



# Overview of DARPA Pentagon Shield Program

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Program Manager





# Agenda

- DARPA Pentagon protection effort
  - DARPA research and development
  - Pentagon Force Protection Agency implementation
- Pentagon Shield Field Campaign
- Model validation strategies





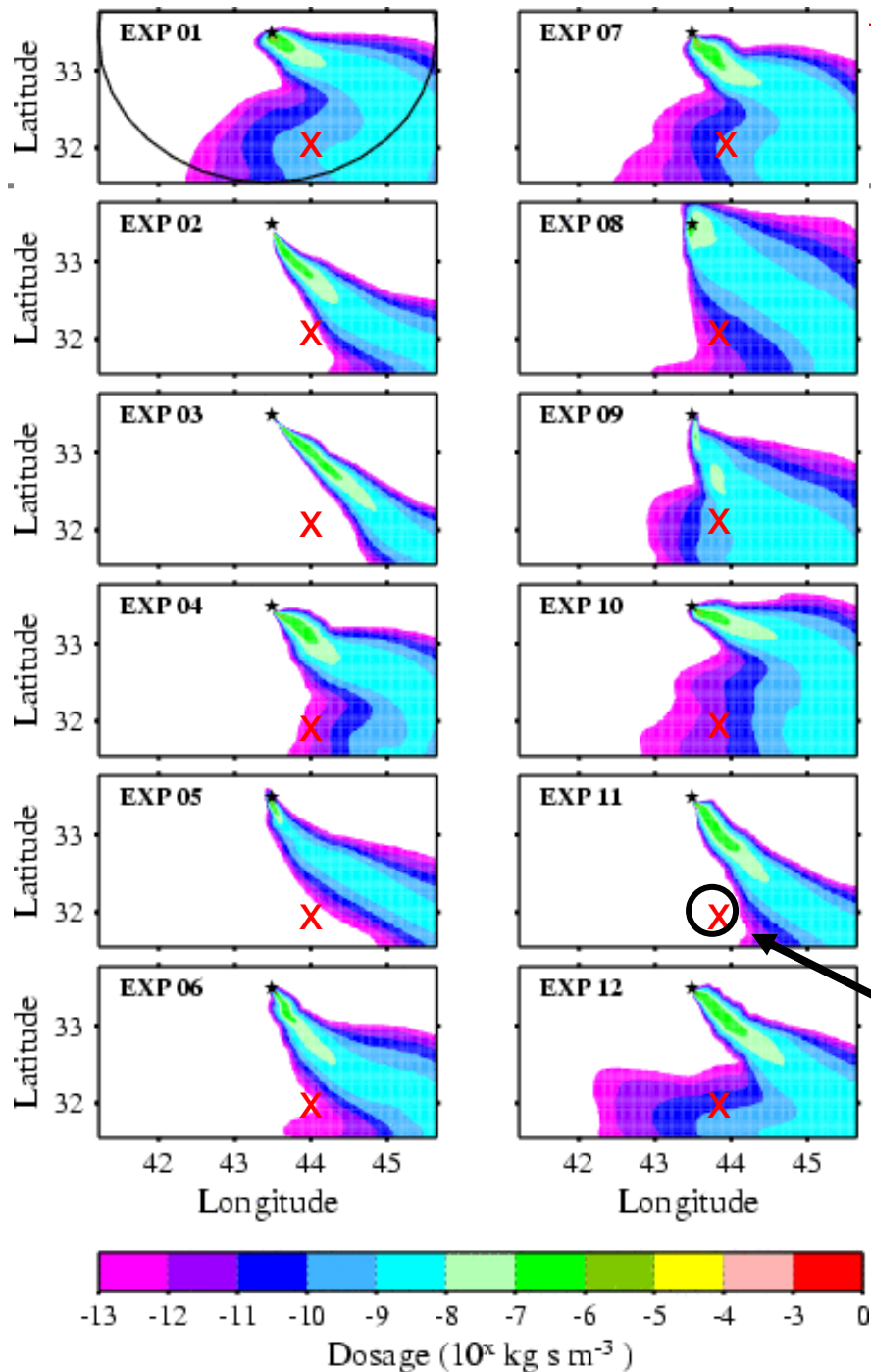


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# Background: S&T challenges and gaps

Accounting for plume evolution in the urban setting, under variety of atmospheric conditions





## Illustration of the sensitivity of the T&D to meteorological uncertainty

SCIPUFF runs with the same source, but based on an ensemble of different meteorological-model simulations with different boundary conditions and physics.

Example receptor



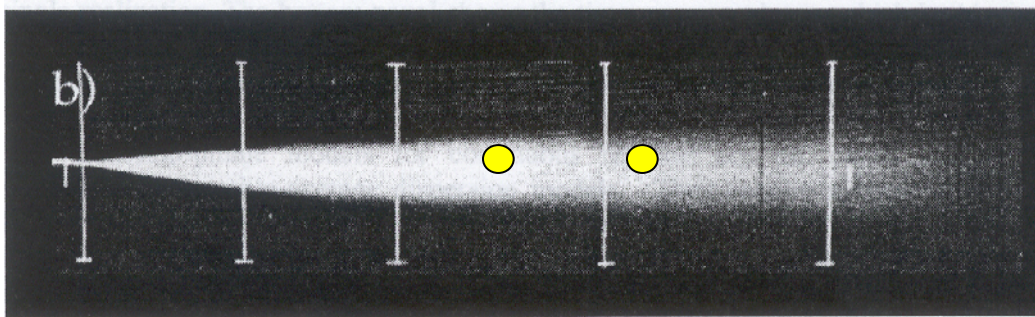
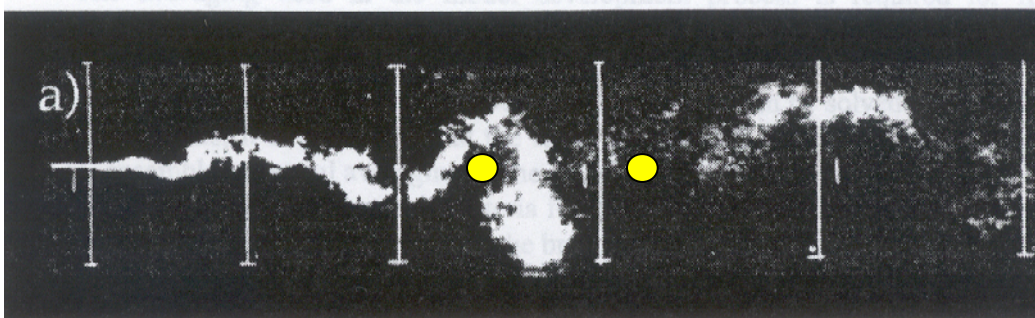


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# Disconnect between simulations and measurements



## NEGATIVE SENSOR RESPONSE



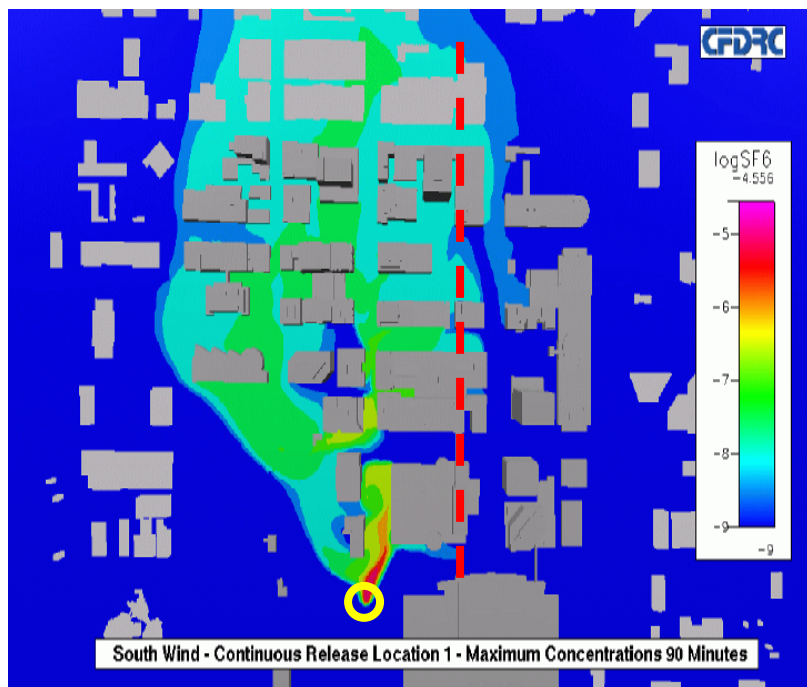
## PLUME MODEL INDICATES A HIT

*Smoke released  
in wind tunnel,  
EPA Fluid  
Modeling  
Facility*

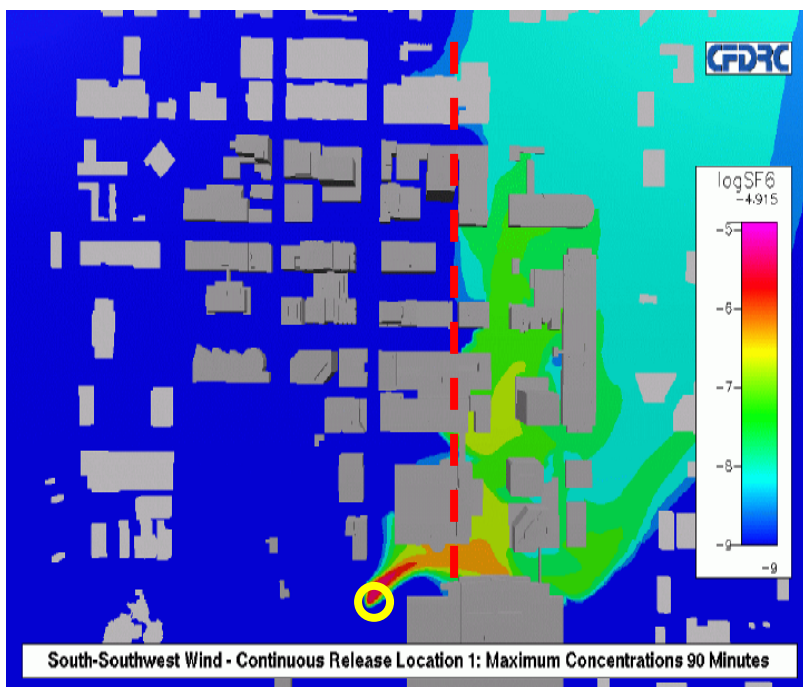


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# “Nonlinear” Scale Response



