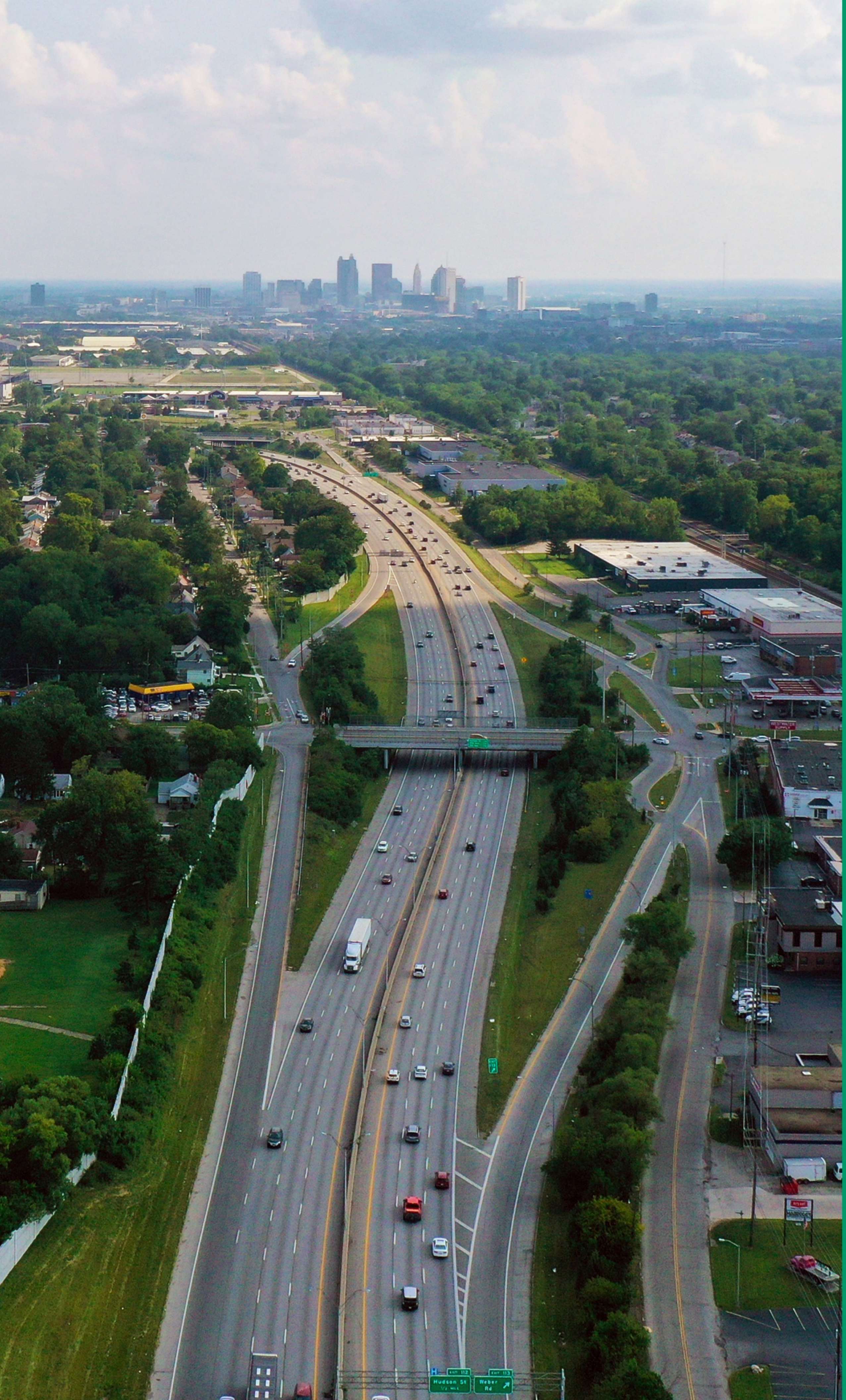

Final

FRA-71-18.52
FEASIBILITY STUDY

PID 110273 | Fed. Project No. E190(550)
5th Ave. to I-270 Congestion Relief

Submitted to ODOT District 6
December 2021

Prepared by Gannett Fleming | Ohio Department of Transportation

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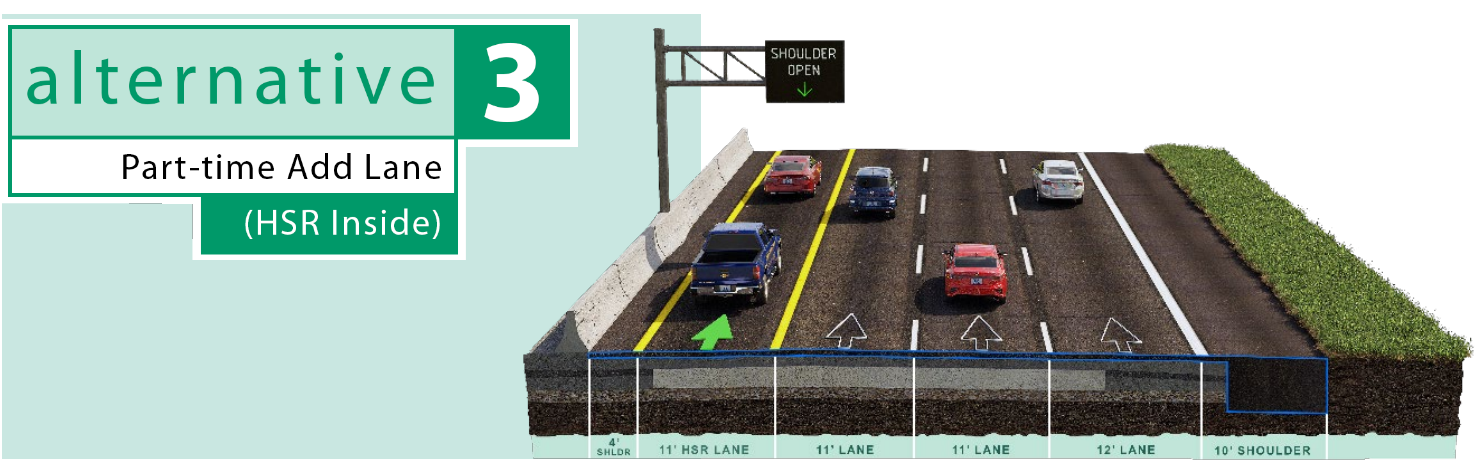
chapter 1 EXECUTIVE SUMMARY

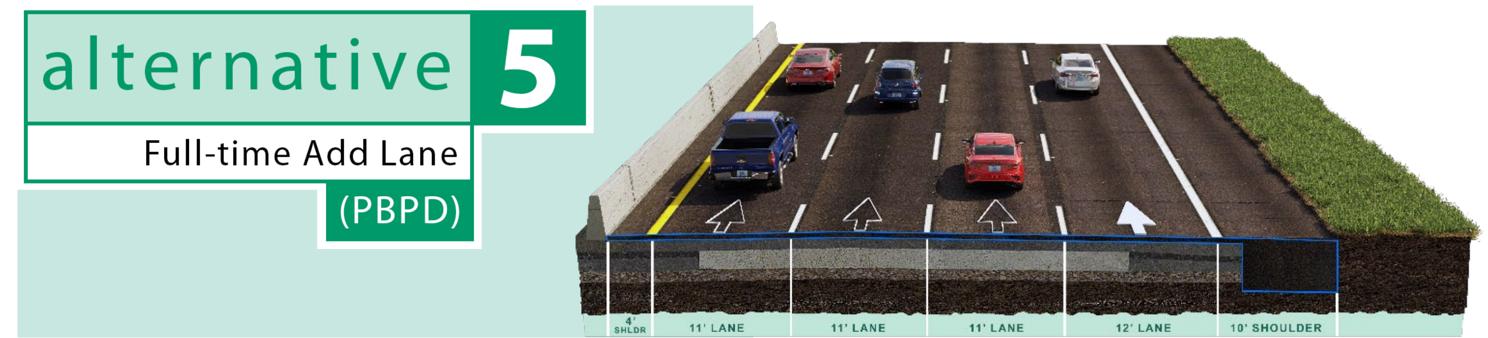
The I-71 project corridor is located in the City of Columbus, Ohio and extends 8.5 miles from 5th Avenue to I-270. I-71 within the project area has remained largely unchanged since it was widened to a six-lane section in the 1960s. Nine (9) service interchanges are located within this urban corridor with several that are very close together. Central Ohio's growing population and number of commuters have caused modern day capacity issues for those traveling into and out of Downtown Columbus during morning and afternoon peak hours. Traditional widening to increase capacity would be costly and impactful to adjacent properties. Transportation Systems Management and Operations (TSMO) strategies to improve congestion that leverage technology and/or existing infrastructure have emerged and are the focus of this Feasibility Study. One approach to implementing TSMO solutions is through Active Traffic Demand Management (ATDM), which uses technology, data, and real-time monitoring to dynamically manage traffic. The 2016 Statewide ATDM Strategies study identified the I-71 corridor as a candidate for Hard Shoulder Running (HSR) based on its issues with capacity and safety stemming from congestion. HSR is an ATDM concept that takes an existing shoulder and converts it to a lane during peak travel hours. HSR corridors operate using a variety of Intelligent Transportation System (ITS) devices with the first implemented in Ohio on I-670 EB in Columbus in 2019. In addition to ATDM solutions, another TSMO approach evaluated in this study is to apply Performance Based Practical Design (PBPD) principles that can be used to increase capacity yet minimize impacts while upholding safety. ODOT has implemented several PBPD solutions across the state.

The subject corridor is scheduled to receive preservation-type work activities including pavement resurfacing, minor bridge rehabilitation, and other potential spot improvements such as lighting, drainage, and ITS. An objective of this study is to determine if a TSMO based solution can be funded and combined with the preservation scope (i.e., no build alternative) to alleviate congestion, improve safety, and improve traffic incident management. Morning and afternoon commuter traffic results in congestion for those entering and leaving Downtown Columbus. Northbound conditions in the No Build scenario operate at an LOS of F during morning and evening peak hours, contributing to bottlenecks that extend far upstream. Southbound conditions in the No Build scenario operate at an LOS of F during the morning peak and D/E during the evening peak, also contributing to bottlenecks that extend upstream. A safety analysis determined the corridor experienced almost 1,200 crashes during the three-year period from 2017-2019. Almost half of the crashes were categorized as rear-end, almost double the statewide average of 26% for a freeway. Nearly one-quarter of the total crashes occurred during the AM and PM peaks, suggesting congestion could play a part and needs further investigation.

Two build alternatives that advanced through the study process are Alternatives 3 and 5.



Alternative 3 is an HSR lane placed on the inside shoulder of I-71 in both the NB and SB directions. It is created by holding the toe of the existing median barrier and creating a 4' inside shoulder, 11' HSR lane, 2 x 11' permanent lanes, 1 x 12' permanent lane and an outside shoulder width of 10'±. Full depth widening and reconstruction of approximately 8' is needed south of N. Broadway, and then transition primarily to resurfacing north of N. Broadway.



Alternative 5 is a PBPD solution that selectively reduces lane and shoulder widths to reduce the overall footprint of the project and limit impacts yet aims to maintain acceptable safety performance metrics for the corridor. The typical section would include a 4' inside shoulder, 3 x 11' and 1 x 12' permanent lanes, and an outside shoulder width of 10'±.

Traffic Operations – Alternatives 3 and 5 are expected to improve failing operations to LOS D or E for nearly all segments of the corridor. Either alternative would provide a significant operational benefit to the I-71 corridor.

Safety – Based on the Highway Safety Manual (HSM) predictive analytics, Alternative 3 is anticipated to see a nearly 8% decrease in overall crashes including one less fatality compared to the no-build. Alternative 5 is anticipated to see a 14% increase in overall crashes including one fatality per year in each direction compared to the no-build. Primary variables contributing to these differences appear to be the narrow lateral clearance to the median barrier wall and daily duration of this condition.

Cost – A conceptual level construction cost estimate was prepared for each alternative. Alternative 3 has an estimated cost of $92M, approximately 7% less than Alternative 5 of $99M. The costs to operate and maintain Alternative 3 has not been included in this estimate. As additional SmartLanes come online across the state, increases in staffing levels with the Traffic Management Center (TMC) and ITS Maintenance are expected.

Impacts – Both alternatives push a similar typical section through the corridor. Similar minor impacts are caused by each alternative and result in minimal to no right of way impacts.

Preferred Alternative – Alternatives 3 and 5 offer similar operational benefits while minimizing impacts compared to a traditional add-lane improvement. The selection of a preferred alternative is not based on a single factor, but the cumulative differences of five factors:

1. Safety – A thorough safety analysis, including an independent review by ODOT's Office of Safety, support Alternative 3 as a safer solution compared to Alternative 5. Wider inside shoulders will be available when HSR (Alternative 3) is closed but would not be available anytime for PBPD (Alternative 5).
2. Incident Management – The inclusion of overhead dynamic message signs (DMS) for incident management and the ability to close the HSR lane and create a 15' wide inside shoulder for parked breakdowns and EMS present a benefit to Alternative 3 compared to Alternative 5.
3. Maintenance – The ability of Alternative 3 to provide a wide inside shoulder by closing the HSR lane improves the safety and work area for maintenance crews compared to Alternative 5.
4. Phased Implementation – Alternative 3 lends itself to become part of a broader implementation plan that addresses the peak hour demands by introducing a part-time lane that could potentially be converted to a full-time lane in the future. Alternative 3 also has the flexibility to dynamically address capacity and safety. Alternative 5 is less flexible and would advance a permanent PBPD solution that poses the risk of impairing safety with the HSM predictive modeling showing an increase in injury and fatal crashes.
5. Costs – While only a minor difference in estimated construction costs, Alternative 3 is anticipated to cost approximately $7M less than Alternative 5, equating to an 7% reduction.

For the reasons noted above, ODOT has decided to eliminate Alternative 5 from further study and advance Alternative 3 into preliminary design as the preferred alternative. Alternative 3 would be combined with Alternative 1 (i.e., no build) to ultimately advance the preservation needs of the corridor and meet the purpose and need of improving capacity, safety, and incident management.

chapter 2
INTRODUCTION

The I-71 project corridor is located in the City of Columbus, Ohio and extends from 5th Avenue to I-270, as shown in Figure 1, which is a distance of approximately 8.5 miles. I-71 within the project area has remained largely unchanged since it was widened to a six-lane section in the 1960s. Nine (9) service interchanges are located within this urban corridor with several that are very close together. Central Ohio's growing population and number of commuters have caused modern day capacity issues for those traveling into and out of Downtown Columbus during morning and afternoon peak hours. Traditional widening to increase capacity would be costly and impactful to adjacent properties. Strategies to improve congestion that leverage technology and/or existing infrastructure have emerged and are the focus of this Feasibility Study.

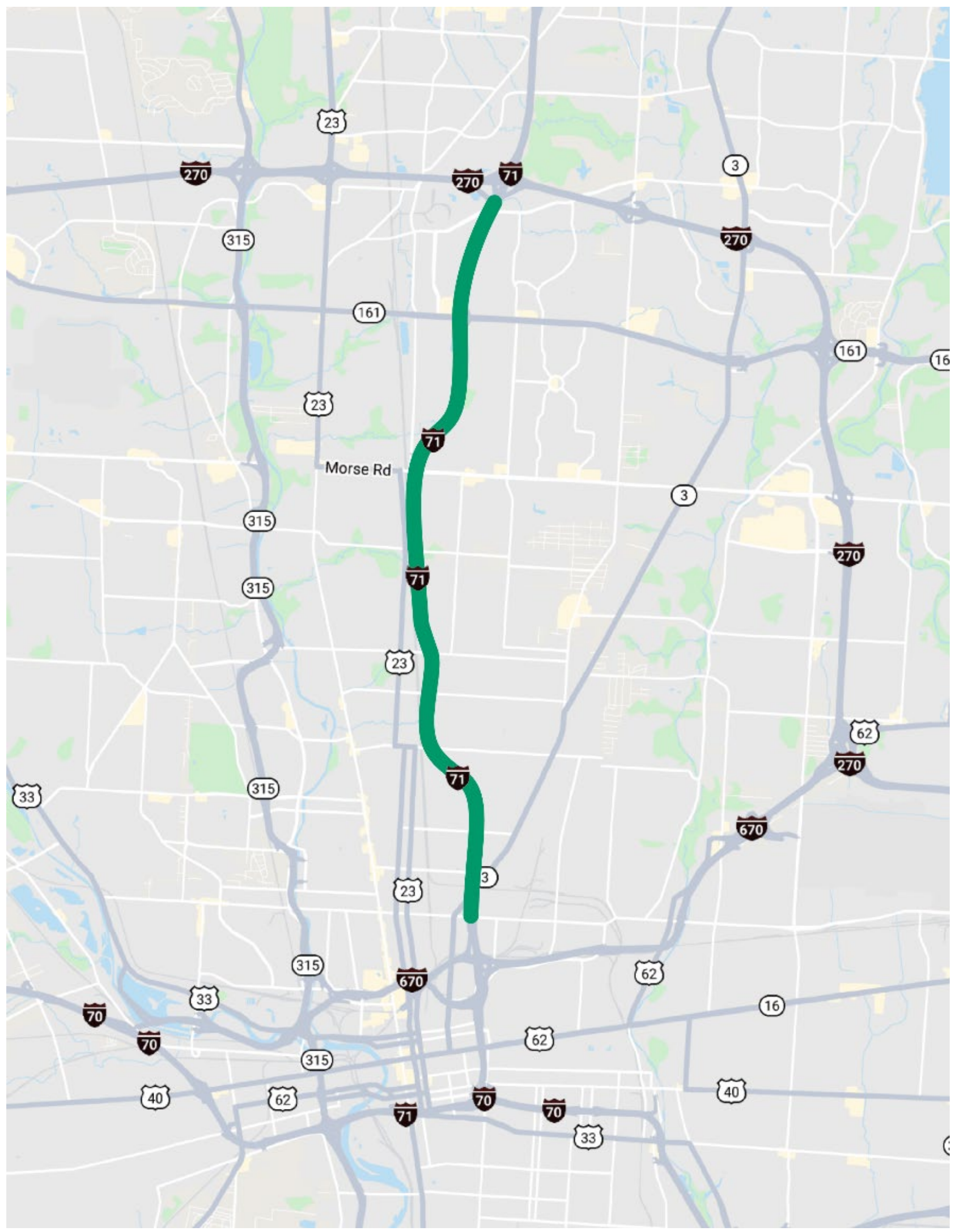


Figure 1. Study Area

ODOT is maturing in their adoption and implementation of Transportation Systems Management and Operations (TSMO) oriented solutions. TSMO uses practical solutions to solve congestion and reliability problems by joining technology with existing infrastructure. It saves tens of millions of dollars by eliminating the need to rebuild and expand existing infrastructure. One approach to implementing TSMO solutions is through Active Traffic Demand Management (ATDM), which uses technology, data, and real-time monitoring to dynamically manage traffic. The 2016 Statewide ATDM Strategies study identified the I-71 corridor as a candidate for Hard Shoulder Running (HSR) based on its issues with capacity and safety stemming from congestion. HSR is an ATDM concept that takes an existing shoulder and converts it to a lane during peak travel hours. HSR corridors operate using a variety of Intelligent Transportation System (ITS) devices with the first implemented in Ohio on I-670 EB in Columbus in 2019. In addition to ATDM solutions, another TSMO approach that will be evaluated in this study is to apply Performance Based Practical Design (PBPD) principles that can be used to increase capacity yet minimize impacts while upholding safety. ODOT has implemented several PBPD solutions across the state.

