stabilized submunitions, anti-armor chute stabilized submunitions, and Dual Purpose Improved Conventional Munitions (DPICM) (with or without a self-destruct mechanism). There are even modern sensor fuzed submunitions that might be referred to as submunitions but are not necessarily classed as such by the CCM.

There are a number of factors that govern the fragmentation effects on a hard surface of a given submunition. Chief among these are the type of fragmentation employed in the submunition, the shape of the submunition, the amount of explosive fill, and the angle of impact.

Type of fragmentation is a key factor. Primary fragmentation comprises fragments that originate directly from the munition. Submunition primary fragmentation may differ from some other munitions. Older mortar rounds for example typically use homogeneous continuous cast or forged body steel that fragments in a much less even manner leaving a relatively less defined pattern or scarring. These fragments are sometimes referred to as natural fragmentation. Submunitons on the other hand often tend to make more defined scarring. Some submunitions might employ a matrix of ball bearings or small cylindrical steel pellets. Examples include the BLU-26 or the 9N210. These will usually form a more defined fragmentation pattern than a continuous cast mortar. However, they will form a less defined fragmentation pattern than submunitions employing pre-formed fragmentation. This involves flat sheet steel processed through a rolling press and scored in diamond-like shapes that fragment along the uniform lines of weakness. The fragmentation pattern produced is, in comparative terms, more uniform. Examples of such submunitions include the BLU-63 and AO-2.5RT and the fragmentation jackets of BLU-97 and DPICM such as the M-77. Pre-formed fragmentation leaves relatively neat scarring.

Shape is another way of characterizing the fragmentation effects of such submunitions. The shape of a submuni-

Image 1

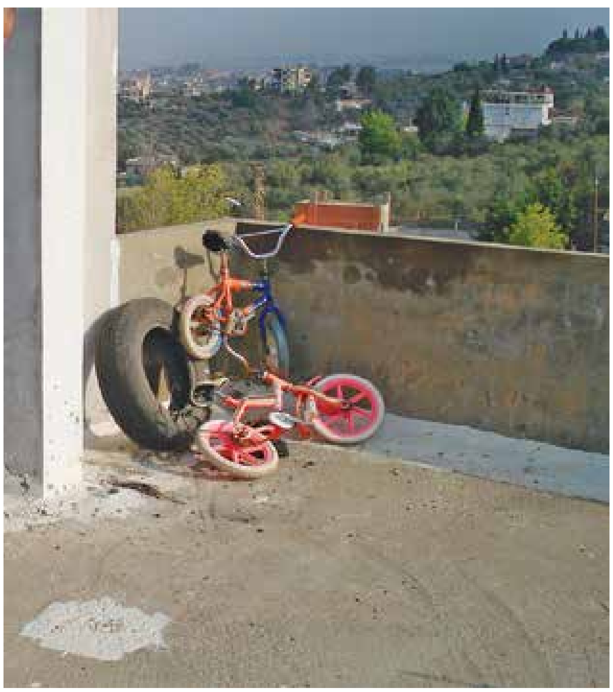

Image 1 (top) and 2 (bottom). Two BLU-63 submunition impact patterns on a roof in southern Lebanon from the 2006 conflict. Note the relatively even distribution of scarring from the fragmentation on the concrete.
Photos courtesy of the author.

tion has a significant effect on the type of fragmentation pattern it creates. A spherical submunition such as a BLU-26 or BLU-63 will likely disperse fragmentation in all directions relatively evenly. An elongated or broadly cylindrical shaped submunition such as a 9N210 will most likely concentrate fragmentation on the side of the point of impact from which the submunition came. The fragmentation will disperse radially, perpendicular to the axis of impact. Most submunitions incorporating a shaped charge such as a BLU-97 or DPICM will also produce fragmentation like this, in addition to a distinct indentation, scabbing or hole created by the shaped charge itself.

The **size** of a submunition will also have a bearing on the size of fragmentation pattern created. Larger submunitions with more explosive will typically create larger scarring patterns or craters. For example, a BLU-97 (explosive fill of 287 g cyclotol) will likely create a larger impact pattern than an M-42 DPICM (explosive fill of 31 g composition A5).

