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HOMELAND SECURITY & DEFENSE

From Detectors to Detection

Duane Lindner

Program Manager,

Chem/Bio National Security

dllindn@sandia.gov

Sandia National Laboratories

Acknowledgments

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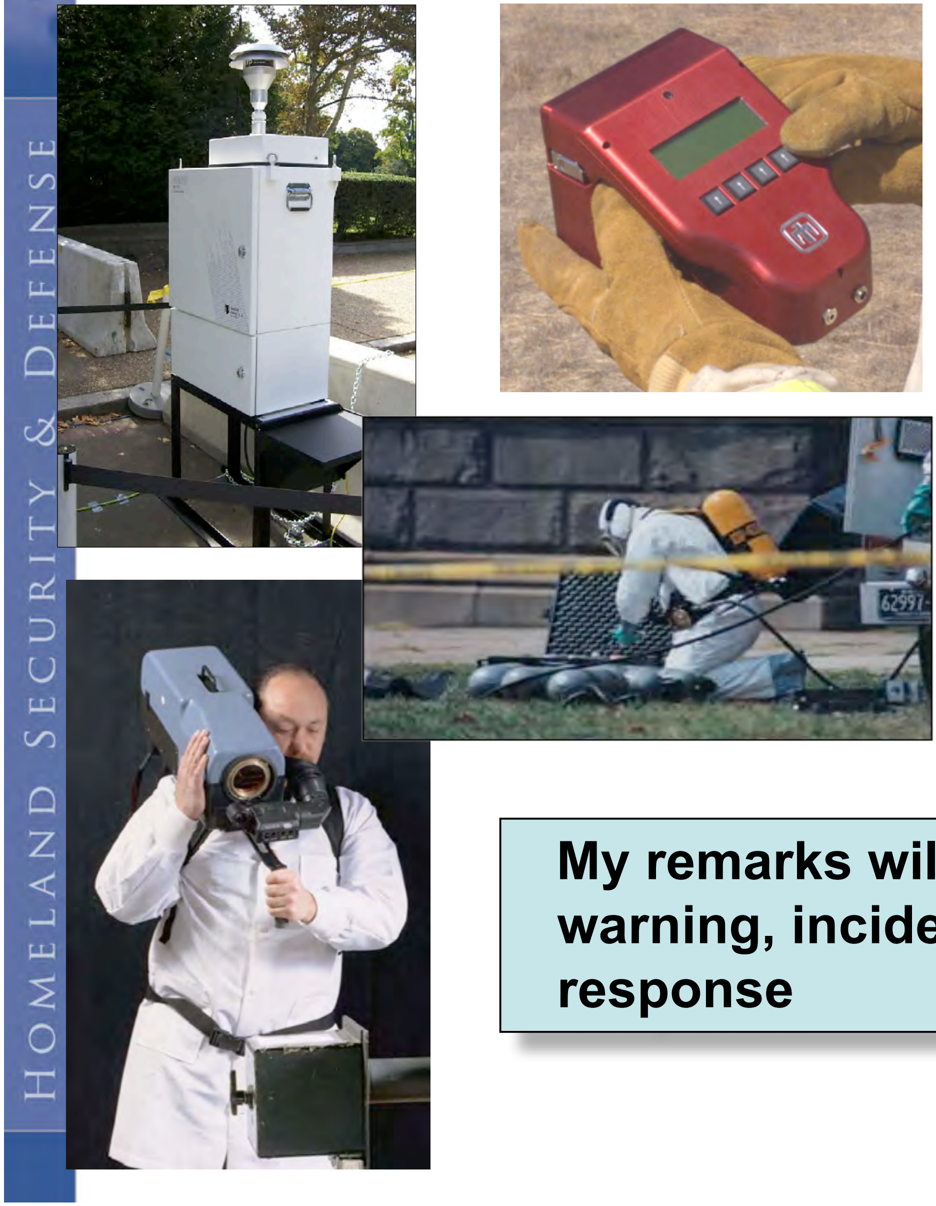
CB Detectors Are Important In a Variety of Roles in Chem/Bio Warning, Response, and Recovery



- Environmental sensors
- Tools for emergency responders
- Public health response
- Contamination assessment
- Forensics and attribution

My remarks will focus on detection systems for warning, incident characterization, and initial response

Over the past decade, we have been heavily involved in the development and/or qualification of a wide spectrum of CB detectors

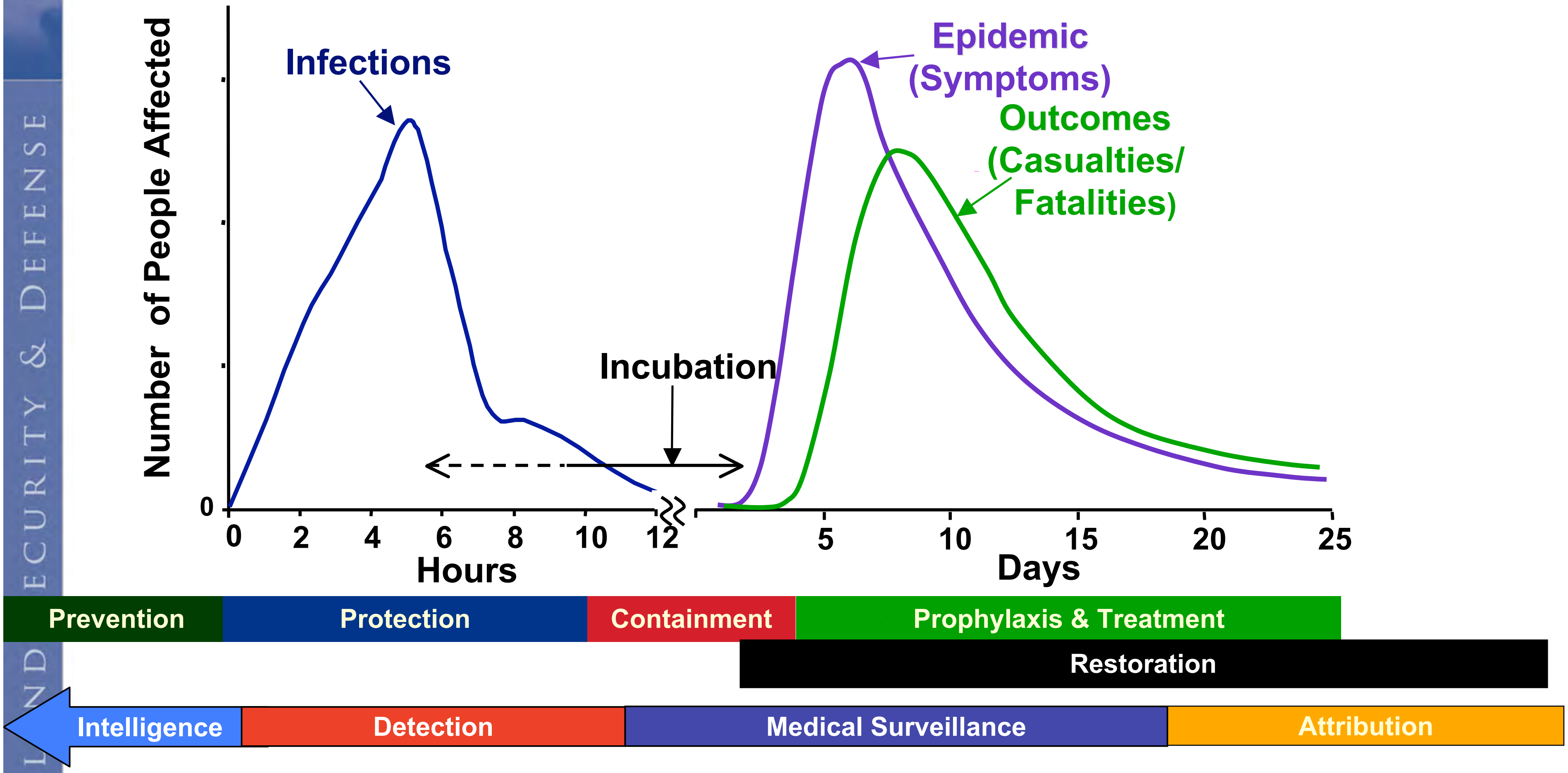
As detectors have moved to deployment, we have increasingly had to confront the challenge of *detection*

For *Detection*--a spectrum of new considerations arise

- **What is the objective?**
  - Minimize casualties?
  - Ensure mission?
- **What am I trying to protect?**
  - Key facilities
  - Cities
  - People at special events
- **What happens when the detector alarms?**
  - *Low consequence actions*
- **Who is in charge?**
  - A CB release is a public health event
  - A CB release is a criminal act

