Areas of harm

Understanding explosive weapons with wide area effects

PAX

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Cover photo: Aleppo, Syria - 2013. A building destroyed by repeated shelling, residents have tried to keep their business on the ground floor running. © Hannah Lucinda Smith

About Article 36

Article 36 is a UK-based not-for-profit organisation working to prevent the unintended, unnecessary or unacceptable harm caused by certain weapons. Article 36 undertakes research, policy and advocacy and promotes civil society partnerships to respond to harm caused by existing weapons and to build a stronger framework to prevent harm as weapons are used or developed in the future. www.article36.org

About PAX

PAX means peace. Together with people in conflict areas and concerned citizens worldwide, PAX works to build just and peaceful societies across the globe. PAX brings together people who have the courage to stand for peace. Everyone who believes in peace can contribute. We believe that all these steps, whether small or large, inevitably lead to the greater sum of peace. www.paxforpeace.nl

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We would like to thank Colin King for his input and advice.

Content

Summary & recommendations

Against the background of international recognition of the humanitarian problems caused by the use of explosive weapons in populated areas, this report analyses how certain explosive weapons create wide area effects. The report considers the implications of these effects when such weapons are used in cities, towns and villages, finding that in some contexts certain explosive weapons are as likely, if not more likely, to cause harm to the civilian population as to damage a specific military target. The report also looks at how the area effects of certain explosive weapons are already recognised in military policy and practice as having a direct link to the risk presented to civilians. However, this recognition is dispersed across various policy and operational frameworks. In view of this, the report promotes the consolidation of this recognition through an international political declaration containing commitments to reduce harm from the use of explosive weapons.

Recommendations

As a humanitarian priority, we call upon states to draw up an international political declaration to reduce harm from the use of explosive weapons in populated areas, based on the following key elements:

- A commitment to stop the use of explosive weapons with wide area effects in populated areas;
- A commitment to assist victims of explosive weapons and affected communities;
- A commitment to gather and share data on the use and impact of explosive weapons in populated areas, including the recording of casualties, and to share policy and practice aimed at enhancing civilian protection;
- A commitment to translate the key elements of such a political commitment into national policy and action.

Introduction

For people living in cities, towns and villages affected by conflict, the use of explosive weapons that affect wide areas represents one of the gravest risks of death, injury and wider long-term harm. Whilst fighting in populated areas inevitably puts the safety of the civilian population at risk, the use of weapons that will affect large sections of that area in a single attack, that may land at significant distances from the intended target, or that see multiple warheads rain down across an area, presents a severe threat. In practice, such weapons repeatedly result in an unacceptable level of civilian harm. Even when not aimed directly at civilians but directed at some form of military target or objective, explosive weapons that have wide area effects are likely to cause high levels of civilian harm if used in areas where populations are concentrated. Therefore, greater efforts should be made to curtail the use of such weapons in populated areas in order to protect civilians.

This report provides illustrations of the types of wide area effects described above. Considering such effects in the setting of populated areas helps us to understand what the technical statistics regarding weapon performance might mean in practice for a civilian population. Whilst the details of weapons technology and functioning can be complex, the implications in many cases are quite simple—such weapons are highly likely to cause severe civilian harm. The experience of real people living through conflict, and our ability to imagine what such weapons use would mean in our own communities, is vital to an assessment of whether current attitudes are really acceptable and how we want conflict to be constrained, now and in the future.

The report also considers how the area effects of explosive weapons are already recognised in military practice as a key determinant of the risk presented to the civilian population. Whilst much diplomatic discussion has revolved around international humanitarian law in relation to

civilian protection, it is in the practical policies of military operations that we see restrictions on the use of explosive weapons with wide area effects already being considered in order to strengthen civilian protection. All militaries recognise that practical rules of conduct are needed to ensure military operations remain within the framework provided by the law. If guided by collective political commitment, it is in this area that practical approaches can be further developed to improve civilian protection in the future.

As the world becomes more urbanised and as population densities increase in towns and cities, what is considered acceptable or unacceptable in warfare must be adjusted to better reflect the needs of the civilian population. The international community should therefore work to curb the use of weapons that are as likely, or more likely, to kill and injure civilians as they are enemy combatants, in order to safeguard humanitarian interests in the long term.

In armed conflict, a proportionate degree of civilian harm is legally permissible within the rules of international humanitarian law in certain circumstances. However, the use in populated areas of explosive weapons that affect a wide area makes it much more likely that those rules will be breached. Regardless of arguments about the legality or otherwise of specific attacks, the ongoing pattern of harm resulting from the use of such explosive weapons in populated areas is a pressing humanitarian concern—one that can be addressed.

Against that background, the working presumption for responsible military commanders should be that explosive weapons with wide area effects should not be used in populated areas. Endorsing and adopting such an assumption would establish a stronger international standard for the protection of civilians. It would build a clearer expectation of how responsible actors should behave in conflict, and provide a practical approach that would reduce civilian harm on the ground. Endorsing and adopting such an assumption would not require a change in legal rules. Rather, this could be achieved through the adoption of a clear political position coupled with the development of practical mechanisms within national military procedures, such as requirements for a higher level of commander authorisation for the use of certain weapon types.

The international community has the opportunity to work together towards the adoption of a political position rejecting the use of explosive weapons with wide area effects in populated areas. The pattern of continuing civilian deaths, injuries, impoverishment and displacement resulting from the use of explosive weapons in cities, towns and villages means that such action is a clear humanitarian priority. ♦

Wide area effects

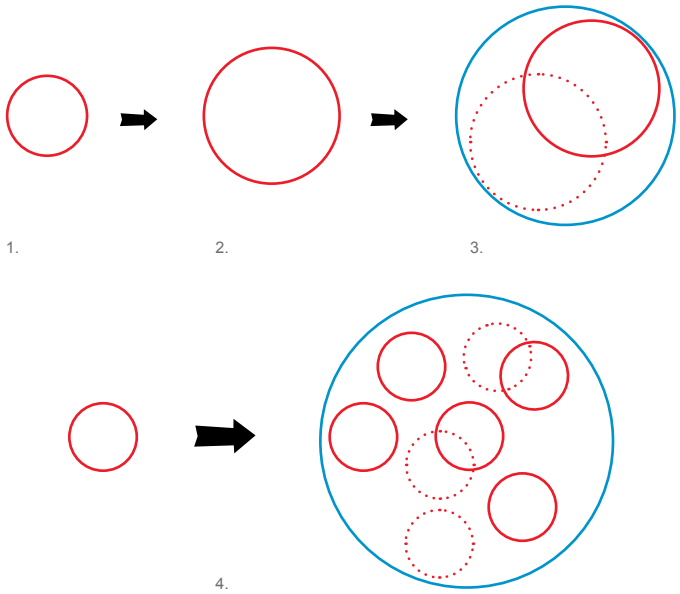
There is broad agreement that wide area effects from explosive weapons can result from three characteristics, either individually or in combination:

- A substantial blast and fragmentation radius resulting from a large explosive content;
- Inaccuracy of delivery, meaning that the weapon may land anywhere in a wide area;
- Use of multiple warheads or multiple firings, sometimes designed to spread, affecting a wide area.

These effects are cumulative, with blast and fragmentation effects always present and with inaccuracy of delivery and the use of multiple warheads, where applicable, extending those effects across a wider area. As well as increasing the likelihood of direct civilian deaths and injuries, the combination of these effects also results in the destruction of civilian property and infrastructure vital to the civilian population, with longer-term implications for public health and development (sometimes called ‘tertiary’ or ‘reverberating’ effects).

Inaccuracy of delivery tends to be most significant for unguided air-dropped bombs and so-called ‘indirect fire’ weapons. Indirect fire weapons fire warheads from the ground in an arc towards a target that is often not visible to the attacker, rather than firing directly in a straight line at a target that can be seen. Indirect fire weapons include artillery projectiles, artillery rockets and mortars.

Figure 1.
Basic structure of wide area effects



1. Combined blast and fragmentation radii of a single explosive weapon centred where the weapon actually detonates

2. Blast and fragementation radii are greater for a weapon with larger explosive content

3. Inaccuracy of delivery means those blast and fragmentation effects will occur somewhere within a larger area. Where within the wider area the actual effects will occur cannot be precisely controlled. Repeated firings will land in slightly different locations

4. Where multiple warheads are used, Even weapons with smaller individual blast and fragementation radii can create effects over a wide area

In the diagram above, the red circle represents the area affected by blast and fragmentation from individual warheads—typically getting larger as the size of the explosive warhead increases. The size of the blue circles depends on the accuracy of the weapon being used, i.e. how likely it is to land close to the point of aim.[1] The blue circle will be larger for a less accurate weapon, meaning that the actual effects will occur somewhere within a wider area. In practice there are numerous factors that influence these different effects. This initial diagram simply provides the basic building blocks for understanding how wide area effects occur.

In the sections below, we discuss these factors in more detail and provide examples of the size of areas that might be affected, illustrated with examples of populated areas.

Large blast and fragmentation radius

The first driver of wide area effects concerns the area affected by the blast and fragmentation from an explosive weapon when it detonates. This area is largely determined by the type and amount of explosive within the weapon and the form of fragmentation that it produces. Regardless of the accuracy of delivery, weapons that have a large blast and fragmentation radius are likely to cause harm if they are used in locations where civilians are concentrated.

1 Later in this report, we comment further on the relationship between 'accuracy' and 'precision'. For the most part, this report uses the term 'accuracy' as a catch-all term for the likelihood of a weapon landing close to the target at which it is aimed.

Heavy explosive weapons, with a large explosive content, are also more likely to cause severe damage to civilian infrastructure, destroying or impairing hospitals, and water and sanitation systems, with wider impacts on public health, destroying schools and rendering education impossible, and destroying housing. This, in combination with the other direct and indirect effects mentioned, drives people from their homes.

The blast and fragmentation radius of the weapon is always a factor in the area effect of an explosive weapon. Whether an explosive weapon is detonated in a fixed position (such as with a car bomb) or whether it is dropped from the air or projected from the ground, the blast and fragmentation radius is always a determinant of the population directly affected and the damage likely to be produced.

