

# **A Roadmap for Integrated Modeling and Simulation of Emergency Response**

*Sanjay Jain, Visiting Professor  
Chuck McLean, Program Manager*

*Manufacturing Simulation and Visualization Program  
National Institute of Standards and Technology  
Gaithersburg, MD*



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

## Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

# Introduction

- *Several ongoing efforts at NIST related to Homeland Security ([http://www.nist.gov/public\\_affairs/factsheet/homeland.htm](http://www.nist.gov/public_affairs/factsheet/homeland.htm))*
- *Modeling and Simulation (M&S) related efforts include:*
  - *Disaster incident modeling tools developments, e.g.:*
    - *Building Fire Simulation*
    - *CONTAMW for indoor air quality*
  - *Integrated M&S effort (this effort)*
    - *By Modeling and Simulation group in Manufacturing Engineering Lab*
    - *Based on extensive experience in integrating distributed simulation tools in manufacturing domain*
    - *Since 2002 under exploratory seed effort funding*

# **Modeling and Simulation for Emergency Response - Workshop in March 2003**

- *Open invitation – attracted 160 attendees*
- *Focus on identifying the technical capabilities in this area*
- *Agenda focused on presentations for 2 days; ½ day devoted to workshop sessions*
- *A number of M&S tools for emergency response available/ being developed*
- *Recommended actions included :*
  - *Standards development*
  - *Integration framework development*
  - *Input from user community*
  - *Development of a roadmap*

# Workshop in March 2004

- *Working group of 30+ invited attendees*
- *Focus on developing the roadmap to allow a coordinated plan that:*
  - *Brings integrated M&S capability to emergency responders in a rapid manner*
  - *Allows collaboration among multiple organizations*
  - *Avoids duplication of effort*
  - *Will be presented to the Department of Homeland Security, other relevant agencies and M&S community.*



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

# Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

# Current Status of Emergency Response

- *Based on reports from past incidents and feedback sessions following a number of scenario events attended by group members*
- *Limitations in current capabilities for responding to multiple simultaneous attacks on a large city like Washington DC*
- *Potential shortcomings in:*
  - *First response*
  - *Infrastructure*
  - *Health care system*
  - *Guarding the interests of general public*

## Simultaneous Attack Scenario in a Large City

# Current shortcomings - First Response

- *Emergency response decisions makers not trained to handle simultaneous attacks*
- *Not enough emergency response personnel available for simultaneous attacks*
- *Emergency responders not trained for the range of attack scenarios and for crowd management.*
- *Responders do not have adequate equipment for responding to attacks.*
- *Emergency responders and vehicles not deployed in the best manner for coordinated response*
- *Communication system problems among first responders.*

## Simultaneous Attack Scenario in a Large City

# Current shortcomings - Infrastructure

- *Critical infrastructure links not provided adequate protection.*
- *Backup plans not adequate and in some cases multiple locations planning on the same one backup source.*
- *Not have enough road/rail capacity for rapid evacuation of all residents and commuters.*
- *No plans available for evacuation when major access routes are closed or damaged (e.g. from DC when bridges to Virginia are closed/ damaged)*

## Simultaneous Attack Scenario in a Large City

# Current shortcomings - Health Care System

- *Hospitals not prepared to handle the large number and type of casualties.*
- *Ambulances not routed properly for the victims who may be fortunate to get one.*
- *The extent of spread of biological agent may not be understood until too late.*

## Simultaneous Attack Scenario in a Large City

# Current shortcomings - Guarding the interests of General Public

- *Communications systems may fail if attacks result in loss of power*
- *Limited means to provide adequate directions to the public for evacuation during and after the incident.*
- *Public not prepared for such occurrences prior to the incident.*



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

## Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

# Potential Roles of Advanced Technology

- *Improved hardware for emergency response managers and for first responders*
- *Improved response through use of Modeling and Simulation (M&S):*
  - *Awareness*
    - *Improved vulnerability assessment and identification and detection using M&S and intelligent agent based technologies*
  - *Preparedness*
    - *Improved planning through simulations of a range of scenarios*
    - *Increased training for first responders using M&S*
  - *Response and Recovery*
    - *Improved anticipation of unfolding events for better real-time response support*

