HUMANITARIAN CONSEQUENCES

Short case study of the direct humanitarian impacts from a single nuclear weapon detonation on Manchester, UK.

Article36

SUMMARY

'One nuclear weapon exploded in one city - be it New York or Moscow, Islamabad or Mumbai, Tokyo or Tel Aviv, Paris or Prague - could kill hundreds of thousands of people. And no matter where it happens, there is no end to what the consequences might be - for our global safety, our security, our society, our economy, to our ultimate survival.'

US President Barack Obama, Prague, 5 April 2009

Whilst this case study provides only a summary of a single nuclear weapon detonation the conclusions are stark. The detonation of a 100kT warhead over the city of Manchester in the United Kingdom would create blast and thermal effects killing more than 81,000 directly, leaving more than 212,000 injured, devastating housing and commercial buildings, destroying vital infrastructure, causing massive population displacement and leaving the local emergency service capacity seriously degraded. Ongoing radiation would have further health effects and hamper any efforts at remedial action. Even outside the zones of direct damage the effects of the detonation would leave systems of communication inoperable and the local population overwhelmed by those fleeing the crisis. The capacity of emergency and health services to provide a meaningful response would be minimal and the long-term impact on the psychological, social and economic fabric of UK society would be massive.

The findings of this case study are not new. Rather it seeks to reinforce a basic understanding of the scale of humanitarian consequences that would result from any use of nuclear weapons. It is very narrow in its consideration of the humanitarian effects, and these in turn are conservatively drawn. The international humanitarian consequences of a nuclear war would be magnified many times from the impacts projected here, extending into environmental impacts that would affect populations far removed from the crisis. Yet by painting a more limited picture we are reminded, at a scale we can relate to, that the consequences of these weapons are far beyond what most people would consider acceptable.

In a context where all other weapons of mass destruction have been prohibited, and a number of conventional weapons banned also, it is a legal anomaly that weapons that create such unacceptable effects have not yet been explicitly outlawed. This anomaly persists primarily because the participation of the states currently armed with nuclear weapons has so far been treated as necessary for a process establishing such a prohibition. Allowing the legal status of nuclear weapons to be dictated only by countries that wield them is a failure of the wider international community.

Concerned states, in partnership with international organisations and civil society, should establish a legal prohibition on the use, production, stockpiling, transfer of nuclear weapons, and on assistance with such acts, regardless of the participation of the nuclear armed states. In the history of weapon prohibitions, it is normal for the change in legal status of the weapons to precede processes of stockpile elimination. In the case of nuclear weapons it is arguably necessary for such a change in legal status to occur as a spur to more serious policy revision amongst those states that continue to assert (in action if not in rhetoric) that nuclear weapons are a legitimate weapon for them to wield over human society. Those states that possess nuclear weapons will protest that a treaty prohibition on nuclear weapons, developed and concluded without them, lacks validity; but their protests will be evidence that they fear such an instrument and that it will bear upon them.

The humanitarian consequences of nuclear weapon use, even when considered most conservatively, demand that such use be explicitly made illegal. It is against a background of international illegality that efforts to eliminate nuclear weapons will most productively be pursued.

INTRODUCTION

This short case study considers basic elements of the direct humanitarian impact of a nuclear weapon detonation on Manchester, UK. The purpose of the paper is to provide a concise and accessible overview of the direct humanitarian consequences of such a nuclear weapon detonation as a contribution to national and international debates on the acceptability of such weapons. In 2012, a growing number of governments endorsed international statements arguing that due to the catastrophic humanitarian consequences their use would cause, moves should be taken to outlaw nuclear weapons.[1] This paper supports such a position; it illustrates that even a single nuclear weapon strike would cause a level of civilian harm that is unacceptable and concludes that this alone provides sufficient basis for prohibiting such weapons.

The impacts outlined in this paper are based on the use of a single 100 kiloton (100 kT) nuclear weapon targeted against central Manchester. The main conclusions, situating the humanitarian impacts in a context of wider arguments, are summarised at the beginning of the paper. The details of the scenario being examined are considered in the next section. The paper then goes on to look at the direct deaths and injuries that would result from such a strike as a result of blast, heat and fire. After that it provides an overview of the key components of societal infrastructure that would be affected by such an attack, the loss of which would contribute to longer term harms to the population. Finally we consider the health impact from radioactive fallout. Whilst this case study is primarily concerned with an 'air-burst' attack, where the weapon is detonated above the city, this section provides an analysis also for a 'ground-burst' attack – which creates a more problematic level of fallout due to the quantities of debris raised by the detonation.

