September 22, 2020

ELECTRONIC COPY

TECHNICAL PROPOSAL

IS-695 from IS-70 to MD 43 Transportation Systems Management and Operations

Baltimore County, MD

PART-TIME SHOULDER USE | MOBILITY | SAFETY | OPERABILITY / MAINTAINABILITY / ADAPTABILITY

CONTRACT NO. BA0065172
MDOT State Highway Administration

LANE | JMT
A Design-Build Team

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2.09.02 Part-Time Shoulder Use

A Design-Build Team

2.09.02 Part-Time SHOULDER USE

BENEFITS OF THE LANE/JMT TEAM

- Increase of 21% in 2040 PM Peak Hour (4PM-5PM) vehicle throughput
- Up to 75% travel time improvement during the 2040 PM Peak hour (6PM- 7PM)
- Lower travel times and increased trip reliability will reduce diversions to local arterial roadways
- Provides 7.6 continuous miles to improve operations and safety
- Addresses 10 out of 15 bottlenecks within the project limits
- Proven PTSU operational methods to improve mobility and safety
- Solution meets all RFP roadway geometric requirements
- Provides traffic conditions to CHART for advance warning to motorists through DMS signs
- Able to provide 6 hours of operation without noise impacts
- Fulfills 2017 Consolidated Transportation Program (CTP) goals for eight lanes of capacity during weekday and Saturday peak periods
- Over 20 years of continuous on-site consultant support staff with MDOT SHA's traffic engineering group
- Performance life of LOS E or better in 2040

IS-695 has some of the worst congestion in Maryland and our proposed improvements will significantly improve operations for the travelling public. Travel speeds are well below the posted speed limit of 55 MPH during the AM and PM Peak periods, which leads to extremely unreliable conditions for the travelling public.

Our team maximized the project budget by identifying the **most effective solution** to improve operations (maximizing vehicle throughput and minimizing vehicle travel times and delays) along the Inner and Outer Loops of this corridor of IS-695.

We balanced the most effective miles against the expense of roadway improvements and environmental impacts. Through a coordinated, collaborative process, our team struck a balance between key constraints and operational benefits to provide the maximum amount of PTSU.

Our traffic analysis team has extensive experience working with MDOT SHA and especially with the MDOT SHA's Travel Forecasting and Analysis Group and the Traffic Design Safety Division. We are frequent users of the study area. We are intimately aware of the bottleneck locations, major traffic patterns, diversion routes, and issues through our daily commutes along the IS-695 corridor. We have experienced the impact of the high crash locations and the impact on reliability. As contractors and engineers, we understand the big picture of the study area operations and will help achieve the project goals.

The collaboration between Lane and JMT began by identifying the worst operating, continuous sections from a safety and operational perspective and developing a rough order of magnitude costs for improvements to those sections. These costs were based on the team's preliminary layout of the required roadway geometry to accommodate the PTSU lane for both the Inner Loop and Outer Loop on IS-695 within the entire project limits from IS-70 to MD 43 while meeting the RFP requirements.

Several design factors had a significant influence on the costs and impacts required to accommodate the PTSU lane within the project corridor, including but not limited to the existing shoulder and lane widths, horizontal curvature and stopping sight distance, pavement cross slope and superelevation, condition of existing median barrier and pavement, drainage needs to accommodate spread requirements, and grading requirements in areas of widening. Every segment within the corridor can have significantly different costs and impacts associated with the ability to accommodate a PTSU lane within that segment as compared to other segments. Our team used our preliminary roadway layout to leverage our individual strengths within the team to iteratively evaluate costs and cost contributors against operational and safety benefits to balance the costs and impacts with operational and safety improvements, guiding our iterative decision matrix to focus our proposed solution to provide effective PTSU today, maximize the ability of MDOT SHA to provide for it within the corridor in the future and minimize the potential constraints our solution may put on future projects.

