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Session 8:

Benefit to Cost (B:C) Calculations

Plus Net Present Value (NPV) Calculations

New Work Program Guidelines

Anthony Chaumont, PE

December 18,2013

"Driving Down Fatalities Through Knowledge Sharing"

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Workshop Series

Wed. Dec 4	Safety Funding Categories/Requirements/Conditions
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2014

Wed. Jan. 8	Safety Projects & The Local Agency Program (LAP)
Wed. Jan. 15	Development of the Safety/LAP Project Schedule for Funding Purposes
Wed. Jan. 22	Safety/LAP Project Development
Wed. Jan. 29	Key to Successful Safety Programs

Today's Presentation

B/C Calculations plus NPV Calculations – New WP Guidelines

"Driving Down Fatalities Through Knowledge Sharing"

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Agenda

- What is BC?
- What is NPV?
- Manual Calculation Steps
- Filling Out the Spreadsheet
- Which One to Use?

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What is Benefit to Cost Ratio?

Highway Safety Improvement Manual

"A benefit/cost analysis compares all of the benefits associated with a countermeasure (e.g., crash reduction, etc.), expressed in monetary terms, to the cost of implementing the countermeasure."

(Estimated Annual Benefit) /
(Estimated Annual Cost)

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Benefit Cost Calculation

Historical Crash Data Benefit

- Total Number of Crashes
- Crash Reduction Factor
- Cost per Crash

→ Annualized Estimated Benefit

(Crashes)(Reduction)(Cost per Crash)

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Benefit Cost Calculation

Total Number of Crashes

- Department of Highway Safety Motor Vehicles (DHSMV)
- FIRES Portal
- Law Enforcement
- Crash Data Management System (CDMS)
- Crash Analysis Reporting System (CARS)
- Signal Four

→ Identify Number of Crashes

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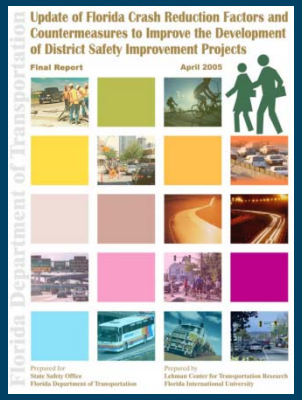
Benefit Cost Calculation

Crash Reduction Factor (CRF)

- "Multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure"
  - http://www.cmfclearinghouse.org/

CRASH MODIFICATION FACTORS CLEARINGHOUSE

- Florida Crash Reduction Factors
  - http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SF/FDOT_BD015_04_rpt.pdf



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Benefit Cost Calculation

Crash Reduction Factor (CRF)

- CMF
  (Crash Modification Factor)
- CRF as Percentage (+/-)
- Quality (Star Rating)
- Crash Type
- Crash Severity
- Area Type

Countermeasure: Install a traffic signal

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference
0.56 [B]	44	★★★★★	All	All	Rural	Harkey et al., 2008
0.23 [B]	77	★★★★★	Angle	All	Rural	Harkey et al., 2008
0.33	67	★★★★☆	Angle	Fatal,Serious Injury,Minor Injury	Urban	McGee et al., 2003
0.4 [B]	60	★★★★☆	Left turn	All	Rural	Harkey et al., 2008
1.58 [I]	-58	★★★★☆	Rear end	All	Rural	Harkey et al., 2008
0.86	14	★★★☆☆	All	Fatal,Serious Injury,Minor Injury	Urban	McGee et al., 2003

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Benefit Cost Calculation

Crash Reduction Factor (CRF)

- Factors can be combined

$$CRF_{Ti} = 1 - \left[(1 - CRF_{1i}) * (1 - CRF_{2i}) * \ldots * (1 - CRF_{ni})\right]$$

example

Is the CRF for two improvements with 25% and 15% equal to 40%?

