Delaware Department of Transportation
Design Guidance Memorandum

Memorandum Number: 1-35

1. Road Design 2. Bridge Design 3. Utilities Design
4. Right of Way 5. Other

Title: Delaware Crash Costs Effective Date: 11/10/2026

I. Purpose

To provide guidance on the usage and application of crash costs for highway safety projects.

II. Applicability

Highway Network Screening

As part of a systemic highway safety analysis, crash costs can be incorporated into network screening efforts to help prioritize sites based on historical crash injury data. The scope of network screening is guided by program priorities, which may target specific crash severities such as fatal and serious injury crashes.

Crash costs may also be used to quantify the economic safety impacts of a specific crash type (e.g., red-light running crashes) or a site type (e.g., signalized intersections).

Benefit Cost Analysis (BCA)

The goal of a BCA is to quantify the societal benefits of a project or countermeasure (e.g., predicted crash reduction) and weigh them against the costs required to achieve those benefits (e.g., installation of a median barrier). This analysis helps decision makers evaluate whether a project is economically justifiable and identify the most cost-effective investment alternatives to pursue.

Although there are several methods analysts can use to compare alternatives in a BCA, the two measures described below are most used and can be used in combination or standalone. [2][3]

Benefit-Cost Ratio (BCR): recommended for project evaluation when funding restrictions exist. The BCR is calculated as the ratio of present value benefits (including negative benefits) to the present value costs (initial and continuing costs over the project lifecycle). BCR can be used to identify the alternative with the highest benefit per dollar spent.

$$\text{Benefit-Cost Ratio (BCR)} = \frac{\text{Present Value Benefits}}{\text{Present Value Costs}}$$

Net Present Value (NPV): recommended for project evaluation when there are no funding constraints. It is calculated as the difference between present value benefits and present value costs. NPV can be used to identify the alternative with the highest benefit to the public.

$$\text{Net Present Value (NPV)} = \text{Present Value Benefits} - \text{Present Value Costs}$$

III. Design Guidance

Each year, DelDOT's Traffic Safety Engineering Section will update and publish Delaware-specific comprehensive crash unit costs, adjusted for inflation, as an attachment to this memorandum. These values are calculated using the three most recent complete calendar years of data.

Delaware-specific comprehensive crash unit costs are adapted from the Federal Highway Administration's (FHWA) Crash Costs for Highway Safety Analysis, published in 2018. National crash costs are adjusted to the state level based on the methodology presented in the FHWA report, which incorporates state-specific crash data and economic factors.

Comprehensive crash unit costs consist of two elements:

- Economic costs: market-valued losses to society associated with a vehicle crash such as medical expenses, insurance costs, legal fees, emergency services, and other measurable impacts.
- Quality-adjusted life years (QALY) costs: non-market losses including pain, suffering, disability, and emotional impacts associated with the crash.

Crash unit costs categorized by severity represent the total cost of a crash based on the most severe injury sustained by any person involved, classified according to the KABCO scale:

- Fatal (K)
- Suspected serious injury (A)
- Suspected minor injury (B)
- Possible injury (C)
- Property damage only (O, also called PDO)

In addition, Equivalent Property Damage Only (EPDO) weights are calculated by normalizing the costs of fatal and injury crashes (KABC) by the cost of PDO crashes. These weights may be used in network screening and prioritization processes.

IV. Justification

As a data-driven tool, crash cost analysis supports the strategic prioritization and selection of highway safety improvements, which optimizes the allocation of available resources.

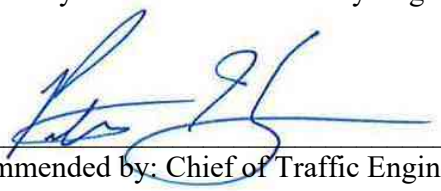
V. References

(1) Harmon, T., Bahar, G., & Gross, F. (2018). *Crash Costs for Highway Safety Analysis*. Report No. FHWA-SA-17-071. United States Department of Transportation. Federal Highway Administration, Office of Safety, Washington, D.C.

