TITLE:	National Capital Region Prompt Effects Summary
REQUIREMENT:	Personnel will be informed on the prompt effects and concerns that follow detonation of an improvised nuclear device
TARGET GROUP:	Radiological emergency responders and planners at the local, state and federal levels
TIME ALLOTTED:	30 minutes
INSTRUCTOR (s):	Brooke Buddemeier, Annmarie Wood-Zika, Priya Doshi
METHOD OF INSTRUCTION:	Presentation
INSTRUCTOR (s):	Health Physicist with Response Experience
METHOD OF INSTRUCTION:	Presentation

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Erika Olsen & Shaida Arbabha, DHS Scholars at LLNL
Date: *July 2011*

Please provide feedback for these draft documents to brooke2@llnl.gov

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Instructional Goal

This module is intended to give an overview of the prompt effects that follow detonation of an IND. This includes injury, structural damage and prompt radiation and thermal exposure.

Instructional Objectives

- Define prompt effects from a low-yield nuclear explosion
- Define Planning Guidance (damage) zones
- Review recent studies and current understanding of nuclear effects
- Review response strategies

At the completion of training, the trainee will be familiar with:

The different types of prompt effects following detonation of an IND, as well as know the Planning Guidance damage zones.

Handouts

Student Guide

References

National Response Framework, Department of Homeland Security, January 2008.

Planning Guidance for Response to a Nuclear Detonation, Developed by the Homeland Security Council Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats.

Trainee Preparation

This presentation is the second in a series, Previously covered material Includes:

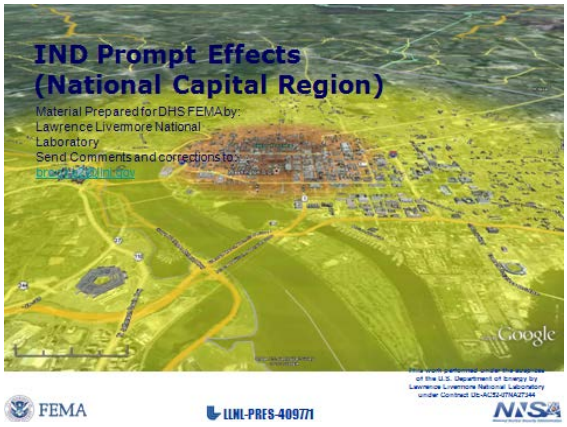
- Nuclear Detonation Modeling and Response Planning

0- INTRODUCTION – Introduce Presenter and summarize experience and qualification

National Capital Region Prompt Effects Summary

- Introduce yourself
- Explain your background
- Why you are giving the presentation

Define presentation objectives



Objectives

- Define prompt effects from a low yield nuclear explosion
- Review recent studies and current understanding of nuclear effects
- Define planning guidance zones
- Review response strategies

FEMA LLNL-PRES-409771 NNSA

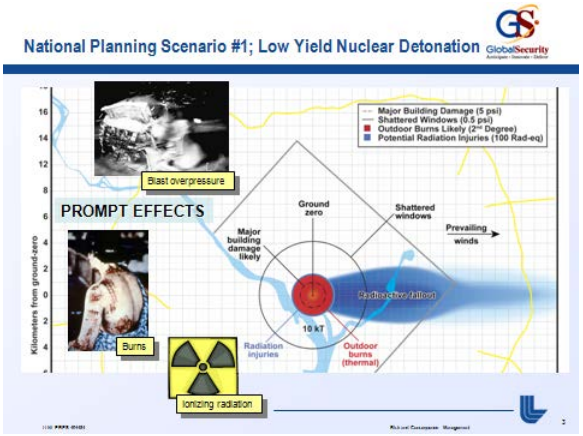
1. Defining Different Effects

National Planning Scenario # 1 is a 10kT nuclear detonation in downtown DC. An overview of the basic effects can be seen in this image.

This module will focus on the prompt effects from a low yield nuclear detonation. **Prompt Effects are those that radiate outward from the detonation site. It includes:**

- Light and thermal radiation
- Blast wave and shock effects
- Radiation given off during the criticality and first minute of fission products
- Electro-magnetic pulse

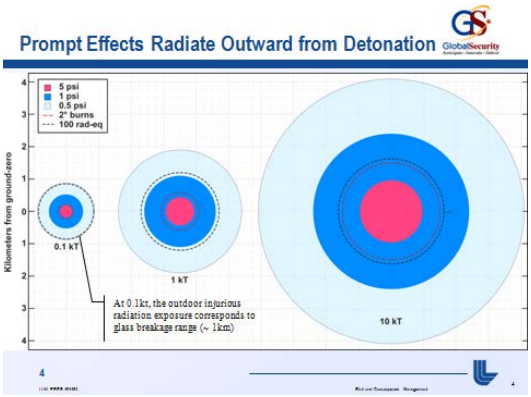
Fallout Effects and Properties will be discussed in a separate module



Prompt Effects

The magnitude and *relative* range of these effects change with yield.

