

WIDE-AREA IMPACT

Investigating the wide-area
effect of explosive weapons



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A still from a video of the immediate after-effects of a Grad rocket attack on Kievskiy Market, Mariupol in Ukraine on the 24 January, 2015.

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Introduction: Wide-Area Effects

“Large bombs and missiles, indirect fire weapon systems including mortars, rockets and artillery, as well as multi-barrel rocket launchers have served armies well in open battlefields. But when used against military objectives located in populated areas, they are prone to indiscriminate effects, with often devastating consequences for civilians... the use of explosive weapons that have a wide impact in densely populated areas should be avoided.”

Statement by the International Committee of the Red Cross, United Nations General Assembly, 15 October 2015.¹

Explosive weapons include a wide range of ordnance, both manufactured and improvised. They range in size and scale from hand grenades to massive ballistic ‘Scud’ missiles. They may be dropped from helicopters and drones, fired by tanks and artillery systems, or launched by hand. What unites all these weapons is their shared ability to project blast and fragmentation effects from around a point of detonation.

All explosive weapons, in this way, affect an area. Their killing and maiming capacity cannot be limited to a single point, as a sniper’s bullet may. They kill or injure anyone, or damage anything, in their vicinity.

The use of such weapons in a populated area is, therefore, of grave concern as it exposes civilians to a high and unacceptable risk of harm.² Since 2011, UK-based charity Action on Armed Violence (AOAV) has recorded the immediate impacts of explosive weapons around the world. Between 2011 and 2014, civilians made up 90 per cent of casualties when explosive weapons were used in populated areas. In other, non-populated, areas this fell to 34 per cent.³

WIDE-AREA IMPACT

The risk to civilians is most severe when explosive weapons that have wide-area effects are used in populated areas. Wide-area effects may result from one of three factors, either alone or in combination. The International Commission of the Red Cross and Red Crescent (ICRC) has broken down this concept into three broad categories of explosive weapons:

- Those that have a wide impact area because of the **large destructive radius** of the individual munition used, i.e. its large blast and fragmentation range or effect (such as large bombs or missiles) – in this case we look at the Paveway air-dropped bomb series;
- Those that have a wide impact area because of the **inherent lack of accuracy** of the delivery system (such as unguided indirect fire weapons, including artillery and mortars) – in this case we look at mortars;
- Those that have a wide impact area because the weapon system is **designed to deliver multiple munitions** over a wide area (such as multi-launch rocket systems) – in this case we look at the Grad multiple rocket series.⁴

In *Wide-Area Impact*, AOAV investigates each of the ICRC’s broad categories in turn. Through fieldwork conducted over the course of 2015, AOAV has taken case studies of explosive violence that occurred in that year and used these to explore how the technical characteristics that give a weapon wide-area impacts translate into severe and long-lasting civilian harm on the ground.

This report is intended to help illustrate the broad descriptive parameters of the term ‘wide-area effects’ and to further the development of a collective understanding of the need for States to act to restrict the use of explosive weapons with wide area effects in populated areas.⁵

METHODOLOGY

Weapon types of concern were identified from AOAV’s dataset of more than 12,000 incidents of explosive violence recorded between 1 January 2011 and 30 June 2015. Analysis of patterns of harm over this time period indicated several weapon types that typically resulted in high levels of civilian harm. Example weapon types were selected which correspond broadly with those identified by the ICRC in the above tripartite definition. A large range of explosive weapons embody the harmful characteristics identified by the ICRC in its three broad descriptive categories, and many could feature in all three. Selection is based on AOAV’s dataset and is intended to be indicative, and the parameters of each ICRC category are not limited to the weapon groups identified by AOAV in this report.

For each selected weapon type, country case studies were identified in which civilian casualties had been reported. This report only considers manufactured explosive weapons, and does not consider improvised explosive devices (IEDs).⁶

During 2015, AOAV conducted field investigations into the use of large aircraft bombs in Yemen (September), the use of inaccurate mortar systems on the Syria-Jordan border (September), and the use of BM-21 ‘Grad’ multiple rockets in eastern Ukraine (August).

Field research for this report was carried out in Jordan and Ukraine by AOAV’s Director of Policy and Investigations, Iain Overton, and in Yemen by investigative reporter Iona Craig. AOAV scrutinised each of these incidents by interviewing victims and witnesses to the attack, searching for potential military targets in the vicinity, and recording photographic, film and GPS data from the site of the attack.

AOAV is a founding member of the International Network on Explosive Weapons (INEW).⁷ We urge States and all users of explosive weapons to:

- Acknowledge that the use of explosive weapons in populated areas tends to cause severe harm to individuals and communities and furthers suffering by damaging vital infrastructure;
- Strive to avoid such harm and suffering in any situation, review and strengthen national policies and practices on use of explosive weapons and gather and make available relevant data;
- Work for full realisation of the rights of victims and survivors;
- Develop stronger international standards, including certain prohibitions and restrictions on the use of explosive weapons in populated areas.⁸



The destroyed al-Asadi family home in Yemen. It was hit by an airstrike from the Saudi-led coalition on the night of 7/8 September 2015. The house is in Libyan City, a relatively new and not densely populated residential area on the edge of Sawfan district in the north west of the city of Sana’a.

LARGE DESTRUCTIVE RADIUS: AIR-DROPPED BOMBS (the Mark 80 series and Paveway attachments)

In many cases in Yemen it is not possible to determine the specific type of weapons used in aerial attacks. The very fact of the destructive power typical of large air-dropped bombs means that after a blast there is commonly little in the way of firm evidence pointing to the responsible munition.

However, Saudi-led coalition forces in Yemen are thought to be making extensive use of aerial bombs with wide area impacts, including JDAM (GPS-guided) and Paveway (laser-guided) aerial bombs.⁹ The war-heads for these weapons are based on the widely-used Mk 80 series of general purpose fragmentation bombs.

Originally developed in the 1960s during the Vietnam War, these weapons are now part of the military arsenal of at least 24 countries, including the UK and US, and have been prominent in many recent conflicts and campaigns.¹⁰

The Mk 80 series of bombs are a group of heavy, high-explosive weapons, weighing between 500lbs and 2,000lbs.

The largest in this family is the Guided Bomb Unit-10 (GBU-10). The GBU-10 consists of an Mk 84 bomb fitted with a Paveway II laser guidance system.

It stands at 4.32m, two and a half times the height of the average adult male.

Even without its guidance system, the basic bomb weighs 2,000lb (approximately 907kg). Nearly half of the weight of a general-purpose bomb is its explosive content. The GBU-10 contains 945lb (approx. 428kg) of high-explosive Tritonal.¹¹

These are extremely powerful bombs, with a large destructive capacity when used in populated areas. They can blow apart buildings and kill and injure people hundreds of metres from the point of detonation.

The fragmentation pattern and range of a 2,000lb Mk 84 bomb are difficult to predict, but it is generally said that this weapon has a 'lethal radius' (i.e. the distance in which it is likely to kill people in the vicinity) of up to 360m.¹²

The blast waves of such a weapon can create a very great concussive effect; a 2,000lb bomb can be expected to cause severe injury and damage as far as 800 metres from the point of impact.¹³ The wide-area impact of these weapons can be affected by a range of tactical, technical, and environmental factors, including fusing and the angle of attack.

THE GBU-10 PAVEWAY II

These are the largest of a series of guided bombs used in Yemen by coalition forces, based on the Mk 84 2,000lb bombs with an added laser guidance kit.

WIDE-AREA IMPACT

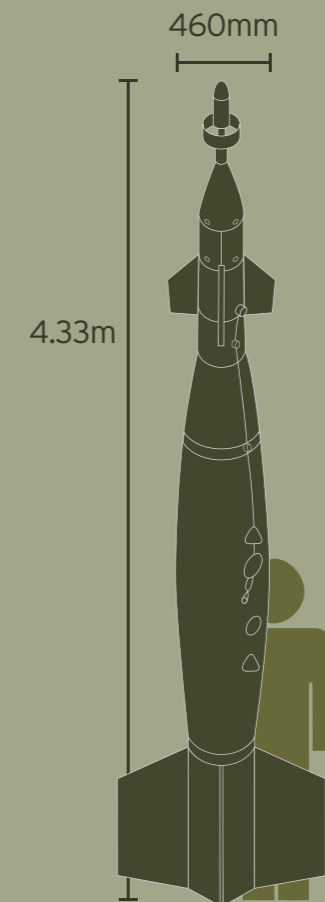
While the lethality is affected by multiple factors including fusing and angle of attack, the general 'lethal radius' of a Mk-84 bomb is up to 360m from point of detonation.



Globally, air-dropped bombs killed **10** civilians on average per incident recorded by AOA between 1 Jan 2011 - 30 June 2015.



This compares to **3** civilian deaths per incident across all explosive weapon types in that time.



DIMENSIONS



24 Countries where militaries use MK 80 series

WEIGHT



Explosives **428kg**



Rocket **907kg**

Raytheon, the producers of the Paveway III LGB Mk 84, claims it has a reported accuracy of less than 10m with later guidance. However, laser guidance does not work well in bad weather, and if the illuminating laser is switched off, guidance is lost.

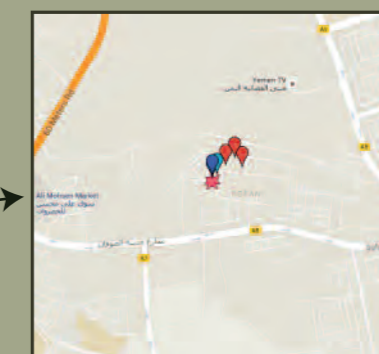


RANGE

More than 14.8km

AIR-DROPPED BOMBS IN YEMEN

8 September 2015: Sana'a, Yemen



References: IHS Jane's Air-launched weapons (2007), FAS, Amnesty International, AOA/Iona Craig

Air-dropped bombs in Yemen

“...those that have a wide impact area because of **the large destructive radius** of the individual munition used i.e. its large blast and fragmentation range or effect (such as large bombs or missiles);”¹⁴

KEY DETAILS

Where: Sana’a, Yemen

When: 8 September 2015

Incident details:

Three members of the al-Asadi household were killed, including two children, when a single aircraft bomb fell on their home. The property was destroyed in the blast, and damage found 70 metres from point of impact.

Weapon type:

Paveway aircraft bomb

Wide-area effect:

The largest of the Paveway bombs weighs 2,000 lbs (907kg) and can cause damage as far as 800m from the point of detonation.

FEATURE UNDER INVESTIGATION

The explosive weapons with a wide impact area that AOVAV investigated in Yemen were those capable of projecting blast and fragmentation effects over a particularly large radius.