i. LOCATIONS

LIMITS OF LOCATIONS

East of Greenspring Avenue to MD 41

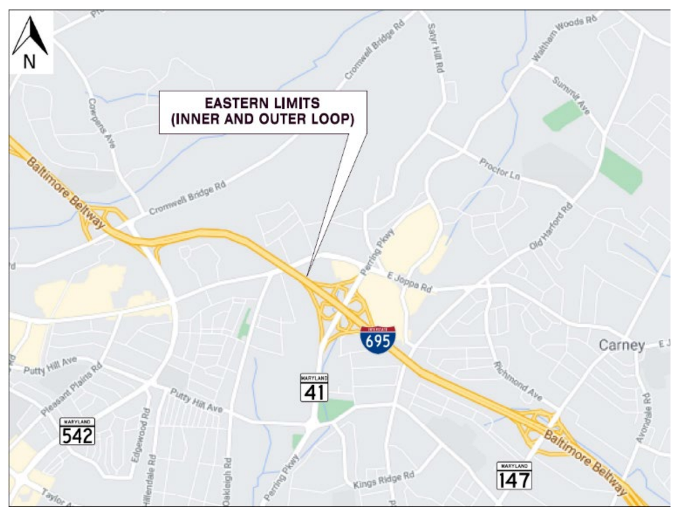
LOCATION SELECTION

OUTER LOOP

MD 41 to East of Greenspring Avenue (approx. MM 22.3 to MM 30.1)

INNER LOOP

East of Greenspring Avenue to MD 41 (approx. MM 30.1 to MM 22.3)



Our team worked collaboratively, through an iterative process to maximize the PTSU on the IS-695 Inner and Outer Loops to a **40,000 linear foot (7.6-miles)** section between Greenspring Avenue and MD 41.

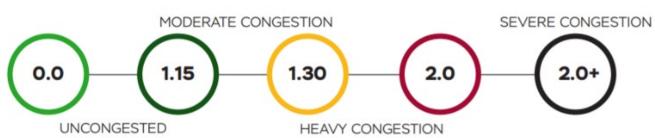
The Lane/JMT team identified key sections to be improved by PTSU and measured the performance outcomes of those sections and weighed the benefits of those sections against the project goals. This was a concerted effort between the contractors, designers, and traffic engineers, to find the optimal solution which aimed to address the following elements:

- Traffic Operations and Reliability (vehicle throughput, minimizing vehicle travel times/delays)
- Safety
- Constraints:
  - Pinch Points
  - Geometric Constraints
  - Pavement Condition
  - Improvements that trigger a traditional Type 1 noise analysis and possible noise wall construction/reconstruction
  - Drainage/SWM
  - Environmental Resources
  - Budget/Constructability

These three key elements were used for the basis of our decision-making process:

TRAFFIC OPERATIONS AND RELIABLITY

The first step in developing our solution was to identify the most congested sections and bottlenecks that cause congestion. Our team relied on information provided in the VISSIM traffic model, as well as Big Data sources which represent real conditions. According to the 2019 Maryland Mobility Report, which utilizes INRIX data, IS-695 has several sections of roadway that rank as the most congested statewide. The MDOT SHA uses the Travel Time Index (TTI) to evaluate trip reliability. The TTI compares the 50th percentile travel time on a segment of roadway for a particular hour to the travel time of a trip during the off peak. A TTI values of 2.0 means that if it takes twice as long to traverse a roadway compared to free flow conditions.



The IS-695 Outer Loop has two sections of roadway and the Inner Loop has one section of roadway listed in the top five most congested AM Peak freeway sections as show in Table 1. During the PM Peak, there is one section of roadway along the Inner Loop within the project limits that has been identified as one of the top five most congested sections of roadway in the state as shown in Table 2.