It should be noted that this case study provides a highly conservative summary of humanitarian impacts. The scenario used is one of only a single detonation, where actual conflict would likely result in multiple detonations. Even within those parameters it is narrowly drawn, with a limited delineation of the wider and longer-term humanitarian effects that such a detonation would have. That this case study represents a conservative view should be clearly recognised, but the key point being made is that the humanitarian consequences described here provide sufficient basis for clearly recognising that such weapons are morally unacceptable.

1. See the Joint Statement on the humanitarian dimension of nuclear disarmament, delivered by Switzerland, 2 May 2012, on behalf of 16 countries at the First Session of the Preparatory Committee for the 2015 Review Conference to the Treaty on the Non-Proliferation of Nuclear Weapons (http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/npt/prepcom12/statements/2May_IHL.pdf) and the Joint Statement on the humanitarian dimension of nuclear disarmament, delivered by Switzerland, 22 October 2012, on behalf of 35 countries at the 67th session of the United Nations General Assembly First Committee (http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/1com/1com12/statements/22Oct_Switzerland.pdf).

SCENARIO & ASSUMPTIONS

This case study is based on a purely theoretical scenario. Its interest is not in the political models of confrontation in which nuclear weapons may be used, nor is it a contribution to civil defence planning, but rather it contributes to consideration of whether the humanitarian effects of such weapons can be considered acceptable.

THE WEAPON

A 100kT warhead is broadly representative of the size of weapon that can be found currently deployed by recognised nuclear powers. For purposes of the argument being made in this paper it should be noted that actual scenarios for deployment would utilise multiple warheads of the size considered here, and there are significantly larger warheads in current arsenals. For this reason (amongst others) the humanitarian impact described here from a single detonation is relatively conservative.

A nuclear exchange between states would likely see a much wider pattern of use, where the effects delineated in this paper (which are themselves conservatively drawn) would be subsumed into a wider national catastrophe. If a nuclear attack was being undertaken by a non-state actor it is unlikely that they would muster a weapon of this scale. However, the focus of concern here are state actors. It is states, as the entities accountable for the management of force, that have so far failed to put in place a clear legal prohibition on nuclear weapons. Through this failure, states effectively maintain the assertion that the humanitarian consequences seen in this scenario are a legitimate political and military tool.

AIR-BURST AND GROUND-BURST

Nuclear weapons can either be detonated in the air above the target (air-burst) or at ground level (ground-burst). The former creates a wider area of immediate blast effects but relatively little radioactive 'fallout'. The latter has a reduced area of blast effect but debris from the ground is pulled upwards by the detonation, irradiated and then distributed as 'fallout' downwind of the strike.

This paper is based primarily on a 100kT warhead being air-burst at an altitude of 850m (2800ft) over the centre of Manchester. Such a use provides the basis for the estimations of direct deaths and injuries as well as damage to infrastructure. However, we note in a separate section on the health impact of radiation the different impact that a ground-burst detonation would have – including the proportionally greater impact of fallout in such a scenario.

National context map indicating the zone of direct impact from a 100kT detonation over Manchester.

MANCHESTER

The city of Manchester lies within a broad urban area of some 2.68 million people, known as Greater Manchester. This is the third largest such urban area in the UK, after London and the West Midlands conurbation around Birmingham. Whilst we refer to "Manchester" in this case study the impact of the detonation considered here affects a number of areas that are distinct administrative entities, including the city of Salford. This case study does not distinguish between these administrative areas, but refers to Manchester as a short-hand for the broad area under consideration.

Manchester was chosen for this paper because it is a major UK city, but would not represent the 'worst case' scenario of a single nuclear weapon detonation in the UK. In addition, Manchester has been a leading nuclear free city. Manchester City Council first carried a resolution declaring the city a nuclear free zone in November 1980 and the Council now coordinates over 75 UK councils that form the nuclear free local authorities. Amongst other priorities, these authorities advocate for the elimination of nuclear weapons. [2]

On 15 June 1996, Manchester experienced the wide area effects of a conventional explosive weapon detonated in the city centre by the IRA. As a result of a warning and evacuation, there were no fatalities, but the 0.82 TNT ton equivalent[3] bomb left 212 people injured, and some £700 million of damage was caused across the city centre's retail area. Glass and other debris were blasted almost one kilometre away.

