

IDD High Performance Resilience Program

Cutting-Edge Risk and Resiliency Tools

NIST – NEHRP
November 8-9, 2011



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Mila Kennett
Infrastructure Protection and Disaster
Management Division

HP Resilience Workshops (2009-2011)

- Designing for a Resilient America: A Stakeholder Summit on High Performance Resilient Buildings and Related Infrastructure
- The Ultra High Performance Concrete (UHPC) Workshop
- Aging Infrastructures Workshop
- Stabilization of Buildings Workshop
- Security, Energy, and Environmental Summit
- Monitoring and Sensing of Near Collapse Buildings Workshop
- Near Collapse Buildings Workshop for Emergency Management Personnel
- Advanced Materials and the Infrastructure of the Future Workshop



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Resilience Definition

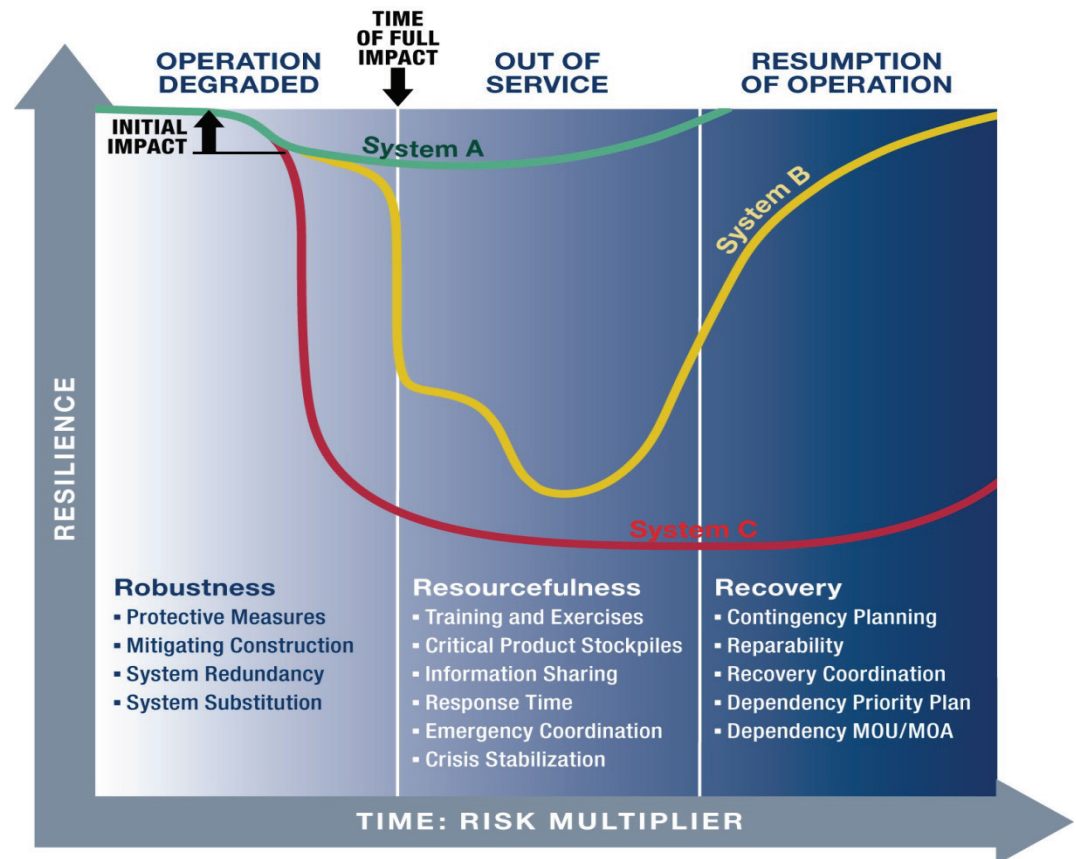
Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to **anticipate, absorb, adapt** to, and/or **rapidly recover** from a potentially disruptive event. (NIAC, 2009)



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Resiliency and Risk Continuum



HP Resilience Model

- Promotes the adoption of high performance and resilience concepts in a comprehensive and cost effective manner
- Promotes an integrated approach that addresses the capacity of the physical environment to anticipate, absorb, adapt to, and rapidly recover from disruptive events
- Promotes an integrated approach that includes design and construction issues related to:
 - Blast, earthquake, high wind, and flood resistance, and cyber security
 - Energy efficiency, environmental sustainability
 - Durability/extension of life and continuity of operations

