Aerosol Facility

April 2020

Heather M. Pennington

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SAND2020-4119 C

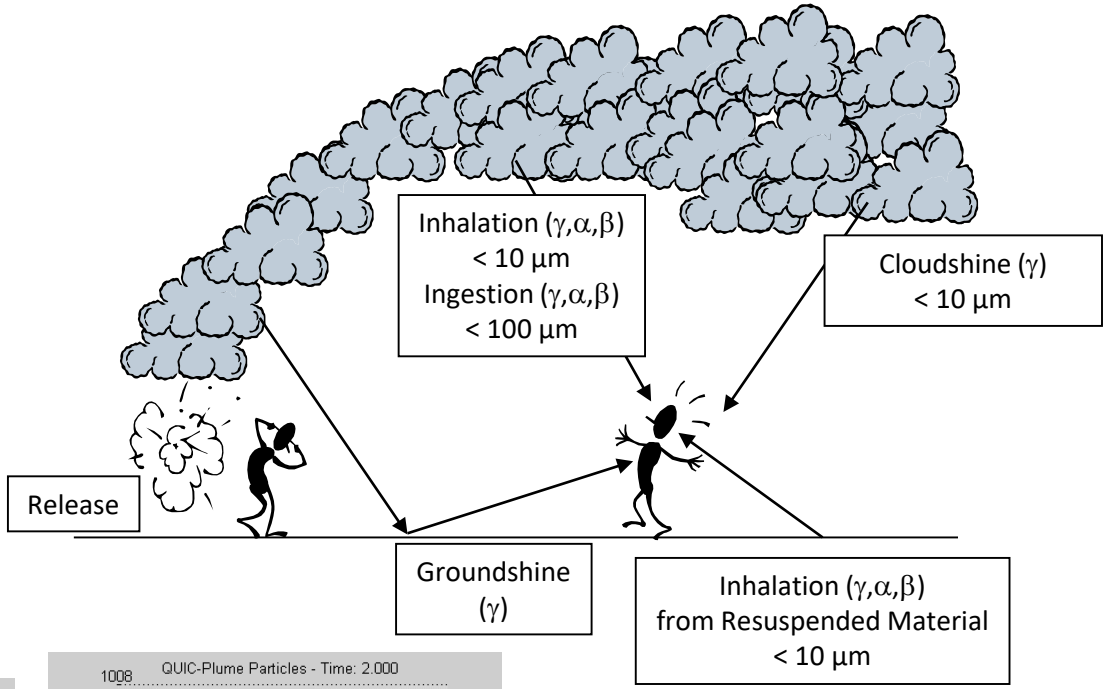
Widespread Dispersion

Small particles (< 10 μm)

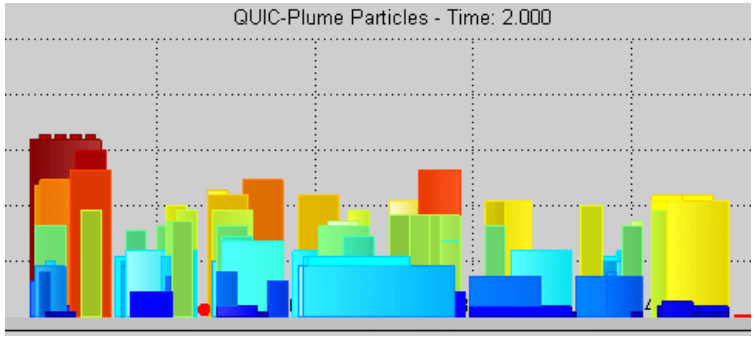
- Also referred to as respirable particles
- Will travel kilometers down wind

Intermediate particles (10-100 μm)

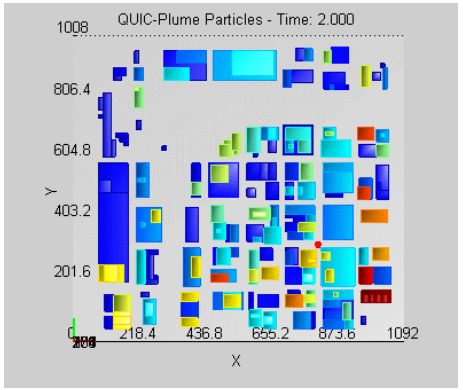
- Primarily a groundshine problem but can also be an ingestion problem
- Will travel a few 100 meters to a few kilometers down wind



Small Particles
(5 μm)



QUIC simulation by Mike Brown (LANL)

