Memorandum

SRF No. 15064.05

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From: Erik Kappelman

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Subject: I-29 Cross-Median Crash Elimination Project

Overview

This document outlines the process through which the benefit cost analysis (BCA) for this grant application was created. BCAs of this kind commonly accompany grant applications to show the economic value or liability of a potential change or improvement. The results of this BCA will be presented, followed by the relevant methods and conclusions.

Description of Alternatives

For the purpose of this analysis, a No Build Alternative and Build Alternative are under consideration.

No Build Alternative

The No Build Alternative assumes the existing conditions on Interstate 29 between Fargo, North Dakota and Grand Forks, North Dakota.

Build Alternative

The Build Alternative is building a high-tension cable median barrier to eliminate over-the-median crashes on this segment of Interstate 29.

Results

Two statistics summarize the findings of the BCA. The first is the benefit cost ratio (B/C) that shows the ratio of measured economic benefits to the total cost of the project. The other is the net present value (NPV) of the project or the benefits minus the costs. The list below displays these statistics along with the costs and benefits. All dollars are displayed as 2021 dollars.

- B/C: 4.44
- NPV: $55,375,812
- Cost: $16,117,042
- Benefit: $71,492,853

These results show the project creates benefits for its community, beyond that of its original capital cost.

Benefit Measures

The methodology used for this BCA is based on Benefit-Cost Analysis Guidance for Discretionary Grant Programs, provided by USDOT.[1] Construction of the project is assumed to be completed in year 2026. Making the first year of benefit in the analysis 2027, and the BCA analyzes the subsequent 20 years ending in 2046. Any values that can be taken from the BCA guidance[1] are used, like truck driver wages or vehicle occupancy. Other sources are used and referenced, when necessary, in the BCA documentation and Workbook.

The main components analyzed included:

1. Safety
2. Travel Time Savings
3. Air Quality
4. Operations and Maintenance Costs
5. Residual Capital Valuation/Project Cost

Safety Impacts

Analysis of safety impacts is based on the new cable median barrier. These barriers are highly effective at stopping vehicles due to the high tension of the cable but are themselves less of a safety hazard than alternatives like a raised concrete barrier. These barriers are also quickly repaired and put back into service after a collision at a relatively low cost. The median cable barrier is expected to reduce injury and fatal crashes, while increasing property damage only crashes. The KABCO crash cost values, from the BCA guidance, were used to value differences in the number of crashes by severity. The safety analysis consists of five years of crash data, 2018 – 2022. This data is used to create an average per-year crash cost for both No Build and Build conditions. Table 1 summarizes existing crash data on the corridor.

Table 1. Crashes by Severity and Type (2018-2022)

Type	Fatal	Serious Injury	Minor Injury	Possible Injury	Property Damage Only	Total
Total	6	17	100	44	387	554

Source: North Dakota Department of Transportation,

[1] U.S. Department of Transportation. 2023. Benefit-Cost Analysis Guidance for Discretionary Grant Programs. U.S. Department of Transportation. https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

The Build scenario adds a median cable barrier, and this analysis uses crash modification factors (CMFs) to model the impact of the barrier on crashes along the corridor. The CMFs for each crash severity are shown in Table 2.

Table 2. Median Cable Barrier CMFs Used in Analysis

Intervention	CMF	Intervention	Source
Fatal	0.57	Install any type of median barrier	HANDBOOK OF ROAD SAFETY MEASURES, ELVIK, R. AND VAA, T., 2004
Injury Crashes	0.7	Install any type of median barrier	HANDBOOK OF ROAD SAFETY MEASURES, ELVIK, R. AND VAA, T., 2004
PDO Crashes	1.6	Install any type of median barrier	Iowa Planning-Level Crash Reduction Factor List, 2019; https://iowadot.gov/traffic/pdfs/CRFListVersion.pdf Page 5. CRF# RS-20A

Tables 3 and 4 display the results of applying the CMFs over the course of the BCA timeline. Table 3 shows the crash reductions by severity. Table 4 shows the same data but the associated crash costs from the BCA guidance have been applied. These tables show nominal results, The total discounted benefit of the changes to safety over the course of the project is about $72.8 million.