**S winds**



**SSW winds**



(Winds shift 22 deg)

*JU 2003, Oklahoma City, courtesy CFD Research Corp.*



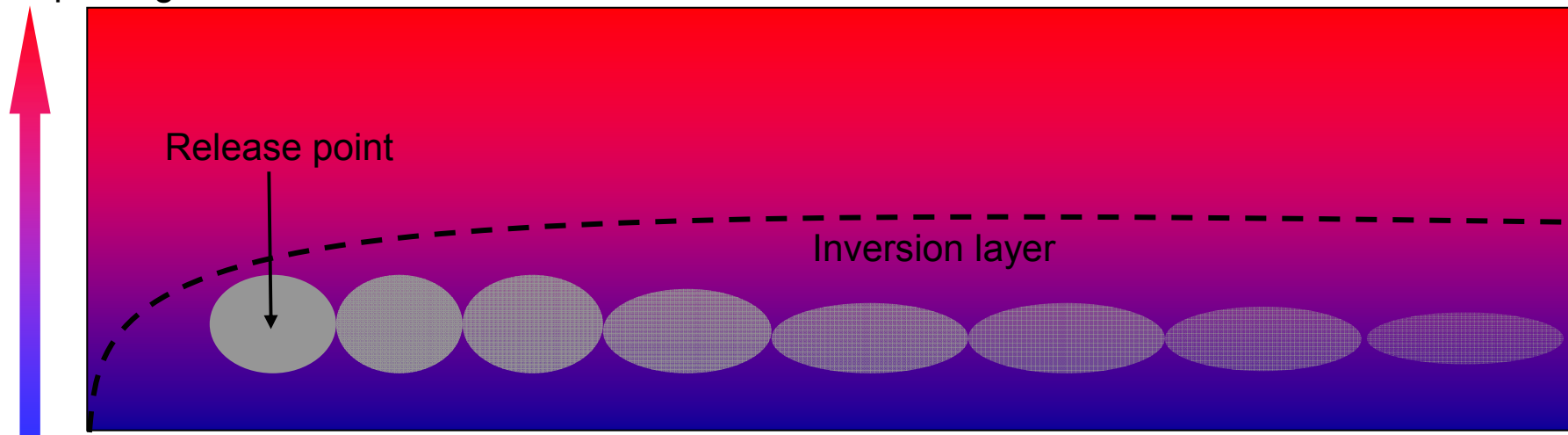


# Plume evolution varies with aspects of atmosphere not easily measured

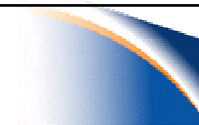


- Shallow surface temperature inversion
  - Sunset to sunrise, light winds, and clear to partly cloudy skies

Temp rising



Particles or gas near the surface are always cooler and denser than the air above, so they can't rise. Plume spreads horizontally







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# Shallow surface inversion



Gases or aerosols trapped close to the surface, at human breathing height

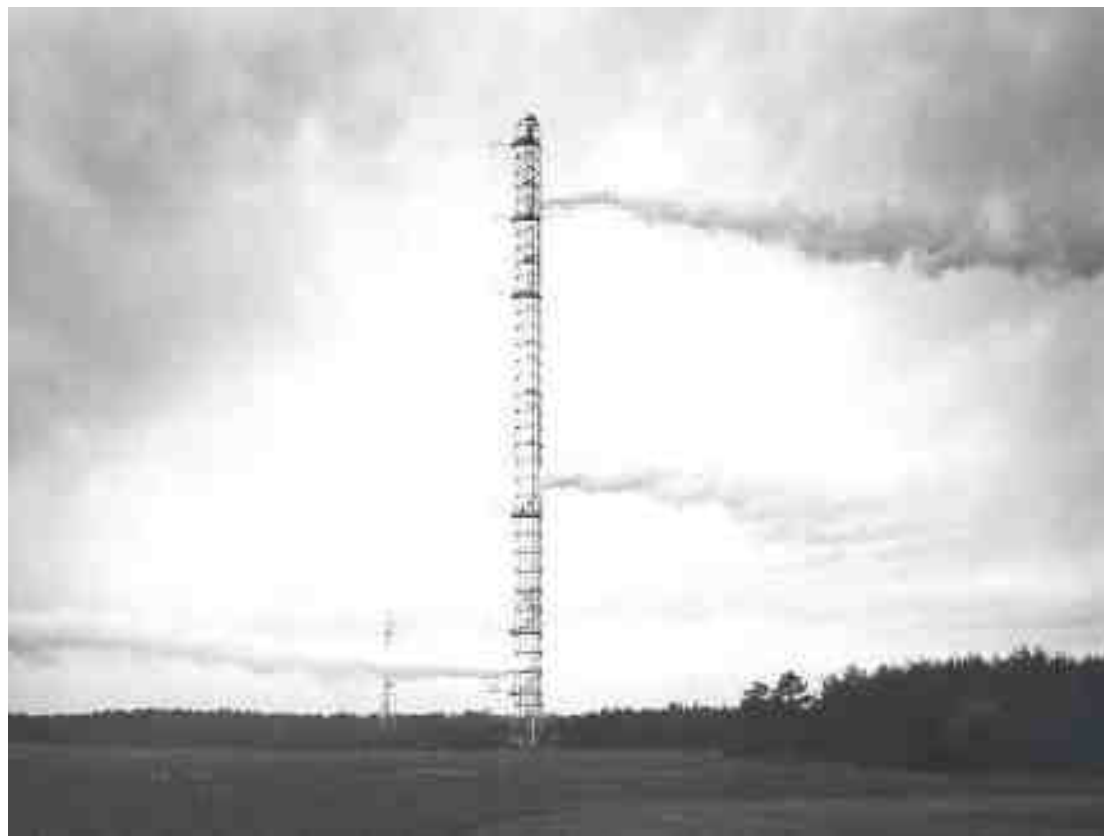


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## Complex vertical structures may exist



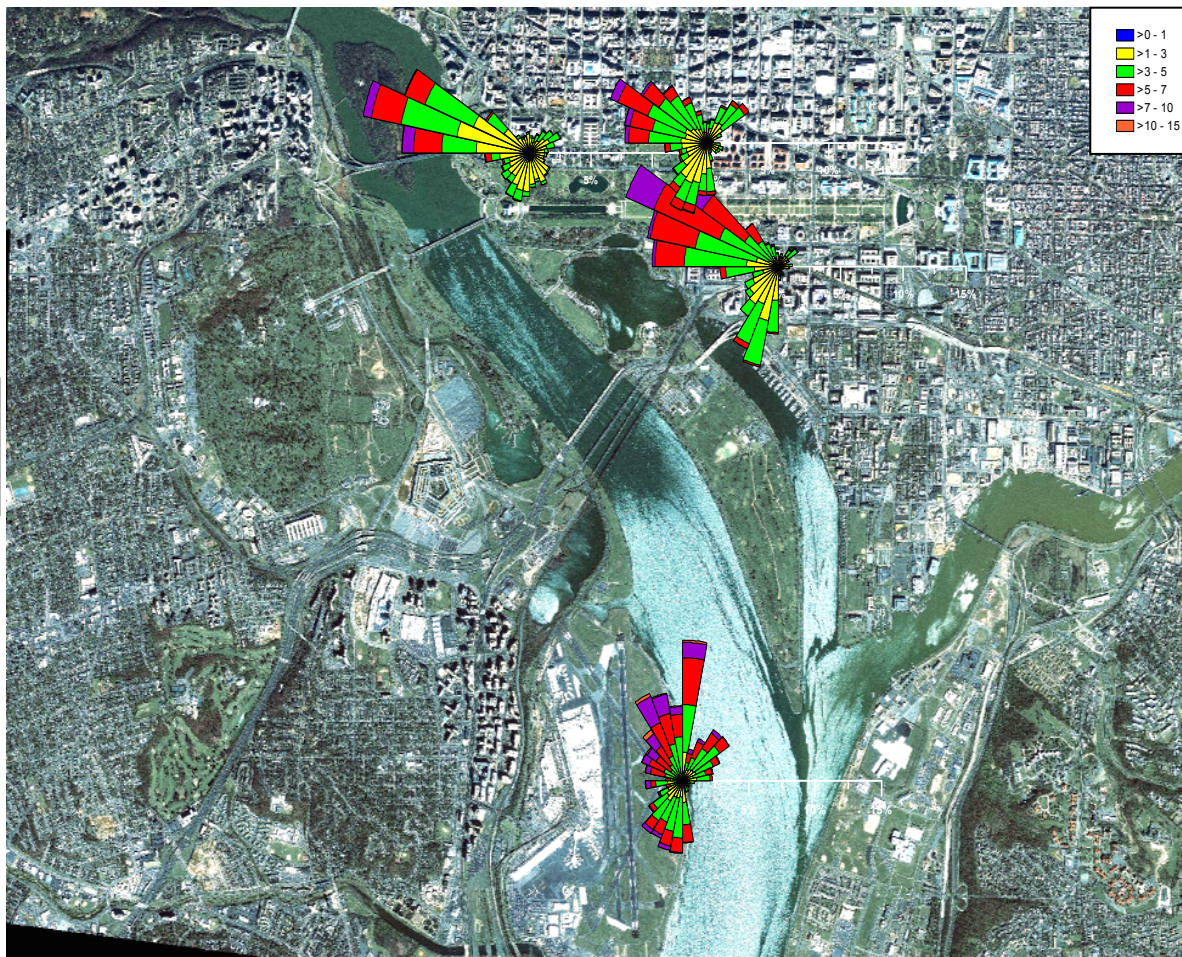
*Courtesy Brookhaven National  
Laboratory, Long Island, 1973*



