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System Test and Evaluation (T&E) in the DARPA Immune Building Program

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CB Attacks, Accidents, and Threats

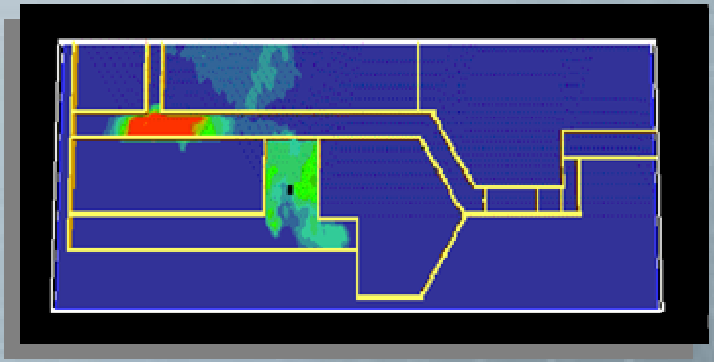
- Threats
  - CWAs and TICS
  - BWAs
  - Radiological Agents

- CB Attacks and Accidents
  - 1984 TIC Methyl isocyanate, Bhopal, India
    - 3,800 deaths, thousands disabled
  - 1995 Nerve gas (Sarin), Tokyo, Japan (subway)
    - 12 deaths, 1000+ illnesses
  - 2001 BWA Anthrax (Florida and New York)
    - 5 deaths, 10,000 treated

