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Ali Rezvani, Ricardo Cruz, Andrew Thomas

A New Cost-Benefit Methodology for Highway-Railway Grade Crossing Safety Programs

Motivation

- Competition for increasingly scarce resources is intensifying
  - Insufficient infrastructure investment over the decades is impacting economic activity
  - Public sector has a large debt and pension fund burden which reduces funding for infrastructure
- Previous research and the resulting models/frameworks were challenged by limited data and computing capacity
  - Reaction of traffic to infrastructure changes such as closures of grade crossings were given minimal consideration
  - Data connected by geospatial coordinates allows for fine tuning infrastructure asset management
- Best practices for identifying needs and defending funding requests are adapting to new technology-driven capabilities
  - More precise estimates of safety incident probabilities
  - More accurate estimates of the costs and benefits of safety enhancements

State of the Practice

Hazard Index

- Produces a values for prioritizing crossings relative to each other
- The higher the value the greater the hazard the higher the priority
- Primarily based upon train and highway traffic volumes
- Other variables used in NC:
  - Sight distance
  - School buses & passenger loads
  - Warning devices
  - Crash history
  - Number of tracks
  - Maximum train speed

Other states may have additional or different criteria

USDOT Accident Prediction Model

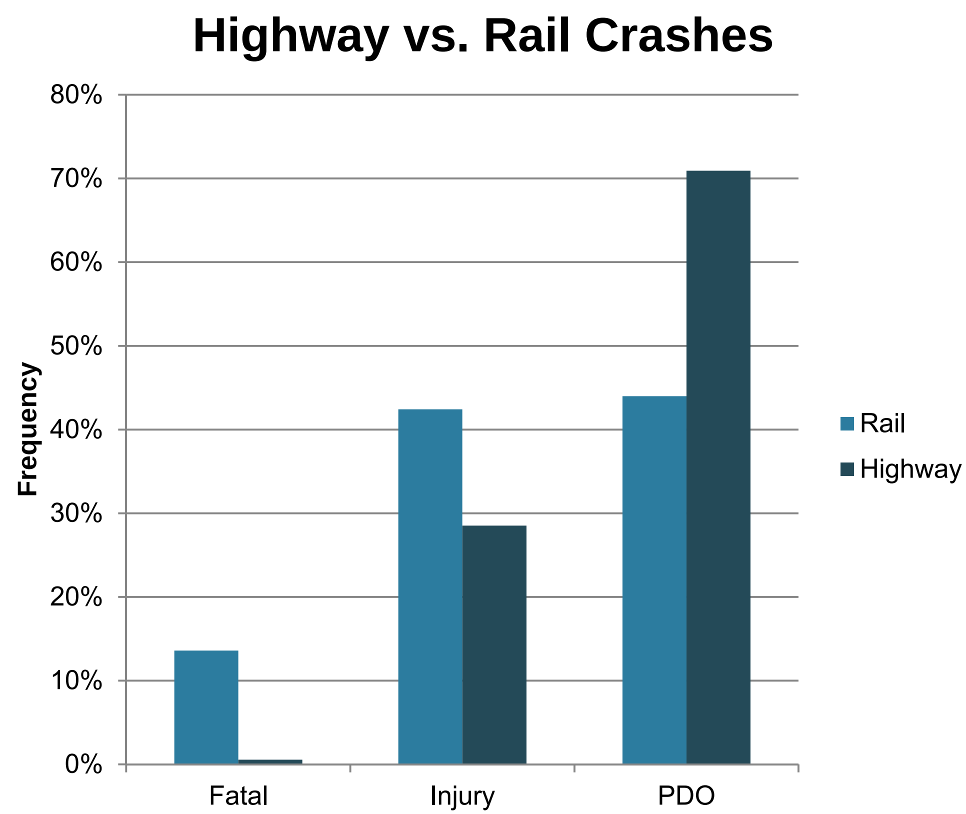
- Produces a value for an individual crossing in “predicted crashes per year”
- Can rank crossings based on predicted crashes as well as rank crossing safety projects with other highway safety projects
- Developed using nationwide crash data and statistical regression
- Variables include:
  - Train and highway traffic volumes
  - Crash history
  - Number of tracks
  - Highway type
  - Highway lanes
  - Among others

How Would the New Method Work?

What do we expect from a data driven method?

