

Prioritizing Ancillary Transportation Assets for Management: A Risk-Based Study

Richard Sarpong Boadi
Adjo Amekudzi, Ph.D.
Georgia Institute of Technology

9th National Conference on Transportation Asset Management
April 16-18, 2012
San Diego, California

Acknowledgements

- Project Title:
  - Comprehensive Transportation Asset Management: Risk-Based Inventory Expansion and Data Needs
- Project Sponsor:
  - Georgia Department of Transportation
- Project Directors:
  - Adjo Amekudzi, Ph.D. (PI); Michael Meyer, Ph.D., P.E. (Co-PI)
- Graduate Research Assistants:
  - Richard Boadi; Margaret Akofio-Sowah

Outline

- Objectives of the study
- Review concepts of risk
- Risk framework with example
- Conclusions and recommendations from study

Objectives

- To review the basics of risk theory
- To develop a risk-based decision-support tool
- To illustrate the model
- To offer recommendations to improve the capabilities of the model

Basic Risk Concepts (1)

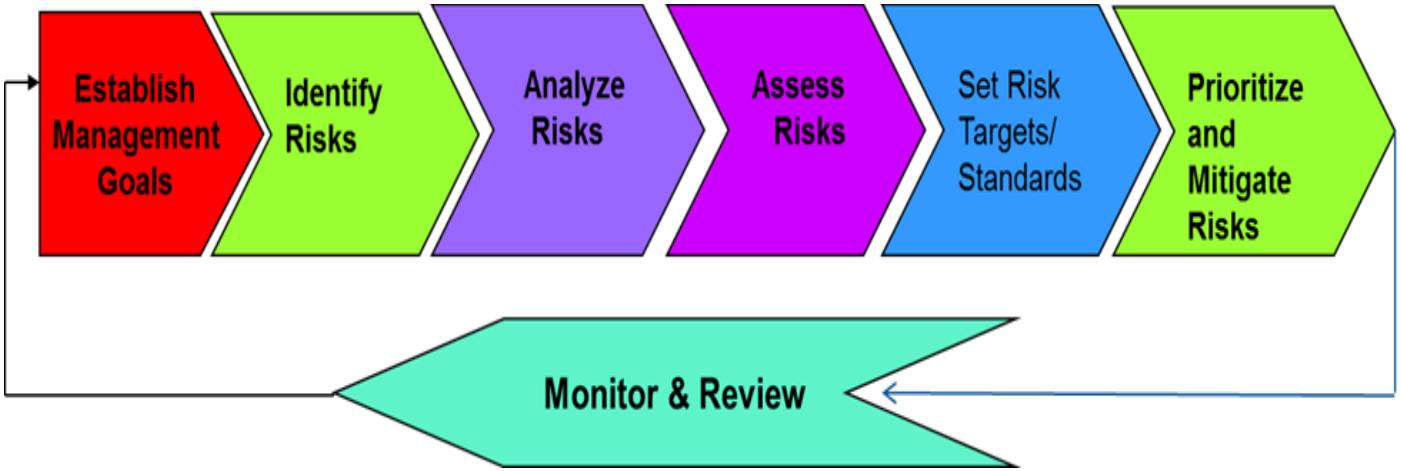
Risk-Management: Definition

"Risk management is a process of identifying sources of risk, evaluating them, and integrating mitigation actions and strategies into routine business functions of the agency."

-TAM Guide, Vol. 2

Basic Risk Concepts (2)

Conceptual Risk Framework



Basic Risk Concepts (3)

- Risk modeling
  - Quantitative risk assessment
    - Risk= Probability*Consequence
  - Qualitative risk assessment
    - Assigns relative values for measures of risk
    - Separates risk into descriptive categories
      - Low – high
      - Not important – very important
      - Scale of 1 - 10

Basic Risk Concepts (4)

- Risk Models
  - Matrix Models
  - Probabilistic Risk Models
  - Indexed-Based Risk Models
  - Real Options Models

Proposed Risk Framework

- Based on the strategic objectives of the agency
- Considers a set of identified performance measures
- Uses a risk matrix modeling approach
- Ranks assets based on risk differentials (i.e., likelihood and consequence of failure)

Evaluation Example (1)

- Agency's objectives
  - Reduce safety risks
  - Reduce mobility risks
  - Reduce the risk of condition failure

Evaluation Example (2)

Sample risk matrix

Risk Level of Performanace Measure		Safety		
		CONSEQUENCE		
		LOW	MEDIUM	HIGH
PROBABILITY	LOW	LOW	LOW	MEDIUM
	MEDIUM	LOW	MEDIUM	HIGH
	HIGH	MEDIUM	HIGH	HIGH