1-((1-CFR1)x(1-CRF2))

1-((1-0.25)x(1-0.15))

= 0.36

= 36% CRF

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Benefit Cost Calculation

Cost Per Crash

- Statewide Values used from FDOT for SHS roadways

Highway Safety Improvement Program Guide (HSIPG) Cost / Crash by Facility Type						
Facility Type	Divided			Undivided		
	Urban	Suburban	Rural	Urban	Suburban	Rural
2-3 Lanes	$85,566	$141,990	$257,007	$102,679	$224,447	$386,705
4-5 Lanes	$113,203	$178,527	$355,526	$80,727	$152,430	$108,519
6+ Lanes	$105,370	$129,058	$505,539	n/a	n/a	n/a
Interstate	$134,415	n/a	$269,193	n/a	n/a	n/a
Turnpike	$116,801	n/a	$221,451	n/a	n/a	n/a

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Benefit Cost Calculation

Cost Per Crash

- Use 50% of the SHS value for local roadways

Local Agency Cost per Crash by Facility Type (2009-2011)						
	Divided			Undivided		
Facility Type	Urban	Suburban	Rural	Urban	Suburban	Rural
2-3 Lanes	$48,862	$71,195	$133,076	$59,784	$101,317	$208,205
4-5 Lanes	$46,434	$71,889	$136,106	$44,362	$95,536	$31,366
6+ Lanes	$50,957	$62,138	$161,441	N/A	N/A	N/A
Interstate	$66,733	N/A	$126,026	N/A	N/A	N/A
Turnpike	$58,213	N/A	$92,073	N/A	N/A	N/A
These values are to be aplied to crashes on off-system roadways. Revised 04/01/13.						

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Benefit Cost Calculation

Cost

- Total Improvement Cost
- Engineering Estimate
  - Structures
  - Roadway
  - Signs and Marking
  - Utilities
  - Maintenance of Traffic
  - Mobilization
  - Design
  - Right of Way
- Life of Improvement
- Capital Recovery Factor (CRF)

→ Annualized Estimated Cost

(Improvement Cost)(Capital Recovery)

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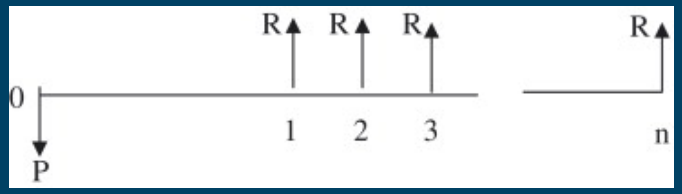
Benefit Cost Calculation

Capital Recovery Factor (CRF)

- Converts a present value into a equal annual payments over a time period at a specified interest rate.
- Interpreted as the value of uniform payments for *n* years such that the present value is equal to one dollar at interest rate *i*.

→ Annualized Estimated Cost

$$CRF = \frac{i(1+i)^n}{[(1+i)^n - 1]}$$



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Benefit Cost Calculation

example

- Calculate the benefit to cost ratio for Installing a traffic new signal at along an urban 2 lane urban undivided highway with the following annual crash history:
  - 4 Angle
  - 1 Left-turn
  - 3 Rear-end

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Benefit Cost Calculation

Calculate the Benefit

- Urban 2 lane urban undivided highway.
- Crashes per year:
  - 4 Angle
  - 1 Left-turn
  - 3 Rear-end
- Crash Cost = $102,679
- Crash Reduction Factors:
  - Angle = 77%
  - Left-turn = 60%
  - Rear-end = -58%

[(4 x 77%) + (1 x 44%) + (3 x -58%)] x $102,679 = $199,197 Annual Benefit

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Benefit Cost Calculation

Calculate the Cost

- Install new signal
- Improvement Life
- Interest Rate
- Capital Recovery

- Crash Cost = $450,000
- Life = 10 years
- i = 4%
- CRF = $\frac{(0.04(1+0.04)^{10})}{(1+0.04)^{10} - 1}$