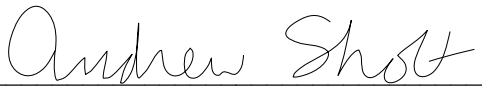
(2) Lawrence, M., Hachey, A., Bahar, G., & Gross, F. (2018). *Highway Safety Benefit-Cost Analysis Guide.* Report No. FHWA-SA-18-001. United States Department of Transportation, Federal Highway Administration, Office of Safety. Washington, D.C.

(3) United States Department of Transportation. (2025). *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*. United States Department of Transportation, Office of the Secretary, Washington, D.C.

Prepared by: DOTS - Traffic Safety Engineering, DOTS Date: 08/26/2026



Recommended by: Chief of Traffic Engineering — 10/30/2026 Date



Attest to Form and Process: Support Engineer — 11/9/2026 Date



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Appendix

The examples below demonstrate the applicability of the Delaware Crash Costs values in Benefit-Cost Analysis for traffic engineering projects.

The 2024 annual attachment of the Delaware Crash Costs DGM is used as the basis for calculating the Present Value Benefits.

Example 1

A countermeasure is estimated to reduce the expected average crash frequency for K, A, B, C crashes by 40%, which is equivalent to a Crash Modification Factor (CMF) of 0.6. The construction cost is estimated at $1,200,000 with an annual maintenance cost of $105.

Since the countermeasure applies only to K, A, B, and C crashes, it is necessary to quantify the proportion of each crash severity at the study location and apply the CMF to each severity category accordingly.

Severity Type	Observed Annual Crash Frequency (crashes/yr)	Estimated Annual Crash Frequency (crashes/yr)	Estimated Annual Reduction in Crashes (crashes/yr)
Fatal (K)	0.67	0.6 * 0.67 = 0.40	0.67 - 0.40 = 0.27
Suspected Serious Injury (A)	1.00	0.6 * 1.00 = 0.60	1.00 - 0.60 = 0.40
Suspected Minor Injury (B)	1.67	0.6 * 1.67 = 1.00	1.67 - 1.00 = 0.67
Possible Injury (C)	1.33	0.6 * 1.33 = 0.80	1.33 - 0.80 = 0.53
Property Damage Only (O)	3.33	1.0 * 3.33 = 3.33	3.33 - 3.33 = 0

Conversion factor from annualized benefits and costs to present value

i = rate of return (or discount rate), assumed to be 3% (i = 0.03)
y = countermeasure service life, assumed to be 10 years

$$(P/A, i, y) = \frac{(1.0 + i)^y - 1.0}{i * (1.0 + i)^y}$$

$$(P/A, 0.03, 10) = \frac{(1.0 + 0.03)^{10} - 1.0}{0.03 * (1.0 + 0.03)^{10}}$$

$$(P/A, 0.03, 10) = 8.53$$

Present Value Benefits

Severity Type = Comprehensive Crash Unit Costs * Estimated Annual Reduction in Crashes

K = $14,577,954 * 0.27 = $3,906,892/yr
A = $1,557,574 * 0.40 = $623,030/yr
B = $376,213 * 0.67 = $251,310/yr
C = $191,716 * 0.53 = $101,993/yr
O = $15,432 * 0 = $0/yr

$$\text{Total Annual Benefit} = \$4{,}883{,}224/\text{yr}$$

$$\begin{aligned}\text{Total Present Value Benefit} &= \text{Total Annual Benefit} * (P/A, i, y)\\ &= \$4{,}883{,}224 * (P/A, 0.03, 10)\\ &= \$4{,}883{,}224 * 8.53\\ &= \$41{,}653{,}905\end{aligned}$$

Present Value Costs

$$\text{Construction Cost} = \$1{,}200{,}000$$

$$\text{Annual Maintenance Cost} = \$105$$

$$\begin{aligned}\text{Total Present Value Cost} &= \$1{,}200{,}000 + \$105 * (P/A, 0.03, 10)\\ &= \$1{,}200{,}000 + \$105 * 8.53\\ &= \$1{,}200{,}896\end{aligned}$$