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# Urban channeling effects

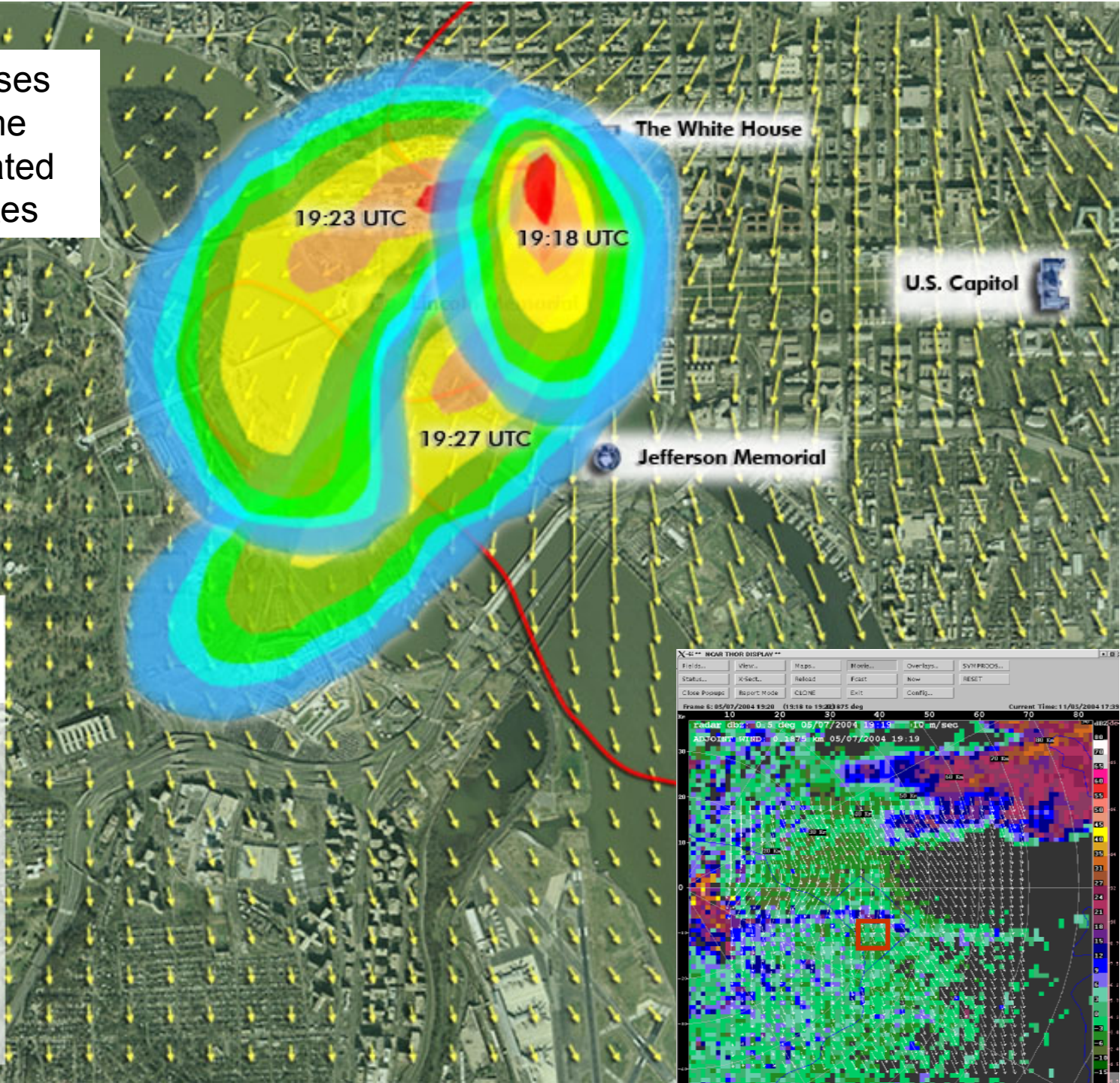


*courtesy  
NOAA ARL*





Notional releases  
from the same  
location, repeated  
every 5 minutes



**SCIPUFF plumes  
and lidar winds over  
Washington DC**

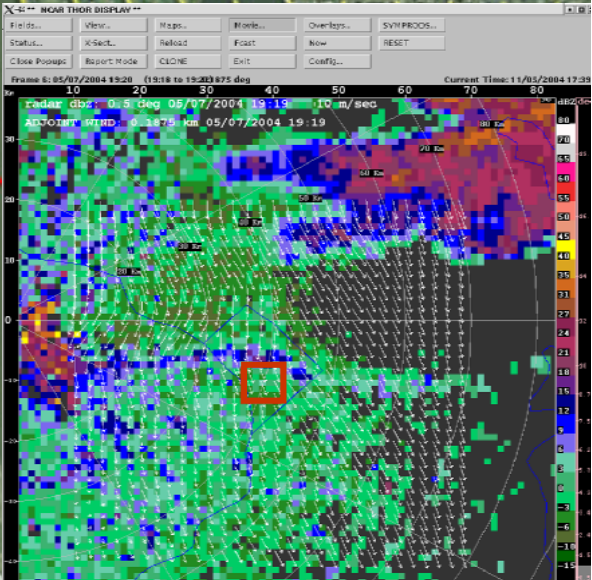
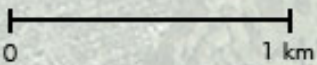
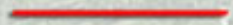
Reference landmarks