All explosive weapons affect an area. When a bomb, rocket, mortar or shell explodes, in a matter of microseconds a devastating shock wave has rippled out at supersonic speeds, followed by a blast wind which is channelled, muffled or magnified in unpredictable ways by the obstacles of buildings, cars and people that crowd a densely-populated area.¹⁵

In the wake of the blast effects comes the fragmentation. Primary fragmentation is the jagged metal shards of the munition casing itself. The ICRC claims that 80

per cent of the injuries seen in wars between classical armies are caused by primary fragmentation.¹⁶ Secondary fragmentation is the shattered glass, falling rubble, swirling dust and dirt that is caught in the maelstrom of the explosion and scattered unpredictably across a wide area. In populated areas this is all too often the cause of multiple deaths and injuries.

This happens every time an explosive weapon detonates, to a greater or lesser degree. What makes a particularly **large destructive radius** is not simply an equation of scale. The impact of a weapon can be a result of many factors of design and deployment, including the ratio of explosive material to casing, the type of explosive used and the fuse on the weapon (whether it is designed to explode above ground, on impact, after contact etc.) It is not as simple as a direct correlation between the size of the weapon and the size of its corresponding impact. However, the two are clearly related, and the use of heavy explosive weapons (such as large aircraft bombs, rockets and missiles) in a populated area will invariably result in a large number of deaths and injuries, demolishing buildings and crushing vital civilian infrastructure.

WEAPON TYPE UNDER INVESTIGATION

Aerial bombs stand out as particularly concerning in AOVAV’s near five-year dataset on explosive weapons harm. Between 1 January 2011 and 31 July 2015, AOVAV found that no manufactured explosive weapon type killed more civilians per incident on average than aerial bombs (see *Figure 1*).

Large air-dropped bombs killed an average of ten civilians per incident in this time period. This is more than three times the average across all manufactured explosive weapons.

The fact that these weapons habitually kill so many people in a single incident is strongly indicative of an inherently large destructive capacity.¹⁷ The broad correlation between the size of a weapon and its impact is suggested in *Figure 1*. Those weapons near

the bottom of the scale are typically light, portable, and deployed by individuals or a crew, such as rocket-propelled grenades (RPGs). Those manufactured weapons that are more likely to kill large numbers of people at a time are largely those deployed by heavy weapon systems like tanks and planes.

COUNTRY UNDER INVESTIGATION

State forces have dropped aircraft bombs in populated areas in many countries over the past five years.¹⁴ Civilians have been killed and injured by explosive weapons dropped from aircraft in at least 19 different countries and territories since 1 January 2011, including Syria, Gaza, South Sudan and Afghanistan.¹⁴

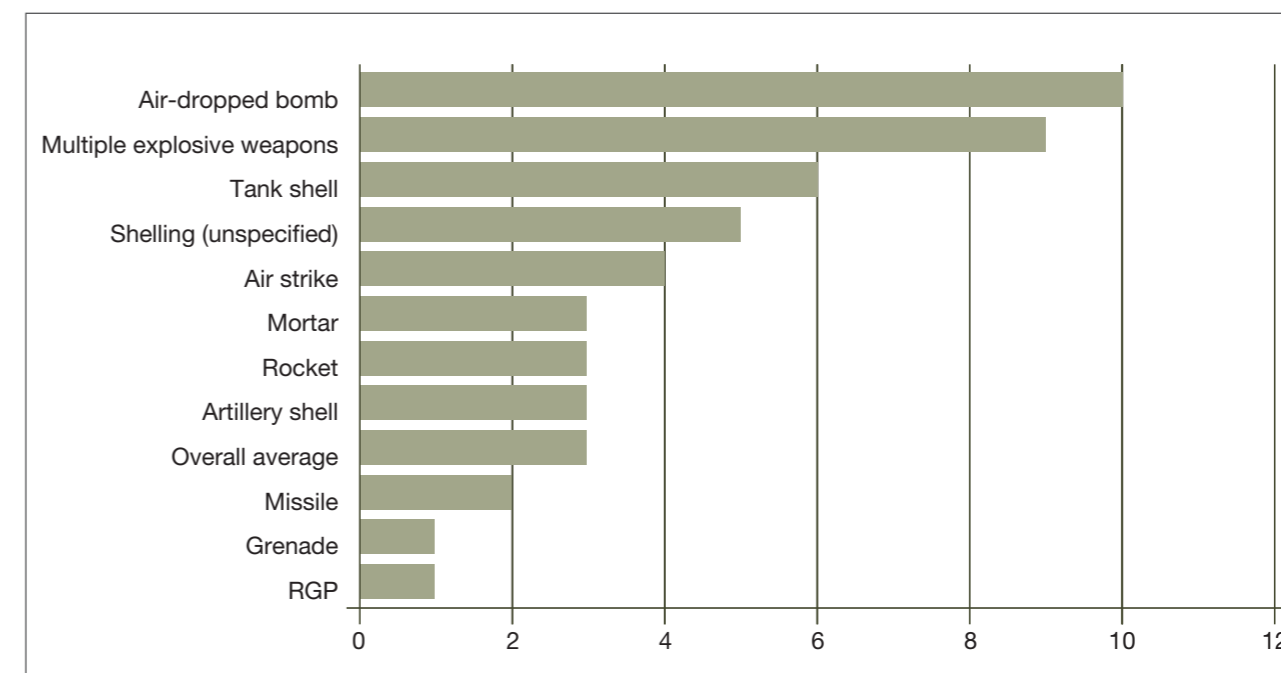
In 2015, though, it was Yemen that suffered most from the use of heavy aircraft bombs in populated areas. On 26 March 2015, a coalition of states led by Saudi Arabia began a campaign of aerial bombing against targets across Yemen. It was an attempt to push back the advances of Shia armed groups—commonly known as Houthis or Ansar Allah—and forces loyal to the country’s former President, Ali Abdullah Saleh. Thousands of aerial bombs have been dropped on Yemen since the March offensive began. The harm they wrought was considerable. Aerial bombing was responsible for 60 per cent of recorded civilian deaths and injuries from explosive violence in Yemen in the

first seven months of 2015. In that time, AOVAV recorded 3,287 total deaths and injuries from air-launched explosive weapons, of whom 2,682 were civilians (82 per cent). On at least eight occasions an aerial bombing incident was reported to have killed or injured more than one hundred civilians. As AOVAV’s data is recorded using English-language media reports only, the true civilian toll from such strikes is likely far higher.¹⁵

Much of the bombing in Yemen has taken place in populated areas, with a widespread pattern of strikes hitting civilian residential areas and vehicles, schools mosques and markets, including within the capital city Sana’a.¹⁶ Military and security installations, as well as buildings used as official Houthi offices, are scattered throughout built up areas of Sana’a. As a result, even where the reported targets are claimed to be military, airstrikes in these locations have resulted in civilian deaths and injuries, as well as extensive damage to nearby civilian homes, shops, hospitals and schools.

The following case study in Yemen focuses on how the use of a large explosive weapon in a populated area impacts on civilians. Research for this case study was carried out in September 2015 by Iona Craig, an award-winning independent journalist who first moved to Yemen in October 2010 as the correspondent for *The Times* (of London).

Figure 1: Average civilian deaths per incident



Case study: Bombing of the al-Asadi home

Shortly after midnight on 8 September 2015 a single aerial bomb hit the residential home of the al-Asadi family. Their home [mark 1 on Figure 2] lay in the north-western district of Sana'a – an area called Libya City. The district is less than 2km from the First Armoured Division base, the city's largest military camp, as well as being less than 150 meters from a state-owned compound that had previously been hit by aerial bombing [12-14 on Figure 2].

The bomb fell between 00:00 and 00:30, completely destroying a single-storey home owned by two brothers, Zaid and Ali al-Asadi.

Three members of the al-Asadi family were killed in the attack on 8 September, including two children. Another eight were injured.

The building was home to 13 family members, as well as three other people being hosted by the al-Asadis. When the bomb struck, 11 people were asleep inside the house. They included Zaid's wife Mariam and their four children, and Ali's wife (also called Mariam) and their three children. The bomb hit the west side of the house, completely collapsing a third of the building, and bringing down the upper floor that was acting as a roof for those sleeping below.

At the time of the blast, Zaid al-Asadi was standing outside his property. He was killed by a falling concrete column. Two of Ali's children inside the house,

18-month-old Buthanyal and seven-year-old Bilal, also died when the building collapsed on top of them.

“A pillow landed on my head and then stone above it otherwise I would be dead. I could hear my wife screaming but not my children.”

Ali al-Asadi

When AOA V visited the al-Asadi home nine days after the strike, a crater approximately two feet deep was clearly visible. A variety of bomb remnants were also found at the site, the largest of which had an estimated weight of more than 1.5 kg. A serial number on that fragment was traced and it is extremely suggestive that the weapon was part a Paveway II series manufactured by the US arms manufacturer Raytheon.²²

A government-owned compound containing the abandoned houses of a southern separatist leader, Mohammed Ali Ahmed (Figure 2, marks 12-14) may have been the intended target. Neighbours claimed that one of the houses in the compound had previously been used by Abu Ali Hakim, a senior Houthi commander, after the Houthis seized control of Sana'a in September 2014.²³ However, although the al-Asadi family could be described as Houthi supporters or sympathisers, none were fighters or political figures.



Figure 2: Map of strikes recorded surrounding the al-Asadii home, 8 September 2015.

WIDE-AREA IMPACT

For a single conventional bomb, the physical damage was significant and widespread.

Women and children living in the neighbouring house (Figure 2, mark 2) were covered with shattered glass as they slept. Furniture and objects were thrown by the blast which tore through the house, destroying glass windows and window frames on the southern side of the building and buckling window frames on the blast exit side of the house. None of those inside the neighbouring house at the time of the bombing were injured.

Witnesses reported seeing a burst of flames when the airstrike hit, and a survivor Abu suffered burns to his legs, but evidence at the site suggested that the fire caused by the explosion was not widespread.²⁴ Rubble scattered by the bomb crushed several vehicles parked outside the home.



Bomb remnant found inside the al-Asadi house. The largest fragment found at the site, it weighed approximately 1.5kg. (Copyright: Iona Craig/AOAV)

The bomb damage extended to the building behind the immediate neighbours' house. Despite some apparent protection due to the neighbouring high wall, this house suffered extensive damage to glass, window frames, and a corrugated metal extension.

The airstrike caused physical damage up to 70 meters away, breaking windows in a house behind a high wall. This building had previously been damaged in a strike on the government compound in June, so was empty during September's bombing.



Munition fragment containing serial numbers that identify it as part of the Paveway series of bombs. (Copyright: Iona Craig/AOAV)

The range of the damage from the bomb appears to have been limited by the fact that the buildings in the immediate area were detached properties, set back from the road and behind high walls. Window damage also appears to have been limited by windows being left open allowing for blast absorption.