As can be seen on this figure, blast effects (represented by the red, blue, and light blue solid colors) and Thermal Effects (red dashed line) scale together with changing yield, however prompt radiation effects ranges contract much more slowly with decreasing yield make prompt radiation the more dominant prompt effect at very low yields like 0.01kT



The following slides represent the "Prompt Effects" in the scenario of a 10 kT improvised nuclear device being detonated in downtown.

- **Click – Light of a Thousand Suns…appears**

The detonation of an improvised nuclear device would produce a flash of light that is equivalent to a thousand mid-day suns at a mile away.

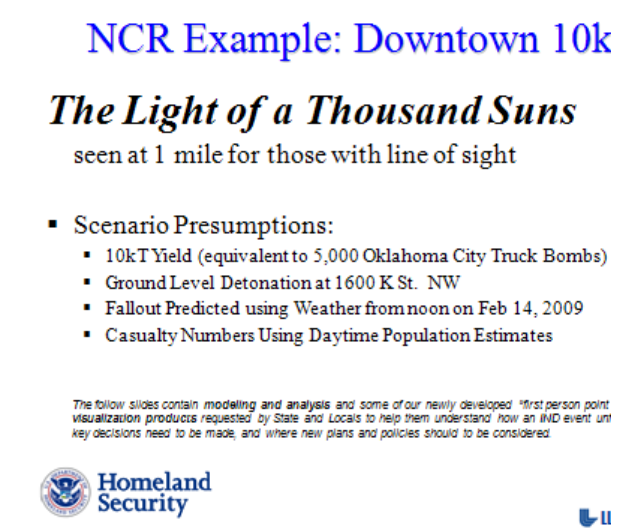
A 10kT yield is about equivalent to the explosive power of 5,000 Oklahoma City Truck Bombs

For this scenario, we used;

- The detonation took place on the ground level at 1600 Kst NW
- The population estimates are based on a typical workday
- The weather profile is taken from actual weather conditions on Feb 14, 2009

The information from these slides may be used to model a detonation in other large cities, although similar response planning information guides are being created for other Tier 1 cities.

- **Slide Transition –Animation on flash blindness begins**



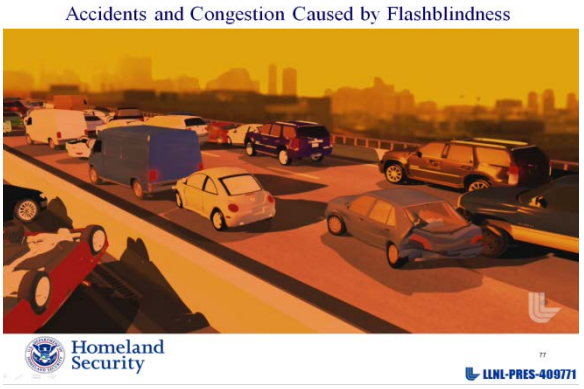
2- Prompt Effects

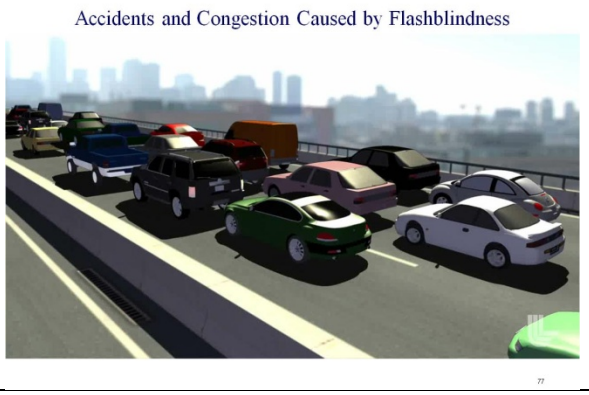
Flash Blindness

The bright flash of light produced by the Detonation of an IND can temporarily blind anyone who sees it within a few miles. This blindness may last for several seconds to, perhaps, minutes. Not a big deal if you are standing on a street corner, but could be a pretty big deal if you are driving 60mph down the freeway. We can expect most roads within a 10km range to be snarled with accidents and many injuries would occur.