2. http://www.manchester.gov.uk/info/500002/council_policies_and_strategies/1130/nuclear_free_local_authorities/1
3. Converted from 1,800 lbs of TNT equivalent from FEMA 459 / April 2008, Incremental Protection for Existing Commercial Buildings from Terrorist Attack, 3.1.4
The 100kT nuclear bomb used in the scenario for this report would therefore be some 122,000 times more powerful.

SUMMARY OF METHODOLOGY AND ASSUMPTIONS

This paper provides only a basic sketch of impacts. More detail regarding methodology is available in an online annex at:

http://www.article36.org/case-study-nuclear-attack-on-manchester/

However, we note the following points on methodology and key assumptions:

- The basic methodology for determining the radii of blast impact zones is taken from Glasstone and Dolan.[4]
- The estimation of population density is based on UK Government Office for National Statistics population estimates, mid-2011.[5] Estimates of impact are made on the basis of the population densities for the Districts that make up Greater Manchester approximately proportionate to their composition of the different impact zones. In order to use this population data as a basis for casualties, it is assumed that the detonation takes place at night. A detonation during the day would have a greater humanitarian impact due to the elevated city centre population.
- The assessment of damage to infrastructure is based on a cataloguing of key facilities within the different blast zones referred to above.
- It is assumed that the detonation does not initiate a 'firestorm' in the central area of destruction. Such a phenomenon can significantly increase harm, but a 100kT detonation is on the threshold of where such an effect is likely to be triggered.
- The impact of radiation is based on fallout calculated using standardised contours as described in Glasstone and Dolan assuming a wind speed of 15 miles per hour and a set of detailed technical assumptions as given in Appendix 2 of London After the Bomb.[6]

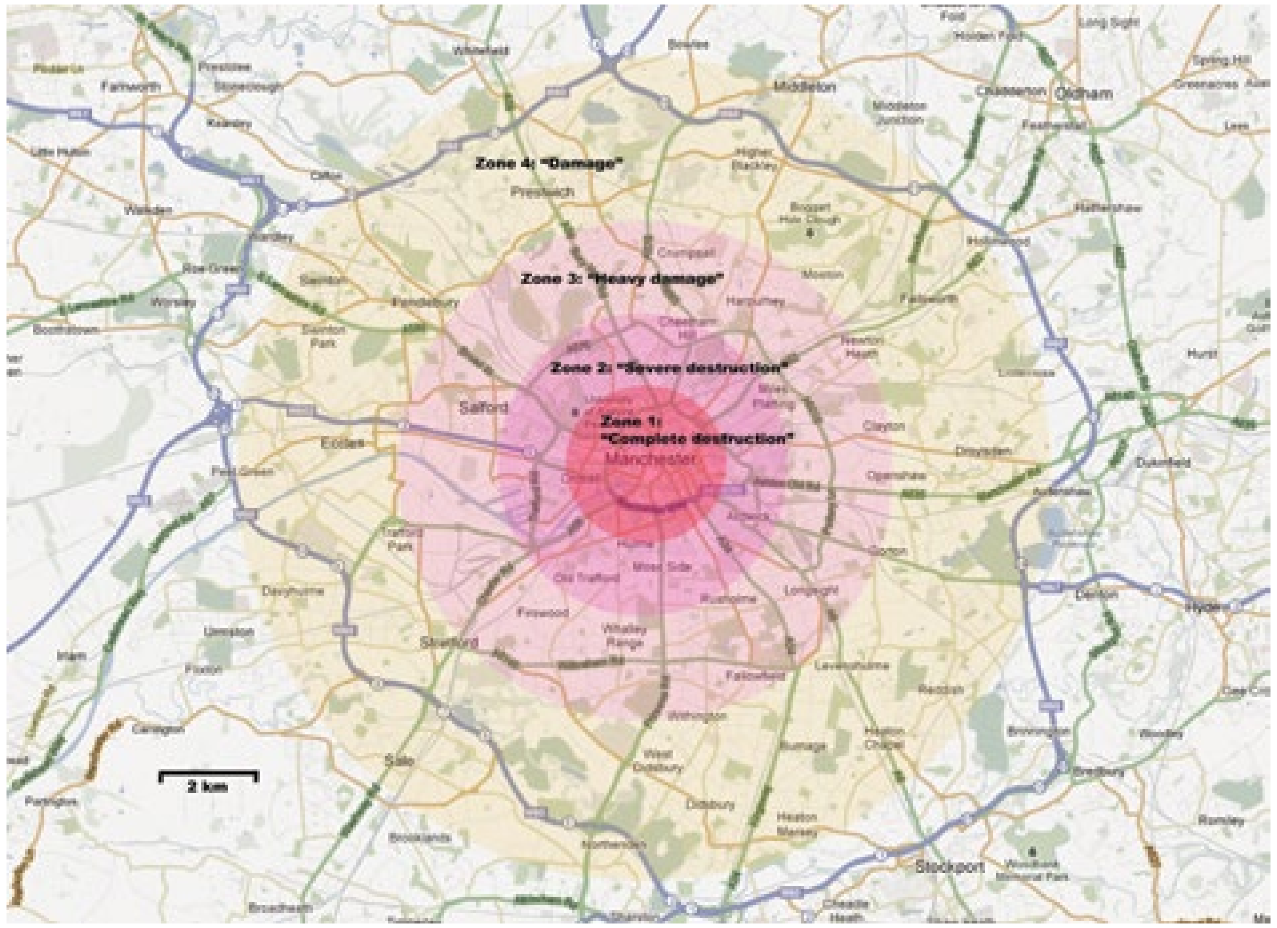
4. Glasstone & Dolan, 1980, The Effects of Nuclear Weapons, Castle Press
5. Population data online at: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-262039
6. Greene, Rubin, Turok, Webber, Wilkinson, 1982, London After the Bomb, what a nuclear attack really means, Oxford University Press (pp 104-107).

