Risk and Resilience I-70 Pilot

Quantifying Annual Risk and System Resilience

CDOT COLORADO Department of Transportation

RISK AND RESILIENCE FOR HIGHWAYS

aem

Conceptual Risk and Resilience Program

- Motivation for pilot
  - Multiple emergency events
  - Mandates from FHWA for performance management and risk assessment
  - Application of process utilized in 2013 and 2016 Emergency Relief Projects to routine business practice
  - Twice damaged asset assessment requirements FAST-Act
  - Good steward of public resources
  - Increasing state population
  - Aging infrastructure
  - Quantitative assessments well received by public and elected/appointed officials

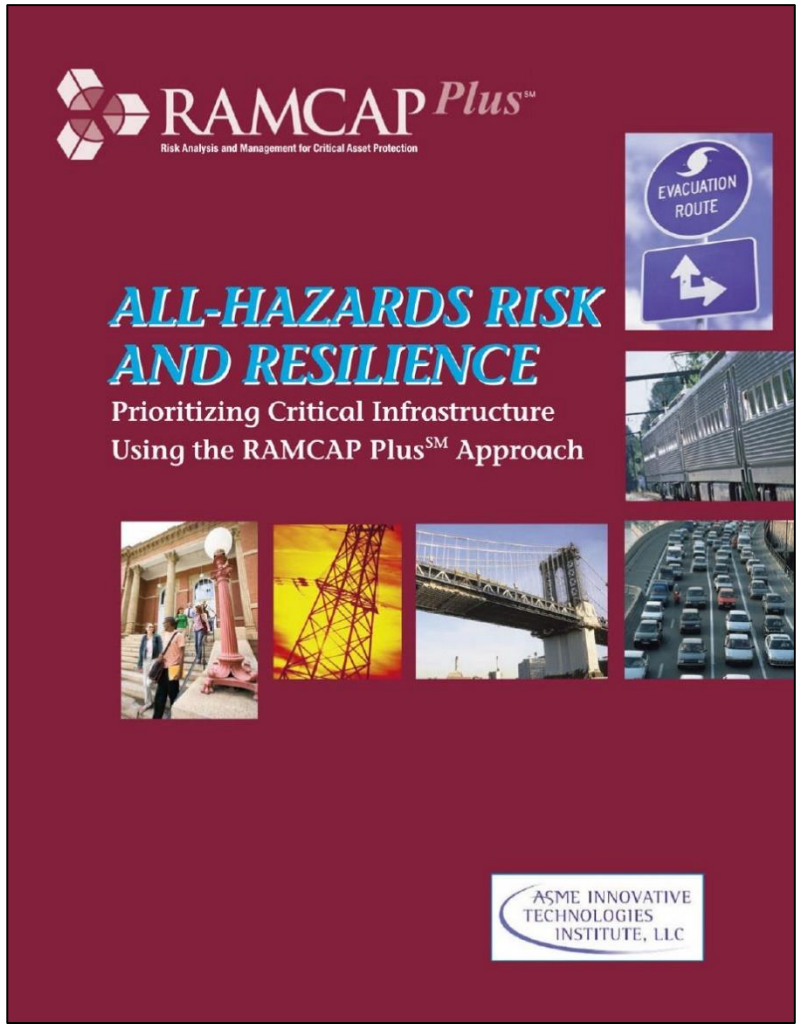
I-70 Risk and Resilience Proactive Assessment of Threats Pilot Project Objectives

1. Identify, understand, and prioritize physical threats
2. Further develop existing CDOT risk reduction program
3. Assess applicability of R&R Pilot methodology to entire CDOT system
4. Input for risk-based, fiscally-constrained Asset Management Plan (TAMP), maintenance strategies, and project selection
5. Keep Commission informed of R&R Pilot progress and potential implications for regions
6. CDOT input to Governor's Colorado Resiliency Framework