Buildings in Sana'a are not made to withstand harsh weather, let alone aerial strikes. Breezeblock homes are often flimsily built using poor materials that may not withstand blast shockwaves easily. As in this case study example, families often live in buildings that are still under construction, and as such may be more vulnerable to collapse.

Traditional Yemeni homes are built with mud-brick and stone bases. Wooden beams support roofs made with mud mixed with straw. While this makes such buildings often more blast resistant, when bombs directly hit traditional homes the consequences are often as deadly. These homes are usually four to seven stories high. When hit they collapse, leading to death by suffocation rather than crush injuries. Such suffocation deaths as a result of aerial bombings have most often been seen in rural areas, where traditional homes are more common.

Saada, one of the worst-affected areas by the Saudi-led bombing campaign, has seen many such deaths, with scores of traditional mud tower houses being bombed and destroyed.²⁵

LACK OF ACCURACY: MORTARS

Mortars fire distinctive fin-tailed munitions from a smooth-bore tube mounted to a base plate on the ground.²⁶ As soon as the mortar round is dropped down the tube it is launched at a high trajectory that can clear obstacles such as tall buildings or hills.

This ballistic trajectory means the weapons are not pointed directly at the target and fired. Instead, they are ‘walked up’ to the target. Each time a round is fired and misses, an observer is nearby to report where the rounds have landed so that the mortar crew can make necessary corrections. Mortars have a high rate of fire and they are commonly used in rapid, intense bursts with several mortars being launched in short succession.²⁷

Mortars are extremely widely used and produced. According to Small Arms Survey, nearly 50 countries have manufactured one or more types of mortars – with 30 continuing to do so as of 2008 – making it the most widely produced light weapon.²⁸

Mortars range in size and power and generally cover three categories: ‘light’ (up to 60 mm), ‘medium’ (61 mm to 82 mm), and ‘heavy’ (83 mm to 120 mm). In Syria in 2012 evidence surfaced of the use of a 240mm mortar bomb, but the most common sizes include 81/82mm and 120mm mortars.²⁹

One of the many mortar types in use in Syria is the M-1943. Syria has hundreds

of these, which have been shipped to the country over the years by Russia and Bulgaria.³⁰ The M-1943 is a heavy 120mm mortar. It is 0.66m tall, and weighs a little over 16kg. This weapon has a thick metal case, and only 2.68kg of high explosive TNT. The M-1943 can be fired as far as 5.7km. Its blast range is estimated to be around 28.44m.^{2 31}

The classic mortar system in use by many armed forces across the world is notoriously imprecise.³²

The dispersion of indirect-fire weapon systems is generally expressed using Circular Error Probable (CEP). This is defined as the radius of a circle within which half of all the weapons fired are expected to fall or explode.³³ If a mortar system had a CEP of 100m, this would mean that, if eight mortar rounds were launched at a target in the middle of a circle measuring 100m, only four would land inside. This definition does not provide a full indication of accuracy. In this hypothetical example, the other four outliers could land immediately outside that distance or far away.

Despite technological advances that have improved accuracy of the most expensive and capable models, most conventional, unguided mortar systems have relatively high CEPs for such a short firing range.³⁴ Conventional NATO High Explosive 120 mm mortar bombs have a CEP of 136m at their maximum ranges if an advanced fire control system is not used.³⁵

THE M-1943/M43

The 120mm, heavy mortar that is common in state arsenals. Many countries have replaced the M1943 with the similar 2B11 Sani but Syria is still believed to have the original model. Basic 120mm bomb is the OF-843/843B.

KILLER FACT

120mm mortar bombs are made in at least 28 countries in addition to Russia.



In populated areas, civilians made up **95%** of deaths and injuries from mortar attacks targeting armed actors.



In other areas, that fell to **14%**.

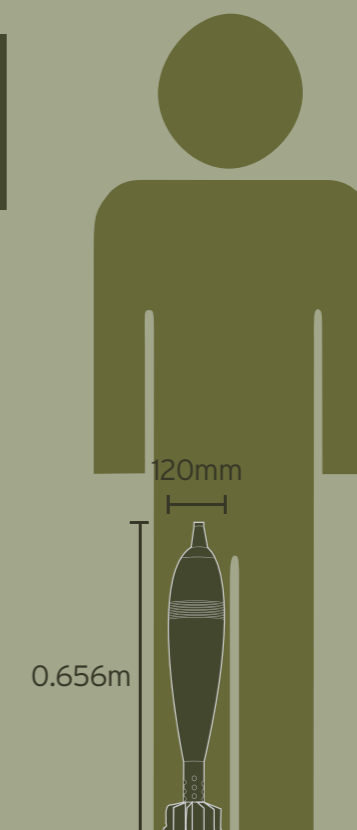
RATE OF FIRE



WEIGHT

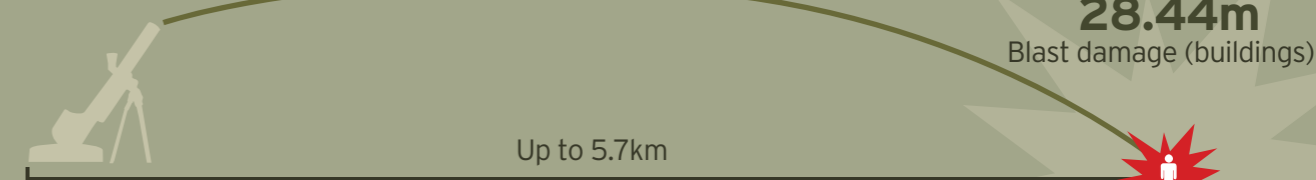
Explosives **2.68kg**

Rocket **16.02kg**



DIMENSIONS

RANGE



WIDE-ARE IMPACT OF INACCURATE WEAPON SYSTEMS

5 June 2015: Ramtha, Jordan/Syria border



*All blast ranges are calculated safety estimates based on US DoD standards. Credit: Nic Jenzen-Jones Sources: Human Rights Watch/Jane's/Norwegian Defence Research Establishment (FFI)/SIPRI/Splav/The Military Balance

Mortar fire from Syria

“those that have a wide impact area because of the lack of accuracy of the delivery system (such as unguided indirect fire weapons, including artillery and mortars)”³⁶

KEY DETAILS

Where: Ramtha, Jordan-Syria border

When: 5 July 2015

Incident details:

Abd al-Mon'em Sami Horani, 23, was killed when a mortar hit the al-Horani coffee house. It was one of 15 wayward mortar strikes that fell across the Jordanian-Syrian border.

Weapon type: Mortar

Wide-area effect:

The M-1943 mortar in use in Syria can be fired as far as 5.7km. Its blast range is estimated to be around 28.44m.

FEATURE UNDER INVESTIGATION

One of the characteristics that unites most explosive weapon types and makes them so integral in contemporary military strategies is that they are delivered from range. Whether dropped from a plane or fired from a rocket launcher on a remote hillside, explosive weapons can often be launched from a great distance.

This distancing effect separates the operator from the target, and protects them from return fire. It also shields them from the blast impact of the weapons they have themselves launched.

This distancing effect, however, presents significant challenges to civilian protection. The use of **inaccurate weapon systems** in populated areas puts civilians at danger even when such weapons are launched at a legitimate military target.

Explosive weapons can miss a target because they lack either accuracy or precision, or both. If a weapon is imprecise but accurate each munition will likely land within a broad designated area, but they will not fall close to each other with regularity. If a weapon is fired with precision but without accuracy, munitions will land close together, but not necessarily near the target. If a weapon lacks either precision or accuracy, as with many conventional indirect-fire systems, munitions are more likely to land haphazardly across a wide area.

Explosive weapons that cannot be delivered with either accuracy or precision may fall short, wide or long of an intended target. They can land seemingly at random – falling without warning on civilian homes, shops and other key infrastructure. In a populated area, each munition that fails to exactly hit its target can mean death or injury to nearby civilians. A failure of even a few metres can mean an entire family is wiped out.

One group of explosive weapons that is particularly concerning in this regard are those that can be delivered by a process called **indirect-fire**. Indirect-fire is where a weapon can be launched without the operator necessarily having a clear line-of-sight to the target.³⁷ Explosive weapons commonly delivered this way include heavy artillery, rockets and mortars.

WEAPON TYPE UNDER INVESTIGATION

Mortars, which fire distinctive fin-tailed munitions from a smooth-bore tube mounted to a base plate on the ground, are one of the most frequently reported explosive weapon types. They consistently cause a high level of harm to civilians and are a prominent weapon of concern in AOA's monitoring. Each year since 2011, mortars have killed and injured thousands of civilians; each year more than 90 per cent of all recorded casualties of mortar use globally have been civilians.³⁸

This percentage is either the highest or second highest across all AOA's explosive weapon types (depending on the year).

On average four out of every five mortar incidents recorded by AOA took place in a populated area. This is again one of the highest frequencies across all explosive weapon types and suggests a strong correlation between use in populated areas and resulting civilian impact.

Inaccuracy and imprecision are difficult concepts to illustrate using AOA's public-health methodology. AOA does record information on targeting but can only do so under limited conditions.³⁹ Between 1 January 2011 and 31 July 2015 AOA coded 89 mortar attacks with a reported armed actor target. Half of these incidents took place in a populated area.

Even when armed actors were targeted by mortars in populated areas, civilians made up 95 per cent of the deaths and injuries recorded by AOA. This fell dramatically to just 14 per cent in other areas. This suggests strongly that, while it is possible for mortars to achieve a military objective, in populated areas they are far more likely to affect civilians than armed actors. In this case study AOA investigates how the use of inaccurate weapons in and near populated areas puts civilians at risk.

COUNTRY UNDER INVESTIGATION

Between 1 January 2011 and the 30 June 2015, mortars were reported to have killed and injured 8,554 civilians in at least 29 countries. Easy to come by, transport and use, they are ubiquitous in many of the most violent conflicts and security crises around the world. But in no conflict are they more common or devastating in recent years than in Syria.

The Syrian civil war has waged since March 2011, when the government of Bashar al-Assad began a crack down against civil uprisings in cities across the country. In the last five years, thousands of civilians have been killed, many as a result of the use of explosive weapons like mortars, rockets, missiles and barrel bombs, that has characterised this brutal conflict. As the dynamics of the conflict have changed, the one constant has remained the repeated widespread use of heavy explosive weapons in populated areas.

Between 1 January 2011 and the 30 June 2015, over half of all of civilian deaths and injuries from mortars recorded worldwide by AOA took place in Syria

(4,552 or 53 per cent of 8,554 – see above). In 2014, AOA recorded 1,910 civilian deaths and injuries from 115 mortar attacks in Syria. Nine of these attacks hit schools in Syria, killing and injuring 254 people. Mortars are used by many parties to the conflict including the Syrian army and fighters allied to the group known as Islamic State.⁴⁰

So inaccurate are these weapons that Syrian-fired mortars have not just killed and injured civilians in Syria. The fighting has spilled over into neighbouring countries, endangering civilian populations living across the border including Syrian refugees.