The **angle** that fin stabilized submunitions impact is also important—the steeper the angle, the greater the potential for a larger pattern. A cylindrical shaped submunition impacting at a steeper angle will project fragmentation in a less concentrated manner to one side—the radial projection of fragmentation likely to be greater than if a submunition impacted at a shallower angle.

Some of the more common submunitions encountered incorporate a number of the characteristics described previously. Spin-stabilized submunitions such as the BLU-26 or the ShOAB-0.5 tend to be high explosive (HE) fragmentation munitions. They also tend to be spherical or at least oval in shape. When a spin-stabilized submunition impacts a hard surface the distribution of fragmentation is relatively even. The scarring lines will normally radiate 360 degrees out from the point of impact. For this reason, it can be hard to discern which direction a strike came from with these submunitions, (see Images 1-2 and Figure 1). For spin-stabilized, HE fragmentation submunitions, the volume of explosive content can range from 85 g cyclotol (BLU-26) to 303 g RDX-TNT (AO-2.5RTM). On a hard surface, this will cause an impact pattern of roughly 30–60 cm in diameter with some scarring possibly radiating further.

Sometimes the same submunition might cause a tighter, yet still even pattern. In southern Lebanon this was observed with BLU-63 impacts onto asphalt, a slightly softer hard surface that absorbs more of the impact leading to less scarring, (see Image 3). At the time these impacts were sometimes referred to locally as pocket marks or pockmarks.

Image 3. BLU-63 impact patterns on asphalt, Yohmor, southern Lebanon, August 2006. Note how in asphalt the fragmentation may be tighter than seen on harder concrete surfaces.
Photo courtesy of Steve Priestley.

While such patterns can indicate a possible cluster strike employing spin-stabilized submunitions, they are not conclusive proof on their own. As a basic principle of survey, corroborating evidence, including distinct fragmentation from submunitions and possibly parts of a parent dispenser should be sought. The above fragmentation patterns are very similar to those that could be created by a grenade with a close or equivalent amount of high explosive. It can be easy to misidentify the cause of a fragmentation pattern on a hard surface.

Cylindrical blast-fragmentation submunitions will normally cause a distinctly different pattern on a flat hard surface. As with any broadly cylindrical or elongated high explosive fragmentation munition, be it a submunition such as the 9N210 or AO-1SCh or a standard high explosive mortar, much of the fragmentation will be concentrated on one side of the impact. The side of the fragmentation pattern from which the munition came is typically grooved by splinters. This is because the fragmentation is projected radially from the body of the munition, meaning broadly half is dispersed upwards, to the sides, and into the air and half into a semi-circular pattern on the hard surface, (see Figures 2 and 3 and Image 4). The resulting pattern has been likened to a "rising sun."

Much land service ammunition will make a similar pattern, with the size determined by the amount of explosive within the munition and the angle of impact. Rockets and larger caliber HE mortar rounds have been known to create large semi-circular splinter patterns with a radius of up to 1 m. This type of pattern from a submunition is evident from a confirmed 9N210 strike in Donetsk in October 2014. Images were gathered by a journalist at two separate sites after

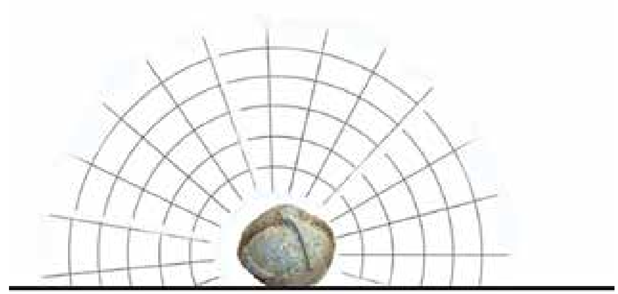

Figure 1. Likely fragmentation dispersion from a spherically shaped spin-stabilized submunition—in this example, a BLU-26. Note the fragmentation spreads in a broadly even manner on a flat surface, especially when compared with fin-stabilized submunitions.
Figures courtesy of the author.

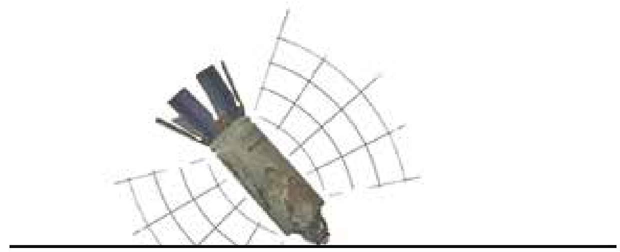

Figure 2. Probable fragmentation dispersion from a 9N210 submunition on a flat hard surface. Fragmentation from such a submunition is dispersed radially with that projected downward scarring on the side from which the submunition came.