Table 1. 2019 Maryland Mobility AM Peak Hour Most Congested Freeways (by ranking)

AM Rank	Roadway	Limits	TTI
1	IS-495 Outer Loop	I-95 to MD 97	3.89
2	**IS-695 Outer Loop**	**US 1 to Cromwell Bridge Road**	**2.85**
3	US 50 WB	MD 410 to Washington D.C. Line	2.46
4	**IS-695 Outer Loop**	**MD 129 to US 40**	**2.35**
5	**IS-695 Inner Loop**	**MD 140 to I-83**	**2.33**

Table 2. 2019 Maryland Mobility PM Peak Hour Most Congested Freeways (by ranking)

PM Rank	Roadway	Limits	TTI
1	I-495 Inner Loop	Virginia State Line to I-270 West Spur	3.55
2	**I-695 Inner Loop**	**MD 139 to Cromwell Bridge Road**	**3.19**
3	I-95/I-495 Inner Loop	I-95 to MD 201	2.66
4	I-495 Inner Loop	I-270 East Spur to MD 97	2.64
5	I-695 Inner Loop	I-95 to I-70	2.41

We considered these ranking in identifying the most effective segments for PTSU.

SAFETY

PTSU will help reduce crashes during recurring congestion and as a result, reduce congestion due to nonrecurring crashes. Reducing congestion will improve headways between vehicles and stop/start traffic which can lead to rear end collisions. We are implementing technology to notify CHART of incidents and alert the travelling public. When evaluating sections for PTSU, we aimed to identify those sections that had an increased number of crashes during the peak periods and would realize significant improvement in speeds and queue reductions.

Several sections of the study area are identified as Priority Candidate Safety Improvement Section (CSIS) from 2013 to 2018 based on crash severity index. From 2015 to 2018, there have been 14 fatal crashes through the study area. The top crash trends are noted below.

Crash Rate Type	I-70 to Stevenson Rd	Stevenson Rd to MD 43
Total Crash	4th - MD 140 5th - MD 26	1st - MD 41 2nd - IS-83 (JFX) 3rd - Charles St
Rear-End Crash	3rd - MD 26 5th - IS-70/MD 122	1st - MD 41 2nd - Charles St 4th - MD 146
Peak Period Crash	4th - MD 140	1st - Charles St 2nd - IS-83 (JFX) 3rd - MD 146 5th - MD 41

Using the mobility and crash data, high crash areas were overlayed with the system operations to provide our team with a tool to determine the sections with the greatest need and visually identify and rank potential roadway sections within the corridor for improvements.

CONSTRAINTS

The Lane/JMT team developed a preliminary layout of an RFP compliant roadway geometry required to accommodate a PTSU lane from IS-70 to MD 43 on both the Inner and Outer Loops. This preliminary layout was used by our team to identify and analyze the constraints within each roadway segment of the project limits. Although constraints in many cases are consistent across the entire project limits, each roadway section and roadway segment within the section has unique constraints that define the roadway footprint required to provide a PTSU lane and the impacts and costs associated with accommodating that footprint.