Benefit-Cost Ratio (BCR)

$$\text{BCR} = \frac{\text{Present Value Benefits}}{\text{Present Value Costs}}$$

$$\text{BCR} = \frac{\$41{,}653{,}905}{\$1{,}200{,}896}$$

$$\text{BCR} = 34.69$$

Net Present Value (NPV)

$$\text{NPV} = \text{Present Value Benefits} - \text{Present Value Costs}$$

$$\text{NPV} = \$41{,}653{,}905 - \$1{,}200{,}896$$

$$\text{NPV} = \$40{,}453{,}009$$

Example 2

Existing condition: Four-leg, minor-road stop-controlled intersection.

Proposed modification: conversion to signal control, with a construction cost of $500,000 and annual maintenance cost of $2,500.

Goal: estimate the safety benefits associated with the proposed conversion.

Collision Type	Observed Annual Crash Frequency (crash/yr)	CMF	Estimated Annual Crash Frequency (crash/yr)	Estimated Annual Reduction in Crashes (crash/yr)
Angle	6.33	0.32	6.33 * 0.32 = 2.02	6.33 - 2.02 = 4.31
Rear end[1]	3.00	1.58	2.9 * 1.58 = 4.74	3.00 - 4.74 = -1,74

[1]Equivalente to Front to Rear

Factor to convert annualized benefits and costs to present value

i = rate of return (or discount rate), assumed to be 3% (i = 0.03)
y = countermeasure service life, assumed to be 25 years

$$(P/A, i, y) = \frac{(1.0 + i)^y - 1.0}{i * (1.0 + i)^y}$$

$$(P/A, 0.03, 25) = \frac{(1.0 + 0.03)^{25} - 1.0}{0.03 * (1.0 + 0.03)^{25}}$$

$$(P/A, 0.03, 25) = 17.41$$

Present Value Benefits

Collision Type = Comprehensive Crash Unit Costs * Estimated Annual Reduction in Crashes

Angle = \$223,070 * 4.31 = \$960,688/yr
Rear end = \$92,870 * -1.74 = -\$161,594/yr (negative value as the CMF is greater than one)
Total Annual Benefit = \$799,094/yr

Total Present Value Benefit = Total Annual Benefit * (P/A, i, y)
= \$799,094 * (P/A, 0.03, 25)
= \$799,094 * 17.41
= \$13,912,232

Present Value Costs

Construction Cost = \$500,000

Annual Maintenance Cost = \$2,500

Total Present Value Cost = \$500,000 + \$2,500 * (P/A, 0.03, 25)
= \$500,000 + \$2,500 * 17.41
= \$543,525

Benefit-Cost Ratio (BCR)

$$BCR = \frac{\text{Present Value Benefits}}{\text{Present Value Costs}}$$

$$BCR = \frac{\$13,912,232}{\$543,525}$$

BCR = 25.60

Net Present Value (NPV)

NPV = Present Value Benefits − Present Value Costs

NPV = \$13,912,232 − \$543,525

NPV = \$13,368,707

Example 3

Existing condition: 0.50-mile segment
Proposed modification: install High-Friction Surface Treatment (HFST)
Goal: estimate the safety benefits associated with the installation

In this example, DelDOT's Benefit-Cost Analysis Calculator is used to support the analysis. Under the Data Entry Tab, the term "hfst" is used to search for countermeasures related to High Friction Surface Treatment. After reviewing the available options, CMF Code 230 is selected and manually entered into the Improvements Information table.

The construction and design costs are overridden to $275,000 and $7,500, respectively.