# Improved Training through M&S

- *Decision makers use experience based on simulations of scenarios that are close to the actual event.*
- *Pre-developed (and tested using simulation) deployment plans for similar scenarios are pulled up and modified for the actual event.*
- *First responders use the experience from virtual training to know what to expect and what equipment to bring along.*

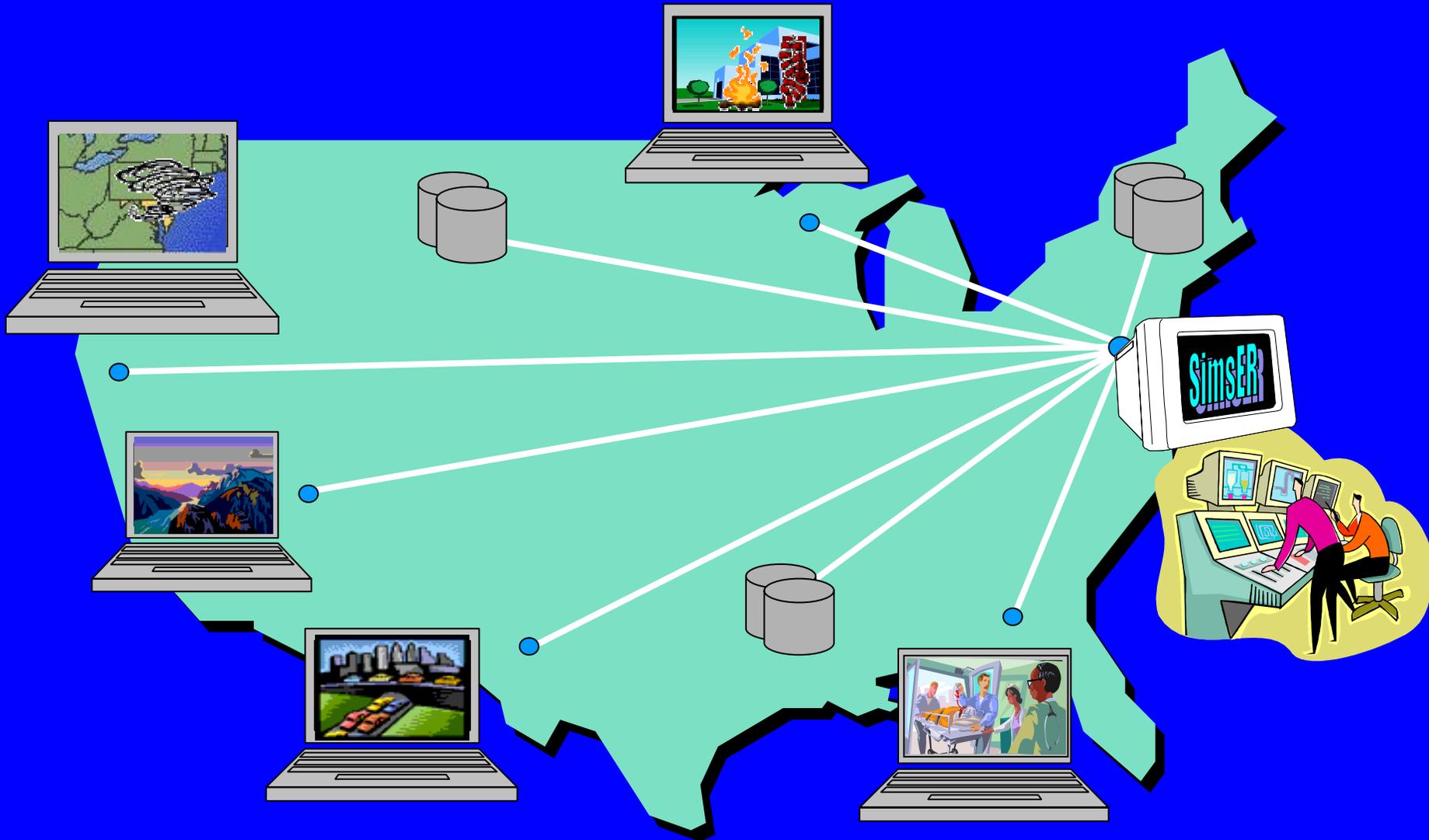
# Vision

- *System for Integrated Modeling and Simulation of Emergency Response – SimsER*
- *Provide M&S support for all applications including: planning, vulnerability analysis, identification and detection, system testing, training, and real time response*
- *For real time response - provide M&S support for personnel in the Emergency Operations Centers (EOCs). Selected applications for scene commanders.*
- *For training – support immersive training through high fidelity simulations*
- *Utilize easy-to-navigate visualization for showing scenario and simulation results*

