Guide to Risk Management of Multimodal Transportation Infrastructure

NCHRP Project SP20-59(17)

Update to the TRB Committee on Critical Infrastructure Protection

Beckman Conference Center
National Academies of Sciences & Engineering
100 Academy
Irvine, CA 92617

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Michael Smith (SAIC/University of Virginia) and Kevin Duffy (SAIC)

(Not for Distribution)

NCHRP SP2-59(17) Project Objective

To develop a *Guide to Risk Management of Multimodal Transportation Infrastructure* that will provide state DOTs and other transportation entities with a risk management methodology that can be used to conduct threat, vulnerability, and criticality assessments of their facilities and to determine cost-effective countermeasures to prevent, detect, and reduce threats to assets on a multimodal basis.

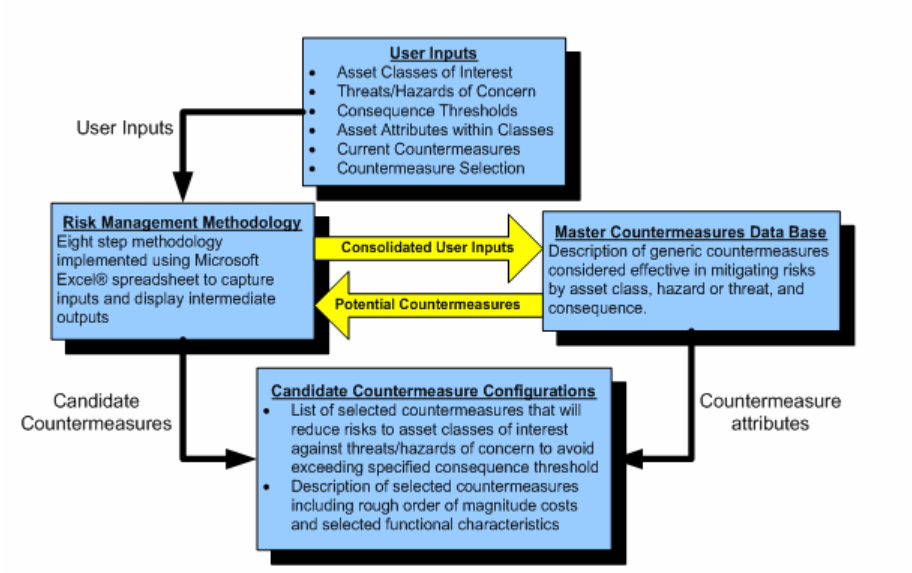
Product

A recommended replacement to the *2002 AASHTO Guide to Highway Vulnerability Assessment for Critical Identification and Protection* that expands, enhances, and updates the 2002 AASHTO guide to include all DOT transportation modes and to include a methodology for determining cost-effective countermeasures.

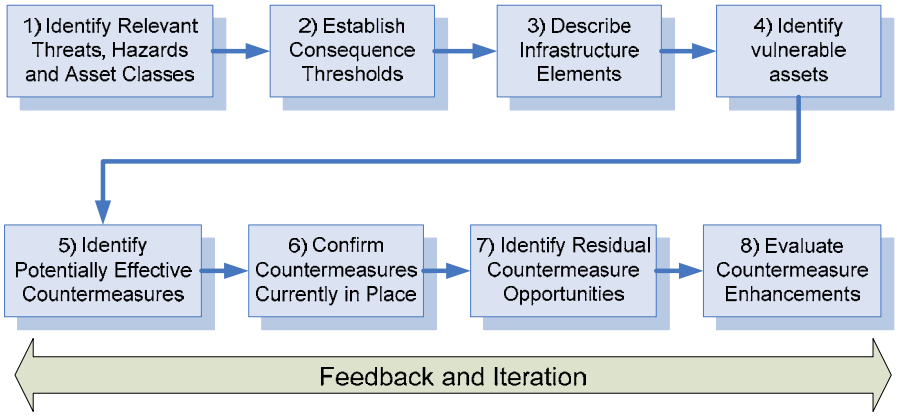
Key Features

- Top-down, program level resource allocation orientation
- Consequence-based approach
- Emphasis on objectivity - avoid "weight & rate"
- Transparent – traceable decision trail
- Implemented using Excel® spreadsheet and countermeasures database
- Designed to be used without external support
- Iterative process to refine assessment
- Expandable to accommodate new threats/hazards, asset types, and countermeasures

Data Model Interactions



Multimodal Risk Management Approach



Feedback considers consequence thresholds versus countermeasures and costs.