The effects of blast and fragmentation dissipate at a distance from the point of detonation. Fragmentation (dispersal of pieces of the weapon or surrounding material) typically affects a greater area than is reached by the blast effects (the shock wave and wind caused by the detonation). The fragments can still be deadly at great distances, but they are generally more dispersed and so the likelihood of striking people decreases. Similarly, the power of the blast wave reduces as it spreads out, making its effects less severe. As a result, these effects are normally conceptualised in terms of the levels of risk presented at specific distances, with different levels of risk being used for different purposes. The following terms are often used:

- Lethal radius: broadly, the area within which any person is likely to be killed.
- Casualty-producing radius: a wider area within which casualties can be expected.
- Risk-estimate distances: based on the 'probability of incapacitation' of protected or unprotected personnel. Distances might be given at which 0.1 per cent (1 in 1,000) and 10 per cent (1 in 10) of such personnel are expected to be incapacitated, where 'incapacitated' in turn is defined in terms of their inability to take part in operations for a period of time. Similar metrics may be applied to the probability of enemy combatants being 'suppressed', and so unable to operate effectively.
- Minimum safe distance: often used during training exercises, a distance at which the risk from the munitions detonation is considered negligible.

Damage to buildings and other infrastructure is usually assessed in terms of how blast pressure is likely to affect different structures, taking into account building materials and their post-damage condition. Damage to buildings can cause casualties from secondary fragmentation (such as flying glass) and to people killed and injured when structures collapse. Furthermore, whilst this report focuses on civilian deaths and injuries as the primary form of civilian harm, the capacity of explosive weapons to cause damage to homes, facilities such as hospitals and schools, and infrastructure such as power, water supplies and sanitation is a major additional component of harm that has long-term consequences for the civilian population.

The multiple metrics and the variations in the data publically available make it difficult to draw simple comparisons of the blast and fragmentation radii associated with different weapon types. Moreover, the affected area also depends on the design of the weapon, how it is used

Figure 2.
Effects radii for a 2,000lb aircraft bomb

PLEASE NOTE: Figure 2, and subsequent diagrams in this report, are reproduced in a larger format on pages 38-43.

and the specifics of the location. For example, in a built-up area the effects of a weapon might be channelled down roads, with the closest buildings effectively shielding those behind. Thus, whilst data on weapon performance can provide a basic indication of the area that will be affected, there will always be variations in practice.

EXAMPLES OF LARGE BLAST AND FRAGMENTATION RADII

Figure 2 shows some of the effects radii for a 2,000lb aircraft bomb. Such 2,000lb bombs are among the largest aircraft bombs in regular use.

- A crater some 14m across is produced at the point of impact, within which everything is destroyed.
- At around 30m from the point of detonation, the blast effect is approximately 11.5 pounds per square inch (psi). At that distance, most people would be killed and even reinforced concrete buildings can be expected to be demolished. In the area beyond that, residential buildings would be expected to collapse (at 5psi) or be significantly damaged (at down to 2psi). Further out still, windows would be shattered, presenting a threat to people nearby.
- Beyond the blast effect, fragments are dispersed over a wider area. There is a risk of lethal fragments out as far as 365m (indicated by the largest black circle in this figure) but some fragments could be projected as far as 1,150m (a distance that extends beyond the edges of this illustration).

The background in the figure is an example of a relatively low-density urban area, with a mixture of housing and commercial properties, administrative buildings and open spaces. Outlined in green are the boundaries of a primary school with a mixture of classrooms and playing fields (with approximate dimensions of 160m x 100m, i.e. 1.6 hectares). It is provided for illustrative purposes here as an example of a complex of buildings that might be familiar to some readers, and that could unfortunately also be similar to the sort of complex that armed forces might utilise during conflict (although many states have recognised that military use, specifically of schools, has significant negative effects and so have made commitments to avoid such a practice).[2]

It can be seen that if the detonation were to occur in the centre of the schools facility, the most severe blast effects would be felt within that perimeter. However, even then the blast effects would have an impact on the surrounding properties. If the bomb detonated anywhere on the perimeter of that target area, the blast effects on surrounding structures would be severe. The fragmentation effects of the weapon clearly present a serious risk across a much broader area—with the density of fragments reducing as the distance from the point of detonation increases.

Without action to mitigate the area effects of the weapon in some way (such as through a 'delayed fuse' that would see the warhead detonate underground and therefore reduce the sideways spread of blast and fragmentation effects) it is hard, if not impossible, to limit the effects of such a weapon to the specific target unless that target extends over a very large area. Ignoring issues around accuracy—how likely a weapon is to actually strike the intended target—it can be seen that heavy explosive weapons of this type are likely to have significant effects on areas around the target unless that target itself covers a wide area or is clearly separated from the surrounding civilian population and its structures.

Inaccuracy of delivery

A second cause of wide area effects is inaccuracy in the delivery of an explosive warhead to its point of detonation. 'Inaccuracy' is used here as a catch-all term for a degree of error that affects the likelihood of a weapon striking the intended target.[3]

Of course, if a weapon is not aimed at the correct location in the first place, this produces an additional level of inaccuracy. Errors or uncertainty in intelligence or targeting information can all contribute to that, regardless of the weapon type being used. In some situations, uncertainty about how to get the weapon on target may require observation of initial firings followed by adjustments to move the aim point closer to the target. Such initial firings are often called 'registration' shots and the process of adjustment referred to as shots being 'walked onto target'. If the target is in a populated area, such a process can clearly put the civilian population at significant risk. This is an issue that militaries have addressed by adopting policies aimed at reducing risk—such as directing registration shots towards areas that are unpopulated and walking them onto the target from there.

2 See the Safe Schools Declaration, 29 May 2015, online at http://www.protectingeducation.org/guidelines/support.

3 In technical literature, 'accuracy' is often used for the extent to which repeated firings will land centred on the aim point, whereas 'precision' is used for the extent to which multiple firings will land clustered closely together.

However, weapons can produce significant variations in where a warhead might land even if directed towards the correct location. Indirect fire weapons (those that fire munitions in an arc, rather than directly at a target that can be seen) tend to produce more variation, particularly when fired over long distances. There are numerous factors that contribute to this variation; some are systemic to the weapon, such as variations in the barrel through which the munition is fired, others are specific to individual firings, such as alignment of the weapon, variations in the munition, weather conditions or crew performance. Some factors can be mitigated, but for any weapons system there will always be some degree of variation in where repeated firings land.

Such variation is usually represented in terms of the statistical likelihood of the warhead landing within a certain distance of the point where it is aimed. The combination of the above factors can mean that the explosive warhead is as likely, or more likely, to detonate amongst the civilian population as it is to detonate on a specific target. This in turn depends upon the size of the military objective and the extent to which it can be separated from the civilian population and its buildings and infrastructure. As we will see below, many weapon types require large area targets, with significant separation from the civilian population, if the civilian population is not likely to be struck directly by at least some firings at that target.

Wide area effects resulting from inaccuracy can be conceptualised in two ways:

- The weapon applies explosive force somewhere within a wide area, or
- Such weapons require the application of force across a wide area if the desired target is to be hit.

The latter is usually achieved by multiple firings or the use of multiple warheads. Both conceptualisations point towards the same conclusion, that inaccuracy presents an elevated risk when such weapons are used against targets in a populated area. As noted in the previous section, the effect of the inaccuracy of delivery is always combined with the blast and fragmentation radius of the warhead—at whatever scale that operates.

"My wife and I heard the sound of bombs nearby, so we went outside to see what was going on. Just as we left our house, the room where our children were sitting took a direct hit. I'll never forget what I saw when we ran inside: my children were lying in a pool of blood and the walls of the house had collapsed around them. […]."

Father of Malak (aged five), Syria.

In December 2015, Malak, aged five, was injured with her brothers and sisters in an air strike. Malak's left leg had to be amputated. Her youngest sibling, an eight-month-old baby, died from its injuries.[4]

4 Handicap International, 'Syria, a mutilated future: A focus on the persons injured by explosive weapons', (May 2016), available at http://www.inew.org/site/wpcontent/uploads/2016/06/Factsheet_Syria_2016_FINAL.pdf.

EXAMPLES OF DELIVERY INACCURACY ON THE IMPACT AREA[5]

120mm mortar accuracy

Mortars are indirect fire weapons that fire mortar bombs from a launch tube. As indirect fire weapons, they launch the mortar bombs into the air that then impact at a location that might be several kilometres away. Mortar bombs come in a range of sizes that reflect the degree of explosive power they release when detonated. This in turn determines the area that is affected by blast and fragmentation. In line with the introduction above, mortars are subject to variations each time they are fired, which affects their likelihood of striking the point at which they are aimed.

In Figure 3, the approximate blast and fragmentation areas of a 120mm mortar are overlaid on circles indicating the probability of that weapon, at its maximum range, landing within a certain distance from the aim point (x):

- The weapon will land within roughly 100m of the aim point (i.e. within the dark blue circle) 50 per cent of the time. This also means that the weapon will detonate more than 100m from the aim point 50 per cent of the time.
- 62 per cent of all firings are expected to land within 160m of the aim point (i.e. within the lighter blue circle).
- This means that a substantial proportion, 38 per cent of firings (more than one in three), will land between the 160m radius and the outer, 480m radius indicated in the figure (the turquoise circle).

The 120mm mortar has a substantial blast and fragmentation radius, though significantly less than the 2,000lb aircraft bomb considered earlier. However, this illustration shows that there could still be explosive effects within a very wide area.

Even the 100m radius within which 50 per cent of firings will land extends significantly beyond the boundaries of the 160m x 100m school facility we used for reference previously. Using that example again, this means that for a single firing, the warhead is more likely to detonate outside the boundaries of that facility than inside it. Thus even when firing at a substantial military target, it is the area in proximity to that target that is most likely to be directly affected by a single firing. Multiple firings will statistically tend to result in the effects being concentrated on the target itself, but this is only likely to be achieved at the cost of direct effects on the surrounding population. With a greater number of firings, there is also an increased chance of detonations at a significant distance from the target. It should be noted that all of this assumes that the mortar is correctly aligned at the target in the first place—this is a significant assumption and an incorrectly aligned weapon would make the likelihood of harm in the civilian area still greater.

Regardless of a commander's intention of striking a legitimate target, the use of such a weapon in a populated area does not allow the effects of the attack to be reliably contained within the target in the example here—and each individual firing is more likely to strike the surrounding civilian population directly than it is to hit the target. It is clearly in the interests of civilian protection that such wide area effects are not produced in areas where civilians are concentrated.