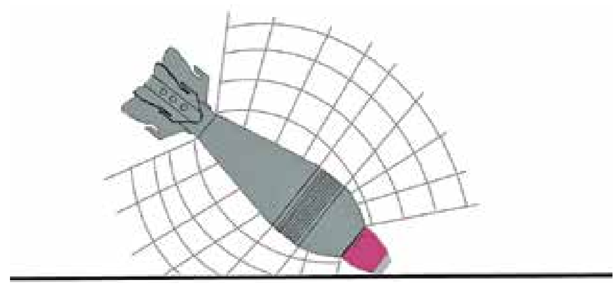

Figure 3. Probable fragmentation dispersion from an 82 mm HE mortar on a flat hard surface. Many mortar rounds, especially older Soviet designs employ pre-cast casing that often results in less defined fragmentation patterns. Broadly the pattern will be similar to submunitions such as 9N210, although possibly with rougher scarring.

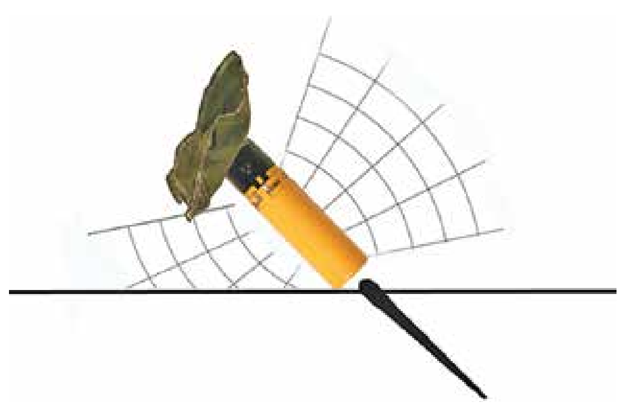

Figure 4. Probable fragmentation dispersion for a BLU-97 submunition on a flat hard surface. Note the fragmentation pattern is broadly similar to a fin-stabilized submunition, but the shaped charge will likely produce a larger hole or scabbing at the base of the pattern.

Image 4. Fragmentation pattern on a hard surface caused by a 9N210 submunition impact outside ICRC office on Universitetskaya Street, Donetsk, October 2014.
Photo courtesy of of Harriet Salem.

the strikes. Patterns within each site were broadly consistent, showing a preponderance of scarring on one side of the impact (see Images 4 and 5).[1]

While these patterns can be caused by munitions such as a HE mortar rounds, the individuals on the ground went to extensive lengths to find all relevant evidence and, in so far as is reasonable, corroborate details of the strike (see Image 6). Finding distinct parts of the submunition including fins, fuze remnants, preformed fragments, and the aluminum skin was enough to confirm a 9M27K cluster munition rocket strike.

Submuntions containing a shaped charge will often produce a fragmentation pattern that can look quite similar to cylindrical fragmentation submunitions such as the 9N210. Fragmentation will typically spread to one side of the impact in a semi-radial pattern, (see Figure 4, page 13). However, there is an important difference. Often the shaped charge will itself make a more prominent indentation or hole into the hard surface. Also, depending on the submunition, more preformed fragmentation can mean less pronounced or neater scarring than a similar pattern from a purely high explosive fragmentation submunition (see Images 8–10).

Submunition impact patterns or craters on a hard surface can reveal important clues about the whole strike that

Image 5. A fragmentation pattern on a hard surface caused by 9N210 submunition impact near an ICRC office, Donetsk, October 2014.
Photo courtesy of the Harriet Salem.

can assist both survey/clearance personnel and journalists or observers. For cylindrical munitions, whether it is a submunition or a simple HE mortar, a line bisecting the radial fragmentation pattern on one side of the impact can give an indication of the direction from which the munition came (see Image 11, page 16). This is a simplification of a technique sometimes referred to in old U.S. Military Field Manuals as the "Main Axis Method."[2] These techniques date back to

Image 6. Fragmentation from a 9N210 submunition collected at the scene of a cluster munition strike in Donetsk, October 2014. It is important to try to corroborate submunition impact patterns with associated fragmentation when possible.
Photo courtesy of Harriet Salem.