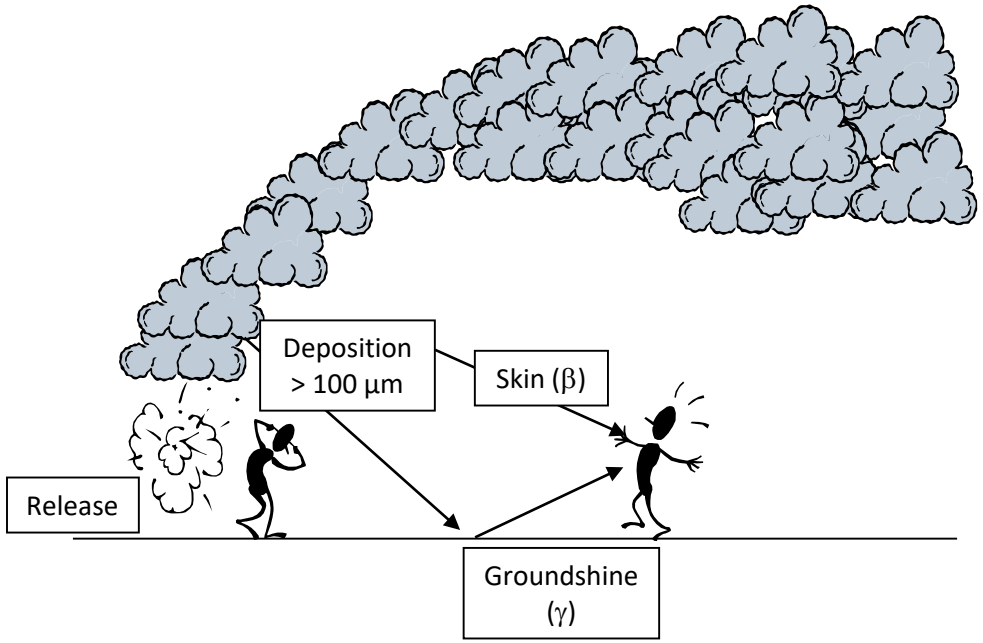


To be an inhalation problem – particles must be in vicinity of people

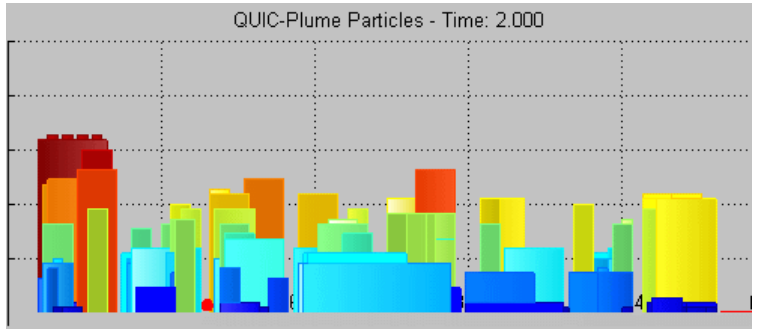
Localized Dispersion

Large particles (> 100 μm)
- Primarily a groundshine problem
- Will stay local only traveling a few hundred meters

Ballistic fragments (> 1 cm)
- Will travel hundreds of meters causing localized hotspots



Large Particles (250 μm)



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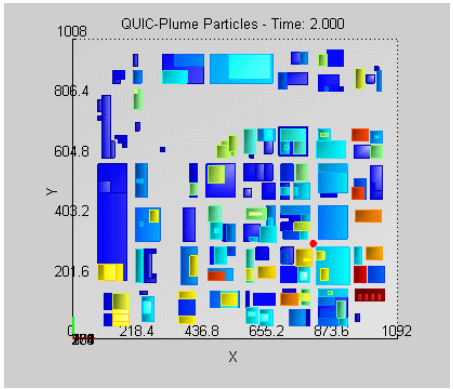
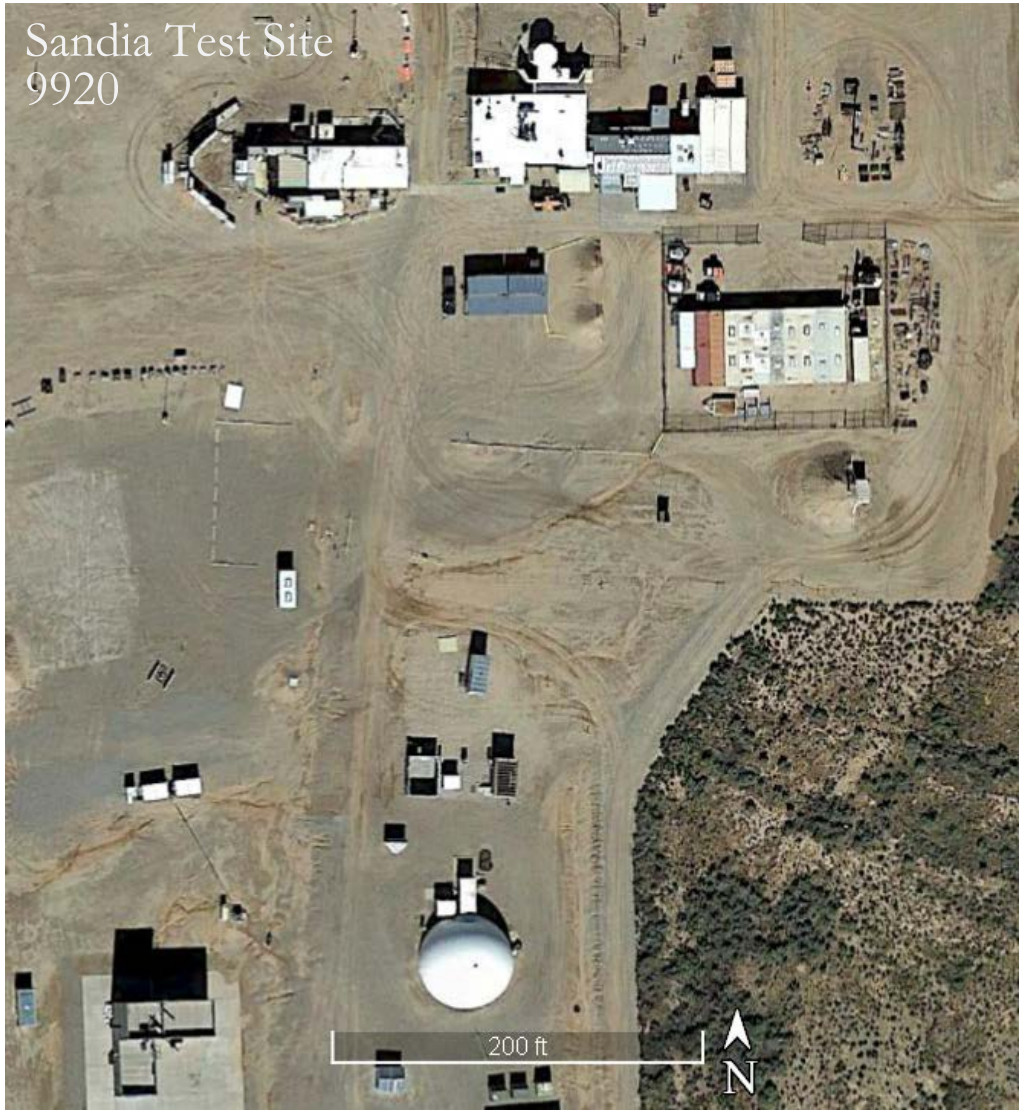


