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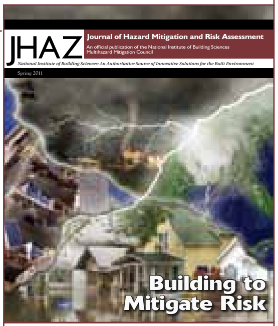

On the cover: Tornados, earthquakes, hurricanes and floods—these threats put millions of Americans at risk each year. The Multihazard Mitigation Council (MMC) is working to reduce the total costs associated with these disasters and other related hazards to buildings by fostering and promoting consistent and improved multihazard risk mitigation strategies, guidelines, practices and related efforts.

Buildings, Tunnels and Mass Transit Stations: DHS Releases Integrated Rapid Visual Screening Tools in 2011

By Michael Chipley, Mohammed Ettouney; Milagros Kennett; Terry Ryan; Philip Schneider; and Richard Walker

TO QUICKLY AND RELIABLY ASSESS the vulnerability of our nation's critical infrastructure, the U.S. Department of Homeland Security (DHS), Science and Technology (S&T) Directorate's Infrastructure Protection and Disaster Management Division (IDD) has developed a unique set of Integrated Rapid Visual Screening (IRVS) tools for buildings, tunnels and mass transit stations.

These next-generation tools are based on FEMA 452[1], which provides a preliminary procedure for architects and engineers to assess the risk of terrorist attacks, and FEMA 455[2], in which the concepts for rapid visual screening are combined with a risk-based procedure for manmade threats defined in FEMA 452 and FEMA 426.[3] The new IRVS screening tools provide the following information:

1. Quantification of resilience;
2. Quantification of risk;
3. Assessment of explosive, chemical, biological and radiological attacks;
4. Assessment of earthquakes, floods and high-wind hazards;
5. Assessment of fire hazards;
6. Assessment of different building types;
7. Assessment of mass transit stations; and
8. Assessment of tunnels.

This is the first set of tools that uniquely computes and quantifies scores for resiliency and risk and combines that with a multihazard assessment for a given building.

IRVS for buildings is a simple and efficient visual procedure for obtaining risk and resiliency scores and multihazard assessments for a variety of general building types. On the other hand, IRVS for mass transit and tunnels uses the same risk methodology but is more unique, attribute-specific and it predominantly calculates man-made threats.

Results obtained from the rapid visual screening process can be used for various applications. They include:

1. Prioritizing for further evaluation;
2. Developing emergency preparedness plans in the event of a high-threat alert;
3. Planning post-event evacuations, rescues, recoveries and safety evaluation efforts;
4. Prioritizing mitigation needs; and
5. Developing specific vulnerability information.

The results are especially useful for identifying a specific asset for more detailed study, verifying results and developing mitigation measures that will reduce the risk ratings to a more acceptable level. TABLE 1 summarizes the key details about each of the tools.

FEATURES AND BENEFITS OF THE DHS S&T IRVS TOOLS

IRVS is a quick and simple tool that determines the risks, resiliency and multihazard interactions of a building. The IRVS methodology can effectively and powerfully compute the level of risk associated with a building from both natural and man-made hazards. For buildings (and largely for tunnels and mass transit stations), it specifically can:

- Obtain numeric risk and resiliency score that produces a quantification of risks, relative risks and an understanding of the most dominant features of the building controlling overall risk.
- Identify, collect and store vulnerability data that can then be re-examined after protective measures have been put in place or are considered to be put in place.
- Rank vulnerabilities and consequences within a community, indicating which buildings are more at risk and require higher protection.
- Determine and rank risk within a particular building in order to allocate potential resources (such as