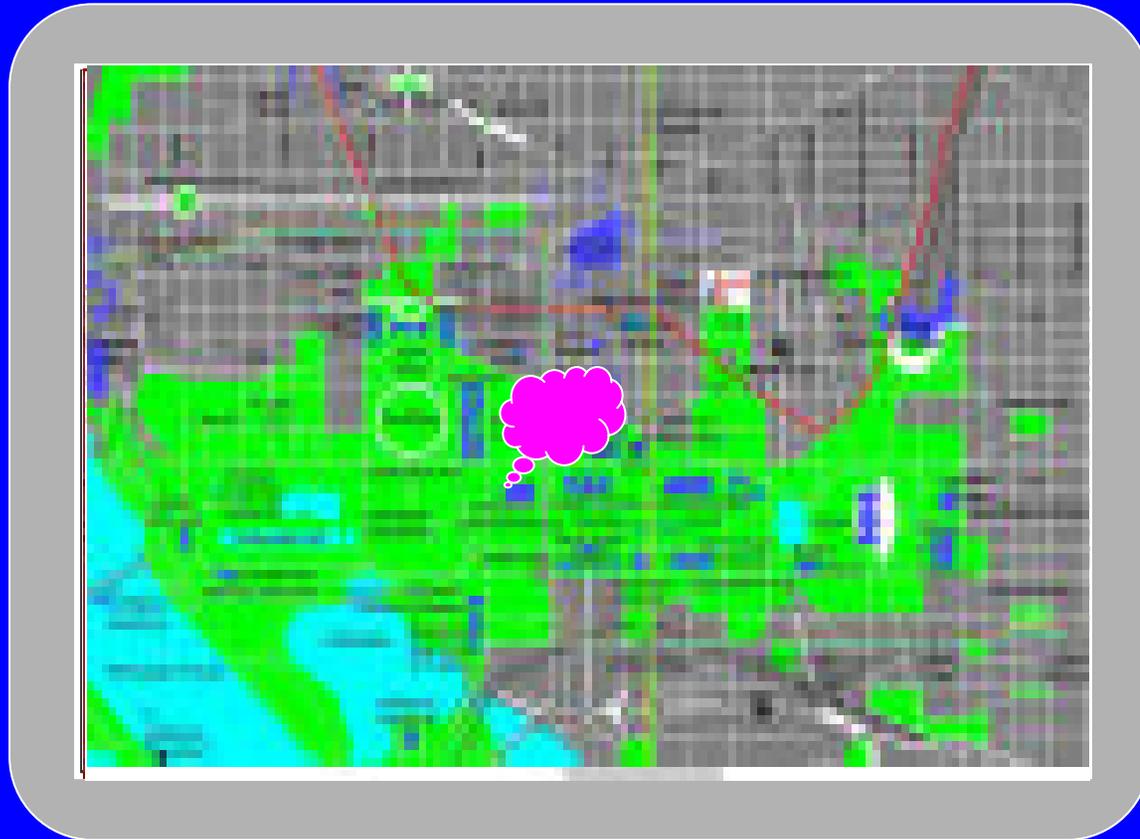
## **Vision (Contd.)**

- *“Low” cost through a subscription mechanism to tools residing at servers at tool support sites accessible through high speed communication network*
- *Seamless and secure integration to data sources*
- *Rapid response through high priority for execution and communications*
- *Multiple secure access points*
- *Integrated with Command and Control systems; include logging for After Action Reviews*

# SimsER Vision



# Layering of multiple views and simulations



**SimsER**



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

## Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

# Business Case for M&S

- *Resources are limited – need to document a business case for development of SimsER*
- *Investment required to develop SimsER – based on roadmap output from workshop*
- *Benefits of SimsER*
  - *Approach(es)*
    - *Study past incidents and estimate the reduction in damage/ losses if SimsER was used*
    - *Study past incidents where M&S was used and estimate reduced losses (most common – weather simulations – hurricanes and storms)*
    - *Project potential benefits from a variety of M&S tools for ER*
    - *Project potential benefits for each application area – awareness, preparedness, and response and recovery.*
    - *Gather expert consensus on the percentage loss reduction through use of M&S for various types of incidents*