- Measure the cost of a highway-rail grade crossing crash
- Use the crash costs to screen for high risk crossings
- Perform Benefit Costs Analysis (BCA) for an individual crossing safety improvement project
- Prioritize safety improvement project under budget constraints

Profiles of Consequences



http://www-fars.nhtsa.dot.gov/Main/DidYouKnow.aspx

http://safetydata.fra.dot.gov/OfficeofSafety/publicsite/summary.aspx

Cost of a Grade Crossing Crash

Elements of Crash Cost

Primary Effect Costs

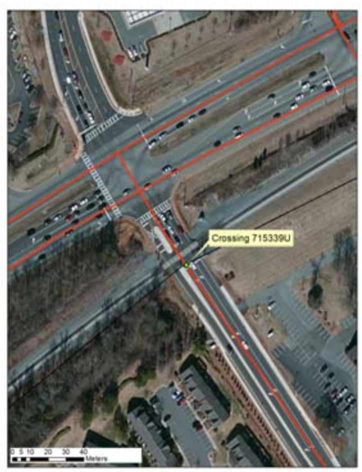
- Direct, indirect, and intangible costs associated with property damage, injury, and fatal crashes (more visible at the time of the crash)
  - Injury and Fatality cost;
  - Highway vehicle damage;
  - Rail Infrastructure Damage;
  - Rail Equipment Damage;
  - HazMat release cost;

Secondary Effect Costs

- Costs accrued to delayed travelers and cargo, and to parties beyond the immediate road and rail travelers and service operators (less visible at the time of the crash)
  - Delay and Rerouting Costs
  - Supply Chain Transport Costs
  - Supply Chain Inventory Cost

Cost of an already existing crash

- Train 55zp304 northbound struck unoccupied vehicle that was stuck on the track. Driver of vehicle exited vehicle prior to impact and was not injured. Engineer advised after striking vehicle fumes from the radiator caused burning and irritation to his eyes. Stated he was not injured and refused medical assistance.
- Simple Crash: No Fatality; No Injury; No HazMat;
- What is the Cost?



	Cost Element	Cost
Primary Effect Costs	Fatality and Injury Costs	0
	HazMat Release Cost	0
	Vehicle Property Damage	10,000
	Rail Equipment Damage	8,045
	Rail Infrastructure Damage	923
Secondary Effect Costs	Vehicle Rerouting Costs	4,768
	Value of Passenger Time	3,536
	Truck Delay/Rerouting Cost	86
	Value of Truck Driver Time	45
	Train Idling Cost	91
	Train Crew Cost	39
	Truck Supply Chain Cost	135
	Rail Supply Chain Cost	23,896
	Total:	**$51,564**

Objective a Data Driven Method

Data Driven		State of Practice
Measure the cost of a highway-rail grade crossing crash	✗	No major frame work before NCHRP-755
Use the crash costs to screen for high risk crossings		
Perform Benefit Costs Analysis (BCA) for an individual crossing safety improvement project		
Prioritize safety improvement projects under budget constraints		

Screening for Potentially Hazardous Crossings

Expected crash cost = crash probability * (primary effect costs + secondary effect costs)

How to calculate the Expected Crash Cost

- FRA formulation uses crossing characteristics to estimate the crash probability:
  - Number of main track; number of through trains, highway paved, maximum timetable speed, highway type, number of highway lanes and ...

- FRA has formulations for calculating:
  - $P(A)$: probability of crash
  - $P(FA \mid A)$: conditional probability of fatality given a crash
  - $P(IA \mid A)$: conditional probability of injury given a crash

- $Expected\ Crash\ Cost =$

$$P(A) \times \begin{pmatrix} P(FA|A) \times (C_{FTL} + PD_{FTL}) + \\ P(IA|A) \times (C_{INJ} + PD_{INJ}) + \\ (1 - P(FA|A) - P(IA|A)) \times PD_{PDO} \end{pmatrix}$$

  - C_{FTL} and C_{INJ} represent the fatality and injury cost of fatal and injury crashes;
  - PD_{FTL}, PD_{INJ} and PD_{PDO} are property damage for Fatal, Injury and Property Damage Only crashes

Non-Injury Costs of the Crash

	Severity	Non Injury Primary Cost	Non Injury Secondary Cost
Crash 1	PDO	13,574	49,408
Crash 2	PDO	5,074	30,764
Crash 3	INJ	94,891	3,042
Crash 4	INJ	54,891	4,071
Crash 5	PDO	13,574	52,186
Crash 6	PDO	5,574	67,495
…	…	…	…

Applying the methodology to NC

crossing	Adjusted Crash Probability	Probability of Fatality, should the crash happens	Probability of Injury, should the crash happens	Expected Injury and Fatality Cost, should the crash happen	Expected Total Cost of the Crash, should the crash happen	Estimated Crash Cost of the Highway-Rail Grad Crossing
1	6.11%	13.14%	28.06%	$848,142	$908,708	$55,556
2	4.52%	14.97%	25.33%	$959,919	$1,022,760	$46,227
3	4.44%	14.55%	31.23%	$939,472	$1,002,613	$44,545
4	4.91%	12.71%	26.00%	$819,679	$879,301	$43,202
5	4.61%	13.31%	25.83%	$856,579	$917,048	$42,279
6	3.99%	15.11%	28.21%	$971,401	$1,034,896	$41,335
7	4.45%	13.14%	25.88%	$846,098	$906,326	$40,323