SUMMARY OF FIRE AND BLAST EFFECT ZONES FOR 100KT DETONATION AIR-BURST AT 850M.[7]

	Blast pressure (pounds per square inch)	Approximate distance from ground zero	Fire damage	Blast damage
ZONE 1 Complete destruction	>12psi	<1.26km	Steel surfaces melt, concrete surfaces explode, glass windows melt.	Bridges and multi-storey buildings destroyed. Cars and lorries blown long distances.
		1.26 - 1.8km	Aluminium window-frames melt, car metal melts.	Multi-storey concrete buildings destroyed or near collapse.
ZONE 2 Severe destruction	5-12psi	1.8 - 3km	Severe fire. Wood, roofing-felt burst into flames.	Unreinforced brick or timber-frame houses destroyed. Multi-storey concrete buildings severely damaged.
ZONE 3 Heavy damage	2-5psi	3 - 4km	Upholstery, canvas, clothing burst into flames. Painted surfaces explode.	Unreinforced brick or timber-frame houses damaged beyond repair. Telephone lines blown down.
		4 - 5km	Severe 3rd degree burns. People flash blinded by reflected light.	Timber-frame houses damaged beyond repair. Brick houses damaged but repairable.
ZONE 4 Damage	1-2psi	5 - 7km	Severe 2nd degree burns. People flash-blinded by reflected light.	Trees blown down. Brick and timber-frame houses damaged but repairable.
		7-8km	1st degree burns	Windows and doors blown in. Interior partitions cracked.
ZONE 5	<1psi	>8km		

7. Original source material in Glasstone & Dolan, 1980 , The Effects of Nuclear Weapons, Castle Press, and the summaries for damage within those zones is taken from Greene, Rubin, Turok, Webber, Wilkinson, 1982, London After the Bomb, what a nuclear attack really means, Oxford University Press. These are estimates based on several US bomb tests. In reality blast radii may easily vary by plus or minus 10%. There could be several reasons for this: topography (hills, valleys); bomb doesn't detonate at chosen altitude. Also, bomb power may be higher or lower than designed or may malfunction. Blast distances vary proportionally to the cube root of the blast power (pages London After the Bomb, pp.102-103).

Map of the Manchester area with zones of blast and thermal impact overlaid.