The need for the subject corridor to receive capacity enhancements was further supported by the Traffic Operation Assessment Systems Tool (TOAST), which identifies operationally sensitive corridors using a variety of data sources. TOAST rates roadways based on twelve categories including Travel Time Performance, Bottlenecks, Safety Performance, and Work Zone Delay. A TOAST study was conducted in 2018, and in 2020, the project study area scored between 5.00% and 21.30%, the lowest score range using TOAST, which means the corridor is very likely to benefit from TSMO strategies. The 2020 TOAST analysis is shown in Figure 2. The TOAST analysis and past studies led to the funding of this study through the TSMO program and ultimately establishes the goal of this study to help advance TSMO-based capacity enhancement and safety improvements that can be funded and potentially combined with preservation projects or packaged in a more strategic implementation plan.

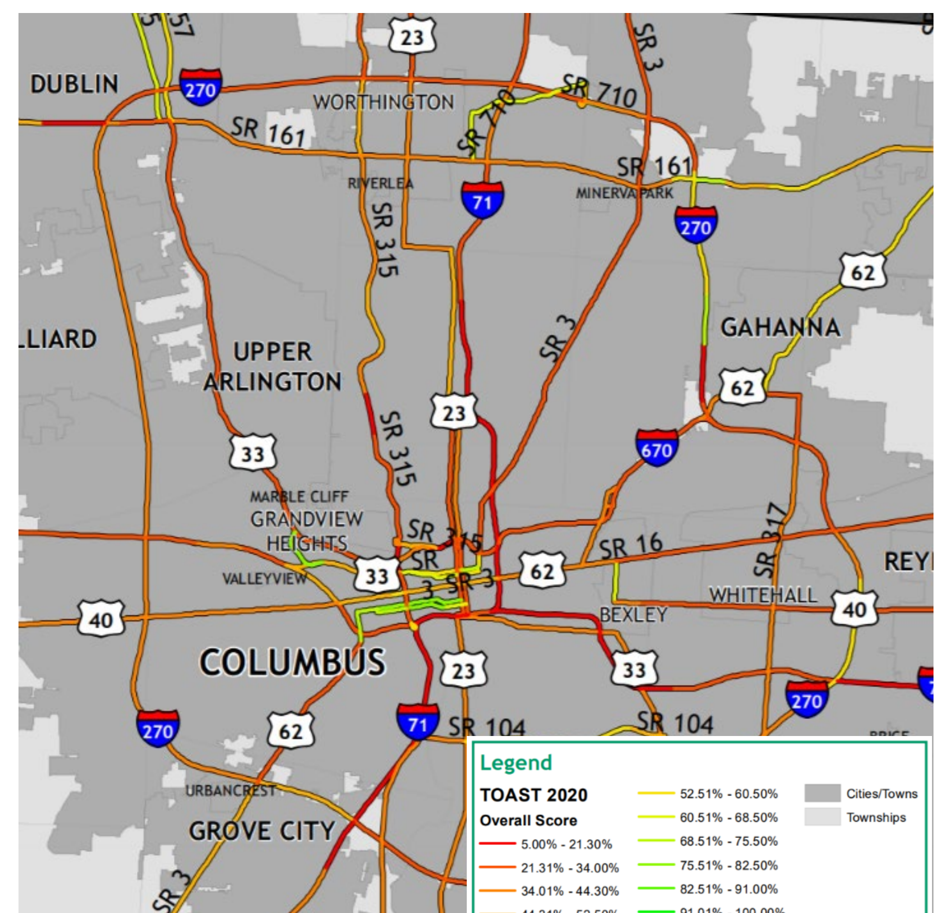


Figure 2. 2020 Traffic Operation Assessment Systems Tool (TOAST) Results

Previous Studies

The I-71 corridor has been previously studied and includes:

1. 2016 Final Report for Determining Candidate Active Traffic and Demand Management Strategies. It reviewed various candidate routes and vetted them for viability.
2. Safety studies completed:
    a. 2015 (slm 18.93 to 20.13)
    b. 2018 (slm 18.02 – 20.28)
    c. 2018 (Cooke Interchange)
    d. 2018 TOAST (20.08 to 21.26, 17th Ave. to Hudson)

In addition, the Statewide Systems Engineering Analysis (SEA) for ATDM Projects was updated in 2021 and is a living document that gets amended with the addition of new ATDM projects.

Purpose and Need Statement

Purpose Statement

The purpose of the project is to alleviate congestion, improve safety, and improve traffic incident management along the I-71 corridor between 5th Avenue and I-270.

Capacity

Morning and afternoon commuter traffic results in congestion for those entering and leaving Downtown Columbus. Northbound conditions in the No Build scenario operate at an LOS of F during morning and evening peak hours, contributing to bottlenecks that extend far upstream. Southbound conditions in the No Build scenario operate at an LOS of F during the morning peak and D/E during the evening peak, also contributing to bottlenecks that extend upstream.

Safety

A safety analysis determined the corridor experienced almost 1,200 crashes during the three-year period from 2017-2019. Almost half of the crashes were categorized as rear-end, almost double the statewide average of 26% for a freeway. Nearly one-quarter of the total crashes occurred during the AM and PM peaks, suggesting congestion could play a part and needs further investigation.

Summary Statement

The purpose of the project is to alleviate congestion, improve safety, and improve incident management along the I-71 corridor between 5th Avenue and I-270. This feasibility study evaluates alternative solutions to improve these conditions.

Feasibility Study Outline

This Feasibility Study evaluates the practicality of several alternatives in order to move forward with the best, most beneficial solution. In *Chapter 3: Alternatives Considered*, five alternatives are defined:

1. No Build (Preservation)
2. Part-time Add Lane (HSR Outside)
3. Part-time Add Lane (HSR Inside)
4. Full-time Add Lane (Standard Design)
5. Full-time Add Lane (PBPD)

Chapter 4: Alternative Screening dissects two alternatives eliminated early in the study.

Chapter 5: Key Issues reviews safety, traffic operations, roadway, ITS, drainage, and MOT.

In *Chapter 6: Alternatives Evaluation*, alternatives are evaluated against one another, leading to a better understanding of the best alternative to advance forward.

Finally, *Chapter 7: Conclusion* recommends a preferred alternative and provides additional next steps for this project to consider.

chapter 3 ALTERNATIVES CONSIDERED

The scope of the study included evaluation of five alternatives: Alternative 1 is the no-build alternative; Alternatives 2 and 3 are part-time add lanes; and Alternatives 4 and 5 are full-time add lanes. Alternatives 2 and 3 are Active Transportation and Demand Management (ATDM) strategies that leverage existing pavement supplemented with ITS devices to implement a Hard Shoulder Running (HSR) concept. Alternative 4 is a full-time add lane and meets normal design criteria. Alternative 5 is also a full-time add lane, but follows a Performance Based Practical Design (PBPD) approach that reduces lane and shoulder widths to minimize impacts to existing infrastructure, private property, and environmental resources.

alternative 1
No Build (Preservation)

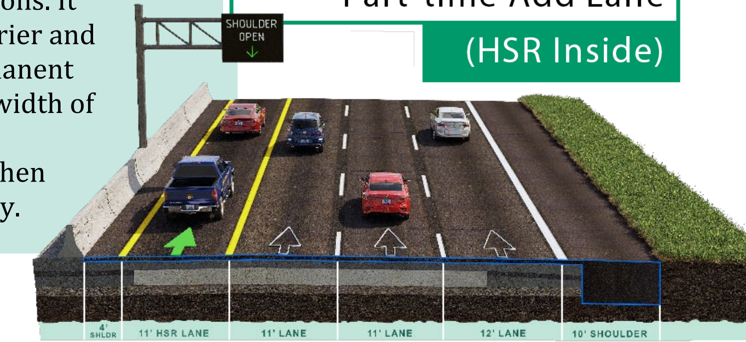
The subject corridor is scheduled to receive preservation type work activities including pavement resurfacing, minor bridge rehabilitation, and other potential spot improvements such as lighting, drainage, and ITS. This alternative does not improve safety, congestion, or reliability. The preservation scope of Alternative 1 will be advanced as the no-build alternative for this study and will also be combined (if applicable) with capacity enhancement alternatives identified in this study.

alternative 2
Part-time Add Lane (HSR Outside)

Alternative 2 is an HSR lane placed on the outside shoulder of I-71 in both the northbound (NB) and southbound (SB) directions. Full depth widening and reconstruction of approximately 5' is needed to convert the existing 10' wide shoulder to an 11' wide HSR lane with an outside temporary shoulder of 4'. When the HSR lane is not in operation, the proposed temporary outside shoulder would be effectively 15' wide.

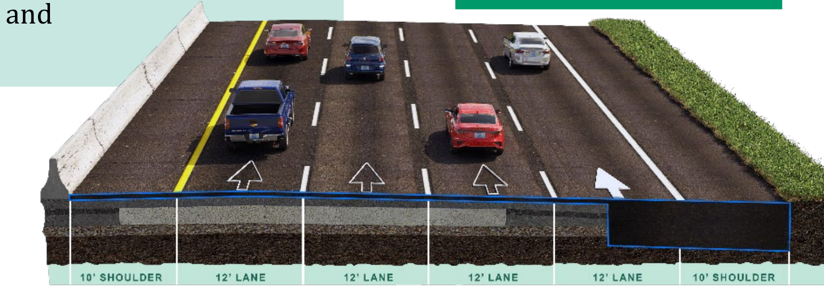
alternative 3
Part-time Add Lane (HSR Inside)

Alternative 3 is an HSR lane placed on the inside shoulder of I-71 in both the northbound (NB) and southbound (SB) directions. It is created by holding the toe of the existing median barrier and creating a 4' inside shoulder, 11' HSR lane, 2 x 11' permanent lanes, 1 x 12' permanent lane and an outside shoulder width of 10'±. Full depth widening and reconstruction of approximately 8' is needed south of N. Broadway, and then transition primarily to resurfacing north of N. Broadway.



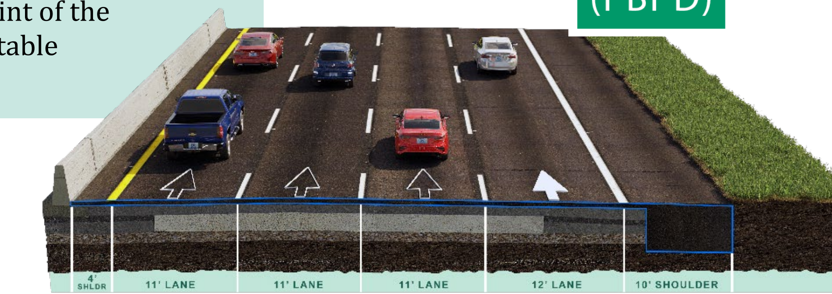
alternative 4
Full-time Add Lane (Standard Design)

In this alternative, a full-time add lane is created that fully meets the requirements of the L&D Manual. This would provide four full-time through lanes (12' wide) for both the northbound (NB) and southbound (SB) directions and 10' wide inside and outside shoulders.



alternative 5
Full-time Add Lane (PBPD)

This alternative will mimic Alternative 4 except for lane and shoulder widths. Performance Based Practical Design (PBPD) principles will be implemented with this alternative to selectively reduce lane and shoulder widths. This will reduce the overall footprint of the project and limit impacts yet aim to maintain acceptable safety performance metrics for the corridor.



chapter 4
ALTERNATIVE SCREENING

Screening alternatives during the early development stages reduces the time and cost of evaluating all alternatives at the same level of detail. As described below, two alternatives are eliminated from further study and did not receive the same level of evaluation and conceptual design as the remaining alternatives.

Alternative 2 – Part-time Add Lane (HSR Outside)

This alternative adds an HSR lane to the outside of the I-71 corridor by holding the existing outside edge line. Doing this requires full depth widening for the length of the corridor to maintain an 11' wide HSR lane and a temporary 4' wide shoulder. No changes to the existing inside shoulder or full-time lanes are assumed. As a result, this alternative requires widening for the length of the corridor, even in areas to the north where the inside shoulder is very wide. The existing pavement will be resurfaced, and the crown point and wheel paths will remain unchanged. The existing Jersey style median barrier would not be replaced, with the exception of disturbance caused by spot improvements including light pole foundations, ITS trusses, and potential drainage inlet replacements. Existing noise walls are present along this corridor for most of the eastern side. There are multiple sections along the western side, but very minimal in length. Most of the noise walls will remain untouched, however there are stretches where the widening required for this alternative would require construction of concrete barrier to protect, and some even smaller stretches that could require relocation of the noise wall or a narrowed outside shoulder. Preliminary typical sections of this alternative are found in Appendix A1.

Outside part-time shoulder operations on I-71 presents concerns particularly within the tightly spaced interchanges of 11th to 17th, Hudson to Weber, and Weber to N. Broadway. The concern is primarily when HSR is closed and how the merge/diverge and weaving operations at the subject interchanges will become less safe. An outside HSR requires unique/complex striping and signing to permanently be in place for both open and closed operations that will likely cause driver confusion as they process this information while completing their desired movements within interchanges and terminals that do not meet current design criteria. When HSR is closed, the diverge will require the driver to shift into the closed HSR lane and then shift over another lane to the exit ramp within a short weave section. Vehicles entering I-71 will complete the weave then be given a runout/pacing lane on the closed HSR lane and then merge into Lane 3. The dotted striping for this merge will likely be violated without a traditional gore detail leading to a possible increase in side-swipe crashes. The striping and operational movements described above are shown in Figure 3 (and Appendix A2), which is a representative section between 11th and 17th Street interchanges.

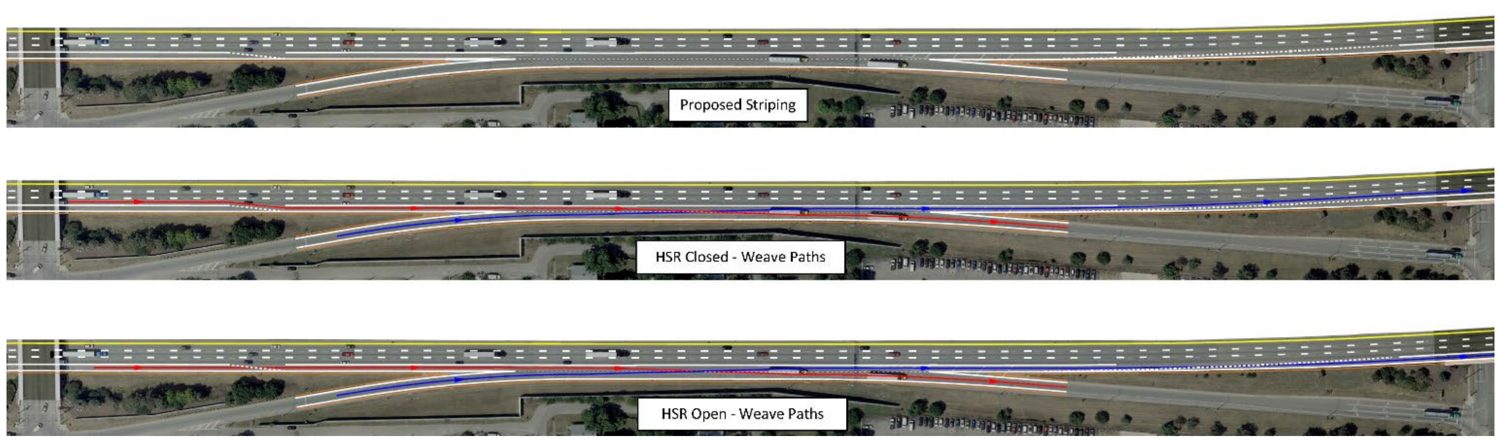


Figure 3. HSR Outside Ramp Terminal Design and Striping

The closed operation, which will be in place with the highest mainline speeds and for the longest duration, will degrade safety and cause greater turbulence compared to existing conditions unless major improvements are made to the interchanges, which is beyond the scope of a TSMO solution that can be implemented within the timeframe and budget constraints of the project.

Another concern related to this alternative is driver expectation. Part-time shoulder lanes are generally expected to serve as a thru lane, not a local lane. The I-670 SmartLane and future I-275 SmartLane are both inside part-time shoulder solutions. Drivers are being/have been conditioned to transition from permanent Lane 1 into a part-time inside shoulder through a simple diverge that enables an extra thru lane of traffic during peak periods of the day. The operational simplicity of an inside part-time shoulder increases the utilization and driver acceptance. An outside HSR on I-71, particularly in the southern section of the corridor, will be an unexpected and potentially controversial SmartLane.

If HSR Outside is eliminated, the only part-time alternative remaining would be HSR Inside. A cursory analysis was performed to confirm that an inside part-time lane would be utilized and bring congestion relief to the corridor thus supporting the elimination of an outside part-time lane. This analysis used StreetLight to perform a planning level Origin and Destination (O&D) analysis to determine the percentage of traffic entering the corridor that had a local versus thru destination. Traffic from 2019 and 2020 were analyzed. There weren't major differences in the percentage distribution across the study time period. The results based on peak hour traffic periods in their respective directions were:

- Peak hour traffic going SB has a 30% local destination and 70% thru destination (i.e., I-71 or I-670). This split seems appropriate given the high volume of traffic coming from I-71 (north of I-270) and the I-270 traffic that gets on I-71SB are traveling to work in Downtown Columbus.
- Peak hour traffic going NB has a 50% local destination and 50% thru destination. People coming from I-71 (south of I-670) and the I-670 traffic that get on I-71NB are going home, leading to a more even distribution of local and thru destinations.

The percentage of thru traffic in each direction creates enough demand to fully use an inside HSR lane. This exercise does not account for incoming traffic from the service ramps within the corridor that also have a thru destination further increasing demand for an inside part-time shoulder lane. Therefore, the O&D characteristics of the corridor support as much, if not more, the development of an inside versus outside part-time lane.

For the concerns expressed above, ODOT District 6 and Office of Roadway Engineering (ORE) supported the elimination of Alternative 2.

Alternative 4 – Full-time Add Lane (Standard Design)

This alternative adds a full-time add lane to the outside of the I-71 corridor and would meet the full design standards set forth by ODOT's Location and Design Manual (L&D) Volume 1. Substantial full depth widening will be required in both the southern and northern portions of the project caused by a typical section with 2-10' wide shoulder and 4-12' wide lanes. See Appendix B for typical sections. The proposed roadway width would require five (5) mainline bridges to be widened and nine (9) crossing street bridges to likely be replaced. The roadway widening would also require ramps to be reconfigured to match into the mainline template. This alternative would also include replacement of the median barrier, lighting, and portions of existing noise walls. Costs and right of way impacts would be high and require an extensive environmental document. The ability to upgrade this corridor for an additional full-time add lane that meets design standards is currently not fiscally responsible and would require a much more in-depth, time consuming process to advance through the Project Development Process (PDP). A more reasonable full-time add lane alternative that could be implemented within current budgetary and time constraints is an add lane that applies a PBPD approach to minimizing impacts and costs. Therefore, Alternative 4 is eliminated from further study.

chapter 5
KEY ISSUES

In this chapter, key issues related to the remaining alternatives (1, 3, and 5) are presented including: Safety, Traffic, Roadway, Bridge, Drainage, ITS, and MOT.