Evaluation Example (3)

- Definition of likelihood and consequence
  - *Likelihood of Asset Failure (l) = Average Age of Asset Class/Average Expected Useful Life*
  - *The consequence is defined based on the impact of failure (Different agencies may value impacts differently)*

Evaluation Example (4)

Likelihood Scale

Priority Scale	Description	Likelihood
1	High	If failure rate $\Gamma \geq 1$
2	Medium	If failure rate $0.5 \leq \Gamma < 1$
3	Low	If failure rate $\Gamma < 0.5$

Evaluation Example (5)

Safety Risk Consequences Scale

Priority Scale	Description	Consequences
1	High	Body injuries and death in 10 yrs.
2	Medium	Property loss or body injuries in 10 yrs.
3	Low	No injuries or death in 10 yrs.

Evaluation Example (6)

Mobility Risk Consequences Scale

Priority Scale	Description	Consequences
1	High	Road closure for a day or more (detour required) in 10 yrs.
2	Medium	Lane(s) closure/delays experienced for a day or more (no detour required) in 10 yrs.
3	Low	Lane(s) closure/delays experienced for a period (within hours, no detour required) in 10 yrs.

Evaluation Example (7)

Maintenance Risk Consequences Scale

Priority Scale	Description	Consequences
1	High	Impacting over 25000 ADT
2	Medium	Impacting between 5000 and 25000 ADT
3	Low	Impacting less than 5000 ADT

Evaluation Example (8)

Evaluation Data

Asset Class	Culverts	Guardrails	Traffic Signals
PROBABILITY			
Average age of asset base (yrs)	20	15	14
Expected useful life of asset (yrs)	45	30	20
Likelihood of asset failure	0.4	0.5	0.7
CONSEQUENCES (10 yr analysis period) - Yes/No			
Safety			
Bodily injury to involved party	YES	NO	YES
Property loss/damage	YES	YES	YES
Death/fatality	YES	NO	YES
Mobility			
Lane closure/delay resolved in hours	NO	YES	YES
Lane closure/delay resolved in days with no detours	NO	YES	NO
Lane closure/delay resolved in days with detours	YES	NO	NO
Maintenance			
Failure on roadway with ADT <5000	YES	NO	YES
Failure on roadway with ADT 5000 - 25000	YES	YES	YES
Failure on roadway with ADT >25000	NO	YES	NO

Evaluation Example (9)

Sample risk matrix

Risk Level of Performanace Measure		Safety CONSEQUENCE		
		LOW	MEDIUM	HIGH
PROBABILITY	LOW	LOW	LOW	MEDIUM
	MEDIUM	LOW	MEDIUM	HIGH
	HIGH	MEDIUM	HIGH	HIGH

Evaluation Example (10)

Computational and Alternative Ranking Matrices

ALTERNATIVES PRIORITIZATION				
ALTERNATIVE ASSET CLASSES	SAFETY	MOBILITY	EFFICIENT MANAGEMENT	TOTAL SCORE
Culverts	2	2	3	7
Guardrails	2	2	1	5
Traffic Signals	1	3	2	6

High Risk Alternative	Action Required if Total Score is <=5 (i.e., at least 1 high risk and 2 medium risks)
Medium Risk Alternative	Consider for action if Total Score is either 6 or 7
Low Risk Alternative	No immediate action required if Total Score >7

Conclusions and Recommendation

- Conclusions
  - Little evidence of the use of risk-based approach in prioritizing ancillary assets
  - Developed framework provides a means for making a prioritizing assets
  - Accuracy of model is dependent on data availability
- Recommendation:
  - Improve the tracking and the documentation of ancillary assets failures

References

- Gordon, M., G. J. Smith., P . D. Thompson., H. A. Park., F. Harrison., and B. Elston. Supplement to the AASHTO Transportation Asset Management Guide: Volume 2 - A Focus on Implementation. 2010.
- Fares, H and T. Zayed. Hierarchical Fuzzy Expert System for Risk of Failure of Water Mains. Journal of Pipeline Systems Engineering and Practice, 2010. 1(1): p. 53-62.
- Dicdican, R. Y., Y. Y. Haimes and J. H. Lambert. Risk-Based Asset Management Methodology for Highway Infrastructure Systems. 2004, Center for Risk Management of Engineering Systems University of Virginia.
- Kannapiran, A., A. Chanan, G. Singh., P. Tambosis., J. Jeyakumaran and J. Kandasamy. Strategic asset management planning of stormwater drainage systems, Water Practice & Technology, IWA Publishing 2008 | doi:10.2166/wpt.2008.065.