Risk Management Assessment Tool

Actions Since January 2007 Panel Meeting

- Added "Extreme Weather" to nominal threats/hazards list
- Added "Ferries" and "Fleets" to nominal asset list
- Improved user interface for navigating process
- Display cost and unit description in "Asset Analysts" display
- Display cost and countermeasure selection by asset class
- Provide high level executive summary of countermeasure decisions
- Updated the consequence threshold calculation for bridge/tunnel "mission" to use national bridge data
- Scheduled visits to Maryland and Boston to validate methodology and tool
- Preparing research report, and users' guide with "quick start" guide

Step 1: Identify Relevant Risks and Asset Classes

	Road Bridges/Tunnels	Transit/Rail Station	Transit/Rail Bridges/Tunnel	Building	Ferry	Fleet
THREATS						
SCE	Y	Y	Y	Y	N	N
LCE	Y	Y	Y	Y	N	N
CBR	N	N	N	N	N	N
Criminal Acts	N	Y	N	Y	N	N
UNINTENTIONAL HAZARDS						
Fire	N	N	N	N	N	N
Struct. Failure	N	N	N	N	N	N
HAZMAT	N	N	N	N	N	N
NATURAL HAZARDS						
Flood	N	N	N	N	N	N
Earthquake	Y	Y	Y	N	N	N
Extreme Weather	Y	Y	Y	N	N	N
Mud/Landslide	Y	N	N	N	N	N

Output of Step 1 - Relevant hazards/threats and asset classes

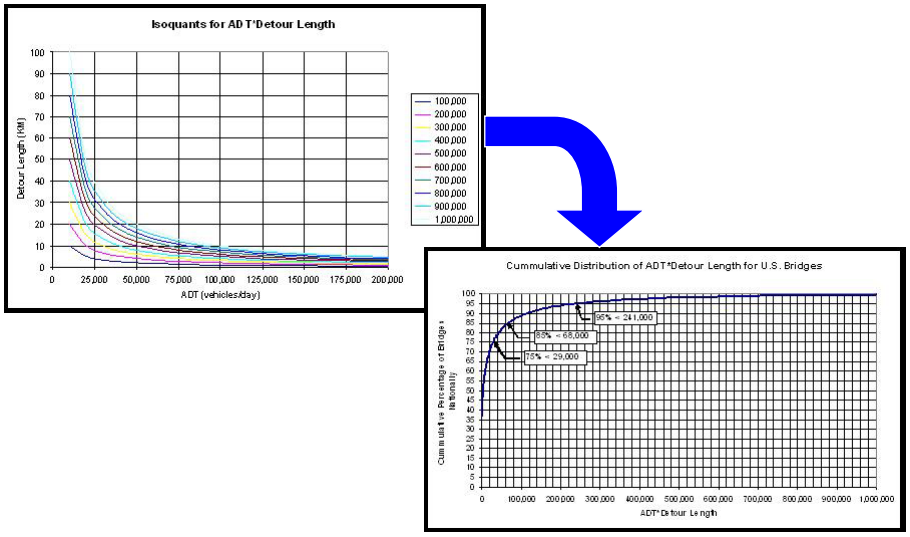
		SCE	LCE	CRIMINAL ACTS	EARTHQUAKE	EXTREME WEATHER	MUDLANDSLIDE
Road Bridges/ Tunnels	Exposure	X	X		X	X	
	Property		X		X	X	X
	Mission		X		X	X	X
Transit/Rail Station	Exposure	X	X			X	
	Property		X			X	
	Mission		X			X	
Transit/Rail Bridges/ Tunnels	Exposure	X	X			X	
	Property		X			X	
	Mission		X			X	
Building	Exposure	X	X			X	
	Property		X			X	
	Mission		X			X	
	Manual Override	X	X	X	X	X	X
Ferry	Manual Override	X	X	X	X	X	X
Fleet	Manual Override	X	X	X	X	X	X