Safety

A safety analysis was conducted along I-71 from just south of 5th Avenue to Log Point 25.61, located south of SR 161. The purpose was to assess the safety impacts of implementing different capacity enhancement alternatives along the corridor.

Existing Crash Patterns

Crash data between 2017 and 2019 was obtained from ODOT's Transportation Information Mapping Systems (TIMS) website and reviewed for accuracy. Any crashes occurring on the ramps or at the ramp terminals were eliminated from the analysis, leaving a total of 532 crashes in the northbound direction and 657 crashes in the southbound direction.

In the northbound direction, 15 crashes resulted in serious injury and six crashes resulted in fatality. Two of the fatal crashes were caused by a vehicle traveling in the wrong direction, one involved a motorcycle traveling at a high speed, one involved vehicles pulled over on the inside shoulder, and the final two fatal crashes involved a fixed object with no noteworthy causes listed. All fatal crashes except one occurred during the early morning hours, between 1-5 AM. Four of the six fatal crashes occurred along the horizontal reverse curves near Hudson Avenue.

In the southbound direction, 21 crashes resulted in serious injury and three crashes resulted in fatality. One of the fatal crashes involved a pedestrian, and two of the fatal crashes were fixed object crashes caused by the driver losing control during icy or wet conditions.

The most common crash type for both directions of travel was rear-end, followed by sideswipe passing, and fixed object. Figure 4 shows the breakdown for crash type frequency for each direction of travel. Output from the CAM Tool is included in Appendix C1.

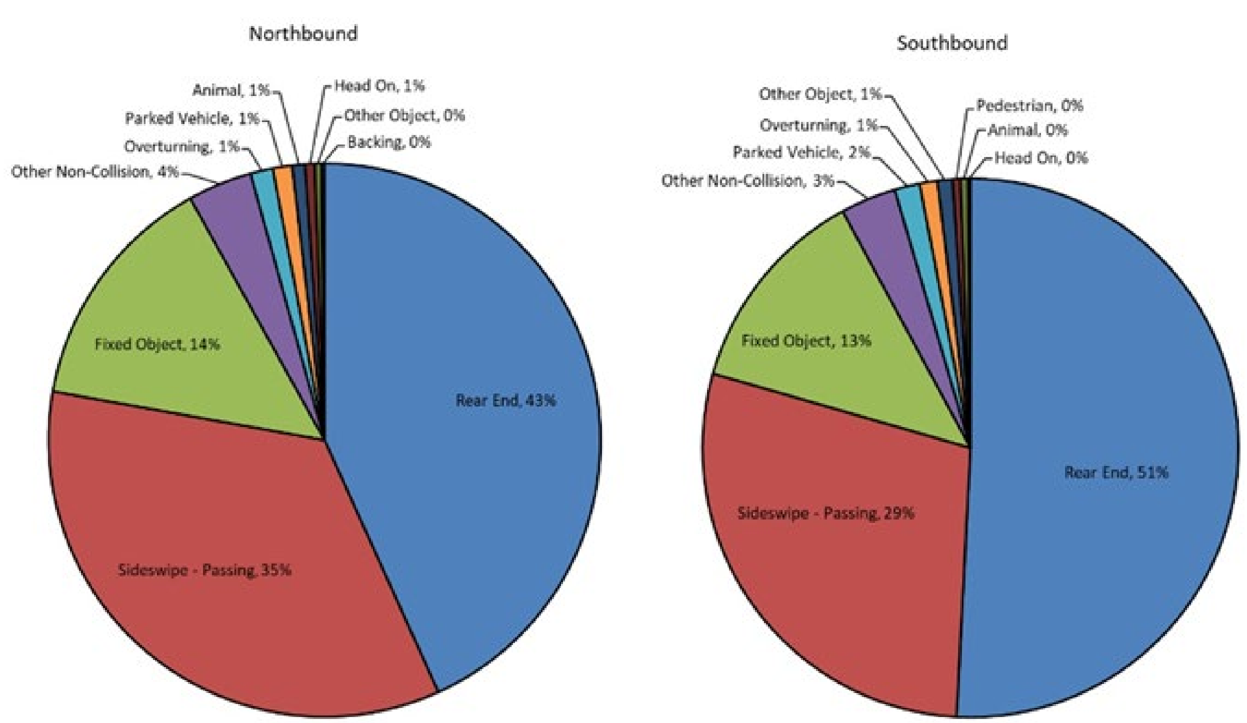


Figure 4. Crash Type Frequency per Direction of Travel

Figure 5 shows notable crash types for the corridor compared to statewide averages in the northbound direction only. Statewide averages shown are provided from ODOT's CAM tool for an urban 6-lane freeway segment. Figure 6 shows this same information for the southbound direction. Crash types shown in red occurred more frequently in the study area compared to the statewide average.

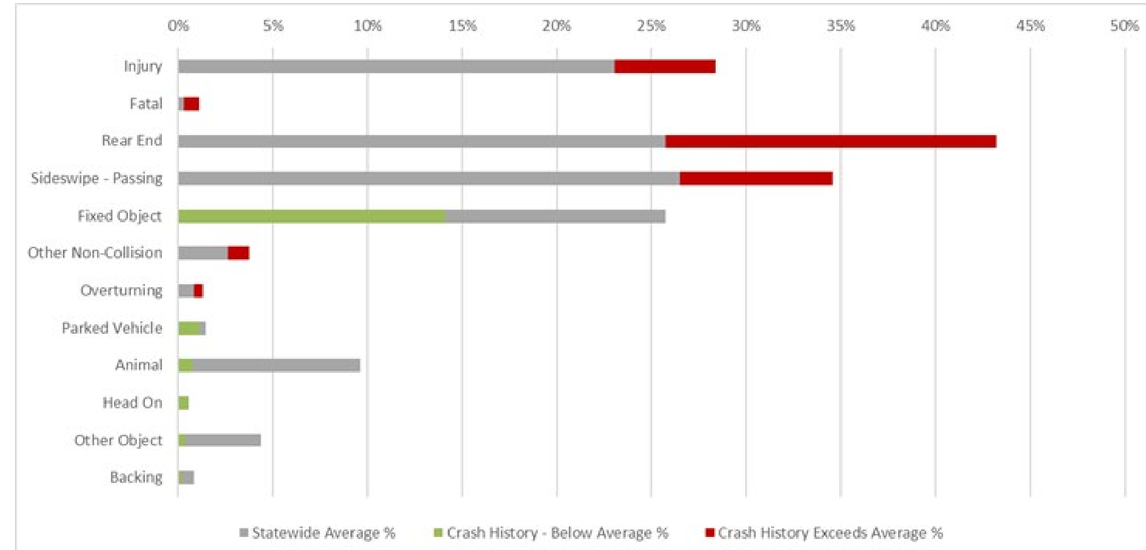


Figure 5. Percentage of Crashes by Type Versus Statewide Averages, Northbound

In the northbound direction the most common crash type was rear-end, accounting for 43% of all crashes, far above the 26% average for a similar corridor. These crashes commonly occurred between the hours of 4 PM and 7 PM (40% of all rear-end crashes), which correlates with the PM peak hour and when congestion is at its peak in this direction. The second most common northbound crash type was sideswipe passing, making up 35% of all crashes which also exceeds its average of 26%. These crashes were most prevalent at the north end of the study area between Cooke Road and Morse Road, with a common cause cited as "improper lane change" (72% of all sideswipe-passing crashes). The third most common crash type, fixed object, occurred corridor wide at all hours of the day. The percentage of fixed object crashes was well below the average for similar corridors. Wet or snowy/icy conditions were a commonly cited factor in fixed object crashes (41% of all fixed object crashes).

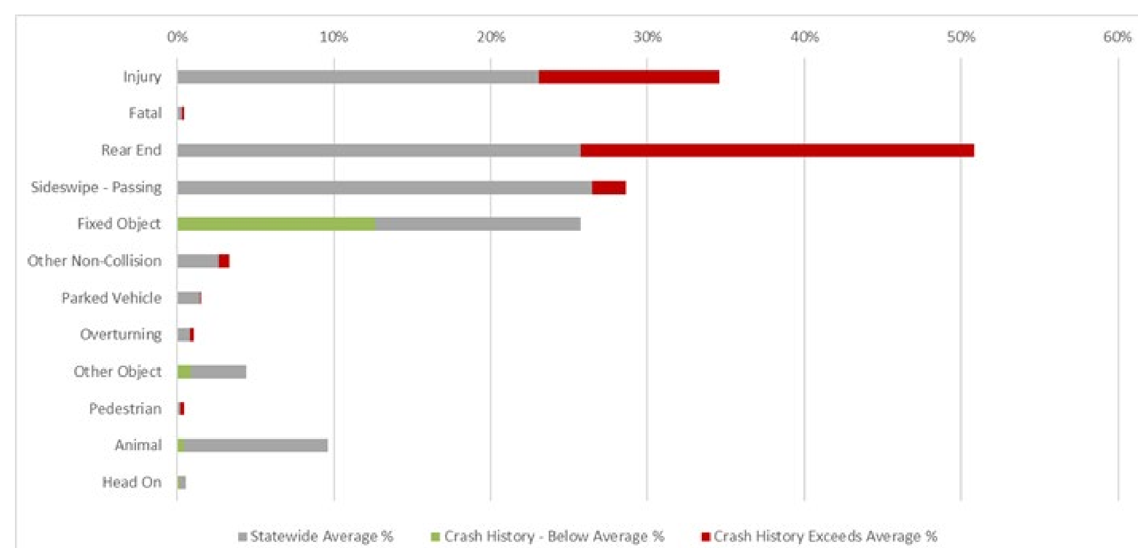


Figure 6. Percentage of Crashes by Type Versus Statewide Averages, Southbound

In the southbound direction the most common crash type was also rear-end, accounting for 51% of all crashes, significantly above the 26% average for a similar corridor. Again, this was followed by sideswipe-passing crashes at 29% (slightly above average), and fixed object at 13% (below average) of all crashes.

Rear-end crashes commonly occurred between the hours of 7 AM and 9 AM, (38% of all rear-end crashes) which correlates with the AM peak hour and when congestion is at its peak in this direction. Again, the most common cause of sideswipe-passing crashes was cited as "improper lane change" (71% of all sideswipe-passing crashes). This crash type was most prevalent at the north end of the project between Morse Road and Cooke Road. The third most common crash type, fixed object, occurred corridor wide at all hours of the day. Again, wet or snowy/icy conditions were a commonly cited factor in fixed object crashes (39% of all fixed object crashes). Injury crashes made up 35% of all crashes in this direction, well above the 23% statewide average for similar corridors.

Existing Conditions Highway Safety Manual Analysis

Highway Safety Manual (HSM) Predictive Analysis principles were used to determine how the study area is performing relative to similar site types. It evaluates safety along the corridor by comparing the existing corridor with associated crash data (expected) with data from peer sites with similar geometrics (predicted). The resulting differential is the Potential for Safety Improvement (PSI) value for each injury severity type. This assessment was done using ODOT's Economic Crash Analysis Tool (ECAT). Google Earth Aerial Imagery was used to segment the freeway into homogeneous sections per direction. For this project, segments were broken at each ramp merge/diverge point and at locations where the number of lanes increased or decreased. Aerials were also used to measure the existing conditions of each segment. Analysis results for Northbound are summarized below in Table 1. Analysis results for Southbound are summarized in Table 2. Full HSM results are provided in Appendix C2. Fatal and incapacitating injury crashes are shown in the KA column, column B represents non-incapacitating injuries, column C is used for possible injuries, and column O is for non-injury crashes.

Table 1. HSM Analysis Results - Northbound Existing Condition

	KA	B	C	O	Total
$N_{predicted}$ - NB Existing Conditions	6.1458	21.3649	24.1210	134.8875	186.5192
$N_{expected}$ - NB Existing Conditions	5.2313	17.5801	19.5992	130.0070	172.4176
$N_{potential\ for\ improvement}$ - NB Existing Conditions	-0.9145	-3.7848	-4.5218	-4.8805	-14.1016

Results show the northbound direction of I-71 is performing better than its peers by just over fourteen crashes per year overall, and also better in all injury types and PDO crashes.

Table 2. HSM Analysis Results - Southbound Existing Condition

	KA	B	C	O	Total
$N_{predicted}$ - SB Existing Conditions	6.0621	20.9882	23.6688	132.8236	183.5427
$N_{expected}$ - SB Existing Conditions	5.3371	17.9125	19.9894	141.7327	184.9717
$N_{potential\ for\ improvement}$ - SB Existing Conditions	-0.7250	-3.0757	-3.6794	8.9091	1.4290

Results show the southbound direction of I-71 is performing worse than its peers by 1.4 crashes per year overall, but better for all injury types.

The overall PSI for the corridor was broken down into the segments to identify hot spot locations. The locations were ranked based on overall crashes per mile and by injury crashes per mile, depicted in the safety performance diagrams presented in Appendix C3. The segments with the highest overall and injury crashes per mile also generally had the highest PSI, which signals a safety issue that could be mitigated with improvements. Those areas in the northbound direction were on the south end of the study area, south of 5th Avenue to north of 11th Avenue, being prominently worse than others. The southbound direction trouble spots were generally in the same southern area but were not as prominent a problem and more spread out.

The two analyses presented in this section comparing the statewide averages and HSM results show differing results. The statewide averages for crash type are useful to identify crash type patterns and high crash locations, but not overall safety operations of a corridor. The HSM analysis in the ECAT tool includes a more complex comparison of not only the number and type of crashes, but the geometric features of the corridor which could contribute to crashes. This data is based on research on existing corridors with similar geometric features and provides a more holistic view of safety operations and expectations.

Proposed Conditions Highway Safety Manual Analysis

ODOT's ECAT tool was once again used to evaluate the safety of the Alternatives listed below:

- Alternative 1 – No Build (Preservation)
- Alternative 3 – Part-time Add Lane (HSR Inside)
- Alternative 4 – Full-time Add Lane (Standard Design)*
- Alternative 5 – Full-time Add Lane (PBPD)

**Alternative 4 is included in the analysis as a baseline for comparison*

Inputs to the ECAT tool include No Build certified traffic volumes and geometric characteristics for each alternative. Through discussions with ODOT, and per their Interoffice Communication memo dated 10/14/21 (included in Appendix C4), a directive was made to utilize No Build certified traffic volumes for all alternatives. ODOT determined this provided a more accurate comparison of each alternative to the No Build condition. This was based on ODOT's statement that the number of "crashes grow exponentially with increases in traffic volumes". It was also determined by ODOT that the certified traffic volumes for the Build condition represented in Alternative 3 exceed the maximum threshold for a six-lane freeway scenario in ECAT and was producing results deemed inaccurate.

Key geometric inputs that varied between alternatives include number of through lanes, widths of lanes, shoulders, and medians, and offset between barriers and traveled lanes. Each segment was analyzed and the collective totals for the corridor were recorded for each alternative, as described below.

<u>Alternative 1 – No Build (Preservation)</u>

The No Build condition was analyzed with existing geometrics in place and using certified traffic volumes for No Build.

<u>Alternative 3 – Part-time Add Lane (HSR Inside)</u>

A part-time add lane to the inside was analyzed with the proposed alternative geometrics and certified traffic volumes for No Build. ECAT volume inputs are Average Daily Traffic and the HSR lane is only expected to be open for a limited number of hours per day, therefore complicating the analysis. The approach taken was to analyze the HSR lane under both the open and closed conditions for each direction and take a weighted average of the results. The same approach was taken on the I-670 HSR ECAT analysis, with the assumed hours for the HSR lane to be open for northbound being 3-7PM, and southbound 6-9AM. Peak hour volumes were not available within the study area when this analysis was performed, but data from the closest ATR was used. According to an average of 2019 and early 2020 data, the northbound "open" traffic accounts for 35% of the daily traffic, and southbound accounts for 25%.

<u>Alternative 4 – Full-time Add Lane (Standard Design)</u>

A full-time add lane scenario was also analyzed with the proposed alternative geometrics and the certified traffic volumes for No Build.

<u>Alternative 5 – Full-time Add Lane (PBPD)</u>

This alternative utilized the same volumes as Alternative 4, but with the proposed alternative geometry.

The results of each Alternative are shown in Table 3 and Table 4 and included in Appendix C5-6.

Table 3. HSM Analysis Results - Northbound Proposed Condition

	KA	B	C	O	Total	% Increase vs. No Build
Alt 1 - No Build (Preservation)	7.9224	28.2148	32.1392	191.9783	260.2547	
Alt 3 - Part-Time Add Lane (HSR Inside)	8.5102	29.0936	32.6447	183.8399	254.0883	-2.4%
Alt 4 - Full-time Add Lane (Standard Design)	9.0453	30.4432	33.9805	211.4583	284.9273	9.5%
Alt 5 - Full-time Add Lane (PBPD)	10.2446	34.5739	38.6283	231.1354	314.5822	20.9%

Table 4. HSM Analysis Results - Southbound Proposed Condition

	KA	B	C	O	Total	% Increase vs. No Build
Alt 1 - No Build (Preservation)	7.7034	27.3058	31.0684	185.5472	251.6248	
Alt 3 - Part-Time Add Lane (HSR Inside)	8.0489	27.6185	31.0521	174.8415	241.5611	-4.0%
Alt 4 - Full-time Add Lane (Standard Design)	8.7477	29.3686	32.7616	202.3784	273.2563	8.6%
Alt 5 - Full-time Add Lane (PBPD)	9.8781	33.2957	37.1973	221.0988	301.4699	19.8%

The red text indicates an alternative which shows an increase in crashes compared to the No Build condition. Several factors negatively affect safety performance including, but not limited to, increased number of lanes, decreased lane/shoulder widths, and decreased offset to barriers. To capture the relative increase in predicted crashes, the last column compares the increase in crashes as a percentage above the No Build condition. The HSR lane is predicted to decrease crashes by at least 2.4% in both directions. The full-time add lane alternatives increase crashes, ranging from around 9% to just over 20% between standard and PBPD designs. One explanation behind the unexpected increase in crashes for the standard design (and to some degree PBPD) is that a lane addition specifically from three to four lanes in ECAT (as is the case here) causes an increase in predicted crashes.

Another function of the ECAT tool is to evaluate safety conditions when other countermeasures to improve safety are implemented. The I-670 analysis applied a Crash Modification Factor (CMF) for installing wider edge lines and lane lines as well as shoulder rumble strips, which is predicted to result in a 20% reduction in fatal and injury crashes. The addition of the CMF to ECAT bears the following results shown in Table 5 and Table 6 and included in Appendix C7-8.

Table 5. HSM Analysis Results - Northbound Proposed Condition with CMF

	KA	B	C	O	Total	% Increase vs. No Build
Alt 1 - No Build (Preservation)	7.9224	28.2148	32.1392	191.9783	260.2547	
Alt 3 - Part-Time Add Lane (HSR Inside)	6.8082	23.2750	26.1157	183.8399	240.0387	-7.8%
Alt 4 - Full-time Add Lane (Standard Design)	7.2362	24.3544	27.1845	211.4583	270.2334	3.8%
Alt 5 - Full-time Add Lane (PBPD)	8.1950	27.6560	30.8990	231.0943	297.8443	14.4%

Table 6. HSM Analysis Results - Southbound Proposed Condition with CMF

	KA	B	C	O	Total	% Increase vs. No Build
Alt 1 - No Build (Preservation)	7.7034	27.3058	31.0684	185.5472	251.6248	
Alt 3 - Part-Time Add Lane (HSR Inside)	6.4974	22.3130	25.0946	177.1287	231.0337	-8.2%
Alt 4 - Full-time Add Lane (Standard Design)	6.9982	23.4950	26.2094	202.3784	259.0810	3.0%
Alt 5 - Full-time Add Lane (PBPD)	7.9023	26.6366	29.7578	221.0988	285.3955	13.4%

The results including the wider markings and rumble strips are much improved over those without. All alternatives show a predicted improvement in safety for some injury crash types, denoted in green text, over the No Build condition. The HSR Alternative shows an overall safety improvement of around 8%. The full-time add lane Alternatives still degrade safety overall, but down to a range of 3% to 14% between standard and PBPD designs.

A newer CMF was found from a 2018 study but was not used in this analysis since it is relatively new, and only applies to an HSR option. It stems from a Virginia DOT project which included hard shoulder running, advisory variable speed limits, and lane use control signs. Further research into that study is suggested if this CMF should be considered, but current research appears to support that a speed limit reduction (through variable speed limit signs) and the use of overhead dynamic lane control signs would further improve safety. Per the above mentioned Interoffice Communication memo, ODOT is in concurrence and does not recommend using this CMF.

Traffic Operations

The Traffic Analysis study area includes the I-71 corridor between the I-670 and I-270 interchanges. The following interchanges were included in the traffic analysis:

- 5th Avenue
- 11th Avenue
- 17th Avenue
- Hudson Street
- Weber Road
- N. Broadway
- Cooke Road
- Morse Road
- SR 161
- I-270 (southern ramps)

Certified Traffic

Certified traffic for the I-71 corridor was provided by the ODOT Office of Statewide Planning and Research, Modeling and Forecasting Section. Traffic forecasts were approved on September 23, 2020. The certified traffic plates include the existing year (2020), opening year (2023) and design year (2043) for the No-Build, Build part-time add lane (i.e., HSR), and Build full-time (i.e., permanent) add lane. In general, the part-time add lane increases the mainline volumes approximately 300 vehicles per hour compared to the No-Build condition. The full-time add lane increases the mainline volumes an additional 300 vehicles per hour. The certified traffic plates are contained in Appendix D1.

Traffic Analysis

Based on Certified Traffic, capacity analysis was performed to determine any impacts to mainline I-71 as well as the merge and diverge of the ramps. Analysis was conducted in the Freeway Facilities module of the *Highway Capacity Software Version 7.9.6 (HCS)*.

Capacity analyses for the No-Build and Build conditions were conducted for the 2043 design year. All design year traffic analyses are based on the procedures outlined in the *Highway Capacity Manual 6th Edition (HCM)*.

The Levels of Service (LOS) for basic freeway segments, ramp merge and diverge areas and weaving areas for the Design Year (2043) are presented in Table 7 for the northbound direction and Table 8 for the southbound direction. Capacity results are discussed below and detailed outputs of the *HCS* analysis are contained in Appendix D2.

Table 7. Northbound I-71 Freeway HCS Operation Level of Service

Segment	Analysis Type	Location (Northbound I-71)	2043 AM Peak (HCS)												2043 PM Peak (HCS)											
			No-Build				Hard Shoulder Running				Permanent Add Lane				No-Build				Hard Shoulder Running				Permanent Add Lane			
			LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c	
					F*	R*			F*	R*			F*	R*			F*	R*			F*	R*			F*	R*
Seg-1	Basic	South of I-670 On-Ramp	F	0.90	1.02	-	F	1.00	1.06	-	F	1.00	1.09	-	F	0.72	0.80	-	D	0.84	0.84	-	D	0.85	0.85	-
Seg-2	Merge	I-670 On-Ramp	F	0.74	0.85	0.38	D	0.84	0.84	0.42	D	0.84	0.84	0.41	F	0.62	0.73	0.61	D	0.77	0.77	0.63	D	0.78	0.78	0.66
Seg-3	Basic	South of 5th Avenue On-Ramp (Start HSR/Add)					C	0.67	0.72	-	C	0.67	0.74	-					C	0.63	0.63	-	C	0.63	0.64	-
Seg-3, 4	Merge	5th Avenue On-Ramp	F	0.79	0.93	0.30	C	0.73	0.73	0.33	C	0.73	0.73	0.34	F	0.70	0.85	0.48	C	0.72	0.72	0.52	C	0.72	0.72	0.53
Seg-4, 5	Diverge	11th Avenue Off-Ramp	F	0.79	0.94	0.41	D	0.73	0.73	0.44	D	0.73	0.73	0.41	F	0.69	0.86	0.34	D	0.72	0.72	0.31	D	0.72	0.72	0.34
Seg-5,6	Basic	South of 11th Avenue On-Ramp	F	0.93	1.11	-	D	0.82	0.87	-	D	0.82	0.90	-	F	0.81	1.04	-	D	0.84	0.84	-	D	0.83	0.85	-
Seg-6, 7	Weave	Between 11th Avenue On and 17th Avenue Off	D	0.83	0.96	#	D	0.77	0.80	#	D	0.77	0.83	#	F	0.75	0.96	#	D	0.82	0.82	#	D	0.82	0.83	#
Seg-7, 8	Basic	South of 17th Avenue On-Ramp	F	0.87	1.04	-	D	0.77	0.81	-	D	0.78	0.85	-	F	0.82	1.09	-	D	0.88	0.88	-	D	0.87	0.89	-
Seg-8, 9	Merge	17th Avenue On-Ramp	F	0.93	0.93	0.21	C	0.82	0.82	0.22	C	0.82	0.82	0.21	F	0.93	0.93	0.39	D	0.96	0.96	0.39	D	0.96	0.96	0.41
Seg-9, 10	Basic	South of Hudson Street Off-Ramp	F	0.93	1.11	-	D	0.82	0.87	-	D	0.82	0.91	-	F	0.93	1.21	-	E	0.97	0.97	-	E	0.96	0.99	-
Seg-10, 11	Diverge	Hudson Street Off-Ramp	F	0.93	0.93	0.32	D	0.82	0.82	0.34	D	0.82	0.82	0.35	F	0.93	0.93	0.35	E	0.97	0.97	0.40	E	0.96	0.96	0.40
Seg-11, 12	Basic	South of Hudson Street On-Ramp	F	0.84	1.01	-	D	0.74	0.79	-	D	0.75	0.82	-	F	0.83	1.10	-	D	0.88	0.88	-	D	0.87	0.89	-
Seg-12, 13	Weave	Between Hudson Street On and Weber Off	D	0.77	0.90	#	D	0.72	0.75	#	D	0.72	0.78	#	F	0.81	1.05	#	E	0.87	0.87	#	E	0.88	0.90	#
Seg-13, 14	Basic	South of Weber Road On-Ramp	F	0.88	1.07	-	D	0.78	0.84	-	D	0.79	0.87	-	F	0.91	1.21	-	E	0.95	0.95	-	E	0.95	0.98	-
Seg-14, 15	Weave	Between Weber Road On and N. Broadway Off	F	0.80	0.96	#	D	0.77	0.81	#	D	0.77	0.84	#	F	0.84	1.10	#	E	0.93	0.93	#	E	0.93	0.95	#
Seg-15, 16	Basic	South of N. Broadway On-Ramp	F	0.84	1.07	-	D	0.78	0.83	-	D	0.79	0.87	-	F	0.86	1.19	-	E	0.93	0.93	-	E	0.93	0.96	-
Seg-16, 17	Merge	N. Broadway On-Ramp	F	0.93	0.93	0.30	D	0.85	0.85	0.34	D	0.86	0.86	0.34	F	0.93	0.93	0.25	D	1.00	1.00	0.29	F	0.99	0.99	0.28
Seg-17, 18	Basic	South of Cooke Road Off-Ramp	F	0.93	1.17	-	D	0.85	0.92	-	D	0.86	0.96	-	F	0.93	1.27	-	E	1.00	1.00	-	F	0.99	1.02	-
Seg-18, 19	Diverge	Cooke Road Off-Ramp	F	0.93	0.93	0.30	D	0.85	0.85	0.30	D	0.86	0.86	0.33	F	0.93	0.93	0.36	E	1.00	1.00	0.40	F	0.99	0.99	0.39
Seg-19, 20	Basic	South of Cooke Road On-Ramp	F	0.84	1.07	-	D	0.78	0.84	-	D	0.79	0.87	-	F	0.83	1.15	-	E	0.91	0.91	-	E	0.90	0.93	-
Seg-20, 21	Merge	Cooke Road On-Ramp	F	0.93	0.93	0.32	D	0.86	0.86	0.33	D	0.86	0.86	0.33	F	0.92	0.92	0.30	D	0.98	0.98	0.36	D	0.97	0.97	0.29

Table 7. Northbound I-71 Freeway HCS Operation Level of Service (Continued)

Segment	Analysis Type	Location (Northbound I-71)	2043 AM Peak (HCS)												2043 PM Peak (HCS)											
			No-Build				Hard Shoulder Running				Permanent Add Lane				No-Build				Hard Shoulder Running				Permanent Add Lane			
			LOS	v/c	d/c F*	d/c R*	LOS	v/c	d/c F*	d/c R*	LOS	v/c	d/c F*	d/c R*	LOS	v/c	d/c F*	d/c R*	LOS	v/c	d/c F*	d/c R*	LOS	v/c	d/c F*	d/c R*
Seg-21, 22	Overlap	South of Morse Road Off-Ramp	F	0.93	1.19	-	D	0.86	0.93	-	D	0.86	0.96	-	F	0.92	1.25	-	E	0.99	0.99	-	E	0.97	1.00	-
Seg-22, 23	Diverge	Morse Road Off-Ramp	F	0.93	0.93	0.71	E	0.86	0.83	0.72	E	0.86	0.86	0.74	F	0.92	0.92	0.71	E	0.99	0.99	0.73	F	0.97	0.97	0.75
Seg-23, 24	Basic	South of Morse Road On-Ramp	D	0.73	0.94	-	C	0.70	0.74	-	C	0.70	0.77	-	F	0.71	1.03	-	D	0.82	0.82	-	D	0.81	0.83	-
Seg-24, 25	Merge	Morse Road On-Ramp	F	0.88	0.88	0.52	D	0.81	0.81	0.50	D	0.81	0.81	0.50	F	0.88	0.88	0.59	D	0.95	0.95	0.57	D	0.93	0.93	0.59
Seg-25, 26	Basic	South of SR 161 Off-Ramp (3 Lanes)	F	0.88	1.12	-	D	0.81	0.87	-	D	0.81	0.90	-	F	0.88	1.21	-	E	0.96	0.96	-	E	0.93	0.97	-
Seg-26, 27	Basic	South of SR 161 Off-Ramp (4 Lanes)	C	0.66	0.84	-	C	0.65	0.70	-	C	0.65	0.72	-	C	0.66	0.91	-	D	0.76	0.76	-	D	0.75	0.77	-
Seg-27, 28	Diverge	SR 161 Off-Ramp	C	0.66	0.66	0.34	D	0.65	0.65	0.38	D	0.65	0.65	0.37	C	0.66	0.66	0.33	D	0.76	0.76	0.35	D	0.74	0.74	0.35
Seg-28, 29	Basic	South Of SR 161 On-Ramp	C	0.68	0.89	-	C	0.64	0.67	-	F	0.61	0.71	-	F	0.69	1.00	-	D	0.79	0.79	-	F	0.73	0.80	-
Seg-29, 30	Weave	Between SR 161 On and I-270 Off	C	0.82	0.98	#	C	0.97	0.97	#	F	0.93	1.09	#	F	0.75	1.01	#	D	1.00	1.11	#	F	0.93	1.09	#
Seg-30, 31	Basic	North of I-270 Off-Ramp	A	0.29	0.48	-	B	0.48	0.50	-	A	0.30	0.46	-	B	0.36	0.70	-	C	0.68	0.68	-	C	0.53	0.73	-

Seg-X = No-Build condition
Seg-Y = Build condition

- Basic Freeway Segment
- Weaving Segment

HCS Results (Facility)

Facility Length, mi	9.38	9.38	9.38	9.38	9.38	9.38
Space Mean Speed, mi/h	50.8	62.2	59.4	44.8	58.9	56.8
Density, pc/mi/ln	36.7	28.3	29.2	41.3	34.7	35.0
Density, veh/mi/ln	30.5	23.5	24.2	37.7	31.0	31.9
Travel Time, min	11.10	9.00	9.50	12.60	9.50	9.90
LOS	F	F	F	F	F	F

Table 8. Southbound I-71 Freeway HCS Operation Level of Service

Segment	Analysis Type	Location (Southbound I-71)	2043 AM Peak (HCS)												2043 PM Peak (HCS)											
			No-Build				Hard Shoulder Running				Permanent Add Lane				No-Build				Hard Shoulder Running				Permanent Add Lane			
			LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c	
					F*	R*			F*	R*			F*	R*			F*	R*			F*	R*			F*	R*
Seg-1	Basic	North of WB I-270 On-Ramp	B	0.46	0.47	-	B	0.45	0.45	-	B	0.49	0.49	-	B	0.39	0.39	-	B	0.38	0.38	-	B	0.37	0.37	-
Seg-2	Merge	WB I-270 On-Ramp	B	0.46	0.46	0.50	B	0.46	0.46	0.52	B	0.48	0.48	0.47	B	0.43	0.43	0.60	B	0.42	0.42	0.62	B	0.42	0.42	0.62
Seg-3	Weave	North of SR 161 Off-Ramp	B	0.48	0.48	-	B	0.48	0.48	-	B	0.48	0.48	-	B	0.45	0.45	-	B	0.46	0.46	-	B	0.46	0.46	-
Seg-4	Basic	North of SR 161 On-Ramp	B	0.45	0.45	-	B	0.47	0.47	-	B	0.46	0.46	-	B	0.45	0.45	-	B	0.47	0.47	-	B	0.46	0.46	-
Seg-5	Merge	SR 161 On-Ramp	C	0.57	0.57	0.55	C	0.60	0.60	0.58	C	0.59	0.59	0.59	C	0.61	0.61	0.73	C	0.64	0.64	0.78	C	0.64	0.64	0.79
Seg-6	Basic	North of Morse/Sinclair Road Off-Ramp (4 Lanes)	C	0.57	0.58	-	C	0.61	0.61	-	C	0.60	0.60	-	C	0.64	0.64	-	C	0.66	0.66	-	C	0.66	0.66	-
Seg-7	Basic	North of Morse/Sinclair Road Off-Ramp (3 Lanes)	D	0.76	0.78	-									D	0.85	0.85	-								
Seg-8, 7	Diverge	Morse/Sinclair Road Off-Ramp	D	0.76	0.76	0.39	C	0.61	0.61	0.40	C	0.60	0.60	0.40	D	0.85	0.85	0.42	C	0.66	0.66	0.40	C	0.66	0.66	0.43
Seg-9, 8	Basic	North of Sinclair Road On-Ramp	C	0.64	0.65	-	C	0.68	0.68	-	C	0.67	0.67	-	C	0.72	0.72	-	D	0.76	0.76	-	D	0.75	0.75	-
Seg-9	Basic	North of Sinclair Road On-Ramp (Start HSR/Add)					C	0.52	0.52	-	C	0.52	0.52	-					D	0.76	0.76	-	C	0.58	0.58	-
Seg-10	Merge	Sinclair Road On-Ramp	C	0.72	0.72	0.25	C	0.56	0.56	0.24	C	0.56	0.56	0.26	D	0.82	0.82	0.34	D	0.85	0.85	0.33	C	0.64	0.64	0.36
Seg-11	Merge	Morse Road On-Ramp	D	0.81	0.81	0.32	C	0.66	0.66	0.40	C	0.65	0.65	0.37	D	0.91	0.91	0.26	D	0.95	0.95	0.28	C	0.72	0.72	0.31
Seg-12	Basic	North of Cooke Road Off-Ramp	D	0.81	0.83	-	C	0.66	0.66	-	C	0.66	0.66	-	E	0.92	0.92	-	E	0.97	0.97	-	D	0.73	0.73	-
Seg-13	Diverge	Cooke Road Off-Ramp	D	0.81	0.81	0.19	C	0.66	0.66	0.17	C	0.66	0.66	0.20	D	0.92	0.92	0.30	E	0.97	0.97	0.30	D	0.73	0.73	0.30
Seg-14	Basic	North of Cooke Road On-Ramp	D	0.75	0.77	-	C	0.62	0.62	-	C	0.61	0.61	-	D	0.82	0.82	-	D	0.86	0.86	-	C	0.65	0.65	-
Seg-15	Merge	Cooke Road On-Ramp	D	0.88	0.88	0.44	C	0.73	0.73	0.49	C	0.73	0.73	0.53	D	0.92	0.92	0.35	E	0.97	0.97	0.37	C	0.75	0.75	0.45
Seg-16	Basic	North of N. Broadway Off-Ramp	E	0.88	0.91	-	D	0.74	0.74	-	D	0.74	0.74	-	E	0.94	0.94	-	E	0.99	0.99	-	D	0.77	0.77	-
Seg-17	Diverge	N. Broadway Off-Ramp	D	0.86	0.86	0.22	D	0.74	0.74	0.22	D	0.74	0.74	0.20	D	0.94	0.94	0.26	E	0.99	0.99	0.27	D	0.77	0.77	0.28
Seg-18	Basic	North of N. Broadway On-Ramp	D	0.79	0.84	-	C	0.69	0.69	-	C	0.69	0.69	-	D	0.85	0.85	-	E	0.89	0.89	-	C	0.70	0.70	-
Seg-19	Weave	Between N. Broadway On and Weber Road Off	D	0.76	0.82	#	C	0.69	0.69	#	C	0.70	0.70	#	D	0.81	0.81	#	D	0.84	0.84	#	C	0.69	0.69	#

Table 8. Southbound I-71 Freeway HCS Operation Level of Service (Continued)