BLAST, THERMAL AND ELECTRO-MAGNETIC PULSE EFFECTS

The following section provides a basic summary of the direct effects as a result of blast and fire.

The detonation of a 100kT nuclear warhead above central Manchester would create blast, thermal and electro-magnetic effects killing more than 81,000 people directly, leaving more than 212,000 injured, devastating housing and commercial buildings, destroying vital infrastructure and leaving the local emergency service capacity massively degraded. Even outside the zones of direct damage the effects of the detonation would leave many systems of communication inoperable and people incapable of effective response work.

Immediately upon detonation, an intense electro-magnetic pulse is emitted, knocking out communications, some power supplies and car electronics across the greater Manchester area. This is coupled with an extremely intense flash that would flash blind anyone who looked at it or its reflected light. Within a few seconds a fierce fireball expands whilst rising quickly into the sky, forming the stalk of a characteristic mushroom cloud. People within a distance of four kilometres and in sight of the fireball would suffer third degree burns and combustible materials including cars, curtains and furnishings inside buildings are set ablaze. Shortly after, a blast wave travelling faster than sound destroys buildings and blocks roads with falling masonry, burning vehicles and other debris.

In a central zone, extending nearly 2km out from ground zero and encompassing the whole central business district of Manchester, all buildings including high-rise structures, houses, communication masts, railway stations, would be completely destroyed. Everyone in this area - around 39,000 people – would almost certainly be killed immediately or buried by a combination of fire, explosive blast and disintegrating buildings.

In a wider ring of severe destruction - out to 3km from ground zero, extending to Cheetham Hill in the north, Old Trafford and Rusholme in the south - approximately half of the population (34,000 people) are killed and most of the rest (a further 27,000) are injured, mainly through penetrating trauma, blunt impact and crush injuries and severe burns. Roads would be blocked by debris and burning vehicles.

Heavy damage extends to a distance of 5km, encompassing the city of Salford as well as Crumpsall, Longsight, Fallowfield and Whalley Range. In this area, another 9,000 people are likely to be killed and a massive 85,000 (45% of people) would be injured – for example from flying glass and masonry and from burns. Damage to buildings would be extensive.

Beyond this, damage extends to a distance of 8km, an area that takes in outlying boroughs of Eccles, Prestwich, Didsbury, Stretford and Sale and is roughly delineated by the M60 motorway that rings Manchester. Across this area, some 25% of the population (more than 100,000) would be injured, primarily from burns and flying debris from smashed windows, roof tiles and the like.

In sum, more than 81,000 people would be dead or fatally injured. A further 212,000 would be injured by a combination of cuts, bruises, crushing injuries and burns or trapped under collapsed buildings and structures. People, including surviving emergency services, would not know what had happened or where. They would not know the level of risk from radiation. Coordination of any response would be hampered by the overwhelming scale of the disaster, the huge numbers of casualties, a lack of communications (see below) and blockage of the roads by people attempting to flee the outlying areas of the city by car or on foot and, nearer the centre, blocked roads and intense fires. People would not have access to information on the fate of family members and loved ones.

ELECTROMAGNETIC PULSE

Beyond the rings of fire and devastation, those on the periphery or trying to assist would find communications and power supplies inoperable as a result of the electromagnetic pulse emitted by the detonation. Equipment connected to the electrical grid may be destroyed by the pulse. Normal communications such as mobile phones, and the internet would be inoperable and emergency services' communications would also be blocked.