Table 3. Total Crash Reductions by Severity (2027-2046)

Scenario	Fatal	Incapacitating	Non-Incapacitating	Possible Injury	PDO	Total
No Build	24.0	68	400	176	1,548	2,216
Build	13.68	47.6	280	123.2	2,476.8	2,941.3
Crash Change	-10.32	-20.4	-120	-52.8	+928.8	+725.28

Table 4. Nominal Yearly KABCO Crash Costs and Benefits (2027-2046)

Scenario	Fatal-	Incapacitating	Non-Incapacitating	Possible Injury	PDO	Total
No Build	$283,200,000	$38,372,400	$61,480,000	$13,816,000	$6,192,000	$403,060,400
Build	$161,424,000	$26,860,680	$43,036,000	$9,671,200	$9,907,200	$250,899,080
Benefit	$121,776,000	$11,511,720	$18,444,000	$4,144,800	($3,715,200)	$152,161,320

Corridor Travel Time Costs

Reducing the number of over-the-center crashes also has a travel time benefit. These crashes often result in a temporary closure of a single lane or the roadway shoulder. Such a closure, even for a short time, will incur an additional travel time cost to the road users.

To estimate the amount of time a shoulder or lane closure will cost as well as how often these closures will occur, the Highway Capacity Manual Software (HCS) was used. This model was developed to represent the Interstate 29 freeway corridor traffic and geometric conditions. Crash rates for No Build and Build conditions were included in the model, and scenarios were modeled to reflect crashes and resulting travel time impacts for a complete year reflecting existing traffic conditions. Tables 5 and 6, below, display outputs of the HCS model and the demand used on the freeway to make the calculations. The HCS models used did not include two-lane closures. This was to keep the analysis conservative when estimating travel time savings. The benefit of the travel time savings after 7% discounting is about $370,000.

Table 5. HCS Travel Time Analysis Assumptions

Incident	No Build Incidents Per Mile	Build	Free Flow Speed	Incident Speed	Duration	Demand (vph)
Shoulder Closed	2.7	1.5	75 mph	63 mph	30 minutes	500
One Lane Closed	0.5	0.3	75 mph	38 mph	30 minutes	500

Table 6. HCS Travel Time Analysis Results

Incident	No Build Per Mile Per Year	Build Per Mile Per Year	Per Mile Per Year Savings	Annual Savings
Shoulder Closed	$299.43	$161.23	$138.20	$9,305
One Lane Closed	$232.89	$133.08	$99.91	$6,720
Total	$532.32	$294.31	$238.01	$16,025

Air Quality and Emissions

Reducing time spent idling or other delay can be used to calculate emissions impacts of the project. Using the change in VHT as a result of reduction in incidents, an equivalent VMT can be estimated for purposes of estimating impacts on emissions. This method uses MOVES model assumptions to translate VHT changes into VMT equivalents. Once these equivalents are calculated, discounted benefits from emissions reductions is $24,000 for NO_x, SO^2, and $PM_{1.5}$ and the discounted benefits from CO^2 reductions is $85,000. Total combined emission benefits are about $109,000 as a result of the project. Specific reductions, by pollutant, are displayed below in Table 7.

Table 7. Emission Reductions

Emission Type	Reduction
CO2 (metric tons)	-1429
NOx (kg)	-1264
SO2 (kg)	-9
PM2.5 (kg)	-28

Maintenance and Operations

The increase to yearly maintenance of the facility after the addition of the median cable barrier is about $245,000 and the total discounted cost over the 2027 to 2046 analysis period is about $1.8 million.

Capital Costs and Residual Value

The median cable barrier has a capital cost of $16,117,042 in 2021 dollars. After the twenty-year analysis period, the cable barrier will have five years of remaining useful life. This leaves a nominal residual value of about $2.7 million. Once the value is discounted and the post-project maintenance is accounted for, total residual value in 2021 dollars is about $314,000.

Conclusion

This BCA shows that installing a median cable barrier between Fargo North Dakota and Grand Forks North Dakota on Interstate 29 is a cost-effective project. After calculating benefits related to safety, travel delays, air quality, state-of-good-repair, this project has a B/C of 4.44 meaning for every $100 spent on this project users will receive benefits of about $444.

[i] Benefit-Cost Analysis Guidance for Discretionary Grant Programs, U.S. Department of Transportation, Revised January 2023. https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf