MDOT OPERATIONS TEMPLATE

PROJECT SUBMITTAL MANUAL

Version 2.4

June 2021

PREPARED BY:

MDOT Congestion and Reliability Section

6333 Lansing Rd

Lansing, MI 48917

Document Change Record				
Version	**Date**	**Author(s)**	**Reviewed by**	**Change**
1.0	June 2019	Jeff Feeney, PE, PTOE Mike Lodes, PE Matt Hunter, PE Adam Engbring	Dani Booms, PE	Draft Document
1.1	July 2019	Mike Lodes, PE Adam Engbring	Jeff Feeney, PE, PTOE	Address comments on v1.0
1.2	August 2019	Mike Lodes, PE Adam Engbring	Jeff Feeney, PE, PTOE	Address Section 1 comments on v1.1
2.0	Sept 2019	Mike Lodes, PE	Skyler Waaso, PE, PTOE	Address Sections 2-11 comments on v1.1 and incorporate C&R Benefit Cost Spreadsheet methodology
2.1	Sept 2019	Mike Lodes, PE	Jeff Feeney, PE, PTOE	Address MDOT comments on v2.0
2.2	Nov 2019	Mike Lodes, PE	Jeff Feeney, PE, PTOE	Add example projects in Appendix A
2.3	Feb 2020	Jason Firman, PE	John Engle, PE	Revises references to the old templates which are combined into one "Operations Template", revised reliability peak periods.
2.4	June 2021	John Engle, PE	Jason Firman, PE	Added information on Crash Investigation Site methodology for calculating a B/C value.

Table of Contents

1. Introduction

The purpose of this document is to provide guidance for the preparation of submittals to the Congestion and Reliability (C&R) Section's Operations Template. Regions/TSCs should consider the following when preparing a submittal to the Operations Template:

- The analysis methodology presented in this guidance document is intended to streamline the analysis process, provide consistency between project submittals, and align with the Operations Template Final Submission Form.
- Refer to the Annual Call for Projects Letter for the most current timeline and evaluation criteria. The Annual Call for Projects Letter will overrule if discrepancies are identified in this guidance document.

1.1 Final Submission Requirements

Regions/TSCs must prepare a Final Submission Form for each project being submitted for funding consideration under the Operations Template. The Final Submission Forms are fillable PDFs. This document provides guidance on how to fill out the forms and identifies several tools available to assist with preparing the necessary information to complete the Final Submission Forms, as shown in **Figure 1**.

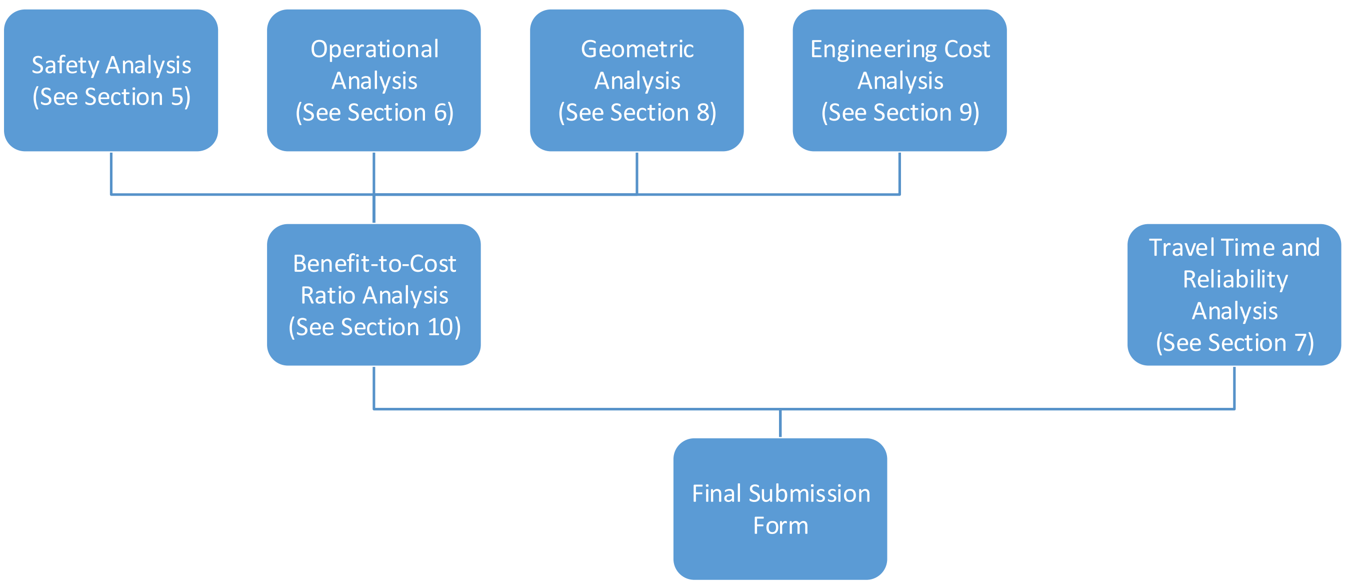


Figure 1: Final Submission Form Requirements

After analyses have been performed and the Final Submission Form is complete, Regions/TSCs should place the Final Submission Form in the ProjectWise folder specified in the Annual Call for Projects Letter.

1.2 Additional Reporting Requirements

There are slightly different requirements for reporting if the form is prepared by MDOT or by a Consultant, as identified below.

MDOT-Prepared: If MDOT performs the analysis for Final Submission Form, relevant supporting documents (e.g., spreadsheets, traffic models) must also be submitted to ProjectWise.

Consultant-Prepared: If a consultant performs the analysis for Final Submission Form, a final report must be prepared according to the sample final report referenced in this guidance document. Final report and relevant supporting documents (e.g., spreadsheets, traffic models) must be submitted to ProjectWise.

1.3 Other Reference Documents

In addition to this guidance document, the submittal process relies on the following external documents. External documents are referenced throughout this guidance document as appropriate and are available upon request from C&R.

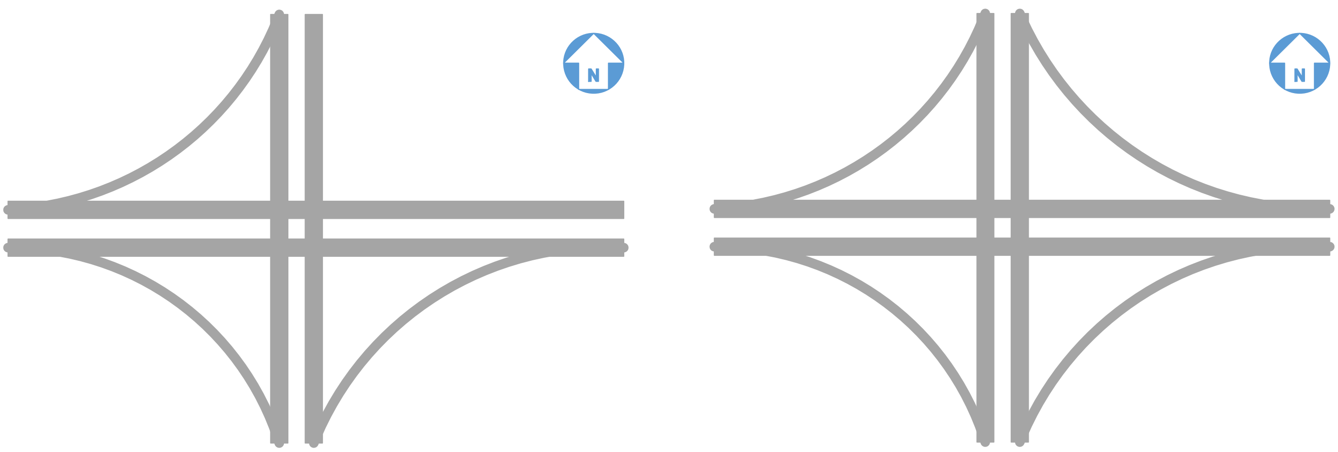
- Annual Call for Projects Letter
- Operations Final Submission Form
- C&R Benefit Cost Spreadsheet
  - Used to estimate construction costs, determine operational benefits from traffic analysis, input benefits (safety and operational), and output Benefit-to-Cost (B/C) ratio
- MDOT's Signal Optimization Benefit Cost Analysis Spreadsheet
  - Alternate tool that may be used to quantify operational benefits from SimTraffic
- MDOT TOR spreadsheet
  - Used to determine safety benefits
- Sample Report
  - Provides an editable Word document with appropriate sections, tables, and figures
- Previous Report Example
  - Provides a final report prepared as part of previous year's call for projects. There may be minor differences between the guidance provided in this manual and the example report (due to being prepared in advance of the manual). The guidance provided in this manual should be used in the case of any contradictions.

2. Project Suitability

The submittal process for Operations Template funds is targeted at operational improvements, rather than capacity improvements.

An operational improvement restores or optimizes theoretical capacity and safe flow of traffic on the existing number of permanent, through travel lanes within the corridor. This may include, but is not limited to, geometric realignments (including new freeway ramps that supplement existing traffic movements) and improvements of existing travel lanes, the addition or improvement of auxiliary lanes (excluding High Occupancy Vehicle or High Occupancy Toll lanes), and the extension of an existing through lane (however it must be shown that the operational issue is not simply moved further downstream of its existing location).