5 Source for statistics: Raymond Trohanowsky, US Army RDECOM-ARDEC, 2005, 120mm Mortar Accuracy Analysis.

Figure 3.
120mm mortar accuracy at maximum range (7,000m)

Figure 4.
120mm mortar accuracy at closer range (2,000m)

For any given weapons system, the level of inaccuracy that might be expected is dependent upon a number of factors. Figure 4 illustrates the likely effects of the same 120mm mortar when fired from a closer range of 2,000m. Whilst the scale of the blast and fragmentation effects remains the same, the likelihood of warheads landing at a great distance from the target is significantly reduced:

- 50 per cent of the time the weapon will land within roughly 30m of the aim point (i.e. within the dark blue circle).
- 62 per cent of all firings are expected to land within 44m of the aim point (i.e. within the lighter blue circle).
- 38 per cent of firings will land between the 44m radius and the outer 132m radius, indicated in the figure.

Whilst the majority of warheads can be expected to land within a 160m x 100m target area, some firings would still land outside of that area. Again, the blast and fragmentation effects from detonations occurring within the target area would still probably have an impact on populations living in proximity to the facility, with detonations occurring on the periphery or outside the target area likely to have a more severe effect. Thus whilst limiting the range at which the weapon is used reduces the degree of inaccuracy, the likely overall effect may still be problematic unless the target against which it is being used extends across a significant area and/or is clearly separated from the surrounding population.

Barrel bombs

In recent years the use of 'barrel bombs', particularly in Syria, has caused large numbers of civilian casualties and captured media and political attention. Barrel bombs are essentially improvised aircraft bombs and they are primarily problematic because their method of delivery and lack of aerodynamic qualities means that they are inaccurate and may land anywhere within a wide area. They also often have large blast and fragmentation effects.

In 2014, Resolution 2139 was adopted by the UN Security Council, demanding that all parties to the conflict in Syria "immediately cease all attacks against civilians, as well as the indiscriminate employment of weapons in populated areas, including shelling and aerial bombardment, such as the use of barrel bombs, and methods of warfare which are of a nature to cause superfluous injury or unnecessary suffering (…)".[6]

Barrel bombs are inappropriate for use in populated areas because of their wide area effects. It is therefore to be encouraged that states object to the use of these weapons in populated areas. However, they should not lose sight of the underpinning technical reasons for this objection, namely the inaccuracy and resulting wide area effects of such weapons. There is a risk that states feel comfortable speaking out against barrel bombs because these are improvised weapons that most militaries have no reliance on. Objections to barrel bombs should come with the recognition that they are one example of the wider humanitarian problem of the use in populated areas of explosive weapons with wide area effects.

6 Security Council Resolution 2139 (2014), S/RES/2139. http://www.un.org/en/ga/search/view_doc.asp?symbol=S/RES/2139(2014)

"It was the end of classes and we were going out of school. I was looking for candies in my bag when bombs started to fall down all over the place. My friend and I got injured. But our other friend died in the explosion."

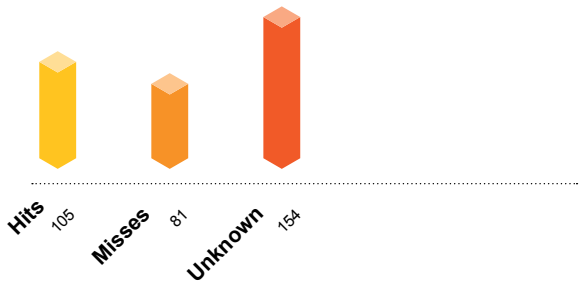
Yara (9), Syria.

In April 2014, nine-year-old Yara and two friends were about to leave their school in Dar'a city when the building was struck by a bomb. The blast and shrapnel caused Yara to lose her left eye and fracture both legs.[7]

UK aircraft bombs in Kosovo

Whilst some aircraft bombs are capable of striking a target with considerable precision, operational reports also indicate uncertainties around the performance of these so-called precision weapons. For example, in Kosovo in 1999, the UK documented its use of 340 aircraft bombs in the 500lb, 1,000lb and 2,000lb classes.[8] No assessments of hits or misses were available in the data released for approximately 45 per cent of the missions. But for those missions where such an assessment was recorded, some 44 per cent were recorded as misses, the majority of these being recorded as 'far' rather than 'near'.[9]

Figure 5.
UK aircraft bombing in Kosovo, data on hits and misses



7 Handicap International, 'The Use of Explosive Weapons in Syria: A Time Bomb in the Making, Testimony collected among Syrian refugees by Handicap International in Jordan', (May 12, 2015), available at https://d3n8a8pro7vhmx.cloudfront.net/handicapinternational/pages/2013/attachments/original/1435772569/May_12_Report_SYRIA_Use_of_explosive_weapons.pdf?1435772569.

8 The data record the use of 62 x 1,000lb air burst, 119 x 1,000lb 'slick', 150 Paveway 2 and 9 x Paveway 3 aircraft bombs.

9 Based on UK bombing records for Kosovo, 1999, spreadsheet 'UK Wpns in Kosovo for EOD – declassified', on record with author.

Target types that were missed in such sorties included ammunition storage buildings, vehicle storage bays, warehouses, control buildings, bridges, factory buildings and barracks, as well as troops and firing positions. Whilst not arguing that these specific strikes had resultant impacts in populated areas, such a pattern of data does indicate that such aircraft bombs can regularly miss even quite substantial targets. There may be numerous factors underpinning this pattern of results, including the altitude from which attacks were undertaken, and as ever we should be wary of drawing broad conclusions from this one example. However, it does illustrate that reliably striking specific targets with aircraft bombs can be challenging even for comparatively highly resourced militaries and will probably present significant risks to the surrounding area.

"Just earlier that evening, a family had come to our house to ask for my daughter's hand in marriage for their son. Now I have lost my wife and all four of my daughters. I cannot believe that everyone I love is gone."

Walid al-Ibbi (35), Yemen.

On 6 May 2015, at least three aerial bombs struck a cultural centre and a residential house in southwest Saada City, killing 28 people (27 from one family), including seven women and at least 17 children, and wounding three men.[10]

INACCURACY OF DELIVERY LEADING TO THE USE OF MULTIPLE WARHEADS OR MULTIPLE FIRINGS

As indicated in the earlier examples here, 'accuracy' for many weapons is conceptualised in terms of the probability of a warhead landing within a particular distance from the aim point. This, in turn, tends towards a probability-based approach in certain aspects of military operations; in particular, towards a recognition that multiple warheads or firings need to be used in order to be sufficiently certain of achieving the desired effect on the target. Whilst increasing the number of warheads used may increase the probability of achieving the desired effect on the target, it also increases the level of risk to which any surrounding population is exposed.

10 Human Rights Watch, 'Targeting Saada; unlawful coalition airstrikes on Saada City in Yemen', (30 June 2015), available at: https://www.hrw.org/report/2015/06/30/targeting-saada/unlawful-coalition-airstrikes-saada-city-yemen.

Use of multiple warheads or multiple firings

The use of multiple warheads or munitions is the final driver of wide area effects that we consider here. This is clearest in the case of cluster munitions, which were prohibited outright in 2009 under the Convention on Cluster Munitions, partly in recognition of the fact that their wide area effects contributed to high levels of civilian harm. However, similar and even wider area effects are also found with multi-barrel rocket systems that are designed to fire salvos of rockets across an area.

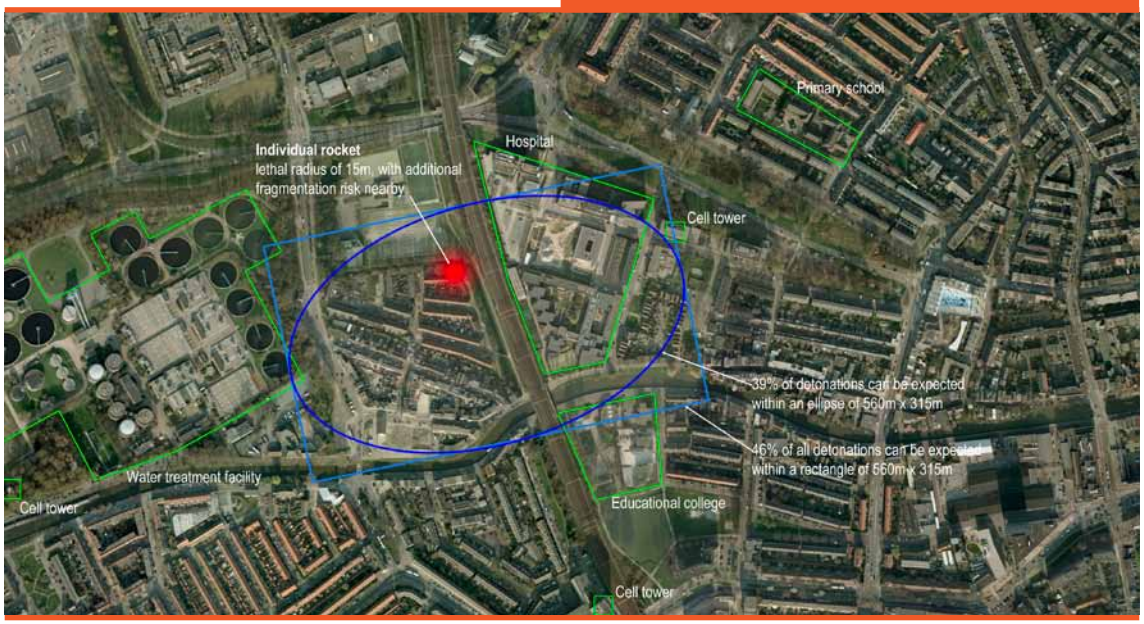
MULTI-BARREL ROCKET LAUNCHERS

Multi-barrel rocket launchers—such as the Russian-made BM-21 Grad and US-made M270 MLRS—are designed to fire salvos of rockets over long distances. With up to 40 rocket tubes on the launch vehicle (depending on variants), they can produce multiple warhead detonations across a target area and can strike at targets at a distance of some 20km or more. Rockets can usually be fired individually, in groups or as a complete set.