Large particles will settle to the ground quickly

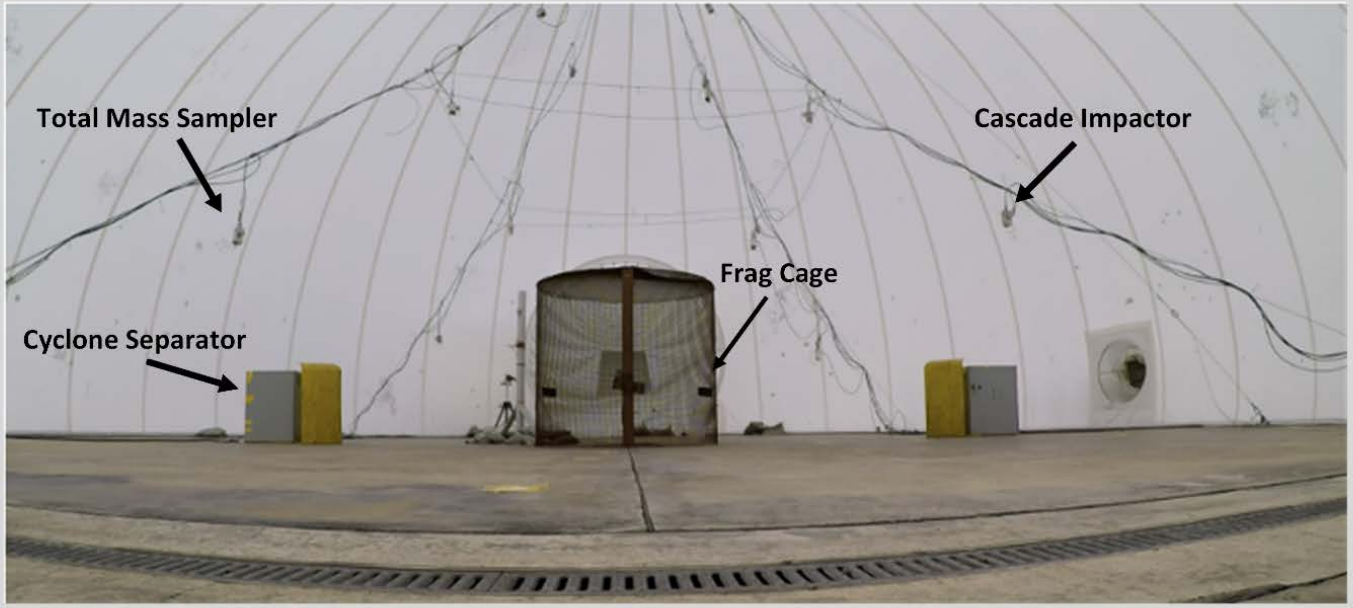
Air Building Used for Source Term Characterization



More than 1,000 RDD characterization tests have been performed at SNL in the last 30 years

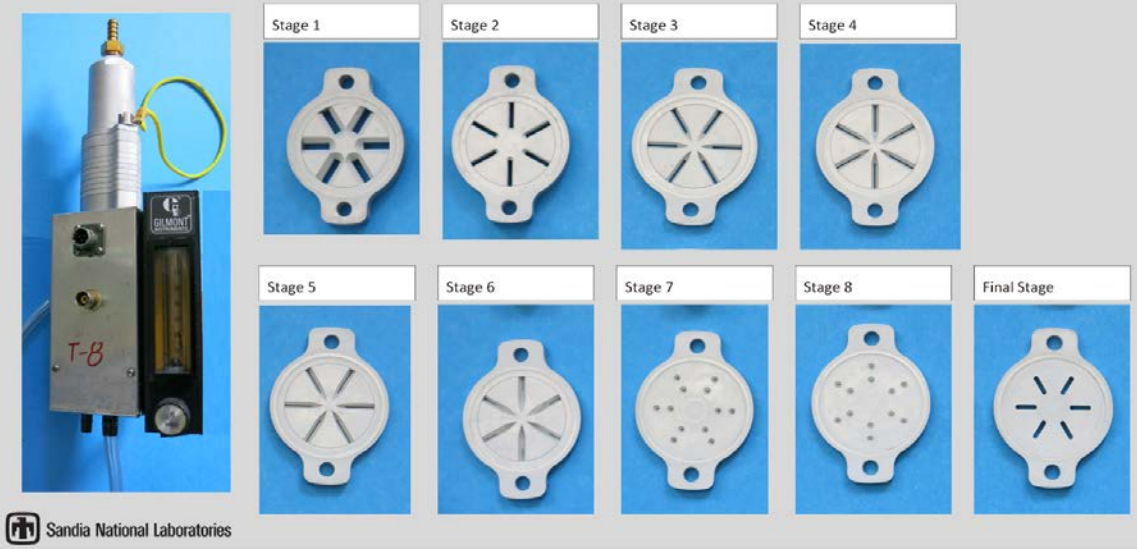
Size of particulate released depends on device geometry material physical and chemical properties

