TERRORISM MODELING

UNIT 3

RMS® CCRA® Training Program

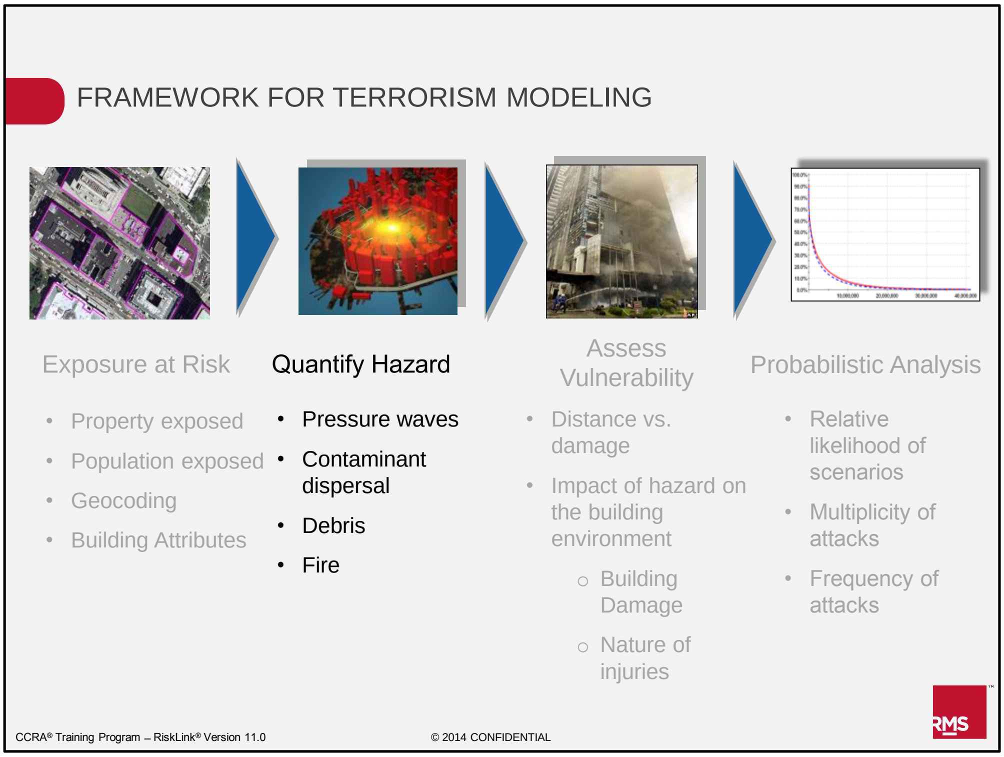
AGENDA

UNIT 3: TERRORISM HAZARD MODULE

Learning Objectives

- Describe the hazard components of different attack modes
- Understand physical and geographical factors that influence hazard
- Explain the difference between terrorism attack footprints that use pre-compiled hazard and those that calculate hazard values

At the end of this unit you should have a good understanding of each of the five learning objectives listed on this slide.



Within our terrorism modeling framework, the quantification of hazard takes place before the vulnerability assessment and financial model calculations. There is a distinct measurement of hazard for each attack mode and includes blast pressure, contaminant dispersion, fire, and debris.

WHAT IS HAZARD?

- Hazard is…
  - A means of quantifying the physical characteristics of a terrorist attack, irrespective of their impact on any set of exposures or portfolio.
  - A numerical value that designates the severity of a terrorism event and usually varies geographically.
  - Determined for each location and precedes the vulnerability assessment and loss calculations.
  - Often a well-defined value (e.g. blast pressure), but can also be a more generic value such as distance or a percentage that will be used to estimate loss.

CCRA® Training Program – RiskLink® Version 11.0 © 2014 CONFIDENTIAL

What is hazard?

Hazard is a means of quantifying the physical characteristics of a terrorist attack, irrespective of their impact on any set of exposures or portfolio.

Hazard is a numerical value that designates the severity of a terrorism attack, which usually varies geographically.

Hazard is determined for each location and precedes the vulnerability assessment and loss calculations within the RMS models.

Hazard is often a well-defined value, such as a blast pressure, but can also be a more generic value, such as the distance to the center of an attack or percentage that will be used to estimate loss.

LOSS AGENTS

- The hazard value may reflect various agents of loss.
- Specific agents considered depend on the attack mode as well as the model used to assess the impacts.
- Attack modes may account for some of the following:
  - Direct physical damage
  - Water
  - Fire
  - Contamination
  - Clean-up: decontamination, debris removal
  - Damage to lifelines and infrastructure
  - Civil exclusion areas
  - Bodily injury, burns, ingestion of toxins, infection, irradiation

The hazard value associated with each attack mode may consist of one or more loss agents. The specific agents that are considered will depend on the attack mode being modeled, as well as the model used to assess the impacts.

Here we have a list of some of the damaging agents that are accounted for in the RMS model.

As an example, consider the hazard associated with a bomb blast. Blast pressure waves, impulse waves, fire, and debris are all factors that cause damage to both property and people. Business interruption is impacted by clean-up and crime scene investigations. Variables that are considered include the building environment, such as whether it is a dense urban population or rural open population, and placement of the bomb around the building. These variables will vary depending upon the RMS model utilized.

Now considering aircraft impact as an example, what are the loss agents used to model an aircraft attack?

The loss agents include fire spread, very high temperatures, projectiles, embers, and debris from collapsing structure; smoke and dust cloud; people killed by building collapse; and business interruption from a civil authority exclusion zone declared around site.

Variables that contribute to the level of hazard include the fuel load of the aircraft; whether the target building collapses, and if so, the time it takes for the building to collapse, the number of people able to evacuate, and the extent of fire spread.

HAZARD FOR TERRORISM ATTACKS

- Different hazard types and scales for different attack modes
- Intuitive measures of hazard (i.e., blast pressure) used to derive hazard scale used in model

HAZARD DESCRIPTION	ATTACK MODES
Distance from target	Aircraft Impact
Dosage/deposition of contaminant	Biological – Outdoor Chemical - Outdoor
Fire ignitions	Conflagration
Particulate contamination	Industrial Sabotage - Toxic Release Hazardous Transportation Sabotage
Blast pressure	Bomb Industrial Sabotage - Explosion Industrial Sabotage - Explosion & Toxic Release Nuclear Bomb
Radiation level	Dirty Bomb Nuclear Plant Sabotage

CCRA® Training Program – RiskLink® Version 11.0

Different attack modes use different hazard values and hazard scales. The scale of the attack mode is determined by the amount of hazard present and its capability to cause damage and injury. Within the RMS models, intuitive measures are used to measure hazard, such as pounds per square inch to measure blast pressure. These measurements are then used to derive the hazard scale used within the models.