PROJECT INFORMATION:

Project:	Project 1
Date:	1/1/2026
Analyst:	DelDOT

LOCATION INFORMATION:

Density:	Urban	(see Gateway→Census 2020→Urban Area)	Speed Limit:	40	mph
Functional Class:	Arterial	(see Gateway→Functional Classification)	Truck Percentage:	0.02	(use 0.02 if unsure)
Segment Length:	0.5	miles (use 0.01 for intersections)	Seasonal Volume Variability?:	Yes	

IMPROVEMENTS INFORMATION:

CMF Code	Improvement	Construction Duration (yr, min 0.01 yr)		Construction Cost		ROW Cost	Design Cost		Annual Maintenance Cost		Analysis Period (yr)		O AM Peak Hour	
		Assumed	User Override	Assumed	User Override	User Input	Assumed	User Override	Assumed	User Override	Assumed	User Override	Intersection Hourly Volume	Change i Intersecti Delay (s/ve
230	Install high friction surface treatment (HFST)	0.10		$350,000	$275,000		$10,000	$7,500	$0		10			

Negative change in dela

CMF SEARCH: Search: hfst *Search complete. 7 results.*

Code	Improvement	Reference	ID	CMF	Crash Type	Severity	Road Type	Area Type	Major AADT	Minor AADT	Conditions
198	Improve pavement frictions (groove)	FHWA		0.75	All	All	All				
199	Improve pavement frictions (groove)	FHWA		0.41	Wet	All	All				
202	Increase Pavement Friction	CMF	194	0.76	All	All	All				Major Road Approach
203	Increase Pavement Friction	CMF	195	0.43	Wet Road	All	All				Major Road Approach
229	Install high friction surface treatment (HFST)	CMF	10332	0.43	All	All	All				
230	Install high friction surface treatment (HFST)	CMF	10334	0.279	Roadway Departure	All	All				
	Install high friction surface treatment										

Then, the column "Relevant Annual Crash Rate without Treatment" is input with annual crash rate data (K = 0; A = 1.5; B = 4.5; C = 3.75; O = 7.25).

IMPROVEMENTS INFORMATION:

CMF Code	Improvement	Construction Duration (yr, min 0.01 yr)		Construction Cost		ROW Cost	Design Cost		Annual Maintenance Cost		Analysis Period (yr)		Operational Delay Changes (Optional)						Relevant Annual Crash Rate without Treatment				
													AM Peak Hour		Midday Peak Hour		PM Peak Hour		K	A	B	C	O
		Assumed	User Override	Assumed	User Override	User Input	Assumed	User Override	Assumed	User Override	Assumed	User Override	Intersection Hourly Volume	Change in Intersection Delay (s/veh)	Intersection Hourly Volume	Change in Intersection Delay (s/veh)	Intersection Hourly Volume	Change in Intersection Delay (s/veh)	(Fatal)	(Suspected Serious Injury)	(Suspected Minor Injury)	(Possible Minor Injury)	(Property Damage Only)
230	Install high friction surface treatment (HFST)	0.10		$350,000	$275,000		$10,000	$7,500	$0		10								0	1.5	4.5	3.75	7.25

After entering the information above, the program automatically converts the annual benefits to present value and presents the results under the Summary tab. The resulting benefit-cost ratio is 106.72.

Check Box to Include in Analysis:

- ☐ Operational Delay Reduction

Crash Reduction Benefits

- ☑ Safety Benefit
- ☐ Travel Time Benefit
- ☐ Fuel Benefit
- ☐ Emissions Benefit

DelDOT Benefit-Cost Ratio Analysis Summary

Project: Project 1
Date: 1/1/2026
Analyst: DelDOT

CMF	Improvement	Analysis Period (years)	Benefits				Operational Delay Change	Costs		Total Benefit	Total Cost	B/C
			Safety	Travel Time	Fuel Use	Emissions		Initial Installation	Maintenance			
10334	Install high friction surface treatment (HFST)	10	$30,147,710.41					$282,500.00	$0.00	$30,147,710.41	$282,500.00	**106.72**

Assumptions:

- Maintenance costs are considered over the first 10 years following installation.
- Project support costs (part of initial installation) are 10% of the installation cost unless known to be less.