Individual rockets each create a blast and fragmentation effect over a certain distance on the ground. This will depend on the specific rocket system, with the warheads used by the 122mm Russian Grad system having a lethal radius of approximately 15m and fragmentation effects extending well beyond that. The individual rockets, in turn, will tend to land within a broad area—usually an approximate ellipse—with the size of that area growing if fired at greater range and in greater quantities. For a traditional 122mm system fired at long range, the dimensions of the ellipse within which approximately 40 per cent of the rockets are likely to land can be up to 560m along the major axis and 315m along the minor axis, and may be larger if multiple rockets are fired due to the influence of the firing process on the accuracy of the system. As with the discussion of accuracy probabilities earlier, such an ellipse represents an area within which the rockets can be expected to be concentrated—however, a significant proportion of rockets (more than 50 per cent in this example) will land in the surrounding area. Again, it should not be taken for granted that the weapon would be aligned correctly on the target in the first place.

It can be seen that when used individually, the likelihood of a rocket striking an individual military target within its 15m lethal radius is relatively low (unless the target is conceptualised as a broad area and the effect being sought is simply to harass people in that area). As a result they are inappropriate for firing individually at targets in populated areas. Furthermore, when multiple rockets are used, these weapons systems are designed to create a pattern of blast and fragmentation effects across a wide area. As a result they shift from applying explosive force somewhere within a wide area to the application of explosive force throughout that wide area. In either case, if that area contains a civilian population it is inevitable that the weapon's effects are likely to cause harm to that population and cannot realistically be restricted to a specific military objective.

Figure 6.
122mm multi-barrel rocket system's effects at a range of 19km—single rocket



In Figure 6, some 40 per cent of rockets would detonate across an area approximately bounded by the 560m x 315m ellipse. Approximately 45 per cent would land within a rectangle with sides equal in length to the ellipse's axes. As can be seen, the specific military target would need to be very large if even a correctly aimed rocket (i.e. one with the likely landing area correctly centred on the target) is not going to create blast and fragmentation effects within the surrounding area. In this figure, a large facility of some 300m x 240m is highlighted for scale. It can be seen that the chances of a single rocket striking this facility are relatively low.

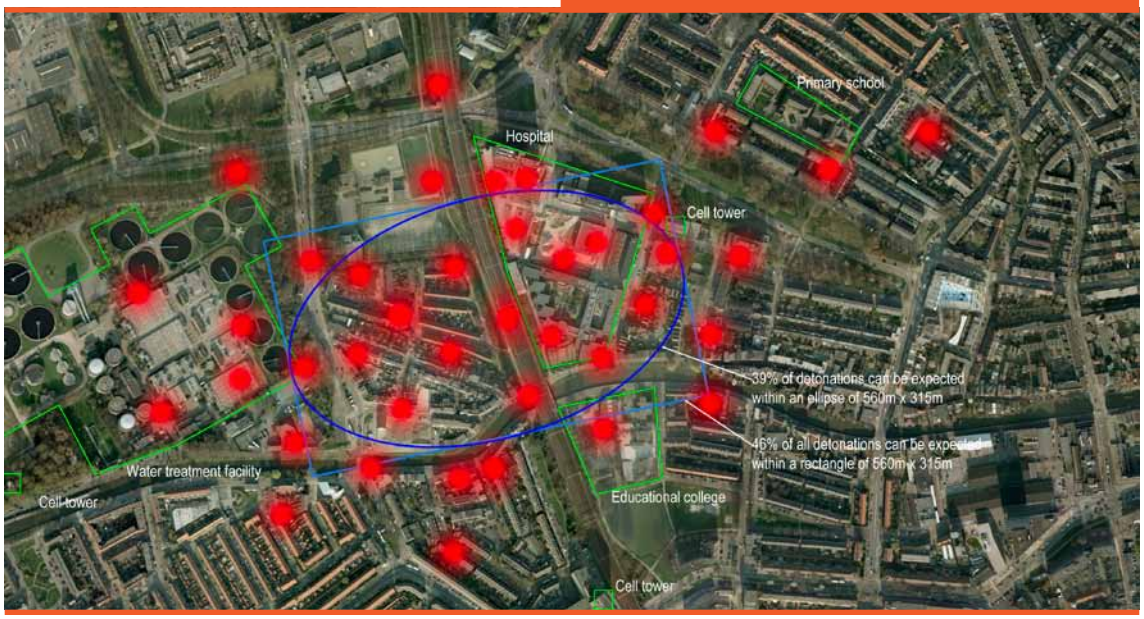
"We were outside, standing in line for bread. My wife was behind me. Her name was Milatovana. We were married for 29 years. We thought we would celebrate our 30th anniversary but now we never will."

Gennadiy (55), Ukraine.

On 6 August 2015, Gennadiy and his wife had already spent 20 days in their basement because of the ongoing shelling when they went outside to get bread. Gennadiy's wife was killed during the incident. Gennadiy and his two children fled their home town in Luhansk region the day after the attack.[11]

11 Interview by PAX and UNOCHA on 18 June 2015, partly published in 'Collateral; the human cost of explosive violence in Ukraine', (September 2015), available at http://www.paxforpeace.nl/media/files/collateral-the-human-cost-of-explosive-violence-in-ukraine-web.pdf.

Figure 7.
122mm multi-barrel rocket system effects
at a range of 19km—40 rockets



Building on this example, if a full salvo of 40 rockets is used, the likely area of effects becomes wider and the impact on the surrounding population increases. The area affected by the salvo of rockets illustrated here encompasses not only residential housing but also a water treatment plant, a hospital, a college and a civilian communications cell tower. These different civilian structures are highlighted here to illustrate that when wide area explosive weapons are used in populated areas, this does not just result in direct deaths and injuries among the civilian population. The impact of such explosive weapons on housing, hospitals, schools, water supplies, sanitation and other vital services has long-term, interconnected social, economic and health effects on the population and serves to drive displacement.

The use of multi-barrel rocket systems in populated areas has been a significant and highly problematic feature of recent conflicts in areas such as Libya, Syria and Ukraine. Functioning as they do, such weapons cannot realistically be used in populated areas without effectively making the civilian population part of the target of the attack, regardless of the commander's intention. Whilst legal rulings should be pursued regarding specific incidents, such legal proceedings are rare in practice. The international community should refuse to condone the use of such weapons in populated areas as an acceptable form of military practice.

Additional factors that determine area effects

These illustrations help give a basic understanding of how wide area effects develop. As noted previously, there are numerous factors that further modify these effects and have a bearing on what actual effects will occur in specific real-life situations. In the analysis above,

we highlighted the fact that the distance over which certain weapons are fired (the range) has significant bearing on the area over which effects might be distributed. Additional factors include where a weapon detonates in relation to the ground (e.g. sub-surface, surface or air burst, which can be moderated by different fusing mechanisms), channelling, reflection and refraction effects that shape the movement of blast and fragmentation, environmental and weather conditions, the condition of the equipment and training of operators. Some of these factors can be controlled at the time of use while some are outside the control of the weapon users.

These additional factors have been highlighted in previous technical reports.[12] For the purposes of this report there is no need to describe their implications in detail—they primarily contribute to, or limit, the effects described here and influence the extent to which aspects of those effects may or may not be controlled by weapon operators. The additional complexity presented by these factors does not prevent the area of an explosive weapon's effects, in general, from being a practical basis for managing the use of such weapons—as we will see in a later section of this paper.

Conclusion from this section

This section has provided illustrations of the three key ways in which wide area effects can be created, whether individually or in combination—large blast and fragmentation radii from a single warhead, inaccuracy in the delivery of a warhead and the use of multiple warheads. It has also highlighted the fact that the size of the target being considered as a military objective has a significant bearing on whether certain weapons are more likely to hit the intended target or the surrounding civilian population. It is clear that in many cases the target would have to be large and/or be significantly separated from the civilian population if any individual weapon is not to be as likely, or more likely, to hit the civilian population as the target.

In the next section we look at how limiting the area effects is already accepted as underpinning military policy and procedures aimed at reducing civilian harm. This in turn should be seen as a basis for recognising that collective political action to curb the use in populated areas of explosive weapons with wide area effects can promote practical responses in military conduct at the national level. ♦

12 See for example, Armament Research Services (ARES), 2016, 'Explosive weapons in populated areas: Technical considerations relevant to their use and effects'.

Density of civilian population

The concern regarding the use of certain weapons in populated areas is primarily that their effects will create a high level of risk to the local civilian population and civilian objects. In the example of the 122mm multi-barrel rocket system above, we noted the potential concentration of civilian services and infrastructure that might fall within the area of an attack. It is difficult, however, to instinctively grasp the likely numbers of people in the kinds of weapon-effect areas considered in the previous section of this report and so to really understand how many people are at risk.

As an example, some 99 per cent of firings of the 120mm mortar at maximum range were estimated to land in a circle with a radius of 480m. This produces an area of approximately 720,000m2. If that area is considered in the context of the average population density for certain urban areas, it gives us an indication of the number of people who might be put at risk by the use of a weapon liable to land across such a wide area. The following table provides some examples from a selection of locations, based on indicative population densities.

Table 1

Location	Approximate population density (persons per km^2)	Persons within the wide risk area of a 120mm mortar at maximum range
Geneva, Switzerland	12,000	8,640
Manhattan, New York, USA	27,000	19,440
Mumbai, India	20,000	14,400
Cairo, Egypt	17,000	12,240
Utrecht, Netherlands	3,500	2,250
Exeter, UK	2,600	1,872

The examples illustrated here are all cities, but they have a range of population densities. Given that the area used here is based on the inaccuracy of the weapon, only a fraction of the people within this risk area would be exposed to direct harm, though arguably all would experience psychological effects from such events happening in their proximity. Such figures simply provide an indication of the population at a significant level of direct risk and suggest that for an individual attack this can be substantial.

Looking more specifically at blast and fragmentation effects, for the 120mm mortar with a lethal radius of 30m and a 10 per cent probability of incapacitation at a radius of 100m, one mortar would affect the following numbers of people.

Table 2

Location	Persons within lethal radius (30m)	Persons within 10% probability of incapacitation radius
Geneva, Switzerland	34	377
Manhattan, New York, USA	79	874
Mumbai, India	59	650
Cairo, Egypt	50	553
Utrecht, Netherlands	10	110
Exeter, UK	7	82

Again, in any specific incident there would be numerous factors that would determine the actual effects that people experience. Yet such basic figures provide an entry point for further considering what it means to apply explosive force in populated areas for populations on the receiving end. Considering such numbers, it is hardly surprising that such applications of force not only result in high levels of direct harm but progressively drive people from their homes and into the vulnerability of displacement.