Step 2: Establish Consequence Threshold

	Category	Critical Threshold	Explanation
ROAD BRIDGE/TUNNEL	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$660,041,666	Replacement Cost
	Mission Importance	Level I	Percentile for ADT * Detour Length
	Level I	29000	The default threshold values for ADT * detour length are taken from the 75th, 85th, and 95th percentiles for the U.S. If these are inappropriate for your state, enter different values in the appropriate fields to the left.
	Level II	68000	
	Level III	241000	
TRANSIT/RAIL STATION	Potentially Exposed Population	100	PEP Threshold
	Property Damage	No	Do you consider below-ground stations to be property-critical?
	Mission Importance	No	Do you consider transfer stations to be mission-critical?
TRANSIT/RAIL BRIDGE/TUNNEL	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$5,000,000	Replacement Cost
	Mission Importance	No	Does at least 25% of the working population utilize rail/transit transportation?
BUILDING	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$5,000,000	Replacement Cost
FERRY BOATS	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$5,000,000	Replacement Cost
TRANSIT FLEETS	Potentially Exposed Population	100	PEP Threshold
	Property Damage	$5,000,000	Replacement Cost

Restore Defaults

Distribution for Bridge/Tunnel "Mission" Threshold



Step 3: Illustrative User Input to Describe Bridges and Tunnels

ROAD BRIDGES/TUNNELS						
Asset ID	ADT	Length (ft)	Lanes	Detour	Type	User-Input Price (Cable-Stay Only)
road1	2010	2600	4	12	Concrete	
road2	12000	5280	2	12	Steel	
road3	31000	8000	4	32	Cable Stay	$2,200,000
road4	23000	4000	4	5	Steel	
road5	3200	3500	4	14	Cable Stay	$21,000,000

- Similar table of assets for other modes and asset types

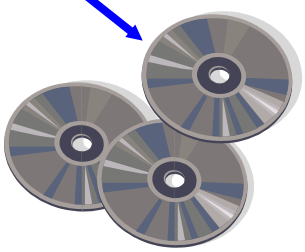
Minimum User Data Requirements

Road Bridges/Tunnels	ADT	Length (ft)	Lanes	Detour (mi)	Type	User-Input Price (Only for Other (i.e. Cable-Stay))
.Transit/Rail Station	Max Car Occupancy	Below Ground?	Transfer Station?			
Transit/Rail Bridges/Tunnel	Max Car Occupancy	Type	Sq. Footage			
Building	Sq. Footage	Replacement Cost (if known)	Occupancy (if known)			
Ferry	Max Occupancy	Max Vehicles				
Fleet	Max Vehicles	Max Occupancy/ Vehicle	Avg Cost/Vehicle			

Comment on Asset Data

"5 guys" using expert judgment

Comprehensive asset data base



Expert judgment used to define logical groupings of assets for further analysis

Model processes asset data to identify assets with potential for exceeding thresholds

Step 4: Identify Critical Assets

ROAD BRIDGES/TUNNELS								CRITICALITY			
Asset ID	ADT	Length (ft)	Lanes	Detour (mi)	Type	User-Input Price (Only for Other (i.e. Cable-Stay))	Manually mark as critical?	E	P	M	MO
Bridge Class A (25 ea)	65000	3200	4	15	Concrete		No	Y		Y	
Bridge Class B (100 ea)	25000	120	4	5	Concrete		No			Y	
Bridge Class C (5 ea)	125000	2750	10	2	Steel		No	Y		Y	
Interstate Bridge X	203680	14429	8	58	Steel		No	Y		Y	
Interstate Bridge Y	173000	9049	6	58	Steel		No	Y		Y	
Interstate Bridge Z	174878	1289	8	14	Concrete		No	Y		Y	
Broad St	104000	131	6	0	Concrete		Yes				Y
Tucker Ave	117000	4160	2	1	Steel		No	Y		Y	
Mayfair	104000	3520	2	13	Steel		No	Y		Y	
Cianci	180000	2245	2	1	Other	$1,000,000,000	No	Y	Y	Y	
Interstate Tunnel	5280	20000	4	20	Other	$8,000,000,000	No	Y	Y	Y	

- Similar table of assets for other modes and asset types

Summary of Critical Assets

look closely at assets that have been manually cal (these cells are highlighted yellow), as you may st the threats or hazards associated with these en done, click continue.