Inside the Air Building

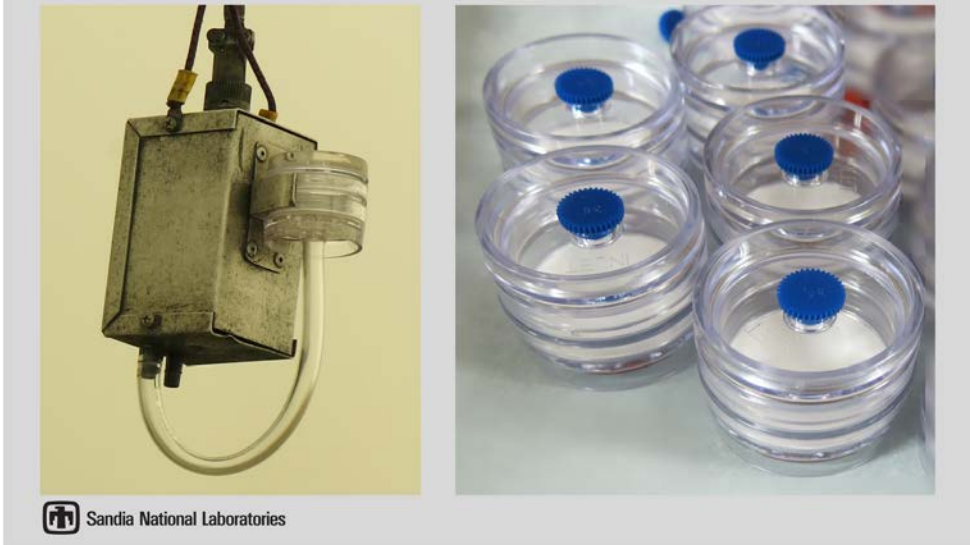


Particle Samplers

Marple Cascade Impactors 0-30 µm

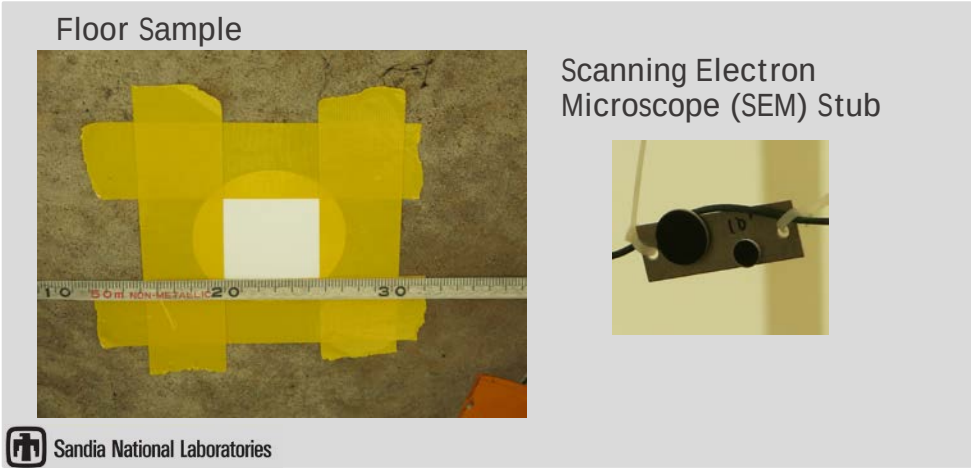


Total Mass Samplers < 30 µm

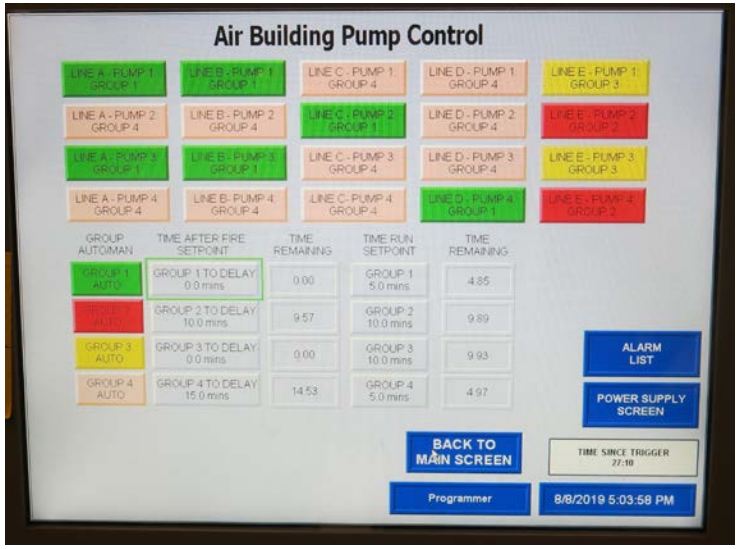


Marple Cascade Impactors 0-30 µm

Particle Collection

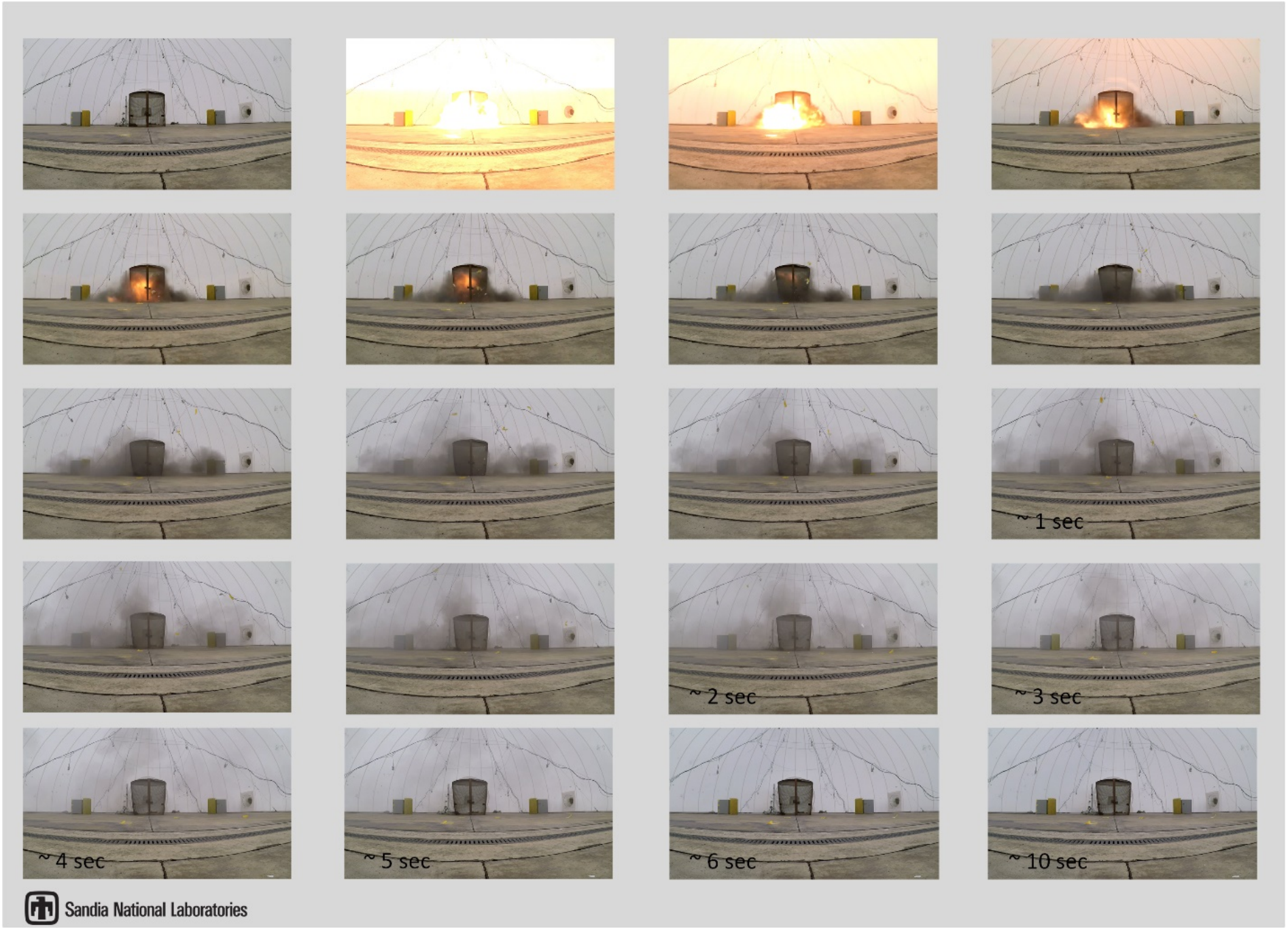


Control Room View



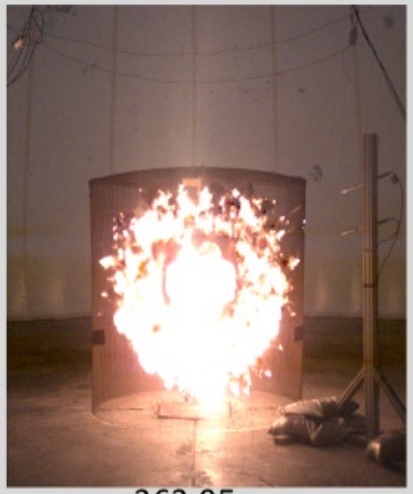
Characterization Shot Video

Real Time Video Images



High Speed Video Images


280.62 µs


363.95 µs


863.95 µs

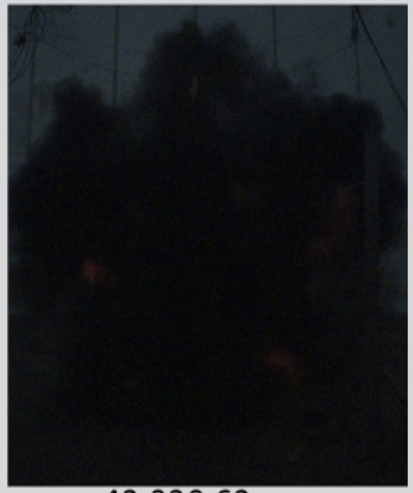

1,530.62 µs


3,113.95 µs