# Business Case for M&S - Measures

- *Reduction in Direct Impact*
  - *Property Damage*
  - *Human casualties*
  - *Emergency response costs*
- *Reduction in Indirect Impact*
  - *Damage to the economy*



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

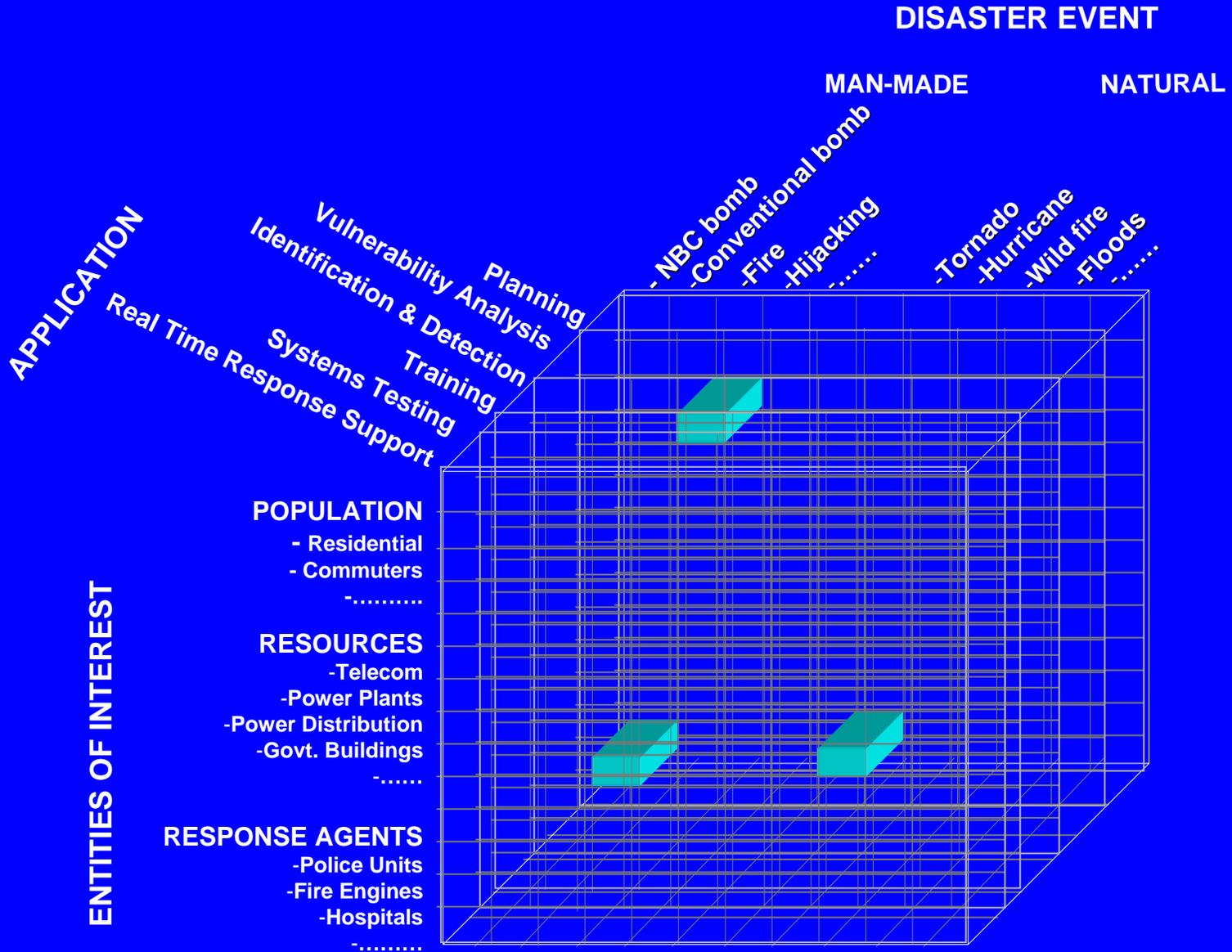
## Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