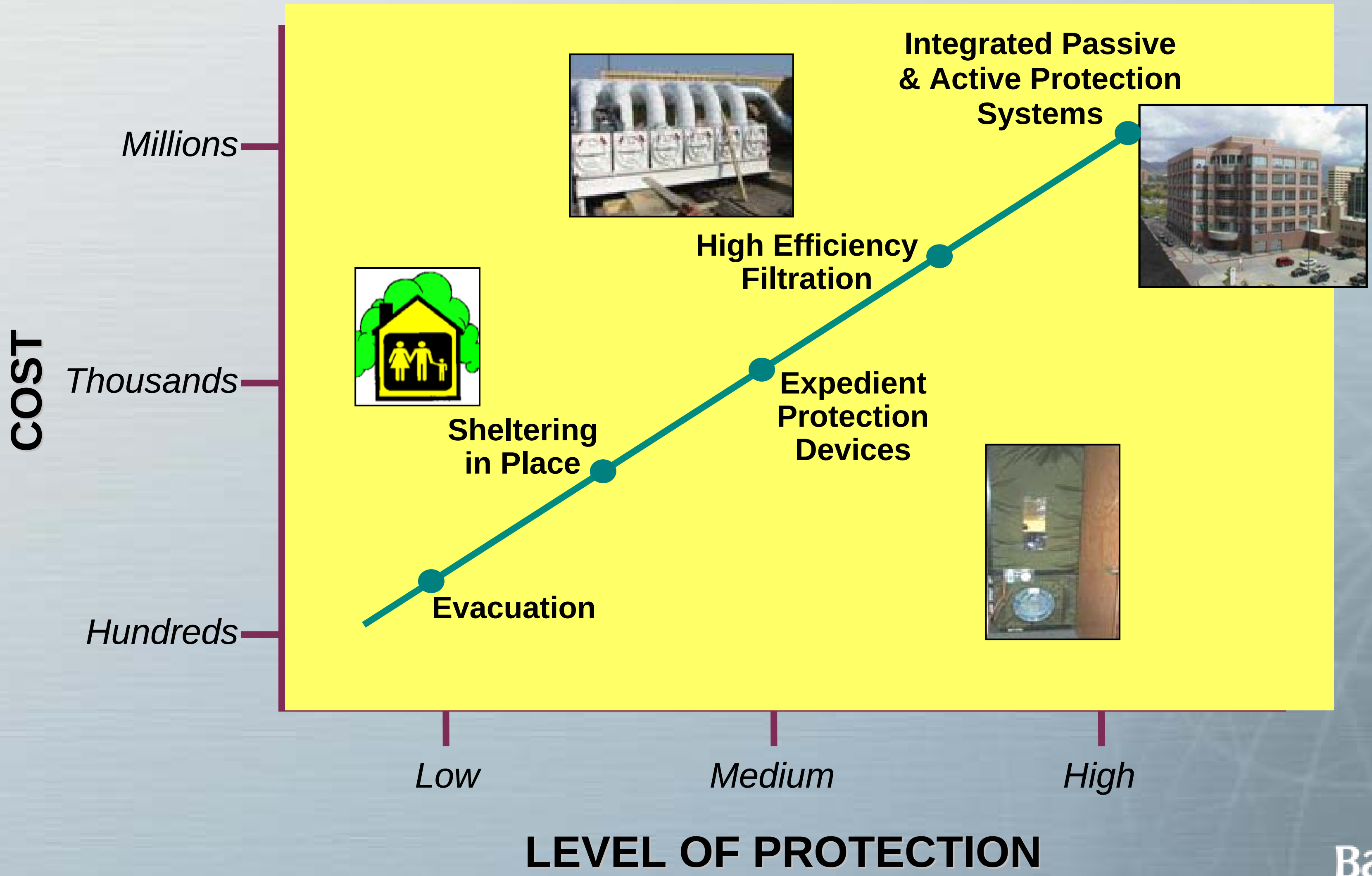
CB Building Protection Overview

Why are buildings vulnerable to CB attack?

- Containment of CB agents within a confined space allows concentrations to rapidly reach and sustain lethal levels
- CB agents are effectively transported throughout a building by mechanical systems
- Population densities are high in buildings
- Agents can be delivered covertly
- Numerous adsorbing surfaces that make building restoration difficult