I-70 Risk and Resilience Pilot

- What was accomplished
  - Repeatable process for risk assessment of physical threats to primary assets developed for CDOT data (availability and maturity)
  - Criticality model for system resilience developed that reflects economic, environmental, social impacts to Colorado
  - 470 centerline miles of system has been assessed for range of physical threats
  - Owner and user annual risk calculated for each threat-asset pair for mainline I-70
  - Five specific site locations analyzed for potential mitigation measures of identified threats
  - CDOT Working Group developed recommendations for next steps

RAMCAP Plus℠



R&R for Highways

1) Asset Characterization	What assets exists and which are critical?
2) Threat Characterization	What threats and hazards should be considered?
3) Consequence Analysis	What happens to assets if a threat or hazard occurs? Expected asset losses, economic impacts, injuries, lives lost?
4) Vulnerability Analysis	What are asset vulnerabilities that would allow a threat or hazard to result in expected consequences?
5) Threat Assessment	What is the likelihood that a terrorist, natural hazard or dependency/locational hazard will occur to asset?
6) Risk/Resilience Assessment	What is anticipated total risk and asset resilience? **Risk** = Consequences x Vulnerability x Threat **Resilience** = Service Outage x Vulnerability x Threat
7) Risk/Resilience Management	What options are there to reduce risk and increase resilience? How much will each mitigation measure reduce risk and increase resilience? How much does each mitigation measure cost? What is the calculated benefit/cost ratio?

Next Steps on Risk and Resilience Assessment

- CDOT working to standardize quantitative assessment methods for physical hazards to highway assets
  - Project underway and intended to be completed in next two years
- Working to identify areas within project life-cycle that quantitative risk and system resilience information can be of use
  - Project underway and intended to be completed in next 18 months
- Moving toward base-risk map of entire CDOT highway system
  - Anticipated project to initiate after completion of previous projects

Advancing Risk & Resilience at CDOT

Department-wide efforts:

- Developing common understanding of resilience.
- Identifying opportunities to integrate resilience into project-selection criteria.
- Generating case studies to highlight actions to increase resiliency.
- Standardizing approaches to conducting risk assessments.

CDOT Asset Management risk efforts:

- Identifying and evaluating assets damaged in emergency events.
- Refining risk register.
- Incorporating risk metrics into Multi-Objective Decision Analysis (MODA) to improve project selection.

Damaged Assets: Evaluating Treatments

- FHWA requires DOTs to identify bridges and pavements damaged repeatedly in emergency events since Jan. 1, 1997. (23 CFR Part 667).
- CDOT developing database of damaged assets.
- DOTs must identify and evaluate “reasonable alternatives” for repeatedly damaged roads, highways and bridges before including those assets in a project in the Statewide Transportation Improvement Plan (STIP).

Evaluating Alternative Treatments
(at planning stage)

1. Asset modeling software (AIMS) creates recommended treatment/project lists based on condition benefit.

2. Compare recommended project lists with damaged-asset database.

3. If projects include previously damaged assets, review mitigation options in CDOT's risk register.

4. Evaluate mitigation options via Risk and Resilience methodologies. (Look at factors beyond condition.)

5. Regions select actual projects.

Note: Process remains in development

Putting Risk Registers to Work

- Risk register identifies and scores risks at agency, program and project level. Example: Bridges whose foundations are at risk of failure due to erosion (scour-critical bridges).
- Register identifies mitigation strategies (treat, tolerate, transfer, terminate)
- May use Risk-and-Resilience project's benefit-to-cost ratios to evaluate treatment options. (Example: For a scour-critical bridge, evaluate placing riprap around piers and abutments vs. changing the path of a waterway vs. adding pier elements vs. reducing water velocity.)