Objective a Data Driven Method

Data Driven		State of Practice
Measure the cost of a highway-rail grade crossing crash		No major frame work before NCHRP-755
Use the crash costs to screen for high risk crossings		Use the Hazard index to screen for high risk crossings
Perform Benefit Costs Analysis (BCA) for an individual crossing safety improvement project		
Prioritize safety improvement projects under budget constraints		

Preliminary Benefit Cost Analysis Using the Expected Crash Cost

Why Benefit Cost Analysis?

- Increasing competition for increasingly scarce resources
  - Insufficient infrastructure investment over the decades is impacting the US economy
  - Public sector has a large debt and pension fund burden which reduces funding for infrastructure

- BCA is a systematic approach to estimating the strengths and weaknesses of alternatives that satisfy transactions, activities or functional requirements for a business. It is a technique that is used to determine options that provide the best approach for the adoption and practice in terms of benefits in labor, time and cost savings etc.
  - To determine if it is a sound investment/decision (justification/feasibility),
  - To provide a basis for comparing projects. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much

Safety Improvement Costs and Benefits

- **Project Cost:** Investigation, Design and Implementation Costs
  - NC-DOT's historical records
- **Crossing Safety Costs:** change the expected likelihood/cost of having a crash in a crossing
  - Highway Safety Manual / Crash Modification Factors Clearing House
- **Maintenance and The State of Good Repair Costs:** change the traffic flow patterns and total vehicle-miles driven on road and change the total maintenance costs
  - NC-DOT's Historical Records
  - FHWA
- **Emission/noise pollutions:** change the total delay time/total drive time and impact the emission cost
  - TIGER Guidelines
- **Roadway Safety Costs:** Traffic flow diversions increases the roadway expected crash costs
  - TIGER Guidelines
- **Travel Time Costs:** Drive/Passenger value of time
  - TIGER Guidelines

Measuring the Benefit Cost Ratio

The recipe:

- **Start with FRA template**
  - Implementation Cost
  - Maintenance Cost
  - Safety Benefits
  - Salvage Value
  - Interest Rate
  - Service Life
- **Identify the Project Type**
  - Grade Separation
  - Installing Warning Devices
  - Closing a crossing
- **Add the missing benefits/costs**
  - Emission/noise pollutions
  - Roadway Safety Costs
  - Roadway Maintenance Costs
  - Travel Time Costs

FRA Benefit Cost Calculation Template

Railroad-Highway Grade Crossing Handbook—Revised Second Edition

Figure 58. Sample Benefit-to-Cost Analysis Worksheet

Evaluation No.: ____________ Project No.: ____________ Date: ____________
Evaluator: ____________

1. Initial implementation cost, I: $ 100,000
2. Annual operating and maintenance costs before project implementation: $ 100
3. Annual operating and maintenance costs after project implementation: $ 1,000
4. Net annual operating and maintenance costs, K (#3 - #2): $ 900
5. Annual safety benefits in number of accidents prevented:

Severity	Actual	– Expected	= Annual Benefit
a) Fatal accidents (fatalities)	0	0	0
b) Injury accidents (injuries)	4	2	2
c) PDO accidents (involvements)	5	3	2

6. Accident cost values (Source Department)

Severity	Cost
a) Fatal accident (fatality)	$ 500,000
b) Injury accident (injury)	$ 50,000
c) PDO accident (involvement)	$ 2,000

7. Annual safety benefits in dollars saved, B:
   (5a) x (6a) = 500,000 x 0 = 0
   (5b) x (6b) = 50,000 x 2 = 100,000
   (5c) x (6c) = 2,000 x 2 = 4,000
   Total = $104,000
8. Service life, n: 20 yrs
10. Interest rate: 10% = .10
9. Salvage value, T: $5,000 (Annual compounding interest)
11. EUAC Calculation:
    Capital recovery factor, CR = 0.1175
    Sinking fund factor, SF = 0.0175
    EUAC = I (CR) + K - T (SF)
    = 100,000 (0.1175) + 900 - 5,000 (0.0175) = 12,562
12. EUAB Calculation: EUAB = B = 104,000
13. B/C = EUAB/EUAC = 104,000 / 12,562 = 8.3
14. PWOC Calcuation:
    Present worth factor, PW = 8.5136
    Single payment present worth factor, SPW = 0.1486
    PWOC = I + K (SPW) - T (PW)
    = 100,000 + 900 (8.5136) - 5,000 (0.1486) = 106,919
15. PWOB Calculation:
    PWOB = B (SPW) = 104,000 (8.5136) = 885,414
16. B/C = PWOB/PWOC = 885,414 / 106,919 = 8.3