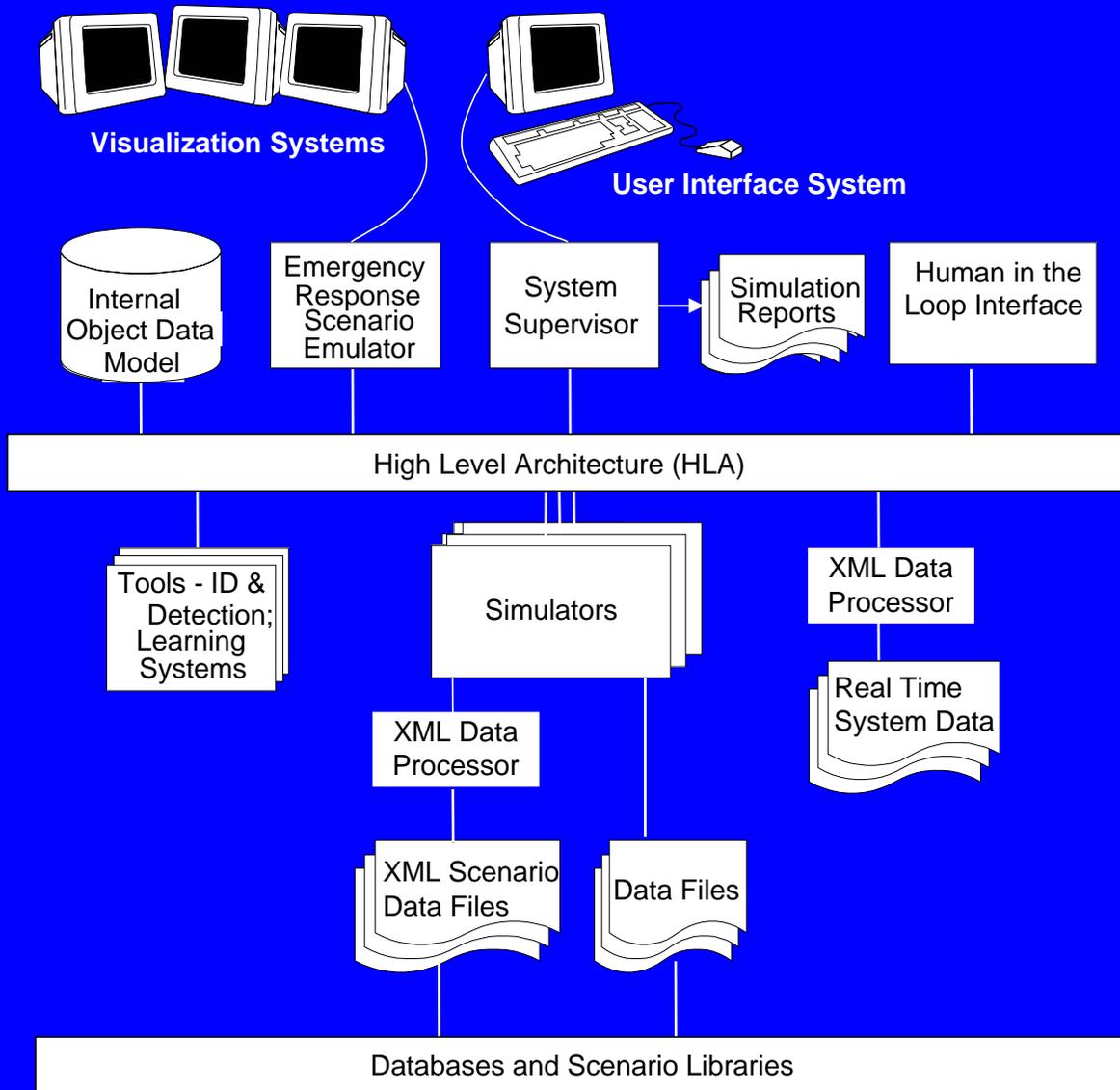
# Scope of efforts for Integrating M&S tools for ER

- *Framework to identify the needed tools and interfaces*
- *Architecture to identify the integration effort*

# integrated Emergency Response Framework (IERF)



# Architecture for SimsER



# Approach to build and deploy the systems

- *Development of framework and distributed architecture*
- *Development of standard data interfaces*
- *Integration of existing simulation tools using the framework*
- *Deployment through a distributed network*
- *Training of users*



Adapted from news item in San Francisco Chronicle on Weapons of Mass Destruction Decision Analysis Center from Sandia National Labs