Doppler lidar vectors  
every second vector plotted

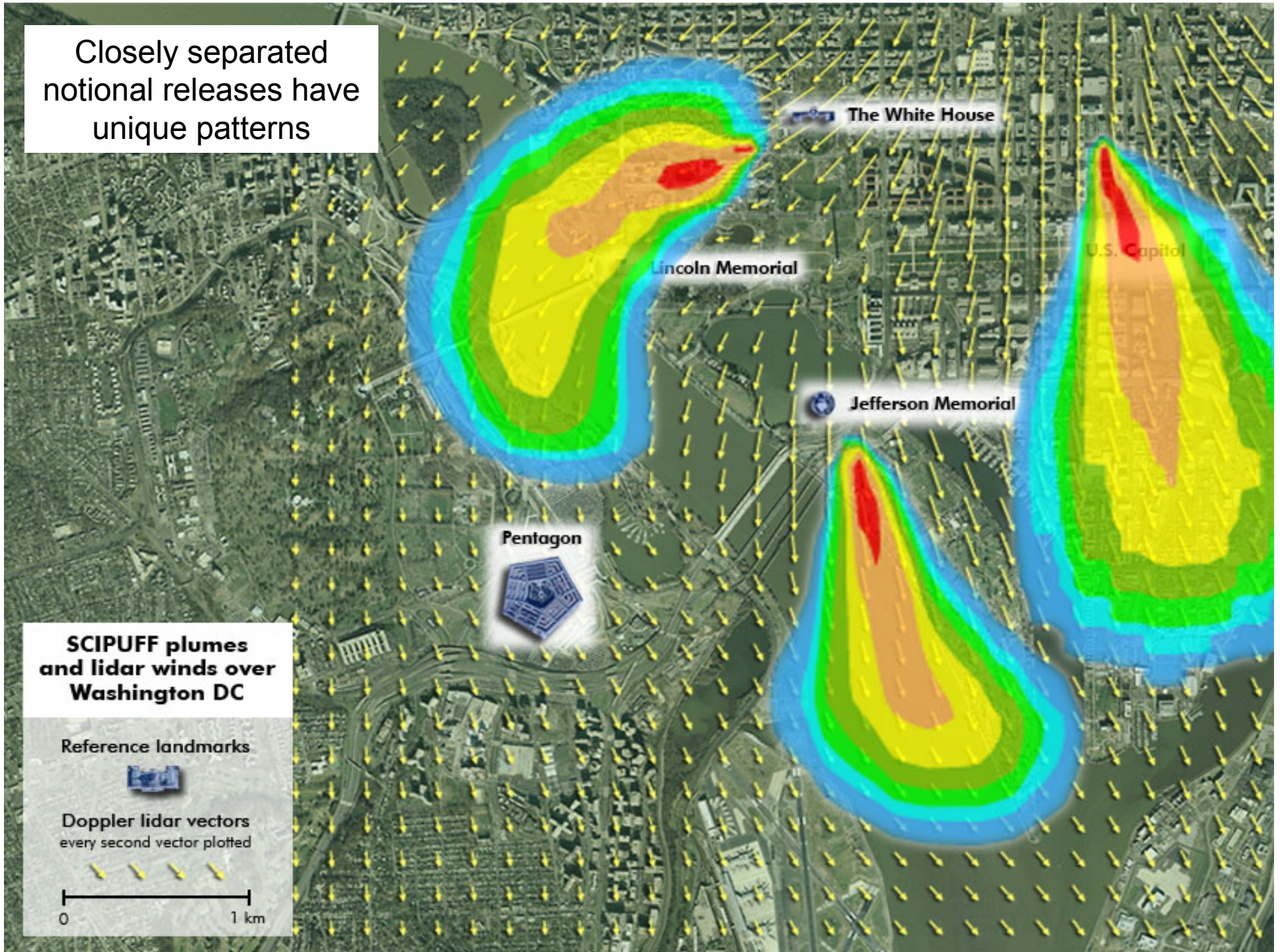


Isotach 3.00 ms<sup>-1</sup>





Closely separated  
notional releases have  
unique patterns



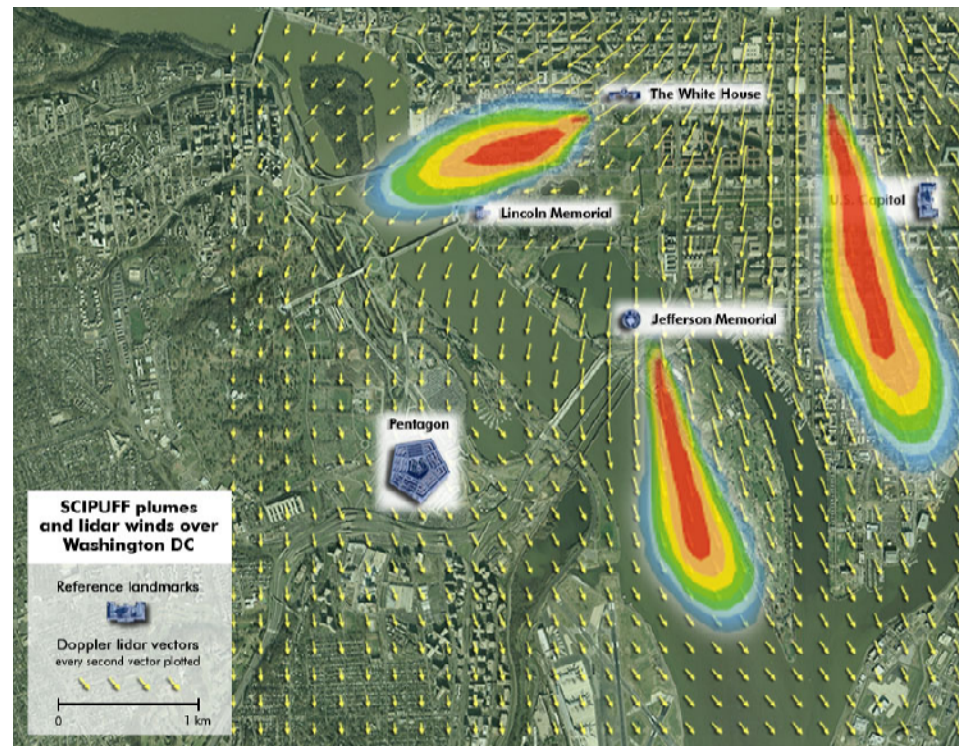
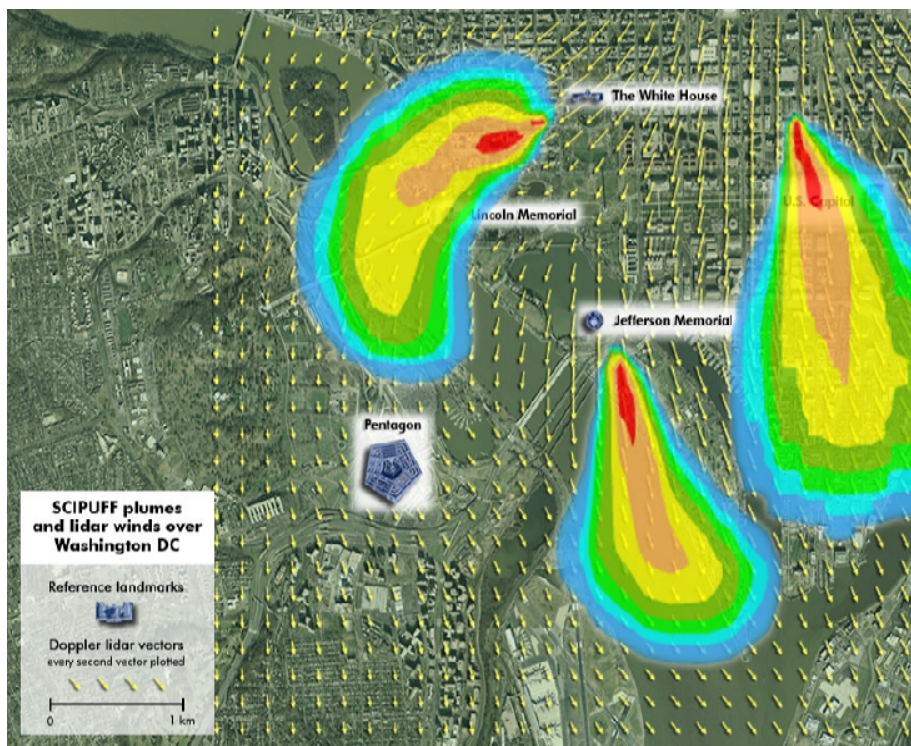




# Sensitivity of notional plume prediction to atmospheric stability conditions

## Neutral/Convective atmosphere

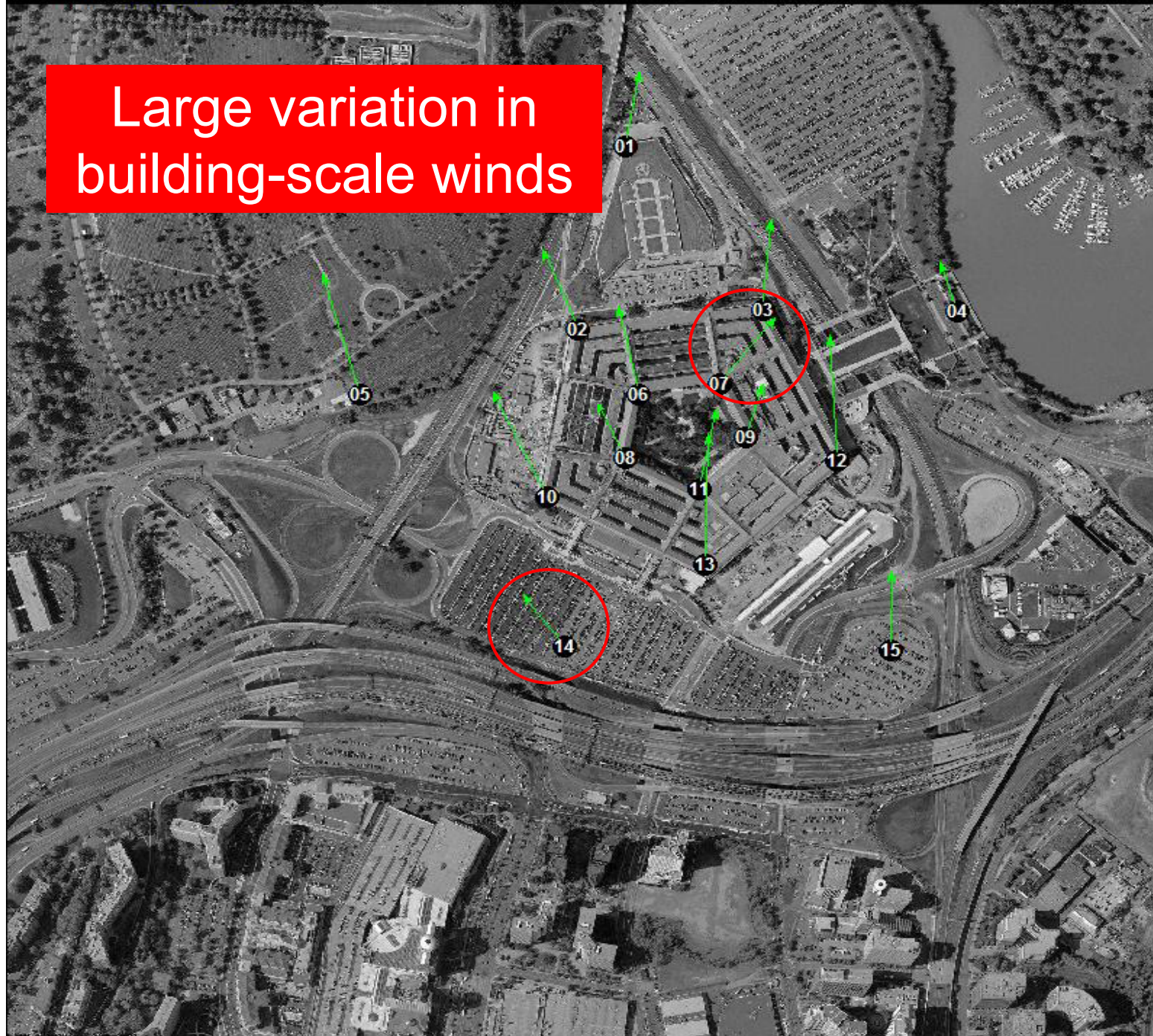
## Stable atmosphere





LST TIME: 22:38:59

# Large variation in building-scale winds



## PWID STATUS

- PWID OBSERVATION GOOD
- PWID NOT UPDATED
- PWID TURNED OFF
- PWID TURNED ON
- CURSOR OVER PWID

## WIND VECTORS

- <1 m/s
- 1-5 m/s
- 5-8 m/s
- >8 m/s
- <.5 m/s



# Protective Architecture Overview







# Protective Architecture Overview



- With PFFPA/CBRN develop passive and active systems to reduce CB threat
- Technology development areas:
  - Geographically Distributed Inlets
  - Control systems that use sensors to modify building airflows
  - Evacuation guidance to route personnel around unsafe areas
- Next generation near real-time threat modeling to support capabilities and decision making