Five countries share land borders with Syria: Iraq, Israel, Jordan, Lebanon and Turkey. In all five, AOA has recorded deaths and injuries from mortar fire originating within Syria. The fact that people are being killed outside Syria's borders by weapons fired from within Syria at apparent targets also within Syria is a sharp illustration of the profound levels of inaccuracy inherent in this weapon system.

Such inaccuracies are not, of course, confined to the Syrian borders. Border populations around the world often come under fire from mortars and other indirect-fire weapons. AOA has recorded 196 incidents of cross-border shelling around the world between 1 January 2011 and the 30 June 2015. These events spanned 25 different countries and territories. These include disputed borders (e.g. Cambodia and Thailand, India and Pakistan), and spill-over violence (e.g. Democratic Republic of Congo and Rwanda, Burma and China).



Bashar Mer'i Al Makhadme – a trainee doctor who was severely injured by a mortar strike on his home, that lies 4.5 km from the border, on the 13 August 2015.

MORTAR AND OTHER INACCURATE WEAPON USE ON THE SYRIAN/JORDANIAN BORDER

AOAV's field investigations in September 2015 charted 15 explosive weapon strikes that crossed the Syrian border into Jordan between 2012 and 2015.

The majority of the strikes seem to have been from mortar attacks. In some cases it was not clear if mortars were indeed responsible, despite being described by locals as such. Some appear to have been either homemade 'Grad'-style rockets or were manufactured ground-launched projectiles of unknown origin. It is hard to establish what weapons were used as the Jordanian military deployed quickly to the scene and the munitions were deposited. The Jordanian military declined AOAV's request for an interview.

This case study shows the rising impact of explosive weapons on the Jordanian border. This investigation catalogued one strike in 2012, two in 2013, one in 2014 and 11 strikes in 2015, highlighting the rising threat of humanitarian harm along the Jordanian-Syrian border in 2015.

GEOGRAPHICAL LOCATION

Of these 15 strikes, the nearest recorded impact occurred 1.7 km away from the Syrian border (case study 13 – see AOAV website for more).⁴¹ The furthest strike from the Syrian border was just under 7.5 km away (case study 14).⁴² The most northern strike in this case study at GPS 32.66849, 35.9416 (case study 15).⁴³ The most southern strike at GPS 32.5213, 35.99725 (case study no. 14) – about 17 km away.⁴⁴

In total the land impacted by strikes in this case study covered an area of about 60 square kilometres.⁴⁵ There was no discernible military or strategic target within that area.

It was not determined – nor was it within the scope of this report to do so – who was responsible for attacks that fell in Jordanian soil.

The locations of the impacts clustered around two border towns, Ramtha and its immediate environs (nine strikes) and Tourra (four strikes), about twenty minutes drive to the north. This record of strikes is based on locally-sourced evidence, media reports and official statements. It does not constitute a

definitive summary of all trans-border use of explosive weapons, as many strikes land in fields and are not reported or widely known about. Where possible a date, a GPS location and a name of a family whose property or persons were damaged in the strike was recorded by AOAV.

This report aims only to highlight the trends of such attacks. All case studies and more is available on AOAV's website at: <https://aoav.org.uk/category/mortar-attacks-in-jordan/>.

CIVILIANS AND INFRASTRUCTURAL HARM

AOAV investigated fifteen strikes which between them killed one civilian and injured another 12. The wounds ranged from the superficial to ones that required extensive surgery. Property damage was recorded in 12 of the 15 strikes, with three strikes landing in fallow ground.

It was almost impossible to verify what type of mortar bombs were used in each and every attack on Jordanian soil. The fluid and anarchic nature of the fighting, combined with poor levels of media coverage, means that munitions evidence was extremely limited.

What can be recorded is the pattern of harm wrought by indirect-fire weapons. Many of those interviewed described symptoms of psychological injury, such as sleep disruption, significant strain on intra-familial relationships or panic attacks.

The structural damage caused by these explosive weapons varied. Many strikes damaged roofs, with some suffering visible damage if the projectile penetrated walls and entered communal living spaces. Unlike aerial strikes, however, the strikes did not collapse buildings or reduce structures to rubble. Some of the incidents would have incurred significant casualties had these shared rooms been occupied at the time.

Financial compensation for the strikes varied from family to family. Those who were wounded in the strikes all received free medical aid from the Jordanian government. The family of the man who was killed in the first case study (see below) was both compensated and the funeral partly paid for. However, while the immediate physical harm (and in some cases psychological harm) incurred by those impacted by the strikes was treated free of charge, victims of the

strikes noted that their work and family life were disrupted – a reality that resulted in financial and emotional damage that was not compensated. Furthermore, those who did not suffer physical damage but did suffer psychological harm were not offered therapeutic treatment by the government.

There were also some instances where repairs to structural damage was paid for by the Jordanian government, although in many cases the damage done was not deemed severe enough to require assistance.



Various missile and rocket fragments that have struck Jordanian territory in the last four years. Some are clearly improvised, but all have the same capacity for wide-area damage. The munition in the top right image was the one that struck the al-Horani coffee shop (see below).

Case study: Mortar and other inaccurate weapon use on the Jordanian/Syrian border

At 1pm on the ninth day of Ramadan in 2015 – 5 June – a mortar hit the al-Horani coffee shop in the centre of Ramtha.⁴⁶ The blast killed Abd al-Mon'em Sami Horani, a 23-year-old Jordanian student. Known to his brother and five sisters as Abood, the young man, who had an ambition to be a civil engineer, died at the scene. His cousins, Ahmed (18), Mousa (21) and Issa (13) were all injured in the blast. Another civilian – a woman walking on the street – was reported injured in the stomach but was not identified.

There was no obvious military target near the shop – which lies in a market district some 4.5 km from the Syrian border.

The young men had arrived at the shop on Wehde Street that day to sell ice cream, orange juice, dates and dried apricots to their customers. Abood was working there with his cousins for a small stipend. When the mortar landed it struck a pole on the roof of a block of shops opposite the cafe, its blast channelling down the road into the coffee shop, spreading fragments behind, in front and to its sides at a distance of almost 100 metres.



This photograph was taken shortly after the strike – the al-Horani Coffee shop is in the background (under the Prestige shoes sign). The crowds that instantly gather after all the strikes that hit Jordan bring with them their own danger – in case of a secondary strike. (Photographer unknown)

Abood died from significant trauma to his chest and head. His death significantly impacted the community. Locals reported as many as 15,000 people attended his funeral. His brother, Mo'tasem, 27, said of Abood that *“he was an ambitious young man, he didn't go out much, he just went to school and came back and studied really hard to become a civil engineer. Everyone who knew him said he was polite, timid and never violent. He was very independent.”*

Abood's brother, a nurse for Doctors Without Borders, was deeply affected by the impact of the death. *“I'm in denial – I don't believe he has left and I expect to see him wherever I go. I feel like I'm living in Syria now – not another city. First, I was helping refugees now I don't know if I want to. I am confused – who dropped the mortar? The regime? The Free Syrian Army? Some other group? I want revenge for my brother's death. I always think of that. The conflict has taken my brother from me.”*



'Abd Al Mone'em Sami Horani (Abood) – a 23 year old Jordanian engineering student – who was killed in a mortar strike on the 5 June, 2015 in Ramtha, a city that lies about 4.5 km from the Syrian border.

The blast also had a deep impact for others on the site.

Mousa Yousef Yaseen Horani, Abood's cousin, was thrown up into the air by the blast. The explosion fractured his hip and punctured his bladder, piercing his intestines. He walks with a limp now and does not know whether this will be a permanent affliction.

Today, Mousa is angry that his treatment was insufficient: he claims it has caused as much harm as good. He claims, too, that he was given too many sedatives and is now addicted to pain medication. He finds it hard to sleep.

His family also say that they were only given psychiatric help after demonstrating at the hospital. His anger and expectations echo sentiments shared by other victims of explosive weapons in this area – that the government has done insufficient to help and that he should be either given a job by them or even – as Mousa said – asylum in another country.

Issa Yousef Yaseen Horani, the youngest cousin, was hit in the leg by a mortar fragment. His bleeding was so profuse that, his family members alleged, the hospital did not have enough blood units. Volunteers stepped forward and 35 units were obtained. He has scarring on his leg but his wounds were not life changing.



Abood's cousins – Ahmed, Mousa and Issa were all injured in the blast. They continue to run the coffee shop but all appear to suffer from post-traumatic stress and some complain of headaches and nightmares.

Ahmad Yousef Yassen Horani was hit in the head by the shrapnel and in his arm. His injuries were not life threatening.

The damage to the grocery shop was relatively superficial. A refrigeration unit was destroyed and shrapnel marks can still be seen in the shop and on the roof of the shops opposite where the weapons first landed. The shop reopened for business relatively soon after the attack happened.

Relatives of Abood spoke – as did many affected by mortar strikes – of the issue of compensation. There was some degree of Jordanian governmental financial aid offered for Abood's death. The government supplied water and coffee for the mourners at his funeral, of which there were many. They also supplied one meal and tents, though the family complained they were of poor quality. 10,000 Jordanian Dinars was also given, though the family claimed that they rejected this as they saw it as blood money.

Overall, people are very critical not only of the Syrians behind the mortar attacks but also of their own government, even though the evidence suggests that the Jordanian government assisted victims in a variety of ways. This, perhaps, reflects not so much shortfalls in the government's intervention, but in the very powerlessness that accompanies any mortar attack out of the blue.

MULTIPLE MUNITIONS: MULTIPLE ROCKET LAUNCHERS – GRAD ROCKETS

Grad means ‘Hail’ in Russian: a name that reflects the power and reach of the weapon system. Each individual Grad rocket stands almost 3m tall, and weighs approximately 66kg.

Grads have a tremendously high rate of fire. A rocket leaves the launcher every 0.5 seconds, meaning an entire 40-rocket salvo can be launched in 19.5 seconds. After firing, it takes just ten minutes to completely reload the Grad launch vehicle and for the system to resume its attack.

Commonly Grads operate in batteries, meaning that there are several launch vehicles operating simultaneously, further extending the area covered by deadly rockets.

Each of these rockets is a potentially devastating weapon in and of itself. Grad warheads are designed to fragment on impact and are scored in such a way as to greatly maximise the spread of fragmentation across an area.