Table 1

IRVS Tool	Screening Time	Field Validation	Release Date
IRVS for Buildings	2 assessors 2 buildings per day	Arlington, Virginia, Albany, New York, New York City, New York Jointly with the Department of Veteran Affairs in Washington, D.C.	Summer 2011
IRVS for Mass Transit Station	2 assessors 1 station per day	Jointly with the Transportation Security Administrations in Boston, Massachusetts, Houston, Texas, Cleveland, Ohio and St. Louis, Missouri Port Authority of New York and New Jersey (PANYNJ)	Spring 2011
IRVS for Tunnels	2 assessors 1 tunnel per day	Jointly with the Transportation Security Administration in Boston, Massachusetts, Houston, Texas, Cleveland, Ohio and St. Louis, Missouri Port Authority of New York and New Jersey (PANYNJ)	Spring 2011

grant money) in an effective manner to reduce, in a cost benefit way, major vulnerabilities.

- Establish building inventories that characterize a community's risk to terrorist attacks and/or natural disasters.
- Understand potential cascading effects to the community by assessing a group of buildings and prioritizing a community's mitigation needs.
- Understand resilience, potential down time and economic and social implications if a building is affected by a catastrophic event.
- Help to identify which security measures should immediately be put in place during high alerts or develop emergency preparedness plans in order to reduce anticipated risk.
- Understand the risks in anticipation of special events that affect the peak occupancy of the building in order to plan properly and introduce protective measures.

By adopting an all-hazard approach, cost-savings, efficiency and better performance can be achieved when assessing a building.

In addition, the methodology includes updates to the building characteristics assessed, an evaluation of the building types and the addition of critical functions. Furthermore, the tool is supported by a digital interface that is supported by database software, which allows for easy storage, retrieval and data management.

UNDERSTANDING THE RISK AND RESILIENCY SCORE FOR THE DHS S&T IRVS TOOLS

Overall risk is determined by evaluating the key characteristics of buildings, mass transit stations or tunnels, based on the formula R = C x T x V, where:

- R = Risk.
- C = Consequence (an impact caused by the incapacity or destruction of an asset important to building operation, the owner and the locality).
- T = Threat (any event, including a blast, chemical, biological and radiological weapon, or natural hazard, with the potential to cause damage and loss to an asset).
- V = Vulnerability (any weakness that can be exploited to make an asset susceptible to damage, casualties and business interruption).

Resiliency is computed using three basic components: robustness, resourcefulness and recovery (known as the three R's). These are based on downtime and operational capacity. According to the DHS National Infrastructure Protection Plan (NIPP), resiliency is the ability to resist, absorb, recover from or successfully adapt to adversity or change in conditions.[4] In comparison, the President's National Infrastructure Action Committee (NIAC) defines resilience as 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[5] (FIGURE 1).

Scoring for risk and resiliency is based on a methodology that uses built-in weights and pre-defined algorithms. Scores are prepared for:

- Building characteristics and options that include physical components, functionality and operations pertaining to risk and resiliency of buildings.
- Attribute options or ranges and choices that the assessor may have when evaluating each building characteristic for both risk and resiliency.

Risk and resiliency ratings are represented by opposing, but not reciprocal, numbers. Low risk is accompanied by high resiliency and vice-versa.

In addition to risk and resiliency ratings, a matrix of threats and hazards is used to quantify interactions among hazards on a scale from 0 to 1, based on built-in weights and building characteristics.

The higher the resulting number, the higher the interaction between hazards. The interaction numbers can be used in decision-making to readily reduce vulnerabilities and improve resiliency in a cost-effective manner.

TECHNICAL SPECIFICATIONS OF THE DHS S&T IRVS TOOLS

One or two assessors can conduct and complete a screening in one to five hours. The IRVS tool operates on Microsoft (MS) Access 2007 with support from MS Excel 2007, MS Word 2007 and PDF files. The software tools facilitate data collection and functions as a data management tool. Assessors can use the software tools on a personal computer tablet or laptop to systematically collect, store and report screening data. The software tools can be used during all phases of the IRVS procedure (pre-field, field and post-field). Data collected from the screening can be transferred to a database to compute the risk score and store records.