World War II when soldiers tried to identify enemy mortar and artillery positions.

Today, field operators looking to survey a cluster strike may try to find out the general orientation of the strike (or strikes) to assist in further survey and clearance. Should all the bisecting lines point in the same direction this might indicate one strike, or more strikes but all delivered from the same direction. This is the case regardless of whether the delivery mechanism was a cluster munition from an aircraft or a rocket, projectile or mortar carrier munition. In the October 2014 Donetsk example the craters revealed two possible strike directions for the two strike locations, coming from different locations to the south of the city. In areas where significant amounts of fighting have taken place over a prolonged period it is more likely that both cluster strikes and indirect fire will have come from multiple directions and the orientation of any resulting fragmentation patterns on hard surfaces could reflect this. In an area of multiple strikes it becomes harder to differentiate the evidence.

There are parts of mine action that can still improve the recording and documentation of all relevant evidence found in the field. Cluster strike fragmentation patterns on hard surfaces are important evidence. Such evidence is stronger when corroborated by associated fragmentation. Locations of fragmentation patterns or craters on soft surfaces and the larger remnants such as the carrier munition should be also recorded—even today this does not happen as much as it should. All recorded evidence should then be reviewed as a whole, ideally using Geographic Information System software. In this way operators have a better chance of estimating the extent of a given cluster strike earlier in the land release process.

Effective survey of any explosive contamination requires good knowledge of the evidence a surveyor is looking for. This is especially true when surveying cluster strikes. Survey

Image 7. Mortar impact patterns, Douma, Syria. Note how the scaring is similar to cylindrical submunition fragmentation patterns. The two are easy to mistake for one another. Also note the same orientation of the three patterns indicating they all came from the same direction and probably from the same mortar barrel. The mortar round tail units are embedded at the base of each pattern.
Photo courtesy of KiloBuzz.

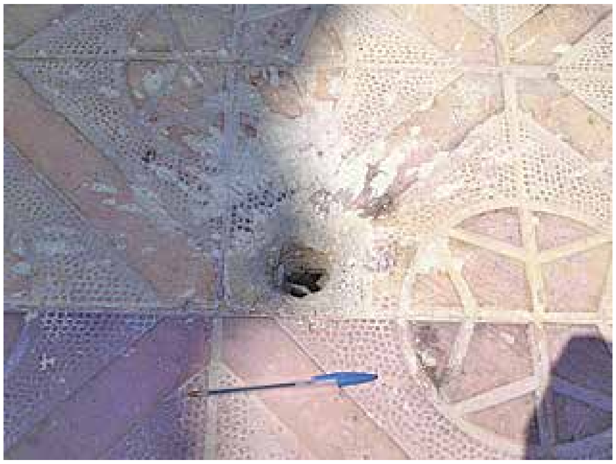

Image 8. M Series DPICM impact pattern on a tiled hard surface, showing the central hole made by the shaped charge, southern Lebanon, August 2006. Note that the fragmentation pattern is broadly similar to a fin-stabilized submunition, but the shaped charge will likely produce a larger hole at the base of the pattern.
Photo courtesy of Steve Priestley.

Image 11. 9N210 fragmentation pattern, Donetsk, Ukraine, October 2014. The superimposed line indicates the direction from which the submunition impacted.
Photo courtesy of Harriet Salem.

Image 9

Image 9 (top) and 10 (bottom). M Series DPICM impact patterns on a roof in southern Lebanon from the 2006 conflict, showing the central hole (since filled with cement) made by the shaped charge. Note the relatively neat scarring from the pre-scoured fragmentation jacket of the DPICM.
Photos courtesy of the author.

training should therefore look to prioritize knowledge of relevant evidence in a given operating environment. It should also look to improve how this evidence is recorded. Operators should also be able to accurately and consistently record not only actual explosive hazards, but where practicable and appropriate, the relevant associated evidence. At present, some databases, be it at operator or national level, do not facilitate the recording of associated evidence. The need to improve this situation shows that there remains more work to be done in order to implement land release principles in mine action.

See endnotes page 66

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