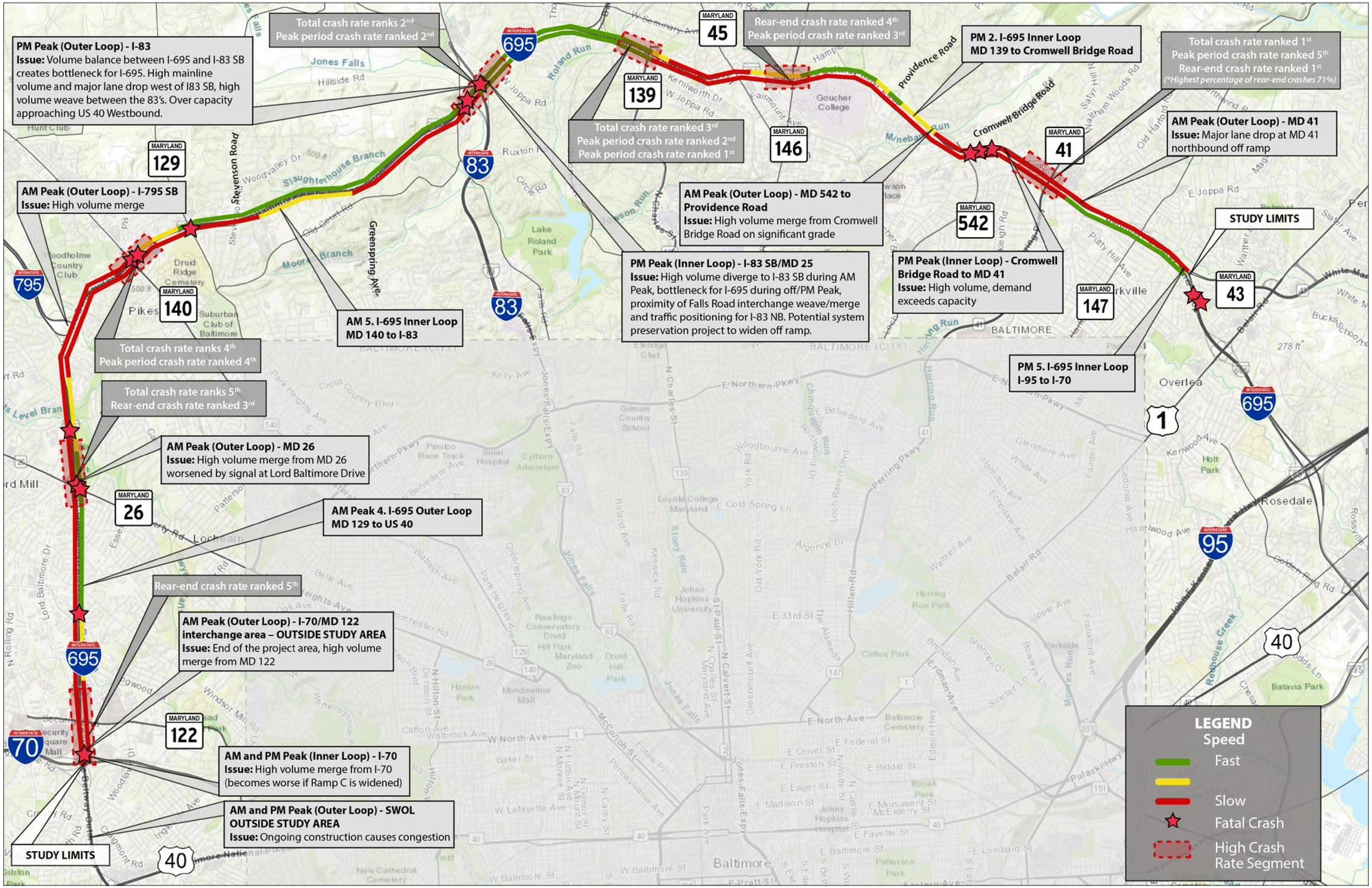
There are several overpass bridges that constrain the IS-695 typical section and/or pose potential vertical clearance challenges. There are also several bridges that carry IS-695 traffic that do not provide for adequate stopping sight distance within the existing median shoulder and therefore will require additional shifting of traffic and bridge widening to accommodate the PSTU lane. Segments of roadway that impact existing bridges result in significant per linear foot cost increases and therefore were identified in our team's decision matrix. The Lane/JMT team identified other constraints to be considered in our decision matrix as we iteratively balanced costs and impacts with providing an effective solution to maximize operational and safety benefits:

- Potential Noise Impacts
- Pinch Points
- Horizontal and Vertical Geometric Constraints
- Existing Pavement Condition
- Drainage and SWM Requirements
- Impacts to existing environmental features and SWM Assets
- Right of Way Constraints
- Budget/Constructability

The Lane/JMT proposed preliminary geometric layout for IS-695 from IS-70 to MD43, used for evaluation and determination of the final PTSU limits to be provided within the projects budget constraints, was designed in accordance with the RFP requirements and provides for the following **Proposed Roadway Typical Section**:

- 12' travel lanes for all lanes (PTSU lanes and general-purpose lanes)
- Provides a minimum 1.5' offset (varies between 1.5' and 12' to accommodate stopping sight distance) to the median barrier for the PTSU lane
- Outside shoulders, where lanes will be shifted, will be either 10' wide (minimum) for mainline and 6' wide (minimum) for auxiliary lanes (except in locations identified in ATC 06/ATC 07)
- Stopping sight distance requirements for a 55 MPH design speed are met for the PTSU lane
- Roadway cross slopes and superelevation meeting current AASHTO requirements are provided for both the PTSU and general-purpose lanes where impacts to these lanes were required
- Upgrades to the existing median barrier where PTSU lane is proposed to ensure a safe and acceptable final condition as evaluated and determined by the Lane/JMT team
- Meet the RFP drainage spread requirements within the median shoulder where PTSU lanes are proposed