8,863.95 µs

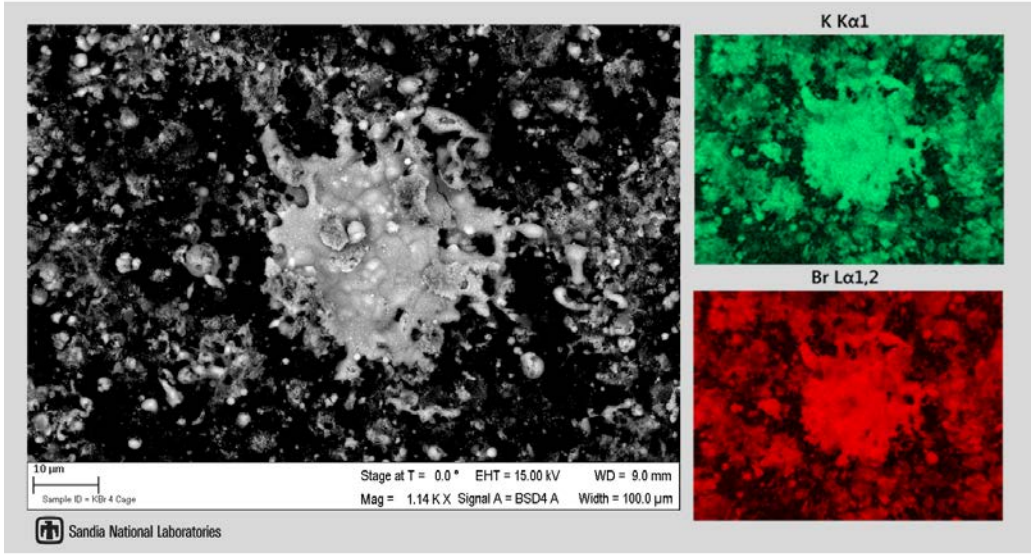

16,780.62 µs

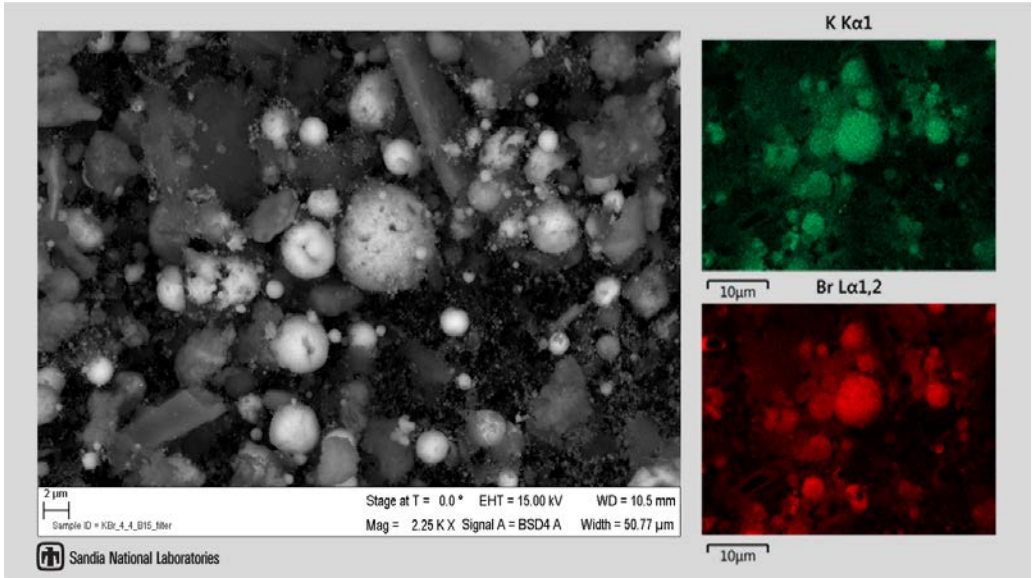

29,030.62 µs


42,030.62 µs

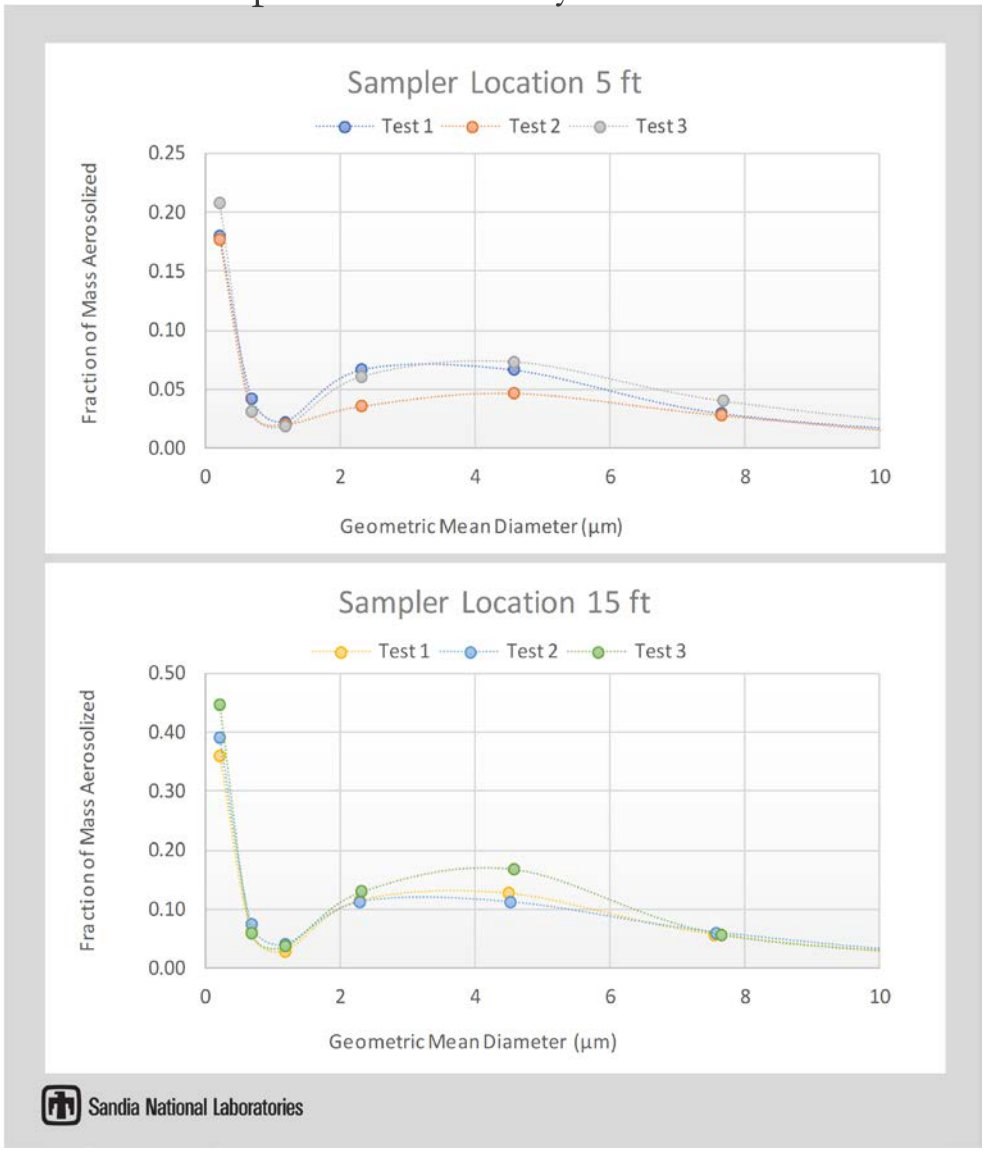
Example Data

Scanning Electron Microscope (SEM) Results





Cascade Impactor Summary



Questions ?