# Real-time Threat Modeling



- Technical Approach

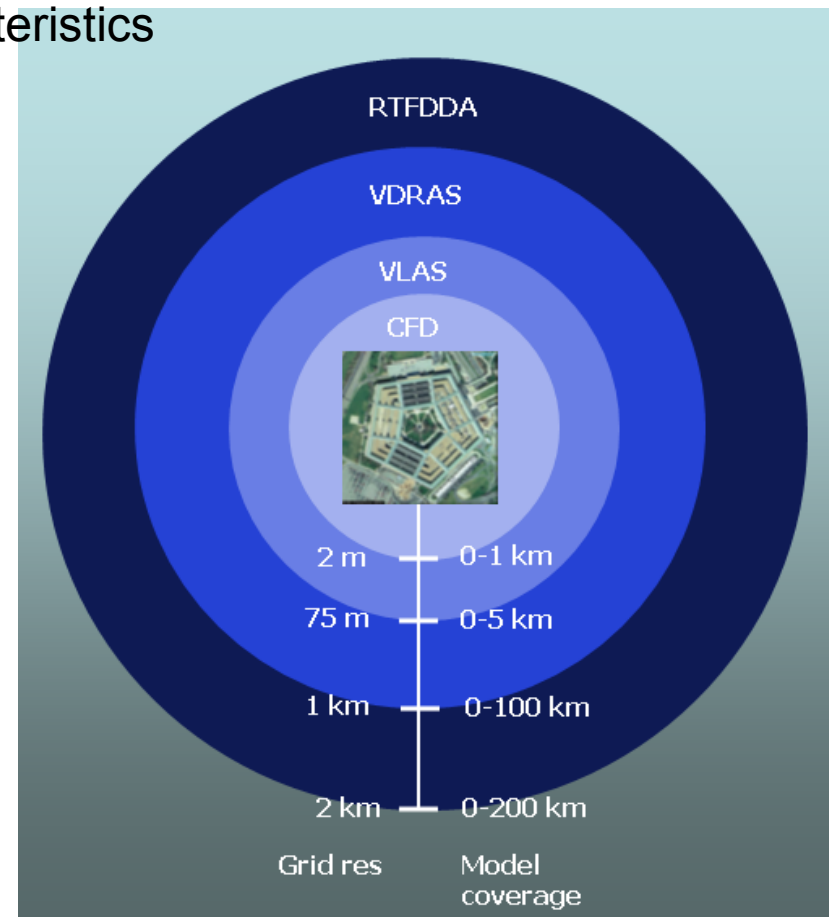
- Develop CBR and weather instrument sensor fusion and modeling system to produce high-resolution fast plume tracking
- Use stand-off chemical and particulate sensors to determine source location and provide initial plume characteristics

- Uses nested met models to provide accurate and timely wind data

- RT-FDDA – Regional model
- VDRAS – Doppler RADAR
- VLAS – Doppler LIDAR
- CFD – QUIC approximation

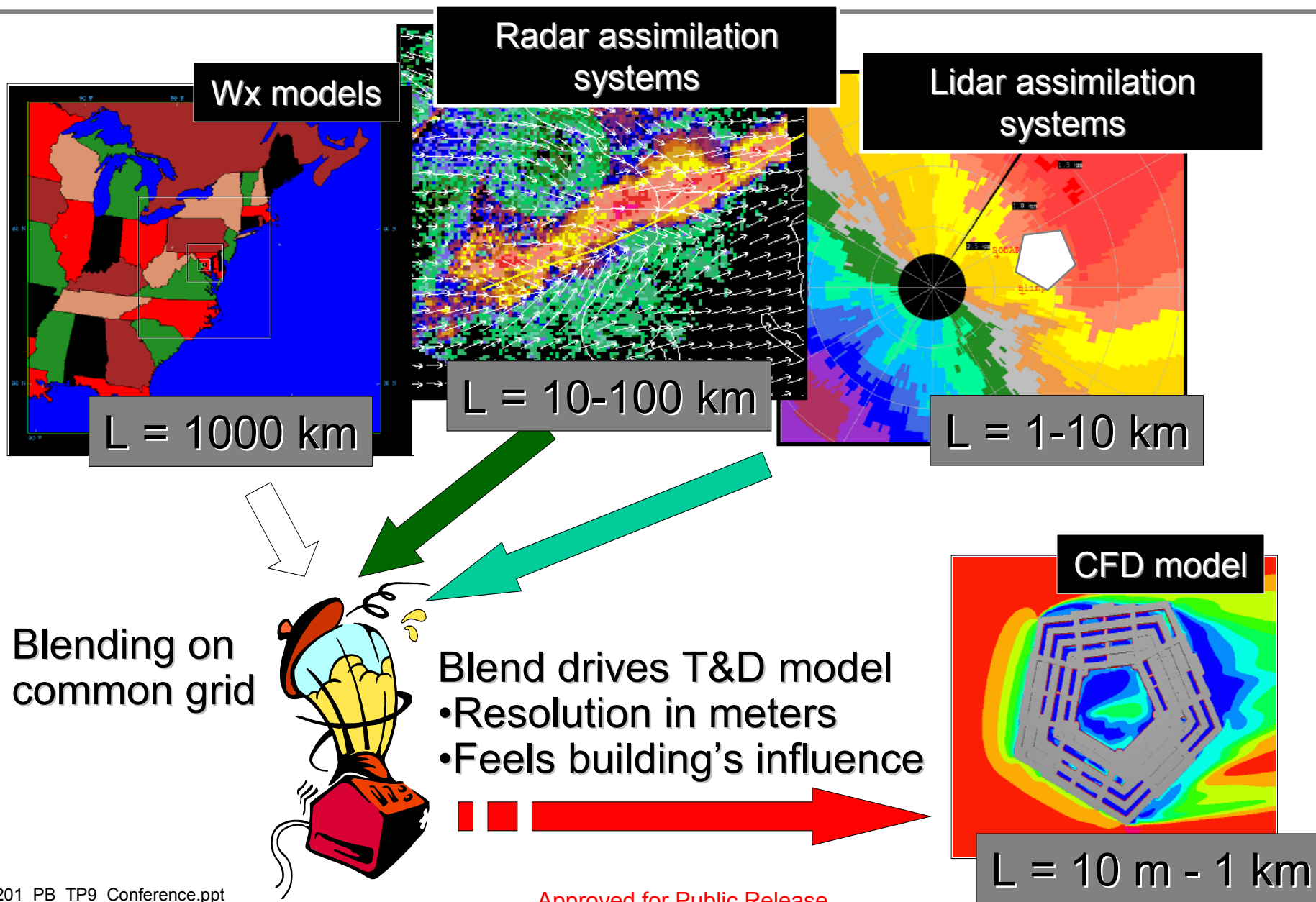
- Always have current winds and predictions

- Directs building response, evacuations, and first responder actions





# Modeling across the scales





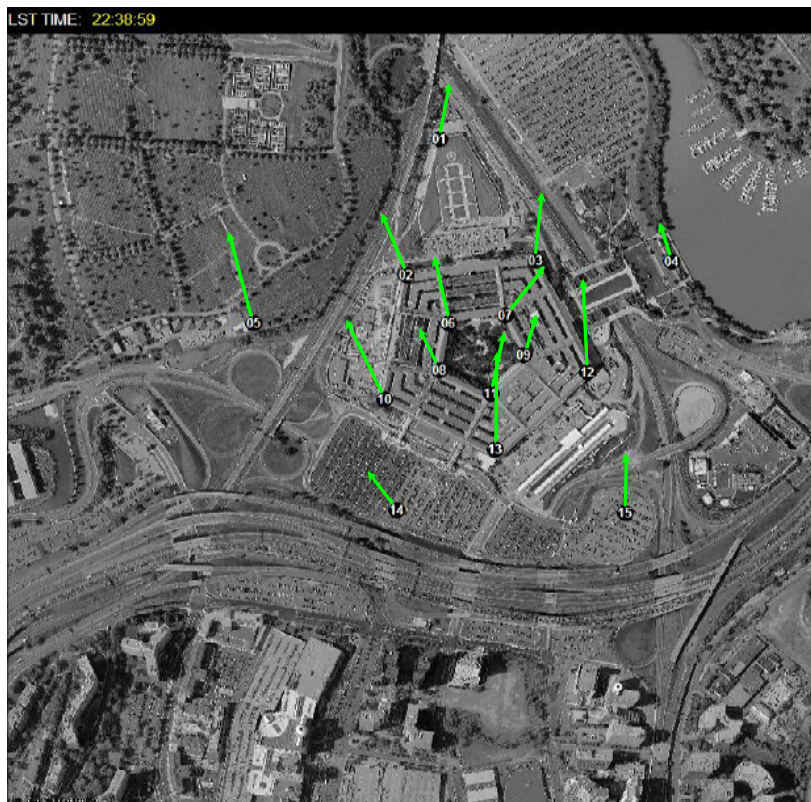


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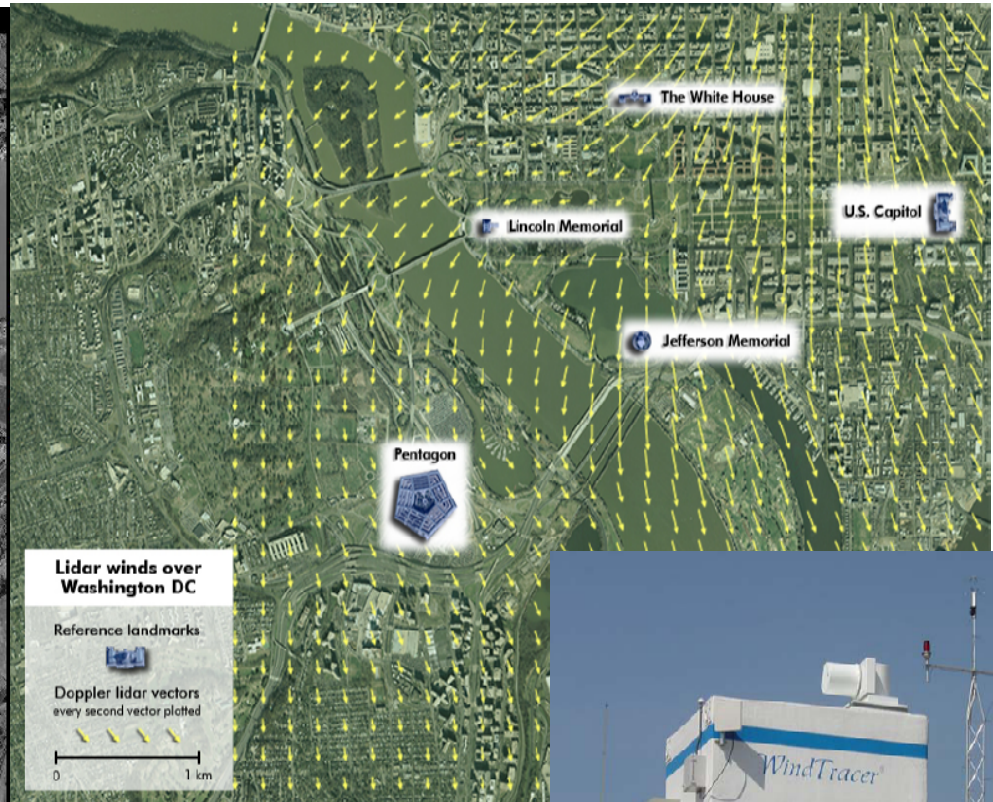
# Real-time Volumetric Wind Profiles