Figure 1. Existing Conditions



The Lane/JMT team submitted several ATCs for review and evaluation by MDOT SHA in an effort to propose alternative and innovative solutions that would effectively and efficiently reduce or minimize the impact to the project's identified constraints and maximize the project's goals within the project's budget constraints. The Lane/JMT team intends to incorporate two (2) of these geometric design related ATCs into our final solution. ATC 06 and ATC 07 were conditionally approved by MDOT SHA. These ATCs were for the reduction in the width of the outside shoulder along certain areas of IS-695 adjacent to the mainline (ATC 06) and auxiliary lanes (ATC 07). The Lane/JMT team intends to incorporate these two ATCs into our final solution and submit for approval of the required Design Exceptions during final design. These ATCs allow for the maximization of the project goals with our proposed solution length within the budget constraints.

Based on congestion, safety and key project constraints, our team initially divided the project into two distinct sections for evaluation:

- **IS-70 to Stevenson Road**
- **Stevenson Road to MD 43**

These sections were evaluated against the project elements and goals:

IS-70 TO STEVENSON ROAD

Traffic Operations and Reliability: The congestion during the AM peak period in this section begins at the Southwest Outer Loop work zone, just south of US 40 and extends through the study area up to the MD 26 (Liberty Road) interchange, meaning the bottlenecks are outside the study area. By the year 2040, the No Build VISSIM model shows the failing weave section between the IS-70 eastbound on ramp to US 40 westbound, and the high-volume merge from MD 122 (Security Blvd.) will cause severe congestion and will cause traffic to queue back to IS-83. VISSIM analysis showed that unless these bottlenecks are removed, adding PTSU will simply manage the queue and will not provide any real relief for the travelling public.

During the PM Peak period, the IS-695 Inner Loop merges from IS-70 and MD 122 both operate over capacity and cause severe queuing. By the year 2040, traffic will be constrained at the IS-70 / MD 122 interchanges since IS-695 is only a three-lane section under IS-70. The demand volume is 6,950 vehicles per hour (VPH) but the three-lane section can only process approximately 6,300 VPH. The volume on IS-695 is further constrained as the traffic destined to MD 122 also must use the three-lane section under IS-70. Furthermore, the IS-70 eastbound to IS-695 northbound (Ramp C) movement is currently constrained and throughput volumes from IS-70 are not expected to increase. This means demand volumes may be increasing along the Inner Loop, however bottleneck locations outside the study area will limit throughput volumes through the study area.

There is a bottleneck at the IS-795 interchange, where the IS-795 on ramp to IS-695 merges. This is due to the ramp reducing from two to one lane. There is a District 4 project studied to provide an auxiliary lane on both the Inner and Outer Loop, which would significantly improve operations and in fact, no signing changes would be needed. There is a short constraint point near MD 26, which would need to be improved or else a design exception is needed because the shoulder here is not wide enough. This solution would be a far better improvement to this merge operation compared to PTSU.

Along the IS-695 Outer Loop, most of the congestion along this section of roadway is due to bottlenecks outside the study limits. If these bottlenecks did not exist, it is likely that this section of the Beltway would operate near free flow conditions. In fact, this section of the Beltway had no programmed improvements in the 2017 Consolidated Transportation Program.

Safety: Crash data was evaluated on IS-695 for the four-year period, from January 1, 2015 through December 31, 2018, between IS-70 (MP 6.80) and Stevenson Road (MP 14.29) to identify crash hotspots and crash causes.

There were 2,073 crashes with the major crash types being rear-end (60%), single vehicle (21%) and sideswipe (16%). Analysis of top five IS-695 crash rates between IS-70 and MD 43 showed that the highest crash rate segments are located between Stevenson Road and MD 43. This analysis includes top five total crash rates, rear end crash rates and peak period only crash rates. Highest crash rate segments from IS-70 to Stevenson Road include MD 140 interchange (ranked 4th total crash rate and 4th peak period crash rate), MD 26 interchange (ranked 5th total crash rate and 3rd rear-end crash rate), and I-70/MD 122 interchanges (ranked 5th rear-end crash rate).