Source: Railroad-Highway Grade Crossing Handbook, Second Edition. *Washington, DC: U.S. Department of Transportation, Federal Highway Administration, 1986.*

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Warning Device – Case Study

- Crossing: 630975D
- Railroad: CSX
- Location: N. First St., Maxton
- Warning Device: Crossbucks
- AADT: 1,564
- Truck Percentage:3%

Warning Device Info

- **Construction Cost:**
  - – Historical 2004-2014;
  - – Adjusted for inflation;
  - – Average inflated adjusted: $223,564

- **Maintenance Cost**
  - – Based on 2010 Maintenance Rate Schedule

- **Crash Reduction Factors**
  - – Highway Safety Manual
  - – Crash Modification Clearing House

- **Device Life:**
  - – 17 years (NCDOT Data)

Warning Device – BCA

- Positive greater than 1 benefit cost ratio;
- Warning Device has safety benefits and is more than the construction and maintenance cost of the project;

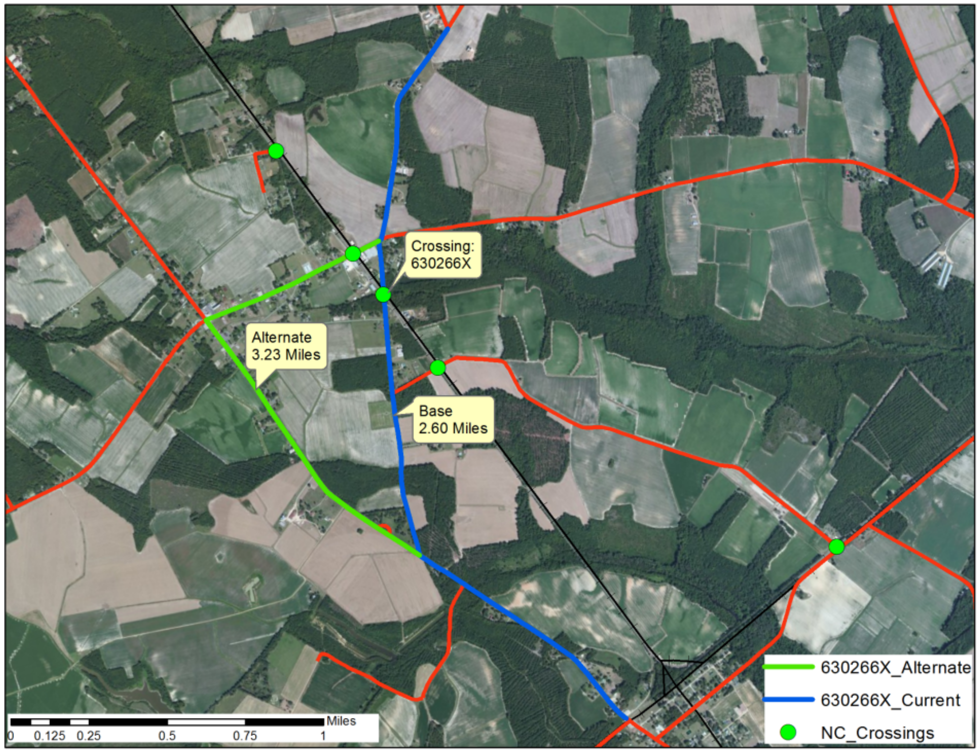
1	Initial implementation cost, I:								$ 218,195
2	Annual operating and maintenance costs before project implementation:								$ 100
3	Annual operating and maintenance costs after project implementation:								$ 3,848
4	Net annual operating and maintenance costs, K (#3 - #2):								$ 3,748
5	Annual safety benefits in number of accidents prevented:								
		Severity			Before (expected) -		After (Exected) =		Annual Benefit
	a)	Fatal accidents (fatalities)			0.0100	-	0.0033	=	0.0067
	b)	Injury accidents (injuries)			0.0369	-	0.0122	=	0.0247
	c)	PDO accidents (involvements)			0.0716	-	0.0236	=	0.0479
6	Accident cost values								
		Severity							Cost
	a)	Fatal accident (fatality)							$ 5,143,870
	b)	Injury accident (injury)							$ 146,064
	c)	PDO accident (involvement)							$ 34,234
7	Annual safety benefits in dollars saved, B:								
	(5a)	x (6a) =	$ 5,143,870	x	0.0067	=			$ 34,488
	(5b)	x (6b) =	$ 146,064	x	0.0247	=			$ 3,608
	(5c)	x (6c) =	$ 34,234	x	0.0479	=			$ 1,641
								Total	**$ 39,738**
8	Service life, n:		17 yrs						
9	Salvage value, T:		$ 1						
10	Interest rate:		8%						
11	EUAC Calculation:								
	Capital recovery factor, CR			=					0.1096
	Sinking fund factor, SF			=					0.0296
	EUAC = I (CR) + K - T (SF) =								$ 27,669
12	EUAB Calculation: EUAB = B =								$ 39,738
13	**B/C = EUAB/EUAC =**								**1.44**
14	PWOC Calcuation:								
	Present worth factor, PW =								9.1216
	Single payment present worth factor, SPW=								0.2703
	PWOC = I + K (PW) - T (SPW)								$ 252,383
15	PWOB Calculation:								
	PWOB = B (PW) =								$ 362,471
16	**B/C = PWOB/PWOC =**								**1.44**