These considerations drive us to heterogeneous networked detector systems that are intrinsically "human in the loop" systems

Timely Detection and Warning Are Critical



Prevention | Protection | Containment | Prophylaxis & Treatment

Restoration

Intelligence | Detection | Medical Surveillance | Attribution

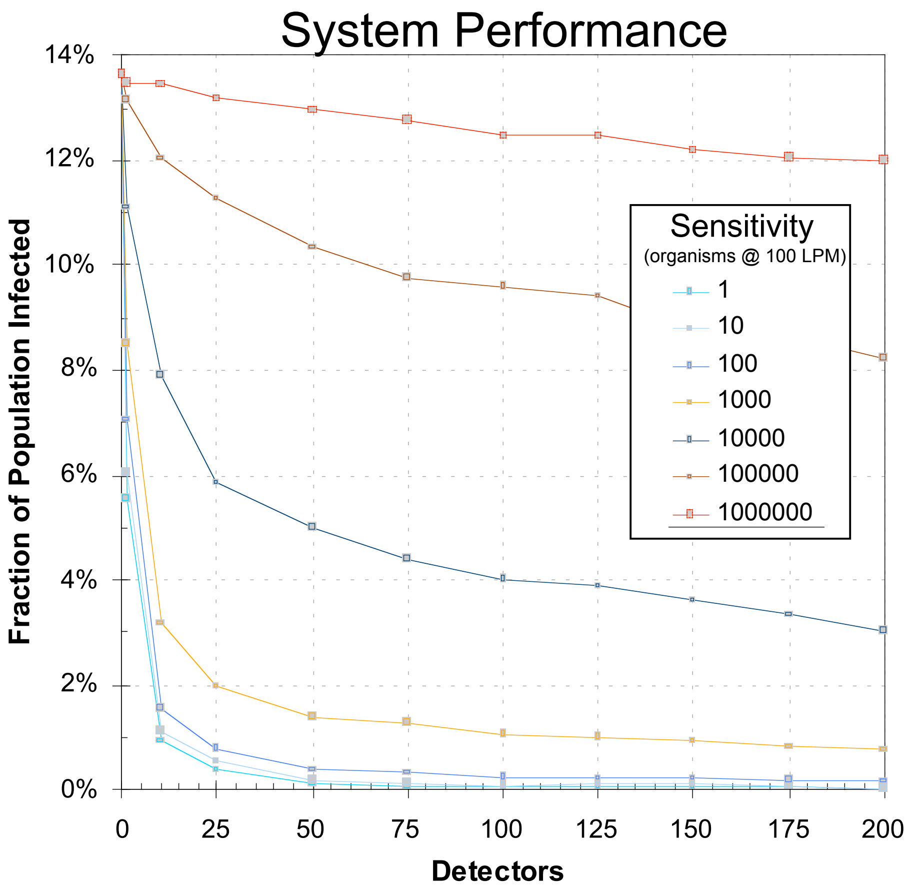
Effects of release of a non-contagious bio agent

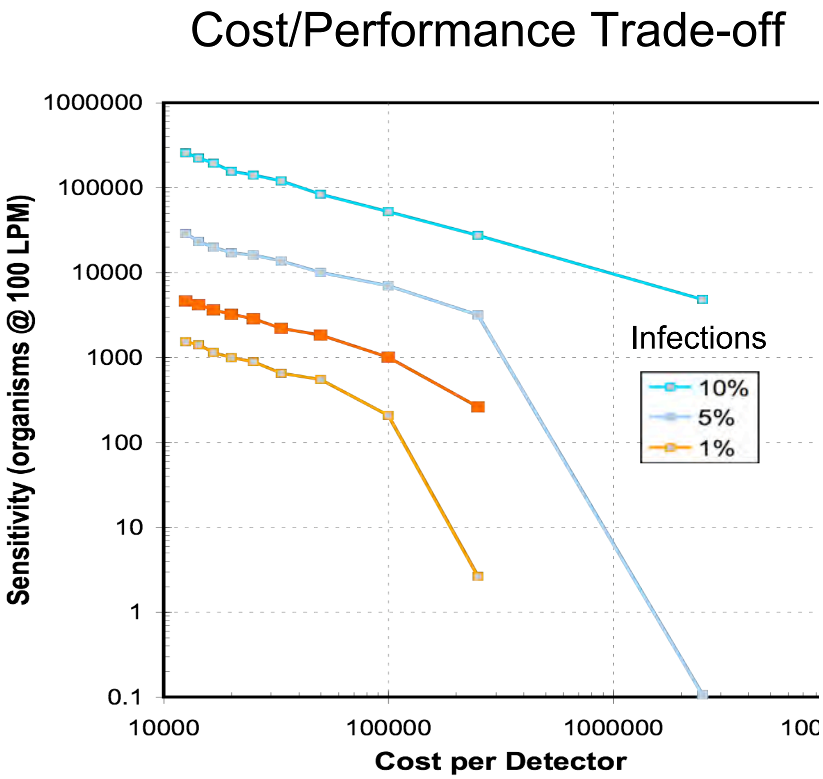
Key Challenges for Environmental Detectors

- **Many different threats**
  - CWA, TICs, toxins, bacteria, viruses,…
- **Typically,very high sensitivity required**
  - Even in the presence of high backgrounds
- **Very low false alarm rates required**
  - $\leq 1 \text{ X } 10^{-6}$
  - High selectivity
- **Need to be “fast”**
- **Need to operate in multiple modes and venues**
- **Cost of ownership**

No single sensor type meets all requirements, so we typically must rely on heterogeneous systems

These requirements are interrelated in complex ways:
For optimal system performance we must understand trade-offs



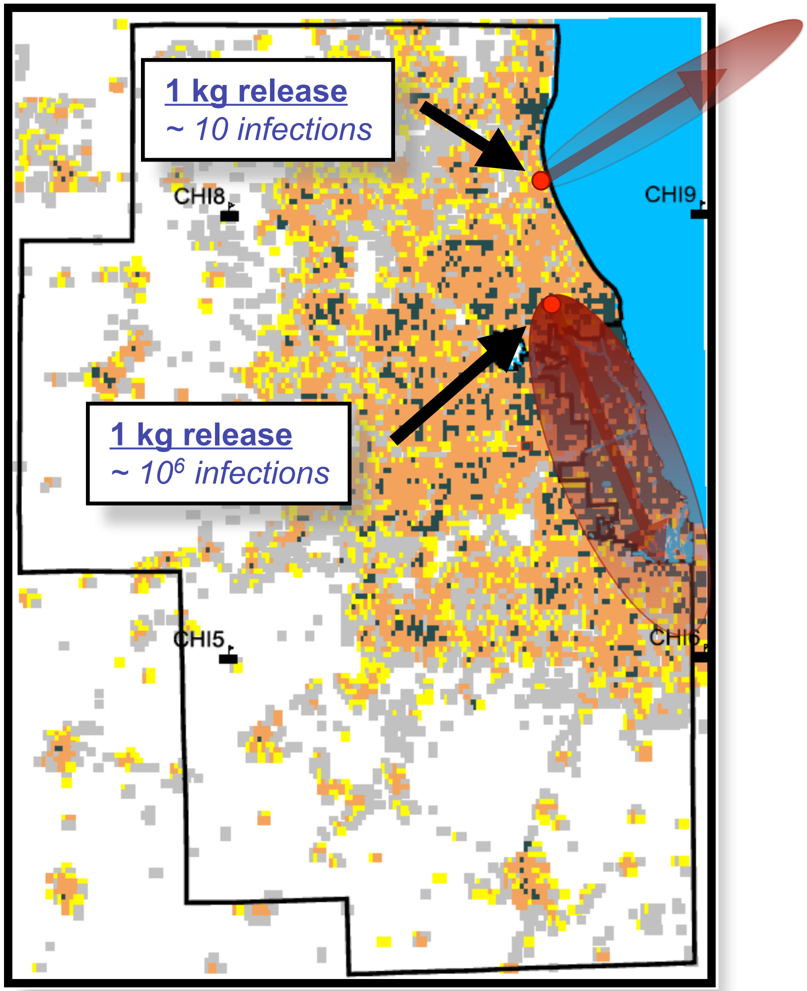


- **Individual detector sensitivity may be traded for cost with no impact on overall system sensitivity**

An aside about metrics and methods: One Metric--Fraction of Population Infected

- Goal: Minimize fraction of population infected (FPI)
  - *FPI is the percentage of a region's population that could receive an infectious dose from an attack that is not detected*