Slide Transition –Animation of zoom-out begins

- It can expected that most roads within about a six mile range will be snarled with accidents and many injuries would occur.
- The potential for flash blindness would be worse at night time, and could cause accidents much further out.





Severe Damage Zone

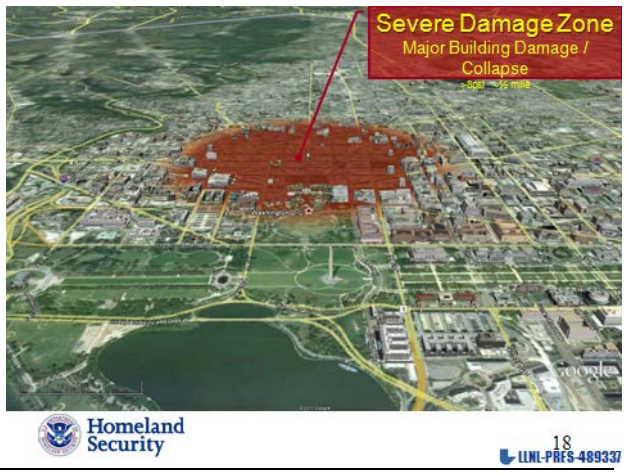
Blast effects are the damages/injuries done to structures/people following detonation.

Click –Severe Damage Zone appears

The Severe Damage Zone extends to about half a mile from the blast site. This zone will see severe structure damage from the initial blast wave, and most likely fatal injuries from the blast, thermal pulse, and prompt radiation.

{note: buildings in the SDZ will disappear from image after a second}

For a 10KT, this would extend about ½ a mile



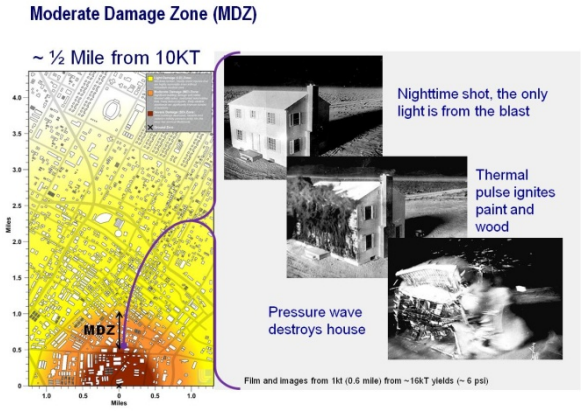
Outer Edge of Severe Damage Zone to the Moderate Damage Zone

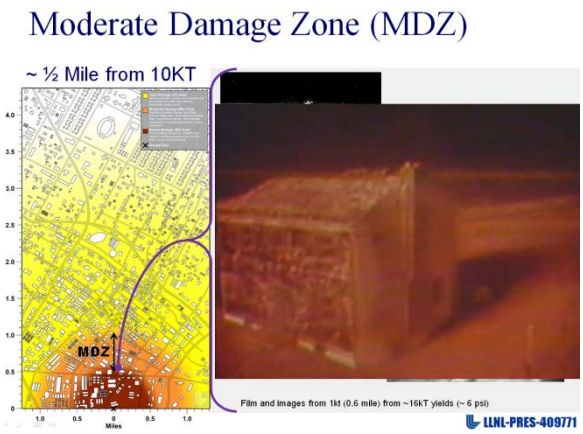
Although this zone has the most potential for saving lives, the closer responders go towards the Severe Damage Zone, the less likely they are to find survivors. Structures close to the Severe Damage Zone are less likely to remain standing.

These pictures, from a test detonation in the Nevada desert, demonstrate the damage done to buildings near the Severe Damage Zone.

Click –Video of detonation begins

The initial thermal pulse, which originated one mile away, starts the house on fire. The blast wave comes first as positive pressure which rips the house apart. This is followed by negative pressure moving the opposite direction. Severe radiation and burn injuries will occur, especially to those outdoors.





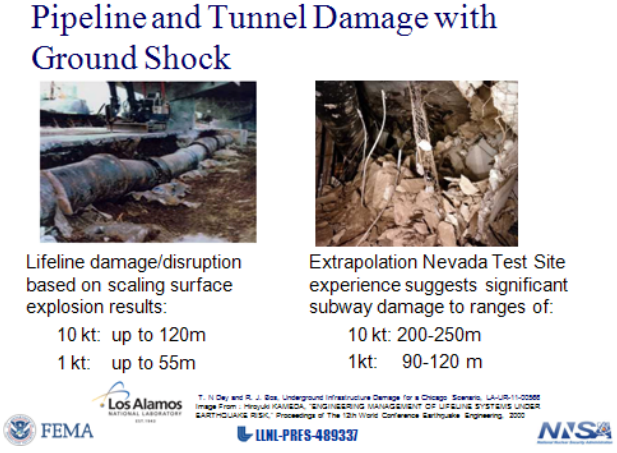
Underground Damage

The shockwave movement underground also creates damage to tunnels, such as subway systems , and infrastructure such as water mains, power, telecommunications, and gas conduits.

