Reducing the Consequences of a Nuclear Detonation.

B. R. Buddemeier

November 12, 2007

Threats At Our Threshold: Securing And Defending The United States In The 21st Century
Army War College, PA, United States
November 14, 2007 through November 15, 2007
Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.
Reducing the Consequences of a Nuclear Detonation.

By Brooke Buddemeier, Lawrence Livermore National Laboratory
Conference On Threats At Our Threshold: Securing And Defending The United States In The 21st Century, November 14 & 15, 2007

ABSTRACT

The 2002 National Strategy to Combat Weapons of Mass Destruction states that “the United States must be prepared to respond to the use of WMD against our citizens, our military forces, and those of friends and allies.” Scenario #1 of the 15 Department of Homeland Security national planning scenarios is an improvised nuclear detonation in the national capitol region. An effective response involves managing large-scale incident response, mass casualty, mass evacuation, and mass decontamination issues. Preparedness planning activities based on this scenario provided difficult challenges in time critical decision making and managing a large number of casualties within the hazard area. Perhaps even more challenging is the need to coordinate a large scale response across multiple jurisdictions and effectively responding with limited infrastructure and resources.

Federal response planning continues to make improvements in coordination and recommending protective actions, but much work remains. The most critical life-saving activity depends on actions taken in the first few minutes and hours of an event. The most effective way to reduce the enormous national and international social and economic disruptions from a domestic nuclear explosion is through planning and rapid action, from the individual to the federal response. Anticipating response resources for survivors based on predicted types and distributions of injuries needs to be addressed.

INTRODUCTION

The Cold War specter of strategic thermonuclear war and mutually assured destruction, with the possibility of hundreds of nuclear strikes on our major cities and the majority of the United State covered with lethal fallout is thankfully greatly diminished. However the possibility of nuclear terrorism still exists through the use of a relatively crude, low yield nuclear device in a modern city. The United States government has made impressive investments to prevent this through non-proliferation activities overseas and by improving our ability to detect such a device as it moves across or within our borders. Even so, as stated in the 2002 National Strategy to Combat Weapons of Mass Destruction; the United States must be prepared to respond to the use of WMD against our citizens, our military forces, and those of friends and allies. We will develop and maintain the capability to reduce to the extent possible the potentially horrific consequences of WMD attacks at home and abroad.”

If a nuclear detonation were to occur in a modern US city, the greatest reduction of casualties is achieved through actions
taken by citizens themselves and their state and local officials. The most critical decisions are those made in the first few minutes. Unfortunately the “potentially horrific consequences” of a domestic nuclear explosion are exactly the reason that preparing for it seems impossible. Many consider such an event to be so catastrophic that local response planning may be useless. There is a misguided impression that there would be no responders left after the detonation or that the initial response would be a federal government responsibility. Without planning, this might be a self fulfilling prophecy with hundreds of thousands of additional potential casualties as a result. By the nature of their work, response organizations are distributed throughout a community and the vast majority of the response base would survive. However, without a basic level of large-scale emergency planning, these response organizations will not know how to apply their skills safely and effectively. Although considerable federal capabilities exist, it is unlikely that comprehensive assets would arrive in the first day and may be further delayed by national actions to prevent or mitigate further attacks.

NUCLEAR DETONATION EFFECTS

The basic anatomy of a nuclear explosion is well known and documented in literature such as Glasstone’s *The Effects of Nuclear Weapons*¹ and NATO documents². Mitigating the impact of a domestic nuclear explosion requires a basic understanding of key effects. These effects can be broken into two main components: prompt and delayed. As an example, the effects identified below are approximate for a 10 kiloton (kt) nuclear explosion in a large city like Washington, DC. This is consistent with the national planning scenario #1 and with early nuclear weapons such as those used on Hiroshima and Nagasaki.

Primary among prompt effects is blast. A 10kt explosion is equivalent to 5,000 truck bombs like the one used to destroy the Murrah building in the 1995 Oklahoma City bombing³. Blast will damage or destroy most buildings within ½ mile of the detonation location and it is unlikely that the population in this area would survive. From a ½ mile to about a mile out, survival will mostly likely depend on the type of structure a person was in when the blast occurred. Even at a mile, the blast wave will have enough energy to overturn some cars and severely damage some light structures.