Capacity improvements are typically not eligible for Operations Template funds. Capacity improvements are defined as adding one or more permanent, through lanes of travel resulting in an increase in the capacity of the roadway. The addition of a new interchange or the addition of a non-existent movement at an existing interchange is also considered a capacity improvement project. For example, adding a WB off-ramp where one previously did not exist would be considered a capacity improvement (See **Figure 2**).



No Build Scenario – No WB off-ramp

Build Scenario – WB off-ramp added

Figure 2: Example of Capacity Improvement

The most suitable projects have evidence of an existing congestion problem, such as a Planning Time Index (PTI) $\geq$ 2.0, Travel Time Index (TTI) $\geq$ 1.5, Level of Travel Time Reliability (LOTTR)$\geq$ 1.5, or as otherwise defined in the Annual Call for Projects.

Table 1 provides project type, description, and examples of suitable projects. The table is not meant to be an exhaustive list, rather provide general direction and guidance on typical projects that align with the Operations Templates' purposes of improving congestion and reliability. "A Michigan Toolbox for Mitigating Traffic Congestion" provides example congestion mitigation strategies that are typically aligned with the Operations Template goals.

Table 1: Suitable Projects

Project Type	Project Description	Project Examples
Safety Improvement	Reduces crashes at high-crash locations where congestion and/or travel-time reliability are known issues.	Road diets, traffic calming techniques, raised median, indirect left-turns, and sight distance improvements. Safety improvements are not required to result in an operational benefit.
Targeted Bottleneck Improvement	Address localized bottleneck issues that improve traffic flow and travel time reliability without moving the issue downstream.	Eliminating/improving weaving sections, acceleration/deceleration lane length deficiencies, closely spaced interchanges, deficient ramp signals, intersection configuration, turn lane capacity, and lane drops.
Demand Management	Reduces the total number of vehicles using the road system and/or spreading vehicles from peak to off-peak periods.	Transit enhancements to increase ridership and predictive traveler information.
Multi-modal/modal shift	Decreases single passenger vehicle trips by improving pedestrian, bicycle, and transit facilities.	Complete street solutions that enable safe access for pedestrians, bicycles, motorists, and transit riders. Complete street solutions may include safe pedestrian crossings, median islands, accessible pedestrian signals, bus pullout lanes, transit signal priority, and queue jump lanes.
Traffic Control	Reduces congestion due to a change in traffic control or operations, such as traffic signals, stop-control, etc.	Signal operations (i.e., phasing adjustments), central signal control system, communications upgrades, roundabouts, signalization. Signalization projects should add new functionality such as monitoring or additional detection; modernizations that replace in-kind are not suitable.
Access Management	Improves traffic flow through access management strategies, such as a reduction in conflict points and restricting access points close to intersections. Agreements for removing or modifying driveways should be arranged prior to requesting funding.	Driveway/crossover consolidation, median treatments, intersection spacing, innovative intersection configuration.
Innovative	Reduces congestion and improves travel time reliability through innovative strategies.	Integrated corridor management, active traffic and demand management (i.e., flex routes, ramp metering), and emerging mobility technologies.

3. Traffic and Safety Analysis Methodology

Previously, the traffic operations and safety analysis required for the Operations Template submittals was managed by C&R. Beginning with FY2021 submittals (for funding through FY2026), the traffic operations and safety analysis should be performed or managed by the Region/TSC staff. This analysis can be performed by Region/TSC staff or contracted to a consultant. If consultant support is utilized, it should be paid for and managed by the Region/TSC, and C&R should be involved in the analysis, included on key correspondence, and included on any meeting invitations. Region/TSC should consider including other stakeholders (e.g., local agencies, MDOT Environmental Section) to analysis meetings.

For the duration of this document, the entity performing the analysis is referred to as "Preparer," which may consist of MDOT staff or a consultant. The Preparer must complete a project analysis to determine the operational benefits, safety benefits, and cost of the project. At a minimum, the analysis should include an alternatives analysis comparing a future no-build alternative and at least two future build alternatives based on proposed improvements. Future conditions should be based on a 20-year horizon. The submittal requirements for consultant-prepared and MDOT-prepared analyses are provided in **Section 1.1**. Contact C&R if additional clarification is needed.

4. Data Collection

Preparers are responsible to collect the data necessary to conduct B/C analysis and complete the Operations Template Final Submission Form. The following sections provide guidance on data collection. The Preparer should coordinate with the Congestion and Reliability Section to confirm data needs.

4.1 Study Area

Typical operational projects include intersections, highway segments, and freeway facilities. The following bulleted list includes guidance on determining the study area for by project type. However, the Region/TSC should confirm the study area with the C&R prior to performing the analysis. The C&R may request additional intersections/segments be included in the analysis to ensure impacts outside the project limits are considered.

- **Intersection** - Include signalized intersections adjacent to each approach of the subject intersection if intersection spacing is <1 mile.
- **Highway Segment** - Segments located >1 mile away from an intersection can be analyzed as standalone segments. If distance to nearest intersection is <1 mile, flow is considered interrupted and the intersection needs to be included in traffic analysis.
- **Freeway Facility –** Contact C&R.

4.2 Traffic Counts

Wherever possible, traffic count data should be collected by the requesting Region/TSC and provided to the entity performing the traffic impact analysis. Traffic counts used in the analysis must be taken within the last 3 years unless it can be shown very little has changed. If there has been a significant operational change since the last traffic counts, new counts should be taken. If the Region/TSC is unable to collect the necessary data, the Region/TSC may request the counts be taken by MDOT Statewide and Urban Travel Analysis Unit or by an outside contract. Any costs for obtaining the traffic data should be paid for by the requesting Region/TSC or as part of the traffic analysis contract. Traffic count data should include 24-hour bi-directional tube counts on study area highway segments and 8-hour intersection peak hour (two hours AM, two hours midday, four hours PM) turning movement counts at study area intersections. Additional traffic data such as vehicle classification, pedestrian, bicycle, speed, queuing, and origin/destination should be collected if applicable to the proposed project, contact the C&R to confirm additional data collection needs.

MDOT's Transportation Data Management System (TDMS) provides previously collected traffic counts that may be used in place of collecting new data.

4.3 Growth and Adjustment Factors

The Preparer must develop projected 20-year horizon traffic volume conditions. Preparer should contact MDOT Statewide and Urban Travel Analysis Unit to obtain annual traffic growth rate and seasonal adjustment factors, if needed due to location of study or time of year data was collected.

If the proposed improvement is anticipated to result in changes to travel patterns, induced demand, modal shift, or other adjustments to traffic volumes, contact the C&R to confirm adjustment factors.

4.4 Crash Data

The most recent full three years of available crash data should be collected from the Traffic Crash Analysis Tool (TCAT) 2.0 from the Traffic Improvement Association (TIA). Crash data for intersections and roadway segments can also be collected using Michigan Traffic Crash Facts Data Query Tool. If fatalities occurred within the three-year timeframe, an additional two years of data should be added. For intersections, include crash data within a 250-foot radius. For freeway or non-freeway highway segments, crash data should include the subject segment(s) and 0.1-mile extensions at the beginning and end.

5. Safety Analysis

Safety improvements are a key consideration in the selection process as they contribute to: 1) the Department's overall effort to reduce crashes on the state highway system, and 2) the quantifiable safety benefits associated with the proposed project. To evaluate safety for projects submitted for funding through the Operations Template, the MDOT TOR spreadsheet should be used to perform a time of return (TOR) analysis for each proposed alternative.

Projects will be evaluated based on the overall B/C ratio, which includes benefits attributable to both safety and operations improvements. For projects that focus on mitigating congestion and reliability related crashes, much of the benefit will be attributable to operations, rather than safety. Therefore, much higher TORs will be acceptable than on typical safety-focused projects.

Table 2 provides an example TOR safety analysis results.

Table 2: Example TOR Safety Analysis Results

Total Network	Alt 1	Alt 2	Alt 3
Annual Benefit (present value with inflation)	$329,558	$369,209	$369,209
Project Cost	$504,613	$1,388,933	$1,374,614
TOR = Cost / Annual Benefit	1.53	3.76	3.72

The safety analysis performed to support this submittal process is needed to compute a B/C ratio. Additional safety analyses, such as a road safety audit (RSA), may be needed at later stages in the project. Each project must follow RSA guidelines, but this document does not include specific guidance on RSA or other safety analyses. C&R encourages Preparers to coordinate with MDOT Region Traffic and Safety Engineer to discuss opportunities to leverage information used in this submittal for the RSA, including completing the RSA process in conjunction with the C&R safety analysis or accounting for the completion of the RSA within the project's schedule and budget. The Preparer should coordinate with MDOT Region Traffic and Safety Engineer to confirm approach.

6. Operational Analysis

The Preparer should perform AM and PM peak hour operational analyses for the future no-build (FNB) alternative and at least two future build (FB) alternatives. It is recommended to perform an Off-Peak analysis to capture operational benefits outside of the peak periods. The operational analysis should include a level of service (LOS) analysis and development of measures of effectiveness (MOEs) sufficient for quantifying the operational benefits in person-$. FNB and FB alternatives should be based on 20-year analysis horizons. The final analysis report should summarize both the benefits quantified through the C&R Benefit Cost Spreadsheet and LOS/delay/density for all study area locations, as shown in the sample report. Existing LOS is a required input on the Operations Template final submittal form. The project may use the worst delay or level-of-service that is applicable to the issue being corrected for final submittal reporting.

Preferred traffic analysis software tools are shown in **Table 3**. Alternate tools and/or methodology may be used but should be approved by the C&R**.**

Table 3: Traffic Analysis Software Tools

Software	Location	Considerations/Approach
Synchro/SimTraffic	Traffic signals and unsignalized intersections	Follow the procedures described in the most recent MDOT Electronic Traffic Control Device Guidelines
RODEL	Roundabouts	Follow guidance provided in MDOT Roundabout Design Aid (MRDA) and NCHRP 672: Roundabouts: An Informational Guide, Second Edition. See **Section 6.6.**
Highway Capacity Software (HCS)	Freeway segments, typically ramp extensions or addition of auxiliary lanes	Follow methodology defined in the Highway Capacity Manual (HCM).
VISSIM	Where the above tools do not adequately measure the traffic impacts (i.e., heavily congested locations, unusual geometric conditions)	Follow guidance provided in MDOT VISSIM Protocol Document. See **Section 6.5**.

After completing traffic operational analysis, Preparer must quantify operational benefits which will be used to support the overall project B/C ratio calculation. The preferred approach is to use the C&R Benefit Cost Spreadsheet to quantify projected operational benefits for each alternative. The following subsections describe the operational benefits tabs included in the C&R Benefit Cost Spreadsheet tool. The cell color conventions shown in **Figure 3** are utilized through the C&R Benefit Cost Spreadsheet tool.

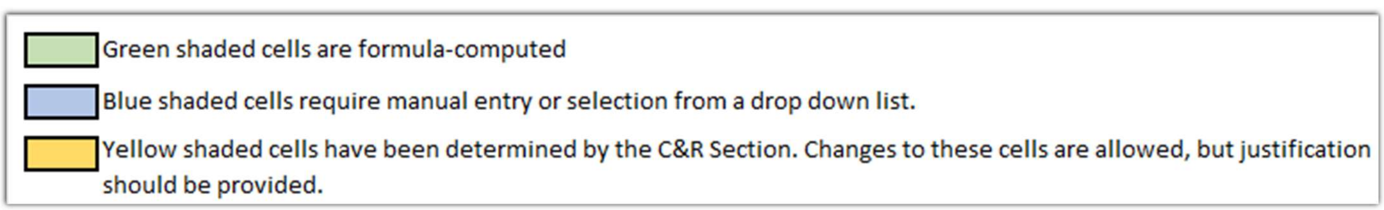


Figure 3: C&R Benefit Cost Spreadsheet Color Conventions

6.1 Intersection - C&R Benefit Cost Spreadsheet

The **Intersection Benefits** tab of the C&R Submittal Benefit Cost Spreadsheet quantifies operational benefits based on average user delay. This tab is intended for intersection analyses (e.g., Synchro, SimTraffic, RODEL) but can also be used for projects where average user delay is reported. The subject tab quantifies operational benefits between FB and FNB conditions based on the Annual Delay Savings (person-$) as indicated in Equations 1 through 4.

$$Total\ Peak\ Period\ Delay = Avg.Delay \times Peak\ Hour\ Volume \text{ (Eq. 1)}$$

$$Daily\ Delay\ Savings = Total\ Peak\ Period\ Delay_{FNB} - Total\ Peak\ Period\ Delay_{FB} \text{ (Eq. 2)}$$

$$Annual\ Delay\ Savings\ (veh - hr) = Daily\ Delay\ Savings \times Avg.Workdays/Year \text{ (Eq. 3)}$$

$$\begin{aligned}\boldsymbol{Annual\ Delay\ Savings\ (person} - \$) &= Annual\ Delay\ Savings\ (veh - hr) \times Avg.Vehicle\ Occupancy \\ &\times Weighted\ Avg.User\ Delay\ Cost\ Rate\left(\frac{\$}{veh}hr\right)(\text{Eq. }4)\end{aligned}$$

The following procedure should be used for quantifying operational benefits using the **Intersection Benefits** tab:

1. Perform operational analysis using chosen tool (e.g., HCS, RODEL, Synchro).
2. Make a copy of **Intersection Benefits** and rename with the appropriate alternative (e.g., Alt 1 – Intersection Benefits).
3. Enter the analysis locations. See #1 on **Figure 4**.
    - *Enter entire network values or individual intersections. If entering individual intersections, all intersections must be accounted for in FNB and FB conditions*
4. Enter Peak Hour Volumes (veh/hour). See #2 on **Figure 4**.
    - *Ensure that Peak Hour Volume entered in the spreadsheet is consistent with the traffic analysis tool and the analysis locations entered in #1 on* ***Figure 4.*** *For example, if each intersection is entered, then the Peak Hour Volume should be the entering volume for each intersection.*
5. Enter Average Delay (sec/veh). See #3 on **Figure 4.**
    - *Spreadsheet will compute Total Peak Period Delay for each analysis location. See #4 on* ***Figure 4.***
6. Confirm default values are suitable for project. See **Figure 5.**
    - *Obtain current user delay costs and enter in "Assumptions" section from https://www.michigan.gov/mdot/0,4616,7-151-9625_54944-227053--,00.html*
    - *Cell will turn red if default value is changed. Provide justification for changes to default values.*
    - *Use* ***Peak Per Adj Factor*** *tab to calculate modified peak period adjustment factor, if needed. Calculated values should only be used if greater than the default value.*
7. Spreadsheet will compute Total Delay and Delay Savings. See **Figure 6**. The total annual delay savings will be used as an input to the B/C ratio. Example 1 and Example 2 in **Appendix A** provide sample intersection and roundabout analyses, respectively.

		Future No-Build								
ID	Location (Network or Intersection)	Peak Hour Volume (vph)			Average Delay (sec/veh)			Total Peak Period Delay(veh-hrs)		
		AM	Off Peak	PM	AM	Off Peak	PM	AM	Off Peak	PM
	Totals				Totals			278.1	[illegible]	518.4
1	Lake Lansing Rd @ Abbott Rd	3500	[illegible]	4405	21.2	[illegible]	23.4	51.5	[illegible]	97.4
2	Lake Lansing Rd @ Hagadorn Rd	3500	[illegible]	4405	18.3	3.0	19.0	44.5	[illegible]	79.0
3	Burcham Drive between Abbot Rd and Hagadorn R	3665	3200	4630	43.0	31.0	47.0	109.4	110.2	205.5
4	Entire Network	3375	1800	4380	31.0	22.0	33.0	72.7	44.0	136.5

1 2 3 4

Figure 4: Intersection Benefit Inputs

Assumptions	
Cells will turn red if changed from default value. Provide justification if modifying these values.	
250	Avg. # of Workdays/Year
1.1	Avg. Vehicle Occupancy
2.0%	Percentage of trucks
$19.07	Avg. Delay Cost Rate for Passenger Car ($/veh-hr)
$33.65	Avg. Delay Cost Rate for Truck ($/veh-hr)
$19.36	Weighted Avg. Delay Cost Rate ($/veh-hr)
2.50	AM Peak Period Adjustment Factor
6.75	[illegible]
3.50	[illegible]

No Change to Default Values

Assumptions	
Cells will turn red if changed from default value. Provide justification if modifying these values.	
250	Avg. # of Workdays/Year
1.4	Avg. Vehicle Occupancy
2.0%	Percentage of trucks
$19.07	Avg. Delay Cost Rate for Passenger Car ($/veh-hr)
$33.65	Avg. Delay Cost Rate for Truck ($/veh-hr)
$19.36	Weighted Avg. Delay Cost Rate ($/veh-hr)
2.50	AM Peak Period Adjustment Factor
[illegible]	[illegible]
[illegible]	[illegible]

Default Values Modified

Figure 5: Intersection Benefit Assumptions

	Total Peak Period Delay		Delay Savings			
	Future No-Build	Future Build	Daily		Yearly	
	veh-hrs	veh-hrs	veh-hrs	Person-$	veh-hrs	Person-$
AM Peak	278	213	65	$ 1,388	16,293	$ 346,984
Off Peak	178	138	40	$ 854	10,028	$ 213,552
PM Peak	518	385	133	[illegible]	[illegible]	$ 710,070
Total	974	736	239	$ 5,082	59,664	$1,270,606

Annual Savings

Figure 6: Intersection Benefit Results

Average delay can be obtained from several traffic analysis tools, as shown in **Figure 7**, **Figure 8**, and **Figure 9** for SimTraffic, Synchro, and RODEL, respectively.