Segment	Analysis Type	Location (Southbound I-71)	2043 AM Peak (HCS)												2043 PM Peak (HCS)											
			No-Build				Hard Shoulder Running				Permanent Add Lane				No-Build				Hard Shoulder Running				Permanent Add Lane			
			LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c		LOS	v/c	d/c	
					F*	R*			F*	R*			F*	R*			F*	R*			F*	R*			F*	R*
Seg-20	Basic	North of Weber Road On-Ramp	D	0.85	0.94	-	D	0.75	0.75	-	D	0.75	0.75	-	E	0.88	0.88	-	E	0.91	0.91	-	C	0.72	0.72	-
Seg-21	Weave	Between Weber Road On and Hudson Street Off	F	0.75	0.86	#	D	0.73	0.73	#	D	0.74	0.74	#	D	0.77	0.77	#	D	0.81	0.81	#	C	0.67	0.67	#
Seg-22	Basic	North of Hudson Street On-Ramp	F	0.79	0.96	-	D	0.76	0.76	-	D	0.78	0.78	-	D	0.83	0.83	-	E	0.89	0.89	-	C	0.69	0.69	-
Seg-23	Merge	Hudson Street On-Ramp	F	0.91	1.08	0.43	D	0.85	0.85	0.43	D	0.88	0.88	0.46	D	0.92	0.92	0.31	D	0.98	0.98	0.33	C	0.76	0.76	0.33
Seg-24	Basic	North of 17th Avenue Off-Ramp	F	0.90	1.09	-	D	0.86	0.86	-	E	0.89	0.89	-	E	0.94	0.94	-	E	1.00	1.00	-	D	0.77	0.77	-
Seg-25	Diverge	17th Avenue Off-Ramp	F	0.89	1.09	0.15	D	0.86	0.86	0.17	D	0.89	0.89	0.15	D	0.94	0.94	0.30	E	1.00	1.00	0.30	D	0.77	0.77	0.32
Seg-26	Basic	North of 17th Avenue On-Ramp	F	0.84	1.04	-	D	0.82	0.82	-	D	0.85	0.85	-	D	0.84	0.84	-	E	0.90	0.90	-	C	0.69	0.69	-
Seg-27	Weave	Between 17th Avenue On and 11th Avenue Off	F	0.82	1.01	#	D	0.83	0.83	#	E	0.86	0.86	#	D	0.83	0.83	#	E	0.87	0.87	#	D	0.71	0.71	#
Seg-28	Basic	North of 11th Avenue On-Ramp	F	0.93	1.17	-	E	0.91	0.91	-	E	0.94	0.94	-	E	0.94	0.94	-	D	0.75	0.75	-	D	0.77	0.77	-
Seg-29	Weave	Between 11th Avenue On and 5th Avenue Off	F	0.86	1.06	#	D	0.85	0.85	#	D	0.88	0.88	#	D	0.87	0.87	#	C	0.73	0.73	#	C	0.72	0.72	#
Seg-30	Diverge	I-670 Off-Ramp	E	0.72	0.72	0.68	E	0.92	0.92	0.70	E	0.96	0.96	0.73	D	0.75	0.75	0.51	D	0.77	0.77	0.48	E	0.79	0.79	0.54
Seg-31	Basic	North of 5th Avenue On-Ramp	C	0.54	0.76	-	D	0.76	0.76	-	D	0.80	0.80	-	C	0.65	0.65	-	C	0.71	0.71	-	C	0.69	0.69	-
Seg-32	Merge	5th Avenue On-Ramp	C	0.51	0.51	0.45	C	0.66	0.66	0.38	C	0.69	0.69	0.41	C	0.56	0.56	0.34	C	0.59	0.59	0.28	C	0.58	0.58	0.30
Seg-33	Basic	South of 5th Avenue On-Ramp	B	0.51	0.67	-	C	0.66	0.66	-	C	0.70	0.70	-	C	0.57	0.57	-	C	0.60	0.60	-	C	0.60	0.60	-

Seg-X = No-Build condition   Seg-Y = Build condition   - Basic Freeway Segment   # - Weaving Segment

HCS Results (Facility)

Facility Length, mi	9.87	9.88	9.88	9.87	9.88	9.88
Space Mean Speed, mi/h	51.0	63.6	63.2	62.1	61.6	64.3
Density, pc/mi/ln	31.2	24.6	25.1	27.0	27.5	23.5
Density, veh/mi/ln	27.9	21.7	22.1	22.4	22.8	19.5
Travel Time, min	11.60	9.30	9.40	9.50	9.60	9.20
LOS	F	C	C	D	D	C

Interpretation of HCS Freeway Operational Results

The use of the Freeway Facilities module in HCS allows the freeway segments, merges, diverges and weaves to be evaluated as a system. It computes performance measures for each of the individual segments within a study section, includes the inter-segment impacts of traffic congestion on all affected segments, and provides overall performance measures for the entire study section. As stated in the HCM, the methodology is consistent with individual segment methodologies if all demand volume-to-capacity (D/C) ratios are less than 1.00 and it properly accounts for the interaction of segments when any D/C ratio is greater than 1.00. Analysis of individual segments may fail to capture potential bottleneck impacts at one segment on adjacent upstream and downstream segments. A bottleneck on one segment that is over capacity will reduce the throughput volume on downstream links because the full demand will be unable to travel through the bottleneck. Likewise, links upstream of the bottleneck will have additional queuing and delay caused by the bottleneck. This interaction between segments is captured in the Freeway Facilities analysis. Table 7 and Table 8 present the Freeway Facilities results for the northbound and southbound directions, respectively. The LOS results reported are based on the vehicles actually able to pass through a segment and is dependent on upstream and downstream bottlenecks in the corridor. D/C ratios are also included and represent how the segment would operate if there were no upstream bottlenecks and the full traffic demand passed through the segment. Finally, the V/C ratio for each segment has been reported. This is based on the volume that can actually pass through a segment. If there are no bottlenecks in the corridor, the V/C ratio and D/C ratios for each segment would be the same. A difference between the V/C and D/C ratios is an indication that there is congestion on the corridor and upstream bottlenecks are preventing the full traffic demand from reaching this segment.

The overall operational goal for this project was to design all mainline, ramp merge/diverge and weave locations to LOS D or better. Locations where this was not achievable will be discussed in further detail below.

<u>Northbound Direction</u>

As shown in Table 7, most segments in the No-Build condition operate at LOS F with D/C ratios well over 1.0 during the AM and PM peak hours. Bottlenecks from these areas extend upstream and cause LOS F conditions for mainline segments that are already operating with D/C ratios near 1.0. These results indicate that the capacity issues are a corridor wide issue and not just a couple of isolated bottlenecks. The segments from the Cooke Road to Morse Road interchanges have the highest D/C ratios in the corridor. The overall freeway facility is LOS F in both the AM and PM Peak hours.

In the HSR condition, the hard shoulder running lane was assumed to be open during both the AM and PM peak hours. The addition of the HSR lane has made significant improvements to the corridor operation. The only segment operating at LOS F is segment 1, which is south of the I-670 on-ramp. This section is the entry leg to the corridor and no improvements were made to this segment. In the PM peak, the operation for most of the corridor has improved from LOS F to LOS E. While this does not fully meet the operational goals for the project, it is a significant improvement over the No-Build condition and all but one of the D/C ratios will be 1.0 or less. The lone exception is the weave between the SR 161 on-ramp and the I-270 off-ramp (segment 30). At this location, it appears that there is an issue with the way HCS is evaluating the weave. The configuration is similar to the No-Build condition and has an additional mainline lane, but the D/C ratio has increased over the No-Build condition. TransModeler will be used to supplement the HCS analysis. Just like the No-Build condition, the segments from the Cooke Road to Morse Road interchanges generally have the highest D/C ratios in the corridor. The overall freeway facility LOS has remained at LOS F in the AM and PM peaks. However, this is caused by the LOS F on segment 1 during the AM peak and the high D/C ratio on segment 30 in the PM peak. Without these segments, the remaining corridor operates at LOS D during both peaks. Also, the travel time for the corridor has reduced by 2.1 minutes (19%) in the AM peak and 3.1 minutes (25%) in the PM peak.

In the permanent add lane condition, the lane use for the permanent add lane alternative is the same as the HSR alternative. Overall, the operation of the permanent add lane is similar to the HSR alternative, however, the permanent add lane draws around 300 additional vehicles to the corridor during the peak hours. This causes a slight increase in the D/C ratios for the corridor compared to HSR. The segments around the Cooke Road and Morse Road interchanges that were operating right at capacity in the HSR alternative during the PM peak are now just over capacity in the permanent add lane. This creates LOS F conditions for a few segments in the PM peak as the congestion from Morse Road spills upstream and affects links that are already operating at capacity. These segments have just crossed the theoretical line between LOS E and LOS F. Also, the weave between SR 161 and I-270 (segment 30) is operating with a D/C ratio of 1.09 in both the AM and PM peaks. As with the HSR alternative, TransModeler will be used to supplement this analysis. During the AM and PM peaks, the overall freeway facility LOS is the same as the HSR alternative with LOS F. The travel time for the corridor increased by 0.5 minutes during the AM peak and 0.4 minutes in the PM peak compared to the HSR alternative.

<u>Southbound Direction</u>

As shown in Table 8, the southbound direction operates with several LOS F locations and D/C ratios greater than 1.0 in the AM peak hour of the No-Build condition. Bottlenecks from these areas extend upstream and cause LOS F conditions for mainline segments that are already operating with D/C ratios near 1.0. The PM peak hour operates with and a mix of LOS D and LOS E and most D/C ratios are less than 0.93. As with the northbound direction, these results indicate that the capacity issues are a corridor wide issue and not just a couple of isolated bottlenecks. The overall freeway facility operates at LOS F in the AM peak and LOS D in the PM peak in the No-Build condition.

In the HSR alternative, the hard shoulder running lane was assumed to be open during the AM peak hour only. The addition of the HSR has made significant improvements to the corridor. There are no segments operating at LOS F in either the AM or PM peak hours. In the PM peak, the additional traffic for this alternative has bumped the LOS for several segments from LOS D to LOS E, and the segments around 17th Avenue are operating with D/C ratios of 1.0. If needed, the operations in the PM peak could be improved by opening the HSR lane. In the AM peak, the overall freeway facility improved from LOS F to LOS C and the travel time has reduced by 2.3 minutes (20%) compared to the No-Build condition. In the PM peak, the overall LOS has remained at D and the travel times are similar to the No-Build condition.

In the permanent add lane alternative, the lane use for the permanent add lane is the same as the HSR alternative, however, the permanent add lane will add a southbound lane during the PM peak while this lane is closed in the HSR alternative. As with the northbound direction, the permanent add lane draws around 300 additional vehicles to the corridor during the peak hours. This causes a slight increase in the D/C ratios for the corridor compared to HSR for the AM peak. While no segments will operate at LOS F, a couple of segments will drop from LOS D to LOS E. Also, two segments will have D/C ratios greater than 0.93. The LOS for the PM peak will be an improvement over the HSR alternative. During the AM peak, the overall freeway facility LOS is the same as the HSR alternative with LOS C. In the PM peak, the overall freeway LOS has improved to LOS C compared to LOS D in the HSR alternative. The travel time has increased by 0.1 minutes in the AM peak and reduced by 0.40 minutes in the PM peak compared to the HSR alternative.

TransModeler Analysis

To supplement the HCS analysis, TransModeler was used to evaluate the I-71 mainline, ramp merge/diverge and weave elements for the freeway. Initially, the model included the ramp terminal intersections and key adjacent intersections along the arterials. However, congestion developed at these intersections that created queues extending to the I-71 mainline. Because these queues blocked traffic on the mainline, it became difficult to determine the benefits the additional lane provided to I-71. To truly evaluate the mainline scenarios in TransModeler, it was necessary to remove the intersections from the model and just focus the analysis on the mainline and merge/diverge locations. It was assumed that congestion at the arterial intersections would be addressed throughout the years to keep traffic from backing up onto the mainline. While analysis of the intersections was not included in the scope of this study, some potential locations for future improvements were identified. While the identification of these locations is not meant to serve as a list of future projects, it can be used to identify locations where additional studies may be to determine the most appropriate improvements to maintain acceptable intersection operations. The following locations were identified:

- Cooke Road corridor including the I-71 ramp intersections and the Indianola intersection
- Hudson Road ramp intersections
- N. Broadway ramp intersections
- 17th Avenue ramp intersections
- 11th Avenue ramp intersections

Table 9 and Table 10 present the TransModeler results for the northbound and southbound directions, respectively. TransModeler output reports are included in Appendix D3.

Table 9. Northbound I-71 TransModeler Level of Service Summary

Location (Northbound I-71)	2043 AM Peak (TransModeler)						2043 PM Peak (TransModeler)					
	No-Build		Hard Shoulder Running		Permanent Add Lane		No-Build		Hard Shoulder Running		Permanent Add Lane	
	LOS	Density	LOS	Density	LOS v/c	Density	LOS	Density	LOS	Density	LOS v/c	Density
South of I-670 On-Ramp	F	44.7	F	49.2	F	52.4	F	111.1	D	33.0	D	34.5
South of 5th Avenue On-Ramp	D	29.2	D	30.6	D	32.3	F	117.0	D	27.8	D	28.4
South of 11th Avenue Off-Ramp (Weave)	D	34.0	C	25.1	C	26.5	F	93.0	D	28.7	D	31.0
South of 11th Avenue On-Ramp	E	41.6	D	27.4	D	28.8	F	102.4	D	30.1	D	30.6
South of 17th Avenue Off-Ramp (Weave)	E	35.2	C	24.0	C	24.7	F	82.4	C	27.5	C	28.4
South of 17th Avenue On-Ramp	E	44.5	C	25.2	D	26.6	F	98.6	D	30.9	D	32.2
South of Hudson Street Off-Ramp	F	52.7	D	30.2	D	29.6	F	67.6	E	37.0	E	38.2
South of Hudson Street On-Ramp	F	59.4	D	26.1	D	26.1	F	78.3	D	32.0	D	32.3
South of Weber Road Off-Ramp (Weave)	F	52.0	C	23.2	C	22.8	F	66.7	D	30.8	D	32.0
South of Weber Road On-Ramp	F	64.8	D	27.5	D	27.0	F	74.2	E	36.0	E	41.3
South of North Broadway Off-Ramp (Weave)	F	55.9	C	25.8	C	25.2	F	60.9	E	35.1	E	41.8
South of North Broadway On-Ramp	F	72.0	D	28.9	D	29.1	F	76.7	E	38.6	F	50.4
South of Cooke Road Off-Ramp	F	68.6	D	31.1	D	31.1	F	65.4	F	46.6	F	53.6
South of Cooke Road On-Ramp	F	80.0	D	29.5	D	29.4	F	79.3	F	60.9	F	66.4
South of Morse Road Off-Ramp	F	48.2	D	33.7	D	33.9	F	47.2	F	55.5	F	55.1
South of Morse Road On-Ramp	D	26.9	C	23.8	C	23.8	F	46.2	D	27.5	D	27.5
South of SR 161 Off-Ramp	D	33.5	D	28.1	D	28.0	D	34.7	D	33.4	D	33.8
South of SR 161 On-Ramp	C	25.4	C	20.8	C	21.1	D	27.9	C	25.8	D	26.3
South of I-270 Off-Ramp	C	24.2	C	20.6	C	21.4	D	27.2	D	26.2	D	31.2
North of I-270 Off-Ramp	B	12.8	B	15.1	B	13.3	C	19.7	C	22.3	D	28.6

Table 10. Southbound I-71 TransModeler Level of Service Summary

Location (Southbound I-71)	2043 AM Peak (TransModeler)						2043 PM Peak (TransModeler)					
	No-Build		Hard Shoulder Running		Permanent Add Lane		No-Build		Hard Shoulder Running		Permanent Add Lane	
	LOS	Density	LOS	Density	LOS v/c	Density	LOS	Density	LOS	Density	LOS v/c	Density
North of I-270 On-Ramps	B	14.9	B	14.3	B	14.6	B	11.6	B	11.8	B	11.5
North of SR 161 Off-Ramp	B	16.5	B	16.2	B	15.1	B	12.2	B	15.5	B	15.4
North of SR 161 On-Ramp	B	15.3	C	18.3	B	14.4	B	11.6	B	15.2	B	15.2
North of Morse/Sinclair Road Off-Ramp	D	28.7	C	21.7	C	19.0	C	24.0	C	21.2	C	21.3
North of Sinclair Road On-Ramp	C	22.3	C	22.7	C	21.9	C	18.4	C	24.9	C	24.3
North of Morse Road On-Ramp	C	24.7	C	21.7	C	21.3	C	21.3	C	27.5	C	25.7
North of Cooke Road Off-Ramp	F	47.8	C	23.6	C	22.4	D	28.3	E	36.1	C	24.7
North of Cooke Road On-Ramp	F	53.1	C	20.5	C	19.7	C	22.2	D	27.4	C	20.6
North of North Broadway Off-Ramp	F	71.8	D	27.1	C	25.3	D	30.2	E	37.7	D	26.3
North of North Broadway On-Ramp	F	73.4	C	23.3	C	22.9	B	13.1	D	28.8	C	22.5
North of Weber Road Off-Ramp (Weave)	F	64.0	C	23.5	C	22.9	B	14.5	C	27.7	C	22.5
North of Weber Road On-Ramp	F	75.8	C	25.5	C	24.6	B	15.7	D	30.0	C	22.7
North of Hudson Street Off-Ramp (Weave)	F	65.3	C	22.4	C	22.3	B	13.5	C	21.0	B	19.6
North of Hudson Street On-Ramp	F	83.2	C	25.4	C	25.5	B	16.4	D	26.3	C	21.1
North of 17th Avenue Off-Ramp	F	75.8	E	38.3	E	39.3	D	27.9	D	33.5	C	24.8
North of 17th Avenue On-Ramp	F	82.2	F	66.5	F	65.6	C	24.5	D	28.4	C	21.4
North of 11th Avenue Off-Ramp (Weave)	F	58.7	F	62.3	F	62.8	C	25.9	C	24.7	C	21.0
North of 11th Avenue On-Ramp	F	55.9	F	73.1	F	73.8	D	30.1	C	23.8	C	25.4
North of 5th Avenue Off-Ramp	E	41.9	F	51.0	F	49.0	C	25.9	C	24.3	C	23.7
North of I-670 Off-Ramp	D	33.9	E	41.6	E	42.1	C	26.6	D	28.8	D	31.1
North of 5th Avenue On-Ramp	C	22.4	C	24.3	C	25.0	C	19.2	C	21.8	C	21.3
South of 5th Avenue On-Ramp	C	19.9	C	19.1	C	19.3	C	24.3	B	17.0	B	17.2

Interpretation of TransModeler Operational Results

As shown in Table 9 and Table 10, the TransModeler results are very similar to the HCS results. In the northbound direction, the I-71 mainline operates at LOS F for most of the corridor in both the AM and PM peak hours of the No-Build condition. It also shows that the Cooke Road to Morse Road segments appear to be a large bottleneck. For the build alternatives, the AM peak generally operates at LOS D, which is the same as the HCS analysis. For the PM peak, the build alternatives operate at LOS D and E with a handful of segments at LOS F around the Cooke Road and Morse Road interchanges. These locations with LOS F correspond to the segments in the HCS analysis that were operating with D/C ratios at or over 1.0.

In the southbound direction, TransModeler showed LOS F conditions beginning around Cooke Road and continuing to I-670 during the AM No-Build. This is about one interchange longer than the LOS F conditions from the HCS analysis. For the build alternatives in the AM peak, TransModeler was similar to the HCS analysis with one exception. The area from the 11th Avenue on ramp through the 5th Avenue on-ramp contains multiple ramps and weaving segments. For this area, HCS generally shows LOS D and E and TransModeler is LOS F. Because TransModeler follows all the individual vehicles through the model and takes into account how they interact with each other, it is believed to be more accurate than HCS for weaving segments. For this reason, the LOS F operation for this area is more likely than the LOS D and E results shown in HCS. In either case, these segments will be near capacity. However, the HSR and add lane have significantly reduced the length of queues in the corridor. During the PM peak, the results between HCS and TransModeler are consistent for the No-Build and build alternatives with each analysis tool showing a mixture of LOS D and E for all three conditions.