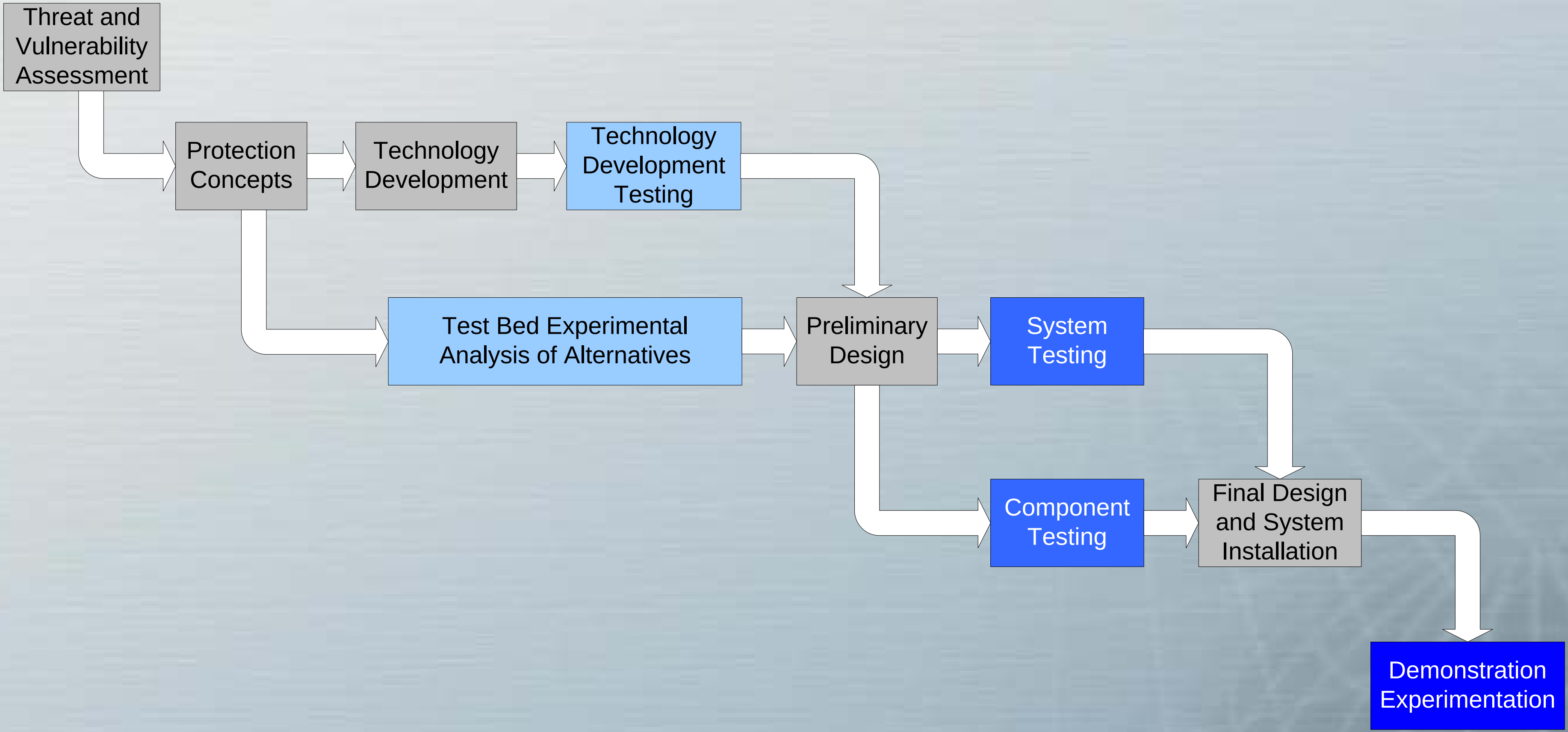
Range of Protection Solutions



DARPA Immune Building Overview

- Objective: To make military buildings less attractive targets for attack with CB weapons
  - Protect human occupants
  - Restore the building to function quickly after an attack
  - Preserve forensic evidence for medical treatment and retaliation
- Protect all parts of the building against internal and external releases of a wide range of agents
- IB Program Accomplishments
  - Developed a highly effective building protection system
  - Extensively tested protection system and subsystems in a full-scale test bed
  - Installed and demonstrated system design in an operational building

System Process Flow



Threat and Vulnerability Assessment

- Threat and Vulnerability Assessments (TVAs) are performed to identify requirements for building protection systems
  - Threat Scenarios were client defined:
    - Agent Types
    - Release Masses & Locations
    - Exposure Limits
    - Environmental Conditions
  - Functional subsystems were developed to counter these threats
    - Filtration/Neutralization
    - Segmentation
    - Detection and Forensics
    - HVAC Responses

Protection Concepts

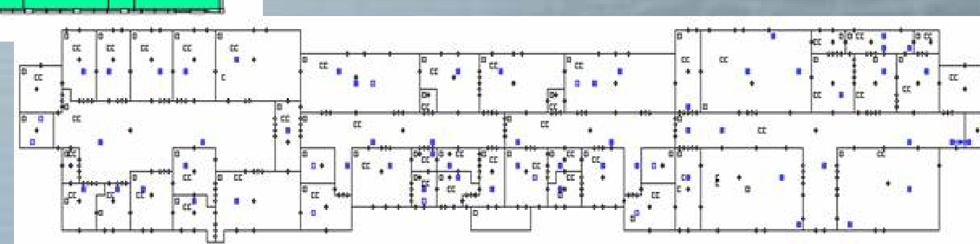
- TVA Outputs:
  - Testable requirements
  - Technology development needs
  - Foundation for initial system protection concepts
- Initial protection concepts were developed based on the requirements of the TVA.
  - Extensive modeling analysis performed to down-select the most promising strategies
  - Generated an initial Test Bed design
  - Defined interfaces for technology development insertions into the system