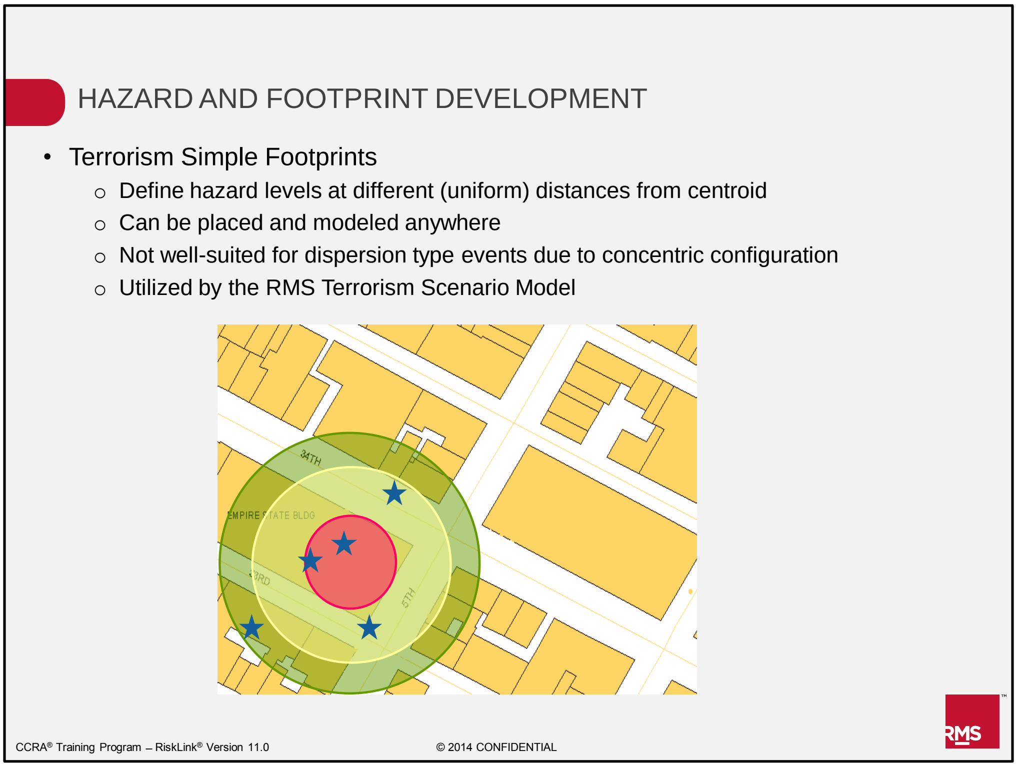
The chart provides a description of the hazard associated with each attack mode. Distance from the attack target is a means to measure the level of hazard present from an aircraft impact.

All hazard values are calibrated for use within the RMS model only.

HAZARD AND FOOTPRINT DEVELOPMENT

- Development of hazard footprints relies on blast and dispersion modeling software.
- Size and orientation of attack footprint depends on many factors:
  - Method and size of attack
  - Centroid of attack
  - Configuration and density of built-up environment
  - Weather conditions (wind speed and direction)
- Footprints developed for average scenario given possible variations in physical conditions and attack scenarios.

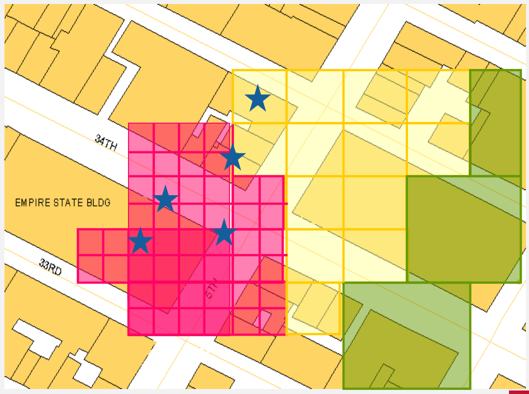
The development of the RMS attack footprints relies on blast and dispersion modeling software. The size of the attack footprint and the orientation of the attack footprint depends on the method of attack and scale (or size) of the attack, the centroid of the attack, and the configuration and density of the environment that surrounds the attack. For certain attack footprints, weather conditions, such as wind speed and wind direction, are taken into consideration. The resulting level of damage associated with each attack footprint will vary with the hazard associated with it.



There are two hazard footprints incorporated into the RMS terrorism model. The first we will discuss are the terrorism simple footprints, utilized by the RMS Terrorism Scenario Model, which define hazard level at uniform distances from the centroid. Concentric rings are overlaid over the attack centroid and hazard is measured at various intervals. To assess the hazard level for a particular location, the distance to the centroid of the attack is measured and the hazard level is interpolated between the measured intervals. By using concentric rings and measuring hazard level based on distance, this attack footprint can be modeled anywhere. However, this method is not well-suited for dispersion attacks, such as the release of a chemical agent, since wind direction and wind speed have a huge impact on the hazard footprint.

HAZARD AND FOOTPRINT DEVELOPMENT

- Terrorism VRG Footprints
  - Hazard pre-compiled by VRG cells
  - Hazard constant within each cell
  - Better reflects local environment and orientation of footprint
  - Can only be modeled for pre-defined locations and scenarios
  - More appropriate for dispersion modeling
  - Utilized by the RMS Probabilistic Terrorism Model



The variable resolution grid (VRG) footprint, utilized by the RMS Probabilistic Terrorism Model, defines hazard levels using pre-compiled hazard values by VRG cell. Hazard is consistent within each cell and the resolution of the cells are determined by the proximity to the attack centroid and the hazard being modeled. In its current platform, the variable resolution grid has the potential to describe hazard at eight resolutions, with the finest resolution being 50 x 50 meter grids and the largest resolution being 100 x 100 meter grids, though in most cases the largest resolution grid is 10 x 10 km meter grid. The result is a hazard-retrieval approach that offers as much detail as necessary for the particular hazard being modeled.

This approach also takes into consideration the local building environment, such as the density of the area, and the orientation of the footprint. We will talk more about how these factors influence hazard in a minute. Since we are taking these factors into consideration, the VRG terrorism footprints can only be modeled for pre-defined locations and scenarios.