One area to note is the I-71 northbound weave between SR 161 and I-270. TransModeler predicts that this segment will operate at LOS C in the AM peak and LOS D in the PM peak for both build alternatives. This is an improvement over the HCS analysis that predicted the weave to be over capacity. While the right three lanes will have some additional congestion related to the weaving maneuvers, TransModeler does not show that it will be over capacity.

Except for a couple locations, the TransModeler results are very consistent with the HCS results and show the same patterns and congestion hotspots.

HSR and Permanent Limits

Based on the traffic analysis and discussions with District 6 and ORE on March 11, 2021 and August 3, 2021 (see Appendix E1), proposed HSR termini and permanent upstream/downstream improvements were identified and preliminarily vetted. With respect to HSR Inside (Alternative 3), the HSR lane going northbound would begin at 5th Avenue and end at SR 161. The HSR lane going southbound would begin at Morse Road and end at 11th Avenue. Special attention was paid to the beginning and termination for the HSR to confirm that it logically fits within the existing interchange configurations and will not cause a significant impact to the capacity on I-71. For example, terminating an HSR lane by merging it with the adjacent mainline lane could create a bottleneck if the freeway segment downstream of the merge is over capacity. Ideally, the HSR lane would be terminated in a way that does not create a merge. In order to maximize the benefit of an HSR lane, permanent changes along I-71 will need to be constructed to facilitate the HSR tie-ins at the northern and southern ends of the corridor.

In the northbound direction, the HSR lane will begin just south of the 5th Avenue on-ramp by simply opening the HSR lane on the left side. The existing condition has four lanes prior to the beginning of the HSR lane which will remain unchanged. The HSR will create a fifth mainline lane. The HSR lane will then continue northbound to just south of the SR 161 on-ramp, where it will become a permanent lane. During times when the HSR is closed, this permanent lane will open up on the inside of I-71. When the HSR is open, vehicles in the HSR lane will just continue in the added lane. This treatment avoids merging the HSR lane into I-71 and is similar to the way the HSR on I-670 eastbound terminates near I-270. The new permanent lane will then continue to the I-270 diverge where it will be terminated with a drop/decision lane to I-270 and carrying four mainline lanes on I-71 northbound. Immediately after the I-270 diverge, the outside lane will merge in to create three mainline lanes prior to the EB I-270 entrance ramp.

In the southbound direction, the HSR lane will begin just south of the Morse Road/Sinclair Road off-ramp by opening the HSR lane on the left side. One permanent change will also be made on the northern end of the project. Currently there are four mainline lanes south of the SR 161 onramp and the right lane merges in 3,500 feet north of the Morse Road/Sinclair Road off-ramp. Rather than taper in a lane on the right side and then open a lane on the left side 1 mile later, the right-side lane drop will be eliminated by extending the rightmost lane 3,500 feet and dropping it at Morse Road/Sinclair Road. Once developed, the HSR lane will continue southbound to just north of the 11th Avenue off-ramp, where it will become a permanent lane. During times when the HSR is closed, this permanent lane will open on the inside of I-71. When the HSR is open, vehicles in the HSR lane will just continue on in the added lane. This treatment avoids merging the HSR lane into I-71 and is similar to the way the HSR in the northbound direction will be terminated. The new permanent lane will then continue to the 5th Avenue diverge where it will be terminated by converting the standard diverge to 5th Avenue to a drop lane to 5th Avenue.

Figure 7 shows the lane usage for the No-Build and Build conditions of the HSR Inside alternative. The permanent lane addition alternatives would follow the same overall proposed improvements.

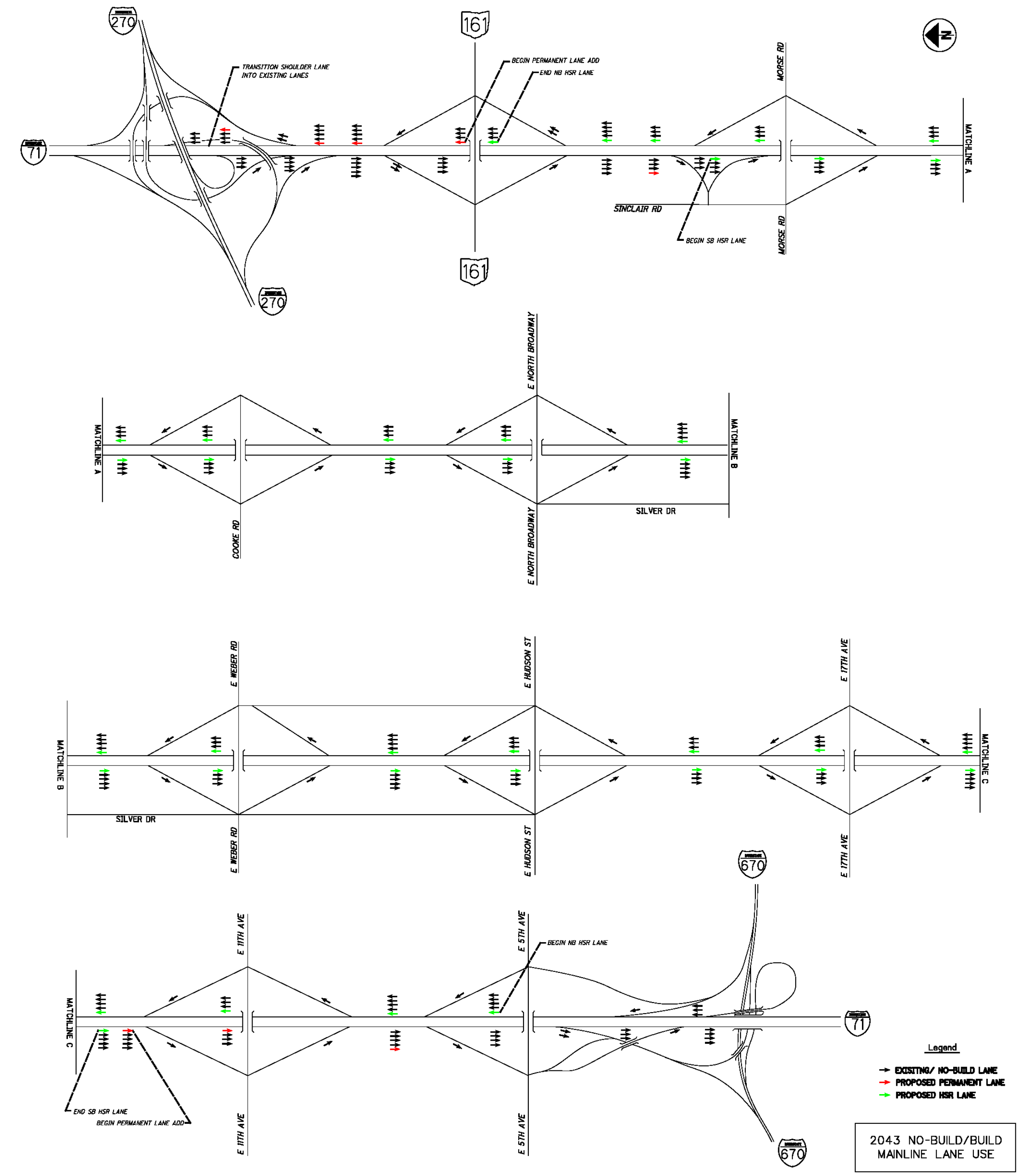


Figure 7. No-Build and Build Conditions – Inside Alternative

Hourly Breakdown for HSR

An investigation was made to determine how many hours the HSR lane would need to be open throughout the day. For this abridged analysis, hourly traffic counts were collected along the corridor on July 13, 2021 to determine how the hourly volumes changed throughout the day. These counts showed that while there were slight peaks in the AM and PM, overall the hourly volumes were high throughout the day. The hourly count volumes were grown in 5-year increments through the 2043 design year and compared to an assumed threshold of 1,600-1,700 vehicles per hour per lane that would trigger the opening of the HSR lane. From this exercise it appears that in the opening year, the HSR lane would need to be open in the southbound direction during the AM peak period and the northbound direction during the PM peak period. Over time, traffic growth will make it likely that the HSR lane will need to be open during both the AM and PM peak periods in each direction. In the 2043 design year, it is estimated that the HSR would be open 6-8 hours per day in each direction.

Travel speeds are generally the primary variable that the determines when an HSR lane is opened. This is true for how the Traffic Management Center (TMC) operates the I-670 SmartLane. To compare the abovementioned collected volumes to speed, INRIX data was ascertained from July 13, 2021, as seen in Figure 8. Average speeds support a substantial peak hour slow down in the NB PM peak with minor speed reductions for the SB AM peak. This data is a very small sampling in addition to representing traffic patterns during COVID-19 that has generally flattened peak hour volumes in urban areas. For comparison's sake, average travel speeds for the month of July in 2019 (pre-COVID) were also obtained, as seen in Figure 9. This data supports that average travel speeds are the lowest during peak hours and would support the abridged hourly analysis suggesting that by 2023 (opening) an HSR lane would likely be open during SB during AM hours and NB during PM hours. The only additional insight gained by talking with the Office of Traffic Operations was that they are seeing high volumes/low speeds regularly on SB in the PM hours towards the southern end of the corridor. This situation could cause HSR to be open in the SB during the PM peak hours, but the permanent addition of a 4th lane between 11th and 17th could alleviate the need for this.

Traffic Operation Conclusions

The No-Build condition operates with LOS F conditions for most of the northbound and southbound I-71 corridors. The HSR and permanent add lane alternatives are expected to improve this operation to LOS D or E for nearly all segments of the corridor. While there are a few segments in the build alternatives that will operate at or slightly over capacity, this is in the 2043 design year. With the traffic growth in the corridor estimated at approximately 1% per year, these segments will not reach capacity until very close to the design year. They are expected to operate for several years below capacity. Both the HSR and permanent add lane alternatives will be a significant operational benefit to the I-71 corridor.

In addition to the HSR and permanent add lane alternatives, ramp metering was investigated as a possible alternative. Given the fact that the No-Build condition is expected to be more than 25% over capacity by the design year, it was determined that ramp metering could not hold back enough traffic volume to improve mainline I-71 and was dismissed from further consideration.

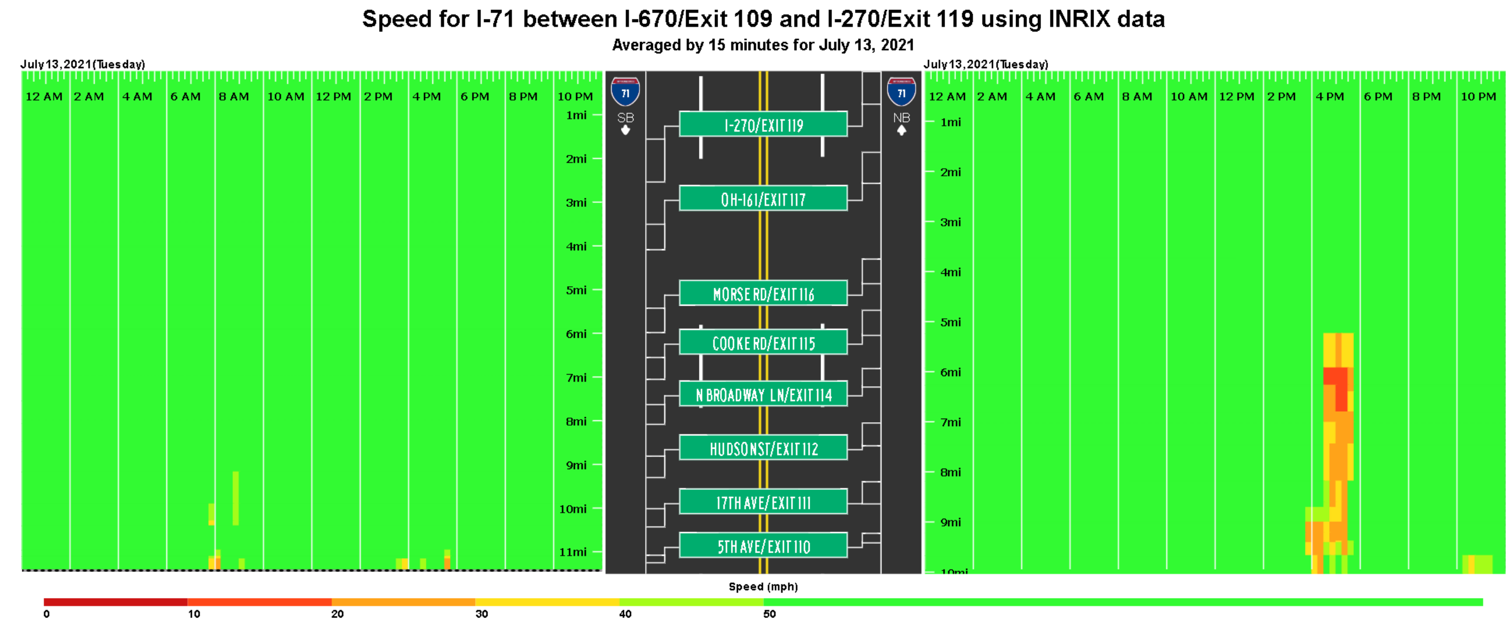


Figure 8. Average Travel Speeds on July 13, 2021

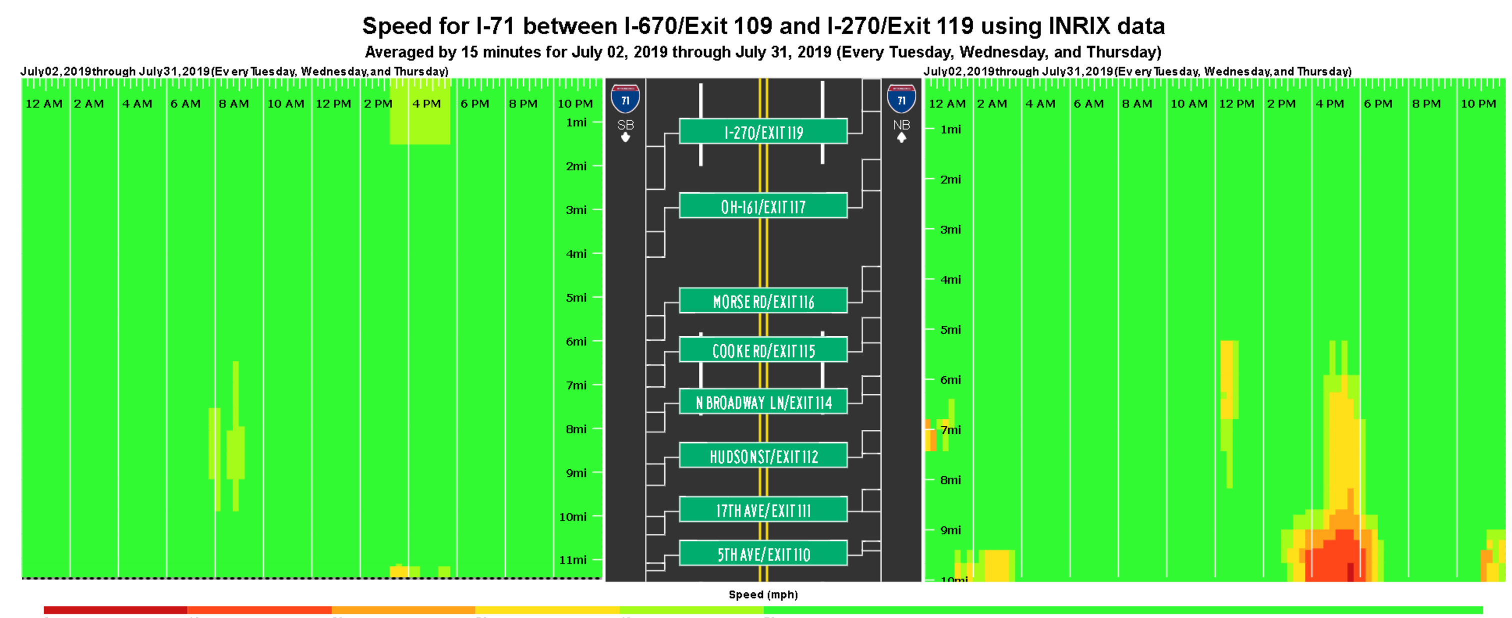


Figure 9. Average Travel Speeds in July 2019

Roadway

Existing Conditions/Overview

The existing geometry was evaluated to document any geometric deficiencies that may exist. While the primary purpose of this TSMO study isn't to address geometric issues, knowing this information could prove useful in evaluating the safety or other aspects of the corridor during the process. The findings of this evaluation can be found in Appendix F and is based on a design speed of 65 mph, which matches the current posted speed limit. A summary of some of the deficiencies and their disposition is listed below:

- Treated Shoulder Width – The required minimum width is 10'. The existing median shoulder width south of North Broadway is generally 4.5' wide and widens out north of North Broadway to 10' and then even wider near SR-161. Some alternatives will improve this geometric element, while others will perpetuate some substandard shoulders, which would require a design exception.
- Degree of Curve – There are two curves along the corridor where widening of 1.5' may be needed per L&D Volume 1, however L&D also states that curve widening of 2' or less may be disregarded. No changes to the alignment of I-71 or addition of curve widening have been made as part of this Feasibility Study.
- Superelevation – There are some deficiencies in superelevation along the corridor, in the range of 0.5-1% off from design requirement. This project will not be replacing the existing pavement in its entirety, so minor cross slope corrections could be accomplished with variable depth mill and intermediate courses if deemed needed.
- Normal crown point is located between Lanes 1 and 2 south of North Broadway and between Lanes 2 and 3 north of North Broadway. This will be perpetuated or offset slightly depending on the alternative.
- Stopping Sight Distance – Four (4) horizontal curves do not meet the design criteria for stopping sight distance. This is caused by a combination of narrow shoulder and tight curve radius. Alternatives 3 and 5 have a narrow shoulder width and will perpetuate the same issue. In addition, Alternative 5 proposes a 4' inside shoulder on the north end (where the existing median shoulder is very wide) leading to an additional horizontal curve that does not meet design criteria. Table 11 lists the deficient curves with the existing and proposed sight distances along with the required sight distance for design speeds between 55mph and 65mph.

Table 11. Stopping Sight Distances

Stopping Sight Distance Evaluation of Lane 1								
Curve No.	Bound	Existing Shoulder Width (ft)	Existing SSD (ft)	Required SSD (ft)			Proposed Shoulder Width (ft)	Proposed SSD (ft)
				65 mph	60 mph	55 mph		
102	SB	5	563	645	570	495	4	545
104	NB	4	448				4	417
201	SB	7	525				4	467
111	SB	4	553				4	539
112	NB	8	654				4	539

Pavement

The existing mainline pavement and shoulders were cored and evaluated by ODOT. Per an Inter-Office Communication (IOC) from Office of Pavement Engineering dated 7/6/2020, the existing mainline and shoulder pavement can carry future planned traffic with a functional mill and overlay, with the exception of the northbound outside shoulders from SLM 25.66 to 26.44. Should these shoulders be needed to support mainline traffic in the permanent condition they should be replaced.

For any full depth pavement needed, for widening or shoulder replacement, ODOT provided the following build up:

1.5" 442 Asphalt Concrete Surface Course, 12.5mm

1.75" 442 Asphalt Concrete Intermediate Course, 19mm

8.75" 302 Asphalt Concrete Base, PG 64.22

6" (var) 304 Aggregate Base

The variable aggregate base thickness is intended to be used to match existing subgrade elevations for drainage purposes. ODOT Office of Pavement Engineering also recommended to avoid placing longitudinal widening joints where a wheel path will be after final striping is in place, yet this may not be achievable when trying to minimize pavement widening. A copy of the IOC is in Appendix G.