- Point anemometers may present conflicting wind directions
- WindTracer is a COTS Doppler LIDAR providing real-time accurate windfields



Wind Anemometers  
(Pentagon Shield exercise)



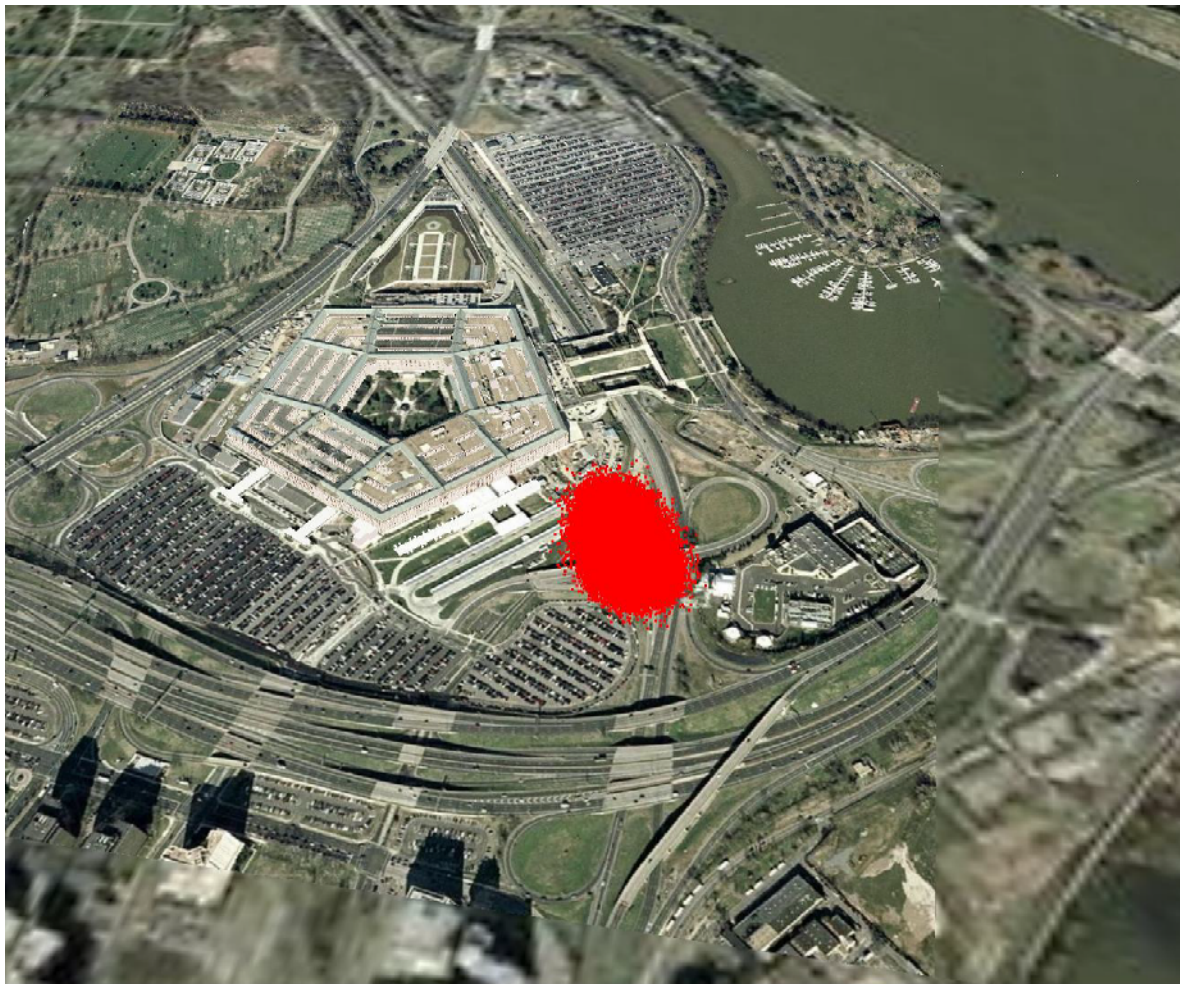
Doppler LIDAR







# Contaminant Mapping for Active Control



Use entire Doppler LIDAR wind volume for better accuracy

3-D model of Pentagon with texture-mapped photographs of wall surfaces

Particle visualization from output of semi-Lagrangian Eulerian CFD model running at 2 m resolution, coupled to Lagrangian particle transport model





# Pentagon Shield Exercise

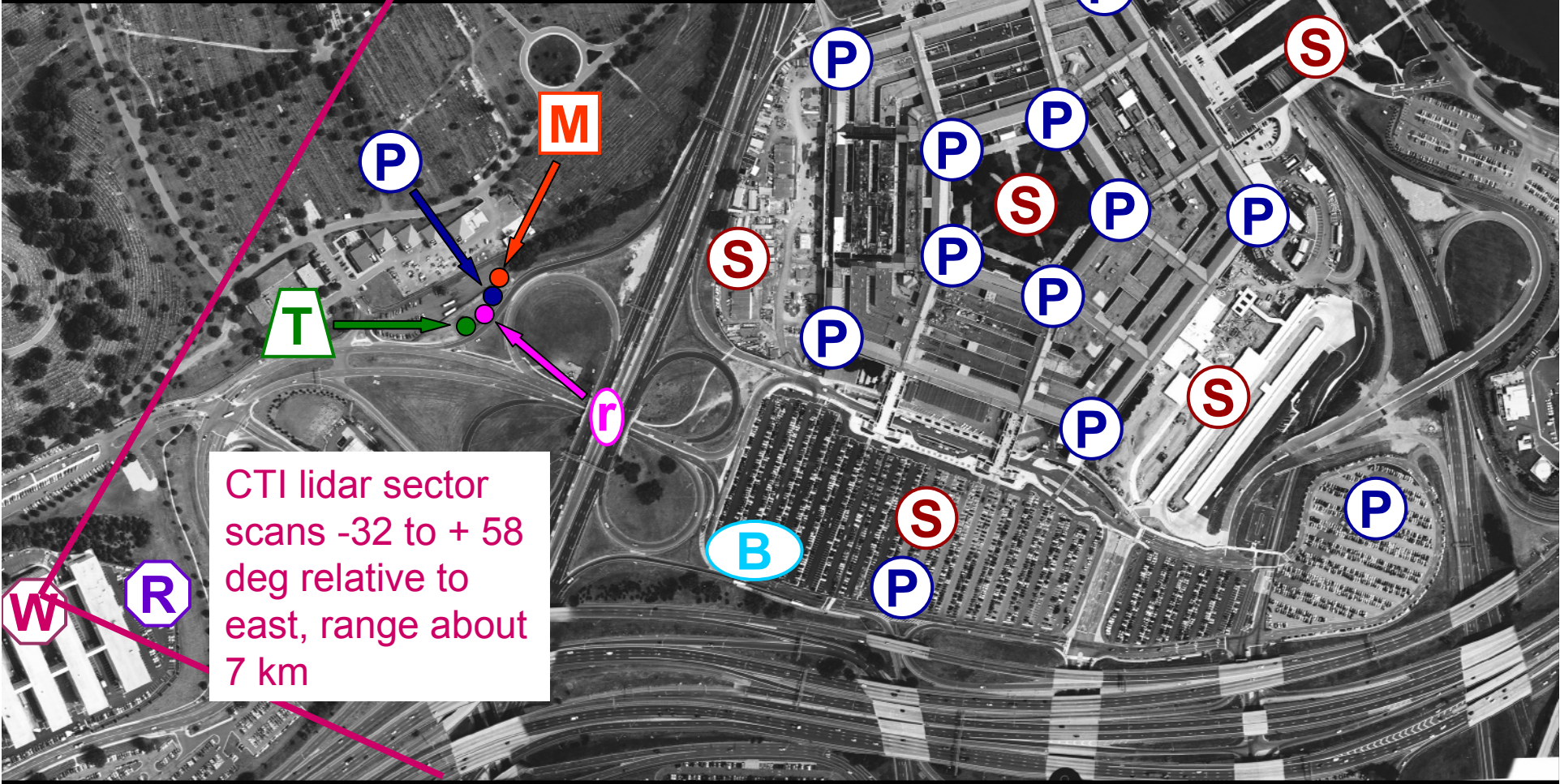


- Pentagon Shield Objectives
  - Test Pentagon HVAC response CONOPS to CBR incident
  - Use a vast array of weather sensors to develop a detailed profile of the atmosphere around the Pentagon
    - ◆ Critical to developing realistic weather and dispersion models
    - ◆ Provides next generation weather feeds for operational models
    - ◆ Identifies optimal placement of CBR and weather sensors
  - Collects data for comparison with wind tunnel testing of 1:200 scale model of the Pentagon
    - ◆ Allows tuning of airflow and transport and dispersion models
  - Provide data to evaluate planned protective systems
- Pentagon Shield Activities (19 April to 15 May)
  - Installed 25 point wind sensors
  - Installed (2) COTS and (1) EBL LIDAR (REAL) at Navy Annex and Bolling AFB
  - Installed 32m weather tower on Arlington Cemetery
  - Flew a 30'x10' blimp to measure wind speeds and turbulence
  - Released more than 80 weather balloons over course of exercise
  - Performed tracer gas (SF6) releases to collect empirical wind flow data





|                      |                     |
|----------------------|---------------------|
| <b>P</b> PWIDS       | <b>R</b> REAL       |
| <b>S</b> Super-PWIDS | <b>M</b> Mini-sodar |
| <b>B</b> TLS blimp   | <b>r</b> Radiometer |
| <b>W</b> WindTracer  | <b>T</b> Tower      |