Technology Development Testing

- Key areas underwent small scale testing/optimization prior to integration
  - Distributed CB Sampling System
  - Wall Leakage Specifications
  - Passive and Active Agent Removal
  - Chemical Forensics Sampler
  - Vestibule Testing
- Generated construction requirements
- Technologies tested in a full scale building and further optimized

Immune Buildings Test Bed Facility

- Test Bed constructed in former barracks building at Fort McClellan in Anniston, AL
  - Three stories with a quarter basement, ~ 30,000 ft^2
  - Entire building used in Integrated Systems Experimentation phase; top two floors only in Demonstration phase
  - Multiple HVAC zones with various protection strategies possible
  - Performed over 250 full scale building experiments



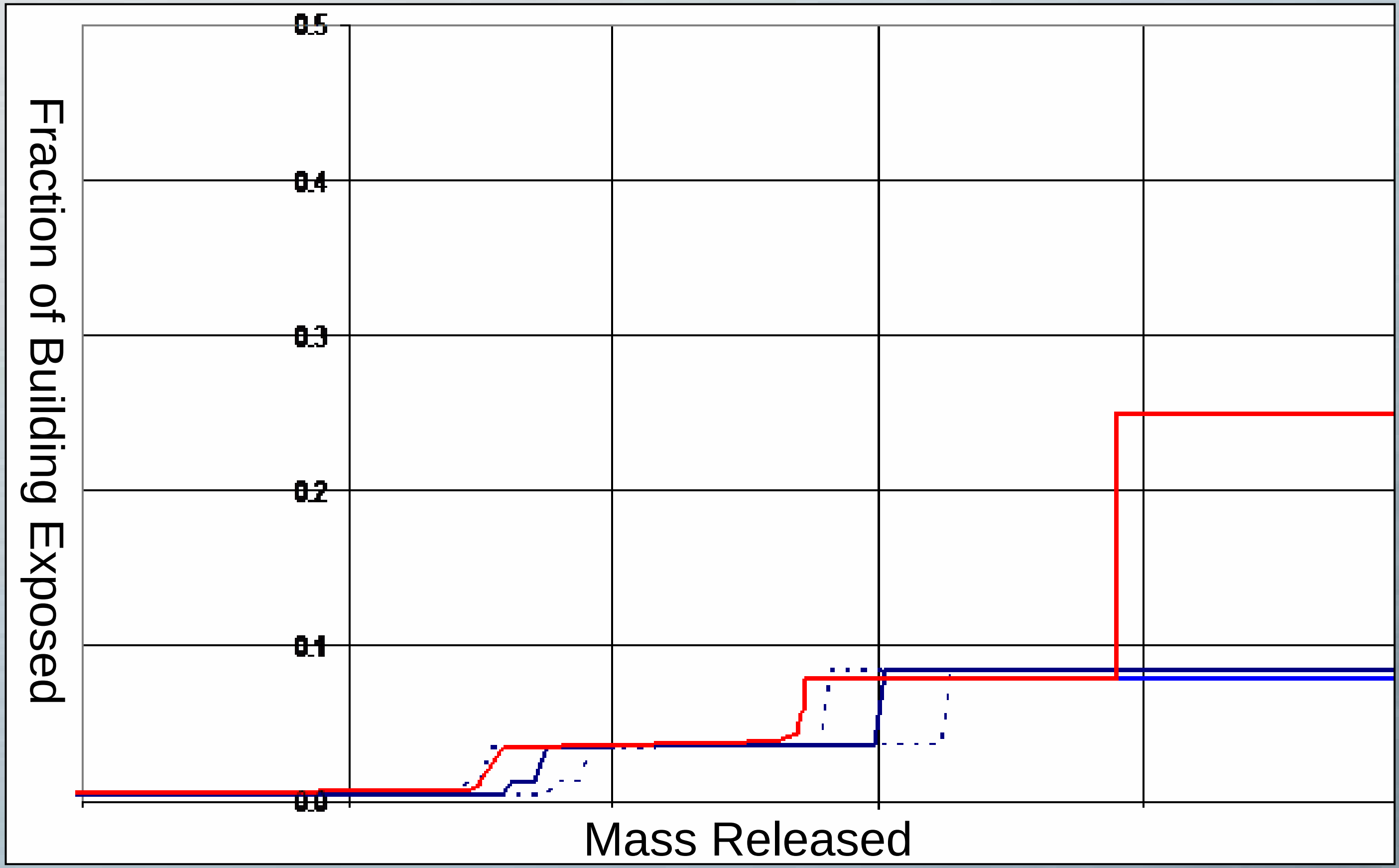
CONTAM Model Schematic

Test Bed Experimentation

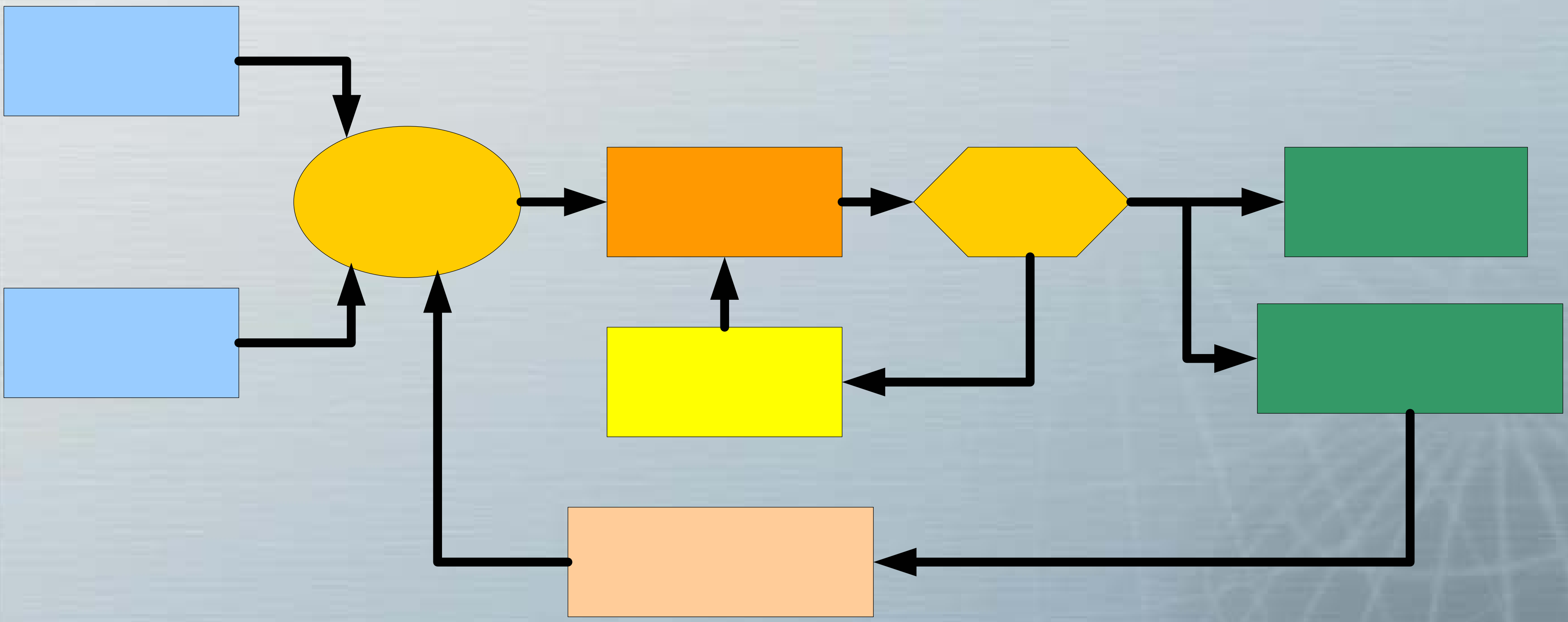
- Testing
  - 4 Simulants to represent CB threats
  - Methods to create repeatable releases of simulants were developed
  - Automated sampling network
    - Whole building coverage
    - 3 types of collectors
    - Remote control of simulant release and sample collection
- Analysis
  - On-site laboratory for chemical analysis
  - Optical analysis of particulate simulants
  - Simulant to agent correlations
  - Data analysis methods (including uncertainty analysis)