At the moment of detonation, the basic warhead scatters a total of 3,922 fragments, killing and injuring anyone in its midst. The area affected by the blast and fragmentation of each high explosive warhead that strikes the ground is measured at 700m.²

This is an area roughly equivalent to a circle with a radius of 15m, although Grad rockets spit most of their fragmentation effects in an area forward of where the rockets land.

These rockets are all completely unguided, and will inevitably fall across a wide area. The original Grad system had a maximum range of 20km. More modern versions have seen the range doubled to almost 40km. If the full salvo is fired across the original Grad’s top range of 20km, the ‘lethal area’ (i.e. the area in which the rockets are likely to cause death to people on the ground) is at least 600m x 600m. A single rocket could fall anywhere within an ellipse measuring approximately 600m x 320m.⁴⁷

GRAD ROCKETS

Grad means ‘Hail’ in Russian. It is a multiple rocket launcher system that fires 40 unguided, high-explosive fragmentation rockets. It is described as the most widespread artillery rocket system in the world.

WIDE-AREA IMPACT

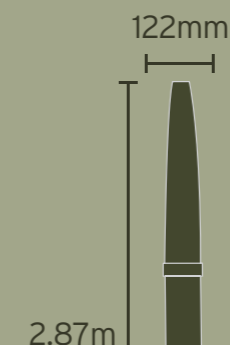
When a full salvo of 40 rockets is fired the ‘lethal area’ of a Grad rocket is 600m x 600m



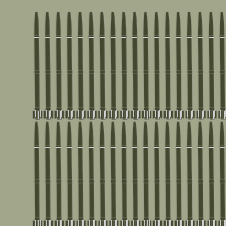
On average there were **14** civilian deaths and injuries from ‘Grad’ rockets per attack in the first year of fighting in eastern Ukraine (1 May 2014 - 30 April 2015).



The average for all explosive weapons incidents in eastern Ukraine is **9**.



RATE OF FIRE



WEIGHT



Explosives **18.4kg**



Rocket **66kg**

DIMENSIONS

RANGE



Up to 20km for original Grad model



36.64m

Blast damage (buildings)*

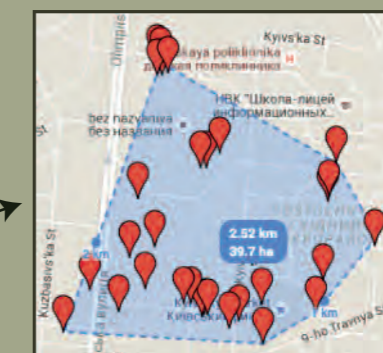


5.97m

Blast damage (personnel)*

WIDE-AREA IMPACT OF MULTIPLE MUNITIONS

24 January 2015: Mariupol, Ukraine



* All blast ranges are calculated safety estimates based on US DoD standards. Credit: Nic Jenzen-Jones Sources: Human Rights Watch/Jane's/Norwegian Defence Research Establishment (FFI)/SIPRI/Splav/The Military Balance

Multi-launch rocket systems (MLRS) in Ukraine

“those that have a wide impact area because the weapon system is designed to deliver multiple munitions over a wide area (such as multi-launch rocket systems).”⁴⁸

KEY DETAILS

Where: Mariupol, Ukraine

When: 24 January 2015

Incident details:

31 people were killed when almost a hundred rockets fell on the port city of Mariupol in eastern Ukraine. Among them were two women trading at a sausage food stall in a central market.

Weapon type:

BM21 Grad multiple rocket launcher

Wide-area effect:

The lethal area of the Grad rocket at full range of 20km is 600m x 600m.

FEATURE UNDER INVESTIGATION

The third and final category of explosive weapons with a wide-area effect covers those that thunder down **multiple munitions** over a large distance in a short space of time.

This category of ‘wide-area effect’ refers both to the technological capacity of some explosive weapons, but also the practice of delivering multiple munitions at once. At its most egregious, such a practice may be deemed tantamount to area bombardment. Area bombardment is defined as *“any method or means which treats as a single military target a number of clearly separated and distinct objectives located in a city, town, village or other area containing a similar concentration of civilians or civilian objects.”*⁴⁹ This practice is illegal under international humanitarian law (IHL).

Explosive weapons collectively originally came to the fore when fighting took place primarily between two standing armies in an open battlefield. The development post-World War Two of heavy weapon systems that are capable of bringing tremendous firepower to bear upon such a battlefield was a logical development. As such, a large variety of weaponry now exists that can rapidly fire munitions, concurrently or simultaneously, across a wide area.

As these weapons are often designed to attack an area rather than a precise target their use in populated areas is clearly inappropriate.

Despite this, such weapons continue to be used in civilian populated areas. The heavy shelling or ‘barage’ of populated areas has caused widespread devastation in countries around the world. It is extremely common for ground-launched explosive weapons to be fired in multiple numbers at a time. Often AOV records incidents of explosive violence in which several types of explosive weapons are used simultaneously, as when fierce exchanges of rockets and mortars are documented, launched across a crowded marketplace. All too often, civilians are caught in the cross-fire.⁵⁰

Between 1 January 2011 and 30 June 2015 AOV recorded 539 attacks worldwide that hit ‘Multiple Urban’ location types at once.⁵¹ These attacks were the most destructive across AOV’s dataset of explosive violence incidents. They account for 10 per cent of incidents but 30 per cent of total civilian deaths and injuries.

WEAPON TYPE UNDER INVESTIGATION

Multi-launch rocket systems (MLRS) are by design intended to attack a wide area. They clearly have no place being used to try and hit a target within a populated area, and yet there has been widespread evidence of their use in varied contexts during the last five years.⁵²

There are many types of multiple rocket launchers. Perhaps the most infamous, and certainly the most ubiquitous, is the BM-21 Grad rocket.

The BM-21 Grad rocket is a vehicle-mounted multiple rocket launcher. Originally designed and developed in the former Soviet Union in the 1960s, the Grad is now thought to be in the stockpiles of more than 50 countries, and in its various forms is the most popular multiple-launch rocket system in the world.⁵³

It is extremely difficult for AOV to accurately capture all incidents in which Grads, or MLRS more generally, are in use on the basis of media reporting. The level of specificity required of journalists or civilian eyewitnesses is rarely met. As such AOV’s data on the humanitarian impacts of MLRS is likely to be a significant underrepresentation of the harm they cause to civilians.

While AOV has recorded the use of MLRS in Libya, Somalia, Syria and Yemen in the last five years, more deaths and injuries were recorded from these weapons in Ukraine than in anywhere else in the world (39 per cent of worldwide harm from MLRS was in Ukraine – or 594 deaths and injuries).

COUNTRY UNDER INVESTIGATION

In April 2014 the political crisis in Ukraine escalated rapidly into armed conflict between state forces and rebel-armed groups. AOV recorded its first incident of explosive violence in eastern Ukraine in May 2014.



A photograph taken just after the sausage stall – the case study explored below – was hit by the Grad missile. The fire may have been caused by rocket fuel burn off.

Since then all parties to the conflict have made regular use of heavy explosive weapons like large-calibre artillery and multiple rocket launchers in populated areas. Several attempts to negotiate a political settlement to the crisis have directly addressed the use of explosive weapons with wide-area effects, in implicit recognition of the severe harm caused to civilians in the disputed regions of eastern Ukraine.⁵⁴

In the first year of explosive violence in Ukraine (1 May 2014 to 30 April 2015), AOV recorded a total of 2,974 deaths and injuries. At least 2,103 civilians were killed or injured (71 per cent of the overall total recorded by AOV).

Weapons like the Grad have been prominent in the fighting in eastern Ukraine, and MLRS attacks account for ten per cent of all incidents of explosive violence in the country in this time period. Both the Ukraine government forces and rebel separatist groups are known to have used the Grad in populated areas.⁵⁵

AOV recorded 22 MLRS attacks in eastern Ukraine that caused deaths and injuries between 1 May 2014 and 30 April 2015. In those 22 attacks, AOV recorded 594 deaths and injuries, 312 of whom were civilians (53 per cent).

On average there were 14 civilian deaths and injuries per MLRS attack. This is far higher than the average across all explosive weapons incidents in eastern Ukraine (at 9).



A memorial to the 31 people killed in the Mariupol strike on 24 January, 2015. Hundreds more were injured both physically and mentally.

Case study: Grads strike Mariupol

On 24 January 2015 the morning sky over the Vos-tochniy district of Eastern Mariupol, Ukraine was calm. It was cloudy and dry and you could see for miles across the stubble fields and grey apartment blocks that mark the flat lands of the region.

That calm was soon broken. At 9.15am, a barrage of Grad rockets hit the sleepy streets of this Ukrainian suburb. At least 30 people were killed in the blasts, including two children aged five and 15. One military serviceman was also killed.⁵⁶

AOAV recorded at least 97 further injuries reported at the time of the attack, but the true figure of injuries may be far higher.⁵⁷ For many of the 30,000 residents living in the district at the time their lives changed in that terrible instant.

The strike – a salvo of up to 100 separate rockets – lasted between 30 seconds and two minutes, according to victims and witnesses interviewed by AOAV. The rockets fell across a wide area, striking schools, markets, shops and public housing.

Three strikes hit kindergarten No.160; five hit school No.5; and two were hit the territory of school No.57. Other rockets landed among the Kyivskiy and Denis markets, a number of shops and a pharmacy.

In total over fifty apartment buildings and about 100 private homes were damaged or destroyed. Ten fires were recorded following the barrage, gutting shops and homes, and twenty cars were also reported destroyed.

The possible target – if indeed there was one – was a checkpoint manned by the Ukrainian government forces on the road to Novoazovsk. But this military target, at the crossroads of Taganrogska and Marshala Zhukova, lay over 400 metres from the closest residential building (73 Kyivska Street). To put this in perspective, the only known military checkpoint in the area lay 830 metres from the site of the nearest recorded Grad strike and some 1900 meters from the furthest. The radius of the area hit by the strike was 817 metres across and 1380 metres wide.

The direction from which the Grad rockets were launched has been the centre of much debate. The Organization for Security and Co-operation in Europe's (OSCE's) initial evaluation suggested that the rockets originated from a north-easterly direction, from areas controlled by the self-proclaimed Donetsk People's Republic (DPR).⁵⁸ This assessment has since been widely accepted and AOAV's analysis at the site in August 2015 did not contradict the OSCE view.

According to one of the leading Accident and Emergency doctors in the city, ambulances and other emergency units were to arrive at the shelling locations within thirty minutes of the strike. Most of those injured were admitted to hospital between by 12.00am – about two hours after the rockets struck. The cumulative reports from these responders that AOAV spoke to repeatedly confirmed the fact that the weapon involved was the Grad. No traces of other weapon types were found.

AOAV's investigation in Mariupol into the fallout from the 24 January attack illustrates in detail the devastating impact of the use of the Grad rocket in a populated area.