Design Exceptions

Alternatives 3 and 5 have reduced shoulder and lane widths to try to minimize the footprint as well as fit on or under existing bridges. The reduced inside shoulder widths will at times result in a stopping sight distance that does not meet design criteria. Existing vertical clearances are listed in Table 13 and exceed the minimum 14.5' as per Figure 302-2 of L&D Volume 1. Maintaining this minimum vertical clearance with the proposed crown shifts will need evaluated during project design.

Table 12 lists the design exceptions anticipated for each alternative:

Table 12. Design Exceptions

Design Exceptions Anticipated		
	Alt 3	Alt 5
Lane Width	X	X
Shoulder Width	X	X
Stopping Sight Distance (Horiz Curve)	X	X

Alternative 1 – No Build (Preservation)

The preservation scope includes pavement resurfacing, minor bridge rehabilitation and replacement, and other spot improvements to lighting, drainage, and ITS infrastructure. Preliminary typical sections of this alternative are included in Appendix H.

Alternative 3 – Part-time Add Lane (HSR Inside)

This alternative adds an HSR lane to the inside of the I-71 corridor by holding the inside barrier toe as the edge of shoulder and striping lanes as described previously. Doing this will require some widening for the southern half of the project, however the northern half of the project will be able to make use of the wider shoulders and will require little to no widening. The ability for this alternative to reuse more of the existing pavement aligns more closely with the intent of an HSR solution to maximize repurposing existing pavement to provide more lanes for traffic.

In addition to the pavement widening on the outside to make room for the HSR lane, the crown point will slightly move which will in turn place wheel paths in different locations with respect to the existing lanes and underlying longitudinal concrete joint lines. This issue has been preliminarily discussed with District 6. Further investigation during the next phase of the Project Development Process (PDP) will be needed to determine what type of mitigation (if any) can be provided.

The median barrier for this alternative is not anticipated to be replaced with the exception of light pole foundations in need of replacement as part of the preservation needs and new ITS cantilever poles and truss supports. Minimal to no new median inlets are anticipated as described in the Drainage section below.

Existing noise walls are present along the corridor for most of the eastern side. There are multiple sections along the western side, but very minimal in length. Most of the noise walls will remain untouched, however there are short stretches where the outside shoulder would need to narrow to approximately 5.4' from STA 354+00 to 365+00 and 7.3' from STA 367+00 to 374+00.

Given the alternative requires widening within the southern portion of the corridor, ramp terminals will also be impacted and likely have a slightly wider footprint than existing. The intent of Alternative 3 is not to upgrade ramp terminals to current design standards, yet not make any deficiencies worse while making minor improvements that can be constructed within the existing roadway footprint/right of way. Two major variables of terminal design were evaluated and include the terminal spacing and speed change.

Terminal Spacing – Of the 17 existing terminal spacings (NB and SB), eight (8) currently do not meet the recommended distance of 1,600 ft (per Figure 503-1a) measured between painted noses as displayed in Appendix I. The conceptual layout of Alternative 3 generally does not make the proposed conditions worse than existing. Two locations that have a conceptual layout that results in shorter terminal spacing are: NB from Weber to Broadway and SB from Morse to Sinclair. Improving the concept layout to not worsen existing conditions NB from Weber to Broadway is achievable without significant impacts. However, to achieve this SB from Morse to Sinclair would result in pulling the painted nose for SB on from Sinclair north so much that it would be sacrificing a lot of acceleration length.

Terminal Speed Change (Accel/Decel Lanes) – The accel/decel evaluation is also shown in Appendix I. Of the 34 existing terminals, 23 currently do not meet the standard design recommendations for speed change. Short auxiliary lanes (connection of the speed change lanes) are common at these deficient terminal locations. Of the ramps that have traditional geometry, such that an accel/decel length can be verified, none have a proposed condition that is worse than existing.

See Appendix J for preliminary typical sections and plan sheets of Alternative 3.

Alternative 5 – Full-time Add Lane (PBPD)

Section 1000 of ODOT's L&D Volume 1 supports the emerging practice to apply a PBPD approach to minimizing impacts and costs by loosening standard design criteria yet not sacrifice safety. In lieu of complying with standard design criteria as per Alternative 4, Alternative 5 provides a full-time add lane that is less disruptive to the existing infrastructure and contains major cost drivers. The PBPD practices applied on Alternative 4 include reducing the inside shoulder width from the required 10' to 4' and reducing the mainline lane width from the required 12' to 11' for three lanes. The outside shoulder maintains the required 10' width. This approach was discussed with ORE on July 7, 2021 as per meeting minutes included in Appendix E2. The PBPD typical section is nearly identical to the HSR Inside typical section with the exception of the permanent (vs. temporary) inside shoulder width of 4' wide. Similar to Alternative 3, the outside shoulder would need to narrow to approximately 5.4' from STA 354+00 to 365+00 and 7.3' from STA 367+00 to 374+00 to avoid impacting existing noise walls on the east side. See Appendix K for preliminary typical sections of this alternative.

Similar to Alternative 3, the intent of Alternative 5 is not to upgrade ramp terminals to current design standards, but should consider making minor improvements that can be constructed within the existing roadway footprint. Project termini are similar to Alternative 3. Right of way impacts are not anticipated. See Appendix K for preliminary plan sheets of this alternative.

Structures

Existing Conditions

The corridor contains 14 bridges, 5 bridges carrying I-71 traffic over roadways and 9 bridges traversing I-71. An evaluation of the existing I-71 bridge decks was performed to determine what preservation work should be included as part of Alternative 1. Evaluation consisted of Ground Penetration Radar (Appendix L1) and deck coring of I-71 over 17th, Velma, Cooke, Morse, and 161 (Appendix L2). Additionally, the southbound bridge deck over Cooke was hand sounded to compare the results with the GPR findings (Appendix L3).

As part of the corridor assessment, ODOT performed a terrestrial scan which provided detailed vertical and lateral clearance data. As a result, any lateral clearance discussions in this report are referencing either this scan data or aerial mapping survey. Table 13 is a summary of the vertical clearance at overhead bridges as returned from the scan data provided by ODOT.

Table 13. Existing Vertical Clearances

Bridge	NB	SB
5th Ave	15.23'	14.64'
Cleveland Ave	14.63'	14.64'
Railroad	14.77'	14.78'
11th Ave	16.45'	16.95'
Hudson St	16.14'	18.70'
Weber Rd	14.96'	16.17'
E N Broadway	15.94'	14.84'
Pedestrian Bridge	15.30'	15.45'

Alternative 1 – No Build (Preservation)

Based on the evaluations noted above, discussions with Tim Peddicord, ODOT District 6 Bridge Engineer, on March 15, 2021, and subsequent decisions at District following receipt of the Draft study, the following bridge work is proposed for Alternative 1:

- FRA-71-1875 over 2nd – 3 span, continuous concrete slab and box beam superstructure. General Appraisal = 8; Overlay, parapet and deck edge repairs, and box beam repairs.
- FRA-3-1774 over I-71 – 2 span, continuous steel beam superstructure. General Appraisal = 5; Deck and approach slab replacement, structural steel painting, and substructure repair.
- FRA-71-2008 over 17th – 3 span, continuous steel beam superstructure. General Appraisal = 8; Overlay, approach slab replacement, joint replacement.
- FRA-71-2075 over Velma/Hiawatha – 4 span, continuous concrete slab superstructure. General Appraisal = 7; Overlay, approach slab replacement, joint replacement, parapet and deck edge repairs, pedestrian accommodations (City of Columbus).
- FRA-71-2346L/R over Cooke – 4 span, continuous concrete slab superstructure. General Appraisal = 5; Overlay, approach slab replacement, joint replacement, parapet and deck edge repairs.
- FRA-71-2451L/R over Morse - 4 span, continuous concrete slab superstructure. General Appraisal = 5 SB, 6 NB; Bridge replacement.

- FRA-71-2646 over SR 161 - 4 span, continuous concrete slab superstructure. General Appraisal = 5; Bridge replacement.

Alternative 3 – Part-time Add Lane (HSR Inside)

Advancing the HSR Inside typical section through all 14 bridges that I-71 traverses or goes under results in a variable outside shoulder width. Table 14 shows the proposed outside shoulder width at each bridge crossing assuming no bridge widening or replacement. The outside shoulder width under local overpass structures assumes a new embedded Type D barrier placed along the existing substructure per STD DWG RM-4.5. Small profile adjustments or crown point transitions near mainline bridges will likely be necessary to avoid being cut into existing bridge decks. The only bridge that has been identified to be widened is the I-71 SB bridge over Morse Road. Widening of this structure is needed for the Sinclair Road on-ramp to transition across the bridge.

Table 14. Outside Shoulder Width at Bridges

Crossing	SB Bridges	NB Bridges
	Available Width of Outside Shoulder (FT)	
E 5TH AVE OVER I-71	-	6.1
CLEVELAND AVE OVER I-71	5.1	5.1
NS RR OVER I-71	5.0	5.0
E 11TH AVE OVER I-71	4.6	5.5
I-71 OVER E 17TH AVE	4.5	4.5
I-71 OVER HIAWATHA PK/VELMA DR	4.8	5.3
E HUDSON ST OVER I-71	7.9	7.8
E WEBER RD OVER I-71	7.4	7.4
E NORTH BROADWAY OVER I-271	7.3	7.5
I-71 OVER COOKE RD	3.9	3.8
I-71 OVER MORSE RD	-12.2	3.5
PED BRIDGE OVER I-71	-	10.0
I-71 OVER SR-161	-	10.0
SCHROCK RD OVER I-71	-	10.0

Alternative 5 – Full-time Add Lane (PBPD)

Alternative 5 will require the same shoulder widths and approach to avoid impacting structures as described for Alternative 3. The only difference is that the inside shoulder width of 4' will be permanent vs temporary for HSR Inside.

Drainage

Existing Conditions

Similar to the roadway characteristics, two distinct drainage segments exist south and north of N. Broadway. To the south, surface drainage of Lane 1 slopes to the 4-5' wide median shoulder and Lanes 2 and 3 slope to the 10' wide outside curbed shoulder. Surface flow is collected via barrier/curb inlets and conveyed via gravity sewer. Inlet spacing is generally laid out as expected along the rolling terrain of six sag curves. To the north, surface drainage of Lanes 1 and 2 slope to the 8-10' wide median shoulder and Lane 3 slopes to the 10' wide outside paved shoulder. Surface flow is collected via barrier inlets and conveyed via gravity sewer. Inlet spacing is fairly spread out given the width of the inside shoulder yet the roadway profile grade line has an average longitudinal slope of 0.3%, which does cause spread to build up quicker than the rolling southern section. Outside surface drainage generally sheet flows into an open ditch.

Part-Time Add Lane Evaluation (Alternative 3)

Drainage criteria for spread along a part-time add lane was coordinated with District 6 and follows a similar approach applied on the I-670 SmartLane project. When the part-time add lane is open, a minimum of 4' of dry pavement shall be maintained assuming a 5-year storm event. When the part-time add lane is closed, standard interstate criteria apply that does not allow any spread on a travel lane based on a 10-year storm event. This criterion assumes that the posted speed limit will be lowered when the part-time lane is open and that the Traffic Management Center will have the ability to close the part-time lane during rain events.

An abbreviated, high-level spread analysis was performed for Alternative 3. For the southern section, a preliminary CDSS analysis was performed on the sag curve under Weber Road to represent how the six sag curves perform against the proposed criteria. The analysis supports that the existing catch basins along the median barrier appear to meet the open[1] and closed[2] spread requirements and do not necessitate additional inlets. A similar representative analysis was done for the outside curbed shoulder meeting standard drainage criteria along the proposed 4' wide shoulder. This analysis[3] is suggesting that a new series of fairly tightly spaced inlets at approximately 200' apart will be needed to limit the spread onto the outside travel lane. Increasing the proposed outside shoulder width should be further investigated in preliminary design to potentially increase the proposed inlet spacing.

For the northern section, a preliminary CDSS analysis was performed assuming an average longitudinal slope of 0.3%. The analysis supports that the existing catch basins along the median barrier generally meet the open[4] and closed[5] spread requirements. There could be limited spot locations that warrant additional inlets that will need finalized during design. While the outside shoulder is generally going to be uncurbed, there will be limited curbed sections approaching mainline bridges and along noise walls that will need evaluated during preliminary design.

Full-Time Add Lane Evaluation (Alternative 5)

Drainage criteria meeting L&D Volume 2 will be followed for a full-time add lane alternative. An abbreviated, high-level spread analysis was performed for Alternative 5. For the southern section, a preliminary CDSS analysis was performed on the sag curve under Weber Road to represent how the six sag curves perform against the proposed criteria. The analysis[6] supports that the existing catch basins along the median barrier appear to meet the spread requirements which is reasonable given that the sheet flow is almost identical between existing and proposed. A similar representative analysis was done for the outside curbed shoulder meeting standard drainage criteria along the proposed 10' wide shoulder. This analysis[7] is suggesting that a new series of inlets spaced at approximately 500' apart will be needed to limit the spread onto the outside travel lane.

For the northern section, a preliminary CDSS analysis was performed assuming an average longitudinal slope of 0.3%. The analysis[8] supports that the existing catch basins along the median barrier do not meet the full-time add lane requirement for a 4' wide median shoulder. This deficiency would be expected given that the existing median shoulder of 8-10' wide would be reduced to 4' wide. Proposed median inlets would need spaced approximately 125' apart. This type of spacing would likely justify or result in full replacement of the median barrier versus 20'-long spot replacements every 125'. While this extremely tight spacing is assumed for cost estimating, if Alternative 5 is advanced as the preferred alternative, consideration should be given to improving this situation by increasing the median shoulder width and evaluating how much additional widening could be performed without major impacts.

^ *footnote numbers represent the Analysis # in Appendix M.*

Intelligent Transportation System

Alternative 3 would employ ATDM practices to manage a part-time lane addition. Proposed ITS improvements would include dynamic message signs (DMS) for motorist awareness of the SmartLane's status, supplemental DMS for traffic incident management, closed-circuit television cameras (CCTV) providing full visibility of the SmartLane as well as the entire the corridor, integrated analytics within the CCTV cameras including wrong-way detection, object tracking and stopped vehicle detection, and variable speed limit (VSL) signs implemented throughout the corridor.

Previous Projects

FRA-670-5.03 SmartLane (PID 104674)
The I-670 EB corridor, immediately south of the limits of this feasibility study, was used as a pilot project and ODOT's first statewide implementation of SmartLane. This SmartLane design included the use of DMS truss overhead sign support structures (gantries) spanning the entire width of I-670 EB, the inclusion of a single DMS spanning all lanes of eastbound traffic for active lane control at each gantry, full CCTV visibility of the SmartLane, and the implementation of the state's first variable speed limit sign-controlled corridor.

The outcome of the I-670 EB SmartLane was a dramatic reduction in travel times during its operation, and the project proved the concept of the SmartLane. However, the gantries and full-span, full-color DMS's had high upfront costs and have relatively high Operations and Maintenance (O&M) costs. Therefore, it is desirable to implement an ATDM system with similar functionality and performance of the I-670 EB SmartLane, but with lower installation, operation, and maintenance costs.

HAM-275-28.69 SmartLane (PID 94256)
The I-275 corridor in Hamilton and Clermont Counties was identified as a SmartLane candidate. This project includes an Inside HSR concept in both bounds from SR-28 to US-42 and will be implemented through two contracts (design-build and design-bid-build). A design scope of services was released for the design-build project scheduled to be awarded on August 26, 2021. This scope followed the Statewide SEA amended for the project dated June 2021 and incorporated cost-saving measures including:

- Reduction in DMS size from individual DMSs that span the full width of all lanes in a travel direction at each DMS support structure location to a DMS over the individual SmartLane only.
- Inclusion of cantilever structures at most locations for driver notification of SmartLane status.
- Reduction in gantry structural requirements. Utilizing smaller DMSs will require a less robust gantry design than the DMSs selected for the I-670 EB SmartLane project.

In coordination with ODOT ITS, some of these cost-saving measures have been incorporated within this feasibility to establish an initial scope and cost for Alternative 3.

ATDM SmartLane Concept

The overall concept of the I-71 SmartLane System is to preserve the core functionality of the I-670 EB SmartLane system (with the exception of individual dynamic lane control) while reducing the installation, operation, and maintenance costs, similar to the HAM-275-28.69 SmartLane concept. The proposed I-71 SmartLane System utilizes a combination of gantry structures, cantilever sign structures, dynamic message signs, CCTV cameras and variable speed limit signs to convey the operability of the SmartLane, as well as provide traffic incident management capabilities and complete visibility of the SmartLane and I-71 corridor for ODOT TMC staff.

SmartLane Cantilever Structure
Cantilever structures are proposed as the primary SmartLane notification structure type along the proposed I-71 corridor to reduce installation, operation, and maintenance costs. This was determined based on the following:

- Cantilever structures can be installed for a fraction of the cost of full-span gantry structures.
- The design intent is consistent with the cost-reduction measures of the HAM-275-28.69 SmartLane project.
- Dynamic lane control over all lanes isn't needed for SmartLane operations.
- These preferences were confirmed in coordination with ODOT ITS.

Based on these preferences, cantilever structures have been conceptually identified along the I-71 corridor with the following requirements:

- Cantilever structures would be located at each interchange between project limits.
- Cantilever structures would be located as strategically as possible to "catch" inbound traffic from each incoming on-ramp to provide SmartLane status to as many motorists as possible.
- Locations of each cantilever structure are mutually exclusive. Northbound structures do not require abutment to southbound structures and vice versa. However, where possible, northbound and southbound structures were located as closely as practical to minimize the amount of median barrier replacement, new underground conduit, laterals and cabling, individual power supply locations, MOT, etc.
- Cantilever structures were placed with approximate one (1) mile spacing, but with consideration of supplemental cantilevers in between tightly spaced interchanges.
- Each cantilever structure is outfitted with:
    - (1) Full-Color Front Access DMS over the SmartLane
    - (1) PTZ CCTV Camera w/analytics
    - (2) Fixed CCTV Cameras w/analytics
    - (2) VSLs; (1) on the cantilever upright / (1) ground-mounted on the outside roadway

SmartLane Gantry Structure
It is preferred to install DMS truss overhead sign support structures (gantries) in strategic locations throughout the corridor to primarily support incident management and secondarily SmartLane notifications. These gantry structures have been preliminarily identified with the following requirements:

- One (1) to two (2) gantry structures located throughout the corridor at locations to be determined.
- Each gantry structure spans a single direction of I-71 from the center median to the outside roadway.
- Each gantry structure is outfitted with:
  - (1) Full-Color Front Access DMS over the SmartLane
  - (1) Full-Color Walk-In DMS for incident management
  - (1) PTZ CCTV Camera w/analytics
  - (2) Fixed CCTV Cameras w/analytics
  - (2) VSLs installed on both left and right end frames of the truss

Gantry structures are proposed to be an ODOT standard *Overhead Sign Support Structure, DMS Truss,* where possible.