= 0.123

$450,000 x 0.123 = $55,481 Annual Cost

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Benefit Cost Calculation

<u>Put it all together</u>

Benefit / Cost =

$199,197 Annual Benefit

_____

$55,481 Annual Cost

= 3.58 BC

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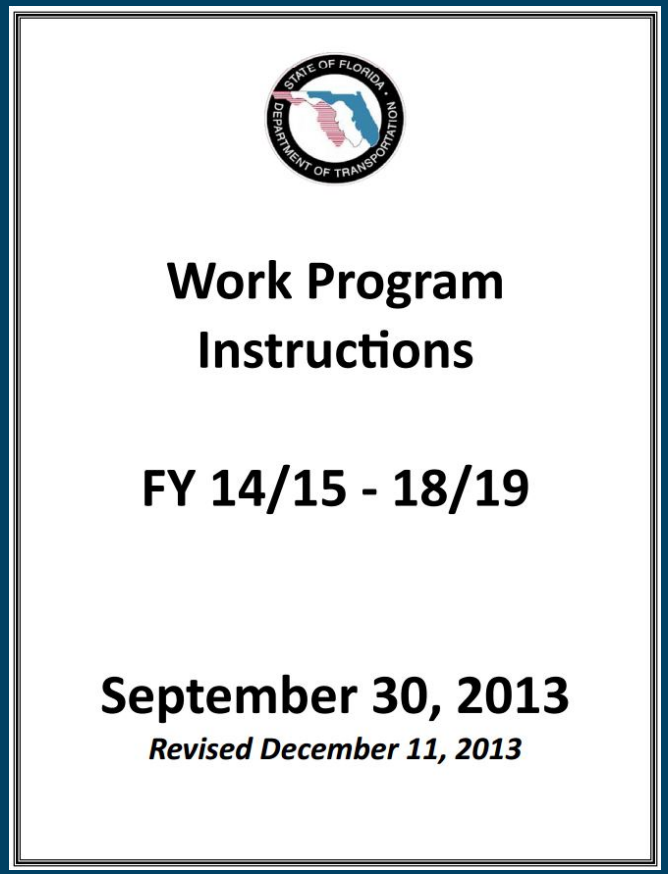
Work Program Instructions

Chapter 31: Safety Section B, Page 2

"Highway safety improvement projects are eligible for HSP funding if they meet one of the following minimum requirements: Address a key highway safety problem area from the Florida Strategic Highway Safety Plan and net present value (NPV) greater than 0."



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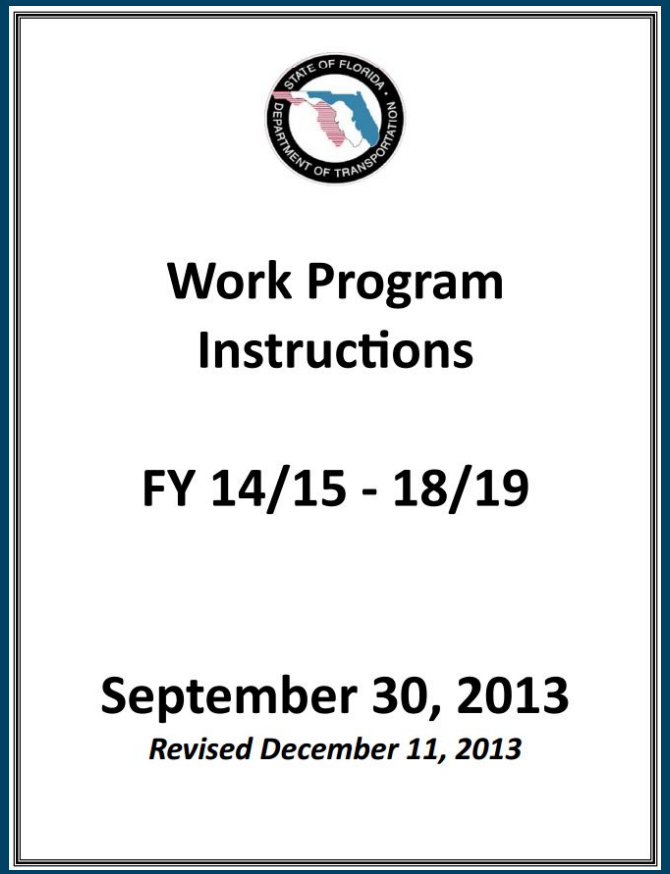
Work Program Instructions