SimTraffic Performance Report
Existing AM Peak 09/11/2019

9044: Pennsylvania & Harper(Push Buttons)/Harper Performance by approach

Approach	EB	WB	All
Denied Del/Veh (s)	0.1	0.0	0.0
Total Del/Veh (s)	0.5	1.2	1.0

9045: Cadillac & Harper Performance by approach

Approach	EB	WB	NB	SB	All
Denied Del/Veh (s)	0.0	0.4	0.1	0.0	0.3
Total Del/Veh (s)	14.1	86.1	56.4	13.7	69.3

9046: M-3 (Gratiot) & Cadillac Performance by approach

Approach	WB	NB	SB	All
Denied Del/Veh (s)	0.0	0.0	0.4	0.3
Total Del/Veh (s)	4.9	0.3	17.5	14.4

Total Network Performance

Denied Del/Veh (s)	0.6
Total Del/Veh (s)	69.9

Average Delay

Figure 7: Average Delay Output from SimTraffic

Lanes, Volumes, Timings
9045: Cadillac & Harper 09/11/2019

Lane Group	EBT	WBL	WBT	NBT	SBL	SBT
Act Effct Green (s)	34.3	46.8	47.3	32.0	32.0	31.5
Actuated g/C Ratio	0.38	0.52	0.53	0.36	0.36	0.35
v/c Ratio	0.14	0.08	0.43	0.15	0.02	0.04
Control Delay	10.3	11.3	13.9	16.1	19.1	12.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	10.3	11.3	13.9	16.1	19.1	12.5
LOS	B	B	B	B	B	B
Approach Delay	10.3		13.8	16.1		14.7
Approach LOS	B		B	B		B

Intersection Summary
Cycle Length: 90
Actuated Cycle Length: 90
Offset: 74 (82%), Referenced to phase 4:EBT and 8:WBTL, Start of Green
Control Type: Pretimed
Maximum v/c Ratio: 0.43
Intersection Signal Delay: 13.4 Intersection LOS: B
Intersection Capacity Utilization 74.6% ICU Level of Service D
Analysis Period (min) 15

Average Delay

Figure 8: Average Delay Output from Synchro

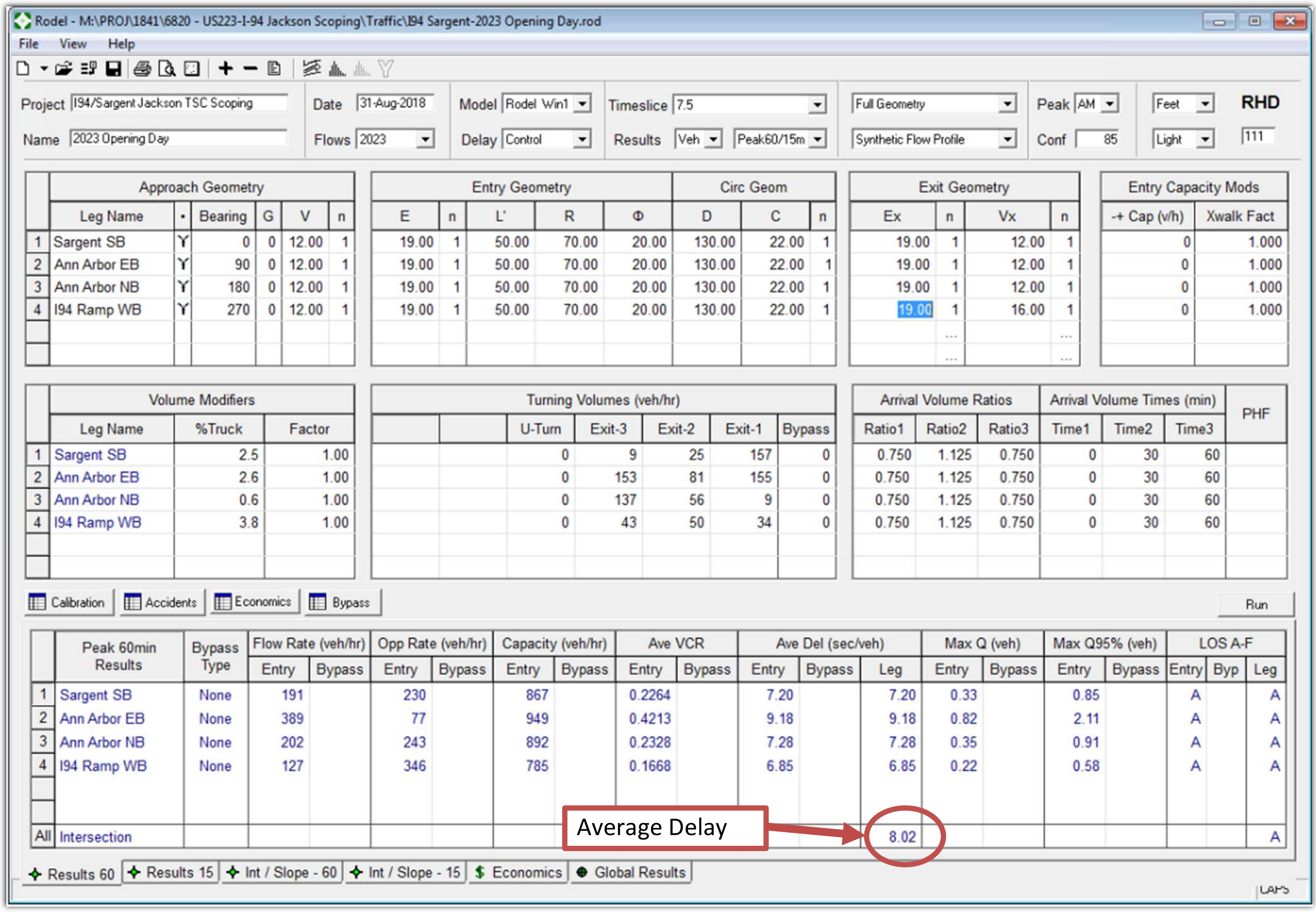


Figure 9: Average Delay Output from RODEL

6.2 Freeway - C&R Benefit Cost Spreadsheet

The **Freeway (HCS) Benefits** tab of the C&R Submittal Benefit Cost Spreadsheet quantifies operational benefits based on average speed. This tab is intended for freeway segment analyses (e.g., HCS analysis) but can also be used for projects where average speed is reported. The subject tab quantifies operational benefits between FB and FNB conditions based on the Annual Delay Savings (person-$) as indicated in Equations 5 through 9.

$$Avg.Travel\ Time = Avg.Speed \times Segment\ Length \text{ (Eq. 5)}$$

$$Total\ Travel\ Time = Avg.Travel\ Time \times Peak\ Hour\ Volume \text{ (Eq. 6)}$$

$$Daily\ Delay\ Savings = Total\ Travel\ Time_{FNB} - Total\ Travel\ Time_{FB} \text{ (Eq. 7)}$$

$$Annual\ Delay\ Savings\ (veh-hr) = Daily\ Delay\ Savings \times Avg.Workdays/Year \text{ (Eq. 8)}$$

$$\boldsymbol{Annual\ Delay\ Savings\ (person-\$)} = Annual\ Delay\ Savings\ (veh-hr) \times Avg.Vehicle\ Occupancy \times Weighted\ Avg.User\ Delay\ Cost\ Rate\left(\frac{\$}{veh}hr\right) \text{(Eq. 9)}$$

The following procedure should be used for quantifying operational benefits using the **Freeway (HCS) Benefits** tab:

1. Perform operational analysis using chosen tool (e.g., HCS).
2. Make a copy of **Freeway (HCS) Benefits** and rename with the appropriate alternative (e.g., Alt 1 – Freeway (HCS) Benefits).

3. Enter the Segment and Segment Type. See #1 on **Figure 10.**
    - *Each segment name must be unique and identify the segment name, type, and analysis alternative.*
    - *All segments must be accounted for in FNB and FB conditions.*
    - *Study area must have the same beginning and end point for the FNB and FB conditions.*
4. Enter segment length (ft). See #2 on **Figure 10**.
5. Enter Peak Hour Volumes (veh/hour). See #3 on **Figure 10.**
    - *Ensure that Peak Hour Volume entered in the spreadsheet is consistent with the traffic analysis tool and the analysis locations entered in #3 on **Figure 10.***
6. Enter Average Speed (mph). See #4 on **Figure 10.**
    - *Spreadsheet will compute Average Travel Time and Total Period Travel Time for each analysis location. See #5 on **Figure 10.***
7. Confirm that default values are suitable for project. See **Figure 11.**
    - *Obtain current user delay costs and enter in "Assumptions" section from https://www.michigan.gov/mdot/0,4616,7-151-9625_54944-227053--,00.html*
    - *Cell will turn red if default value is changed. Provide justification for changes to default values.*
    - *Use **Peak Per Adj Factor** tab to calculate modified peak period adjustment factor. Calculated values should only be used if larger than the default value.*
8. Spreadsheet will compute Total Travel Time and Delay Savings. See **Figure 12.** The total annual delay savings will be used as an input to the B/C ratio. Example 3 and Example 4 in **Appendix A** provide sample ramp extension and weave analyses, respectively.
    - *For HCS analysis on ramp extensions or auxiliary lane additions, preparer may omit analyses that do not result in positive delay savings. To omit, preparer should enter zero in the appropriate row in the Person-$ column.*

Future No-Build															
				Peak Hour Volume (vph)			Average Speed (mph)			Average Travel Time (sec/veh)			Total Period Travel Time (veh-hrs)		
ID	Segment	Segment Type	Length (ft)	AM	Off Peak	PM	AM	Off Peak	PM	AM	Off Peak	PM	AM	Off Peak	PM
	Totals		9156	Totals			65.9	0.0	65.0				225.6	0.0	396.4
1	I-75 SB Brist[illegible]	Diverge	1500	3500		4405	63.8		64.0	16.0		16.0	39.0		66.5
2	I-75 SB Bristol	Basic	11[illegible]5	3500		4405	70.0		68.9	10.8		10.9	26.2		45.5
3	I-75 SB Bristol	Weave	[illegible]37	3665		4630	61.7		60.5	10.4		10.6	[illegible]		46.2
4	I-75 SB Bristol	Basic	914	3375		4380	70.0		68.7	8.9		9.1	20[illegible]		37.5
5	I-75 SB Brist[illegible]	Merge	1500	3465		4505	63.7		62.6	16.1		16.3	[illegible].6		69.5
6	I-75 SB S of Bristo	Basic	1700	3465		4505	70.0		68.3	16.6		17.0	39.8		72.2
7															
8															
9	I-69 WB to I-75 SB	Merge	1500	3075		3795	62.8		62.1	16.3		16.5	34.8		59.0

Figure 10: Freeway (HCS) Benefit Inputs

Assumptions	
Cells will turn red if changed from default value. Provide justification if modifying these values.	
250	Avg. # of Workdays/Year
1.1	Avg. Vehicle Occupancy
2.0%	Percentage of trucks
$19.07	Avg. Delay Cost Rate for Passenger Car ($/veh-hr)
$33.65	Avg. Delay Cost Rate for Truck ($/veh-hr)
$19.36	Weighted Avg. Delay Cost Rate ($/veh-hr)
2.50	AM Peak Period Adjustment Factor
6.[illegible]	[illegible]
3.[illegible]	[illegible]

No Change to Default Values

Assumptions	
Cells will turn red if changed from default value. Provide justification if modifying these values.	
250	Avg. # of Workdays/Year
1.4	Avg. Vehicle Occupancy
2.0[illegible]	Percentage of trucks
$19.07	Avg. Delay Cost Rate for Passenger Car ($/veh-hr)
$33.65	[illegible]g. Delay Cost Rate for Truck ($/veh-hr)
$19.36	Wei[illegible]ted Avg. Delay Cost Rate ($/veh-hr)
2.50	AM Peak [illegible]eriod Adjustment Factor
[illegible]	[illegible]
[illegible]	[illegible]

Default Values Modified

Figure 11: Freeway (HCS) Benefit Assumptions

	Total Peak Period Travel Time		Delay Savings			
	Future No-Build	Future Build	Daily		Yearly	
	veh-hrs	veh-hrs	veh-hrs	Person-$	veh-hrs	Person-$
AM Peak	226	207	18	$ 390	4,584	$ 97,621
Off Peak	0	0	0	$ -	-	$ -
PM Peak	396	354	42	$ [illegible]	[illegible]	$ 225,804
Total	622	561	61	$ 1,294	15,187	$ 323,425

Annual Savings

Figure 12: Freeway (HCS) Benefit Results

Average speed can be obtained from several traffic analysis tools. **Figure 13** and **Figure 14** show example MOE reports containing average speed from HCS2010 and HCS7, respectively.

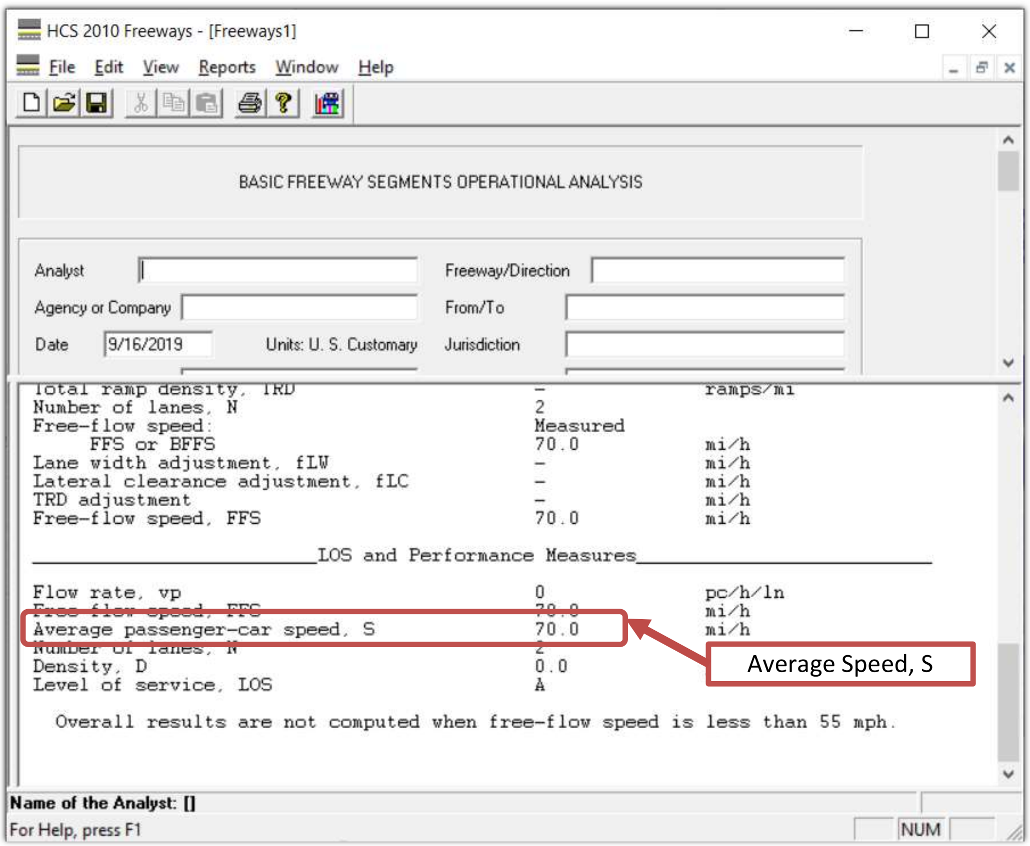
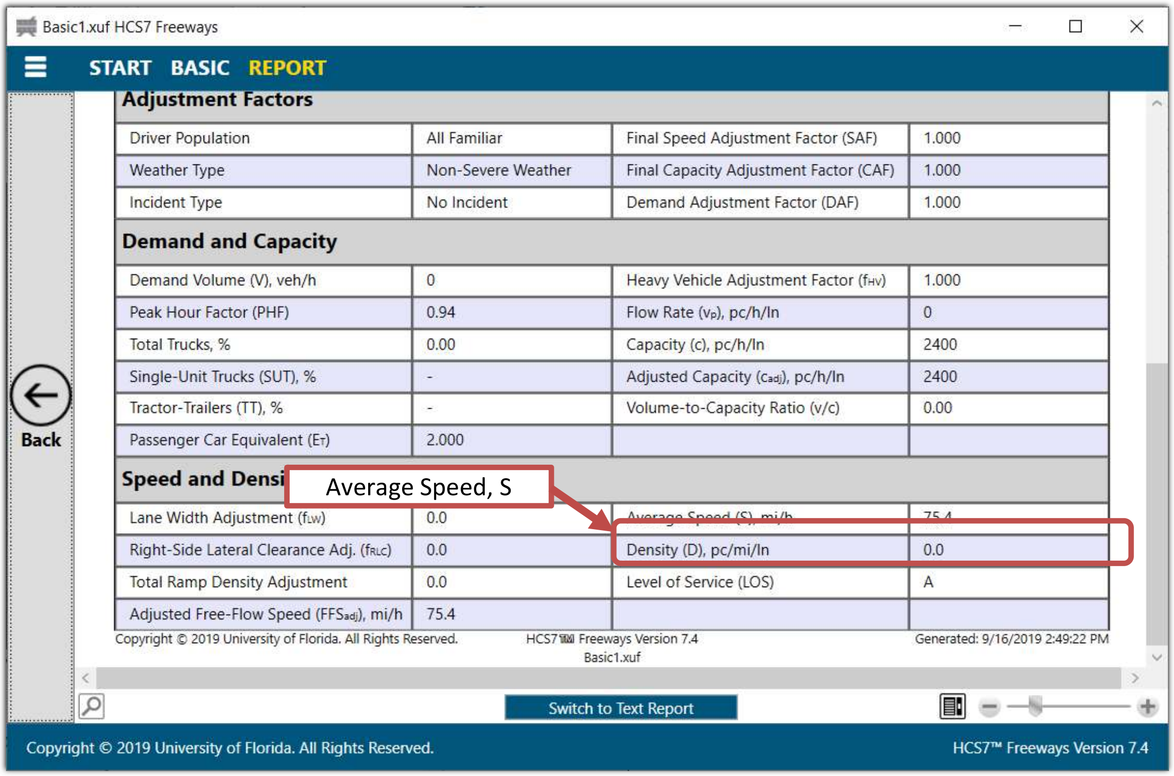