Warning Device – Results Comparison

GRADEDEC RESULTS	Before	After	Reduction	$ Benefit
Fatal	0.009991	0.003297	0.006694	$ 34,433.07
Injury	0.035919	0.011853	0.024066	$ 3,515.18
PDO	0.08169	0.026958	0.054732	$ 1,873.70
			GradeDec Annual Safety Benefit	**$ 39,821.94**

M&N RESULTS	Before	After	Reduction	$ Benefit
Fatal	0.01	0.0033	0.0067	$ 34,463.93
Injury	0.0369	0.0122	0.0247	$ 3,607.78
PDO	0.0716	0.0236	0.0480	$ 1,643.23
			M&N Annual Safety Benefit	**$ 39,714.94**

Closure 1 – Case Study



- Crossing: 630266X
- Railroad: NCVA
- Location: Cemetery St, Roxobel
- Warning Device: Corssbucks
- AADT: 385
- Truck Percentage: 5%

Closure – Info

- Closure Cost: $25,000

- Traffic Diversion Costs: FHWA 2000 Pavement, Congestion, Crash, Air Pollution, and Noise Costs for Illustrative Vehicles Under Specific Conditions (Cents/Mile, CPI Adjusted)

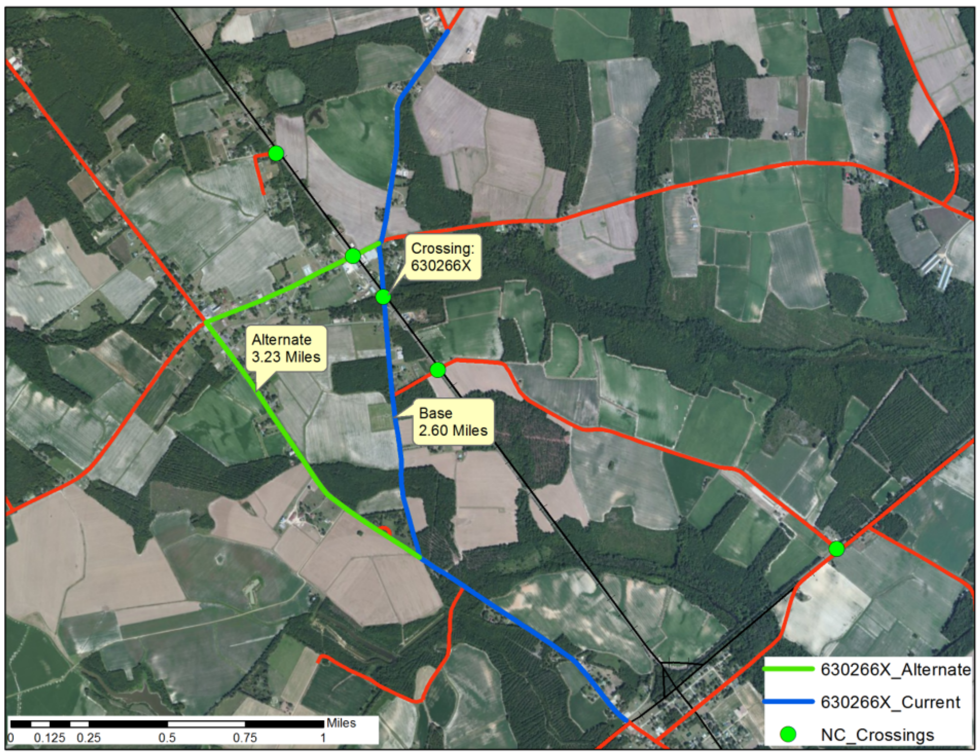
Vehicle Class/Highway Class	Pavement	Congestion	Crash	Air Pollution	Noise	Total
Autos/Rural Interstate	0.00	1.05	1.32	1.54	0.01	3.93
Autos/Urban Interstate	0.14	10.40	1.61	1.80	0.12	14.05
40 kip 4-axle S.U. Truck/Rural Interstate	1.35	3.31	0.63	5.20	0.12	10.61
40 kip 4-axle S.U. Truck/Urban Interstate	4.19	33.05	1.16	6.06	2.03	46.48
60 kip 4-axle S.U. Truck/Rural Interstate	7.56	4.41	0.63	5.20	0.15	17.96
60 kip 4-axle S.U. Truck/Urban Interstate	24.44	44.06	1.16	6.06	2.27	77.99
60 kip 5-axle Comb/Rural Interstate	4.46	2.54	1.19	5.20	0.23	13.61
60 kip 5-axle Comb/Urban Interstate	14.18	24.83	1.55	6.06	3.71	50.33
80 kip 5-axle Comb/Rural Interstate	17.15	3.01	1.19	5.20	0.26	26.80
80 kip 5-axle Comb/Urban Interstate	55.22	27.08	1.55	6.06	4.10	94.01