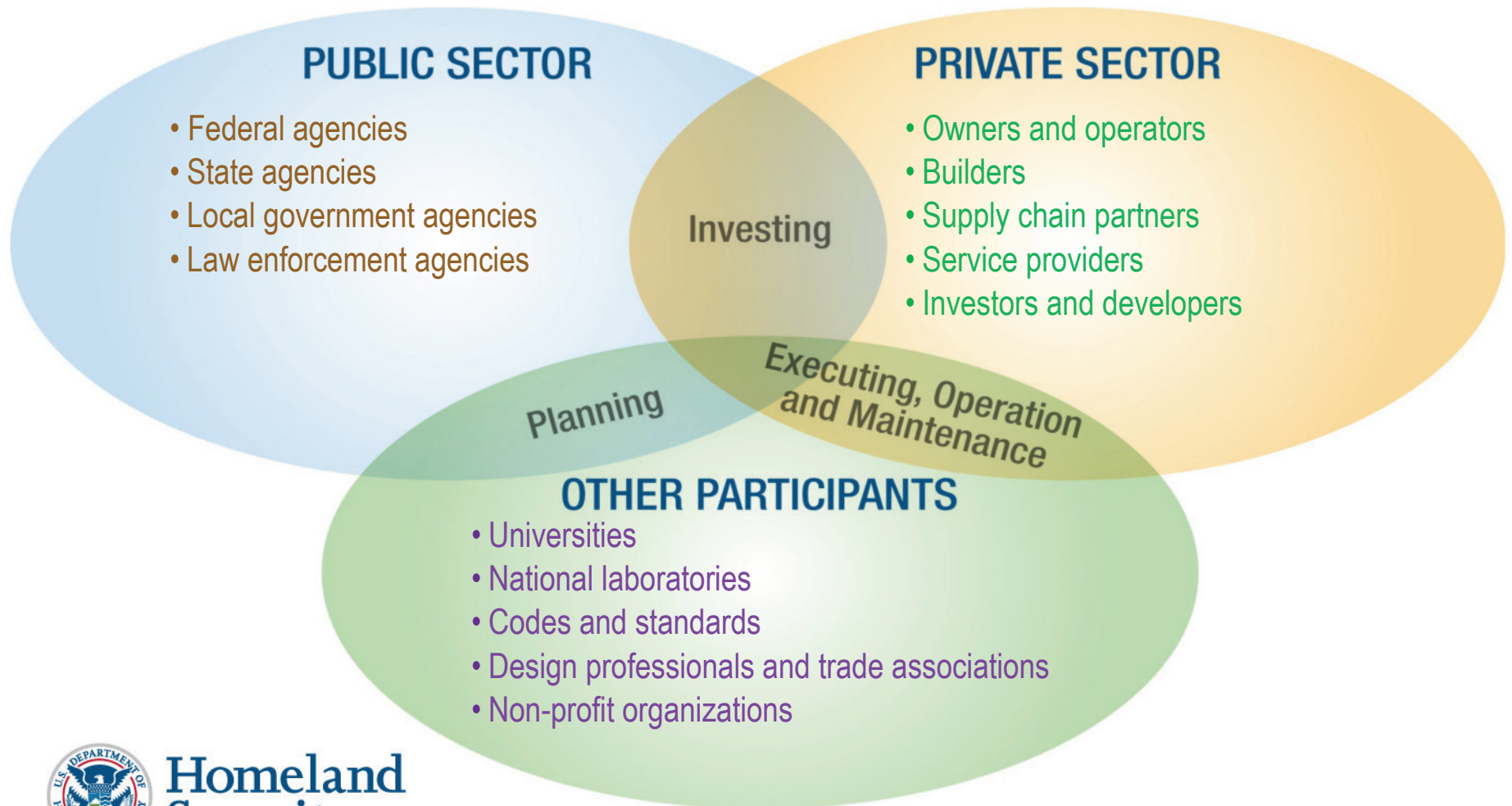


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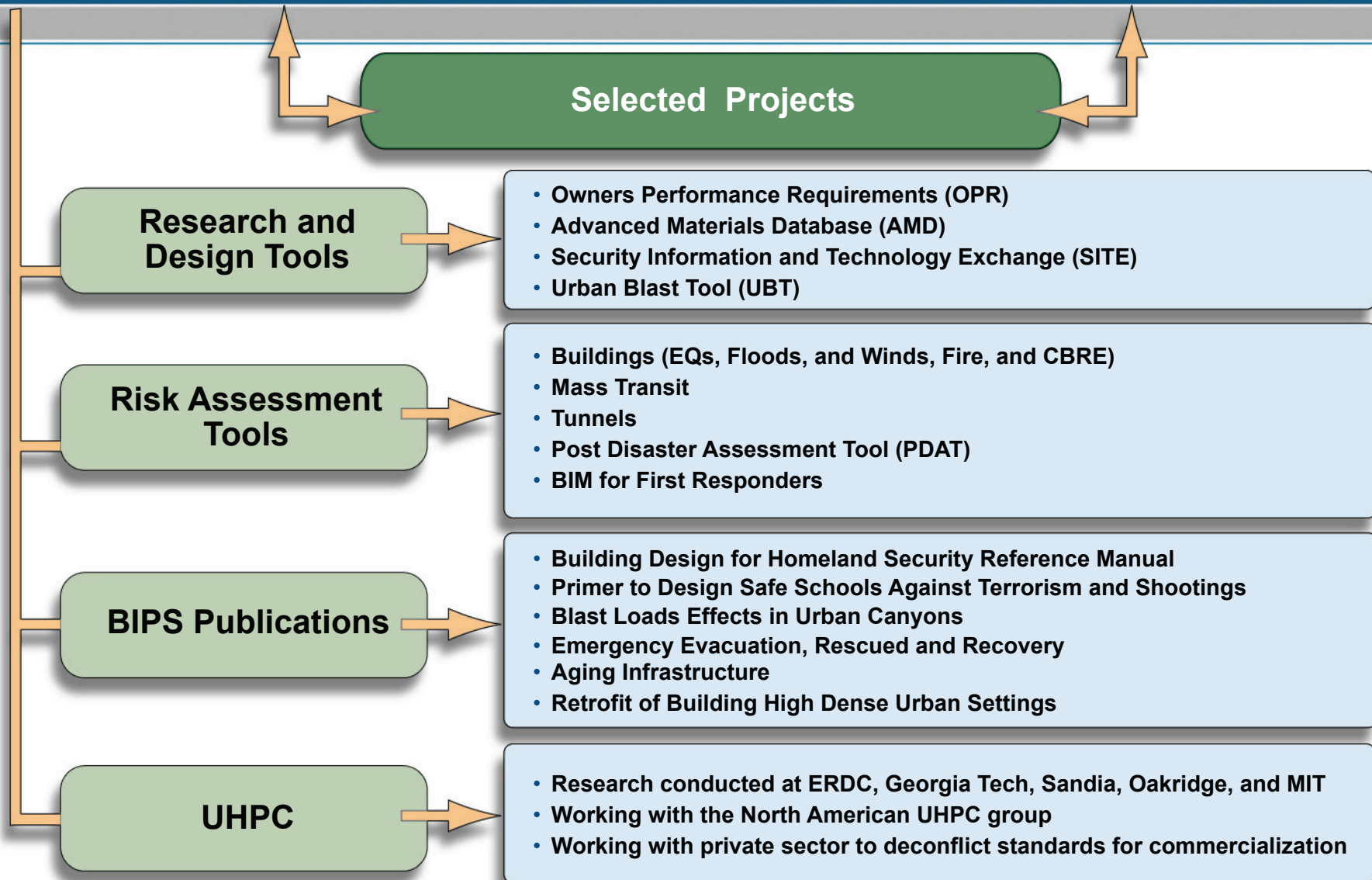
HP Resilience Stakeholders



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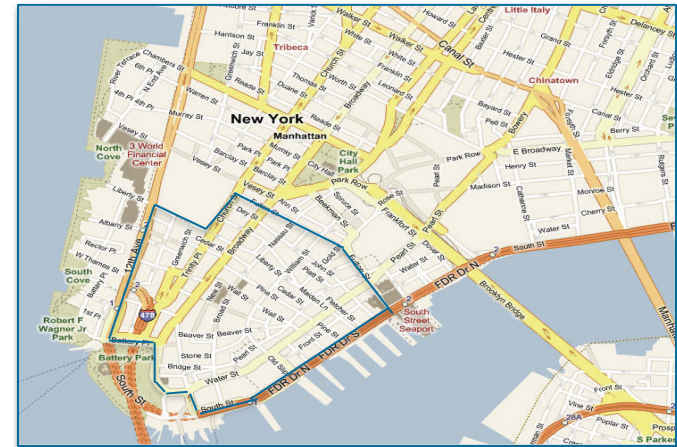
HP Resilience Program Taxonomy



Urban Blast Tool (UBT)

NYC Financial District (completed) and Mid Manhattan

- Geared toward the design community and first responders
- Very fast running providing guidance on Airblast loads based on CFD analysis
- Addresses column damage and potential for progressive collapse
- Displays glass debris hazards
- Use for evaluating emergency evacuation rescue and recovery (EERR) systems after an event



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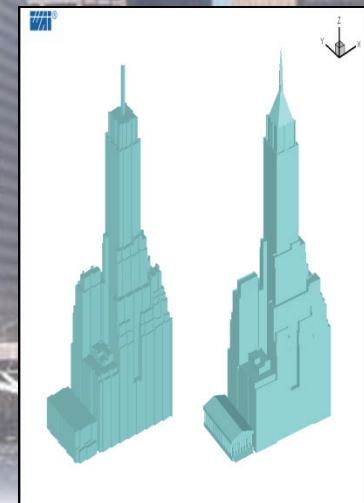
UBT Codes

- Airblast Codes for data base computations
- DTRA MAZ code for analyzing 3D propagation
- FLEX finite element software is used to analyze structural performance in response to explosive loading
- ProCAT module to be evaluated against FLEX analyses of typical construction