Each of the three IRVS tools contains:

- Digital catalogues and forms;
- Field data collection and storage;
- Automatic risk and resiliency scoring;

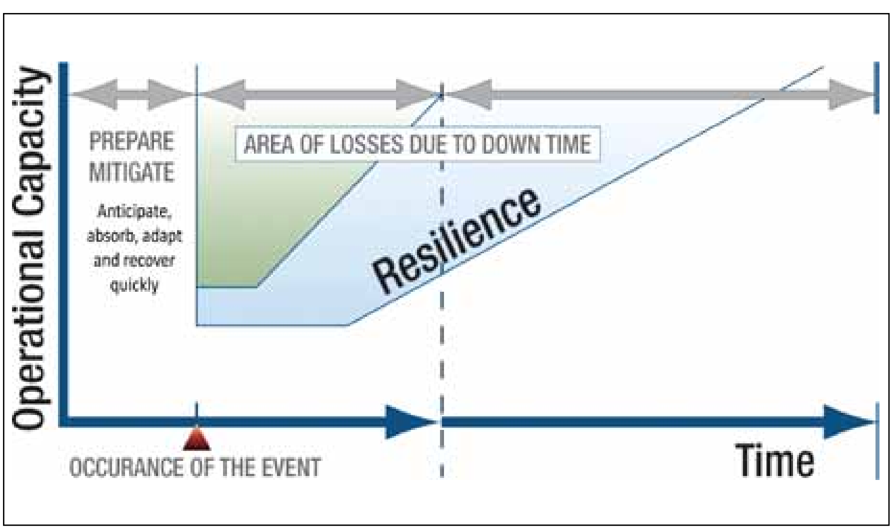

Figure 1.

Tornado winds caused severe damage to this family home.

- Printable reports;
- The ability to add photos;
- Export capabilities;
- Interaction with Hazards U.S. (HAZUS), a powerful risk assessment software program for analyzing potential losses from floods, hurricane winds and earthquakes;
- The Google Earth application;
- A fast-running air blast tool; and
- Chemical, biological and radiological (CBR) plume modeling.

The digital catalogue provides guidance to the user on each of the assessment questions in the screening and includes background information to assist with answering questions. Assessors will need to become familiar with the catalogue in order to maintain accuracy and consistency from one screening to another.

STANDARDIZED IRVS SCREENING PROCESS

The process for performing a rapid visual screening is comprised of three steps:

1. Assemble a team and mobilize:
   – Fill out pre-field data on the data collection form.
2. On-site assessment:
   – Conduct a visual assessment (consequence, threats and vulnerability module).
   – Perform an on-site field evaluation of exterior features, publicly accessible internal areas and other internal areas accessible only with permission.
3. Interpret and use the results for decsion-making:
   – Quantify a risk and resiliency score.
   – Quantify a multihazard score (IRVS tools for buildings only).
   – Provide information for further prioritizing evaluations or mitigation.

The reliability and quality of the screening depends on the time that is devoted to the collection of information and field inspections. The quality can be increased if structural, mechanical and security features are verified, interior inspections are carried out, interviews with security and other key personnel take place, and drawings and security operation manuals are reviewed.

INTENDED USERS

The IRVS tools were designed by and intended for use by:

- Engineers, architects and other design professionals;
- City, county and state officials;
- Emergency managers;
- Law enforcement agencies;
- Lenders;
- Insurers;
- Building owners and operators;
- Facility managers; and
- Security consultants.

SPECIFIC UNIQUE FEATURES OF EACH IRVS TOOL

IRVS for buildings

The IRVS buildings tool is the first and only software to quantify a building's overall risk, resiliency and multihazard risk scores. The screening process takes a few hours guided by the IRVS tool.

- Risk and resiliency scores: The building's risk and resiliency scores are based on 16 building types in the 18 critical sectors affected by man-made threats (explosive and CBR attacks), natural hazards (earthquakes, floods and high wind) and fire hazards, all with the potential to cause catastrophic losses (fatalities, injuries, damage and business interruption).
- Multihazard risk score: IRVS methodology determines the compound level of risk to a building from both natural and man-made hazards. A list of these hazards is provided in **TABLE 2**.