CTI lidar sector scans -32 to + 58 deg relative to east, range about 7 km





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# Field Campaign Equipment



CTI Windtracer LIDAR (2)



REAL Aerosol LIDAR (1)



Super-PWIDS (10)



Portable Weather Instrumentation Display (15)





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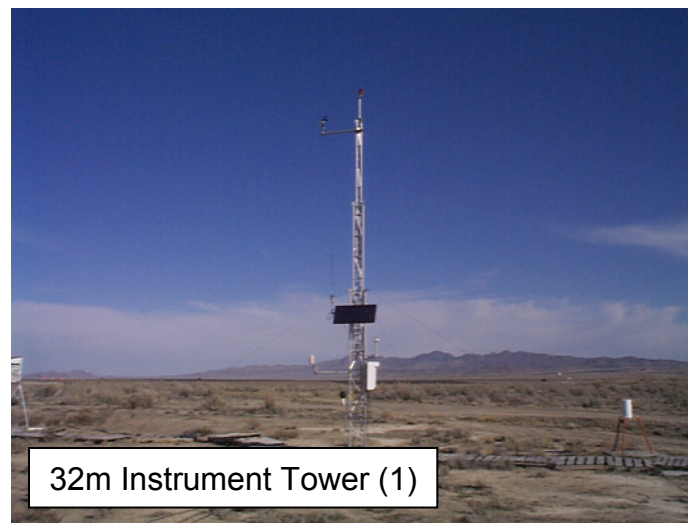
# Field Campaign Equipment



Mobile Operational Meteorological Station (1)



Sonic Detection & Ranging (1)



32m Instrument Tower (1)



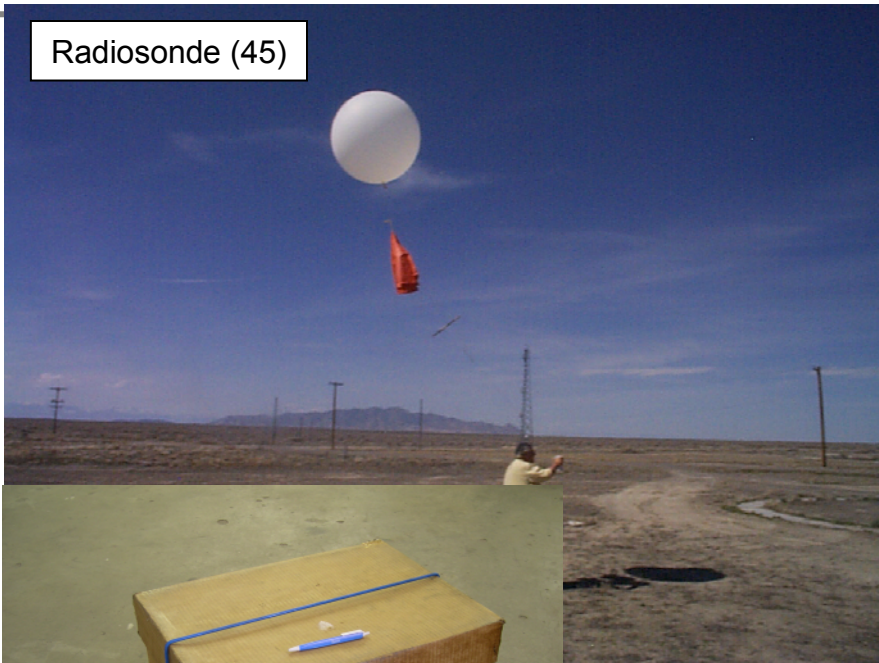
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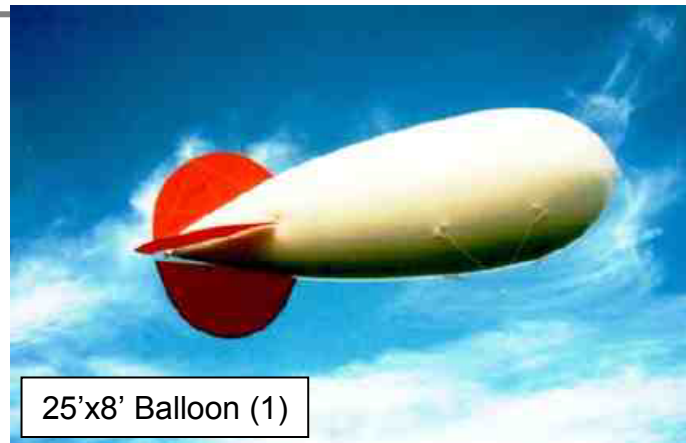


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# Field Campaign Equipment



Radiosonde (45)



25'x8' Balloon (1)



SF6 Bag Sampler (50)



SF6 Trace Gas Analyzer (5)



NOAA SF6 Support Trailer (1)



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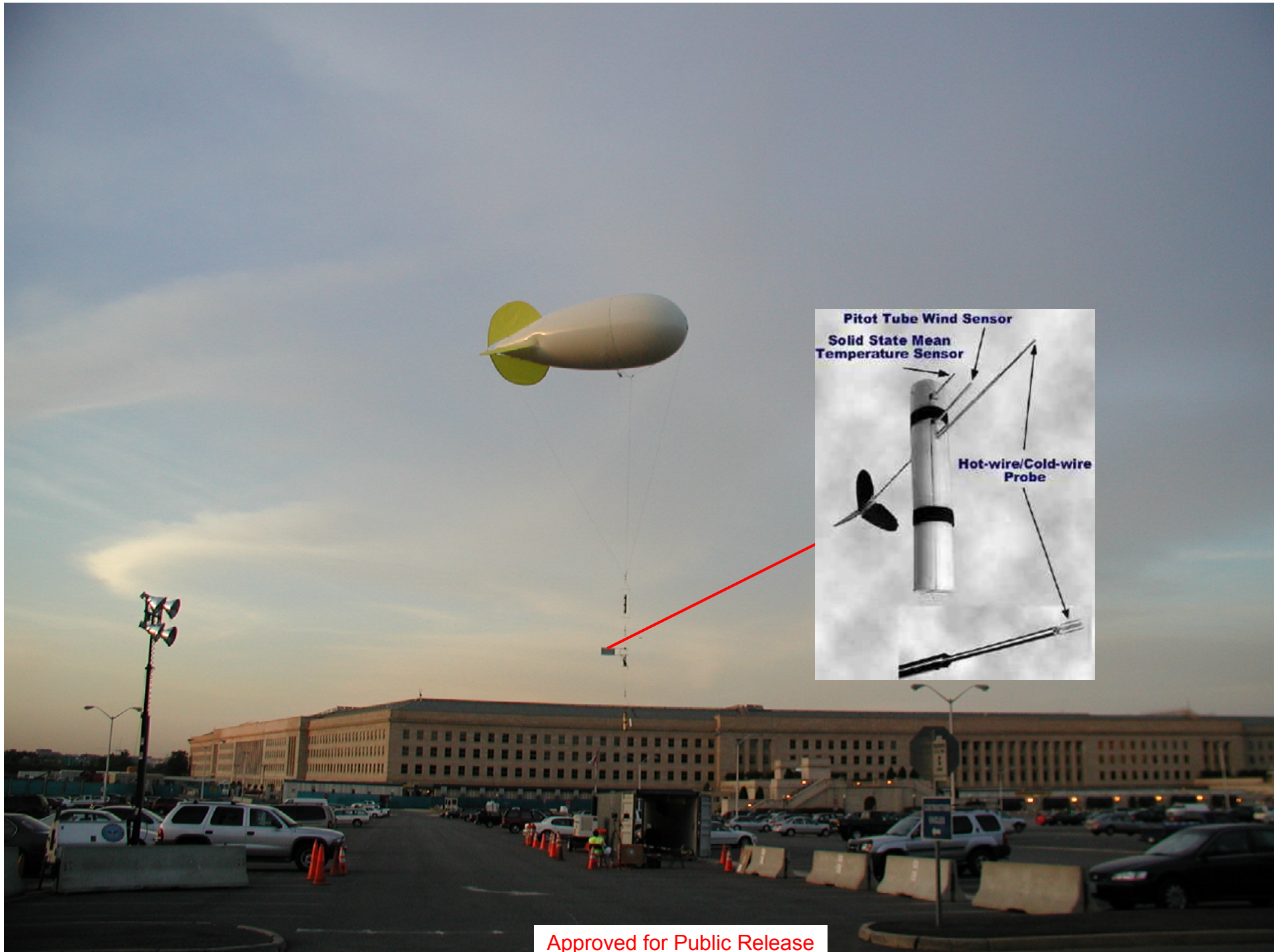
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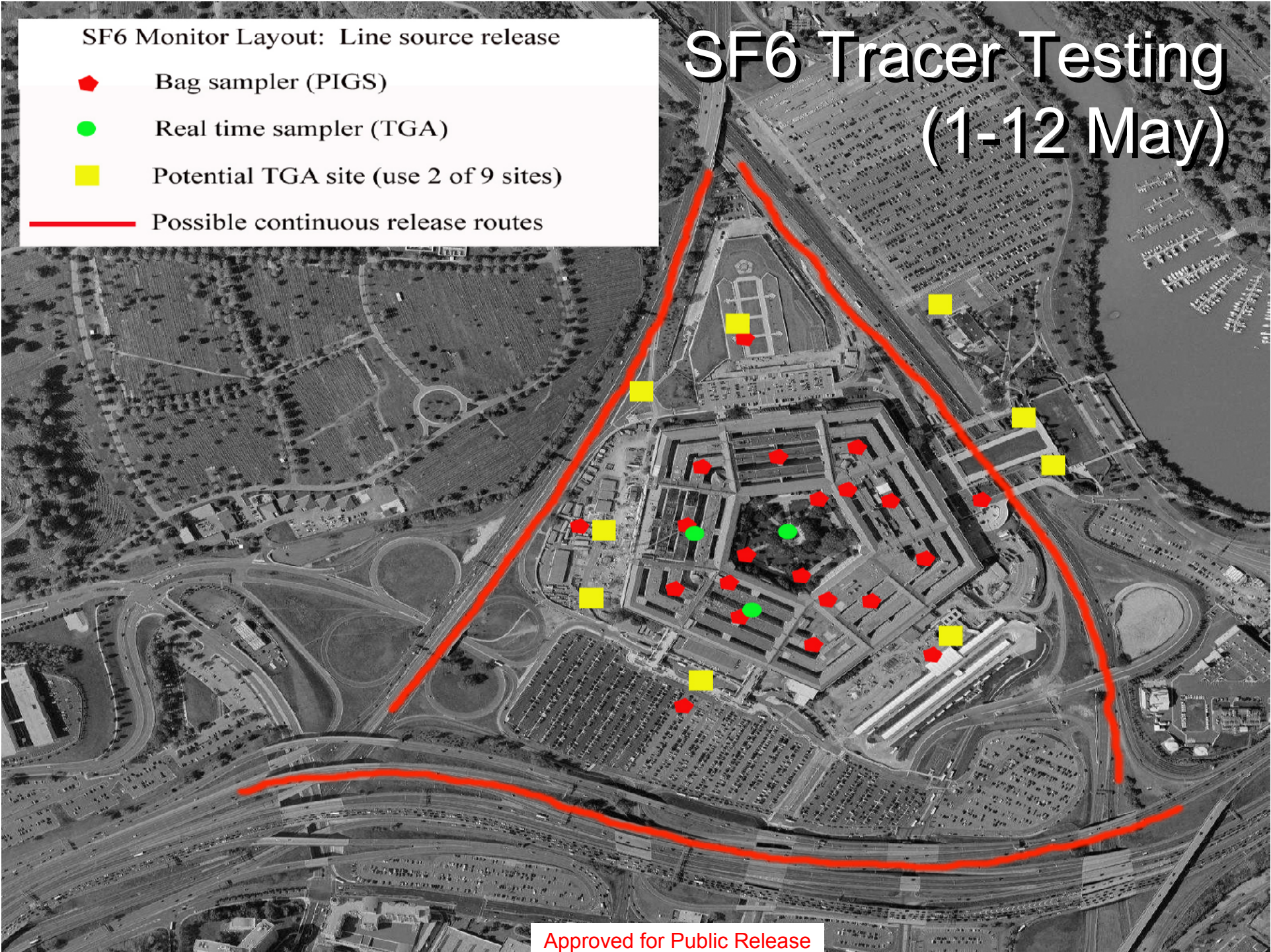