Go Back to Asset Entry | Continue to CM Costs

		RD B/T												STATION									BUILDING		
		Bridge Class A (25 ea)	Bridge Class B (100 ea)	Bridge Class C (5 ea)	Interstate Bridge X	Interstate Bridge Y	Interstate Bridge Z	Broad St	Tucker Ave	Mayfair	Cianci	Interstate Tunnel		Peck	Remington	Aborn	Shaw	Bluff	Park Exchange	Norwood Exchange		DOT Headquarters	
CRITICALITY	Exposure	Y		Y	Y	Y	Y		Y	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y		Y	
	Property										Y	Y											
	Mission	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y											
	Manual Override							Y															
RELEVANT THREATS/ HAZARDS	SCE	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	
	LCE	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	
	CBR																						
	Criminal Acts																						
	Fire																						
	Struct. Failure																						
	HAZMAT																						
	Flood																						
	Earthquake	X	X	X	X	X	X	X	X	X	X	X											
	Extreme Weather	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X			
	Mud/Landslide	X	X	X	X	X	X	X	X	X	X	X											

Step 5: Identify Potentially Effective Countermeasures – Countermeasure Filters

		Road Bridges/Tunnels	Transit/Rail Station	Transit/Rail Bridges/Tunnel	Building	Ferry	Fleet	Other
PREDICT	Is prediction a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y
DETER	Is deterrence a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y
DETECT	Is detection a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y
INTERDICT	Is interdiction a desirable countermeasure function?	Y	Y	Y	Y	Y	Y	Y
RESPONSE PREP.	Is response preparedness a desirable countermeasure function?	N	N	Y	Y	Y	Y	Y
DESIGN/ENGINEERING	Are countermeasures related to design/engineering desirable?	Y	Y	Y	Y	Y	Y	Y
Area -Wide and Asset-Specific	Do you wish to consider only area-wide countermeasures, only asset-specific countermeasures, or both?	Both	Area-Wide	Asset-Specific	Asset-Specific	Asset-Specific	Both	Both
Temporary/Redeployable	Do you wish to consider temp/redeployable countermeasures?	Y	Y	Y	Y	Y	Y	Y
Multipurpose Potential	Are you willing to consider CMs that are NOT multipurpose?	Y	Y	N	Y	Y	Y	Y
Basic and Enhanced	Do you wish to consider only basic countermeasures, only enhanced countermeasures, or both?	Both	Both	Basic	Both	Both	Both	Both
Threat Responsive	Do you wish to consider threat responsive countermeasures? (Answer "N" if only want permanent countermeasures.)	Y	Y	Y	Y	Y	Y	Y
Max Unit Cost (x1000)	What is the maximum per unit countermeasure cost you are willing to pay?	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0	$999,999.0

Countermeasure Cost and Description (sample)

			ESTIMATED PER-UNIT COST (x1000)	Comments	Unit of measure
Physical Security Countermeasures	1	Lighting	$9.7	one per 100 feet of road or perimeter. Assumes nearby power connection, no demolition or excavating.	1
	2	Barriers & Berms	$6.9	10 jersey barriers and two end planters to cover 100 feet of space	1
	3	Fences	$18.5	12 foot height security fence, in concrete with 4 gates(6 feet high, 3 feet wide). Infrared detection system. Power install, relay to central monitor. Excludes central monitoring station operation..	100 linear feet
	4	CCTV	$65.8	4 remote PTZ cameras, one control panel	
	5	Intrusion Detection Devices	$6.3	1 burglar alarm with remote signal installed	1
	6	Physical Inspection of asset	$208.0	1 Full Time Employee dedicated to this task	1 FT employee
Access Control Countermeasures	7	ID Cards	$22.2	6 zone system with database, installed	6 zones
	8	Biometrics	$42.6	6 facial and fingerprint scanners, database, installed	6 zones
	9	Background Checks	$208.0	1 Full Time Employee dedicated to this task	1 FT Employee
	10	Metal Detectors	$38.8	6 portals, 4 handhelds, installed. Assumes no demolition and nearby power source	
	11	Restricted Parking	$208.0	1 Full Time Employee dedicated to this task	1 FT Employee
	12	Random Inspections	$208.0	1 Full Time Employee dedicated to this task	1 FT Employee
	13	Visible Badges	$208.0	1 Full Time Employee dedicated to this task	1 FT Employee
	14	Limited Access Points	$208.0	1 Full Time Employee dedicated to this task	1 FT Employee
	15	Visitor Control & Escort	$104.0	1 Full Time Employee dedicated to this task	1 PT employee
	16	Locks	$1.7	1 cipher lockset, installed. Assumes no demolition or heavy construction	
	17	Explosive Detection	$103.4	2 portals, 2 handhelds, with power	2+2
	18	Establish Clear Zones	$8.0	100 sq yards. Assumes no demolition	
	19	Visible Signs	$1.3	1 aluminum sign 18 inches high, with base	

Step 6/7: Evaluate Countermeasure Enhancements

- General countermeasures that apply to *all* asset types and risks (e.g., response preparedness)
- Countermeasure asset/threat/hazard combinations that provide basic protection
- Countermeasures that offer synergy across asset types and modes and have ancillary operational benefits
- Countermeasure cost assessment

"Guide" provides rough order of magnitude cost and relative effectiveness (High, Low, N/A) against threats of concern to infrastructure of interest based on countermeasure selection business rules.