The Grazi sausage store in Kyivskiy market

When looking at the issue of multiple launch rockets a narrow analysis of a single explosive detonation is not as helpful as in other analyses of individual cases of explosive weapon harm.

A look at the whole of the area affected is, when it comes to Grad strikes, arguably of greater utility. Such an overview demonstrates the wide area impact of a multiple delivery system. It shows how the area affected by the system as a whole is magnified as each rocket's own individual lethal area overlaps with others to create a situation where there is nowhere to hide under a barrage.

However, a closer analysis of the human impact of a single Grad rocket is important, as it helps to build understanding of how such an impact, when multiplied twenty or forty fold, can cause cataclysm in a matter of minutes.

To this end, AOAV focused on a Grad rocket that landed at the entrance of the Kyivskiy market in Mariupol. Although just one of a number of strikes that hit the market, it was to cause the most damage. It killed two people, including a woman who ran a sausage-selling stall, and injured several others. The rocket demolished the Grazi sausage stall – part of a small chain of cooked meat stands – that stood at the entrance to the market.⁵⁹ It sent fragments flying dozens of metres away, penetrating walls and cars.

It has been estimated that the radial area impacted by one single Grad rocket is 1,046 square metres. In this case study, a survey of the area of impact supports this. Fragmentation was found over 120 metres to the south of the blast – penetrating the outer walls of a pharmacy – and 50 metres to the north – piercing metal stalls where traders had been selling oil. The blast radius was only contained by the large selection of metal-fronted shops that proliferated around the edge of the market.

A more detailed analysis of the strike illustrates the primary, secondary and tertiary impacts of the Grad rocket.

The primary explosive weapon effects from a Grad rocket launcher are those that are caused “*directly by the destructive effects that radiate from a point of initiation and include blast and back over-pressure, fragmentation, heat and light.*”⁶⁰ The Grad rocket issues a high-pressure blast wave that moves at supersonic speed. It can burst ear-drums, collapse lungs and seriously injure gastro-intestinal tracts. Fragments from the Grad's warhead have an initial velocity greater than 1,500 metres per second⁶¹. While the specific injuries from the strike on the Grazi stand could not be catalogued, an AOAV interview with one of Mariupol's leading trauma doctors confirmed that many victims from the strike suffered significant respiratory, auditory and internal damage.

The sausage stall owner died immediately. A nurse who was purchasing food from her died shortly after. Her final moments were captured on video, and showed her bleeding profusely from shrapnel wounds.

The fragmentation that was thrown up and sideways from the blast was blasted outwards at a raised height. The upward spray of metal shards was clearly visible in the puncture marks of various metal shipping containers that surrounded the stall – all above knee height and most at about 1 to 2 metres from the ground.

The secondary explosive weapon effects of the Grad strike were its impact on the surrounding man-made and natural environments. The nature of the secondary explosive weapon effects is governed by the precise impact location. If the weapon impacts onto a hard brittle surface, such as concrete, stone or brick, the detonation of the rocket's high-explosive warhead will cause parts of the surface to break off and become as deadly as the original warhead steel.

In this case, the rocket caused glass and brick to be sprayed in all directions; a local shoe trader was hit by concrete fragments that remained embedded in her skin months after the strike. Her son was harmed by flying glass. Other traders talked of significant cuts from flying concrete and glass.

The fire that engulfed the sausage stall was also a secondary effect – likely to have been from the burn-off of the remaining fuel in the Grad rocket.

This report does not seek to address the tertiary effects of the Grad's use, for example the reverberating, indirect and/or longer-term damage caused. Nonetheless, the market traders interviewed nearby spoke of a marked down-turn in profits. They had to contend with destroyed stock, a drop in clientele and a permanent sense of unease; the fear that the Grads would return.

This sense of unease was something that all the case studies shared. The fear that the use of explosive weapons in populated areas creates can be deep and insidious. It harms minds, tears apart families and damages societies. It is a fear that is all too often neglected. Post-traumatic stress disorders often go unrecognised or untreated. And it hints to how the harm caused by explosive weapons when used in populated areas goes far beyond the moment of detonation. That is just the beginning.

THE IMPACT OF EXPLOSIVE WEAPONS

2011-2014: Four years of data

From 2011-2014, AOVAV has recorded the impact of explosive weapons around the world using English-language media sources. Explosive weapons include manufactured ordnance like mortars, rockets and air-dropped bombs, as well as improvised explosive devices (IEDs).

EXPLOSIVE VIOLENCE IN POPULATED AREAS



6,372 (61%)

90%
OF CASUALTIES FROM EXPLOSIVE VIOLENCE IN POPULATED AREAS WERE CIVILIANS

EXPLOSIVE VIOLENCE IN NON-POPULATED AREAS



4,025 (39%)