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# SF6 Tracer Testing (1-12 May)

- SF6 Monitor Layout: Line source release
- ◆ Bag sampler (PIGS)
  - Real time sampler (TGA)
  - Potential TGA site (use 2 of 9 sites)
  - Possible continuous release routes







# Impacts and Safety Issues



- Safety issues addressed
  - EPA compliance for SF6 studies (Same as OK City and SLC)
  - Int'l Electrotechnical Commission (IEC) 60825-1:1993 and A2:2001 compliance for eye safe lasers
  - FAA FAR Part 101 and CFR Title 14 compliance for balloon flights
  - ACE evaluation of sensor rooftop mounting on Navy Annex Bldg 7
- Operations
  - Pentagon air traffic control coordination and support (NOTAMs)
  - Sensors that look like suspicious packages (SF6 bag samplers – roof and inside)
  - Laser signature from Windtracer and REAL
- Logistics
  - Equipment footprint (use of parking spaces, hallways, rooftops, light poles)
  - Tether anchors and location for 32 m tower
  - PFPA support for building and facilities access
  - Non-DoD frequencies for wireless comm. support for instrumentation
- Public Affairs





# Field Program Participants



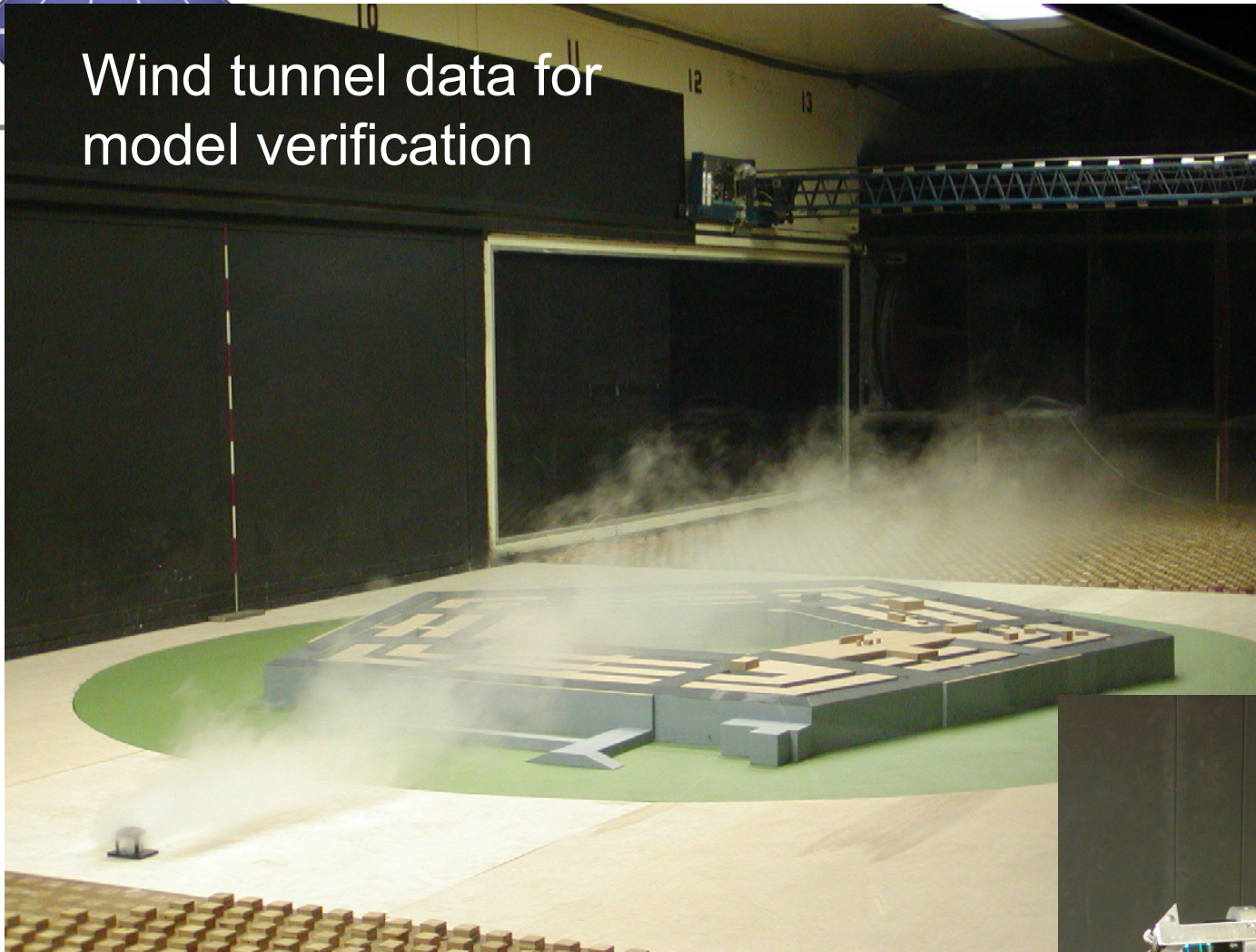
- DARPA Program Manager
- NCAR Planning, test direction, overall logistics, aerosol lidar demo, experiment design, FP plan
- University Colorado Turbulence profiling
- Dugway PWIDS, 3-D sonics, SODAR, tower, forecast support for SF6 tracer study planning
- NOAA SF6 tracer study and sampling
- NSWC Operational support
- ACE Engineering and contract support
- WHS PBMO, PenRen and Navy Annex personnel



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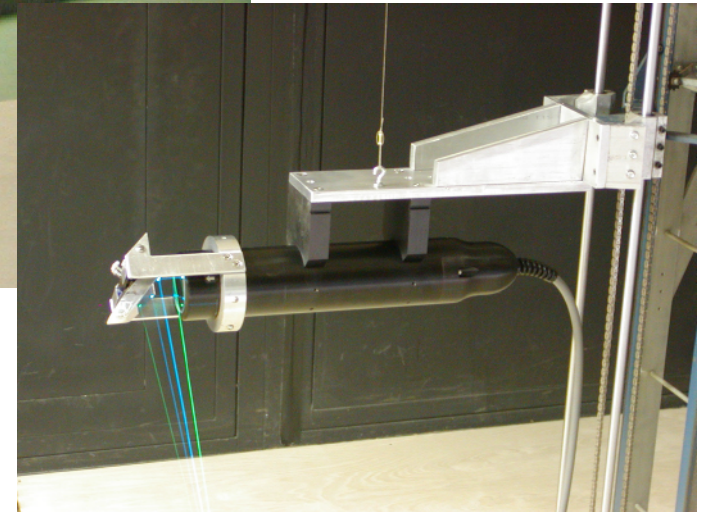
# Wind tunnel data for model verification



Completed Pentagon model, inside wind tunnel

*Laser Doppler velocimeter to measure flows*

*1:200 scale wind tunnel model courtesy EPA Fluid Modeling Facility, 2004*





# Program Testing and Transition



- DARPA investing in development, prototyping and testing of new technologies
  - Sensors
  - Command and control systems
  - Active HVAC controls
- Installed “DARPA-Net” mimicking operational CBRN “Sensor-Net”
  - All sensors and systems tested on DARPA-Net
  - Allows in-situ testing of all systems that may be used operationally
  - Testing continues through FY05
- Final system demonstration scheduled for end GFY05
  - Full-up system test including
    - ◆ Simulant releases
    - ◆ Sensor detections
    - ◆ Active HVAC system responses
- Switch to operational use will be made by Pentagon Force Protection Agency