Figure 13: Average Speed Output from HCS 2010

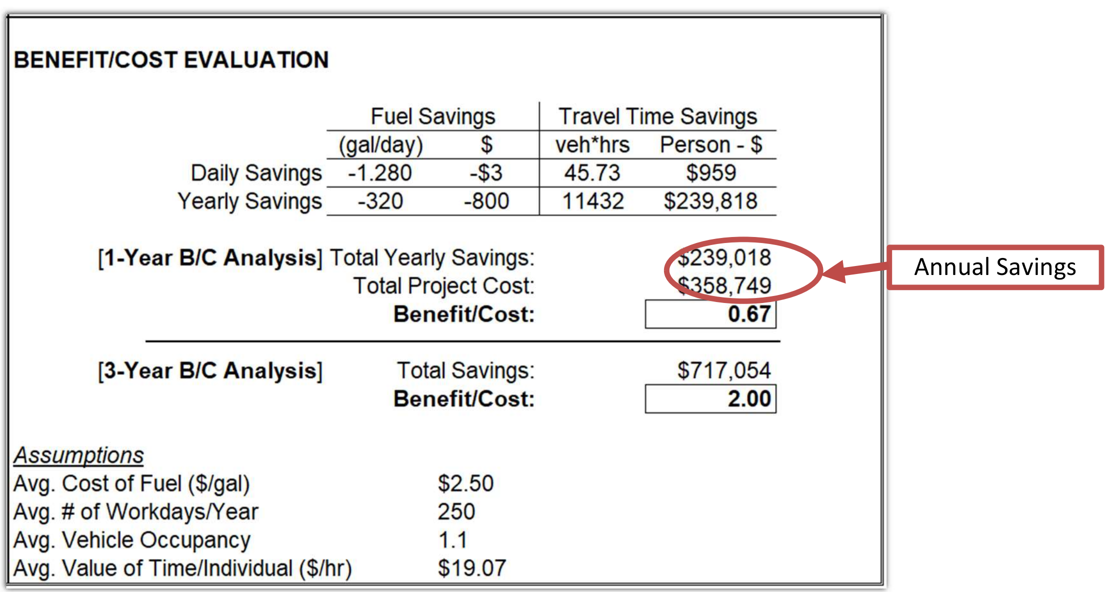


Adjustment Factors			
Driver Population	All Familiar	Final Speed Adjustment Factor (SAF)	1.000
Weather Type	Non-Severe Weather	Final Capacity Adjustment Factor (CAF)	1.000
Incident Type	No Incident	Demand Adjustment Factor (DAF)	1.000
Demand and Capacity			
Demand Volume (V), veh/h	0	Heavy Vehicle Adjustment Factor (f_{HV})	1.000
Peak Hour Factor (PHF)	0.94	Flow Rate (v_p), pc/h/ln	0
Total Trucks, %	0.00	Capacity (c), pc/h/ln	2400
Single-Unit Trucks (SUT), %	-	Adjusted Capacity (c_{adj}), pc/h/ln	2400
Tractor-Trailers (TT), %	-	Volume-to-Capacity Ratio (v/c)	0.00
Passenger Car Equivalent (E_T)	2.000		
Speed and Density			
Lane Width Adjustment (f_{LW})	0.0	Average Speed (S), mi/h	75.4
Right-Side Lateral Clearance Adj. (f_{RLC})	0.0	Density (D), pc/mi/ln	0.0
Total Ramp Density Adjustment	0.0	Level of Service (LOS)	A
Adjusted Free-Flow Speed (FFS_{adj}), mi/h	75.4		

Figure 14: Average Speed Output from HCS7

6.3 MDOT Signal Optimization Benefit/Cost Analysis Spreadsheet

The C&R Benefit Cost Spreadsheet is the preferred method of quantifying operational results, but the MDOT Signal Optimization Benefit/Cost Analysis Spreadsheet can also be used to quantify operational benefits. The Preparer should follow the procedure in the MDOT Electronic Traffic Control Device Guidelines if using the MDOT Signal Optimization Benefit/Cost Analysis Spreadsheet. Error! Reference source not found. shows an example of the **BC Analysis** tab and the total yearly savings to be used as an input to the B/C ratio.



	Fuel Savings (gal/day)	Fuel Savings $	Travel Time Savings veh*hrs	Travel Time Savings Person - $
Daily Savings	-1.280	-$3	45.73	$959
Yearly Savings	-320	-800	11432	$239,818

[1-Year B/C Analysis]	Total Yearly Savings:	$239,018
	Total Project Cost:	$358,749
	Benefit/Cost:	**0.67**
[3-Year B/C Analysis]	Total Savings:	$717,054
	Benefit/Cost:	**2.00**

Assumptions

Avg. Cost of Fuel ($/gal)	$2.50
Avg. # of Workdays/Year	250
Avg. Vehicle Occupancy	1.1
Avg. Value of Time/Individual ($/hr)	$19.07

Figure 15: Example of Operational Benefits Spreadsheet

6.4 MDOT Crash Investigation Site (CIS) Methodology for B/C

This protocol is intended to provide direction on how to calculate the B/C score for a proposed Crash Investigation Site (CIS) being submitted for Operations Template funds. To have statewide consistency, and an equal comparison of the B/C between proposed CIS submittals from different regions, please follow the instructions in this protocol. Please note this process is only for the B/C portion of the Operations Template scoring. The TOR scoring for potential CIS's should still follow the normal TOR process as approved by the Safety Programs unit.

The submitter is asked to obtain information on all crashes that occurred at or within 3-miles upstream of a proposed CIS, over the proposed analysis period. The analysis period must be a 3-year period. Only eligible crashes, as defined below, should be used in the analysis.

Eligible Crashes to be used for Benefit Calculation:

-Crashes used in the calculation must have occurred within 5 years of the date the analysis was performed, and all crashes must have occurred within a consecutive 3-year time frame. (i.e. March 2017- Feb 2020).

-The crash must have occurred within 3-miles upstream of the proposed CIS. Any crash downstream, or more than 3-miles upstream from proposed CIS location, will not be eligible, as it is unlikely the crashed vehicle would utilize the CIS from outside of that distance.

-If, within the 3-miles upstream of the proposed CIS site, there is an exit ramp to a rest area, weigh station, or off-ramp to a non-freeway facility, then the 3-mile distance shall be shortened to the gore point of the nearest exit ramp. (i.e. crashes further upstream than the exit ramp should be excluded, as a tow truck would likely tow the crashed vehicle to the rest area, weigh station, exit ramp etc.)

-The crash must have occurred in the same direction as the proposed CIS. (i.e., if the proposed CIS is for the EB direction, then crashes that occurred on the WB direction are not eligible). Crashes involving vehicles crossing the median and impacting both directions of travel are eligible.

-Crashes that result in a full freeway closure are not considered eligible, because if a given direction of the freeway needs to be fully closed to service the crash, the pavement of the freeway itself could/would be used in place of a proposed CIS.

Calculating the Benefit:

For all eligible crashes during the 3-year period used, the user delay costs (UDC) will be obtained using the RITIS program. **The Congestion and Reliability Unit will pull the data from RITIS**. It will be the responsibility of the TSC/Region to provide the Congestion and Reliability Unit the dates and times of the eligible crashes. The TSC/Region may submit up to 10 eligible crashes to have RITIS data analyzed, per proposed CIS. If more than 10 eligible crashes occurred, the TSC/Region is encouraged to submit the 10 crashes that resulted in the greatest amount of delay.

The Congestion and Reliability Unit must be provided with a list of eligible crashes no later than September 1st, to have enough time to pull the necessary data and provide feedback. Submitting earlier is encouraged. The Congestion and Reliability Unit will provide the TSC/Region the resulting user delay cost. It will then be up to the TSC/Region to follow the steps below to achieve a B/C score. Again, only up to 10 crashes may be used for each proposed CIS.

Calculation of the B/C Ratio for proposed CIS locations:

1- Sum together the obtained UDC associated from each crash analyzed in RITIS. (This value is provided by the Congestion and Reliability Unit)
2- Take the sum-total UDC of all crashes, divide by 3 (the range of crash years), and then multiply by 20 to get a 20-year benefit.
3- Finally, divide by the cost of the proposed CIS to obtain a B/C score.

6.5 VISSIM Analysis Considerations

Sections 6.1 and **6.2** provide guidance for using the C&R Benefit Cost spreadsheet with the analysis tools typically utilized for typical Freeway and Non-Freeway projects. For projects where the standard traffic analysis tools (e.g., Synchro, SimTraffic, RODEL, HCS) do not adequately measure the traffic impacts (i.e., heavily congested locations, unusual geometric conditions), the Preparer may use a more customizable traffic analysis tool, such as VISSIM. The preparer should complete a VISSIM analysis according to the guidance provided in MDOT VISSIM Protocol Document. On projects where VISSIM is used, either the **Intersection Benefits** or **Freeway (HCS) Benefits** tabs may be used to convert delay and speed outputs into operational benefits in person-$, respectively. Other output processing tools are acceptable to calculate operational benefits in person-$; however, backup information and calculations should be submitted as part of the Final Submission Form.