Analysis by Los Alamos National Laboratories using data from nuclear tests at the Nevada Test Site and extrapolation from earthquake damage of the effects on these systems indicate that:

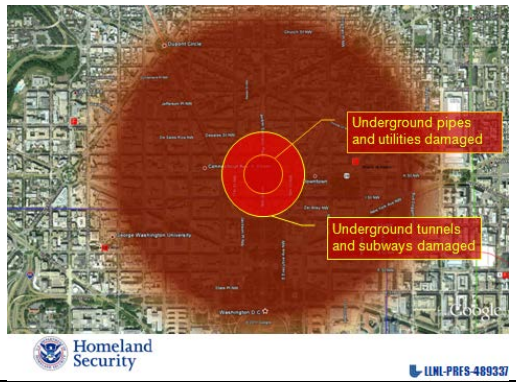
Water, power and Telecommunication conduits may be damaged out to 120 meters from a 10 kT surface detonation.

Larger tunnels, such as subway systems may be damages out to 250 meters (~ 2 city blocks) from a 10kT.



Underground Damage in comparison to Above Ground Damage

Since the Severe Damage Zone extends ~ ½ mile (~800m), this means that the primary underground infrastructure damage is contained by the Severe Damage Zone



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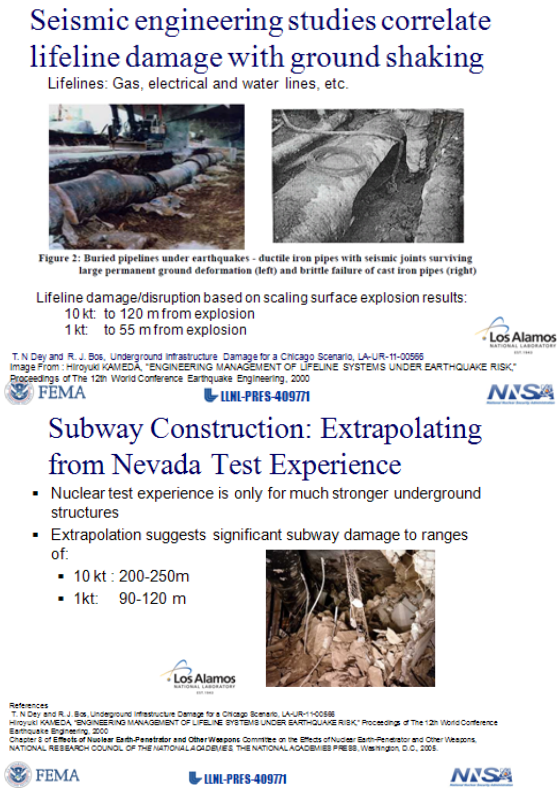
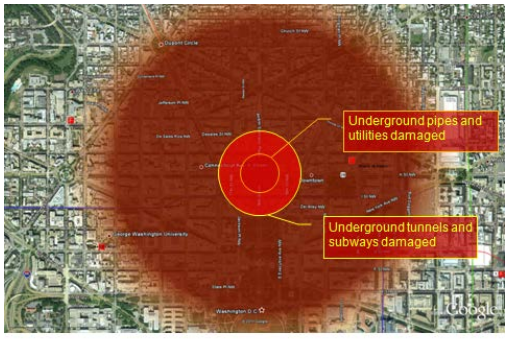




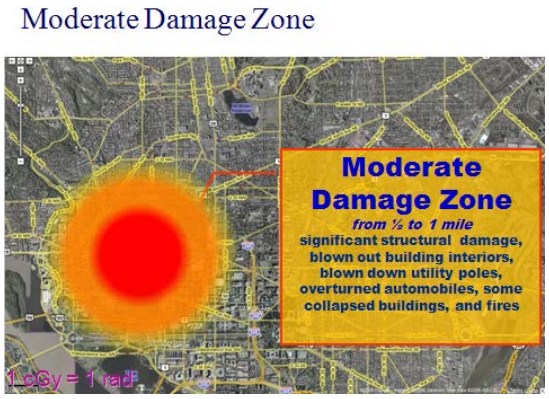
Moderate Damage Zone

Blast effects are the damages/injuries done to structures/people following detonation.