10,395

TOTAL NUMBER OF INCIDENTS RECORDED

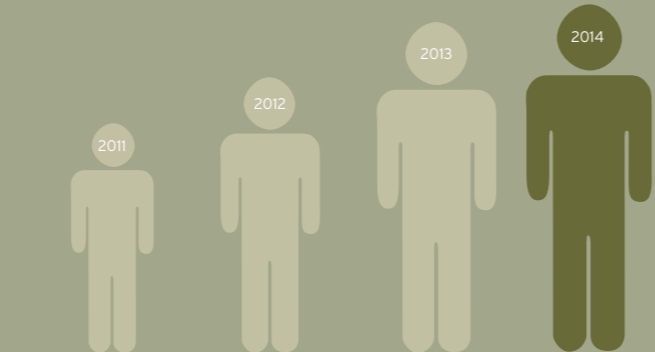
34%
OF CASUALTIES FROM EXPLOSIVE VIOLENCE IN NON-POPULATED AREAS WERE CIVILIANS

CASUALTIES (DEATHS & INJURIES) OF EXPLOSIVE WEAPONS



TOTAL CIVILIAN CASUALTIES: 112,26
TOTAL CASUALTIES: 144,545

78% OF ALL CASUALTIES FROM EXPLOSIVE VIOLENCE WERE CIVILIANS



21,499 CIVILIANS KILLED & INJURED

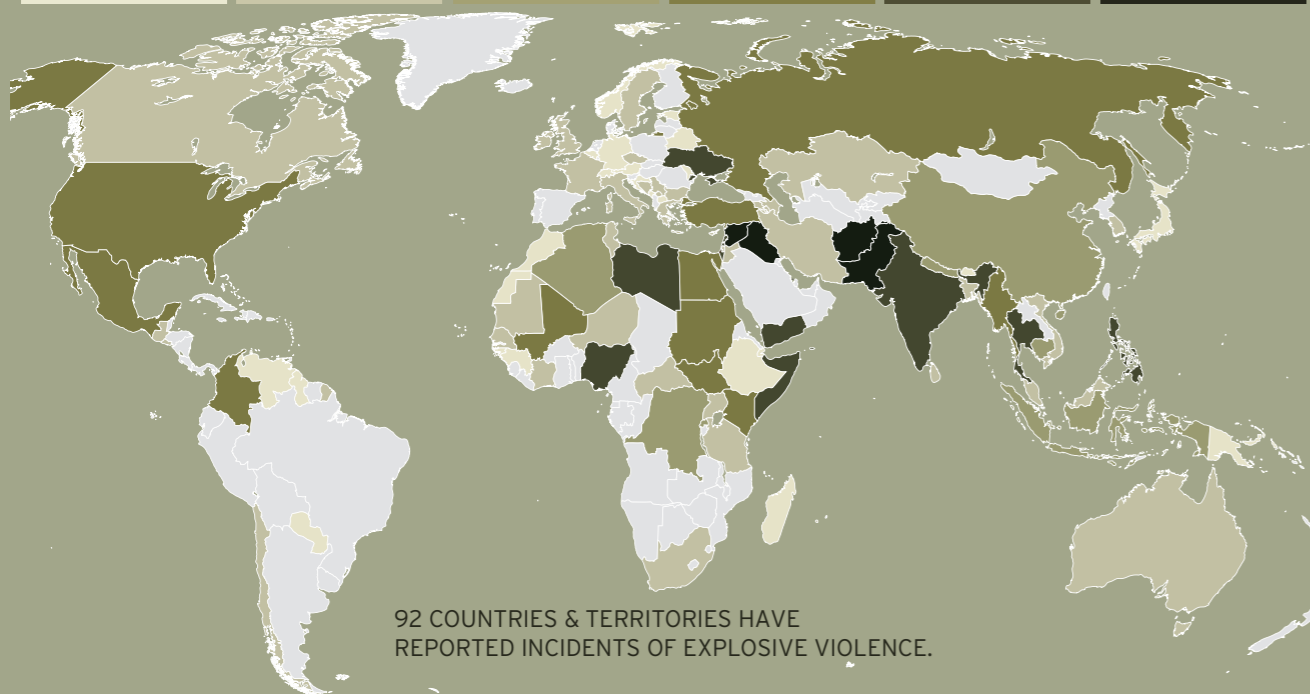
27,025

31,076

32,662

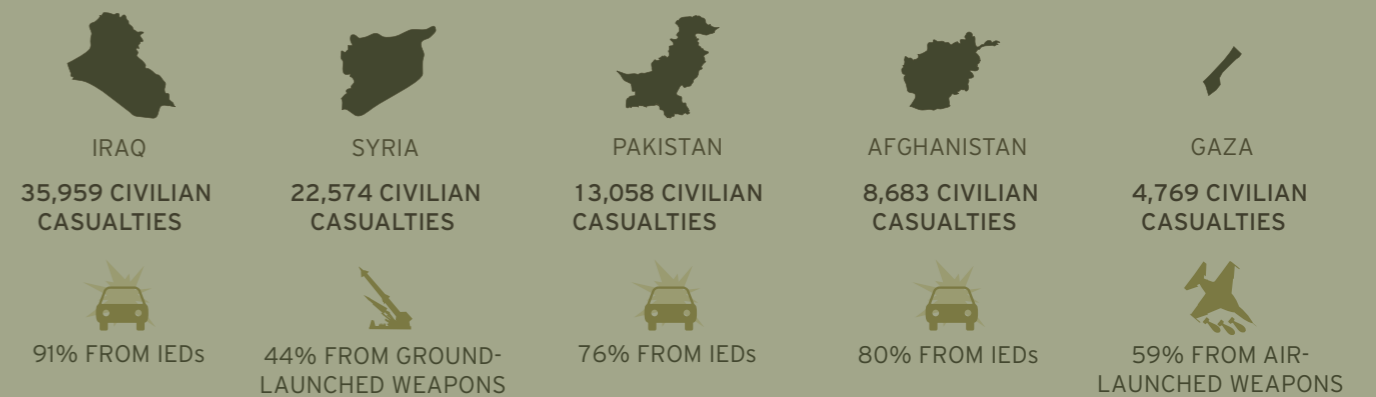
+ 52% INCREASE IN CIVILIAN CASUALTIES RECORDED IN 2014 COMPARED TO 2011

A GLOBAL PROBLEM

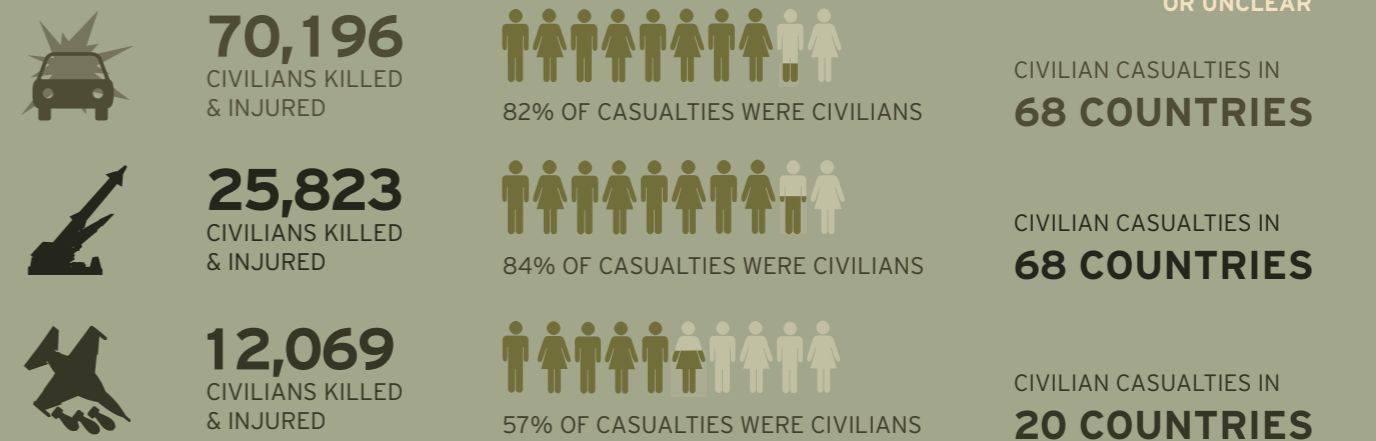


92 COUNTRIES & TERRITORIES HAVE REPORTED INCIDENTS OF EXPLOSIVE VIOLENCE.

MOST AFFECTED COUNTRIES

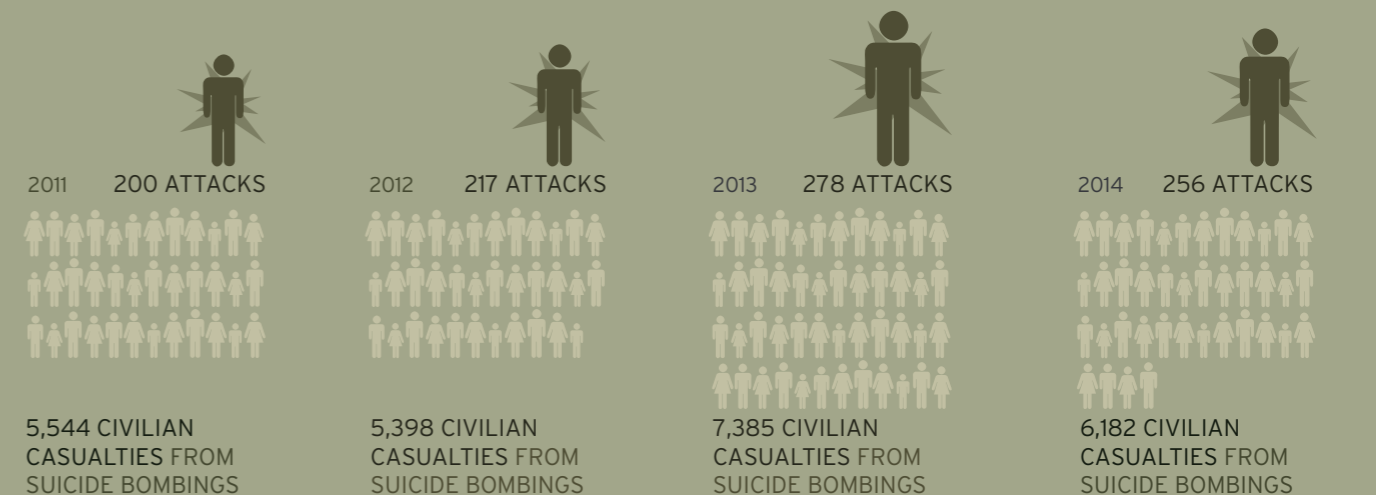


LAUNCH METHODS



SUICIDE BOMBINGS

Since 2011, AOVAV has recorded 24,509 civilian casualties from 951 suicide bomb attacks in 29 countries.



Conclusion

All explosive weapons affect an area. The use of any explosive weapon in a populated area thus puts civilians at significant risk of death and injury and should be avoided.

Many explosive weapons affect a wide area; either because they have a large destructive radius, are delivered without accuracy, or are fired in multiple munitions. Some weapons, like the Grad rocket, combine all three characteristics.

The example munitions highlighted in this case study are intended to be indicative. Their characteristics are common to many bombs, rockets, and shells made and used by governments and armed actors around the world.

Crucially, efforts to tackle one factor (i.e. improving accuracy) cannot alone remove the risk to civilians when these explosive weapons are used in populated areas. The use of precision-guided aircraft bombs may reduce one aspect of threat, but if the weapon in question has a large destructive radius it will still have a wide-area impact that puts civilians at grave danger when the weapon is used in a village, town or city.

AOAV's previous research has shown the importance of strong, progressive rules of engagement in shaping how explosive weapons are used.⁶² In many ways, these are the most impactful practical measures a responsible state actor can take to reduce the impact of these weapons on civilians.

The cases told here from Yemen, the Syrian border and eastern Ukraine are all part of a widespread pattern of harm. AOA's research in the past five years has shown that the use of explosive weapons with wide-area effects is all too common within populated areas, by a range of state and non-state actors alike. Explosive violence is a global problem and it requires global action.

The case studies highlighted here show clearly why governments are right to be concerned with the issue of explosive weapons with a wide area impact. More than 50 governments have now spoken out against the problem of explosive weapon use in populated areas.⁶³ On 21-22 September 2015 a group of governments, UN agencies and civil society organisations affiliated with the International Network on Explosive Weapons (INEW) met in Vienna to discuss how the harm from these weapons could be prevented. Representatives there took the opportunity to express support for developing a political commitment to tackle the issue.⁶⁴

It is a hugely positive moment and one that points towards a more positive future where these cases are harder and harder to find. AOA is a founding member of the International Network on Explosive Weapons, and warmly welcomes efforts to develop a political commitment to end the use of explosive weapons with wide area effects in populated areas.



Life still goes on in Mariupol, Ukraine - but the scars of war are visible everywhere.

Recommendations

States and other actors should stop using explosive weapons with wide-area effects in populated areas.

States should work together with international organisations and civil society to develop a political commitment to refrain from using explosive weapons with wide-area effects in populated areas.

States should review national policies and practice and share such information relating to the use of explosive weapons in populated areas, in response to the UN Secretary-General's Note Verbale of 1 October 2014.

States and international organisations should publicly condemn the use of explosive weapons in populated areas.

States and all users of explosive weapons should work towards the full realisation of the rights of victims, including those killed and injured, their

families, and affected communities. They should strike to ensure the timely and adequate provision of needed services for the recovery, rehabilitation and inclusion of victims of explosive violence, without discrimination.

States, international organisations and civil society should work together to collect and make available information relating to the civilian harm from the use of explosive weapons, including gender, age and disability disaggregated data, to better understand the impacts of such use.

In light of the widespread harm caused by these weapons to civilians, states manufacturing and exporting these weapons should seriously consider refusing or revoking licenses of arms to contexts where such harm could equate to serious violations of international humanitarian or international human rights law, in line with their obligations under the Arms Trade Treaty.



The devastation from explosive weapons in populated areas – such as here in Yemen – has deep and profound impact. Such use should be publicly condemned at all times.