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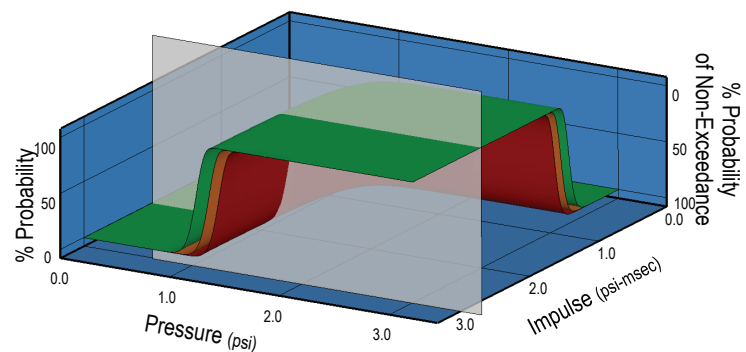
UBT and EQ Related Issues

- **Progressive collapse potential**

- Use lateral structural systems in the algorithms and logic for assessing progressive collapse potential

- **Emergency, Evacuation, Recovery, and Response (EERR) fragilities**

- Use seismic non-structural components design methods in validating the results for some of the EERR blast fragilities
- With appropriate consideration of the essential differences between seismic and blast responses



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UBT Future Development

- Create a generic version applicable to most cities in the US
- Develop an interactive version to allow owners to input detailed building data
- Add the Air Force Progressive Collapse Analysis Tool to improve current UBT assessments
- Analyze and add more structural detailed studies to the UBT models
- Improve accuracy and generate additional emergency and evacuation equipment fragility models



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UBT - Demo

Threat definition

TNT

Weight: 1000 lb

Location	Value	Units
x	2420	ft
y	1275	ft
Street	Wall Street	

Compute Threat Effects

Display

Threat effect: None (Height)

maximum value for each building

Click button to start Computation



Shortcut to ubdowntownusav7.mp4.lnk



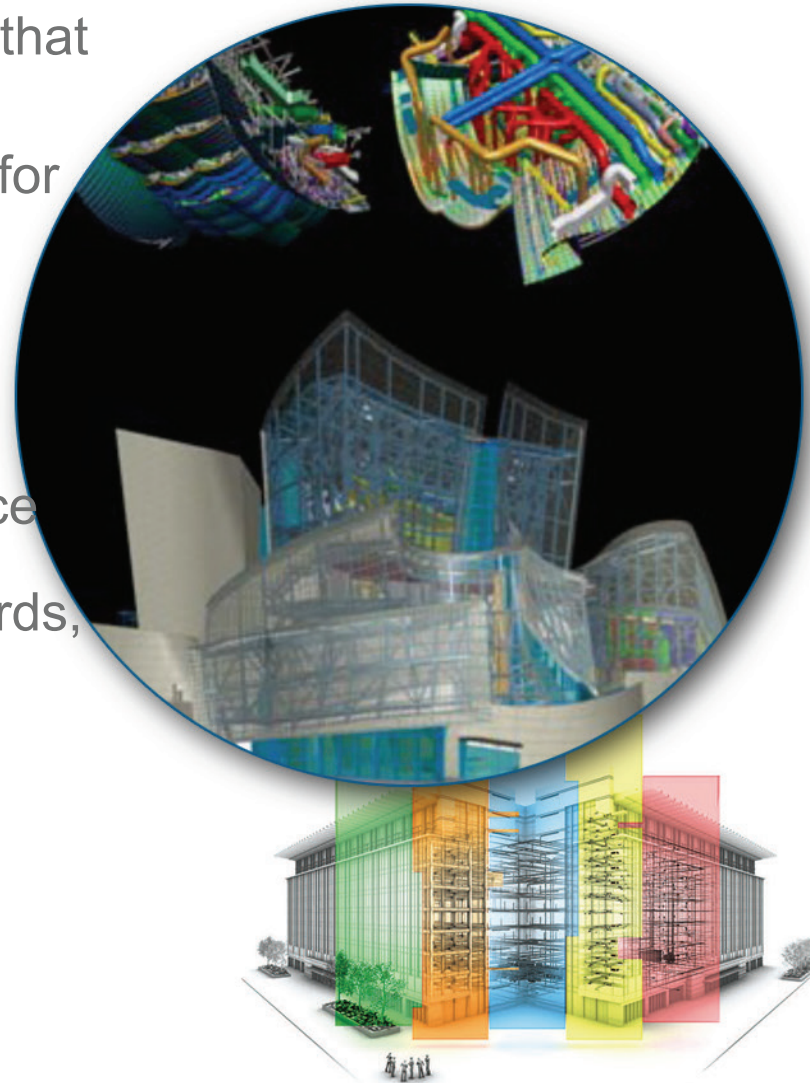
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Owners Performance Requirements Tool (OPR)

The OPR Tool is a web-based system that allows building owners to:

- Determine specific performance goals for new and existing buildings
- Analyze a range of high-performance requirements based on EISA 2007
- Evaluate tradeoffs between high performance attributes and performance goals required by energy and environmental demands, threats, hazards, and building functions
- Performance goals may range from minimum standards (baseline) to high performance solutions (benchmarks)



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OPR Tool

The model employs **multi-attribute analysis and performance modeling** that allows the owner to identify performance goals, by evaluating different scenarios based on the following attributes:

■ Energy Conservation

- Thermal Transfer
- Air Leakage

■ Environment

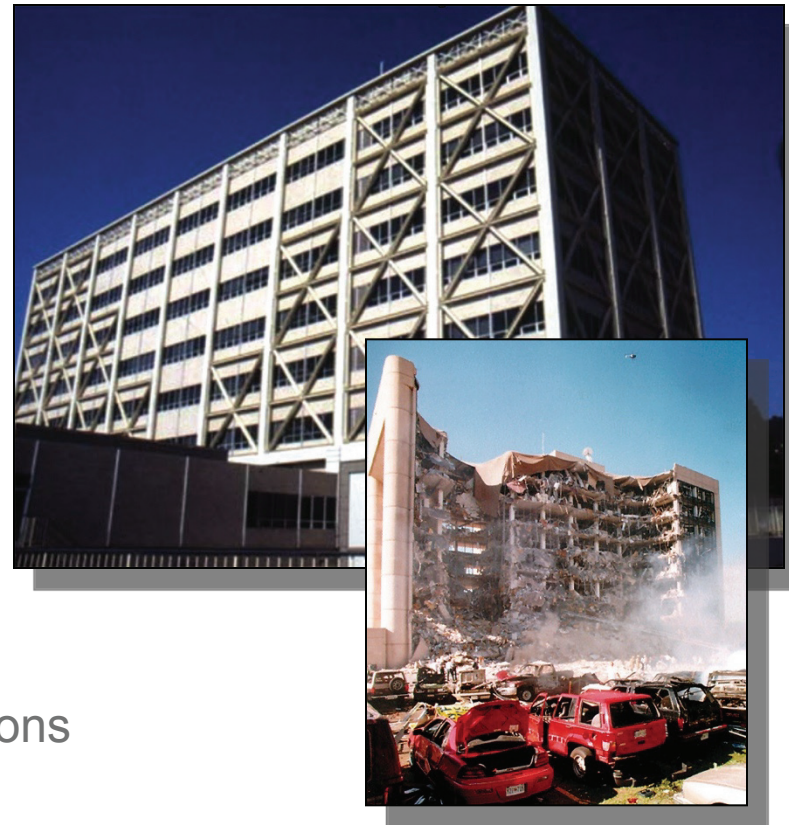
- Environmental Footprint
- Moisture Migration
- Water Penetration
- Acoustic Transmission