The 16 building types addressed by the IRVS tool are:

1. Wood frame;
2. Steel moment frame;
3. Steel braced frame;
4. Steel light frame;
5. Steel, pre-engineered metal;
6. Steel frame with cast-in-place concrete shear walls;
7. Steel frame with unreinforced masonry infill walls;
8. Concrete moment frame;
9. Concrete shear walls;
10. Concrete frames with unreinforced masonry infill walls;
11. Precast concrete tilt-up walls;
12. Precast concrete frames with concrete shear walls;
13. Reinforced masonry bearing walls with wood or metal deck diaphragms;
14. Reinforced masonry bearing walls with precast concrete diaphragms;
15. Unreinforced masonry bearing walls; and
16. Manufactured homes.

The analysis of man-made threats takes into account the following characteristics from the perspective of the perpetrator:

- Occupancy use;
- Number of occupants;
- Site population density;
- Visibility/symbolic value (not recognized to internationally recognized);
- Target density at 100, 300 and 1,000 feet (30, 92 and 304 meters);
- Overall site accessibility; and

Table 2	
Threat Type	**Threat Scenario**
Internal	Internal explosive attack. Internal CBR release.
External Explosive Attack	External Zone 1 explosive attack. External Zone 2 explosive attack. External Zone 3 explosive attack.
External CBR Release	External Zone I CBR release. External Zone II CBR release. External Zone III CBR release.
Earth-quake	Ground shaking. Ground failure.
Flood	Stillwater. Dynamic velocity surge.
Wind	Hurricane (wind and water). Tornado. Other high winds.
Landslide	Rainfall.
Fire	Resulting from earthquake. Resulting from blast. Arson or accidental.

- Target potential.

Based on both man-made threats and natural hazards, consequences are analyzed from the point of view of the owner to determine the effect on continuity of operations and the debilitating impact that would be caused by incapacity or destruction of the building. Characteristics for consideration include:

- The locality type;
- The number of occupants;
- The replacement value (based on use type and material, as well as R.S. Means and HAZUS databases);
- The historic registry;
- Business continuity; and
- The physical loss impact.

Vulnerability is the existence of weaknesses that can be exploited to make an asset susceptible to damage. An evaluation of potential damage and the loss of visually dominant characteristics can be conducted to indicate overall performance:

- Site;
- Architecture;
- Building envelope;
- Structural components and systems for the 16 structural types;
- Mechanical, electrical and plumbing systems;
- Fire;
- Security;
- Cyber;
- Continuity of operations; and
- Operational resilience.

Analysis of continuity of operations and operational resilience is the key to determining the resiliency of the building. TABLE 3 lists the basic operations considered to be critical to all buildings.

IRVS screening facilitates the comparison of the national building inventory independent of the region, multihazard exposure and type of building. These results can be used to prioritize buildings for further assessment or mitigation, allowing for an efficient allocation of resources. IRVS is also intended to be used to identify the level of risk and resiliency for a facility, as a basis for prioritization for further risk management activities and to support higher-level assessments and mitigation options by experts.

To further refine the methodology and to verify its accuracy, the IRVS building tool has been alpha-tested with multiple public and private users in Arlington, Virginia; Albany, New York; New York City; and jointly with the Department of Veteran Affairs.

IRVS for mass transit stations

To effectively use limited resources, the goal for the IRVS mass transit station tool is to identify stations as having either relatively high or low levels of potential risk based on the potential of a damaging terrorist attack or related hazard. The types of hazards assessed with this tool are described TABLE 4.

As with buildings, analysis of man-made threats takes into account the following main characteristics from the point of view of the perpetrator: the significance of the mass transit station, its location and the protective deterrence measures already in place at the station.