Click –Moderate Damage Zone appears

From ½ a mile to 1 mile from the blast site of a 10KT is the moderate damage zone, This is the area with a large number of significant injuries and represents the area with the most life-saving potential.

This area has significant structural damage and fires. Victims in this area have the greatest chance of avoiding deadly radiation doses by seeking shelter immediately.



Outer Edge of Moderate Damage Zone to Light Damage Zone

The outer edge of the Moderate Damage Zone typically shows building damage consisting of broken glass and partial destruction of weaker structures. Injuries in this zone are mainly from broken glass.

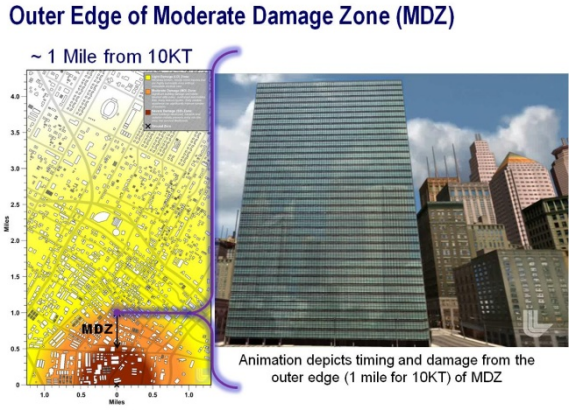
Click –Movie of breaking glass from blast begins

This animation depicts the timing and type of effects that might be observed on the outer edge of the moderate damage zone.

The bright flash will be followed by a “thump” as the shock is transmitted through the earth. This will be followed in several seconds by the air blast which will severely damage many structures and blow the glass into building causing injuries and bringing the façade of many building tumbling into the street.

This type of debris poses serious injury risks to those in the building and on the ground below.

Slide Transition –Image grows and LDZ appears

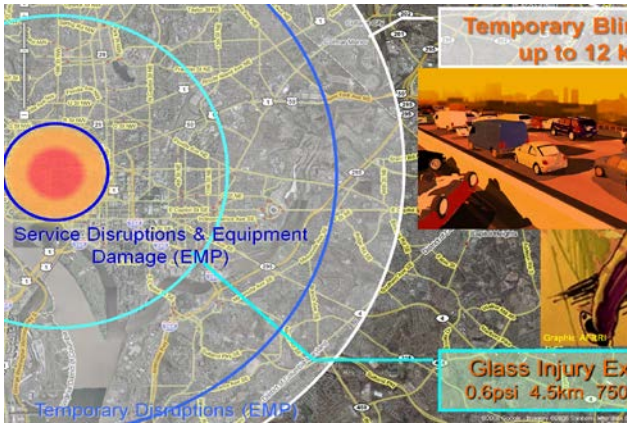


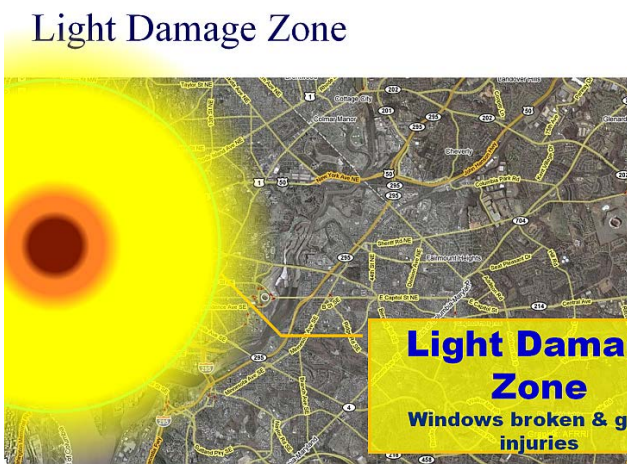
Other Long Range Effects

The blue line that appears is where glass is broken with enough force to cause injuries. The D.C. population during the workday in this area is about 750,000 people.

The white area that appears is the area where people outside have the potential to be blinded by the brilliant flash that appears during detonation. This blindness may last for several seconds, or as long as a couple minutes. The potential flash blindness is not expected to be of issue for pedestrians, however, drivers will be unable to see the road or other drivers which could potentially cause additional accidents clogging major thoroughfares. Because of that, we can expect most roads in about a 10km range to be snarled with accidents.