Managing wide area effects — lessons from current practice

Focusing concern on explosive weapons with wide area effects when used in populated areas provides a clear basis for understanding the relationship between the weapon technologies used and the likelihood of harm to the civilian population. The relationship of wide area effects to the likelihood of civilian harm is concrete and direct, although the actual effects in practice will always depend upon specific circumstances.

It is significant in this regard that whilst the general rules of international humanitarian law are not explicitly concerned with the wide area effects of weapons, current practice in many militaries does use area effects as a key aspect for managing risk to civilians in the use of force. Yet the central role of limiting area effects in efforts to improve civilian protection is obscured because this central factor is dispersed across different legal, policy and operational frameworks. The severe humanitarian impact of explosive weapons in populated areas ought to make collective political recognition of the fundamental importance of avoiding wide area effects in populated areas a top priority in order to increase civilian protection.

The section below highlights a number of separate reference points that illustrate recognition of the threat to civilians posed by explosive weapons with wide area effects, or the importance of 'populated areas', as a basis for controlling the threat to civilians from weapons. It covers the following issues:

- **Managing wide area effects in relation to the context of use**. Protocol III of the UN Convention on Certain Conventional Weapons (CCW) uses 'concentrations of civilians' as a basis for managing the risks to civilians presented by certain weapons, and the term 'populated areas' has been used in relation to the management of weapons in UN Security Council resolutions.

- **Managing wide area effects through collateral damage estimation methodologies.**
  Collateral damage estimation methodologies draw heavily on the area effects of weapons, and reducing area effects is a primary mechanism for reducing the likelihood of civilian harm. The methodologies also use assumptions about the size of the civilian population in the area.

- **Addressing wide area effects in operational directives aimed at reducing civilian harm.**
  Certain operational directives and 'lessons learned' have highlighted risks posed by certain types of explosive weapons and have promoted efforts to reduce the areas of effect.

- **Area effects as a basis for controlling risks to friendly forces.**
  Certain mechanisms to protect 'friendly forces' from harm are based on the area effects of the weapons that might be used in proximity to those forces in conjunction with mechanisms for ensuring sufficient accountability.

- **Cluster munitions: rejecting certain weapons because of their wide area effects.**
  Prior to cluster munitions being banned outright, a number of countries endorsed a position that these weapons should be prohibited from use in populated areas. In the ban treaty, the area effects of these weapons are recognised as a key issue of humanitarian concern.

- **Specific weapons with 'reduced' area effects.**
  So-called 'low collateral damage' weapons are based on reducing the area effects of the explosive munitions.

Recognising the central role of reducing area effects in populated areas as a practical mechanism for reducing risk, albeit dispersed across different legal, policy and operational tools, provides a basis for further consideration of how a collective policy position could promote operational policies at a national level that could help reduce civilian harm in practice and promote a stronger expectation of civilian protection internationally.

Managing wide area effects in relation to the context of use

Central to concerns regarding explosive weapons has been their use in 'populated areas', where they are increasingly recognised as generating an ongoing pattern of elevated civilian harm. For working purposes, the term 'populated areas' can be understood to be broadly synonymous with 'concentrations of civilians' as it is used in existing legal instruments regulating the use of weapons.

CCW Protocol III on incendiary weapons provides a definition of 'concentration of civilians' that can be used as a basis for understanding the term 'populated areas' in relation to policy on explosive weapons. It states that "concentration of civilians" means "any concentration 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 groups of nomads".

Protocol III then goes on to prohibit the use in all circumstances of air-delivered incendiary weapons against military objectives located within a concentration of civilians. It prohibits the use of ground-launched incendiary weapons against such objectives except when that military objective "is clearly separated from the concentration of civilians **and** all feasible precautions are taken with a view to limiting the incendiary effects to the military objective and to avoiding, and in any event to minimizing, incidental loss of civilian life, injury to civilians and damage to civilian objects" [emphasis added].

Whilst Protocol III is insufficient in a number of respects as a response to the humanitarian problems posed by incendiary weapons, it illustrates that states can adopt legal obligations that control the use of certain weapons on the basis of the area in which they are being considered for use.[13] It also suggests that a clear separation of the military objective from the surrounding civilian population can also be a factor in managing the use of certain weapons.

It should also be noted that the term 'populated areas' has been used as a basis for controlling certain weapons in international political instruments. UN Security Council Resolution 2139, as we have noted previously, makes appeals regarding the employment of weapons in 'populated areas'.

These two examples are made by way of introduction simply to make a more basic point: that controlling the use of weapons in relation to the context in which they will be used is widely accepted as a practicable approach, and that the term 'populated areas' is accepted as political language that can be used as part of such an approach.

Managing wide area effects through collateral damage estimation methodologies

Collateral damage estimation methodologies provide a standardised general tool for producing an estimate of civilian harm in the planning of certain military attacks. As such, they can support decision-making by commanders. Such methodologies do not predict actual outcomes; rather they use certain information and assumptions to allow commanders to evaluate levels of risk and to channel decision-making in certain directions in order to mitigate those risks. US policy, as laid out in the 2012 Joint Chiefs of Staff instruction on collateral damage estimation, provides a number of interesting points with respect to the threat posed by explosive weapons with wide area effects when used in populated areas, including the following:[14]

- Such a methodology draws on assessments of the likely size of the civilian population, including population density data.

13 For further analysis of this, see Human Rights Watch and the Harvard Law School International Human Rights Clinic, 2011, 'Q & A on Incendiary Weapons and CCW Protocol III', online at https://www.hrw.org/sites/default/files/related_material/2011_arms_qandaincendiaryweaponsccwpiii.pdf.

14 Analysis based on US policy as laid out in Chairman of the US Joint Chiefs of Staff, 2012, Instruction – No Strike Policy and Collateral Damage Estimation, 12 October 2012, online at https://publicintelligence.net/cjcs-collateral-damage/.

- Estimates at the most refined level are considered not possible for certain explosive weapons—notably cluster munitions, rocket-assisted projectiles, extended range artillery, mortar and naval guns—because of limitations in the capacity to control their area effects. This is identified as a particular problem in urban areas.

- Such a methodology promotes the use of explosive weapons with a more limited area of effect in order to avoid harm to civilians if these can be used to achieve the mission.

- It considers target size as a significant factor in assessment of the use of unguided aircraft bombs and unguided indirect fire weapons, because if the target is not large enough, the munition is likely to land in the surrounding area rather than on the target.

- The metric 'collateral error radii'—values assigned to specific munitions in specific configurations or modes of use—is used as a basis for assessing the level of civilian risk. These radii reflect the anticipated area of effect, as discussed previously in this report. Such methodologies promote the choice, configuration and deployment of munitions in such a way as to reduce the collateral error radius and avoid damage to 'collateral concerns'.

All of these factors indicate that the scale of the area effects of a weapon is a central and direct technical factor that influences the likely level of civilian harm. These factors all directly incorporate recognition that reducing area effects and refraining from the use of weapons with a wide area effect are central mechanisms for reducing the risk to civilians.

"It was the start of the weekend, and my cousin Hamza was getting married in a few days, so the family was all there making preparations for the wedding. The power had gone out, as it often did at the start of the summer, so the children had gone out to the garden to play in the remaining sunlight. The missile landed in the small yard, instantly killing seven children and Hamza. Hamza's eldest brother, Tariq, and his daughter were both fatally injured and died one week apart."

Hamza's cousin, Libya

On 14 May 2015, a missile struck the home of Othman Almusrati, killing two of his sons and nine of his grandchildren.[15]

15 PAX and UNOCHA, 'Shattered Lives; Civilians suffer from the use of explosive weapons in Libya', September 2015, available at http://www.paxforpeace.nl/media/files/pax-rapport-libya-shattered-lives-web.pdf.

Addressing wide area effects in operational directives aimed at reducing civilian harm

In some operations, states and multi-national forces have adopted specific restrictions or advice on the use of certain explosive weapons. Many such restrictions and recommendations have related specifically to 'indirect fire weapons'. As we have noted, these are generally surface-to-surface weapons, such as artillery and mortars, that project explosive munitions in an arc towards a target at a distance, as opposed to 'direct fire' weapons that fire munitions on a flatter trajectory towards targets that can be seen directly by the operator. Other such policies have been applied specifically to air-to-ground attacks.

Examples of such measures include various ISAF Tactical Directives in Afghanistan restricting air-to-ground attacks and the use of indirect fire explosive weapons, applying specific restrictions regarding the use of such weapons on residential compounds and promoting the assumption that areas with civilian buildings are inhabited unless demonstrated otherwise. Other lessons from Afghanistan on reducing civilian casualties have included more training in the use of indirect fire weapons, greater use of 'low collateral damage' munitions, avoiding indirect fire explosive weapons when alternatives are available, increasing the safety zone around targets from which civilians should be excluded, measures to reduce harm during initial fires that are being used to calibrate accuracy (registration and walking onto target), avoiding the use of indirect fire explosive weapons on moving targets, choosing an angle and direction of attack that reduces risk to civilians, adjusting weapon fusing to avoid civilian casualties and assuming the presence of civilians rather than their absence.