Closure 1 – BCA

- Benefit/Cost ratio close to zero;
- Closing the crossing has safety benefits;
- The traffic diversion has a significant cost;

1	Initial implementation cost, I:						$	25,000
2	Annual operating and maintenance costs before project implementation:						$	2,032
3	Annual operating and maintenance costs after project implementation:						$	-
4	Net annual operating and maintenance costs, K (#3 - #2):						$	(2,032)
5	Annual safety benefits in number of accidents prevented:							
	Severity			Before (expected)	-	After (Exected)	=	Annual Benefit
a)	Fatal accidents (fatalities)			0.0011	-	0.0006	=	0.000442089
b)	Injury accidents (injuries)			0.0068	-	0.0040	=	0.002805587
c)	PDO accidents (involvements)			0.0149	-	0.0087	=	0.006106331
6	Accident cost values							
	Severity							Cost
a)	Fatal accident (fatality)						$	5,143,870
b)	Injury accident (injury)						$	146,064
c)	PDO accident (involvement)						$	34,234
7.a.	Annual safety benefits in dollars saved, B:							
(5a)	x (6a) =	$ 5,143,870	x	0.00044209	=		$	2,274
(5b)	x (6b) =	$ 146,064	x	0.00280559	=		$	410
(5c)	x (6c) =	$ 34,234	x	0.00610633	=		$	209
						Total Benef	$	**2,893**
7.b.	Trafic Diversion Costs							
	Adional Annual Vehile Miles	109,663						
	Environmental and Infrastructure Cost (rural interstate)						$	4,308
	Additional User Cost						$	64,153
	Adional Annual Truck Miles	5771.745						
	Additional AnnualTruck Cost (60 kip 5-axle Comb/Rural Interstate)						$	78,542
	Environmental and Infrastructure Cost (rural interstate)						$	5,945
	Pre Closure Delay Cost						$	-
						Total Additional Costs	$	**152,948**
8	Service life, n:	30 yrs						
9	Salvage value, T:	$ -						
10	Interest rate:	8%						
11	EUAC Calculation:							
	Capital recovery factor, CR	=						0.0888
	Sinking fund factor, SF	=						0.0088
	EUAC = I (CR) + K - T (SF) =						$	153,137
12	EUAB Calculation: EUAB = B =						$	2,893
13	**B/C = EUAB/EUAC =**							**0.02**
14	PWOC Calcuation:							
	Present worth factor, PW =							11.2578
	Single payment present worth factor, SPW=							0.0994
	PWOC = I + K (PW) - T (SPW)						$	1,723,978
15	PWOB Calculation:							
	PWOB = B (PW) =						$	32,568
16	**B/C = PWOB/PWOC =**							**0.02**

Results Comparison: Closure Case Study 1



- GradeDec B/C 1.519
- M&N B/C 0.019
- Discussion:
  - Traffic Diversion:
    - GradeDec reassigns traffic to crossings based on proximity as determined by railroad milepost – not based upon the surrounding roadway network.
  - Travel Time, Delay and Related Costs
    - All benefits due to reductions in travel time, delay and related costs in GradeDec are calculated at the crossing. Costs due to traffic diversions are not captured in the B/C analysis.

Objective a Data Driven Method

Data Driven		State of Practice
Measure the cost of a highway-rail grade crossing crash	✗	No major frame work before NCHRP-755
Use the crash costs to screen for high risk crossings	✗	Use the Hazard index to screen for high risk crossings
Perform Benefit Costs Analysis (BCA) for an individual crossing safety improvement project	✗	Looks only at the safety benefits
Prioritize safety improvement projects under budget constraints		

Future Work

Project Prioritization – Extending the New Method

- The new method uses a cost based approach for screening of high-risk crossings;
- The new method expands the benefit cost analysis beyond the construction costs and safety benefits;
  - The new method monetizes external costs and benefits

What's next?