Caveats

- Projects not meeting NPV requirements but have supporting documentation to warrant the project as a potential safety project will be evaluated on a case by case basis.
- All projects not meeting NPV requirements will require approval by the state Safety Office.



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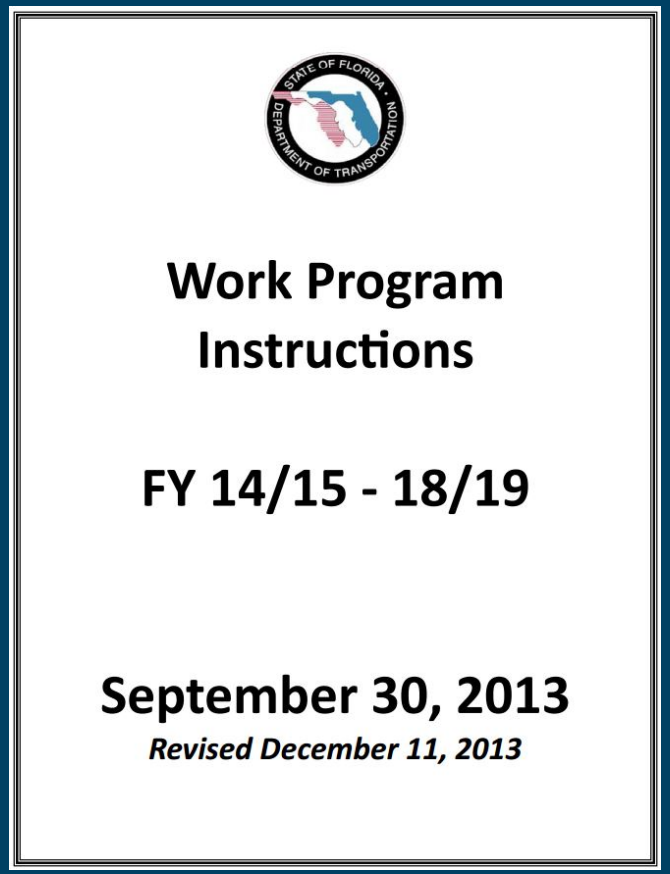
Work Program Instructions

Caveats

- Acquisition of right of way (R/W) should be limited to only projects that are required to alleviate the immediate safety problem and to achieve the three year concept to construction goal.
- As specified in Section 1533 of MAP-21, HSP funds may not be used for any program to purchase, operate, or maintain an automated traffic enforcement system (speeding or red-light) in fiscal years 2013 and 2014, unless such systems are used to improve safety in school zones.



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What is Net Present Value?

Highway Safety Improvement Manual

"Expresses the difference between the discounted costs and discounted benefits of a safety improvement project."

(Sum of Discounted Benefit) - (Estimated Cost)