Notes

- 1 Statement of the International Committee for the Red Cross, United Nations General Assembly 70th session, First Committee General debate on all disarmament and international security agenda items, 15 October 2015, http://reachingcriticalwill.org/images/documents/Disarmament-fora/1com/1com15/statements/16October_ICRC.pdf.
- 2 The term 'populated areas' should be considered synonymous with 'concentrations of civilians'. Indeed, the definition of a populated area used by AOAAV is based on Protocol III of the 1980 Convention on Certain Conventional Weapons (CCW)'s characterisation of concentrations of civilians, which reads: "any concentrations of civilians, be it permanent or temporary, such as in inhabited parts of cities, or inhabited towns or villages, or as in camps or columns of refugees or evacuees, or group of nomads." The full definition is available at: "Protocol on Prohibitions or Restrictions on the Use of Incendiary Weapons (Protocol III)," ICRC, Geneva, 10 October 1980, posted by U.S. Department of State, www.state.gov/documents/organization/190579.pdf
- 3 AOAAV, "The Impact of Explosive Weapons, 2011-2014: Four years of data," June 2015, <https://aoav.org.uk/wp-content/uploads/2015/06/AOAV-Four-years-of-explosive-violence-2011-14-FINAL1.pdf>.
- 4 ICRC Group of Experts meeting, February 2015, <https://www.icrc.org/en/document/explosive-weapons-populated-areas-consequences-civilians>.
- 5 Action on Armed Violence (AOAV), "Four years of harm: Explosive Violence Monitor, 2011-2014," 14 September 2015, <https://aoav.org.uk/2015/four-years-of-harm-impact-of-explosive-weapons-2011-2014/>.
- 6 AOAAV includes improvised explosive devices (IEDs) within its data collection on the harm caused by all explosive weapons. It is possible for IEDs to fall into one of the three general categories of explosive weapons with wide-area effects as defined by the ICRC (e.g. large car bombs). Insofar as this is the case the use of such improvised explosive weapons in populated areas should be considered cause for concern. However the protection challenges that surround the development and deployment of IEDs differ substantially from the use of heavy explosive weapons (primarily by State forces), and thus a different set of policy responses should be developed. The harm to civilians caused by IEDs, including those that may affect a wide area, therefore is not considered in this report.
- 7 For more information go to www.inew.org
- 8 For more on INEW's policies on explosive weapons, see INEW, "A Commitment to Act: Protecting civilians from the use of explosive weapons in populated areas," 2015, www.inew.org/news/a-commitment-to-act-new-inew-briefing-booklet.
- 9 Human Rights Watch, "Targeting Saada," 30 June 2015, <https://www.hrw.org/report/2015/06/30/targeting-saada/unlawful-coalition-airstrikes-saada-city-yemen>; Amnesty International, "The Human Carnage of Saudi Arabia's War in Yemen," 27 August 2015, <https://www.amnesty.org/en/latest/news/2015/08/the-human-carnage-of-saudi-arabias-war-in-yemen/>.
- 10 During the Iraq War for example the GBU-12 Paveway II was the most commonly dropped bomb in the opening 'shock-and-awe' phase of the conflict. Between 20 March – 30 April 2003, 7,114 Paveway II bombs were dropped in Iraq, 24 per cent of all aerial munitions deployed. The next most common was the unguided equivalent, the Mk-82 (5,504 bombs, 19 per cent of the total). For more information see Jenna Corderoy and Robert Perkins, "A Tale of Two Cities: The use of explosive weapons in Basra and Fallujah, Iraq, 2003-04," Action on Armed Violence (AOAV), December 2014, <https://aoav.org.uk/2015/tale-of-two-cities-aoav-investigates-explosive-weapons-iraqwar/>. In addition to the US and UK, operators of Paveway family bombs include: Australia, Belgium, Canada, France, Germany, Greece, Hungary, India, Israel, Italy, South Korea, Netherlands, Norway, Oman, Pakistan, Saudi Arabia, Spain, Sweden, Taiwan, Thailand, Turkey, and the UAE. Robert Hewson (ed.) "Air-Launched Weapons," IHS Jane's, Issue Forty-nine (2007), pp. 463-467.
- 11 "Guided Bomb Unit-10 (GBU-10) Paveway II," Federation of American Scientists (FAS), <http://fas.org/man/dod-101/sys/smart/gbu-10.htm> (accessed 19 October 2015); Robert Hewson (ed.) "Air-Launched Weapons," IHS Jane's, Issue Forty-nine (2007), pp. 463-467.
- 12 <https://aoav.org.uk/2016/the-mark-80-series-and-paveway-attachments/>
- 13 Robert Hewson, editor of Jane's Air-launched Weapons, in Mark Sauer, "Precision JDAMs can pack big punch; On-board systems guide air-to-surface weapons," *The San Diego Union-Tribune*, 21 March 2003, www.globalsecurity.org/org/news/2003/030321-jdam01.htm.
- 14 ICRC Group of Experts meeting, February 2015, <https://www.icrc.org/en/document/explosive-weapons-populated-areas-consequences-civilians>.
- 15 ICRC, "War Surgery," Volume 2, <https://www.icrc.org/fre/asets/files/publications/icrc-002-4105.pdf>
- 16 ICRC, "War Surgery," Volume 2, <https://www.icrc.org/fre/asets/files/publications/icrc-002-4105.pdf>
- 17 There are many types of aircraft bombs. As AOAAV's data analysis is based on the reporting of incidents in English media sources, it's weapon types are designed to capture the vagaries of reporting. The term can include makeshift barrel bombs, and prohibited cluster bombs. They can be guided or unguided, and not all are as powerful as the munitions investigated in this case study.
- 18 These weapons have been almost exclusively used by State-allied air forces since 2011, when AOAAV began monitoring explosive violence. The only known exception were recorded incidents of aerial bombing in Libya during 2014 hostilities by forces not affiliated with the internationally-recognised government.
- 19 It is often not clear from AOAAV's source material when a bomb was dropped from an aircraft as opposed to other air-launched munitions like rockets and missiles. Aerial explosive weapons can be recorded as being either 'bombs', 'rockets' or 'missiles', or more generally as 'air strikes' when more specific information is not available in media reporting.
- 20 AOAAV records deaths and injuries from explosive weapons that are reported in English-language media sources. AOAAV uses an incident-based methodology that requires the reporting of a clear date, location and specific number of casualties in order to code an incident. The narrow focus and methodology of AOAAV's explosive violence monitor means that no claims are made that every death, injury or incident of explosive violence in Yemen can be recorded.
- 21 Ewan MacAskill, "UN report into Saudi-led strikes in Yemen raises questions over UK role," *The Guardian*, 27 January 2015, www.theguardian.com/world/2016/jan/27/un-report-into-saudi-led-strikes-in-yemen-raises-questions-over-uk-role.
- 22 One serial number identified a "forward adapter assembly for the MXU-650/B airfoil group" for the Paveway series of bombs. Email discussion between AOAAV and munition identification experts, including at Human Rights Watch. The serial numbers identified on casing fragments read 96214ASSY7459083 / CDA-15090 / MFR 3YYJ9. See also <http://www.designation-systems.net/dusrm/app5/paveway-2.html>.
- 23 Hakim is a senior Houthi commander, head of the Houthi's Revolutionary Council and one of three Yemeni figures sanctioned by the U.N. Security Council's 2140 Sanctions Committee in November 2015. Houthi sources contacted to confirm these claims denied Hakim had been resident in the area at any time. Security Council 2140 Sanctions Committee Designates Three Individuals as Subject to Assets Freeze, Travel Ban, 7 November 2014: <http://www.un.org/press/en/2014/sc11636.doc.htm>.
- 24 A stack of dry wood kindling inside the house approximately 20 meters from where the bomb landed was undamaged.
- 25 Human Rights Watch, "Targeting Saada," June 2015, <https://www.hrw.org/report/2015/06/30/targeting-saada/unlawful-coalition-airstrikes-saada-city-yemen>.
- 26 Mortars, like other weapon systems, have a number of different designs. Rather than concentrate on exceptions to the rules, this report highlights the most commonly encountered varieties of mortar.
- 27 Mortars are often used alongside other weapon systems. This means that attribution of damage caused by a specific munition is difficult. In this report AOAAV has tried, where possible, to ensure that those weapons fired were either distinctly mortars or were explosive weapons with an indirect-fire trajectory with high levels of inaccuracy.
- 28 Erich G. Berman, Pierre Gobinet, and Jonah Leff, "Mortars", Research Notes – No. 2, Small Arms Survey, February 2011, www.smallarmssurvey.org/fileadmin/docs/H-Research_Notes/SAS-Research-Note-2.pdf.
- 29 Robert Perkins & Sarah Leo, "Syria's Dirty Dozen: The M-240," AOAAV, 23 September 2013, <https://aoav.org.uk/2013/syrias-dirty-dozen-m-240/>.
- 30 SIPRI Arms Transfer Database, "Transfers of major conventional weapons: sorted by supplier. Deals with deliveries or orders made for year range 1980 to 2012," Information generated: 3 June 2013.
- 31 Robert Perkins & Sarah Leo, "Syria's 'Dirty Dozen': The M-1943/M43," AOAAV, 23 September 2013, <https://aoav.org.uk/2013/syrias-dirty-dozen-m-1943m43/>.
- 32 See for example the judgments of the International Commission of Inquiry to investigate all alleged violations of international human rights law in the Libyan Arab Jamahiriya, UN Human Rights Council, 1 June 2011, http://www2.ohchr.org/english/bodies/hrcouncil/docs/17session/A.HRC.17.44_AUV.pdf, p. 62.
- 33 United Kingdom Ministry of Defence, "Handbook of Defence Land Ranges Safety, Volume IV: Glossary of Terms and Definitions," April 2008, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/428566/JSP403_Vol4v2_3.pdf.
- 34 As with most weapon systems, the size of the CEP increases with range, which is another way of saying that it is more difficult to reliably hit targets that are further away than those that are closer. More modern mortars now have advanced fire control systems and better designs incorporating GPS guidance that have improved both accuracy and precision. For example, the US military has recently introduced the XM395 high explosive mortar, which has a CEP of only 10m at its maximum range. As each XM395 costs about \$10,000 to manufacture however, it is unlikely that such a system will take over from conventional unguided mortar systems in the near future. Data on the XM395 was sourced from Andrew Trantola, "The Army's Smart New Mortars Could Actually Hit A Target," *Gizmodo*, 30 July 2012, <http://gizmodo.com/5929158/the-armys-smart-new-mortars-could-actually-hit-a-target>.
- 35 David Super and Travis Kundel, "Mortar Fire Control System," www.benning.army.mil/magazine/2007/2007_4/07_pf.pdf.
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- 37 Robert Perkins, "Under Fire: Israel's artillery policies scrutinised," AOAAV, December 2014, <https://aoav.org.uk/wp-content/uploads/2015/03/AOAV-Under-Fire-Israels-artillery-policies-scrutinised.pdf>.
- 38 Download AOAAV's annual reports on explosive violence at <https://aoav.org.uk/explosiveviolence/>.
- 39 The target for an attack is only recorded if one of the three conditions below are met: the target is declared by the user; it is clearly reported in the source; or if the specific contextual conditions of use clearly indicate a target (e.g. if an IED is attached to the car of a police officer or soldier, 'State armed' is recorded as the target). See more information on
- AOAV's monitoring methodology in Jane Hunter and Robert Perkins, "Explosive States: Monitoring explosive weapons in 2014," AOAAV, 2015 <https://aoav.org.uk/wp-content/uploads/2015/06/AOAV-Explosive-States-monitoring-explosive-violence-in-2014.pdf>.
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- 46 GPS location: 32.56255, 36.01005.
- 47 Fragmentation and Lethality Analysis Tool for natural and controlled fragmentation, and Prefragmented Warheads; Z Jelic, A Zagorecki, A Hameed and S Nandecha. A paper presented to the 27th International Symposium on Ballistics, Freiburg, Germany on April 22-16, 2013.
- 48 ICRC Group of Experts meeting, February 2015, <https://www.icrc.org/en/document/explosive-weapons-populated-areas-consequences-civilians>
- 49 ICRC, Customary IHL Database, "Rule 13: Area Bombardment," https://www.icrc.org/customary-ihl/eng/docs/v1_rul_rule13.
- 50 To take just one example, in the first six months of 2015 the United Nations recorded 1,577 civilian deaths and injuries from ground engagements involving explosive weapons in Afghanistan. The UN's Assistance Mission in the country called on both Afghan Security Forces and Anti-Government Elements to cease firing mortars, rockets and grenades into civilian populated areas. See UNAMA, "Afghanistan: MidYear Report 2015, Protection of Civilians in Armed Conflict," August 2015, https://unama.unmissions.org/sites/default/files/unama_protection_of_civilians_armed_conflict_midyear_report_2015_final_august.pdf.
- 51 AOAAV's methodology specifies that recording locations should be kept as narrow as possible. Multiple Urban is the broadest of AOAAV's recording location types and is designed specifically for incidents in which people have been killed and injured in more than one narrow recording location type at once and it is impossible using media sources to disaggregate the casualties.
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- 63 www.inew.org/acknowledgements.
- 64 Read a full report on the outcome of the meeting of the Group of Experts on Explosive Weapons at www.inew.org/news/vienna-report.

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