The consequence analysis for a mass transit station rating is based on the degree of impact that would be caused by its incapacity or destruction. Transit station characteristics are evaluated from the owner/operator perspective and include:

- Use;
- Occupancy;
- Economic impact of physical loss;
- Number of vehicles/trains per day;
- Target density; and
- Replacement values (costs).

The vulnerability rating is based on the likely damage and loss. The following is a sample of characteristics of systems that are evaluated at a transit station that could improve or hinder its performance under terrorist attack:

- Site:
  - Elevation;
  - Approaches; and
  - Concourses.
- Architecture:
  - Service entrances;
  - Retail space; and
  - Plaza size/public areas.

Table 3					
Continuity of Operations					
	Interruption of Operations (Length)				
Critical Support	**0 days**	**2 to 5**	**5 to 7**	**7 to 14**	**More than 14**
Water supply/Storages					
Power supplies					
Heating/Cooling					
Generator/ Backup power (ups)					
Waste water systems					

Table 4	
Threat Type	**Threat Scenario**
Blast	Internal External (Direct) External (Collateral)
CBR	Internal (Platforms/ Plaza/etc.) Internal (Tunnel) External
Fire	Internal External Tunnel/Track/Smoke
Other	Flood Collision(Grade/Tunnel/ Elevated) Cyber

- Ventilation systems:
  - Degree of protection; and
  - Ventilation hardware exposure.
- Fire systems:
  - Quality of systems.
- Operations:
  - Power supply;
  - Surveillance and control; and
  - Public notifications and general awareness.
- Structural:
  - Construction material; and
  - Overall structural conditions.
- Non-structural:
  - Security booths; and
  - Barriers and curbs.
- Physical security:
  - Blast threat detection and security; and
  - CBR threat detection and security.
- Cyber:
  - Security of communications, signals, and power systems.
- Operational security:
  - Emergency plans; and
  - Security plans.

The IRVS tool for mass transit stations is nearing release. It has been reviewed and validated by the Transportation Security Administration (TSA) together with transit personnel at the Port Authority of New York and New Jersey (PANYNJ) and in the cities of Boston, Massachusetts; Houston, Texas; Cleveland, Ohio; and St. Louis, Missouri. The tool is expected to be widely used by the TSA.

Transit authorities can prioritize mass transit stations for improvements based on the scores generated using the tool.

IRVS for tunnels

The tunnels methodology is similar to that of the mass transit station tool and can be used as a complementary model or as a stand-alone tool. The tunnel model is tailored as follows: different characteristics for consequences, threats and vulnerability modeling, and different threat scenarios.

To effectively use limited resources, the goal for the IRVS tool is to identify tunnels as having either relatively high or low levels of potential risk based on the potential of a damaging terrorist attack or related hazard. The types of hazards assessed with this tool are listed in TABLE 5.

The IRVS tool for tunnels also is nearing release and has been also reviewed and validated by the TSA together with transit personnel at the PANYNJ, and in the cities of Boston, Houston, Cleveland and St. Louis. This tool also is expected to be widely used by the TSA.

Transit authorities can prioritize tunnels for improvements based on the scores generated using the tool.

IRVS for bridges

Looking forward to the future of rapid visual screening, a new tool to access bridges is planned to begin in 2011, following this same approach. ■

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Mohammed Ettouney, a Principal of Weidlinger Associates, Inc., focuses his professional work on infrastructure aging, security and health, and has introduced many concepts, guidelines and theories on hazards, experimentation and progressive

Table 5	
Threat Type	**Threat Scenario**
Blast	Internal External (Direct) External (Collateral)
CBR	Internal External (Direct)
Fire	External Tunnel/Track/Smoke
Other	Flood Collision (Grade/Elevated) Cyber

Snow that melted too fast caused this home to flood in 2008.

collapse. He was awarded the Homer Gage Balcom life achievement award by the MET section of ASCE (2008). He also won the Project of the Year Award, Platinum Award (2008), and the Project of the Year "New Haven Coliseum Demolition Project" (ACEC, NY).

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Firefighters couldn't stop the flames that swept through this family home.

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