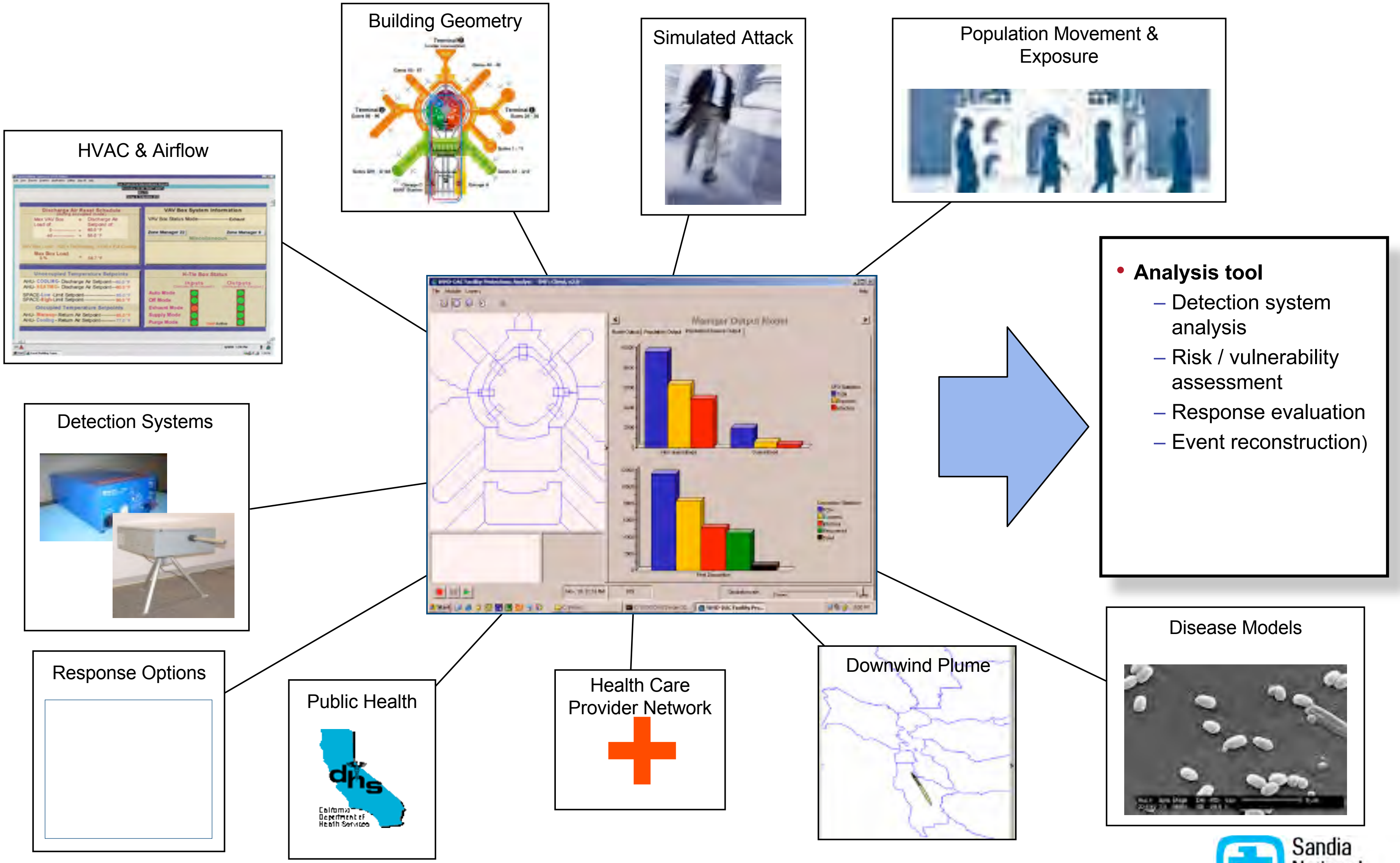
- *For a given detection system, algorithm will calculate the highest impact attack scenario that system would not detect*
- *Considers not just **release amount**, but also **weather conditions** and **release location** relative to populated areas*
- *De-emphasizes releases that have little impact, which are typically the hardest to detect*
- ***Optimized architecture provides better protection with fewer detectors***



1 kg release
~ 10 infections

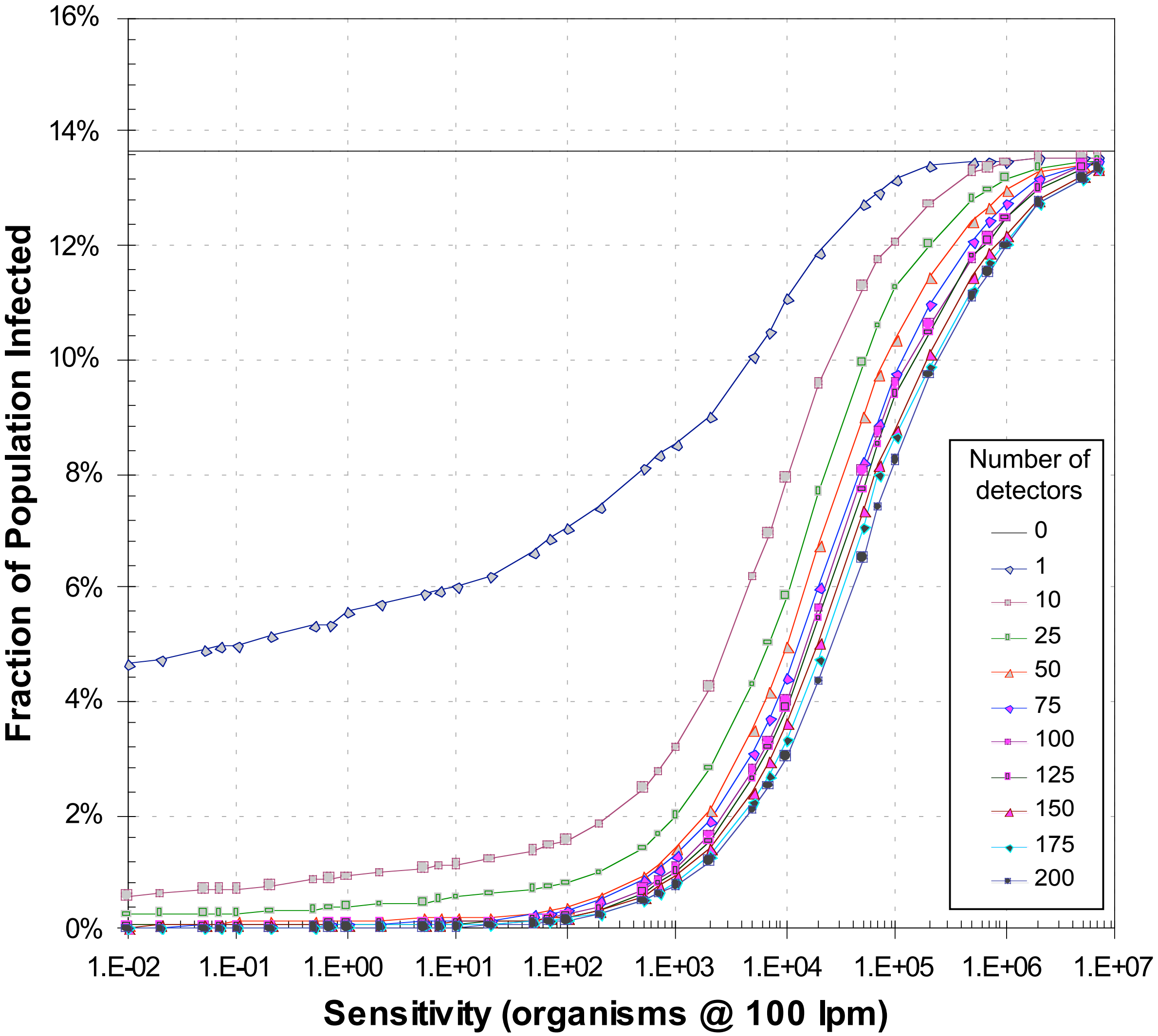
1 kg release
~ 10^6 infections

Metrics and Methods:
Casualties as a metric involves even more complex considerations and interactions