- Expand the cost-benefit domain
- Look at corridors
- Add optimization capability to select project that maximize the expected benefits under budget constraints
- Measure the Economic Impacts of safety improvements

Objective a Data Driven Method

Data Driven		State of Practice
Measure the cost of a highway-rail grade crossing crash	✗	No major frame work before NCHRP-775
Use the crash costs to screen for high risk crossings	✗	Use the Hazard index to screen for high risk crossings
Perform Benefit Costs Analysis (BCA) for an individual crossing safety improvement project	✗	Looks only at the safety benefits
Prioritize safety improvement projects under budget constraints	☺	No common consensus, Anticipated NCHRP project;

Questions?

Appendix

Measuring the cost elements

Primary Effect costs

- Injury and Fatality cost;
  - 2011 Standardized Crash Cost Estimates for North Carolina
- Highway vehicle damage;
  - Federal Railroad Administration (FRA) Table 6180.57
- Rail Infrastructure Damage;
  - Federal Railroad Administration (FRA) Table 6180.57
- Rail Equipment Damage;
  - Federal Railroad Administration (FRA) Table 6180.57
- HazMat release cost;
  - Comparative Risks of Hazardous Materials and Non-Hazardous Materials Truck Shipment

Secondary Effect Costs

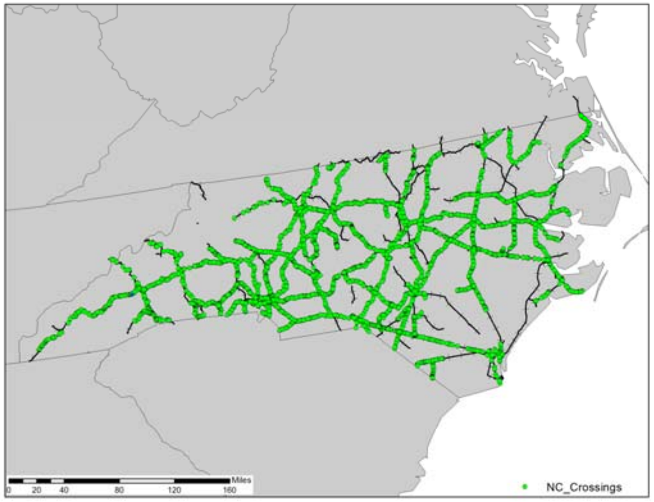
- Delay and Rerouting Costs
  - NCHRP 755
  - TIGER Guidelines
- Supply Chain Costs
  - Freight Analysis Framework
  - FHWA (The Impact of Congestion on Shippers' Inventory Costs)

Screening for high risk crossings: Where is the next improvement candidate?

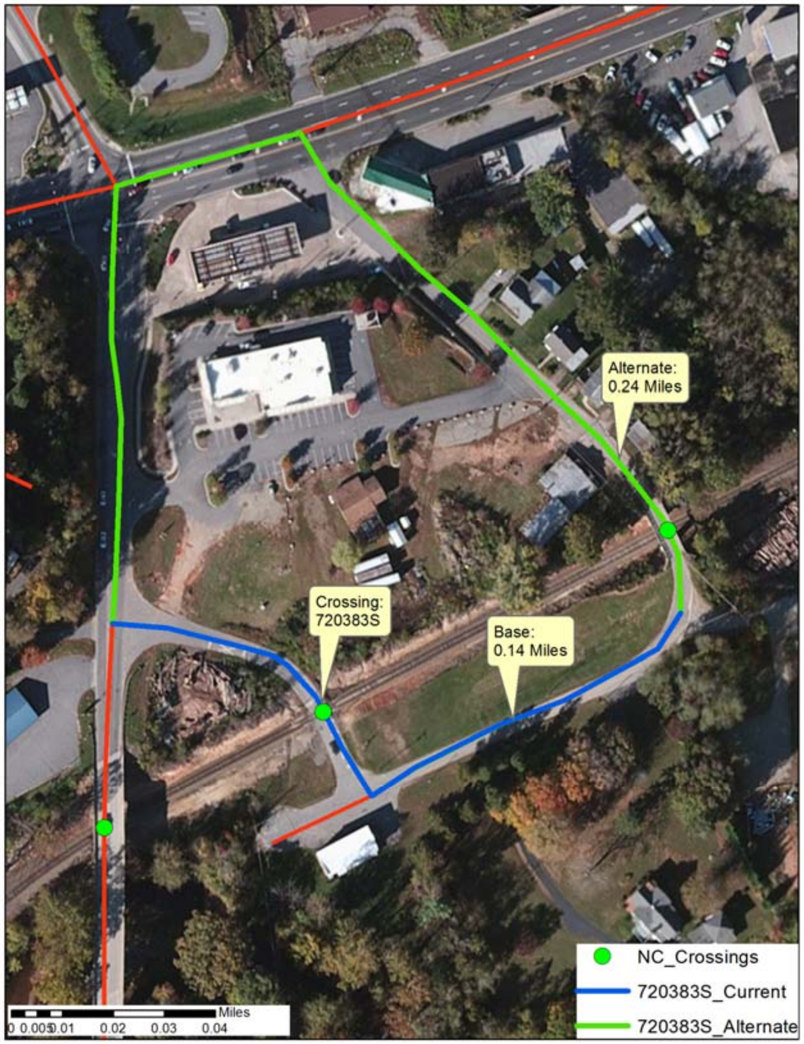
- The objective of the network screening process is to identify potential improvement sites:
  - Investigative Index
  - New Hampshire Hazard Index
  - …