Available VRG grid resolution:

1.0 degrees (about 100 kilometers, or 60 miles)

0.5º (50 km / 30 mi)

0.1º (10 km / 6 mi)

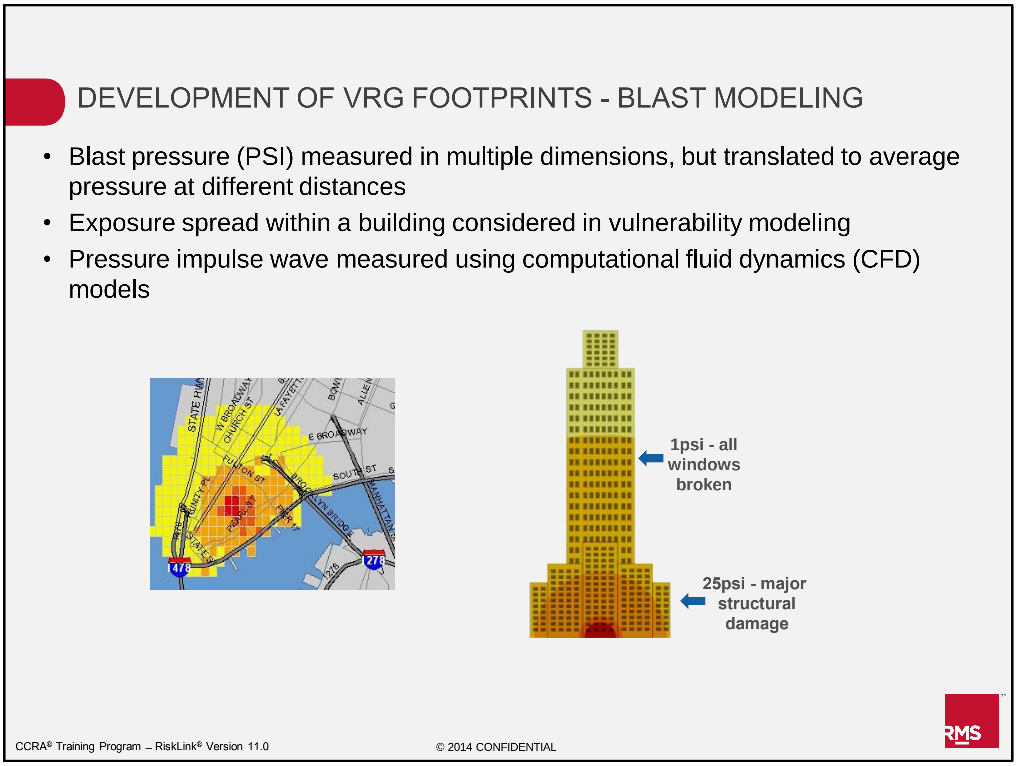
0.05º (5 km / 3 mi)

0.01º (1 km, or 1000 meters / 0.6 mi, or 3,300 feet)

0.005º (500 m / 1,650 ft)

0.001º (100 m / 330 ft)

0.0005º (50 m / 165 ft)

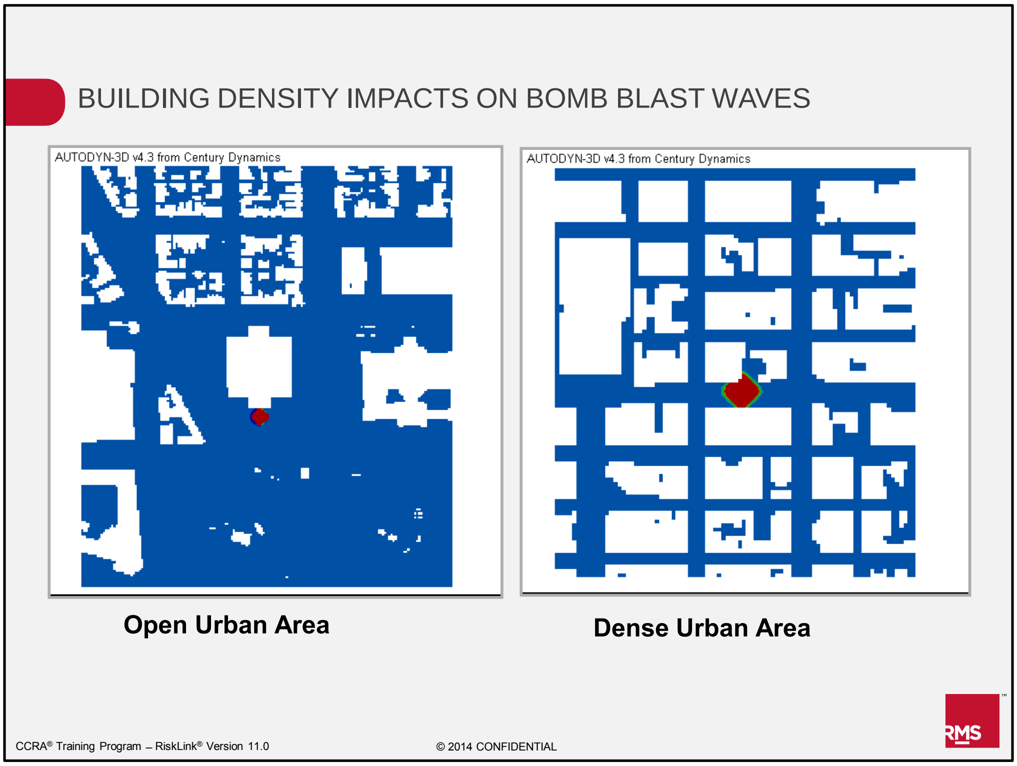


Bomb blast is a benchmark attack scenario utilized by the insurance industry to estimate loss. This is because of its relative likelihood of occurrence and its potential to cause significant property and casualty loss.