A mile from the detonation is also the approximate distance that a person outdoors could get a significant exposure of initial ionizing radiation. The closer to the detonation point, the higher the exposure. The same is also true for an outdoor individual’s exposure to the thermal pulse from the detonation, which may also cause burns to exposed skin out to this range and possibly further on a day with good visibility. Both of these effects are reduced for people inside buildings.

In addition to ionizing and thermal radiation, the detonation creates a brilliant flash of light that can cause temporary blindness to those outdoors over 5 miles away. This effect could go further if there is good visibility, clouds to reflect the light, or if the event occurs at night. “Flash blindness” can even occur if the victim is not looking in the direction of the detonation. It can last
several seconds to minutes. Although this effect does not cause permanent damage, the sudden loss of vision to drivers and pilots could cause a large number of traffic casualties and make many roads impassable.

Another, poorly understood, long range prompt effect is glass breakage. Most of the injuries outside of the Murrah building in the 1995 Oklahoma City bombing were caused by this phenomenon. Extrapolating from more recent work on conventional explosives, a 10kt explosion could break certain types of windows (e.g., large monolithic annealed) over 8 miles away. Also noted in this same study was the tendency for glass to fail catastrophically even at extreme ranges, causing severe injury to those behind it. NATO medical response planning documents for nuclear detonations state that “… missile injuries will predominate. About half of the patients seen will have wounds of their extremities. The thorax, abdomen, and head will be involved about equally.” A significant number of victims from Nagasaki arriving at field hospitals exhibited glass breakage injuries.

Other effects, such as the electromagnetic pulse (EMP) and fires, also need to be considered in response planning. For a ground level detonation most EMP effects will be limited to within a mile, with a few, random, longer range disruptions occurring out to a few miles. Although the possibility of a “firestorm” is unlikely given modern construction, there will be a large number of small, disparate fires started from thermal and blast effects (generally around the 1 mile perimeter) which could spread and coalesce if not mitigated.

The primary delayed effect from a ground level nuclear detonation is from “fallout.” Fallout is generated when the dust and debris excavated by the explosion is combined with radioactive fission products and drawn upward by the heat of the event. This cloud rapidly climbs through the atmosphere, up to 5 miles high for a 10kt, and highly radioactive particles coalesce and drop back down to earth as it cools. It is important to note that Hiroshima and Nagasaki did not have significant fallout because their detonations occurred at altitude.

The hazard from fallout comes not from breathing the particles, but being exposed to the ionizing radiation they give off after they have settled on the ground and building roofs. Radiation levels from these particles will drop off quickly, with most (55%) of the potential exposure occurs in the first hour and 80% occurs within the first day. Although it is highly dependant on weather conditions, the most dangerous concentrations of fallout particles (i.e., potentially fatal to those outside) occur within 10 miles downwind of the event and are clearly visible as they fall, often the size of fine sand or table salt.

Unlike prompt effects which occur too rapidly to avoid, fallout health impacts can be mitigated by leaving the area before it arrives or by sheltering. Although some fraction of ionizing radiation can penetrate buildings, the 1) shielding offered by walls and 2) distance from outdoor fallout particles can easily reduce exposures by a factor.
of ten or more for urban buildings (see Table 1).

**Table 1: Transmission factors for various shelter locations**

<table>
<thead>
<tr>
<th>Shelter Location</th>
<th>Transmission Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-feet Underground</td>
<td>0.0002</td>
</tr>
<tr>
<td>Frame House</td>
<td>0.3-0.6</td>
</tr>
<tr>
<td>Basement</td>
<td>0.05-0.1</td>
</tr>
<tr>
<td>Vehicle</td>
<td>0.5-0.7</td>
</tr>
<tr>
<td>Apartment (Upper stories)</td>
<td>0.01</td>
</tr>
<tr>
<td>Apartment (Lower stories)</td>
<td>0.1</td>
</tr>
<tr>
<td>Concrete Blockhouse</td>
<td></td>
</tr>
<tr>
<td>9-inch walls</td>
<td>0.007-0.09</td>
</tr>
<tr>
<td>12-inch walls</td>
<td>0.001-0.03</td>
</tr>
</tbody>
</table>