SmartLane Variable Speed Limit (VSL)

As part of the I-71 SmartLane System, variable speed limit (VSL) is an anticipated feature that will reduce the regulatory speed when SmartLane is open to account for the temporary inside shoulder width of 4', which is less than the standard design width of 10'. The temporary, narrow lateral clearance adjacent for median barrier wall also restricts the sight distance for vehicles using SmartLane. The reduced regulatory speed limit will be determined during the SEA Addendum, but a drop of 10mph from 65mph to 55mph could be expected. VSL signs are proposed to be deployed in strategic locations that meet the following criteria:

1. At SmartLane Cantilever Structures – Each cantilever structure would have one (1) VSL sign mounted to the cantilever pole in the median. In addition, one (1) ground-mounted VSL sign is proposed on the outside shoulder paralleling the cantilever structures. This is consistent with the HAM-275-28.69 SmartLane concept. At this time, a 30' light pole is proposed for the ground-mounted VSL, which is consistent with the I-670 EB SmartLane approach.
2. At SmartLane Gantry Structures – Each gantry structure would have one (1) VSL sign mounted to each truss end frame for a total of two (2) VSL signs per structure. This is consistent with the HAM-275-28.69 SmartLane concept.
3. At Interchange On-Ramps – Where traffic enters the I-71 corridor via interchange on-ramps, one (1) ground-mounted VSL sign is proposed along the on-ramp to notify incoming traffic that they are entering a corridor with variable speed control, as well as the current speed limit. In an effort to minimize costs, breakaway structures are proposed to mount the VSL signs. This is consistent with the I-670 EB SmartLane approach.

Currently, the proposed I-71 corridor is not approved for the deployment of variable speed limits. Further coordination with ODOT will be required to ensure the legal framework will be in place for the approved use of variable speed limit signs. After initial coordination with ODOT, it is anticipated that approximately 6-9 months of coordination will be required for the proposed I-71 corridor to be approved for the use of variable speed limit signs.

SmartLane CCTV Camera Coverage

It is critical to provide a complete view of both the entire length of the SmartLane and the entire overall I-71 corridor from the I-670 Interchange to the I-270 Interchange. Providing these views is critical for two reasons:

- ODOT TMC staff must be certain the inside shoulder is clear of any incidents, disabled vehicles, or debris prior to opening the SmartLane.
- ODOT TMC staff must be aware of any incidents anywhere along the corridor. This is critical for the dispatch of emergency vehicles and for maintaining traffic flow. Depending on the severity of the incident and its impact on traffic, ODOT TMC staff may determine whether to open the SmartLane to alleviate traffic backups or close the SmartLane to provide a pull-over area for emergency vehicles depending on the location of the incident.

Three CCTV criteria are established to provide complete SmartLane and corridor visibility:

- Installing (1) pan-tilt-zoom (PTZ) CCTV camera with analytics, and (2) Fixed CCTV cameras with analytics, on each new gantry and cantilever structure to provide views of the SmartLane and the nearby corridor. The CCTV analytics can automatically detect stopped vehicles, wrong-way traffic and other data points to assist ODOT TMC staff.
- Using existing CCTV camera pole locations to supplement views of the corridor but upgrading the cameras to new models with analytics capabilities. This will be elaborated in *Existing ITS Infrastructure* below.
- Adding new CCTV camera poles in areas with poor or no visibility from the existing CCTV pole locations and the new structure-mounted CCTV cameras to complete the views of the corridor. These CCTV cameras would also have analytics capabilities.

It is recommended that all CCTV cameras are of the same manufacturer with the same analytics package for best results.

SmartLane Permanent Fiber Optic Cable Plan

As per coordination with ODOT ITS, assumption at this Feasibility Study is to provide the following new permanent fiber optic backbone through the existing median barrier wall conduit:

- 72-Count (CT) fiber optic cable for ODOT
- 288-CT fiber optic cable for City of Columbus

Existing ITS Infrastructure

Existing ITS infrastructure is currently installed and functioning along the proposed I-71 corridor. Based on information provided by ODOT, this existing ITS infrastructure includes:

- (8) Existing CCTV Cameras
- (1) Existing Dynamic Message Sign
- (2) Existing Vehicle Detector Stations
- (1) Existing Highway Advisory Radio (HAR)
- (1) Existing HAR Flashing Beacon
- (1) Existing Standalone Cabinet
- (11) Existing Ramp Metering
- Existing Fiber Optic Cable

The existing ITS infrastructure listed above is based on a KML file provided by ODOT. Further coordination with ODOT is required to confirm the completeness of this list. Each item on this list shall be explored in greater detail below.

Existing CCTV Cameras
Existing CCTV cameras are currently operating throughout the I-71 corridor. The preferred alternative is to maintain the operation of the existing CCTV camera pole locations to provide supplemental views of the corridor. However, it is recommended to upgrade the existing CCTV cameras with new CCTV cameras with analytics capabilities. To be

consistent with the HAM-275-28.69 SmartLane project, the camera type proposed is *CCTV IP-Camera System, Quad Multi-View Fixed With PTZ*. Further coordination with ODOT is necessary to confirm this camera type.

This upgrade will allow the ODOT TMC to check the corridor more easily for stopped vehicles and incidents, wrong-way drivers and other potential hazards that may warrant the use of, or closing of, the SmartLane. Retrofitting the existing poles and cabinets with the new CCTV cameras will provide enhanced functionality at a fraction of the cost of constructing all new infrastructure.

Existing DMS
Currently, a functioning DMS exists on a gantry truss structure along I-71 SB approximately 1,200 feet north of the E 17th Avenue Interchange. A new SmartLane cantilever structure for southbound traffic could conflict with this existing DMS gantry structure and will need evaluated during preliminary design.

A new SmartLane mid-span gantry structure with a supplemental DMS for incident management purposes could conceivably be located approximately 1.5 miles north of this existing DMS gantry truss structure. Further coordination with ODOT will be required to determine if the existing DMS and gantry structure should be maintained, relocated, or decommissioned and permanently removed if it is determined that the new incident management mid-span DMS is sufficient for the corridor.

Existing Vehicle Detector Stations
Currently, existing vehicle detector stations are installed at:

- I-71 SB at Hudson Street Interchange
- I-71 NB at Velma Avenue (approximately 0.5 miles north of E 17th Avenue Interchange)

Coordination with ODOT is necessary to determinate if the existing vehicle detector stations should be maintained.

Existing Highway Advisory Radio (HAR)
Currently, existing Highway Advisory Radio equipment is installed at:

- I-71 NB at I-270 Interchange

Coordination with ODOT is necessary to determinate if the existing HAR equipment should be maintained.

Existing HAR Flashing Beacon
Currently, existing HAR Flashing Beacon equipment is installed at:

- I-71 NB south of Morse Road Interchange

Coordination with ODOT is necessary to determinate if the existing HAR Flashing Beacon equipment should be maintained.

Existing Standalone Cabinet
Currently, an existing standalone cabinet is installed at:

- I-71 NB at E North Broadway Interchange

Coordination with ODOT is necessary to determinate if the existing standalone cabinet should be maintained.

Existing Ramp Metering
Currently, there appears to be eleven (11) ramp meters throughout the corridor. Coordination with ODOT is necessary to determine if ramp metering should be maintained/upgraded with Alternatives 3 and 5. While ramp metering is not a viable alternative to address the capacity issues of the corridor, no final decision has been made with ODOT regarding the future state of ramp metering on the corridor.

Existing Fiber Optic Cable
Existing fiber optic cable is currently installed within the project limits of the I-71 corridor. This includes, at a minimum:

- ODOT 24-CT fiber optic cable in median barrier wall.
- ODOT 48-CT fiber optic cable in median barrel wall.
- City of Columbus CTSS 288-CT fiber optic cable in ROW and median barrier wall.

Additional coordination will be necessary with ODOT and City of Columbus to verify additional fibers throughout the corridor.

Temporary Fiber Optic Cable Plan

The ITS infrastructure detailed in *Existing ITS Infrastructure* above must be maintained during construction. This will require a Temporary Fiber Optic Cable Plan, including, at a minimum:

- Temporary ODOT fiber optic cable of sizes and types required to provide endpoint-to-endpoint connectivity as necessary, and laterals/fiber drops to maintain connectivity for all operating ODOT ITS devices.
- Temporary 288-CT fiber optic cable for City of Columbus CTSS for endpoint-to-endpoint connectivity, and laterals/fiber drops to maintain any City of Columbus devices and equipment.
- Wood poles as necessary for temporary aerial fiber optic cable installation.
- Splice enclosures as necessary for temporary fiber splices.
- Fiber drop cables and laterals as necessary for existing device connectivity.
- Guardrail as necessary to protect any temporary wood poles that cannot be installed outside the clear zone.
- Any other appurtenances required to maintain network connectivity.

Further coordination with ODOT and City of Columbus will be required to develop a list of all equipment requiring temporary connectivity during construction, as well as requirements for decommissioning and recommissioning existing devices.

Statewide SEA for ATDM Projects

If Alternative 3 is selected as the preferred alternative, then the Statewide SEA for ATDM Projects will need to be amended to include this project. The process to amend the document will help finalize the ATDM practices to be implemented on this project. All ATDM assumptions for Alternative 3 stated in this Feasibility Study are subject to change per the formal SEA addendum process.

Operations and Maintenance (O&M) Staffing

If Alternative 3 is selected as the preferred alternative, an additional ODOT ITS Specialist and Traffic Management Center (TMC) specialist may be needed to cover the additional O&M responsibilities of another SmartLane. Staffing costs are not included in the comparative project costs shown in Chapter 6.

Maintenance of Traffic

Temporary traffic control for the project will adhere to the latest ODOT and, where applicable, City of Columbus maintenance of traffic policies. The ODOT permitted lane closure chart (PLCC) will be followed and will incorporate any updated guidance from ODOT. The project alternatives have been screened and have been reduced to two. These two alternatives are Alternative 3-HSR Inside and Alternative 5-Full-time Add Lane (PBPD).

Alternative 3 proposes the construction of the HSR lane on the inside shoulder for the northbound and southbound directions. The preliminary investigation determined that full depth outside shoulder widening in both directions is required. The replacement of the barrier median, other than to install ITS/SmartLane related signage and some light foundations, is not anticipated. Any required shifting of the roadway crown will be accomplished through project-wide mill and resurfacing. Maintained traffic will be separated from the work zone by using portable barrier. Current guidance for barrier-to-edgeline and barrier-to-saw cut line will be provided when practical. It is anticipated that reduced offsets are required across the Morse Road bridge until bridge widening is complete. Construction of the corridor improvements would likely be through part-width methods. One conceptual sequencing could include the outside shoulder widening, and ramp improvements as the first phase. A minimum of three mainline traffic lanes will be shifted to the inside for this phase while outside improvements are completed. It is anticipated that both southbound and northbound directions can be completed concurrently to reduce project duration. Once complete, mainline traffic is shifted outside and a protected work zone adjacent to the median barrier is provided to allow the completion of spot improvements along the median barrier. Once the median work is completed, the corridor is milled and resurfaced, and permanent traffic control is installed.

Alternative 5 proposes the construction of an additional full-time through lane for the northbound and southbound directions. By using PBPD methods, reduced shoulder and lane widths are proposed. Alternative 5 requires the replacement of the median barrier north of North Broadway. Any required shifting of the roadway crown will be accomplished through project-wide mill and resurfacing. Like Alternative 3, the construction of the corridor improvements would likely be through part-width methods. The outside full depth shoulder widening, and ramp improvements are proposed for the first phase. A minimum of three mainline traffic lanes will be maintained and shifted to the inside for this phase. Southbound and northbound outside shoulder improvements can be completed at the same time. Once complete, mainline traffic lanes are shifted to the outside and the replacement of the median barrier can begin.

It is anticipated that both alternatives will include minor rehabilitation of four mainline bridges and one bridge overpass and replacement of two mainline bridges, FRA-71-2451L/R (Morse Rd) and FRA-71-2646 (161). The bridge scope expanded from this draft study and will require a more detailed evaluation of MOT during the next phase of engineering design. The MOT described above for mainline work will need revaluated to account for and be consistent with the proposed bridge construction. Two-way traffic is intended to be maintained for all local roadways under these bridges. Initially identified minor bridge work including replacement of approach slabs and repair of joints, had the potential of implementing short-term, temporary traffic control measures. Mainline traffic lanes could be reduced to two lanes to provide a wider work zone to complete the improvements. Since the available mainline traffic lanes are reduced, further investigation will be required to determine if detour(s) are needed to address the anticipated delay to through traffic. Detour routes are readily available for the project. A northbound detour can use a I-670 to SR 315 to I-270 routing. A southbound detour can use the reverse of the northbound route or I-270. It is anticipated that the work related to the approach slabs and joints can be completed quickly and the revised MOT would be short-term. Once these improvements are completed the temporary traffic control would be returned to match that of the current project improvements. The potential of leveraging these temporary traffic control measures and short-term detours will need reevaluated as part of the MOTAA that will be developed in the next part of the PDP.

Safety

The HSM predictive analysis with CMFs shows a difference between Alternatives 3 (HSR Inside) and 5 (PBPD). Alternative 3 is anticipated to see a nearly 8% decrease in overall crashes including one less fatality compared to the no-build. Alternative 5 is anticipated to see a 14% increase in overall crashes including one fatality per year in each direction compared to the no-build. Primary variables contributing to these differences appear to be the narrow lateral clearance to the median barrier wall and daily duration of this condition. While both alternatives are proposing a 4' inside shoulder along the median barrier, Alternative 3 only has this condition when SmartLane is open. When SmartLane is closed, Alternative 3 has a 15' wide inside shoulder. The inside shoulder width of 4' also restricts sight distance at five curves, which is more pronounced for Alternative 5 given that it is a full-time condition that maintains the existing speed limit of 65mph. Higher speeds during off-peak hours would be traveling in Lane 1 with these restrictive sight distances while higher speeds during off peak hours for Alternative 3 would have additional sight distance at the curves due to the 15' wide shoulder.

One way to improve safety for Alternative 5 is to increase the median shoulder width, yet this would effectively increase the outside widening thus begin negating the benefits of a PBPD alternative of maintaining a tight footprint. Potentially widening the inside shoulder to 10' was summarily evaluated north of North Broadway, but ultimately not advanced as an optimized version of Alternative 5 due to additional impacts and costs.

Traffic incident management is accounted for with both alternatives. Alternative 3 provides a maximum inside shoulder of 15' that is available when the HSR lane is closed. The outside shoulder width of Alternative 3 is a standard 10' wide except at constraints. Alternative 5 maintains a 10' wide outside shoulder for the length of the corridor yet would be the only location for parked breakdowns.

Traffic Operations

Alternatives 3 and 5 are expected to improve failing operations to LOS D or E for nearly all segments of the corridor. While there are a few segments in the build alternatives that will operate at or slightly over capacity, this is in the 2043 design year. With the traffic growth in the corridor estimated at approximately 1% per year, these segments will not reach capacity until very close to the design year thus are expected to operate for several years below capacity. The hourly analysis supports this conclusion and while off peak hours are heavy, a distinct spike in reduced travel speeds is attributed to normal peak hour congestion. Either alternative would provide a significant operational benefit to the I-71 corridor.

Roadway

Both alternatives push a similar typical section through the corridor. The biggest difference is the increase in new inlets north of North Broadway for Alternative 5, which would lead to replacement of the median barrier wall.

Impacts

Design exceptions for lane and shoulders widths are expected. Exceptions for lane width and shoulder width to avoid impacting noise walls and all but one bridge have a high probability of getting approved. Obtaining a design exception for the 4' wide inside shoulder for the length of Alternative 5 may be more challenging with the expected degradation of safety.

Cost

A conceptual level construction cost estimate was prepared for each alternative and broken down between preservation and TSMO costs (Appendix N). Table 15 compares the cost of Alternatives 3 and 5. Pavement and drainage costs are higher for Alternative 5 while ITS is higher for Alternative 3. Overall, Alternative 3 has an estimated cost of $92M, approximately 7% less than Alternative 5 of $99M. The costs to operate and maintain Alternative 3 have not been included in Table 15. As additional SmartLanes come online across the state, increases in staffing levels with the TMC and ITS Maintenance are expected.

Table 15. Preliminary Cost Estimates

	Alternative 3 - Part Time Add Lane (HSR Inside)	Alternative 5 - Full Time Add Lane (PBPD)
ROADWAY/PAVEMENT	$14,449,196	$18,048,766
EROSION CONTROL	$500,000	$500,000
DRAINAGE	$5,566,000	$8,931,000
LIGHTING	$247,000	$510,500
INTELLIGENT TRANS. SYSTEMS	$7,758,873	$2,967,973
TRAFFIC CONTROL	$515,000	$910,000
RETAINING WALLS	-	-
NOISE BARRIERS	-	-
STRUCTURES	$13,748,000	$13,748,000
MAINTENANCE OF TRAFFIC	$6,528,000	$7,380,000
INCIDENTALS	$2,084,000	$2,084,000
CONTINGENCY (35%)	**$17,988,624**	**$19,278,084**
INFLATION (12.6%) MIDDLE OF PROJECT: 3/30/2026	**$8,742,471**	**$9,369,149**
CONSTRUCTION ENGINEERING (6%)	**$4,687,630**	**$5,023,648**
CONSTRUCTION	**$82,800,000**	**$88,800,000**
RIGHT OF WAY	**$0**	**$0**
PE ENVIRONMENTAL (10%)	**$8,280,000**	**$8,880,000**
PE DETAILED DESIGN (1%)	**$828,000**	**$888,000**
PROJECT GRAND TOTALS	**$91,908,000**	**$98,568,000**

chapter 7
CONCLUSION

Alternatives 3 and 5 offer similar operational benefits while minimizing impacts compared to a traditional add-lane improvement. The selection of a preferred alternative is not based on a single factor, but the cumulative differences of five factors:

1. ***Safety*** – A thorough safety analysis, including an independent review by ODOT's Office of Safety, support Alternative 3 as a safer solution compared to Alternative 5. Wider inside shoulders will be available when HSR (Alternative 3) is closed but would not be available anytime for PBPD (Alternative 5).
2. ***Incident Management*** – The inclusion of overhead DMS for incident management and the ability to close the HSR lane and create a 15' wide inside shoulder for parked breakdowns and EMS present a benefit to Alternative 3 compared to Alternative 5.
3. ***Maintenance*** – The ability of Alternative 3 to provide a wide inside shoulder by closing the HSR lane improves the safety and work area for maintenance crews compared to Alternative 5.
4. ***Phased Implementation*** – Alternative 3 lends itself to become part of a broader implementation plan that addresses the peak hour demands by introducing a part-time lane that could potentially be converted to a full-time lane in the future. Alternative 3 also has the flexibility to dynamically address capacity and safety. Alternative 5 is less flexible and would advance a permanent PBPD solution that poses the risk of impairing safety with the HSM predictive modeling showing an increase in injury and fatal crashes.
5. ***Costs*** – While only a minor difference in estimated construction costs, Alternative 3 is anticipated to cost approximately $7M less than Alternative 5, equating to an 7% reduction.

For the reasons noted above, ODOT has decided to eliminate Alternative 5 from further study and advance Alternative 3 into preliminary design as the preferred alternative. Alternative 3 would be combined with Alternative 1 to ultimately advance the preservation needs of the corridor and meet the purpose and need of improving capacity, safety, and incident management.