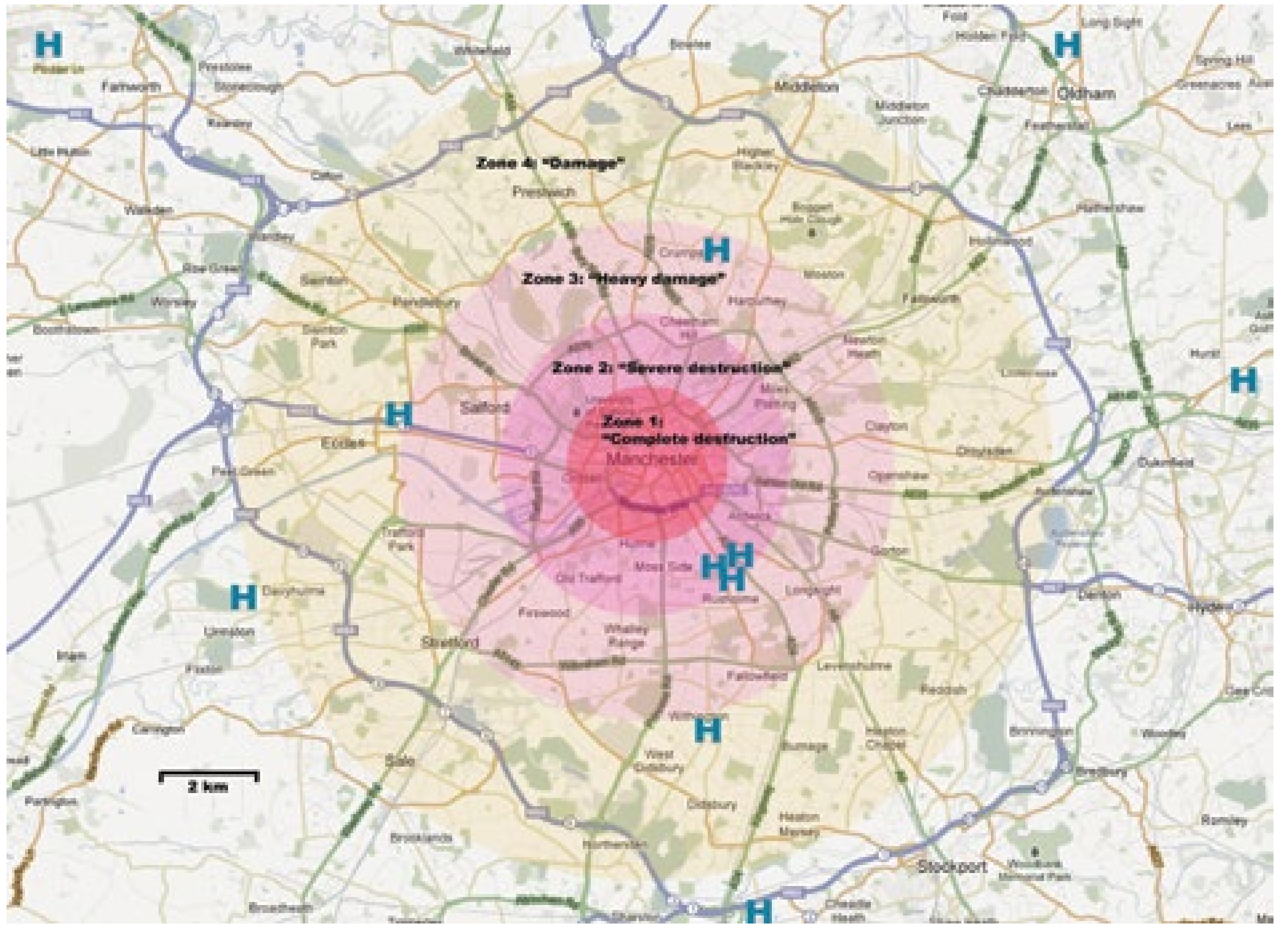
Electricity, water and gas supplies would be cut or severely disrupted and emergency back-up power where it exists (e.g. hospitals) may fail. Such effects would greatly hamper efforts to respond to the humanitarian impact experienced by those directly affected by heat and blast.

DAMAGE TO HOUSING, EMERGENCY SERVICES AND TRANSPORT

Beyond the immediate deaths and injuries, a range of other impacts would have massive longer-term implications.

Manchester has extensive emergency service provision, much of it ringing the perimeter of the urban area and so to an extent protected from the worst effects of the detonation. However, there would still be a catastrophic long-term loss of physical capacity, coupled with immediate incapacitation of the human resource base, communications and power needed to operate the facilities that physically survived the detonation.

Location of key hospital facilities in the Manchester area. Not all of those marked have an accident and emergencies capacity and other hospitals are situated outside of the area shown on this map but included in the analysis in the text.



In the summary analysis below outlying service providers can be up to 25km away from the city centre of Manchester.