Program Metrics

- Metrics
  - Fraction of Building Exposed (FBE)
  - Fraction of Occupants Exposed (FOE)
  - Life-cycle Cost

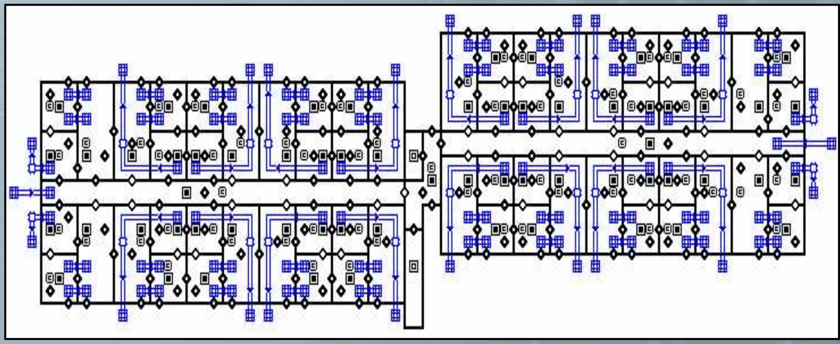


Modeling / Experimentation Process



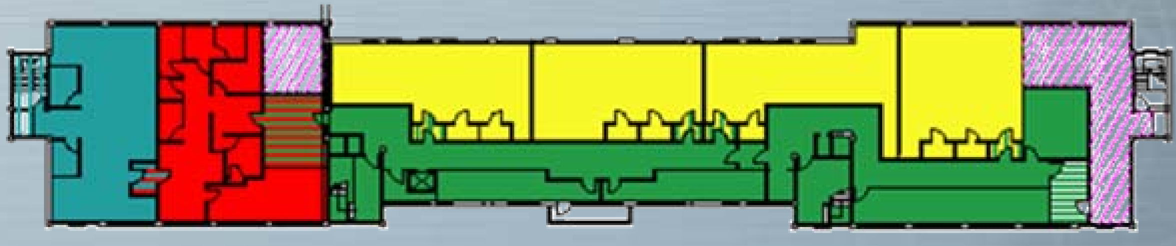
Modeling and Simulation

- Every test performed during the Immune Building Program was modeled prior to experimentation
- CONTAM modeling, predicted the flow of contaminant throughout the building
  - Used to determine the optimum sampling locations
  - Generated data for alternate agents and mass releases
  - Generated data for locations where releases were not possible
- Test data were used to verify and improve model performance