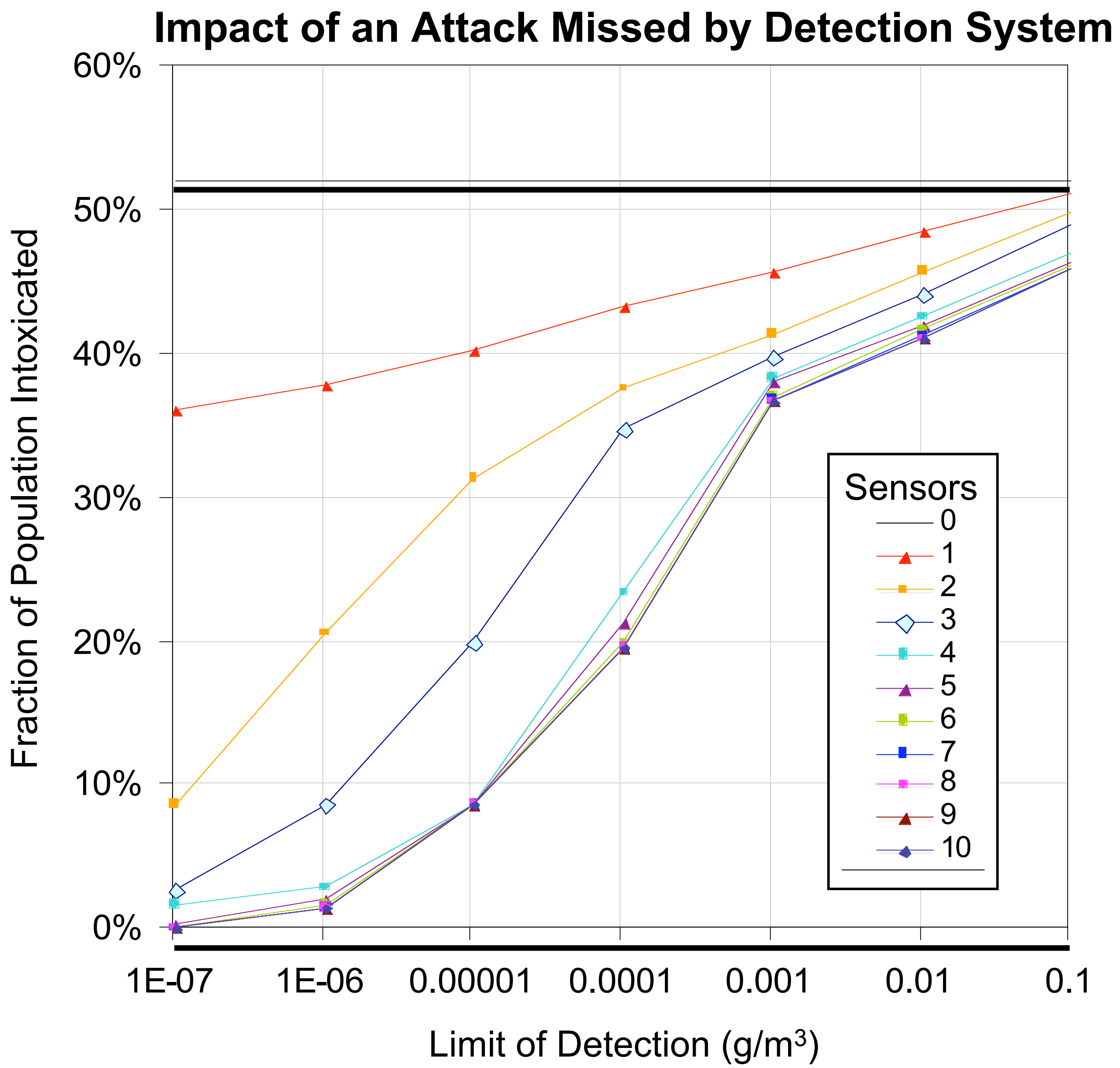
- **Analysis tool**
  - Detection system analysis
  - Risk / vulnerability assessment
  - Response evaluation
  - Event reconstruction)

Analysis is used to set bounds for detector sensitivity

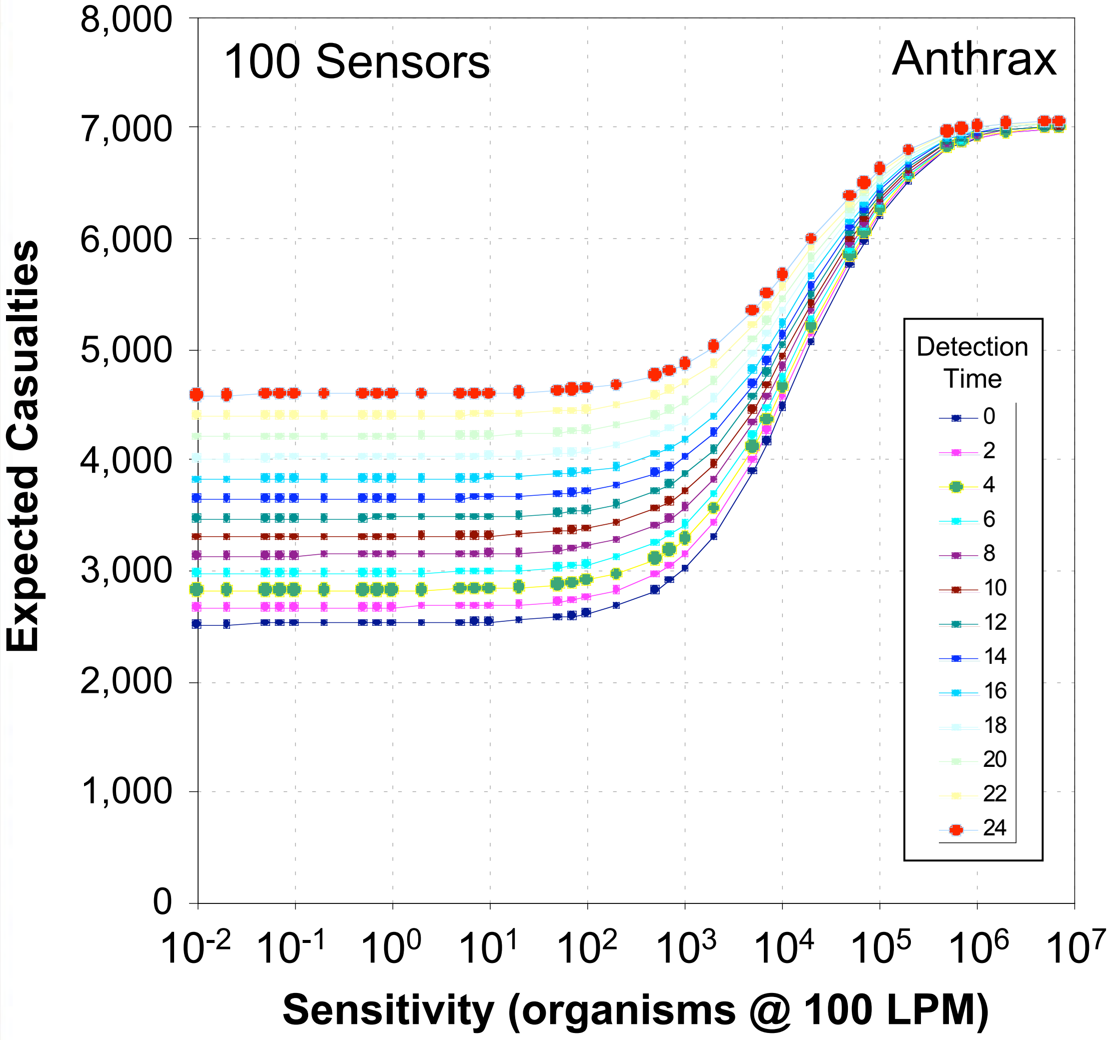


- But a system optimized for anthrax is not optimized for all pathogens of concern