The smaller the transmission factor, the lower the dose that a sheltered person would receive compared to an unsheltered person in the same area. For example, a person in the lower stories of an apartment building would receive only 10% of the dose that someone outside would receive. Someone on the upper floors would receive only 1% of the dose. In fallout areas, this could determine whether someone lives or dies.

**LACK OF GUIDANCE**

Although it may be initially unsafe for responders to enter significant fallout areas, the majority of prompt effects survivors will not be in these contaminated areas. Most response organizations lack fundamental awareness and planning to understand a nuclear event. Given a daytime population density of a city like Washington DC, initial casualties could easily be in the hundreds of thousands and timely medical intervention could greatly improve the prognosis of the injured

Unfortunately response planners face a lack of federal guidance and scientific consensus on the correct actions to take. The 2006 Federal Register Notice published by the Department of Homeland Security\(^\text{17}\), which clarified how existing protective action guidance can be applied for radiological and nuclear terrorism, did not specifically address guidance for the acute effects of a domestic nuclear explosion\(^\text{18}\).

The Cold War civil defense program can help with some insights and advice, but many of the paradigms no longer apply. For example, the concept of a fallout shelter worked well with a few minutes warning of incoming missiles but is far less effective for an attack with no notice. There also appears to be a lack of scientific consensus on the appropriate actions to take after a nuclear detonation. The recommendations of the Department of Homeland Security’s Ready.gov, which are consistent with the recommendations of the National Academy of Sciences\(^\text{19}\), were recently criticized by the Federation of American Scientists\(^\text{20}\) because of conflicting recommendations with a RAND study\(^\text{21}\)\(^\text{22}\).

Work needs to be done to update our Cold War guidance to address the asymmetric threat we now face. Both our society and our cities have changed significantly over the last half century and new preparedness guidance is required.

The issue is gaining attention in Washington, as stated in House Report 110-107\(^\text{23}\): “The conferees are concerned that cities have little guidance available to them to better prepare their populations to react in the critical
moments shortly after a nuclear event.”
This report also provided direction to the Department of Homeland Security and the Department of Health and Human Services to improve preparedness programs for responding to a nuclear attack.

UPDATING PREPAREDNESS

The Department of Homeland Security has extensive preparedness activities, including preparedness grants to states and urban areas totaling billions of dollars. The Department’s preparedness programs and strategies favor an “all hazards approach” that stresses mitigating the effects of a variety of events\(^24\). In this regard, preparedness for the low yield nuclear detonation scenario will create important capabilities for a number of catastrophic events that require:

- coordinated regional response,
- time critical decision-making,
- mass casualty response,
- crisis communication, &
- resource prioritization.

As noted above, the sheer number, type, and distribution of injuries around a detonation represents a significant challenge to public health and emergency medical response. Technical issues and uncertainty regarding contamination also complicate the medical response. In order to be effective, concepts such as field triage, reception centers, field hospitals, and resource prioritization need to be considered in advance. With the large number of prompt injuries, methods to stabilize and identify viable patients will be essential. There will be insufficient resources to treat everyone, and prioritization planning will be required to respond and help a community manage mass casualty events.

CONCLUSION

Preparing a response to national planning scenario #1 can help bring a region together to address a number of difficult issues. The capabilities gained through this process can facilitate an effective response to a variety of natural and manmade catastrophic events involving large-scale incident response coordination, mass casualty, mass evacuation, and mass care.

However, before preparedness activities like those identified by Congress\(^{23}\) can begin, scientific consensus and federal guidance must be developed to support preparedness planning strategies.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.


11 Noland, R. & M. Quddas, 2004, Improvements in medical care and technology and reductions in traffic related fatalities in Great Britain. Accident Analysis and Prevention, 36.