Design Modification and Phase II Test Bed Testing

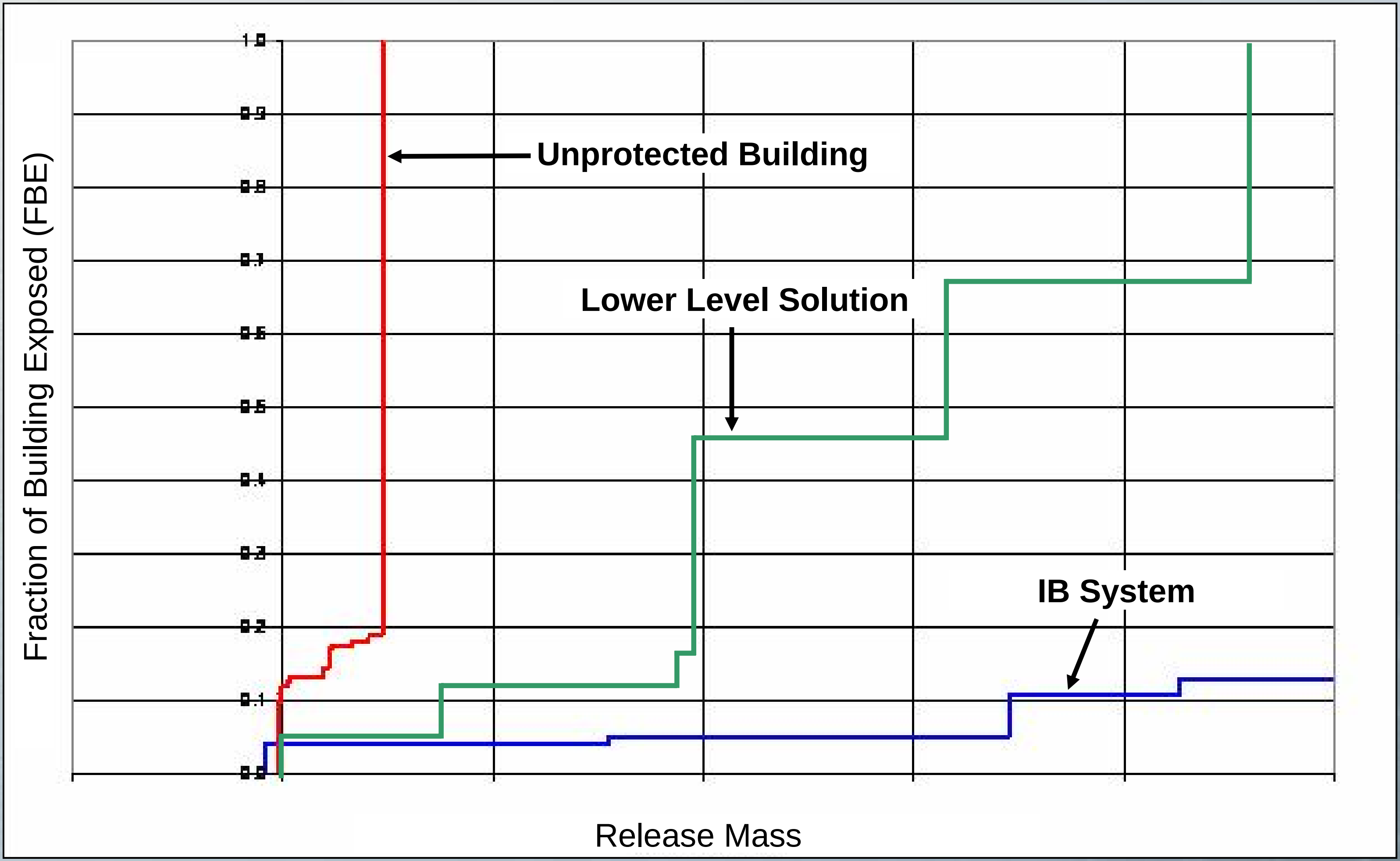
- The Phase I testing results guided the modifications from the protection concept to the preliminary design
- The Test Bed was reconstructed to represent the Demonstration building (preliminary design)
- Over 100 Tests were performed, results were gathered on the:
  - Overall system protection
  - Subsystem performance
  - Effects of human transport on the protection system



Design Optimization

- The final design was generated based on the results of the Preliminary Design testing
  - The Test Bed was modified during testing to reflect design changes as they occurred
  - The Final Design components were tested in the Test Bed
- The final design was installed in the Demonstration building
  - Applications of Lessons Learned from the Test Bed allowed for an expedient commissioning and characterization process
  - Performance Testing showed little deviation from the Final Test Bed design

IB Protection Performance



Conclusions / Results

- The Immune Building program employed a T&E centric approach to developing designs per good Systems Engineering practice
- Data gathered in early stages of the design process allowed optimization prior to installation avoiding costly post-construction modifications.
- Integrating T&E into all stages of the design process created a system that was verified through testing to meet client requirements.
- End result is a state of the art system that provides the highest level of protection against CBR threats.

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