■ Safety

- Seismic
- Wind
- Flood
- Fire

■ Security

- Blast
- CBR
- Ballistics
- Continuity of Operations

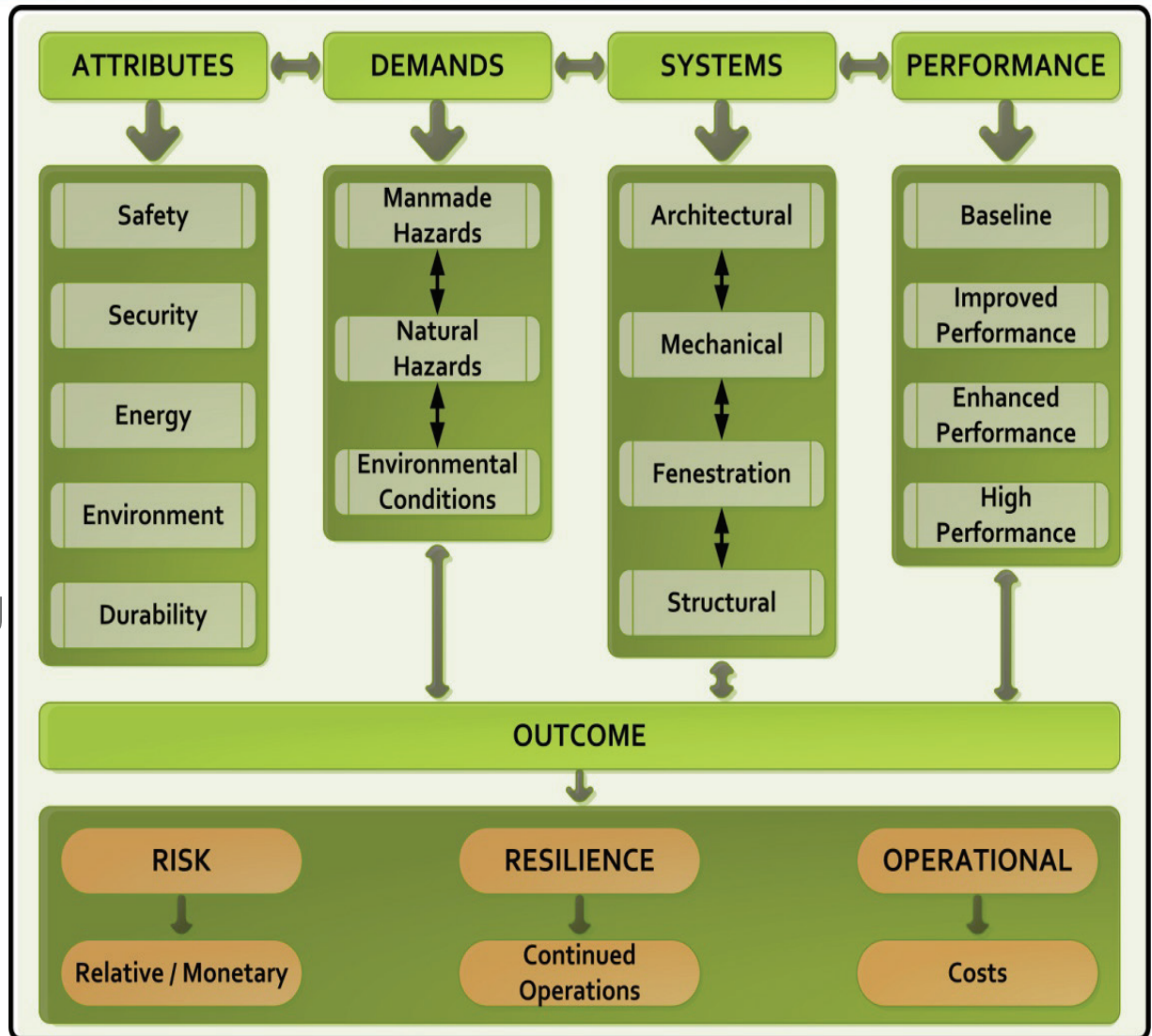


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OPR Tool

- Five expert committees were formed to provide the performance and cost data.
- The OPR Tool is expected to be part of the ASTM E06.55.09 Standard
- The OPR Tool is being released for external review at: www.oprtool.org/demo



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OPR Tool

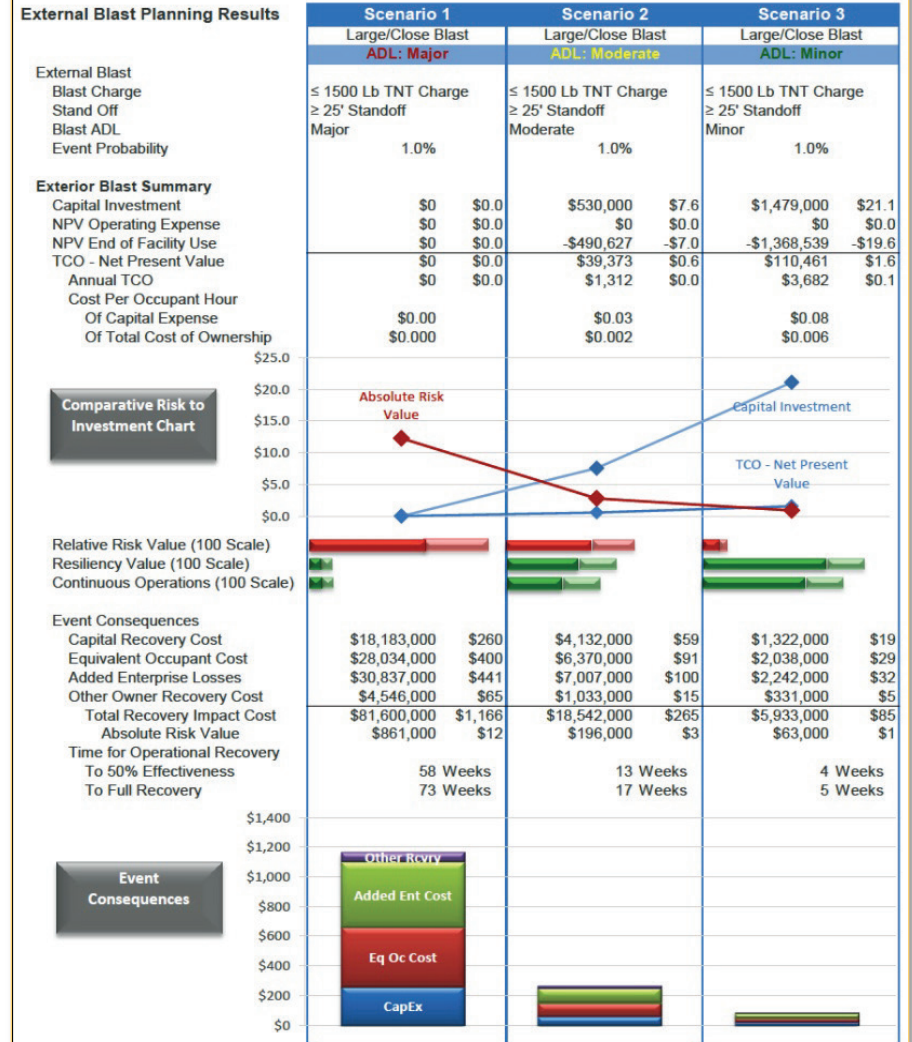
- **OPR outputs** are based on analyzing multiple attributes simultaneously
- **OPR cost outcomes** rely on the consensus and knowledge of the technical committees
- The model is strictly **performance based** and does not identify prescriptive solutions