Analysis is used to set bounds for detector sensitivity



Impact of detection time depends on detector sensitivity – Anthrax

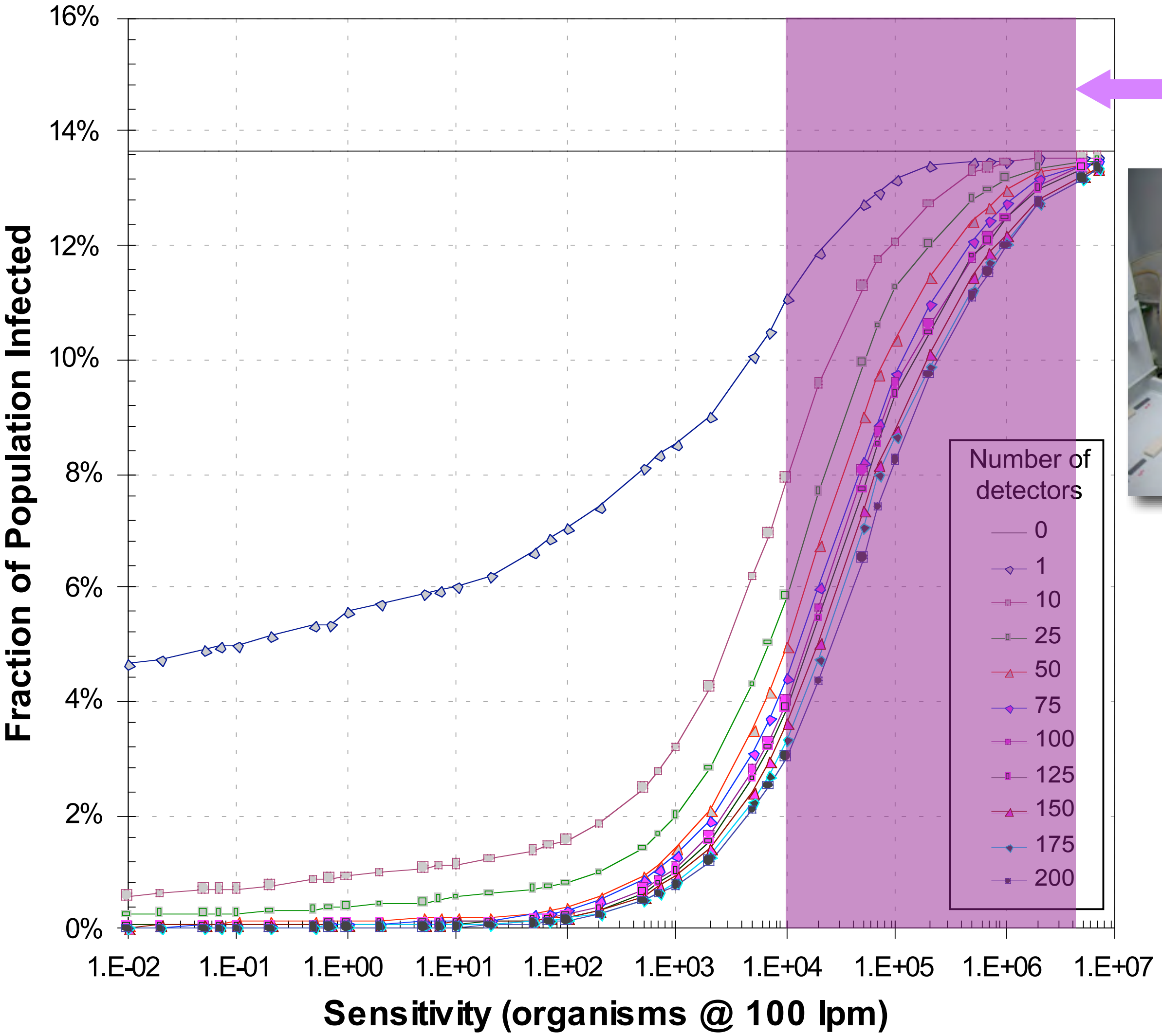


- At poor sensitivities, undetected attacks dominate metric; improving detector sensitivity provides biggest impact
- At better sensitivities, detected attacks dominate metric; improving detection time provides biggest impact
- Detection time strongly influences metric at sensitivities better than 100 organisms

When the human decision makers enter the picture, additional information is required…

Is it a *real* alarm? Not a false alarm Not an environmental positive	**We need solid confirmatory information**	**0 - 12 hours**
Who is at risk?	**Need information such as** Environmental conditions Estimates of release details	**1 - 2 days**
How many are at at risk?	**What exactly is the agent?** How virulent is it? **How much agent was released?**	**1 - 2 days**
What do I do now?	**We need a ConOps** **We need decision support and the means to act**	**Immediate**

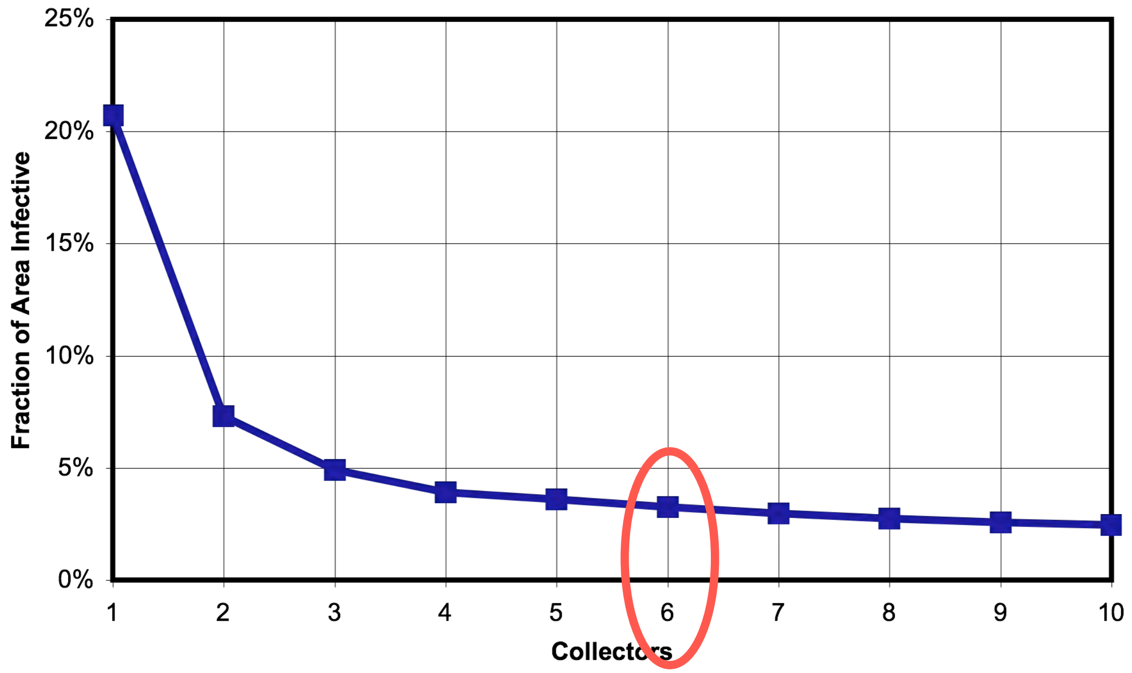
Requiring positive surface samples can greatly reduce system performance



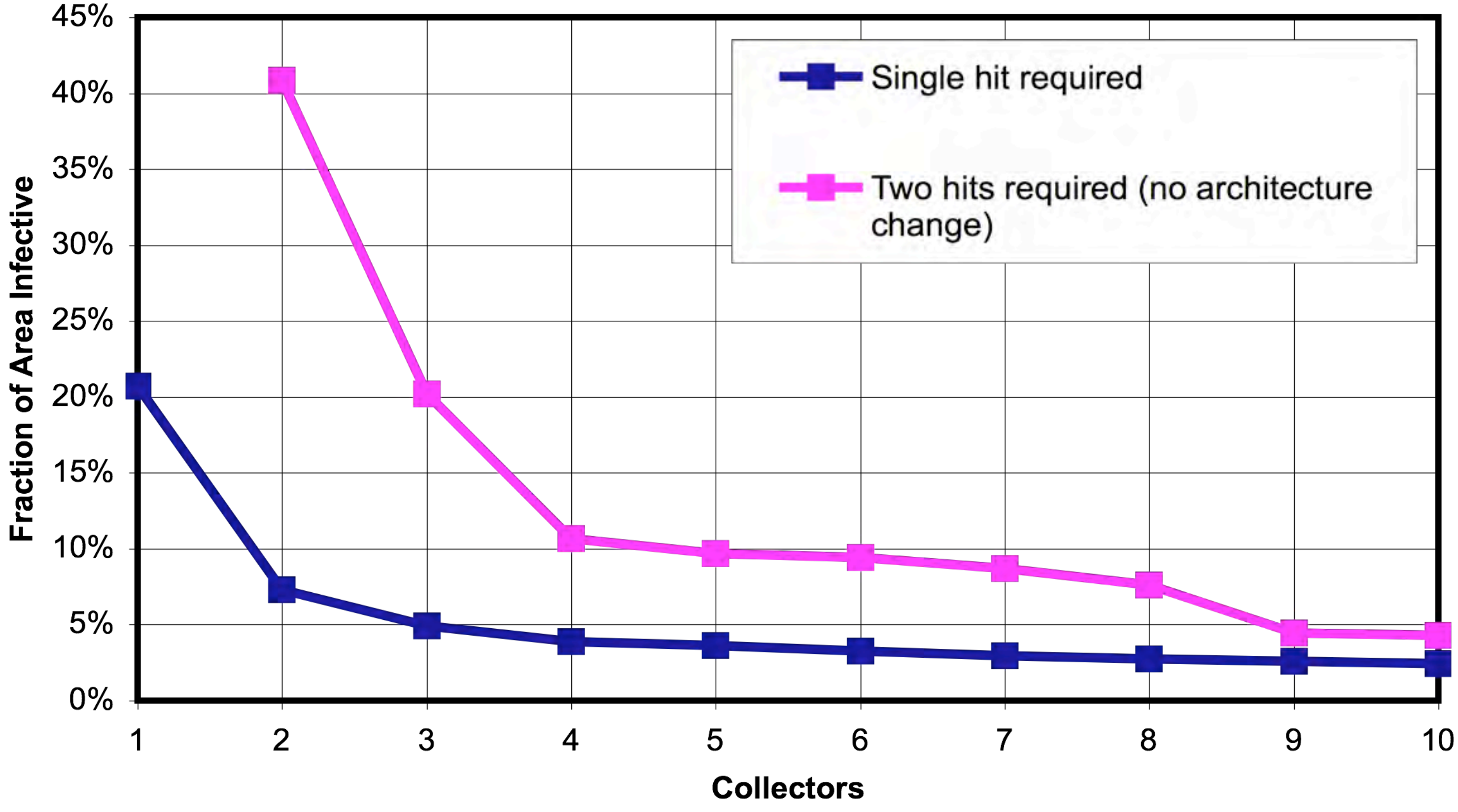
Wipes: 5 μm particles

Requiring a positive in two separate detectors is another approach

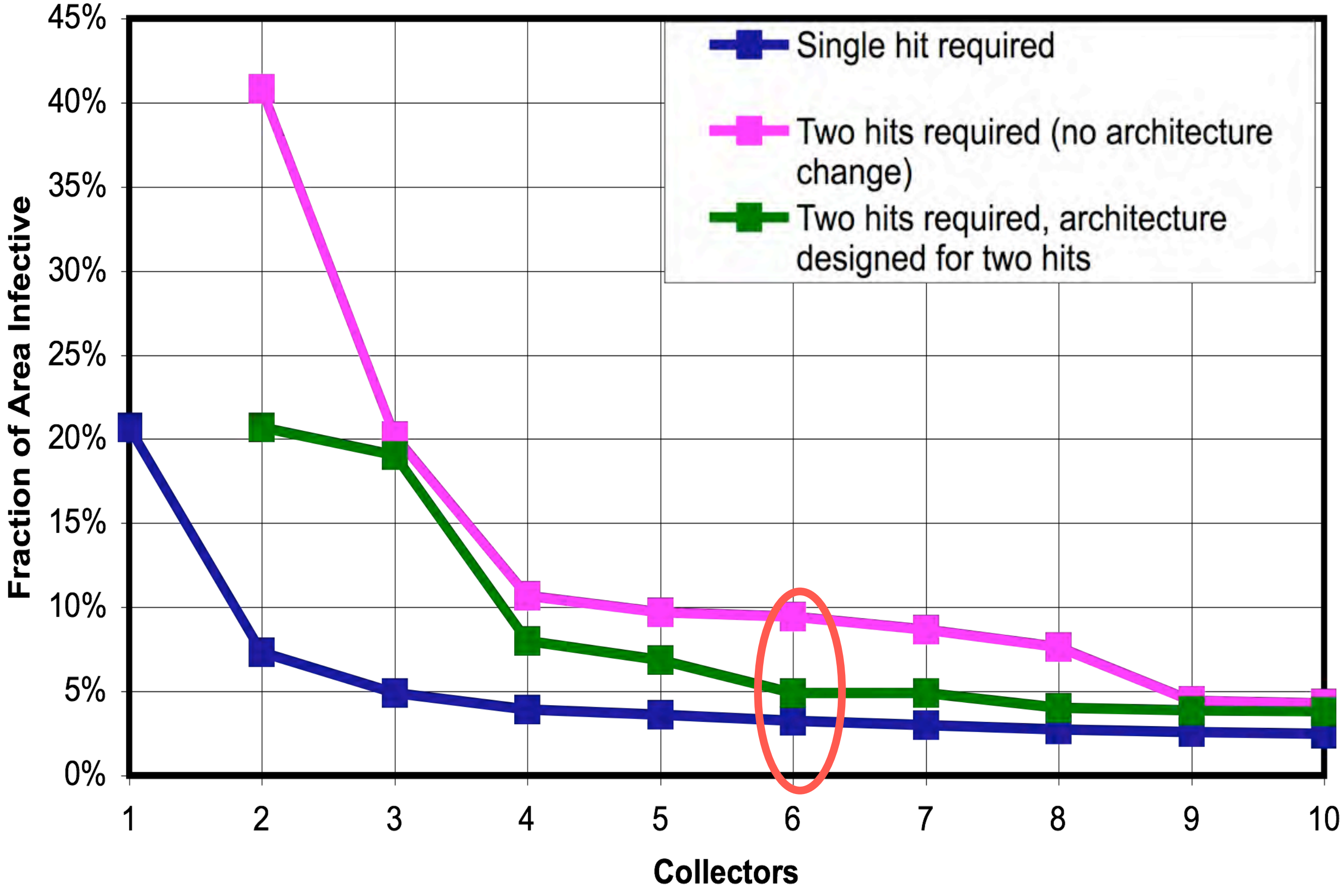
- **Current approach:**
  - Deploy collectors to maximize the chances of getting one (or more) positives for the "worst" scenarios
  - Add more collectors until the point of diminishing returns is reached



Requiring multiple positives can greatly reduce system performance if deployments are not optimized to generate multiple hits

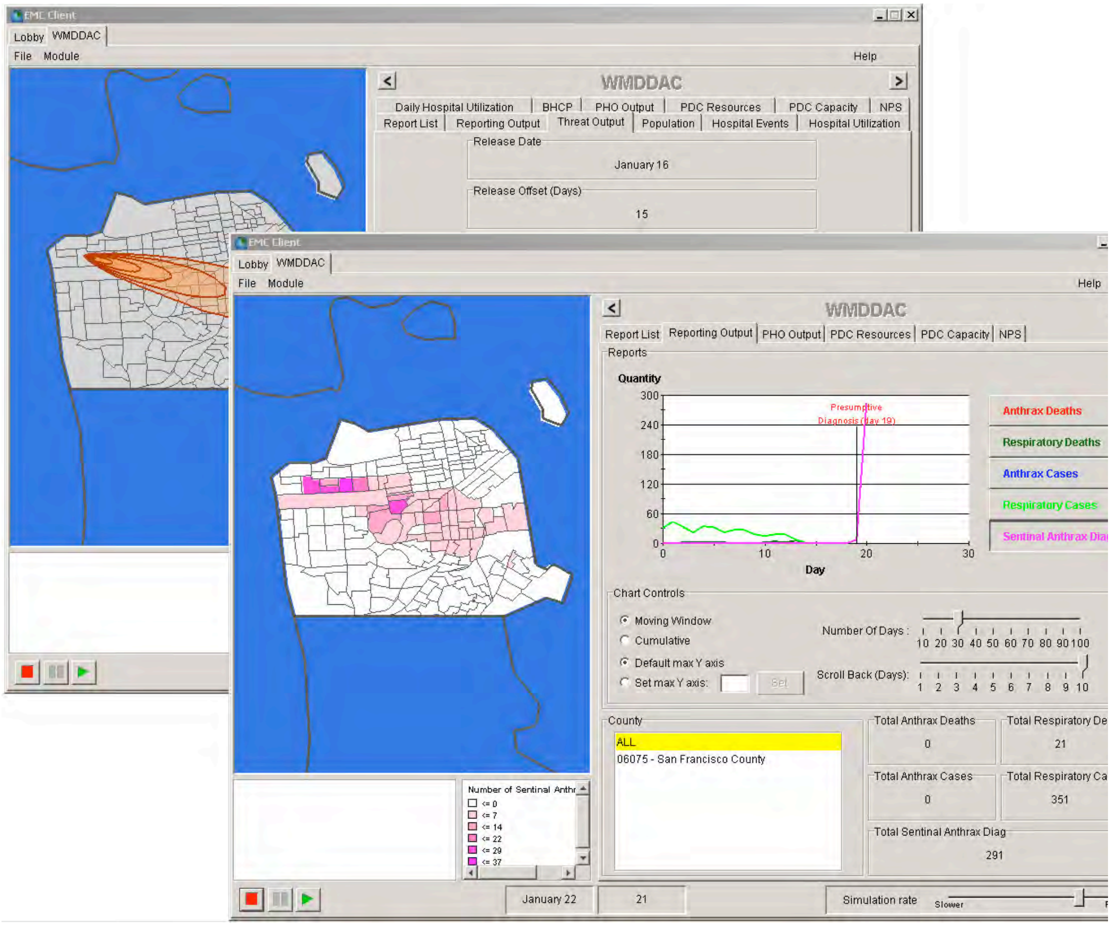


Optimizing detector deployments to generate multiple positives gives much better performance



Environmental Sensors are an Insufficient Solution

plume from aerosol release



Release Date: January 16

Release Offset (Days): 15

◉ Moving Window
○ Cumulative
◉ Default max Y axis
○ Set max Y axis:

Number Of Days:

Scroll Back (Days):

County: ALL; 06075 - San Francisco County

Total Anthrax Deaths	Total Respiratory De
0	21
Total Anthrax Cases	Total Respiratory Ca
0	351
Total Sentinal Anthrax Diag	
291	

January 22 | 21 | Simulation rate

infections (days later)

- A clandestine release could appear first in environmental sensors or it could appear in the public health system
- Public health officials are extremely reluctant to take significant action without confirmatory evidence

Environmental Detection v. Medical Surveillance

- *Relatively* Insensitive
- Subject to false alarms
- Relatively easy signal acquisition

- Sensitive
- Selective
- Variable response
- Difficult signal acquisition

A Comprehensive Detection Strategy Requires an Integration of Both Approaches

So, We Need More Than Threat Agent Detectors

- **Many Different "Sensors"**
  - Environmental threat agent detectors (various types)
  - Sample collectors
  - Medical surveillance
  - Meteorological information
  - Video
- **Situational awareness (may require reachback to central resources)**
  - Sensor state of health
  - Dispersion modeling (location sensitive)
  - Epidemiological modeling
- **Visualization & decision support**
  - ConOps implementation
- **Supporting information and communications architecture**

We Must Have a Viable Concept of Operations (ConOps)

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All These Elements Must Be Linked Together and Integrated to Allow Rapid, Optimal Decision Making

Environmental Monitoring

Atmospheric Modeling

Medical Surveillance

Operations Center

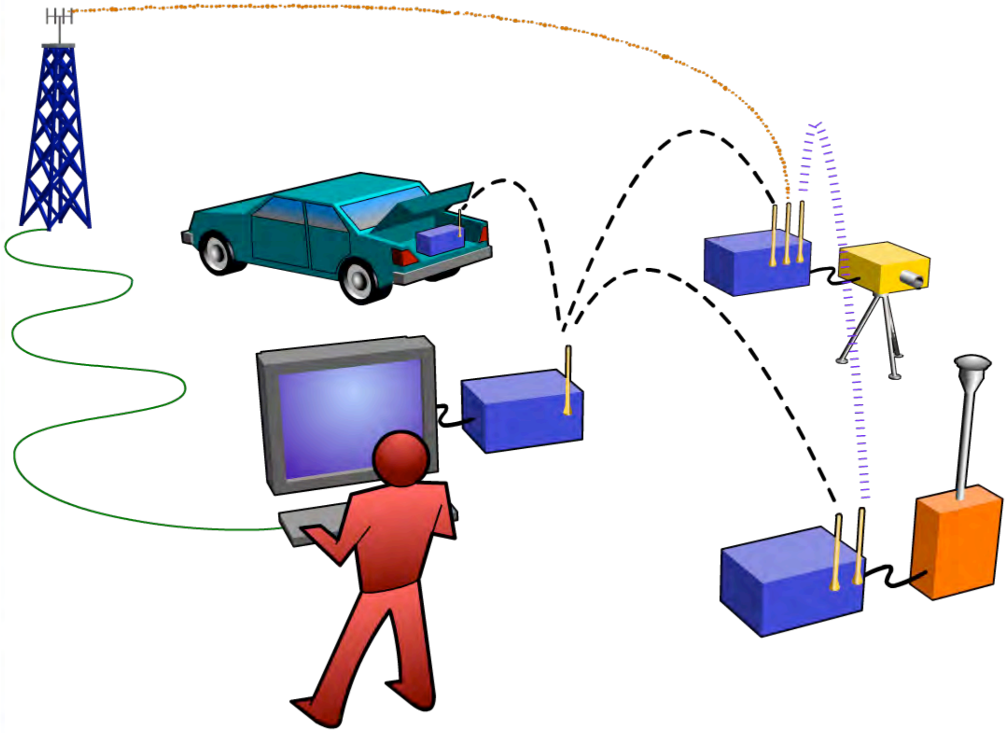
Facility Monitoring

Lab Capabilities

Situational Awareness is Enhanced With Improved (PreEvent) Understanding

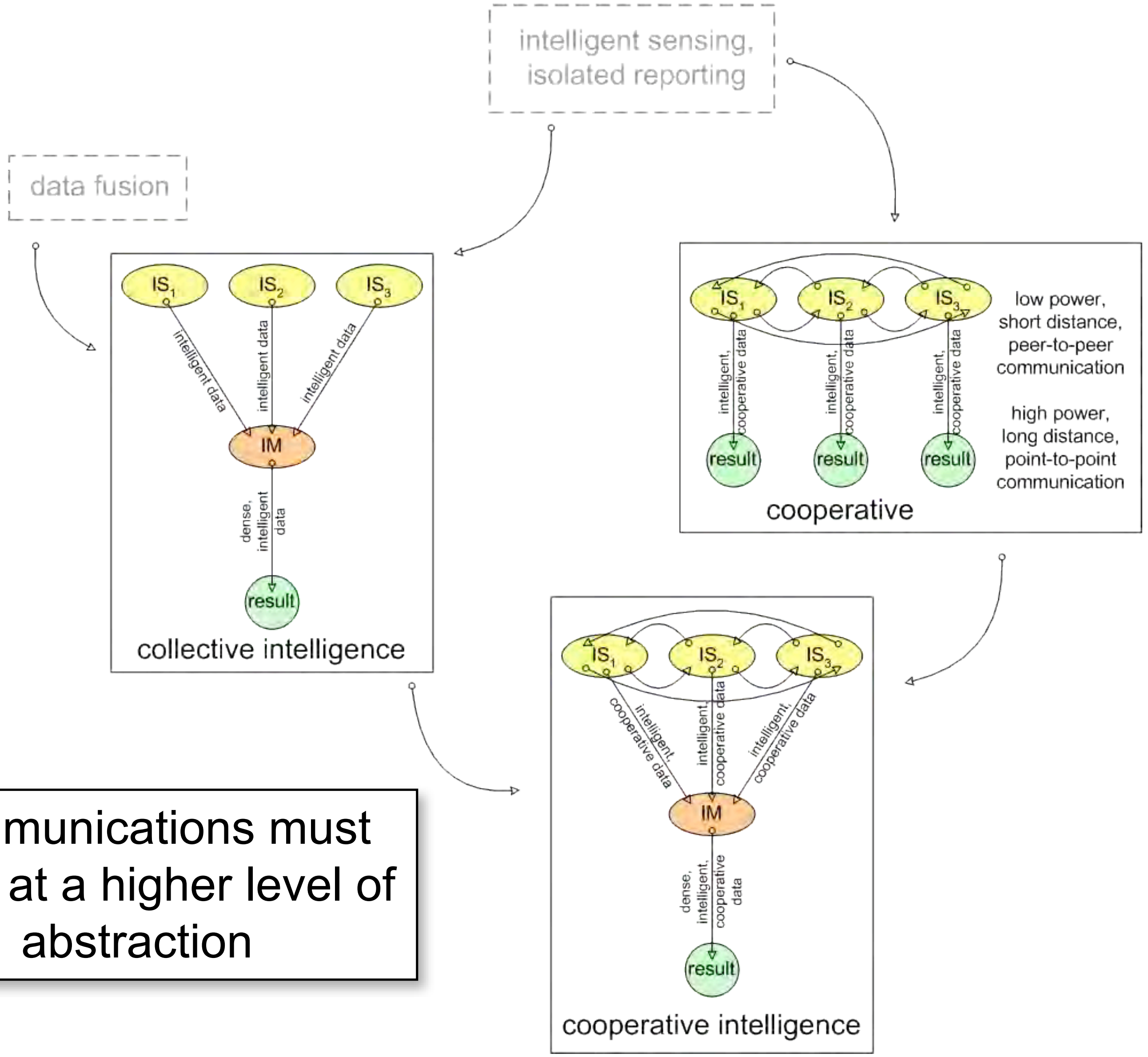
- Characterization of the operations site
- Optimal sensor siting
- Evaluation of response options
- Testing of ConOps
- Training