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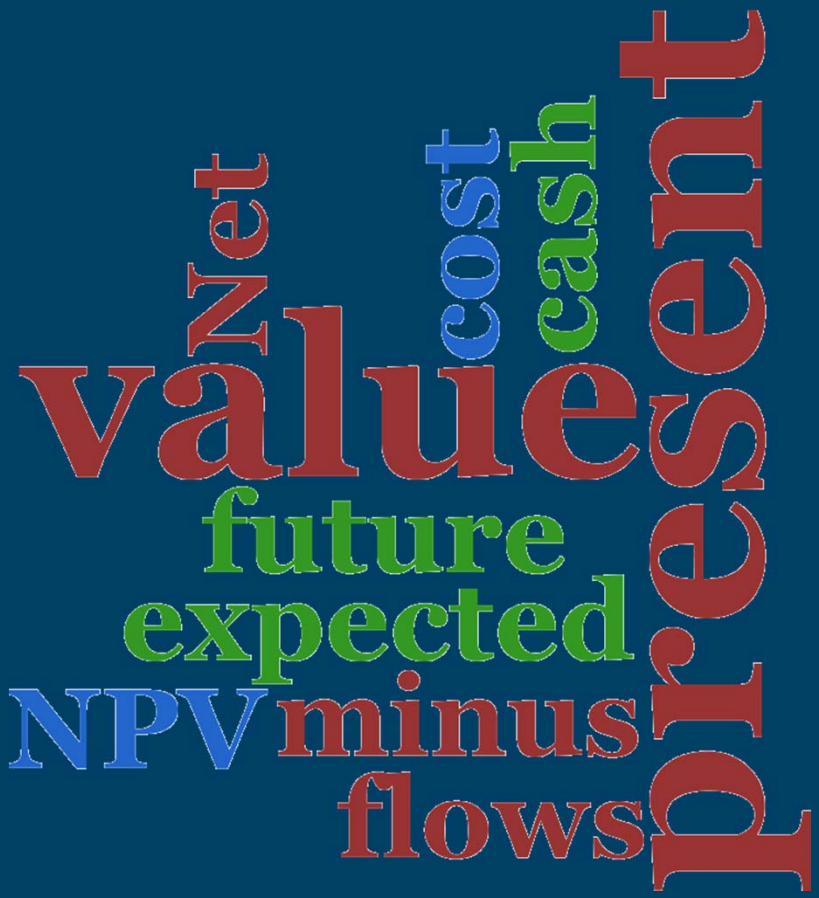
What is Net Present Value?

Highway Safety Improvement Manual

Two basic purposes:

- Used to determine which countermeasure(s) provides the most cost-efficient means based on the countermeasure(s) with the highest NPV.
- It also can determine if a project is economically justified meaning a project has a NPV greater than zero (or the benefits are greater than the costs).



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Net Present Value Calculation

- Total Benefit (Same As before)
  - Number of Crashes
  - Crash Reduction Factor
  - Cost Per Crash
- Discount Rate
  - 1 / ((1+i)^n)
  - Create a table with values for each year of the improvement life
  - Apply discount to each year

→ Sum the benefit for each year

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Net Present Value Calculation

example

- Calculate the net present value for Installing a traffic new signal at along an urban 2 lane urban undivided highway with the following annual crash history:
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Net Present Value Calculation

Calculate the Benefit

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[(4 x 77%) + (1 x 44%) + (3 x -58%)] x $102,679 = $199,197 Annual Benefit

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Net Present Value Calculation

- Calculate Discount Factor for each year of the lifecycle

Year	1	2	3	4	5	6	7	8	9	10
Estimated Benefits	$199,197	$199,197	$199,197	$199,197	$199,197	$199,197	$199,197	$199,197	$199,197	$199,197
Discount Factor	0.962	0.925	0.889	0.855	0.822	0.790	0.760	0.731	0.703	0.676
Discounted Benefits	$191,536	$184,169	$177,086	$170,275	$163,726	$157,428	$151,374	$145,551	$139,953	$134,571

Sum of the benefit = $1,615,688

Total Improvement Cost = $450,000

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Net Present Value Calculation

Put it all together

Benefit - Cost =

$1,615,668 Benefit - $450,000 Cost

= $1,165,668 NPV

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Is there an easier way?