- Expected crash costs can also be used as a mean for network screening (cost based)
  - Is more tangible;
  - Can be used for across the mode screening of potentially hazardous location (single unit of measurement for highway and highway-rail crashes)

- **Expected crash cost = crash probability * (primary effect costs + secondary effect costs)**



Closure 2 – Case Study



- Crossing: 720383S
- Rail Road: NS
- Location: Old Pisgah Hwy, Asheville
- Warning Device: Crossbucks
- AADT: 73
- Truck Percentage: 0%

- Closure Cost: $25,000

Closure 2 – BCA

- Benefit-Cost Ratio is greater than 1
- Closing the crossing has safety befits
- The traffic diversions costs are less than safety benefits

#		Description							
1		Initial implementation cost, I:						$	25,000
2		Annual operating and maintenance costs before project implementation:						$	100
3		Annual operating and maintenance costs after project implementation:						$	-
4		Net annual operating and maintenance costs, K (#3 - #2):						$	(100)
5		Annual safety benefits in number of accidents prevented:							
		Severity	Before (expected) -	After (Exected) =				Annual Benefit	
	a)	Fatal accidents (fatalities)	0.0010	-	-	=			0.000975644
	b)	Injury accidents (injuries)	0.0046	-	-	=			0.004604047
	c)	PDO accidents (involvements)	0.0100	-	-	=			0.010020663
6		Accident cost values							
		Severity						Cost	
	a)	Fatal accident (fatality)						$	5,143,870
	b)	Injury accident (injury)						$	146,064
	c)	PDO accident (involvement)						$	34,234
7.a.		Annual safety benefits in dollars saved, B:							
	(5a)	x (6a) =	$ 5,143,870	x	0.00097564	=		$	5,019
	(5b)	x (6b) =	$ 146,064	x	0.00460405	=		$	672
	(5c)	x (6c) =	$ 34,234	x	0.01002066	=		$	343
							Total Benef	**$**	**6,034**
7.b.		Trafic Diversion Costs/Benefits							
		Additional Annual Vehile Mile	2,665						
		Environmental and Infrastructure Cost (rural interstate)						$	105
		Additional User Cost						$	1,559
		Adional Annual Truck Miles	0						
		Additional AnnualTruck Cost (60 kip 5-axle Comb/Rural Interstate)						$	-
		Environmental and Infrastructure Cost (rural interstate)						$	-
		Pre Closure Delay Cost						$	-
							Total Additional Costs	**$**	**1,663**
8		Service life, n:	30 yrs						
9		Salvage value, T:	$ -						
10		Interest rate:	8%						
11		EUAC Calculation:							
		Capital recovery factor, CR	=						0.0888
		Sinking fund factor, SF	=						0.0088
		EUAC = I (CR) + K - T (SF) =						$	3,784
12		EUAB Calculation: EUAB = B =						$	6,034
13		**B/C = EUAB/EUAC =**							**1.59**
14		PWOC Calcuation:							
		Present worth factor, PW =							11.2578
		Single payment present worth factor, SPW=							0.0994
		PWOC = I + K (PW) - T (SPW)						$	42,601
15		PWOB Calculation:							
		PWOB = B (PW) =						$	67,931
16		**B/C = PWOB/PWOC =**							**1.59**

Prioritization of safety improvement projects under budget constraints

- Current methods focus on metropolitan-only or small community-only benefits
- They don't generally use the same metrics for measuring the costs and the benefits
- Using multiple metrics in screening and benefit cost analysis leads to unnecessarily complex project prioritization approaches;
  - Exposure indices identify hazardous spots (with no associated costs)
  - Benefit cost method looks at the Safety Related benefit Cost ratio
  - Other decision-making criteria are considered through scorecards, multi-dimensional comparison and …