Hospital facilities providing some 1,178 beds would fall within the zones of severe destruction and a further 1,420 beds would fall within zones of significant damage. This amounts to nearly 40% of the total hospital capacity across the broad Greater Manchester area and includes much of the dedicated major trauma capacity. In addition to the damage to hospitals, 8 ambulance stations also fall within zones of destruction and damage, though a further 26 ambulance stations ring the wider area. With more than 200,000 people injured the remaining facilities (themselves already operating near to full capacity under normal circumstances) would be utterly inadequate to the level of demand.

Three fire stations would fall within the zone of severe destruction and a further six in the wider zones of damage, representing some 22% of the regions' capacity. Some 17 (25%) of pumps (fire engines) would also fall within the broad zone of damage. In addition, the Fire Service HQ Command and Control, with responsibility for the coordination and management of fire service resources, and for taking the operational lead in disaster response context, is situated within the zone of damage (and so also within a wider immediate context of extensive damage to housing and injuries amongst the surrounding population.) In such a context the meaningful prioritisation of resources would be very difficult.

Some five Police Division Headquarters would fall within the broad zone of damage, providing coordination for divisional areas staffed by some 2,760 police personnel. This represents just under 50% of the capacity for the Greater Manchester area. The overall Force Headquarters is located in the zone that would be heavily damaged.

Based on a rough approximation of population data, the housing of some 106,000 people would fall within zones of complete or severe destruction. Housing of a further 588,000 people would be in areas of heavy or significant damage. For those not killed (more than 600,000 people) the damage to housing, failure of essential services and residual risks from radiation and other toxic remnants would result in massive displacement. This in turn would have an overwhelming impact on the population and facilities of surrounding areas.

The international airport is situated some 11km from the city centre, and would likely remain physically undamaged. As with many cities the main railway stations lie at the edge of the central business district, and thus the railway network would be particularly badly hit. All of the main train stations and central bus stations serving Manchester would fall within the zone of complete destruction. Manchester's tram network, Metrolink, has three main lines, which run from north of the city to the south and west, all of which cross central Manchester and would therefore be rendered inoperable. Most of the rolling stock operating out of Manchester would fall within the area of severe destruction. The Trafford Park World Freight Centre is the largest road/rail freight interchange in the UK outside London and would be heavily damaged. The M60 motorway that encircles Manchester lies roughly on the periphery of the zone of damage. Whilst not structurally damaged significantly sections would likely be obstructed by debris.

ADDITIONAL LONGER-TERM IMPACTS AND LOSSES

In addition to the loss of life, and degradation of capacity to respond to those losses, and a legacy of massive long-term humanitarian suffering, the detonation would also devastate cultural, social and economic resources that are at the heart of the region. Manchester is an economic centre for culture, media, real estate, financial services, legal services and manufacturing. The destruction of this urban centre would represent an unprecedented social and cultural loss, and would create unpredictable economic shocks.

A significant proportion of the city's cultural and sporting heritage, including the facilities of Manchester City and Manchester United football clubs, would be destroyed or badly damaged. The zones of complete or severe destruction would include major art galleries, museums, theatres, the cathedrals of Manchester and Salford and other religious buildings and major international sporting venues. There are three universities in Salford and Manchester[8] clustered around the city centre. The main campuses of the three universities would all fall within the zones of complete or severe destruction.

Greater Manchester is a major economic centre within the UK. Investment and reconstruction following the 1996 IRA bombing has seen a major programme of regeneration across the city and the surrounding area. The region generates £48 billion in Gross Value Added, a measure of localised economic output, which is more than one third of the whole North West region. The urban area is home to over 93,000 businesses.[9]

The city has a thriving and growing tourism and leisure economy, hosting over 1 million visitors per year and with a value of £5.8 billion annually.[10] It is also a major conference centre, with more than 5 million delegates attending conferences in the city each year. It is a leading employer in the UK in various sectors, with the largest financial and services sector outside London, a major education centre employing over 100,000 people, and a growing Creative and Digital centre.

The region remains a major manufacturing area for the UK, with over 38,000 employees working in the sector. Large companies with national or regional headquarters in Greater Manchester include Guardian Media Group, Siemens, the Co-operative Group, Kellogg's and the BBC.[11]

Specific infrastructure that would be greatly impacted by a detonation include the MediaCityUK, the home of much of the creative and digital industry, commercial centres including the Trafford Centre (the sixth largest shopping and commercial centre in the UK[12]), and the headquarters of the Co-operative Group, which employs 8,000 people in Manchester.[13] A huge number of hotels, conference centres, business headquarters and economic real estate would be destroyed or heavily damaged in the event of a nuclear detonation, with an enormous impact on economic production, development and growth.