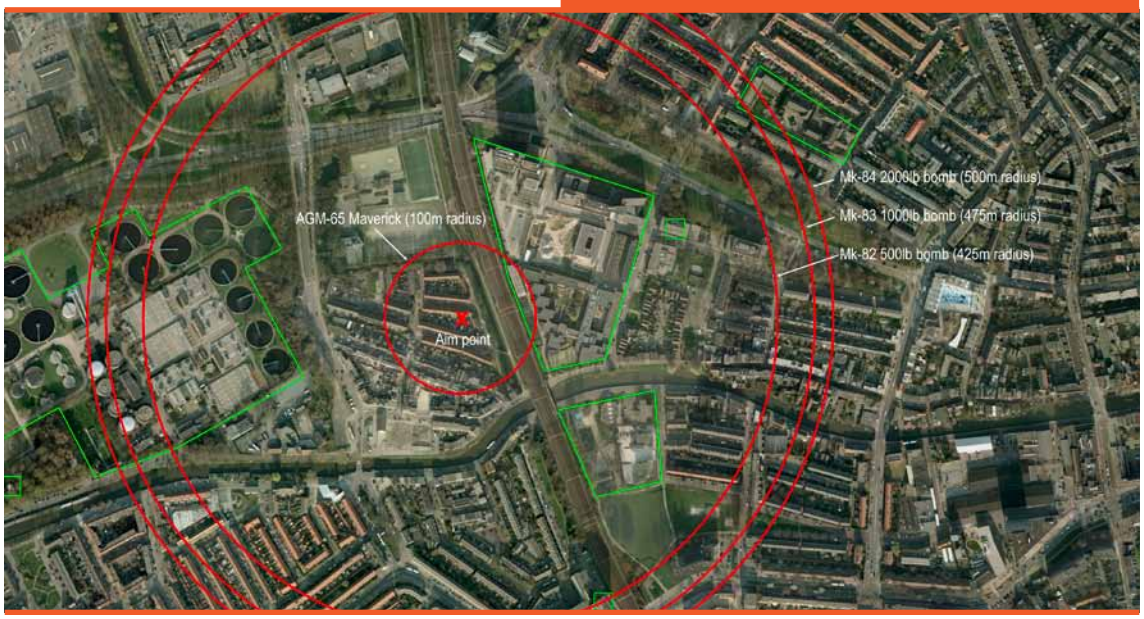
These approaches reinforce the recognition that:

- Indirect fire explosive weapons present particular risks to civilians (due to the challenge of observing civilian presence in the target area, and their wide area effects).
- Approaches can be adopted that serve to reduce the area effect of the weapons being used—through the choice of weapons or the way in which they are deployed.
- The likely area of effect will have the least overlap with any civilian population when civilians are clearly separate from the target or when the likely area of effect corresponds to an area of reduced civilian risk.
- Adopting an assumption that civilians are present may serve as a way of enhancing civilian protection.

Such approaches stem from a recognition that explosive weapons with wide area effects present a greater risk of harm to that civilian population if used in areas where civilians can be assumed to be concentrated, and that measures should be taken to prevent this.

It is also significant in the formulation of a number of the lessons that the term 'avoid' is regularly used—and is understood as guiding behaviour in a certain direction. Such examples provide an indication that military operations can be conducted against the background of additional guiding principles driven by political or humanitarian imperatives, beyond the obligations of law.

Figure 8.
Risk distances for the use of certain explosive weapons in proximity to friendly forces



Area effects as a basis for controlling risks to friendly forces

States have also used data on the possible area effects of specific explosive weapons as a basis for protecting their own forces in combat situations.[16] This again illustrates the potential utility of focusing on area effects as a way of reducing risk to civilian populations. When airstrikes and artillery are being used against targets in proximity to friendly forces, certain risk distances are used to ensure that the commander of those friendly forces takes responsibility for the risk being generated. For example, regarding the use of aircraft bombs in proximity to friendly ground forces:

"The ground commander must accept responsibility for friendly risk when targets are inside 0.1 percent PI [probability of incapacitation]. The passing of the ground commander's initials indicates his acceptance of the risk for intentional ordnance delivery inside the 0.1 percent PI distance."

In Figure 8, the 0.1 per cent probability of incapacitation radii from the aim point (x) are shown for:

- Air-dropped bomb: Mk-84HD/LD 2,000lb bomb—500m radius
- Air-dropped bomb: Mk-83 HD/LD 1,000lb bomb (GBU-16)—475m radius

16 See for example: The Infantry Battalion, FM 3-21.20, 13 December 2006, US Dept of Army. Chapter 10 - Warfighting Functions, Table 10-4. Risk estimate distances for mortars and cannon artillery; US J-FIRE - MULTISERVICE PROCEDURES FOR THE JOINT APPLICATION OF FIREPOWER, 1997.

- Air-dropped bomb: Mk-82 LGB 500lb bomb (GBU-12)—425m radius
- Air-to-ground missile: AGM-65 Maverick (TV, IIR, Laser Guided)—100m radius

As can be seen, there is a substantial difference in the risk area for the 500lb to 2,000lb aircraft bombs and the air-to-ground missile of the type in the example. This clearly illustrates why recognising the different area effects of specific explosive weapons is important in managing behaviour. There are some important points that can be drawn from this for consideration in developing stronger civilian protection:

- The protection of friendly forces is based on an assessment of the area effects of specific weapons coupled with a practical process that ensures accountability.
- Estimated distances are used despite a recognition that specific contexts will affect the actual distribution of force in practice—i.e. the complexity of specific environments or circumstances is thought not to undermine the utility of the basic data as a tool for protection.
- Adopting such a process does not undermine the flexibility of operations nor does it have implications in relation to the law.
- The essence of this approach is that the use of explosive weapons should be avoided if a protected population is within their area of effects, unless specific command authorisation is given to use them.

"It was 11:30 at night. The men were gathered and socializing right outside of the fence, and the women and children were inside. We heard a loud explosion, and then it was dark and the house was gone. We heard women and children crying and yelling. We ran toward a thick, black cloud of dust, but we could not see anything. The house was under a meter or so of rubble."

Ateya, Libya

On 8 August 2011, NATO forces struck four homes in Majer. One of those homes belonged to Ateya's maternal uncle. He had been living at his uncle's home for three months along with 14 other families when the house was struck.[17]

17 PAX and UNOCHA, 'Shattered Lives; Civilians suffer from the use of explosive weapons in Libya', September 2015, available at http://www.paxforpeace.nl/media/files/pax-rapport-libya-shattered-lives-web.pdf.

Cluster munitions: rejecting certain weapons because of their wide area effects

Cluster munitions are prohibited outright under the 2008 Convention on Cluster Munitions. This prohibition was adopted because it was recognised that these weapons generated two particular effects that posed a consistently unacceptable risk to the civilian population: high levels of unexploded ordnance after use and wide area effects at the time of use.

On 17 November 2006, a group of states adopted a Declaration on Cluster Munitions in the UN Convention on Conventional Weapons. The declaration asserted that, "due to their tendencies of having indiscriminate effects and/or a high risk of becoming explosive remnants of war", cluster munitions are of "serious humanitarian concern during and after armed conflict". On this basis it called for an agreement that should "prohibit the use of cluster munitions within concentrations of civilians…". The declaration was endorsed by Austria, Belgium, Bosnia-Herzegovina, Croatia, Costa Rica, the Czech Republic, Denmark, Germany, the Holy See, Hungary, Ireland, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, New Zealand, Norway, Peru, Portugal, Serbia, Slovakia, Slovenia, Sweden and Switzerland. Although this declaration was inadequate as a response to the humanitarian problem presented by cluster munitions, it suggests at a more basic level that all of these states considered certain types of explosive weapons to be inappropriate for use in populated areas.

The Convention on Cluster Munitions itself highlights "the suffering and casualties caused by cluster munitions at the time of their use" and lists characteristics that munitions should have "to avoid indiscriminate area effects". These requirements are directly linked to a recognition that the wide area effects of cluster munitions, if used in populated areas, are a problematic threat to civilians irrespective of the problem of unexploded ordnance.

Such a precedent shows that certain states have already recognised in a declaration that specific explosive weapons should not be used in populated areas because of their wide area effects.

Specific weapons with 'reduced' area effects

Certain weapons are presented as intended to reduce 'collateral damage'—typically by reducing the risk of death and injury from fragmentation. Weapons of this sort tend to use modified casing materials to avoid the wider area effects of fragmentation and to focus the weapon's energy on the more localised blast effect. For example, the US-manufactured BLU 129/B uses a "carbon-fiber-wound construction of the warhead … [that] disintegrates instead of fragmenting [which adds] explosive force nearby, but lowers collateral damage".[18]

Elsewhere, it has been argued that simply using smaller explosive weapons, such as the GBU-39 Small Diameter Bomb, can reduce the risk to civilians because they employ less explosive force (though the primary motivation for such weapons often relates more to their size, which allows more weapons to be carried per aircraft). In a reply to a parliamentary question, Dutch government ministers noted that, whilst "humanitarian law does not require the use of precision

18 Aeroject Rocketdyne website: http://www.rocket.com/blu-129.

weapons … by using weapons like the Small Diameter Bomb, it is indeed possible to operate with more precision and possibly less risk of collateral damage."[19]

The fact that a reduced area of effect is the primary distinguishing feature of weapons that have been developed and are labelled as reducing civilian harm (by comparison with other weapons) again demonstrates the underpinning recognition of the relationship between area effects and civilian risk that should inform militaries' action. This is not to endorse the use of such weapons as a solution in themselves, but to reiterate that their marketing and presentation shows an underpinning acceptance that the area effects of weapons are directly related to civilian risk.

Conclusion from this section

All of the examples in this section have shown that the area effects of explosive weapons and a concentration of civilians in the location where an attack is planned are already key building blocks in different efforts to minimise civilian harm from weapons in practice. The procedural examples illustrated above are undertaken as practical processes. They are undertaken not because international humanitarian law explicitly requires them, but because restricting the area effects of weapons used in populated areas is one of the practical actions through which the wider requirements of international law or political policy are met.

The area effects of explosive weapons are thus clearly recognised as having a direct relationship to the threat presented to civilian populations, and provide a basis for efforts to manage the level of risk to which civilians or friendly forces may be exposed. Given that this recognition is dispersed across different legal, policy and practical mechanisms, consideration should be given to how collective policy approaches can facilitate recognition that curbing the use of explosive weapons with wide area effects in populated areas will strengthen the protection of civilians.

At a practical level, national operational approaches to restricting the use of explosive weapons with wide area effects in populated areas should be embedded in rules of engagement. Rules of engagement may be adopted for specific operations and can be understood as being 'nested' within international humanitarian law, whereby what is allowed by the rules of engagement must always fall within what is allowed by the requirements of international law (as interpreted). It is then not difficult to envisage how a commitment to curb the use of explosive weapons with wide area effects in populated areas might be implemented.