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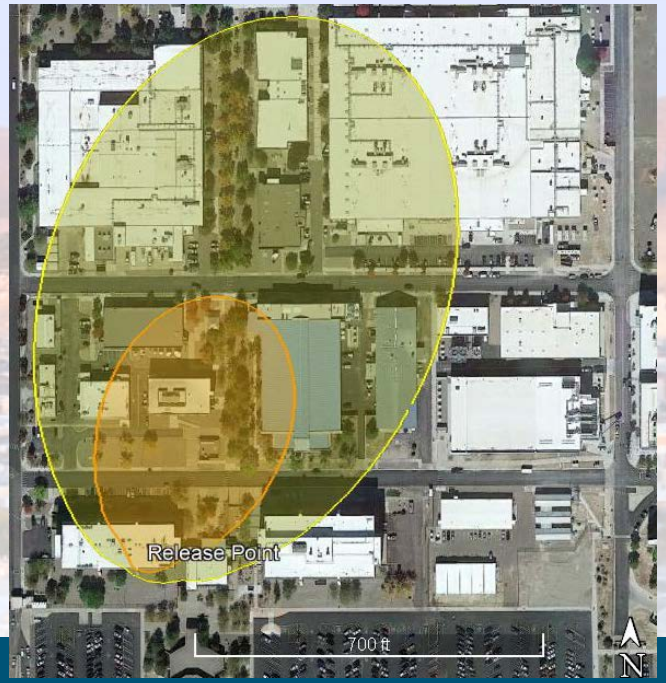

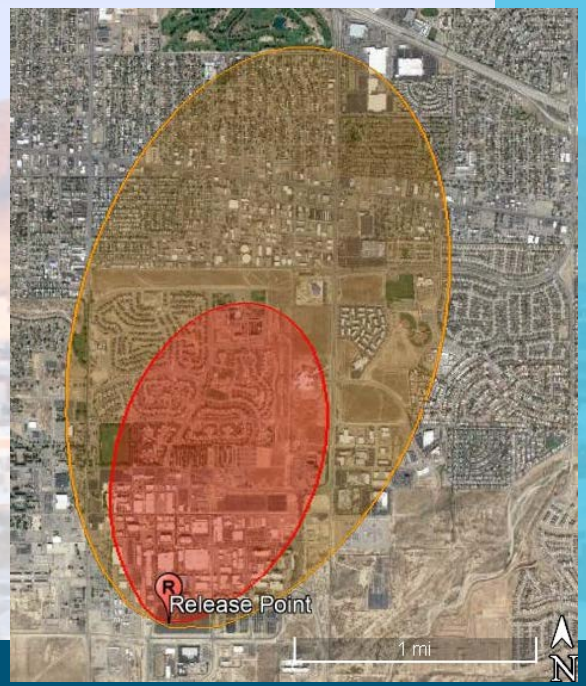

Sandia National Laboratories

Radiological Dispersal and Prediction Models

April 2020

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Discussion

Time Scales for Explosive Aerosolization

Comparison of DOE Dispersal Models

Overview of Dispersion Models HotSpot and NARAC

In-depth Look at the SHARC Model

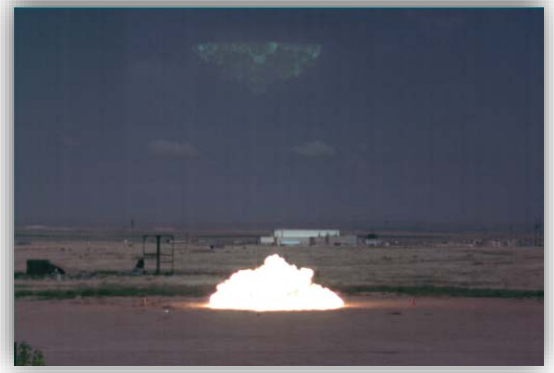
Mitigation Methods

Turbo FRMAC Overview

Briefing Products

Time Scales for Explosive Aerosolization/Fragmentation Phenomenology

µs



ms

< s

Microseconds (µs)

- Shock wave interaction with material
- Initial particle size distribution

Milliseconds (ms)

- Fireball dynamics
- Final particle size distribution

Milliseconds to seconds

- Plume rise

Seconds to minutes

- Late dispersal flow downwind

Models Based on Time Scale

Microseconds to Milliseconds: Computational Fluid Dynamics or Finite Element Analysis Codes:

- Energy deposition, initial particle size distribution
- Examples are:
  - Eulerian (Finite Volume, finite difference schemes)
  - Lagrangian (Finite Element Schemes)

Milliseconds to Seconds: Dispersal Models

- Plume rise, early dispersal, downwind dispersal
- Examples are:
  - HotSpot, SHARC[1] and NARAC[2]

1. Specialized Hazard Assessment Response Capability
2. National Atmospheric Release Advisory Center

Building a Source Term Database

Over the last 30 years Sandia has performed more than 1,000 characterization tests.

Finding: size of particulate released depends on explosive properties, device geometry, and material physical/chemical properties

MATERIAL	PHYSICAL FORM	DEVICE STRATEGIES TESTED
Ag	Metal	17
Al	Metal	5
Bi	Metal	3
Co	Metal	1
Cu	Metal	2
Mo	Metal	1
Pb	Metal	1
Ir	Metal	3
Stainless Steel	Metal	2
Ta	Metal	1
U	Metal	1
CeO2	Ceramic (2 densities per device)	7
$SrTiO_3$	Ceramic (3 densities per device)	8
Tb/Pd	Cermet	1
Various Materials	Liquid	8
BaSO4	Slurry	1
CeO2	Ceramic Powder	7
MnO2	Ceramic Powder	4
UO2	Ceramic Powder	1
CeO2	Pressed Powder	3
CsCl	Powdered Salt	7
BaSO4	Powdered Salt	2

DOE Dispersal Modeling Tools

The capabilities of different modeling tools – *HotSpot*, *SHARC,* and *NARAC* have different, complementary capabilities:

HotSpot's strengths are minimal input data requirements, very fast computations, and portability to run on computers at multiple locations.

SHARC's strengths are moderate input data requirements, vertical variation in meteorological conditions, fast computations for running a range of possible scenarios, population database and ability to run in a wide variety of locations and on different computer systems including a variety of different classified systems.