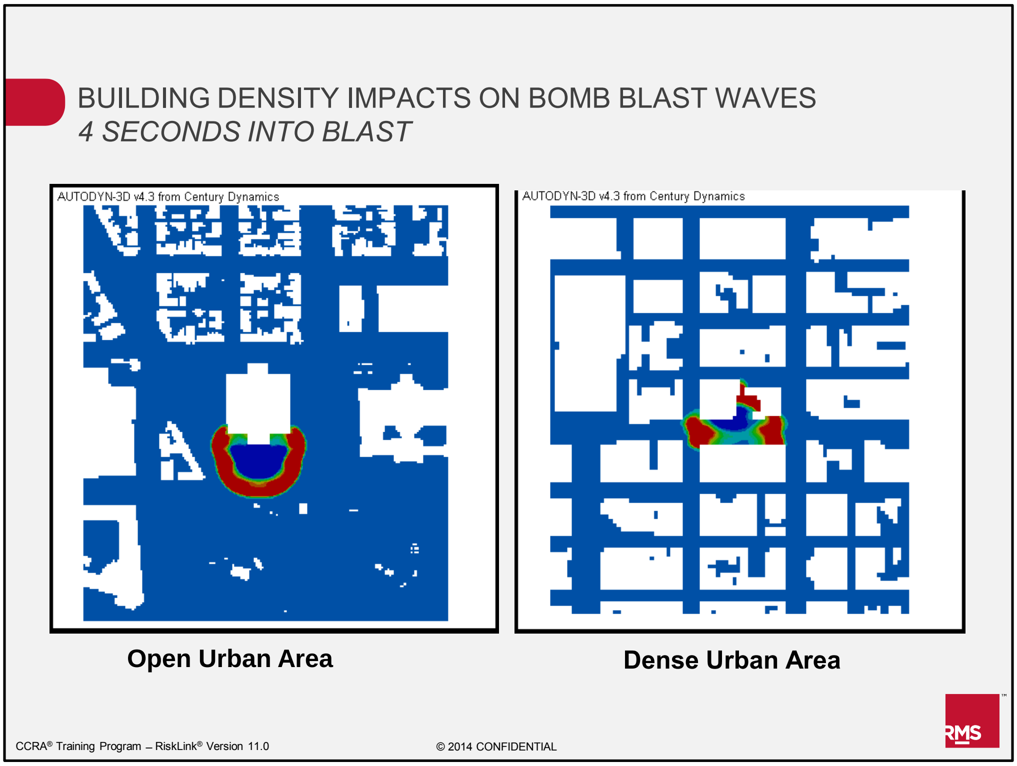
RMS utilized blast modeling software to generate average hazard values for VRG footprints. A three-dimensional view of different building environments was created to measure the impact of pressure and impulse waves through space and time. Using computational fluid dynamics, this multi-dimensional measurement of hazard was translated into average pressure at different distances.

To illustrate, let's look at how blast pressure, measured by psi (pounds per square inch), impacts a skyscraper in lower Manhattan. As a blast occurs, pressure and impulse waves are both absorbed and reflected by the structure and surrounding structures. In this example, at the centroid of an attack, hazard is measured as 25 psi and causes major structural damage to the lower floors of the building. On the floors in the middle of the building, hazard is measured at 1 psi and causes all windows to shatter. The size of the explosion and the speed at which the waves travel affect how the building will respond and ultimately impacts the level of hazard that is present at various distances. The resulting hazard is averaged and compiled by VRG grids.

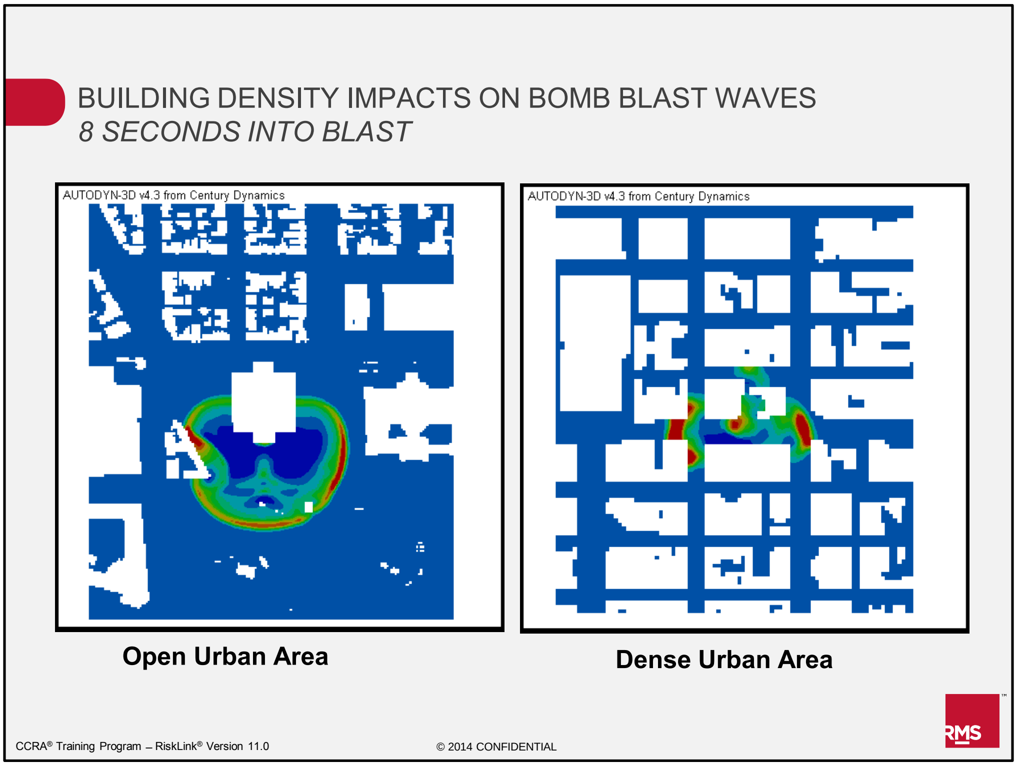
This exercise was performed on various building environments and resulted in two distinct building environments, a high density and a low density building environment. Building density and height were considered when compiling the hazard values for the bomb blast. We can see that placement within a building could have a significant impact on damage and the exposure spread within a building is considered in the vulnerability module.