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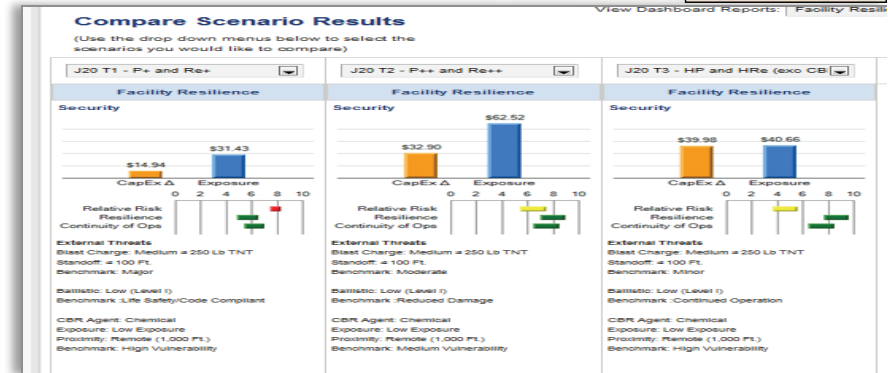
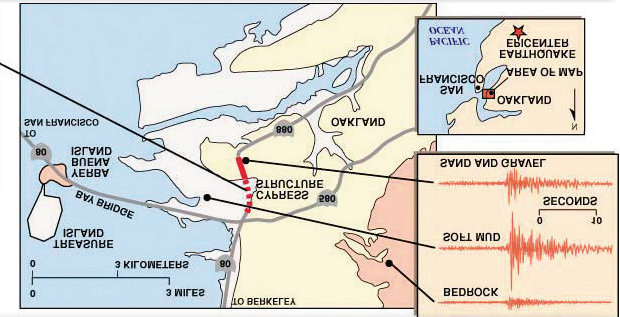
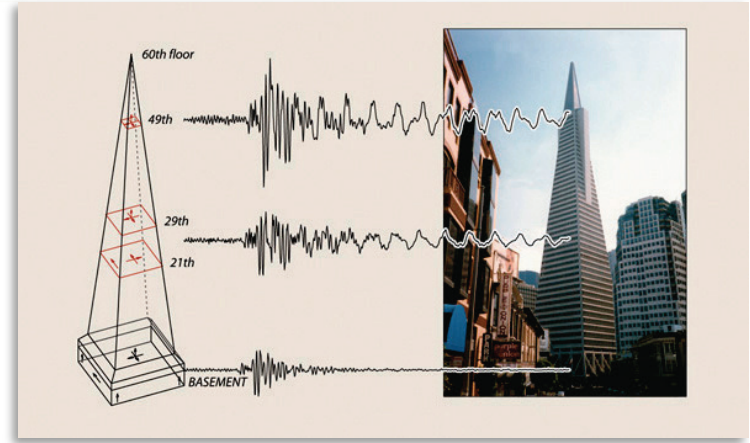
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Department of Homeland Security HPB/Enclosure Program: OPR Tool Planning Scenario Comparison Summary



OPR and EQ Related Issues

- Demand levels for varying EQ intensities
- Range of seismic performance levels covers four categories: Baseline (code minimum) to High Performance (continued operations)
- Exposure estimated for each performance level (measured in \$\$\$)
- Relative risk
- Resiliency measure
- Ranges of envelope system types considered as they relate to seismic demands and seismic performance
- Uncertainties of cost and performance estimates are covered
- Interactions with other hazards (blast, wind, fire, etc.) and attributes (architectural, environmental, energy, etc.) are built in



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OPR Tool Website



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Owner Project Requirements (OPR) Tool

for Performance Based Design

developed and managed by the National Institute of Building Sciences

in partnership with Department of Homeland Security/Science and Technology Directorate

[ABOUT](#) | [CONTACT](#)



The Owners Performance Requirements (OPR) Tool helps building owners identify priorities and prepare a performance plan for a project by selecting targets for each of the attributes identified as comprising high performance by the Energy Independence and Security Act of 2007 (EISA). The OPR Tool, focused in this version on the building envelope for office buildings, establishes a performance based plan for the owner to provide to the design team at the beginning of project programming. [Learn more...](#)

Please Sign In

Username:

Password:

Remember my login at this computer.



Resources

- ▣ [OPR Resource 1](#)
 - [OPR Resource 1a](#)
 - [OPR Resource 1b](#)
- ▣ [OPR Resource 2](#)
 - [OPR Resource 2a](#)
 - [OPR Resource 2b](#)
- ▣ [OPR Resource 3](#)
 - [OPR Resource 3a](#)
 - [OPR Resource 3b](#)

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PROJECT REQUIREMENTS REPORT

Project Information

Scenario Name: Trial 1	Project Type: Existing Building Retrofit	Location: Pittsburgh, PA
Gross Building Area: 100000 SF	Number of Floors: 3 (Including 1 below grade)	Quality: Class B
Performance Targets: P++	Enhanced Performance Re++ Enhanced Resilience	Ri-- Moderate Risk

Life Cycle Baseline Information

Use Period (TCO)	25 Years	Unit Cost		Occupancy Information	
		Energy Cost (\$/KBtu)	\$0.05	Census (GSF/Occupant)	150
Service Life (Years)		Service & Maintain Cost (\$/GSF)	\$0.25	Operation (Hours/Week)	40
Whole-building	50 Years	Annual Escalation Trend		Operation (Weeks/Year)	51
Exterior Wall	30 Years	Energy	5.0%	Indirect Project Cost	
Exterior Glazing	20 Years	Service & Maintain	5.0%	Construct	10%
Roof System	15 Years	Present Value Discount Rate	5.0%	Design, Test, Commission	12%

Facility Resilience

Safety

Seismic

Seismic Design Category SDC C

Performance Benchmark: Reduced Damage

Extent of Damage and Continuity of Operations: Moderate damage to cladding may occur but cladding remains anchored to building structure. Seals and gaskets may tear and ability to provide weather protection is locally compromised. Glass edge damage may occur and glass may fall off setting blocks, but glass breakage is mitigated. The building remains safe to occupy; structural and nonstructural repairs are minor. There shall be no failure or gross permanent distortion of the building envelope system anchorage and framing. Minor cracking and deformation of cladding may occur, but is not expected. Interstory drift limits all structures: 0.0075h to 0.01h; h = story height

Performance Standard(s)

- IBC-2009
- ASCE 7-05
- ASCE 41-06
- NEHRP Recommended Provisions for Seismic Regulations
- FEMA E-74
- ASTM E 2026




Basis of Earthquake Design: 10% probability of exceedance in 50 Years.