RECONSTRUCTION

In the longer term, clearing up the devastation of the city centre would be hampered by fear of radiation, though this would likely be less acute as a result of an air-burst rather than a ground-burst detonation. Painstaking survey work would be needed to determine any areas where radiation presented a continued risk.

8. Manchester University, Salford University and Manchester Metropolitan University
9. Greater Manchester Key Facts 2012, New Economy. Available http://neweconomymanchester.com/stories/1660-greater_manchester_key_facts. GVA is a measure of the value of goods and services produced in an area, for figures see http://www.ons.gov.uk/ons/rel/regional-accounts/regional-gross-value-added–income-approach-/december-2012/stb-regional-gva-2011.html#tab-Sub-regional–NUTS2–and-local–NUTS3–estimates
10. http://www.marketingmanchester.com/media-centre/press-releases/5th-march-2012.aspx
11. Greater Manchester Key Facts 2012, New Economy. Available http://neweconomymanchester.com/stories/1660-greater_manchester_key_facts
12. http://en.wikipedia.org/wiki/Trafford_Centre
13. http://www.topcompanies.co.uk/subdomains/manchester/manchester_major_employers.html

HEALTH IMPACT OF RADIATION

The following section provides an indication of the radiation effects of a nuclear weapon detonation.

In addition to blast and thermal effects on health, nuclear weapons also produce radiation that can be lethal to affected populations and makes responding to the crisis significantly more difficult due to its potential threat to the health of those in the contaminated environment.

IMMEDIATE RADIATION EFFECTS

Prompt radiation, released in the seconds immediately after detonation, severely affects people within a radius of approximately 2km from ground zero. Radiation doses within this area can be sufficient for 50-90% mortality. However, given the high levels of mortality within this zone from the blast and thermal effects of the detonation, this component of mortality is subsumed within those effects for the model presented here. So although the prompt radiation would in many cases be sufficient for a lethal dose, the people affected would die sooner from the violent effects of the intense fireball, blast and fires.

RADIOACTIVE FALLOUT

For an air-burst weapon as described in this case study, the effects of radioactive fallout are relatively limited and we do not factor fallout into the casualty figures presented here. However, for a ground-burst detonation, fallout would be a significant contributor to overall mortality. Notes on this are presented overleaf.

GROUND BURST DETONATION

FALLOUT FROM A GROUND-BURST DETONATION

If a 100kT bomb was detonated at ground level, the areas of blast and heat destruction zones are reduced to approximately half of those used in the analysis above, as a result of the ground shielding the blast wave. However, a detonation at ground level lifts huge quantities of earth and debris into the explosion as it develops. A plume of highly radioactive fallout (deposited debris) then spreads downwind. This material can result in a fatal dose of radiation, killing for many kilometres downwind or in areas of rainfall after the explosion.

In the case of a 100kT ground-burst detonation, a lethal “finger” of fallout could kill anyone even inside their house up to 13 kilometres downwind. Theoretically this “finger” would be approximately one kilometre wide, but in reality wind and rain could drop lethal radiation in a wide area downwind. Beyond the worst blast damage areas (i.e. within 3 kilometres of ground zero) the lethal fallout area would still be 10km long and 1km wide (10 sq km). Using the Borough of Manchester’s average urban population density of 4,349 people per sq km this suggests that more than 40,000 people could die from fallout radiation over a period of 2 weeks or more. Children and the elderly would be most at risk, along with people who have existing medical conditions. In the case of those aged under 14 or over 70, those with medical conditions and/or in lighter weight housing that offers less physical protection, the width of the lethal finger is effectively extended.

The people affected would not know that they had received a lethal dose and would experience nausea, vomiting, diarrhoea and a range of other extremely severe symptoms before death. Other people would receive non-lethal doses but experience similar symptoms and suffer long-term impairments to their health.

An analysis of immediate blast and thermal casualties from a 100kT ground-burst suggests some 41,000 killed. Where these are combined with the mortality projections from fallout indicated here the projected level of deaths totals approximately 81,000, equivalent to the immediate deaths suggested for an air-burst detonation.

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