Adapted from article in National Defense Magazine on VERTS developed by U.S. Army STRICOM

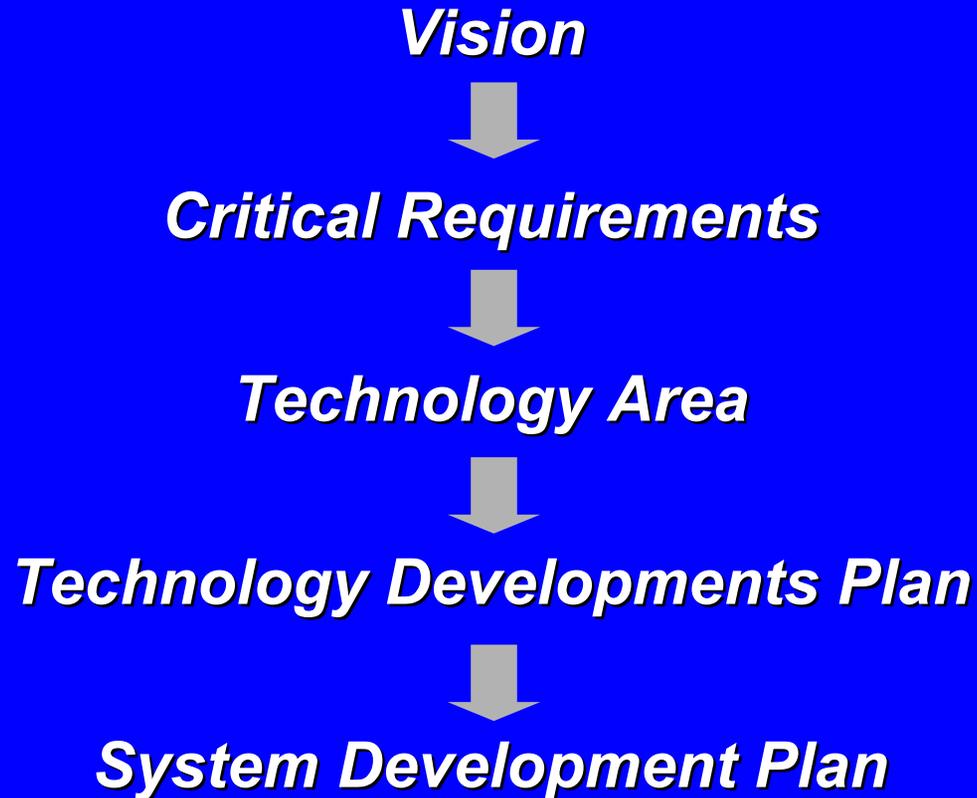
## Outline

- *Introduction*
- *Current status of emergency response capabilities*
- *Vision*
- *Business Case*
- *Scope of efforts for integrating M&S tools for ER*
- *Roadmap*

# Roadmap

- *Proposed development is complex requiring a coordinated approach from several fronts – standards, technology, program issues, resources with expertise, and funding.*
- *With the urgency to develop and deploy and resource constraints – need to avoid duplication of efforts*
- *Need a roadmap that:*
  - *The major research and development organizations can jointly follow*
  - *Can be supported by relevant government agencies*

# Developing the Roadmap



# System Level Critical Requirements (draft)

- *Comprehensive in scope*
- *Trusted collaboration environment for training*
- *Authoritative, Credible recommendations on actions to take to emergency responders*
  - *VV&A process to be agreed upon*
  - *Confidence levels to be defined*
- *Accessibility & Security*
  - *Access to legacy data*
  - *Override in Defined Emergency*
- *Privacy*
- *Scalability*
- *Ability to integrate multiple paradigms – discrete, continuous, agent-based*
- *Ease of Use*

## **System Level Critical Requirements (draft – Contd.)**

- *“Low” cost access – lower than having all tools at each location*
- *Speed of creating the representation of the complete scenario*
- *Speed of executing the models*
- *Interactive analysis*
- *Expert guidance integratability*
- *Reality Synchronization – update with real time data, sensor management, sensor fusion*
- *Realistic representation for training*
- *Embedded training – I/F similar to operational systems*
- *Interoperable with Command and Control environment*
- *Archiving capability*