11. CRASH TYPES	NO. OF CRASHES			CRF %	TOTAL TO BE PREVENTED
A. FATAL AND SERIOUS INJURY	2009	2010	2011		
FATAL CRASHES					0.00
SERIOUS INJURY CRASHES					0.00
					0.00
					0.00
SUBTOTAL: CORRECTED SEVERE INJURY CRASHES:					***0.00***
B. MINOR INJURY CRASH TYPES	NO. OF CRASHES			CRF	PREVENTED
MINOR INJURY CRASHES					0.00
					0.00
					0.00
					0.00
SUBTOTAL: CORRECTED MINOR INJURY CRASHES:					***0.00***
C. ALL OTHER CRASHE TYPES	NO. OF CRASHES			CRF	PREVENTED
Angle	4.0	4.0	4.0	77%	9.24
Left Turn	1.0	1.0	1.0	60%	1.80
Rear End	3.0	3.0	3.0	-58%	-5.22
					0.00
SUBTOTAL: CORRECTED ALL OTHER CRASHES:					***5.82***
D. TOTAL CRASHES (ALL TYPES)	8.00	8.00	8.00		
12. TOTAL TO BE PREVENTED	1.94	1.94	1.94		**5.82**
13. BENEFIT					
A. TOTAL CRASH BENEFIT					$ 597,592
B. TOTAL ANNUAL BENEFIT:					**$ 199,197**

14. CRASH INFORMATION FOR FACILITY		
A. COST PER CRASH:	$ 102,679	
B. CRASH CLEANUP:	$ 100	per year
C. INTEREST (DISCOUNT) RATE:	4.0%	

15. ANNUAL COST OF IMPROVEMENTS				
TYPE	COST	LIFE (YR)	CRF	COST/YR
A. R.O.W.:				
B. P.E.C.E.I.:				
C. STRUCTURE:	$ 450,000	10	0.123	$ 55,481
D. ROADWAY:				
E. PAVEMENT:				
F. SIGNAL:				
G. LIGHTING:				
H. SUBTOTAL:	*$ 450,000*	*10*		$ 55,481
I. CHANGE IN MAINTENANCE:				$ -
J. CRASH CLEANUP:				$ 194
K. TOTAL ANNUAL COST:				**$ 55,675**
16. BENEFIT/COST:				**3.58**
17. NET PRESENT VALUE				
A. CURRENT YEAR				2013
B. PROJECT COMPLETION				2014
C. NPV				**$ 1,165,668**
Prepared By:			Date:	
Approved By:			Date:	

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More Fun With Numbers

- $100,000 Crash Cost
- 15 Crashes Per Year
- 20% Crash Reduction Factor
- $500,000 Improvement Cost
- 10 Year Life

- BC = 2.71
- NPV = $708,175

VS

- $100,000 Crash Cost
- 30 Crashes Per Year
- 20% Crash Reduction Factor
- $1,000,000 Improvement Cost
- 10 Year Life

- BC = 2.71
- NPV = $1,416,350

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More Fun With Numbers

- $100,000 Crash Cost
- 15 Crashes Per Year
- 20% Crash Reduction Factor
- $500,000 Improvement Cost
- 14.0607 Year Life

VS

- $100,000 Crash Cost
- 30 Crashes Per Year
- 20% Crash Reduction Factor
- $1,000,000 Improvement Cost
- 10 Year Life

- BC = 2.12
- NPV = $442,111

- BC = 1.62
- NPV = $442,111

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Final Thoughts

- BC and NPV is both art and science
- There may not be a “cookie cutter” solution
- Complex situations may require manual calculations
- Not all countermeasure are in the CMF
- Application of multiple countermeasure require creativity
- Selection of countermeasure requires judgment
- Contact FDOT for technical questions and tips

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Questions?

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Today's Presentation

Safety Projects & The Local Agency Program (LAP)

"Driving Down Fatalities Through Knowledge Sharing"

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Questions? Need Assistance?

Anthony D. Chaumont, P.E.
Project Manager
Tindale-Oliver & Associates, Inc.

Phone: (813) 224-8862
Email: achaumont@tindaleoliver.com