IRVS Buildings, Subways, and Tunnels

- A rapid (3 hours instead of 3 days) but comprehensive group of assessment tools
- Designed to assess risk and resilience for buildings, mass transit, and tunnels
- Evaluates risk related to all hazards, such as explosives; chemical, biological, and radiological events; and earthquakes, floods, high winds, and fires
- Expected to save millions of dollars to federal, state, local governments and private sector
- Computes risk and resilience providing scores and ratings

The screenshot displays the IRVS software interface. On the left, a vertical stack of FEMA 455 Data Collection Forms (Pages 2, 3, 4, 5, 6, 7) is shown, categorized by building characteristics, site, and security. The main window shows a 'Main Menu' with options: 'Rapid Visual Screening', 'Administrative Functions', 'Change Passwords', and 'Exit'. Below the menu is a grid of data points. To the right, there are three book covers from the 'Buildings and Infrastructure Protection Series': 'Rapid Visual Screening of Subways', 'Field Guide for Integrated Rapid Visual Screening of Buildings', and 'Rapid Visual Screening of Tunnels'. Each book cover includes the Homeland Security logo and the text 'Science and Technology'.

IRVS Dictionaries

Consequences	Threat/Hazard	Vulnerability	
Buildings			
<ul style="list-style-type: none"> • Locality Type • Number of Occupants • Replacement Value • On Historic Registry • Business Continuity • Physical Loss Impact 	<ul style="list-style-type: none"> • Occupancy Use • Number of Occupants • Site Population Density • Visibility/Symbolic Value • Target Density • Overall Site Accessibility • Target Potential 	<ul style="list-style-type: none"> • Site • Architecture • Building Envelope • Structural Components and Systems • Mechanical/Electrical/ Plumbing (MEP) Systems • Security 	
Mass Transit Stations			
<ul style="list-style-type: none"> • Number of Tracks • Number of Station Levels • Impact of Physical Loss • Number of Riders per day • Commercial, and Industrial Facilities • Adjacent Stations • Adjacent Critical Infrastructure • Social Effect of Loss • Replacement Value • Operational Redundancy • Function Criticality 	<ul style="list-style-type: none"> • Visibility • Historic Nature/Landmark Status • Number of Riders per day • Previous Threats • Accessibility • Elevation • Site Locality • Adjacent Critical Infrastructure • Function Criticality • Storage Use 	<ul style="list-style-type: none"> • Site • Architectural • Structural • Ventilation (including HVAC) • Fire Systems • Operations (including power supply, lighting, etc.) • Non-Structural 	
Tunnels			
<ul style="list-style-type: none"> • Impact of Physical Loss • Number of Vehicles/Trains per Day • Nearby Commercial Facilities • Adjacent Critical Infrastructure • Social Effect of Loss • Replacement Value • Operational Redundancy • Function Criticality 	<ul style="list-style-type: none"> • Visibility • Historic Nature • Number of Vehicles/Trains per day • Previous Threats • Accessibility • Elevation • Site Locality • Adjacent Critical Infrastructure • Function Criticality 	<ul style="list-style-type: none"> • Site • Architectural • Structural • Ventilation (including HVAC) • Fire Systems • Operations (including power supply, lighting, etc.) • Non-Structural • Physical Security 	

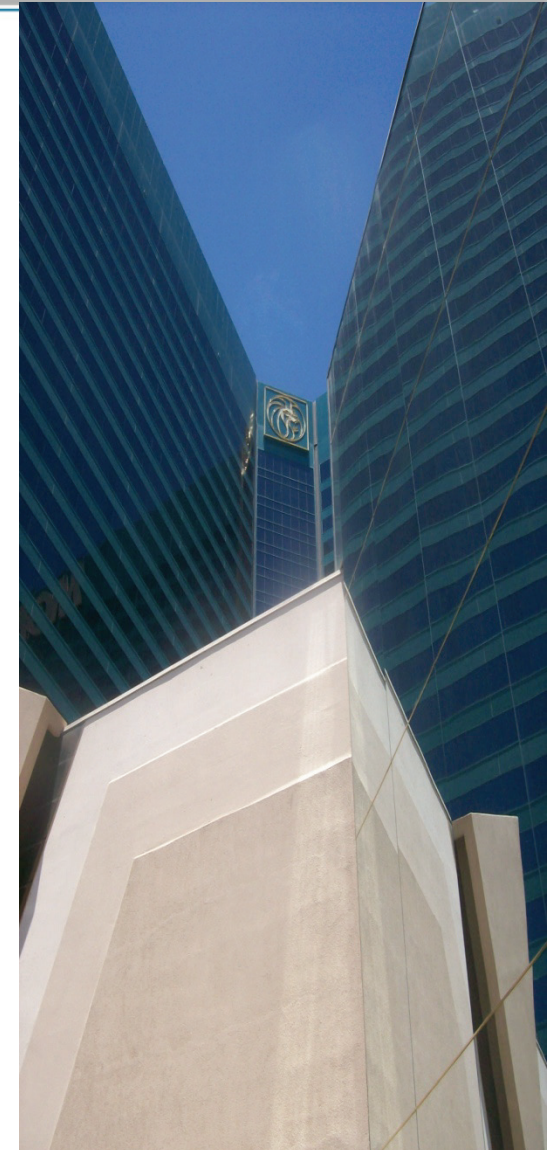
IRVS Analytical Background

- **Methodology:** knowledge is embedded in the tool. Major tool interactions are automatically calculated. Pre-assigned weights, interaction logic, and context-based algorithms based on knowledge and tool validations
- **Risk:** For man-made hazards, deals with target attractiveness. For natural hazards, it uses probability of occurrence. Risk is calculated as follows: $R = C \times T \times V$
- **Resilience:** computes robustness (R1), resourcefulness (R2), and recovery (R3) using information, such as hardening, training, and redundancies. Resilience is calculated as follows: $\text{Resilience} = R1 \times R2 \times R3$



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IRVS and EQ Related Issues

- Two specific seismic scenarios are considered:
 - Ground shaking
 - Ground failure
- Consider important factors that affect seismic threats and building vulnerabilities:
 - Seismic zone, soil/foundations, building types, irregularities, seismic anchoring, etc.
- Consider potential interactions between seismic vulnerabilities and vulnerabilities to other hazards (blast, wind, fire)
- Consider a fire scenario resulting from seismic event



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IRVS Tool - Scores

mfrmRVS_Summary_TotalRisk

Total Risk Summaries - All Assessments

Buildings			Total Risk														
Site Name	Facility ID#	Assessment Date	Total Risk All Scenarios	Total Resiliency	Intrusion	Blast Interior	CBR Interior	Blast Exterior	CBR Exterior	Seismic	Flood	Wind	Fire	Internal Intrusion	Internal Explosive	Internal CBR	Explosive Zone 1
Test 2	Test 2	3/10/2011	62.2	18.3	65.8	49.5	70.4	53.8	59.5	72.1	71.8	77.7	57.3	65.8	49.5	70.4	50.9
Test site 3	333	3/11/2011	47.6	35.4	51.5	46.1	53.2	33.5	36.7	38.0	61.9	36.5	45.7	51.5	46.1	53.2	29.3
Test site 4	4444	3/14/2011	19.5	71.5	11.7	15.2	11.2	20.8	20.2	17.8	13.9	24.3	13.9	11.7	15.2	11.2	13.5

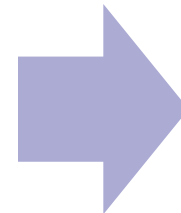
Mass Transit Stations			Total Risk													
Site Name	Facility ID#	Assessment Date	Total Risk All Scenarios	Total Resiliency	Blast Internal	Blast External Direct	Blast External Collateral	CBR Internal	CBR Tunnel	CBR External	Fire Internal	Fire External	Fire Tunnel Smoke	Other Flood	Other Collision	Other Cyber
Mass Transit 1	666	3/14/2011	17.6	89.4	5.0	9.5	4.1	0.6	0.5	3.0	10.7	3.8	0.5	3.3	22.6	5.0
Mass Transit 1	666	3/14/2011	29.0	90.8	9.9	24.5	23.3	1.1	1.0	25.7	24.8	29.7	1.2	13.4	36.4	20.5

Tunnels			Total Risk													
Site Name	Facility ID#	Assessment Date	Total Risk All Scenarios	Total Resiliency	Blast Internal	Blast External Direct	Blast External Collateral	CBR Internal	CBR Tunnel	CBR External	Fire Internal	Fire External	Fire Tunnel Smoke	Other Flood	Other Collision	Other Cyber
Tunnel 1	5555	3/14/2011	10.8	93.8	4.5	11.3	7.1		4.5	13.3	0.7		5.1	2.3		5.1
Tunnel 1	5555	3/14/2011	38.0	55.5	14.6	43.0	34.1		22.2	46.9	2.6		23.5	18.9		23.5

Comprehensive scores for mass transit, tunnels, and buildings



Scores for a single building based on 20 hazard scenarios



Risk and Resiliency Summary

RVS Building/Facility: Demo of Bldg 1
 Facility ID#: 0001
 Assessment Date: 2/2/2002 Site Type: Building

Scales		Scores and Color Mapping			
Risk Color Scale		0-30	30-50	50-70	70-100
Resiliency Color Scale		100-70	70-50	50-30	30-0

Summary Categories	Internal Intrusion	Internal Explosive	Internal CBR	Explosive Zone 1	Explosive Zone 2	Explosive Zone 3	CBR Zone 1	CBR Zone 2	CBR Zone 3
Total Consequences (%)	66.83%	59.61%	57.91%	61.97%	59.33%	69.13%	57.41%	61.75%	65.10%
Total Threat (%)	27.18%	66.34%	62.83%	85.34%	58.67%	49.69%	84.00%	71.18%	53.30%
Total Vulnerabilities (%)	8.92%	61.04%	61.62%	56.01%	57.28%	57.10%	57.42%	56.99%	60.93%
Total Risk Percent (%)	25.30%	62.26%	60.75%	66.66%	58.42%	58.10%	65.18%	63.03%	59.57%

Summary Categories	Earthquake General Shaking	Earthquake Ground Failure	Flood Stillwater	Flood Velocity Surge	Wind Hurricane	Wind Tornado	Wind Other	Landslide Rainfall	Fire From Earthquake	Fire From Blast	Fire From Arson
Total Consequences (%)	61.31%	93.45%	61.04%	59.50%	61.30%	61.97%	61.33%	61.47%	61.15%	63.67%	62.90%
Total Threat (%)	0.00%	0.00%	77.07%	78.64%	54.31%	48.44%	52.10%	62.05%	0.00%	67.89%	29.80%
Total Vulnerabilities (%)	30.30%	35.30%	35.34%	41.30%	42.99%	39.99%	39.50%	33.16%	2.04%	3.14%	3.12%
Total Risk Percent (%)	0.00%	0.00%	55.15%	57.71%	52.31%	48.92%	50.16%	50.19%	0.00%	23.97%	18.02%

Resiliency Scales (%)					Multihazards Interaction Matrix						
Performance Measure	Time Measure	Robustness Measure	Resource-Fullness Measure	Recovery Measure	... will result in this change for other hazards:						
48.6%	47.3%	43.4%	48.6%	43.3%	a change in:						
					Blast	CBR	Seismic	Flood	Wind	Fire	
					a change in Blast	100.0%	9.3%	33.0%	9.7%	47.5%	22.6%
					a change in CBR	12.7%	100.0%	0.0%	16.8%	1.2%	5.2%
					a change in Seismic	55.5%	0.0%	100.0%	35.9%	50.7%	16.3%
					a change in Flood	7.5%	9.6%	16.7%	100.0%	8.8%	10.2%
					a change in Wind	68.2%	1.3%	43.3%	16.3%	100.0%	16.1%
					a change in Fire	83.2%	14.1%	35.7%	48.4%	41.5%	100.0%

Total Risk All Scenarios (%)	Resiliency (%)
60.88%	23%

Record: 1 of 6 | No Filter | Search | Print | Close



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HP Materials Databases

- **AMD** provides a platform for the systematic organization of advanced materials through the documentation and search ability of their high-performance properties

The screenshot shows the homepage of the Advanced and High-Performance Materials Database. At the top, there is a navigation bar with links for 'ABOUT', 'COUNCIL MEMBERSHIP', 'CONTACT', and a 'SEARCH' button. Below the navigation bar is a header section with the title 'Advanced and High-Performance Materials Database' and the subtitle 'Funded by the Science and Technology Directorate / Infrastructure and Geophysical Division / DHS'. A main menu bar contains links for 'ADVANCED MATERIALS', 'SECTORS', 'TESTING PROTOCOLS', 'PUBLICATIONS', 'CASE STUDIES', and 'COMMITTEES'. The main content area features a 'Sample Material' section with a placeholder image and text. Below this, there are three columns: a main text block describing the database's purpose, a 'NEW MATERIALS' section listing 'Casing Material 2' and 'Micro Material 1', and a 'FEATURED CASE STUDY' section for 'Home Depot House'.

- **SITE**, a web-based database for security products meeting ISC, VA, and DOD requirements

The screenshot shows the homepage of the Security Information & Technologies Exchange (SITE). At the top, there is a navigation bar with links for 'ABOUT', 'INTERAGENCY SECURITY COMMITTEE', and 'CONTACT'. Below the navigation bar is a header section with the title 'Security Information & Technologies Exchange (SITE)' and the subtitle 'developed by the DHS / Science and Technology Directorate / Infrastructure Protection and Disaster Management Division managed by the National Institute of Building Sciences'. A main menu bar contains links for 'PRODUCTS & TECHNOLOGIES', 'STANDARDS', 'POLICIES', 'PUBLICATIONS', 'CASE STUDIES', 'RESOURCES', and 'SEARCH'. The main content area features a 'Sample Products' section with a placeholder image and text. Below this, there are two columns: a main text block describing the SITE's purpose and a 'BROWSE PRODUCTS & TECHNOLOGIES' section with a list of categories including 'Site', 'Building Envelope', 'Structural System', 'Utilities & Distribution Systems', 'Building Systems', 'Security Systems', and 'Functional Spaces'. At the bottom, there is a 'BOOKMARK AND SHARE SITE' button and a footer with contact information for the National Institute of Building Sciences.