6.6 Roundabout Analysis Considerations

The Preparer should complete a roundabout preliminary operational and capacity analysis according to guidance provided in MDOT Roundabout Design Aid (MRDA) and NCHRP 672: Roundabouts: An Informational Guide, Second Edition. Each roundabout analysis should include a table of design parameters as shown in the MRDA, as well as a table of operational results that includes, at a minimum, average delay and level of service (LOS). The operational analysis should consider the geometric configuration per the guidance, and include performance checks for entry speed, speed consistency, entry angle, and path overlap. The traffic analysis should be conducted per the methods highlighted in Exhibit 4-4 of NCHRP 672. RODEL is the recommended deterministic software; however, other software packages are available and can be used with concurrence from the Congestion & Reliability Section.

7. Travel Time and Reliability Analysis Requirements

When applicable, the Regional Integrated Transportation Information System (RITIS) will be used by C&R to conduct an analysis of the proposed area to determine the existing Planning Time Index (PTI), Level of Travel Time Reliability (LOTTR), and Travel Time Index (TTI) values, which are good indicators of the roadway's reliability and congestion.

7.1 Level of Travel Time Reliability (LOTTR)

The LOTTR is a MAP-21 requirement and is calculated on all National Highway System (NHS) routes in the State of Michigan. The LOTTR is the ratio of the 80^{th} percentile travel time to the 50^{th} percentile travel time. This information can be obtained directly from RITIS. All projects on the NHS system should use the LOTTR value.

7.2 Planning Time Index (PTI)

For locations not on the NHS system, the PTI is the recommended reliability measure. The PTI is the ratio of the 95^{th} percentile travel time to the free-flow travel time. The measure is typically computed during the AM (6-9AM) and PM (3-6PM) peak periods on weekdays, but an alternate time frame can be used if appropriate. It should also use the most recent year without construction impacts. A PTI value greater than or equal to 2.0 is deemed unreliable and only one day in one direction must meet the criteria to qualify. PTI values can be found using the Probe Data Analytics Suite within RITIS.

7.3 Travel Time Index (TTI)

The Travel Time Index (TTI) is the ratio of the average peak period travel time to the free-flow travel time. This is more of an indicator of the level of congestion. This measure is computed for the AM (6-9AM) and PM (3-6PM) peak periods on weekdays. It should also use the most recent year without construction impacts. A TTI value greater than 1.5 is deemed congested and only one day in one direction must meet the criteria to qualify.

8. Geometric Analysis

Conceptual layout exhibits should be prepared for project alternatives based on the following documents:

- MDOT Road Design Manual
- MDOT Geometric Design Guides
- Other guidelines as needed

Conceptual layout exhibits should be prepared that depict existing conditions and each proposed build alternative. The purpose of the exhibit is to perform geometric analysis of each proposed alternative, assess right-of-way (ROW) impacts, and estimate the construction cost of each alternative. An example geometric exhibit is provided in **Figure 16** and in the sample report.

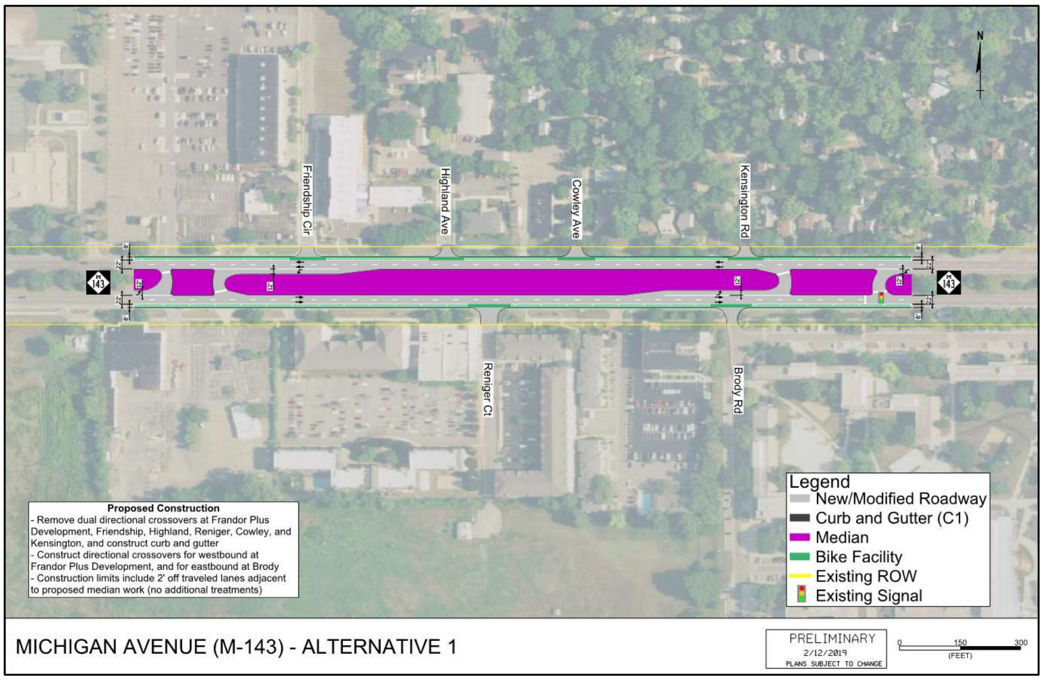


Figure 16: Example Geometric Exhibit

8.1 Geometric Data Collection

Existing ROW and major utilities should be gathered from existing MDOT ROW maps, existing plans, and aerial imagery and shown on the conceptual layout exhibit. Existing ROW for roadways throughout Michigan can be found using MDOT's Right-of-Way Map Files website. Requests for further ROW information or as-builts for the project area should be directed to the appropriate Region/TSC.

Design and/or ROW survey is not required for this stage of the project analysis. However, if existing ROW boundaries are not available, consider gathering information before continuing the analysis, especially if it is expected that the proposed alternative will require ROW acquisition. In the case that additional ROW is needed and funds are being requested from operations funding, the cost of land acquisition must be considered and included in the cost estimate. If an alternate funding source is being used, cost of ROW acquisition does not need to be considered in cost estimate submitted to the C&R. All projects are subject to NEPA regulations and processes. Preparer should contact MDOT Environmental Section to discuss NEPA requirements.

ROW can be purchased prior to project selection and be reimbursed by the Operations Template if the project is selected. ROW reimbursement will not be provided for projects not selected or for ROW not included in the project's cost estimate and B/C ratio. Purchases that are eligible to be reimbursed must have occurred no earlier than 2018 and a project must be selected within eight years of ROW acquisition. The full ROW amount or a portion of the ROW amount may be requested.

9. Engineering Cost Estimate

An Engineer's cost estimate should be developed for each proposed alternative. Each cost estimate should calculate the overall project cost, including the appropriate amount of Early Preliminary Engineering (EPE), Preliminary Engineering (PE), Construction (CON), Construction Engineering and Administration, and Right-of-Way (ROW). All cost estimates should be developed using current year dollars. If a project is selected, the Region/TSC will be responsible for project costs exceeding the overall engineering cost estimate.

Routine maintenance costs for roadway, signs, traffic signals, etc. should not be included in the Engineer's cost estimate unless directed by the C&R; this will be applicable to most projects. If non-routine costs are needed to deploy the project, such as ITS projects that require dedicated staff to operate (e.g., FlexRoute TOC operators), the ongoing costs should be identified in the Additional Annual Costs portion of the **INPUT – Costs** tab as shown in **Figure 19** . Alternate funds will need to be identified and approved before the project can be selected as the Operations Template will not fund operations and maintenance.

The preferred method for cost estimating is to use the **Construction Costs** tab of the C&R Benefit Cost Spreadsheet, as shown in **Table 4**. The **Construction Costs** tab includes the following components:

1. **Removal and Construction –** Quantified using geometric exhibits described in **Section 8**; based on MDOT Pay Items/Standard Specifications for Construction where possible. Typical item quantities of interest include: curb and gutter removal, pavement removal, embankment fill, earth excavation, base aggregate, hot mix asphalt or concrete, saw cuts, new concrete curb and gutter, new sidewalk, detectable warning surfaces, and traffic signal upgrades, etc. Quantity measurements should be documented per item. Unit prices for removal and construction should be based on MDOT's most recent weighted average item price report.
2. **Miscellaneous Removal and Construction* –** Determined as a percentage of pay item-based removal and construction items in #1. Default percentages can be adjusted based on project-specific conditions with appropriate justification. Includes the following items:
   a. Pavement Markings
   b. Maintaining Traffic
   c. Environmental
   d. Permanent Signing
   e. Drainage Items
   f. Soil Erosion and Sedimentation Control
   g. Utility Relocation
3. **Percentage Based Construction Cost* -** Determined as a percentage of the sum of removal and construction costs in #1 and #2. Includes the following items:
   a. Mobilization
   b. Contractor Staking
   c. Contingency
4. **Engineering and Design Services* –** Determined as a percentage of sum of construction costs in #1, #2, and #3. Includes the following items:
   a. Environmental Analysis – Lump sum cost item. Contact MDOT Environmental Section to discuss NEPA requirements and develop cost estimate for NEPA completion, if required.
   b. Early Preliminary Engineering
   c. Preliminary Engineering
   d. Construction Engineering and Inspection
5. **Right of Way (ROW) –** Determined as a lump sum based on needs identified during the development of geometric exhibits described in **Section 8**.