# Requirements

- *System level*
- *Functional – domain specific*
- *Use Case examples*
  - *Command & Control simulation*
  - *Dispersion simulation*
  - *Emergency responder movement simulation*
  - *Traffic/ evacuation simulation*
  - *Hospital system simulation*
  - *Weather sim*

# Mapping Requirements to Technology Areas (draft)

Technology Area	Critical System Requirements									
	Comprehensive	Credible Recommendation	Accessible & Secure	Ease of use	Speed of creation	Speed of execution	Interactive Analysis	Expert guidance	Reality Synchronization	Realistic Representation
Data Storage & Access	●		●	○	●	●			○	○
Domain Modeling & Simulation	●	●					●			●
Tool Integration	●	●	○	●	●	●	○	○	○	○
Distributed simulation		○	○		○	●				
Visualization		○		●		○	●			●
Immersive interfaces				●		●				●
Real time communications		○				○			●	
Artificial Intelligence							○	●		○
User verification			●	○						

● - Major impact; ○ - Minor impact.



# Technology Development Roadmap (draft)

Technology area	2004	2005	2006	2007	2008
Technology developments					
<b>Data Storage &amp; Access</b>					
Data ontology standards					
Data storage standards (domain specific)					
Data interface standards					
Database standardization					
Metadatabase					
Rapid access mechanism					
<b>Domain Modeling &amp; Simulation</b>					
Framework document (for tool reqmts)					
Domain specific M&S tools (Legacy)	Audit against standards as they become available; Modify as needed for compliance				
Domain specific M&S tools (New)	Requirements-Design-Develop-VV&A process				
<b>Tool Integration</b>					
Framework document (for defining integration requirements)					
Architecture					
Tool Interface standards					
<b>Distributed simulation</b>					
Time representation					
Distributed Simulation Standards					
Hardware infrastructure					

# System Development Plan (draft)

Release	2004	2005	2006	2007	2008
<b>SimsER Prototype</b>	Identification of initial toolset	Development and release of prototype			
<b>SimsER Release 0.1</b>		Integration of identified tools; Release 0.1 (R0.1)			
<b>SimsER Release 0.5</b>	Requirements	Design	Develop and deploy Release 0.5 (R0.5)		
<b>SimsER Release 1</b>		Update requirements based on prototype and R0.1 experience	Update design based on draft standards and R0.5 experience	Implement design changes based on approved standards and deploy Release 1 (R1.0)	
<b>SimsER Future Releases</b>					Integrate additional tools (new and legacy) and deploy a new release every year (Rx.0) →

# Workshop sessions

## *Tuesday*

*11-12:30*

*Document Business Case – Perspectives and current technologies*

*2-3:30*

*Document Business Case – Potential uses and gains*

## *Tuesday*

*4-5:30*

*Roadmap – High level tasks*

## *Wednesday*

*8:15-10:15*

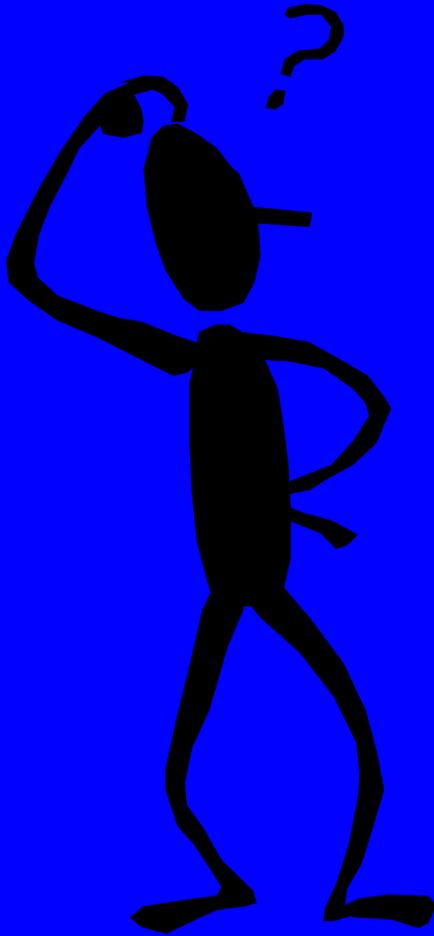
*Roadmap – Ongoing efforts to high level tasks*

*10:45-12:15*

*Roadmap – Next level of detail*

*1:45-3:15*

*Roadmap – Funding and collaboration*



**Questions  
and  
discussion?**