Another area of concern is the EMP range. EMP is the electromagnetic pulse that will radiate outwards from the blast site. The most damaging EMP effects will be limited to within a mile. An EMP blast will disrupt most electronics, but cause little direct harm to people. Although a "firestorm" isn't likely to occur, there will be a large number of small fires that started from the thermal and blast effects (generally around the 1 mile perimeter) which could spread



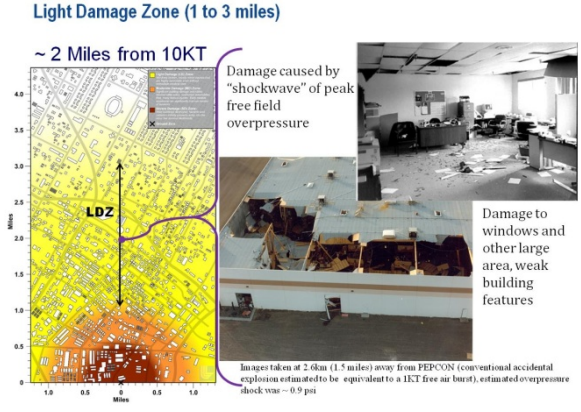


Light Damage Zone

The last blast zone is the light damage zone. This extends from one to three miles from a 10KT and represents the largest of the three blast zones.

The majority of injuries within this zone consist of cuts from broken glass. There will also be minor structural damage, mainly consisting of the destruction of large, weak and flat surfaces.

- The damage in this area is caused by the "shockwave" following the blast. This is similar to a "sonic boom" and consists of free field overpressure. The images to the right are a mile and half from an accidental explosion in Henderson Nevada of a booster rocket manufacturing facility. The explosion was estimated to be the equivalent of ~ 1KT.
- As can be seen in the image, the office glass has been blown into the building and the ceiling tiles have caved in. The large flat roof of the warehouse also collapsed.
- Injuries in this area are expected to survivable lacerations and minor crush injuries.



3. Other Effects

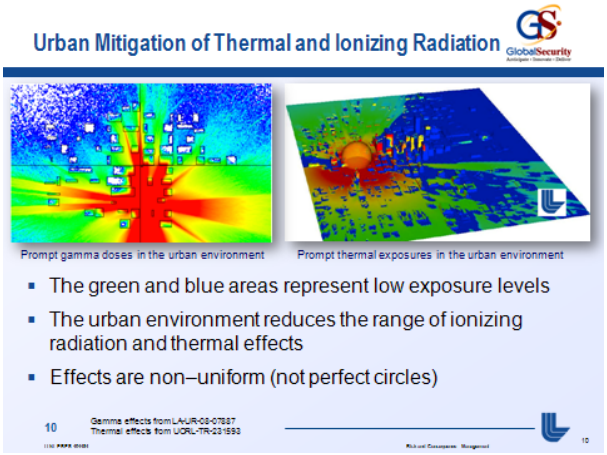
Urban Mitigation of Line of Sight Effects

The ranges of effects previously discussed are really only relevant for an open plane (like the Nevada Desert where the tests were conducted).

The protection afforded by the urban environment can greatly reduce the number of previously calculated burns and radiation exposure that have been cited in many previous studies.

These images, which model a ground level, low yield nuclear detonation, demonstrate how some types of radiation and thermal effects are greatly mitigated by the urban environment.
The blue and green areas on the images represent low (survivable) exposure levels. Without the urban environment, most the images would represent harmful levels of gamma radiation and thermal burns.

Another key point is that the ranges for these effects are not uniform, and perfect "circles" depicted on earlier slides should be taken as examples of maximum ranges and not an average range.

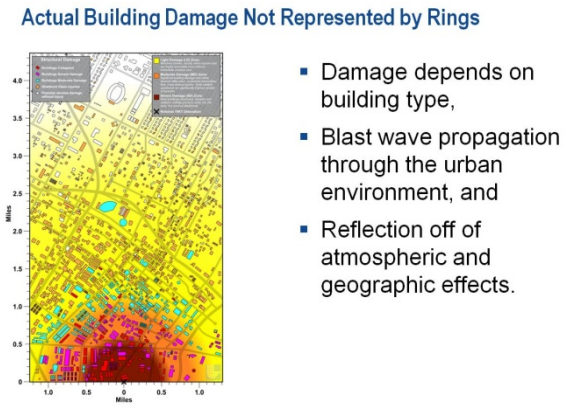


Building Damage is Non-linear

The circles of blast effect can also be misleading. Blast "waves" can be greatly modified as they move through the urban environment. The overpressure can be reflected off of buildings, channeled down streets, and even reflected off of different layers of the atmosphere.