19 Joint written reply to Parliamentary question by Minister of Foreign Affairs Bert Koenders, Minister of Defence Jeanine Hennis-Plasschaert and Minister of Foreign Trade and Development Cooperation Lilianne Ploumen, https://zoek.officielebekendmakingen.nl/kst-27925-571.html: "On the basis of humanitarian law, an assessment must be made prior to every attack as to whether the probable collateral damage, such as fatalities or injuries amongst the civilian population or damage to civilian objects, is excessive in relation to the concrete, direct military advantage that can be achieved through the attack. The weapon that is to be used and its effects should be taken into account among other factors. Humanitarian law does not require the use of precision weapons, but by using weapons like the Small Diameter Bomb, it is indeed possible to operate with more precision and possibly less risk of collateral damage. This is one of the reasons why the involvement of the Netherlands in the coalition's campaign is so valuable." Translation from Dutch by PAX.

For example, the Sanremo Handbook on Rules of Engagement, which aims to provide guidance for the development of such rules, suggests as an option a prohibition on the use of indirect fire weapons in populated areas.[20] This is not an assertion that all use of indirect fire weapons in populated areas is necessarily illegal under international humanitarian law. Rather, it is a suggestion for a practical way of limiting civilian harm in the context of a specific operation whilst acting within the wider legal framework. It is a practical option because it provides a concrete understanding of weapon types and contexts that military commanders can implement in the field.

Responding to an ongoing pattern of harm, the UN Secretary-General, the International Committee of the Red Cross and civil society organisations are all calling on states to adopt a political commitment to curb the use of explosive weapons with wide area effects in populated areas. A significant number of states have endorsed that call. Based on the analysis here, it is not too difficult to imagine how such a commitment could be implemented. For example, a process at the national level for implementing such a commitment might involve:

- Assessing the area effects of explosive weapons in service;
- Determining whether any of these weapons should not be used in populated areas under any circumstances;
- Determining which weapons should require a higher level of command approval for use in populated areas;
- Establishing rules of engagement on that basis.

In many countries, such policies might well already effectively be in place. Yet adopting a commitment to this effect, and implementing it at a national level, would demonstrate a determination to directly address the relationship between the wide area effects of certain explosive weapons and the risk of civilian harm when such weapons are used in populated areas. Such a commitment would also promote transparency and the sharing of practice aimed at stronger civilian protection. Whilst the desire of militaries to retain maximum flexibility of action is understood, civilian populations deserve better than a continued acceptance that weapons can be used in their cities, towns and villages that will predictably kill them in their streets and their homes even when directed at a legitimate military object.♦

20 Sanremo International Institute for International Humanitarian Law, 2009, Handbook on Rules of Engagement.

Conclusion & recommendations

The examples in this paper have illustrated that certain explosive weapons have such wide area effects that they could not reasonably be expected to have an effect on a military target without also affecting the nearby civilian population. People living in many conflict zones experience this continuously, with levels of force being directed at military goals that also kill and injure civilians, preventing them from accessing basic services and driving them into displacement. There is a pressing humanitarian imperative to take action to address this pattern of harm, and in doing so to set a stronger shared standard for civilian protection in military operations.

Increasing political constraints on the use in populated areas of explosive weapons that have wide area effects would be a major step forward for the protection of civilians in armed conflict. Establishing an expectation that greater restraint should be applied in the use of explosive force in such contexts will help prevent the bombing and bombardment of people in their homes, schools and hospitals. Whilst fighting in populated areas will always put civilians at risk, the use of explosive weapons with wide area effects in these contexts exposes them to an unacceptable risk of harm. A political commitment to curb such use is operationally practicable and would be fully consistent with the purpose and rules of international humanitarian law.

Arguments that existing international humanitarian law is adequate and all that is needed is better implementation of the law do not do justice to the reality faced by civilians in conflict areas in the world today. Military actors recognise that practical guidance is needed to provide a framework for action in operations that is in line with both legal obligations and the political will behind those operations. Military actors also recognise that, in a given context, certain weapons pose greater risks to civilians than others. A political commitment to curb the use of explosive

weapons with wide area effects in populated areas would provide a basis for practical guidance at national level and for stronger expectation of civilian protection internationally.

Actors that take the protection of the civilians seriously would not use wide area explosive weapons in areas where civilians are concentrated. Despite the variety and complexity of technologies and circumstances involved, such a policy denotes a simple position that speaks directly to the key technological characteristics that put civilians in harm's way. Promoting such a policy will also promote restraint even amongst those actors that refuse to endorse such a position directly. Such restraint is desperately needed by civilian populations worldwide, now and in the future.

Recommendations

As a humanitarian priority, we call upon states to draw up an international political declaration to reduce harm from the use of explosive weapons in populated areas, based on the following key elements:

- A commitment to stop the use of explosive weapons with wide area effects in populated areas;
- A commitment to assist victims of explosive weapons and affected communities;
- A commitment to gather and share data on the use and impact of explosive weapons in populated areas, including the recording of casualties, and to share policy and practice aimed at enhancing civilian protection;
- A commitment to translate the key elements of such a political commitment into national policy and action.♦

Figure 2.
Effects radii for a 2,000lb aircraft bomb

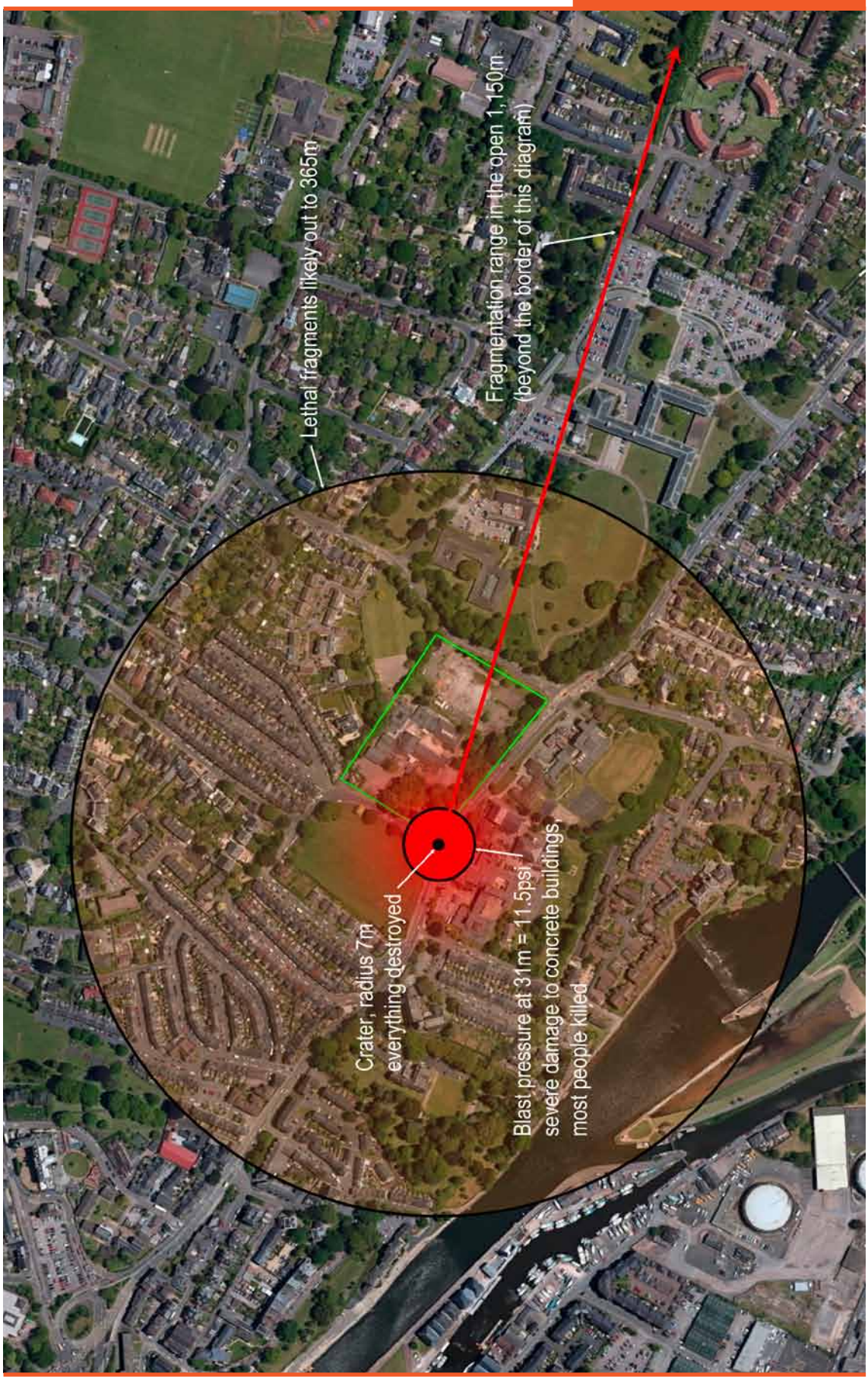


Figure 3.
120mm mortar accuracy at maximum range (7,000m)