Risk Level	Asset Class	Event/ Occurrence	Likelihood[1]	Consequence Score[1]				Other Considerations					Risk Score	Risk-Management Strategy (Treat, Tolerate, Transfer, Terminate)	Benefit in % Risk Score Reduction	Annual Cost of Strategy—$mm	Owner (Identified for Agency Level Risks and Top 50 Risk Scores)
				Safety	Mobility	Asset Damage	Other Financial Impact	Funding	Insurance	Regulatory	Political	Reputation					
Program	Pave-ment	Lack of industry capacity results in delayed pro-jects.	3	1	2	3	5				•	•	9.1	Advanced com-munication with contrac-tors and delay of projects.	30%	4.8	External owners.
Project	All	Flooding (or any inclement weather event) resulting in long-term impacts, including dam-age to assets, requiring replacement.	4	5	5	5	5	•	•		•	•		Treat—Deter-mine risk and resilience strat-egy and organi-zational structure and communication plans to sup-port future events.	5%	0.5	Director of Office of Emergency Management for response; multiple CDOT owners working on strategy.
Project	All	Subsurface utili-ties impact CDOT Right of Way and infra-structure.	4	3	3	4	2	•	•		•	•	14.4	Tolerate—Use Transportation Commission contingency, or get funds from local agency (partially)—fix it when it happens.	0%	0	Region Director.
Project	Bridge	Bridge Strike (Highest fre-quency)—clear-ance less than 16 feet.	5	4	3	4	3		•		•	•	20.1	Replace or raise low bridges, lower grade.	65%	7	Bridge Engineer coordinating inspection, design and working with maintenance.
Project	Bridge	Essential repairs—Major cost/risk.	5	3	3	3	2		•		•	•	15.8	Contingency fund—repair (Bridge funds).	50%	10	Bridge Engineer coordinating inspection, design and working with maintenance.
Project	Bridge	Load-restricted bridges—Uncer-tainty of ability to support loads of trucks ignoring rules.	5	2	2	2	3		•		•	•	12.9	Need better data.	25%	0.1	Bridge Engineer will deal with accelerated deterioration by inspection.
Project	Bridge	Scour Critical Bridges are vul-nerable to a storm event—less than or equal to 500 year.	3	4	3	4	3		•			•	11.6	Treat with mitigation strategies.	10%	5	Statewide and Region Hydraulic Engineer working with Staff Bridge.

**Higher numbers = higher risk*

Integrating Risk into MODA

- CDOT is implementing Multi-Objective Decision Analysis (MODA).
- Helps prioritize asset-management projects based on criteria beyond asset condition.
- Prioritization based on potential to make progress in Department's goal areas:
    - Safety
    - Infrastructure condition
    - Mobility
    - Economic vitality
    - Other considerations (e.g., risk and resilience)

MODA Goals and Measures

- Comparing projects by ability to make progress in multiple goal areas.

	Scale		Usage		
	Scale Name	Scale Score	Usage Factor Name	Usage Factor Score	Total Score
Economic Vitality	Economic Impact-Low	1	Urban, Truck Average Annual Daily Traffic-Low (<1,000)	1	Scale Score * Usage Factor Score
	Economic Impact-Medium	5.5	Urban, Truck Average Annual Daily Traffic-Medium (1,000-2,500)	2	
	Economic Impact-High	10	Urban, Truck Average Annual Daily Traffic-High (>2,500)	3	
			Rural, Truck Average Annual Daily Traffic-Low (<200)	1	
			Rural, Truck Average Annual Daily Traffic-Medium (200-600)	2	
			Rural, Truck Average Annual Daily Traffic-High (>600)	3	
Other Considerations (e.g., Risk)			Alternate Routes (Redundancy)-High (>3.0)	1	Usage Factor Score
			Alternate Routes (Redundancy)-Med (1.8-3.0)	2	
			Alternate Routes (Redundancy)-Low (<1.8)	3	

Future scoring:

- Risk and Resilience Benefit-to-Cost Ratio for each project?
- Resilience measure for each asset?
- Criticality?
- Social Vulnerability Index (SoVI) score?

Contact Information

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