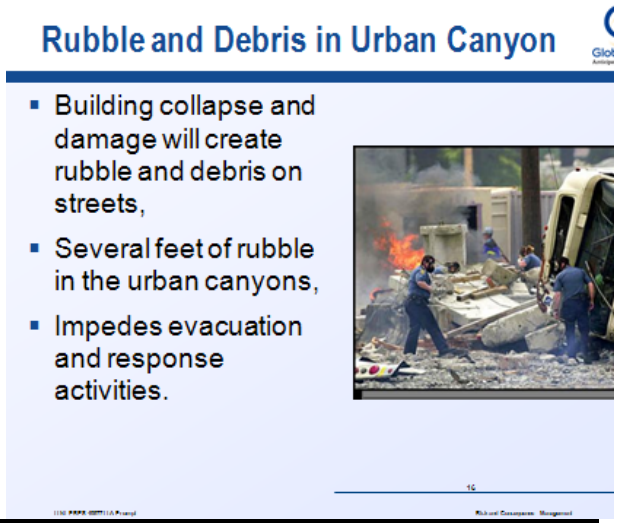
You can see that some building collapse beyond the range predicted by the ideal air blast model because of this phenomenon.

Also, some building can survive unscathed fairly close the detonation.



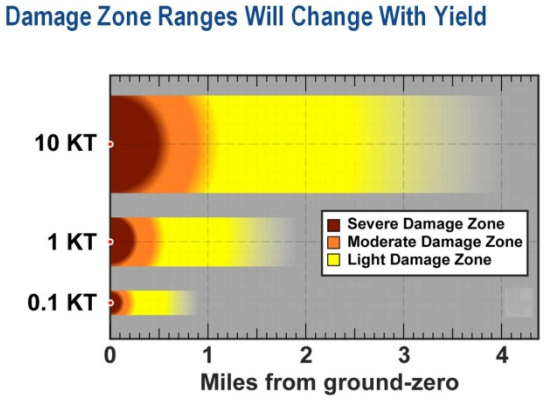
Rubble

The damage and collapse of buildings will also create significant amounts of rubble and debris in urban canyons. This graphic from ARA demonstrates that rubble, often 10s of feet of rubble, which can block urban roadways and limit the movement of evacuees and responders.



Damage Zone Ranges Change with Yield

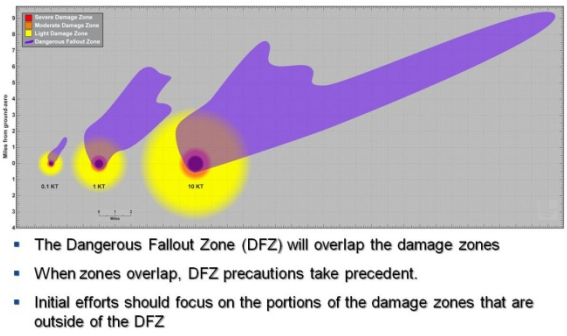
The size of the IND determines the area covered by each damage zone. It is important to have some idea of the detonation size to help determine zones when starting the response process. Failing to do this could cause harm to emergency responders.

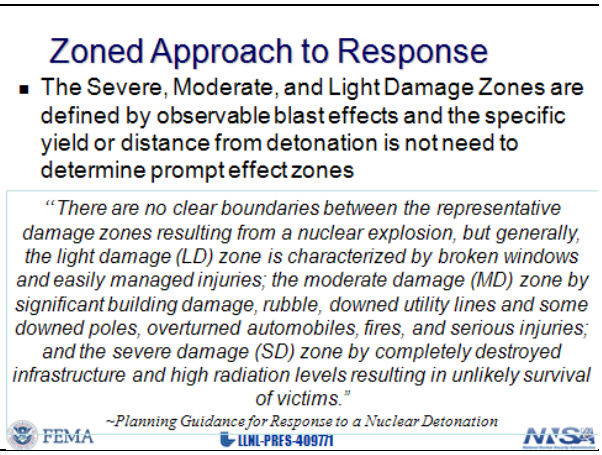
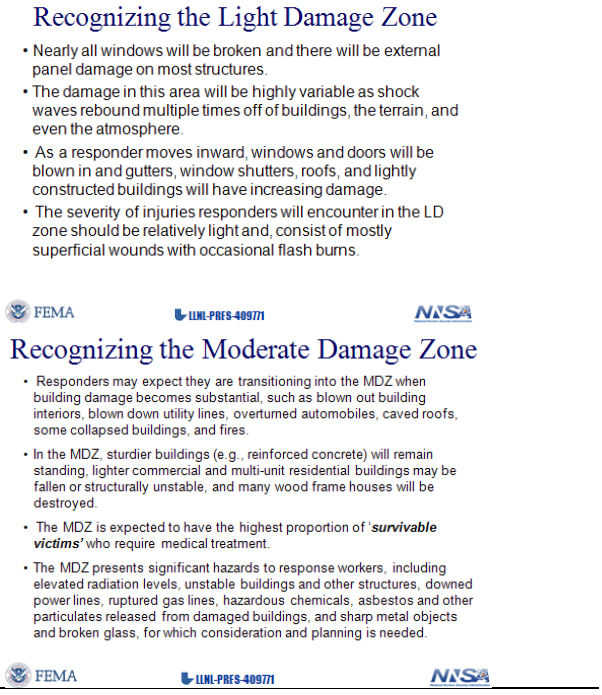