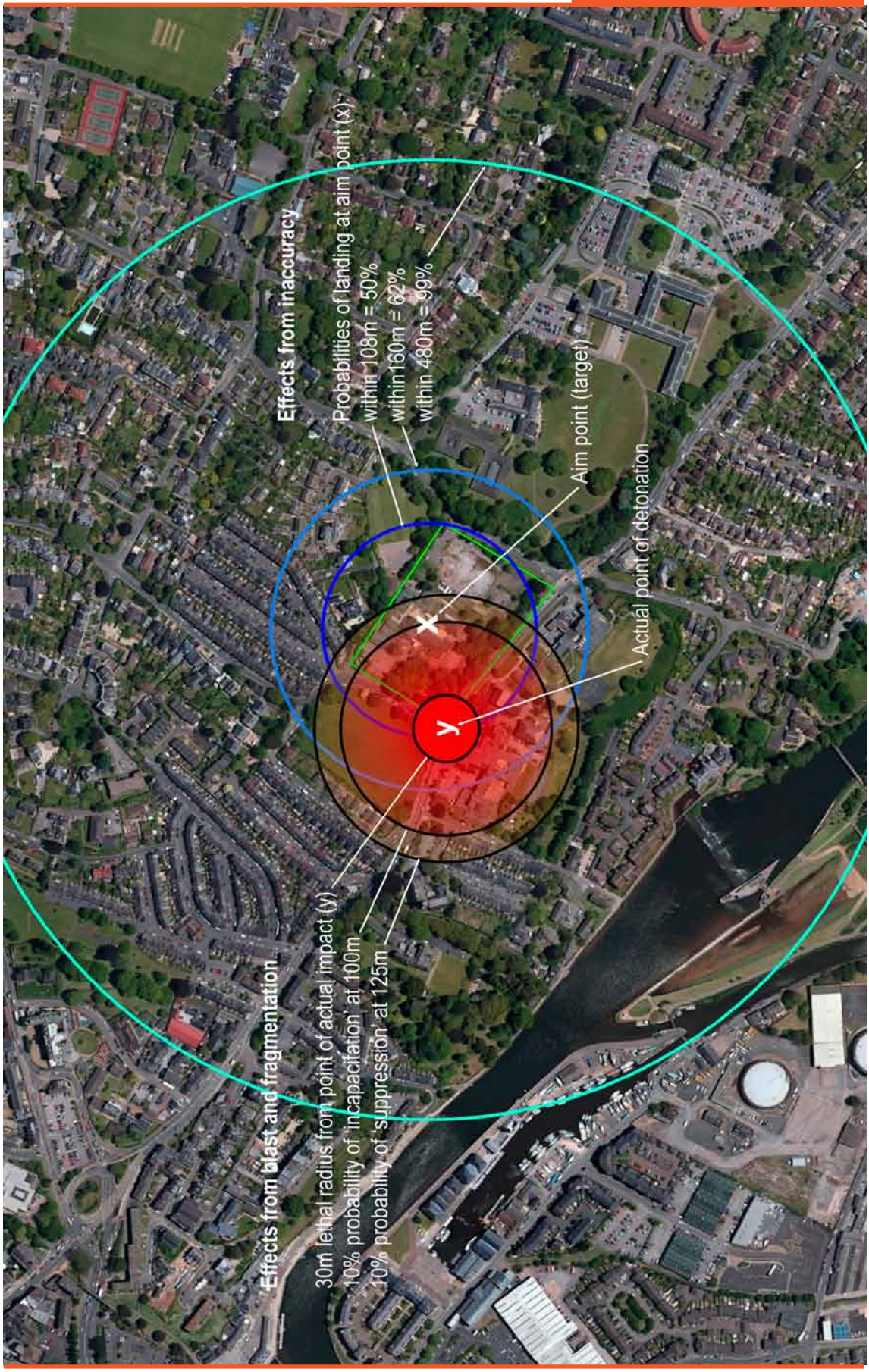


Figure 4.
120mm mortar accuracy
at closer range (2,000m)

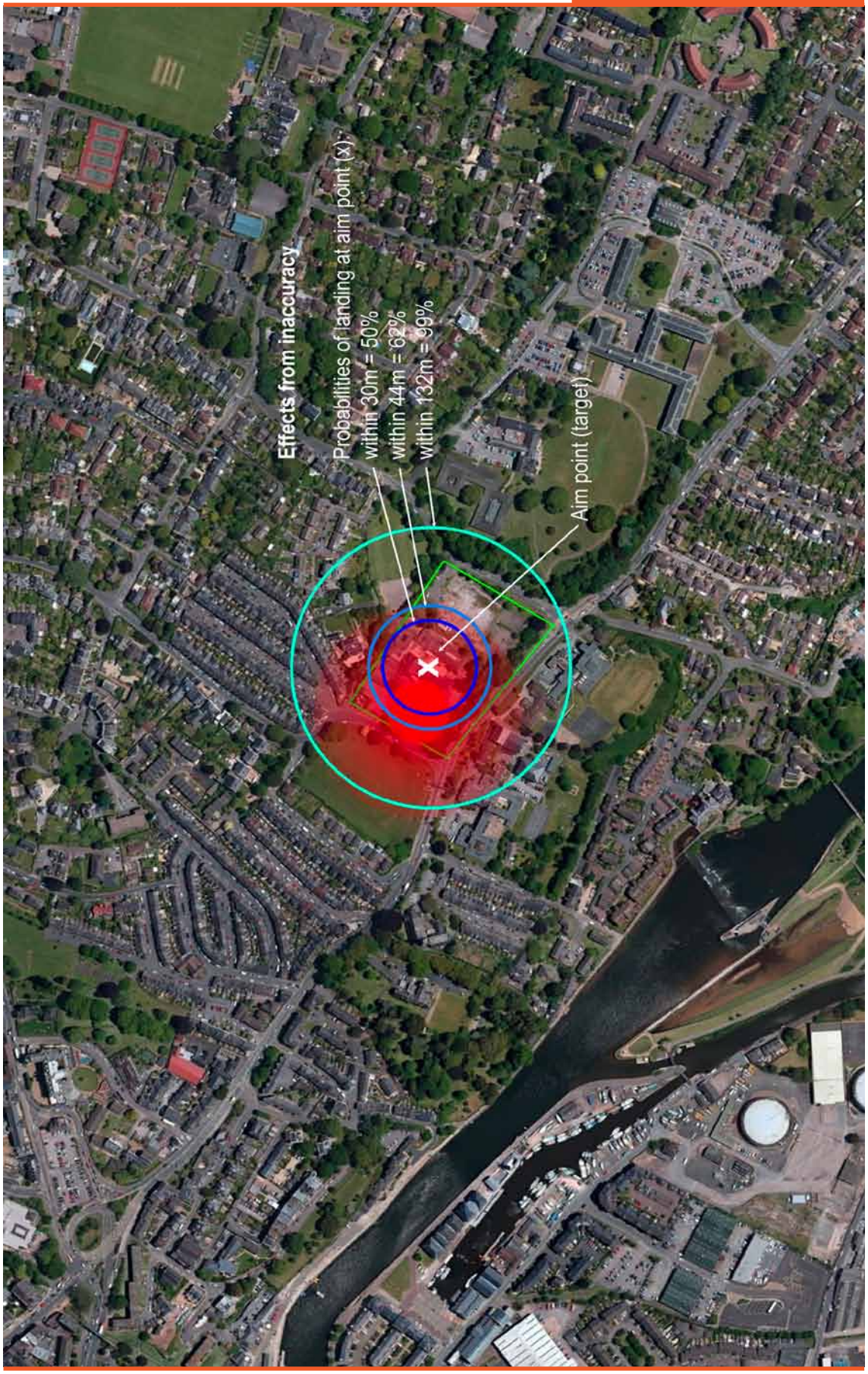


Figure 6.

122mm multi-barrel rocket system's effects at a range of 19km—single rocket

Figure 7.
122mm multi-barrel rocket system effects
at a range of 19km—40 rockets

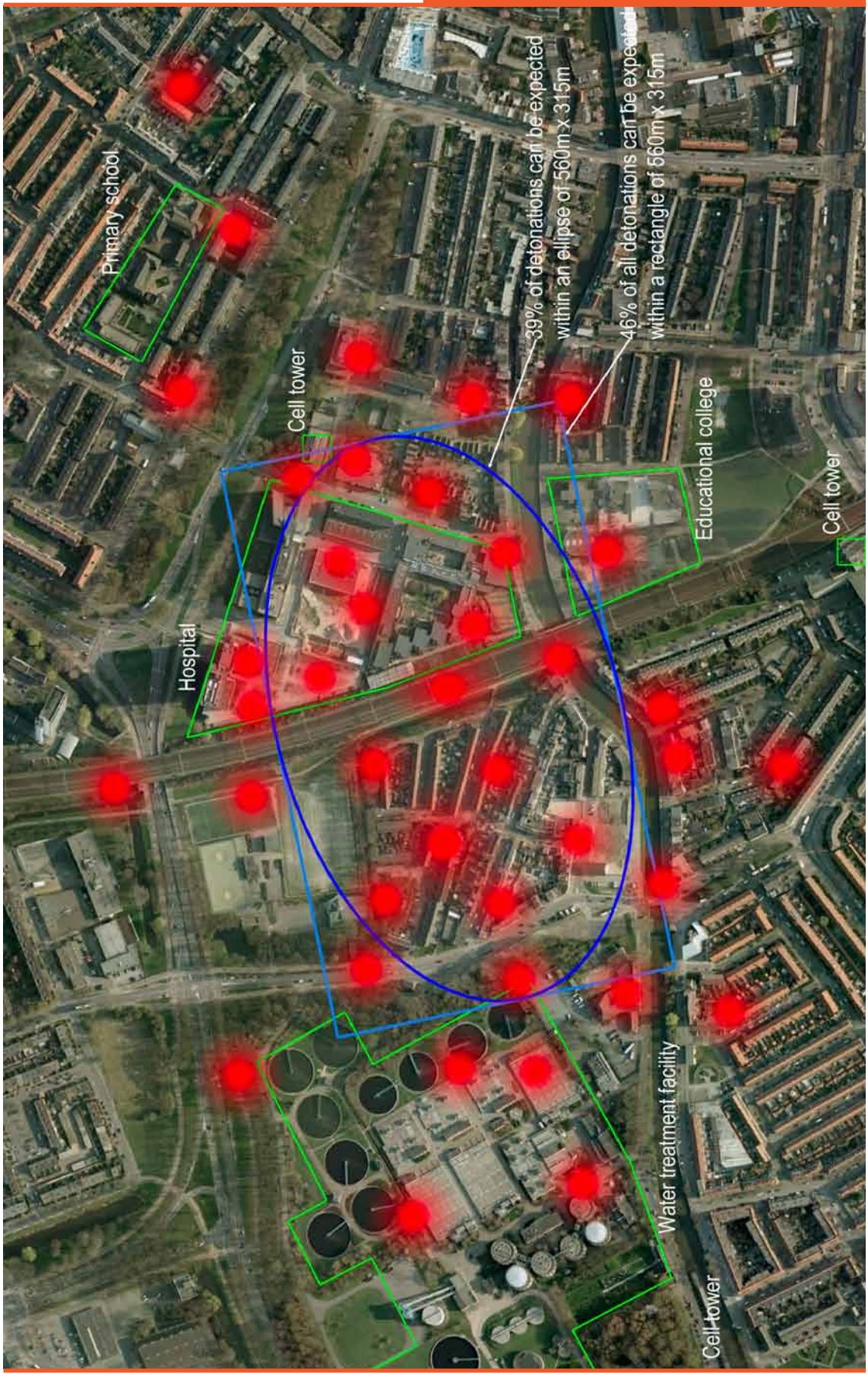


Figure 8.

Risk distances for the use of certain explosive weapons in proximity to friendly forces

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