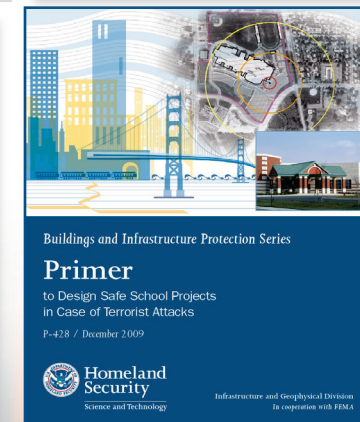
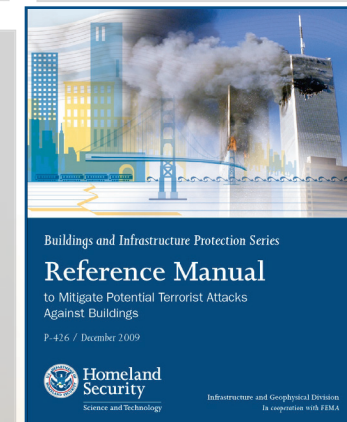
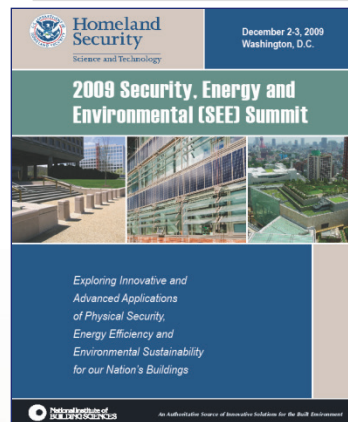
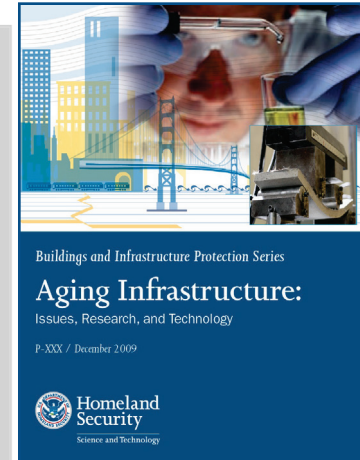
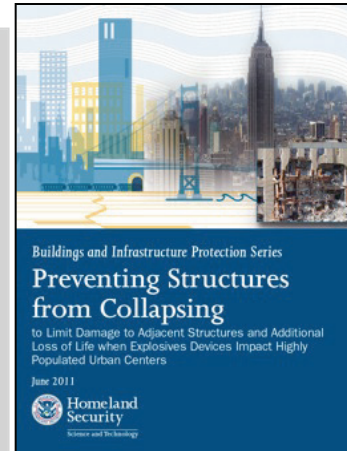
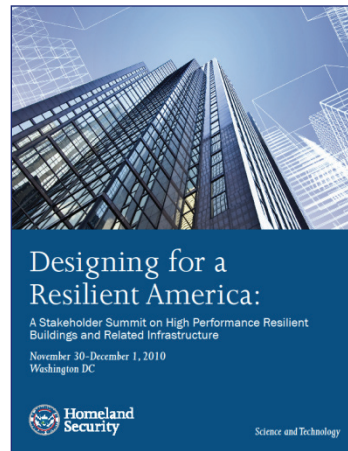
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BIPS Publications

Publications

- Aging Infrastructure
- IRVS Manuals
- Update of FEMA 426
- Update of FEMA 428
- Preventing Structures from Collapsing
- Designing for a Resilient America
- Security, Energy, and the Environment



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EQ Framework Used in the IVRS and OPR

- IBC-2009, “2009 International Building Code”
- ASCE 7-05, “Minimum Design Loads for Buildings and Other Structures”
- ASCE 41-06, “Seismic Rehabilitation of Existing Buildings”
- NEHRP Recommended Provisions for Seismic Regulations
- FEMA E-74, “Reducing the Risks of Nonstructural Earthquake Damage”
- ASTM E2026, “Standard Guide for Seismic Risk Assessment of Buildings”



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High Performance Concrete

- Working with the Association of Cement and Concrete to identify and advance effective methods of promoting the construction and commercialization of reliable UHPC materials in the U.S. construction market
- Working with ERDC, ORNL, Sandia, Georgia Tech, MIT, UConn in advancing the performance of UHPC
- Final product is expected to exhibit major performance in:
 - Ultra high strength, ductility, flexibility and toughness, impact resistance, dimensional stability Ability to construct thin sections and complex structural forms
 - Durability - increased usage life
 - Impermeability – freeze/thaw resistance, corrosion resistance, abrasion resistance, and aggressive environment and chemical resistance



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Building Stabilization Project

- An overall strategy that serves for the stabilization of buildings after an IED attack including
- To enhance the protection of first responders during search and rescue operations from events such as an explosives, wind, flood, fire, or general building collapse
- Major deliverables include monitoring and sensing techniques; **post disaster analysis tool (PDAT)**; field guide for shoring techniques; and BIM First Responders Standard
- In terms of seismic, the PDAT useful information for first responders, such as building types, potential failure modes, instability issues, fire potential, soil conditions, etc.

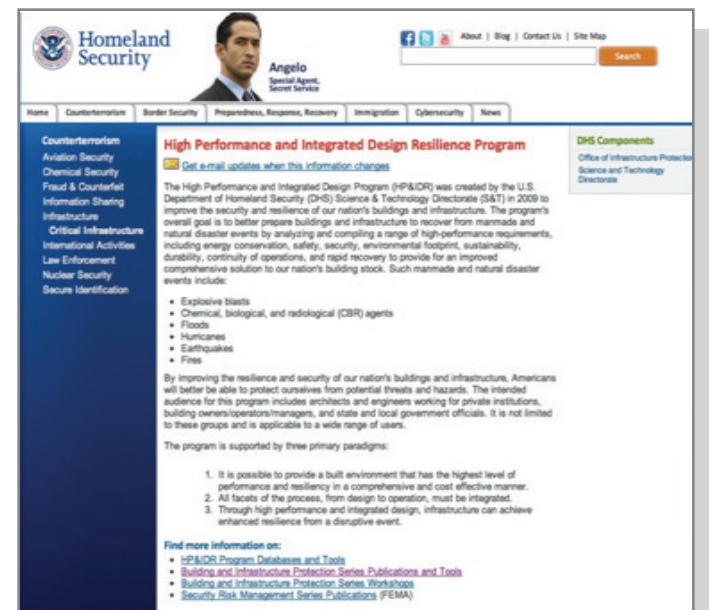


HP Resilience Website

Main Link:

<http://www.dhs.gov/files/programs/high-performance-integrated-design-program.shtm>

- It currently holds:
 - 4 demos, 2 software tools
 - 7 DHS S&T IDD publications and 20 Risk Management Series publications
 - 7 groundbreaking workshops



The website will be complete by the end of 2011



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Questions?



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<http://www.dhs.gov/files/programs/high-performance-integrated-design-program.shtm>