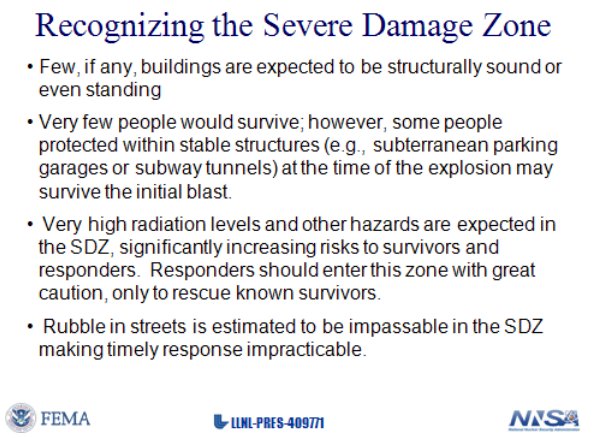
Radiation Zones Take Precedent

When determining damage zones, radiation levels must also be taken into account. After determining the path of the dangerous radiation zone from fallout, certain rules will apply. These are:

- **The dangerous radiation zone from fallout will overlap damage zones**
- **When zones overlap, radiation precautions take precedent** – even if responders know there are victims within the moderate and light damage zones, they should not enter until dangerous radiation levels are no longer present
- **Initial efforts should focus on the portions of the damage zones that are outside the dangerous radiation areas** – responders should initially wait to



enter areas within the light and moderate damage zones, and focus on responding to areas outside of the dangerous fallout zone	
Zoned Approach to Response **Click –Defining Zones appears** A well-thought out response plan can help maximize life-saving potential, and minimize the risks to emergency responders. When setting up a response plan, it is important to:	
Recognizing the Light Damage Zone As an example of how to recognize the varios prompt effect zone, let us review the zone description from the planning guidance. For the light damage zone… For the moderate damage zone… For the Severe damage zone…	

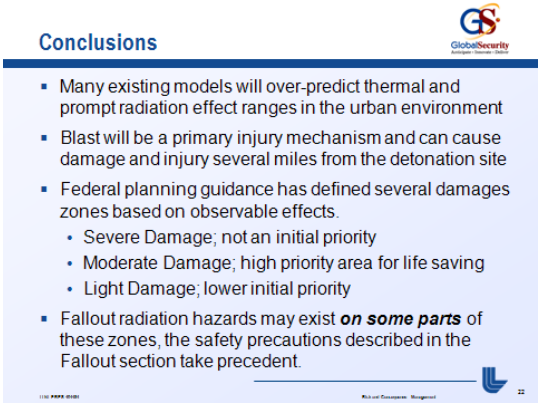


6. Conclusion

- **Many existing models will over-predict thermal and prompt radiation effect ranges in the urban environment**
  - Responders should be aware that while they should not initially enter areas with dangerous fallout levels, these levels will fall quickly

- **Blast will be a primary injury mechanism and can cause damage and injury several miles from the detonation site**
  - **100,000s casualties** can occur from the prompt effects in the first few minutes within a few miles of detonation site,
  - Overall number of casualties likely to be reduced by protection from the urban landscape and being within heavy buildings, however
  - Tertiary effects (building collapse, glass and debris missiles, and flash-blindness accidents) may increase number of casualties.

- **Federal planning guidance has defined several damage zones based on observable effects**
  - Severe Damage – responders should not focus on this area, as radiation levels will be too high and survival is unlikely
  - Moderate Damage – This should take highest



priority as there is the highest potential to save lives – Light Damage – This is a lower initial priority, as most injuries can be treated with minimal or no medical care. • **Fallout radiation hazards may exist in some parts of all zones. Safety precautions should be taken within every zone**	
Review the "Check Your Understanding" slide with the Student