Construction Costs** tab includes default percentages for percentage-based items. The default values may be modified but justification must be provided. Cell will turn red if default is changed as shown in **Figure 17.

No Change to Default Values

Miscellaneous Removal and Construction					
Instructions: Typical miscellaneous … been determined by the Congestion and Reliability Section … tion should be provided. Cells in Unit Price column will turn red if changed from default value.					
-	Pavement Markings	LS	$ 217,152	5%	$ 10,858
-	Maintaining Traffic	LS	$ 217,152	10%	$ 21,715

Default Values Modified

Miscellaneous Removal and Construction					
Instructions: Typical miscellaneous … been determined by the Congestion and Reliability Section … tion should be provided. Cells in Unit Price column will turn red if changed from default value.					
-	Pavement Markings	LS	$ 217,152	11%	$ 23,887
-	Maintaining Traffic	LS	$ 217,152	10%	$ 21,715

Figure 17: Default Value Changed on Percentage-Based Item

Table 4: Engineer Cost Estimate Template Example

Project	{Project Title}
Alternative	{Alternative Name}
Source	{MDOT Average Unit Price Version Used}
Date	{Date}

Pay Item Code	Item Description	Unit	Quantity	Unit Price	Cost
Removal and Construction					
Instructions: Sample removal and construction items provided. Add, remove, and modify as needed based on project specifics.					
2040020	Curb and Gutter, Rem	Ft	421	$ 6.76	$ 2,846
2040050	Pavt, Rem	Syd	869	$ 7.36	$ 6,396
2050010	Embankment, CIP	Cyd	338	$ 7.78	$ 2,630
2050016	Excavation, Earth	Cyd	225	$ 13.61	$ 3,062
3020020	Aggregate Base, 8 inch	Syd	338	$ 11.01	$ 3,721
5010005	HMA Surface, Rem	Syd		$ 3.00	$ -
5010061	HMA Approach	Ton	68	$ 129.08	$ 8,777
6030090	Saw Cut, Intermediate	Ft		$ 2.24	$ -
8020038	Curb and Gutter, Conc, Det F4	Ft	516	$ 16.95	$ 8,746
8030010	Detectable Warning Surface	Ft	38	$ 31.91	$ 1,213
8030034	Sidewalk Ramp, Conc, 6 inch	Sft	687	$ 6.93	$ 4,761
	Traffic Signal Modernization	Ea	1	$ 175,000.00	$ 175,000
					$ -
SUBTOTAL					**$ 217,152**

Pay Item Code	Item Description	Unit	Quantity	Unit Price	Cost
Miscellaneous Removal and Construction					
Instructions: Typical miscellaneous removal and construction items provided have been determined by the Congestion and Reliability Section. Changes to these cells are allowed, but justification should be provided. Cells in Unit Price column will turn red if changed from default value.					
-	Pavement Markings	LS	$ 217,152	5%	$ 10,858
-	Maintaining Traffic	LS	$ 217,152	10%	$ 21,715
-	Environmental	LS	$ 217,152	1%	$ 2,172
-	Permanent Signing	LS	$ 217,152	2%	$ 4,343
-	Drainage Items	LS	$ 217,152	6%	$ 13,029
-	Soil Erosion and Sedimentation Control	LS	$ 217,152	1%	$ 2,172
-	Utility Relocation	LS	$ 217,152	5%	$ 10,858
SUBTOTAL					**$ 65,146**
SUBTOTAL REMOVAL AND CONSTRUCTION COST					**$ 282,298**
Percentage-Based Construction Cost					
Instructions: Typical percentage-based construction cost items provided have been determined by the Congestion and Reliability Section. Changes to these cells are allowed, but justification should be provided. Cells in Unit Price column will turn red if changed from default value.					
1500001	Mobilization, Max	LS	$ 282,298	10%	$ 28,230
8240001	Contractor Staking	LS	$ 282,298	2%	$ 5,646
	Contingency	LS	$ 316,174	20%	$ 63,235
SUBTOTAL					**$ 97,110**
CONSTRUCTION ESTIMATE (ROUNDED)					**$ 380,000**
Engineering and Design Services					
Instructions: Engineering and Design Services determined by the Congestion and Reliability Section. Changes to these cells are allowed, but justification should be provided. Cells in Unit Price column will turn red if changed from default value.					
-	Environmental Analysis	LS	1	$ -	$ -
-	Early Preliminary Engineering	LS	$ 380,000	5%	$ 19,000
-	Preliminary Engineering	LS	$ 380,000	12%	$ 45,600
-	Construction Engineering and Inspection	LS	$ 380,000	10%	$ 38,000
PE ESTIMATE (ROUNDED)					**$ 103,000**
ROW					
-	ROW	LS	1	$ -	$ -
ROW ESTIMATE (ROUNDED)					**$ -**
TOTAL PROJECT COSTS (Present Year Value)					**$ 388,000**
			Rate	**Years**	
TOTAL PROJECT COSTS (With Inflation)			**1.30%**	**5**	**$ 413,220**

10.Benefit-to-Cost (B/C) Ratio

The Preparer must perform a B/C analysis, comparing the quantifiable project benefits with the Engineer's cost estimate using the C&R Benefit Cost Spreadsheet. The B/C ratio is calculated in the **OUTPUT – Benefit-Cost** tab of C&R Benefit Cost Spreadsheet once the following tabs are completed.

- "INPUT – Benefits". See **Figure 18**.
    - See **Section 5** for Annual Safety Benefits
    - See **Section 6** for Annual Operational Benefits
    - **Annual Additional Benefits** should only be used to account for benefits (e.g., incident management) that are not included within Annual Safety Benefits or Annual Operational Benefits. Provide justification in the C&R Final Submittal Form if additional benefits are included.

INPUTS-Benefits	Alt 1		Alt 2	
Annual Safety Benefits	$	100,000	$	100,000
Annual Operational Benefits	$	200,000	$	200,000
Annual Additional Benefits	$	111,000	$	300,000

Figure 18: INPUT - Benefits Tab

- "INPUT – Costs" – See **Figure 19**
    - See **Section 9** for Construction Cost
    - **Additional Annual Cost** should only be used to account for costs (e.g., ongoing operations and maintenance) that are not included in construction cost or MDOT routine maintenance. Most costs for typical roadway elements such as resurfacing, signs, traffic signals, etc. are included in routine maintenance funds; therefore, most projects will not need to include any additional annual costs. Examples of additional annual costs are ITS projects that will require dedicated staff to operate (e.g., Flex Route TOC operators).

INPUTS-Costs	Alt 1		Alt 2	
Total Construction Cost	$	483,000	$	222,000
Additional Annual Cost	$	200,000	$	200,000

Figure 19: INPUT - Costs Tab

The C&R Benefit Cost Spreadsheet will calculate a 1-year and 20-year B/C ratio for each project alternative, as shown in Table 5. Total annual benefit is the sum of safety (**Section 5**), operational (**Section 6**), and additional (miscellaneous) benefits which are calculated per **Section 6** and **Section 7** of this document. The benefit can be calculated solely from the safety or operational benefit if the other benefits are negligible.

Table 5: Total Annual Benefit and 20-Year Benefit Results

OUTPUT

Benefits	Alt 1	Alt 2
Annual Operational Benefits	$ 200,000	$ 200,000
Annual Safety Benefits	$ 100,000	$ 100,000
Annual Additional Benefits	$ 111,000	$ 300,000
Total Annual Benefit	$ 411,000	$ 600,000
Estimated 20-year Benefit	$ 8,220,000	$ 12,000,000
Costs		
Construction Costs	$ 483,000	$ 222,000
Additional Annual Costs	$ 500,000	$ 200,000
Total Cost - Year One	$ 983,000	$ 422,000
Estimated 20-year Cost	$ 10,483,000	$ 4,222,000
Benefit/Cost (B/C)		
B/C Ratio (1-year)	0.42	1.42
B/C Ratio (20-year)	0.78	2.84

11. Other Considerations

11.1 Inclusion of Key MDOT Units

If a project utilizes or impacts ITS equipment, traffic signal equipment, or changes the geometry of the intersection/roadway/roundabout, the appropriate contact from the ITS, Traffic Signals, or Geometrics section should be contacted and involved as part of the analysis stage. Any improvement must be approved by the applicable MDOT engineer from the subject section(s).

11.2 CMAQ Documentation

If the location is in a non-attainment area and is eligible for (Congestion Mitigation and Air Quality) CMAQ funds, the C&R may require CMAQ documents be completed and submitted for possible funding. The following link: www.michigan.gov/cmaq provides the necessary FHWA Emissions Calculator Toolkit/MDOT forms along with the list of additional items needed to determine eligibility.

11.3 Other Templates

Operational and reliability issues can be very broad and do not necessarily fall perfectly under one template. Collaborating with the other templates to maximize improvements to operations, reliability, and safety is encouraged.

Appendix A – Project Examples