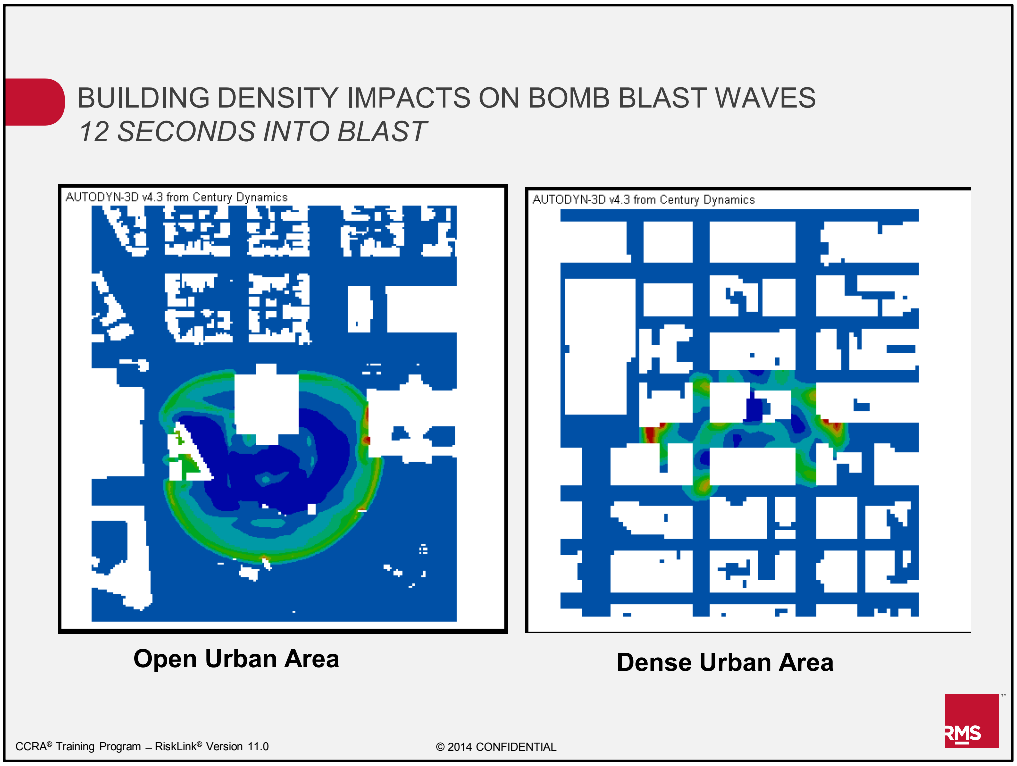
This illustrates how blast pressure waves travel through space and time. To see how the building environment impacts how waves travel, the following slides are time steps through a simulation of a blast in both an open urban area and dense urban area. You can see that each environment responds differently to blast pressure. In the open urban environment, the pressure waves are able to travel freely, not impacted by the shielding effects of buildings. In the dense urban environment, pressure waves are both absorbed by buildings and bounced off of building.



This slide is at four seconds into the blast.

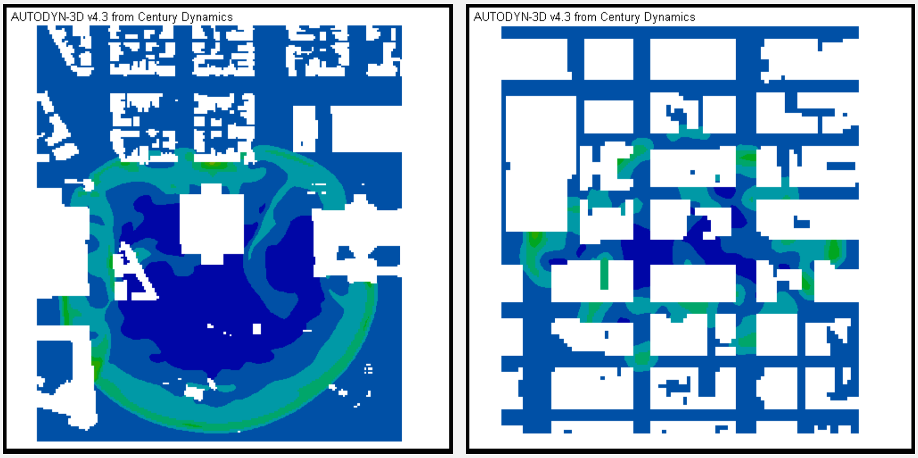


This slide is at eight seconds into the blast.



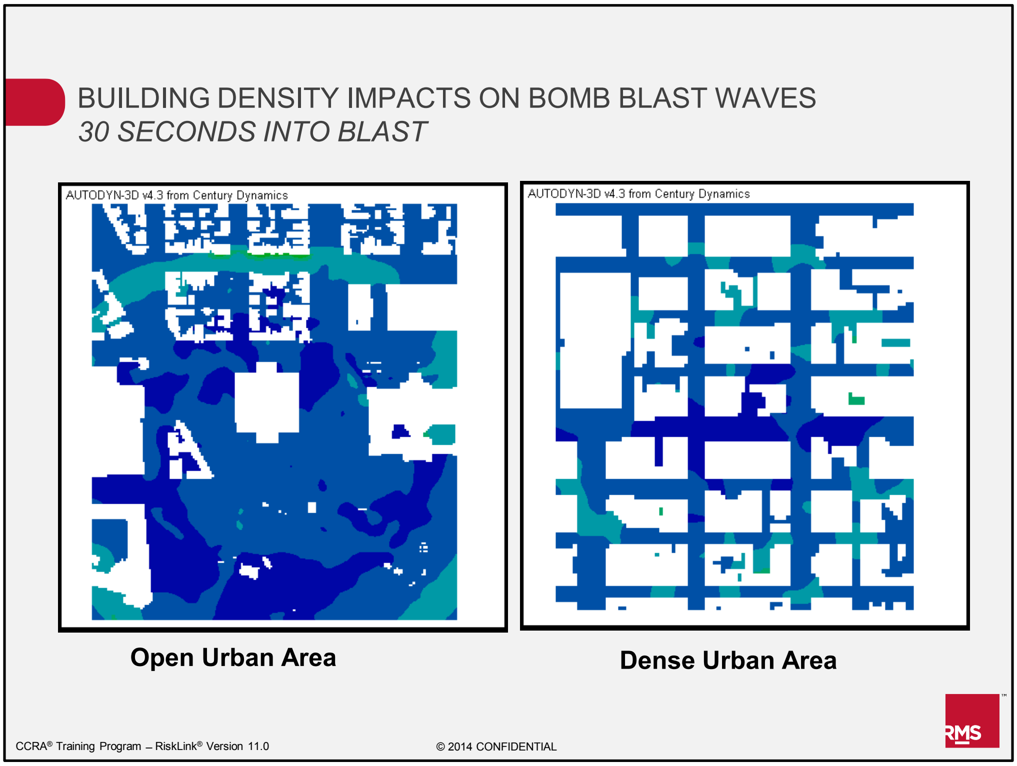
This slide is at twelve seconds into the blast.

BUILDING DENSITY IMPACTS ON BOMB BLAST WAVES
20 SECONDS INTO BLAST

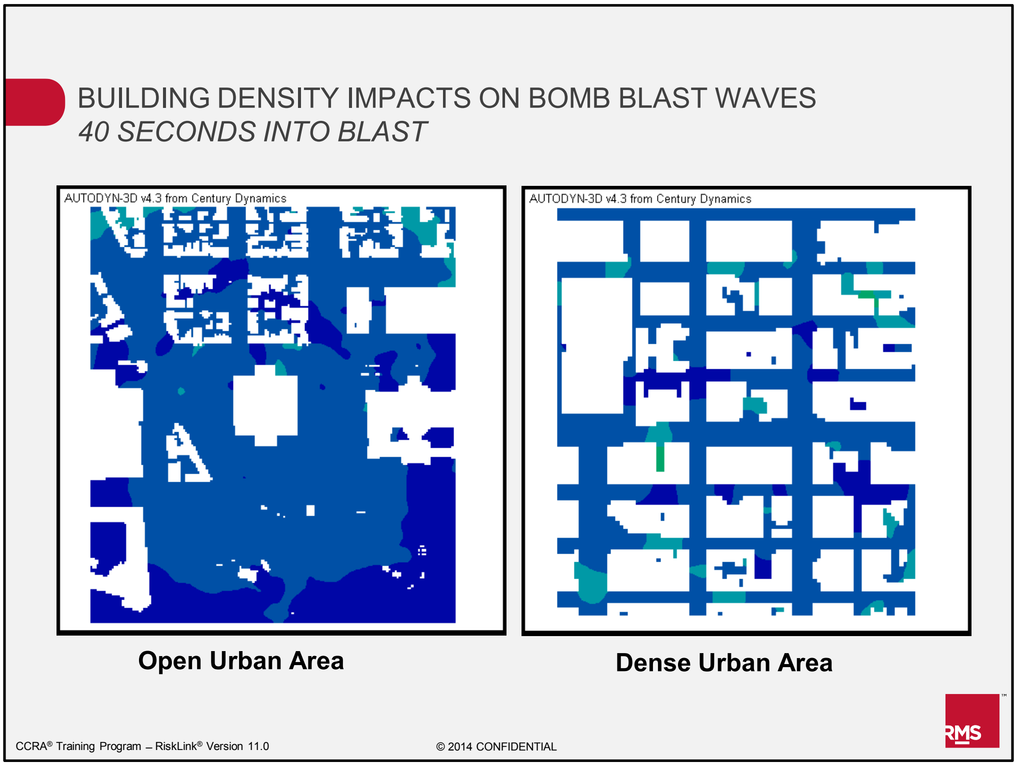


Open Urban Area **Dense Urban Area**

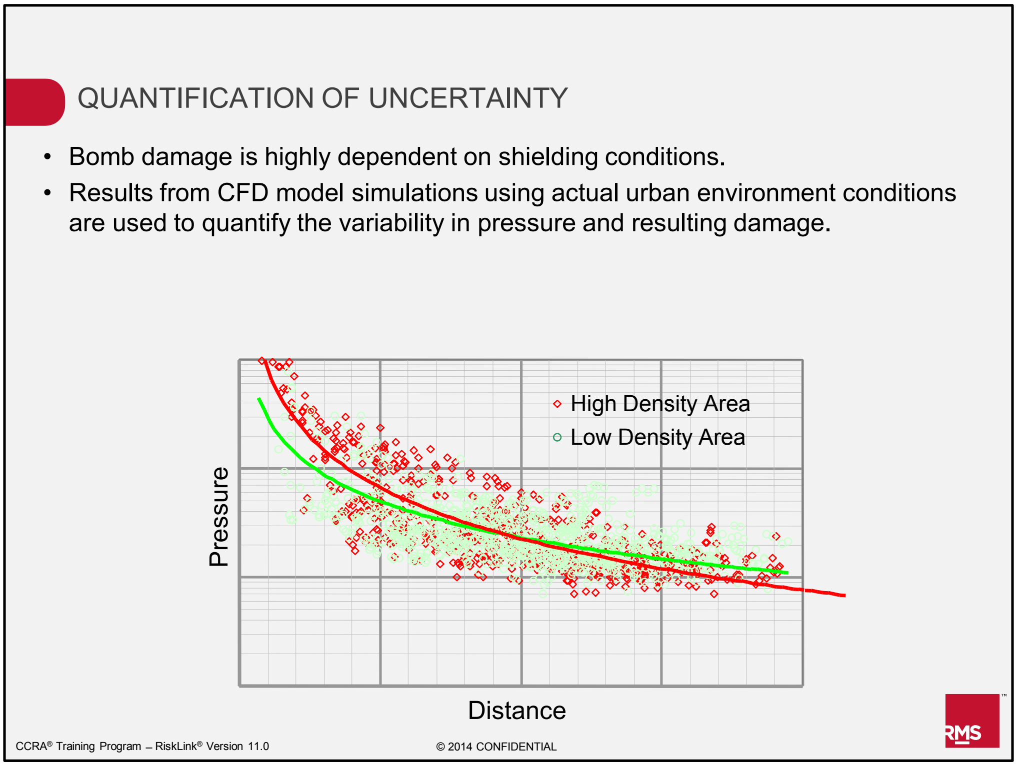
This slide is at twenty seconds into the blast.



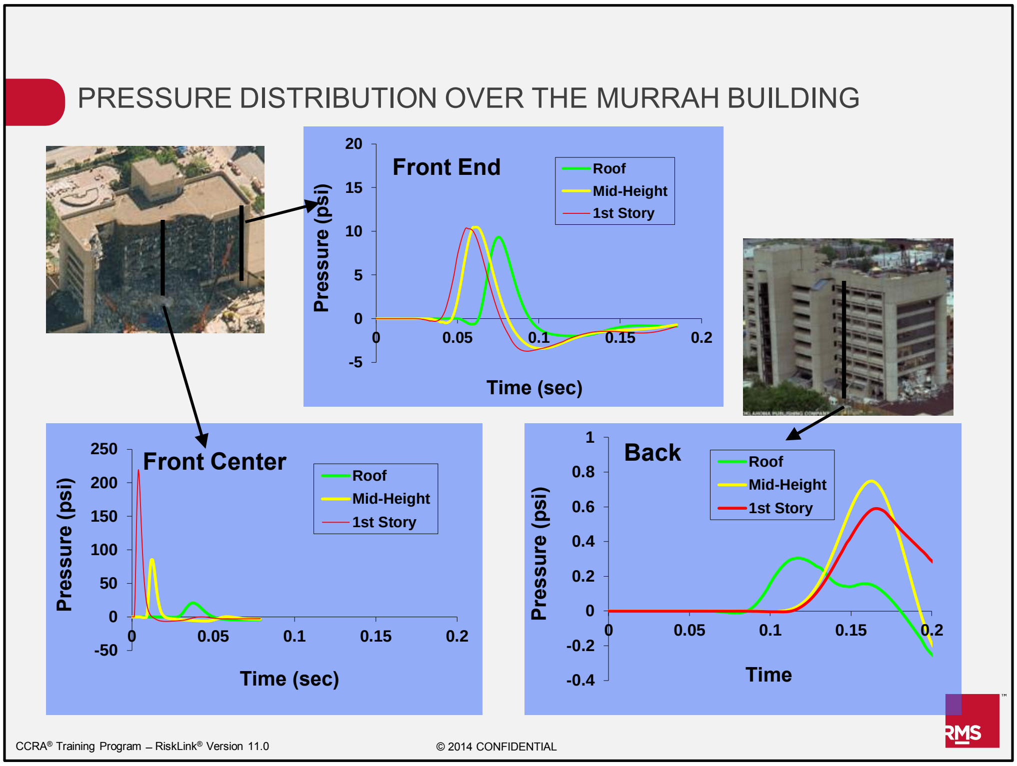
This slide is at thirty seconds into the blast.



This slide is at forty seconds into the blast.

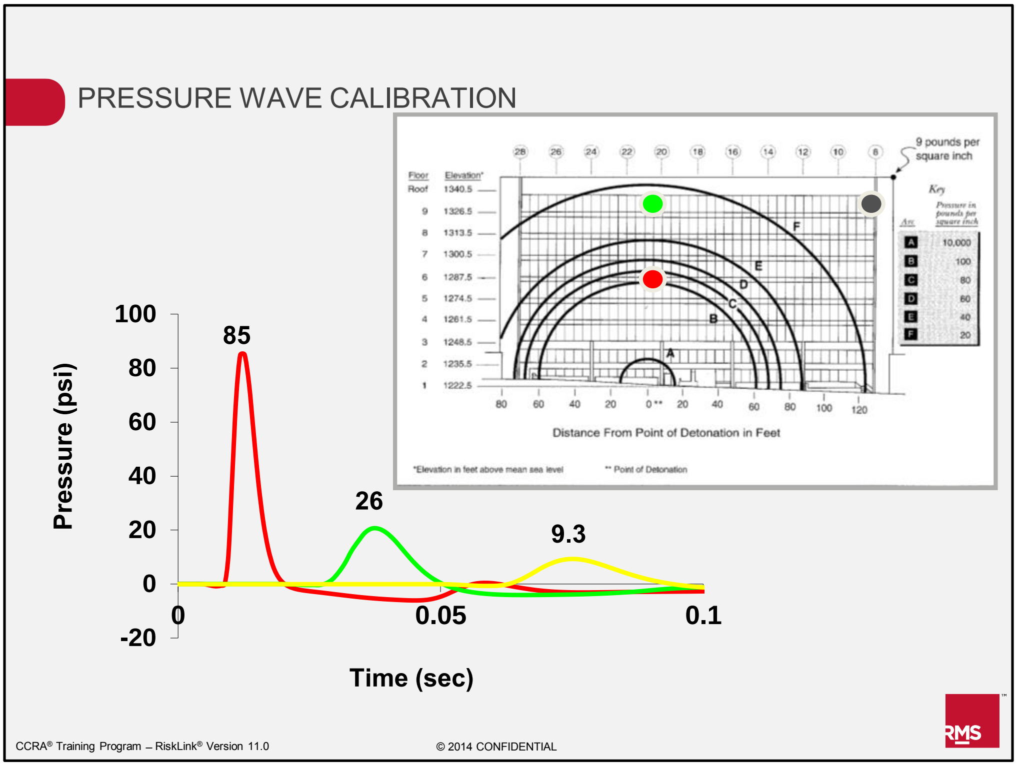


The previous slides illustrated how bomb damage is impacted by shielding conditions of the environment. The results of the computational fluid dynamics (CFD) model are used to quantify the variability in pressure and the resulting damage.



The Oklahoma City bombing was used as both an example and validation exercise. Three points of the building are used to measure the pressure distribution over time. The bomb occurred at the front center of the building. The amount of pressure that was felt on the first story is extremely high yet quickly drops off. By the time the waves reach the mid-height floors of the building and the roof, the pressure is much lower. The pressure waves take more time to reach the front end of the building and there is less variation in the amount of pressure felt on the first story compared to the roof. You will notice that the front end experiences a negative pressure similar to a vacuum effect.

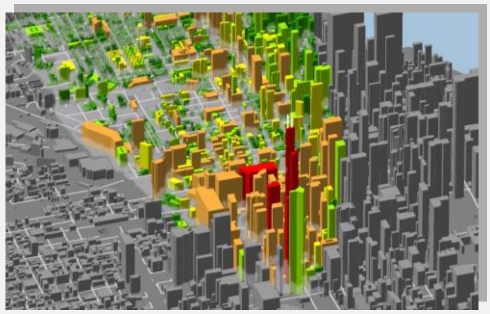
It takes even longer for the pressure waves to reach the back end of the building and relatively low hazard is measured. The building environment is rather open around the Murrah building so blast pressure waves follow a similar pattern as the open urban environment simulation we saw earlier since there is no bounce back of pressure waves off of buildings in the area.



Blast pressure waves are loss agents that cause damage to both property and people. There has been a lot of research on the effects of blast pressure and the RMS model is calibrated against actual observations to ensure a reasonable level of hazard is being modeled. A hazard scale, such as pounds per square inch to calibrate blast pressure, is used within the RMS models to measure the amount of hazard present at a given location. Hazard estimation is carried out using various sophisticated tools and software. For example, the hazard for vehicle bombs is modeled using Autodyn which allows the modeling of the pressure wave propagation while taking into account the shielding and focusing effects.

DISPERSION MODELING

- Dispersion related events
  - Biological
  - Chemical
  - Dirty bomb
  - Nuclear plant sabotage
  - Industrial plant sabotage