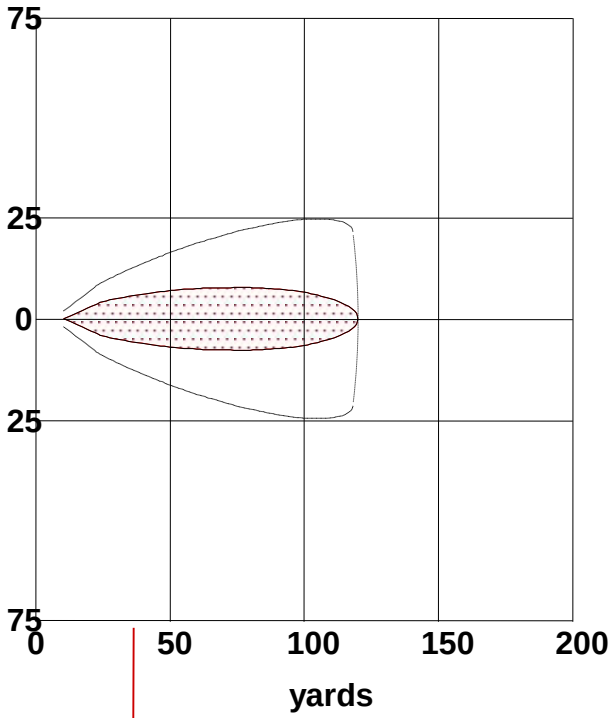
NARAC's strengths are 3-D time-varying weather conditions, complex terrain effects, the ability to predict longer distance and longer time impacts, population database, and the ability to update predictions using environmental measurement data.

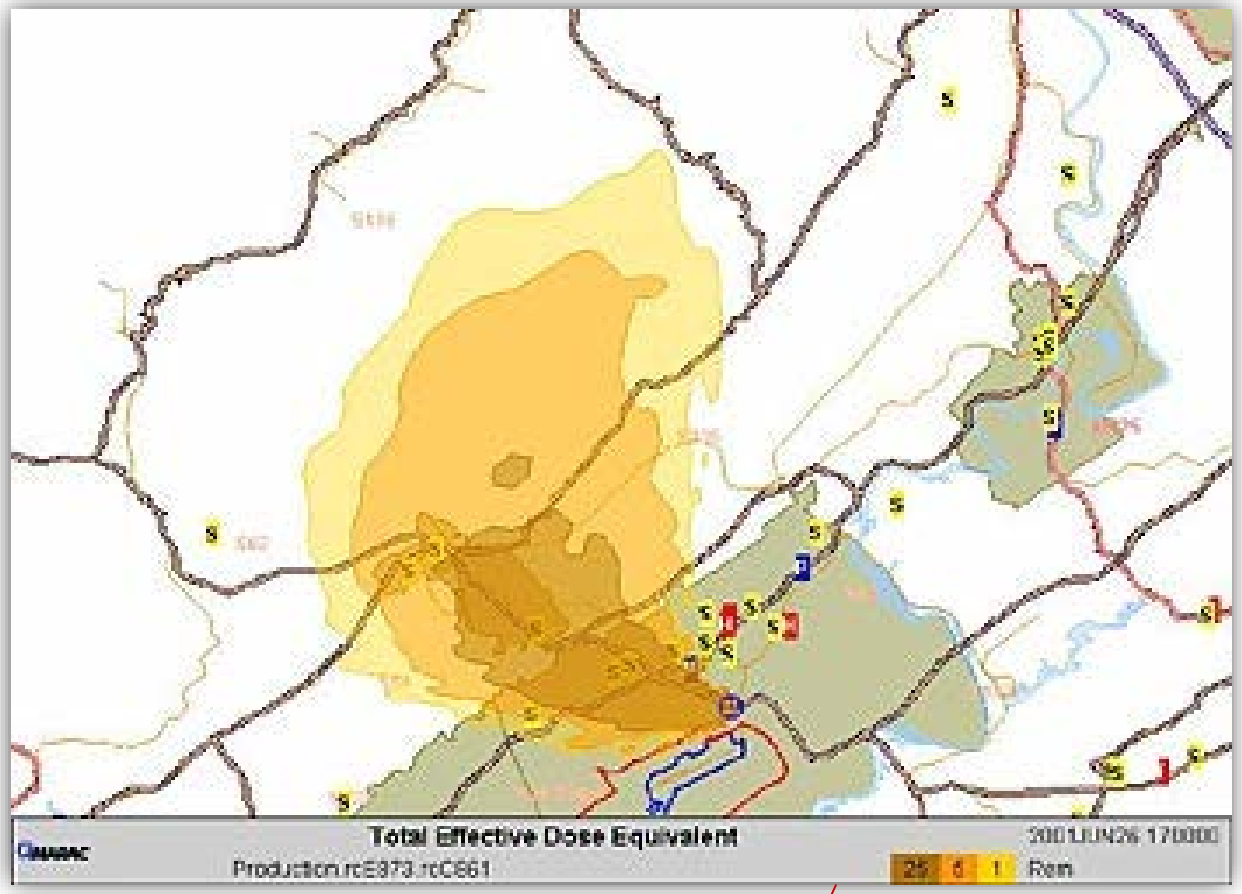
Comparison of Modeling Software Tools Capabilities

Model	HotSpot	SHARC	NARAC
Scenarios	• Nuclear detonation • Radiation dispersal device • General radiological release • Weapon accident fire • Facility fire • Stack venting	• Nuclear detonation • Radiation dispersal device • General radiological release	• Nuclear detonation • Radiation dispersal device • General radiological release • Weapon accident fire • Facility fire • Stack venting • Nuclear power plant accident

Heather Pennington, John Nasstrom. *DOE/NNSA Office of Nuclear Incident Response Atmospheric Dispersion, Fallout, and Effects Modeling Concept of Operations.* DC : NNSA, 2015.

Differing Levels of Complexity





Simple Model

Sophisticated Model

Run Time

Questions ?

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