Step 8: Evaluate Countermeasure Enhancements – Allocate Resources to Cost-Effective Countermeasures

- Constrained by available resources
- Balanced against competing demands
- Considering multipurpose applications
- Integrated with existing capability
- Coordinated with other resources (e.g., local, state, national)

Step 8: Evaluate Countermeasure Enhancements – Configuration Report

Highway Bridges and Tunnels Summary:

	PREDICT	DETER	DETECT	INTERDICT	RESPONSE PREP.	DESIGN/ENGINEERING	Area-Wide	Asset Specific	Temporary/Redeployable	Multipurpose Potential	Basic	Enhanced	Threat Responsive	Bridge Class A (25 ea)	Bridge Class B (100 ea)	Bridge Class C (1 ea)	Interstate Bridge X	Interstate Bridge Y	Interstate Bridge Z	Broad St	Tucker Ave	Mayfair	Claend	Interstate Tunnel	TOTAL COST (x1000)
Lighting		X	X					X		X	X							10							$97.2
Barriers & Berms		X	X					X		X	X			25											$171.3
Restricted Parking		X						X			X							1							$208.0
											TOTAL COST (x1000)			$171.25	$0.00	$0.00	$0.00	$305.22	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$476.5

Transit Stations Summary:

	PREDICT	DETER	DETECT	INTERDICT	RESPONSE PREP.	DESIGN/ENGINEERING	Area-Wide	Asset Specific	Temporary/Redeployable	Multipurpose Potential	Basic	Enhanced	Threat Responsive	Peck	Remington	Acorn	Shaw	Bluff	Park Exchange	Norwood Exchange	TOTAL COST (x1000)
Random Inspections			X				X		X				X	1	1	1	1	1	1	1	$1,456.0
Patrols			X				X		X	X	X		X	1							$208.0
WX/Seismic Information	X				X		X			X	X			1							$208.0
											TOTAL COST (x1000)			$624.00	$208.00	$208.00	$208.00	$208.00	$208.00	$208.00	$1,872.0

- Similar table of assets for other modes and asset types

Typical Summary Report

	Click Heading for Detailed Expenditure Report	Road Bridges/Tunnels	Transit/Rail Stations	Transit/Rail Bridges/Tunnels	Buildings	Ferries	Fleets	Other
Relevant Risks	BCE	X	X	X	X			
	LCE	X	X	X	X			
	CBR							
	Criminal Acts		X		X			
	Fire							
	Struct. Failure							
	HAZMAT							
	Flood							
	Earthquake	X	X	X				
	Extreme Weather	X	X	X				
	Mud/Landslide	X						
Thresholds	Exposure	Persons 100	Persons 100	Persons 100	Persons 100	Persons 100	Persons 100	--
	Property	Damage $660,041,666	Below Ground Stations Critical? No	Damage $5,000,000	Damage $5,000,000	Damage $5,000,000	Damage $5,000,000	--
	Mission	ADT * Detour Length 241000	Transfer Stations Critical? No	25% of Working Pop Use Rail Transport? No	Never Critical --	Never Critical --	Never Critical --	--
#	# Critical Assets	11	7	0	1	0	0	0
Expenditures	Physical Security CMs (x1000)	$268.5	$0.0	$0.0	$208.0	$0.0	$0.0	$0.0
	Access Control CMs (x1000)	$208.0	$1,456.0	$0.0	$8.0	$0.0	$0.0	$0.0
	Asset Design/Engr CMs (x1000)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Operational CMs (x1000)	$0.0	$416.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Other CMs (x1000)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
	Total CM Expenditures (x1000)	**$476.5**	**$1,872.0**	**$0.0**	**$216.0**	**$0.0**	**$0.0**	**$0.0**

Totals	
Physical Security CMs	$476,470
Access Control CMs	$1,672,025
Design/Engr CMs	$0
Operational CMs	$416,000
Other CMs	$0
Overall Total	**$2,564,498**

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