Information Architecture Requirements



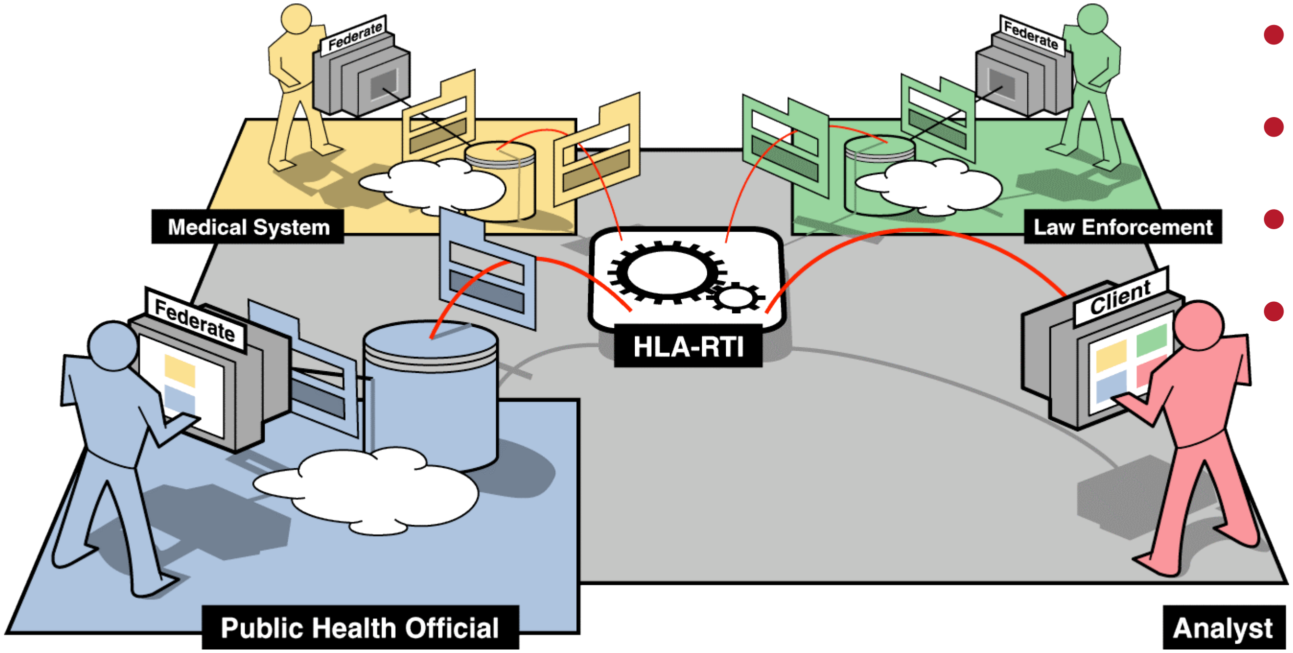
- **Robust communication channels**
- **Reconfigurable**
- **Security**
  - Including privacy
  - Authentication
- **Persistence**
- **Directory/Discovery Services**
- **Reachback**
- **Scaleable**
- **Testable**

Complex System Topologies and the Number of Sensors Can Overwhelm Communications


intelligent sensing,
isolated reporting
data fusion
IS1
IS2
IS3
intelligent data
intelligent data
intelligent data
IM
dense, intelligent data
result
collective intelligence
IS1
IS2
IS3
intelligent, cooperative data
intelligent, cooperative data
intelligent, cooperative data
result
result
result
cooperative
low power, short distance, peer-to-peer communication
high power, long distance, point-to-point communication
IS1
IS2
IS3
intelligent, cooperative data
intelligent, cooperative data
intelligent, cooperative data
IM
dense, intelligent, cooperative data
result
cooperative intelligence

Communications must occur at a higher level of abstraction

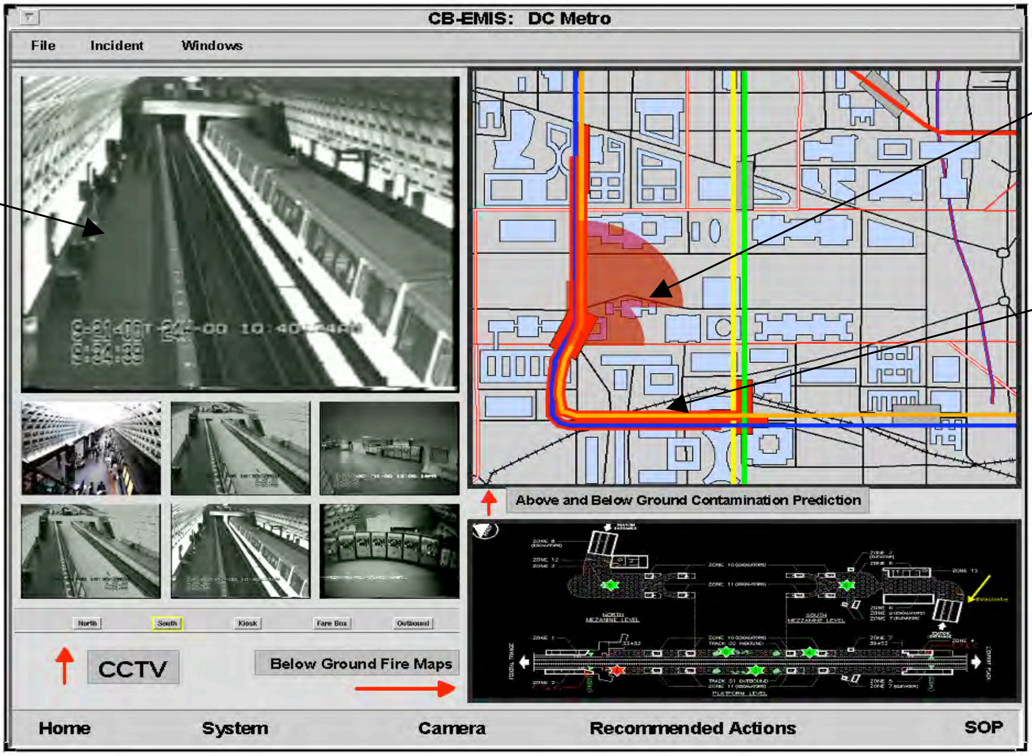
Information Standards are Required at Many Levels



- Ontologies
- Semantics
- Vocabularies
- Data models

An Example: Chem/Bio Emergency Management Information System (CB-EMIS)

Multiple camera views in station



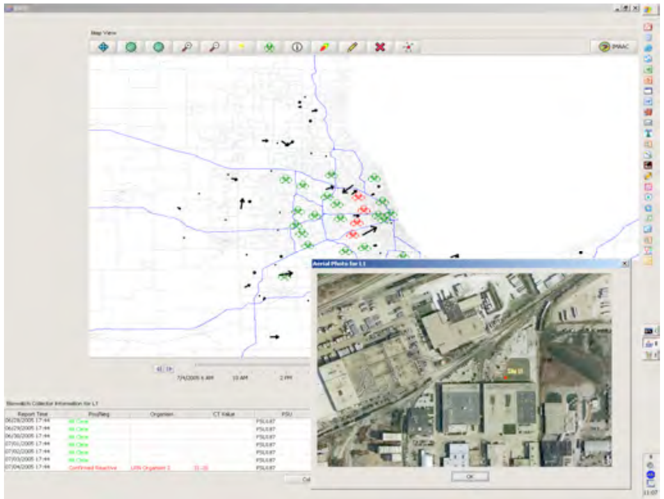
Above-ground hot zone

Below-ground hot zone

Station map showing which detectors have alarmed

Information available to Operations Control Center and to Incident Commander at the scene

Where is this Going?



Biowatch Collector Information for L1

Report Time	Pos/Neg	Organism	CT Value	PSU
06/28/2005 17:44	All Clear			PSU187
06/29/2005 17:44	All Clear			PSU187
06/30/2005 17:44	All Clear			PSU187
07/01/2005 17:44	All Clear			PSU187
07/02/2005 17:44	All Clear			PSU187
07/03/2005 17:44	All Clear			PSU187
07/04/2005 17:44	Confirmed Reactive	LRN Organism 1	31-35	PSU187

- ConOps for deployed systems are being refined
- Medical information systems are being improved
- Advanced decision support tools are in development
- Communications standards and architectures are being refined
- Design tools for integrated systems are being improved
- Completely integrated warning and response systems are being deployed

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