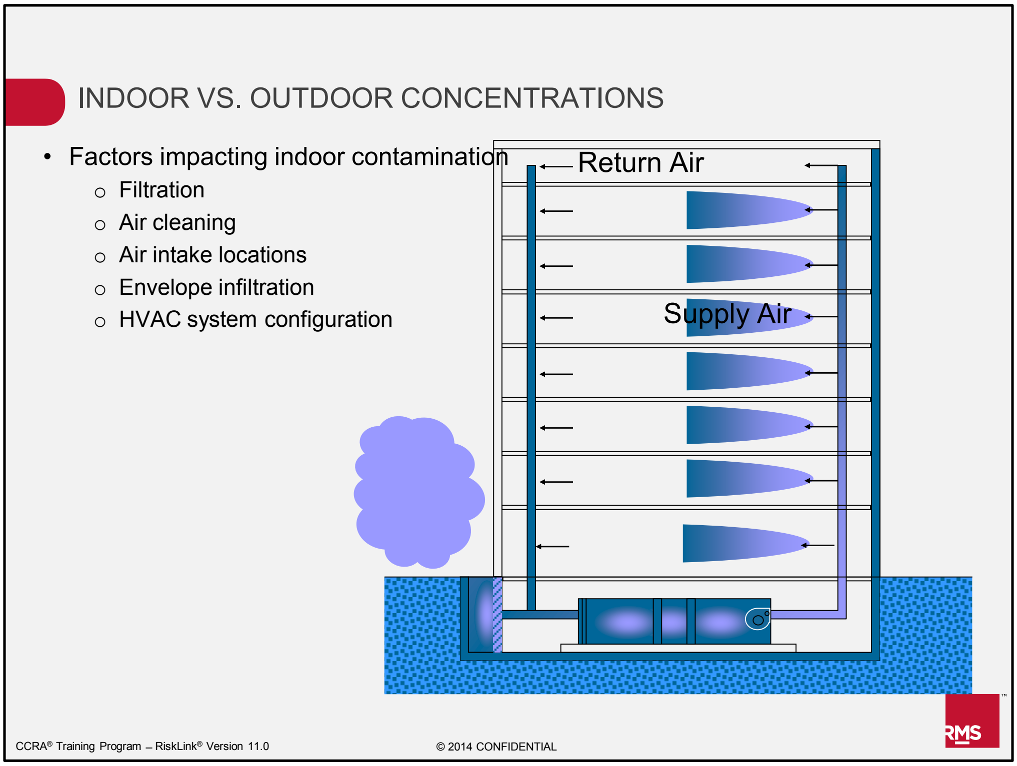
- Advanced dispersion modeling tools have been used to model downwind particulate concentrations considering material size and density and variability in wind speeds
- Eight wind directions are modeled

CCRA® Training Program – RiskLink® Version 11.0

We have talked about blast modeling, so now let’s talk about how dispersion modeling is used to measure the level of hazard for biological, chemical, radiological, and nuclear/industrial plant sabotage. The dispersion effects of various materials were analyzed and both the weight and size of the particles being dispersed were taken into consideration, as well as the wind speed and wind direction. RMS models both the plume and puff effects to quantify the level of contaminant present.

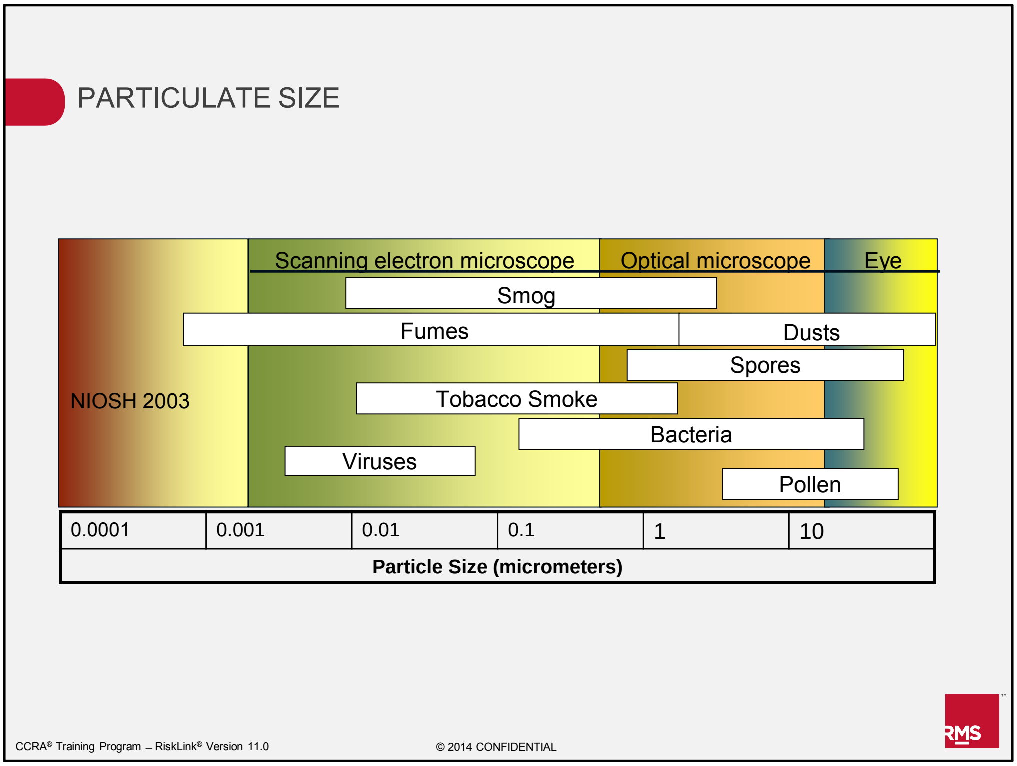
The damaging agents vary by attack mode, but hazard can be defined by the level of contaminate present. RMS has selected a representative attack mode for each of the categories listed here. For example, there are four main classes of chemical weapons – blister agents, choking agents, blood agents, and nerve agents. Nerve agents are deadly and Sarin is one of the most lethal of them. It is used to represent the class of chemical weapons with potential for terrorist use.

The quantity, type, and granularity of material released will impact the level of contaminate. The more finely ground material leads to more efficient dispersal, impacting the level of hazard present. Time of day and emergency response measures also impact the area affected.



The measurement of hazard released within a building will differ from the measurement of hazard for an outdoor release. The level of contamination resulting from an indoor release is dependent upon factors such as the filtration system within the building, HVAC system configuration, air intake locations, etc., although these factors are not modeled explicitly. The RMS terrorism models are based on assumptions and a separate set of assumptions are used for indoor attack release.

For example, RMS models anthrax as a representative biological agent. The assumption is that 40 grams of weaponized anthrax (weaponized meaning dried and refined to a fine powder) is released into the ventilation system of a target building. Once introduced into a ventilation system, only the highest quality air filtration system can prevent spores from circulating. Other variables include the time of day and occupancy of the building, and emergency response measures, including the speed at which an attack is recognized and the speed at which antibiotics are issued to those exposed.



The chart shown is an illustration of the particle size of various materials. Some particle sizes are visible to the human eye, such as pollen and dust, while others require the use of microscopes. The higher the quality of the filtration system, the finer the particle size that can be filtered out.

TERRORISM HAZARD MODULE
KEY CONCEPTS

- Hazard is a reflection of various loss agents
- Hazard is dependent on attack mode as well as the model used to assess the impacts
- Two hazard footprints available
  - Simple footprint analysis
  - VRG footprint analysis
- Size and orientation of attack footprint depends on
  - Method and size of attack
  - Centroid of attack
  - Configuration and density of built-up environment
  - Weather conditions (wind speed and direction)

This slide summarizes the key points from Unit 3. If any of these points are unclear, please revisit the associated slides within the unit.