This section had three 2017 Priority Candidate Safety Improvement Section (CSIS) based on crash severity index and there were six fatal crashes.

There are other nontangible safety benefits to the local roadway network if PTSU is implemented along this section. Many motorists divert to local roadways such as Rolling Road or Lord Baltimore Drive to avoid congestion along IS-695.

Constraints: The Lane/JMT team identified several constraints within this section of the project, IS-70 to Stevenson Road. These constraints were analyzed and evaluated as part of our team's decision matrix. The impacts and project costs associated with each of these constraints were weighed against the operational and safety benefits provided by incorporation of PTSU within that roadway segment. The following identifies several of the major constraints within this section of the project limits and the cost-drivers that were considered as a result:

- Existing Overpass Bridges – These existing bridges do not accommodate the required IS-695 typical section for PTSU lane and would require replacement, a significant cost and impact driver including impacts to many utilities and significant impact to the secondary roadway network and adjacent communities during construction.
    - Windsor Mill Road
    - MD 129 (Park Heights Avenue)
    - Stevenson Road
- Existing Horizontal Curvature – To accommodate the stopping sight distance requirements for the PTSU lane, the entire roadway will need to be shifted to the outside.
    - Outer Loop south of IS-795
    - Outer Loop north of IS-795*
    - Outer Loop north of MD 140*

*The stopping sight distance (SSD) constraint along the Outer Loop north of IS-795 and north of MD 140, results in significant impacts due to the need to shift the lanes to accommodate the required SSD for the PTSU lane. Due to the tight right of way constraints in these areas, a significant proposed retaining wall would be required to provide for the widening and maintain the proposed project solution within the existing right of way.

- Existing Median Barrier and Drainage Replacement – Many roadway segments within this section will require removal and reconstruction of the existing median barrier and drainage system to accommodate the RFP requirements for replacement of the existing median barrier and drainage spread within the PTSU lane.

With each of the identified constraints within this section of the project, the Lane/JMT Team went through a process to identify the constraint, estimate the costs and construction impacts, evaluate potential alternative and innovative solutions, propose potential ATCs to avoid/minimize the impact of the constraint, and then incorporate an optimized design to develop the potential costs of each of these roadway segment to evaluate the benefits against the project goals and costs.

Other Considerations: Considering MDOT SHA intends to make proposed improvements to the IS-70/IS-695 interchange, it may also be desirable to defer this section so that those improvements are not potentially constrained by the improvements proposed as part of this project. This interchange reconstruction project will likely reconfigure most ramps at the interchange. When originally conceived, the major movement through the interchange was the IS-70 eastbound and westbound movements to and from Baltimore City. Since the IS-70 freeway into the city was never completed, the primary movements became the ramps to and from IS-695. It is anticipated that the interchange will be reconfigured to better meet traffic patterns.

Providing median part-time shoulder use along IS-695 adjacent to the IS-70 interchange may impact potential low-cost solutions for the interchange reconstruction project.

Conclusion: This section experiences severe congestion, however most of the bottlenecks are outside the study area. Providing PTSU would simply manage the queue and send the bottleneck downstream.

STEVENSON ROAD TO MD 43

Traffic Operations and Reliability: During the AM Peak period, congestion begins along the Outer Loop at the end of auxiliary lane between MD 43 and MD 41 northbound and at the same time, the high volume merge from MD 542/Cromwell Bridge Road on a significant grade begins to fail. Queues often extend to US 1. It was determined that congestion was due to bottlenecks within the study area and that PTSU would resolve operational issues.

Also during the AM Peak Period, along the Inner Loop, the lane drop at ramp to IS-83 southbound causes severe queueing and is compounded by the high volume weave at MD 25 (Falls Road) loop ramps with heavy volumes destined to IS-83 northbound in right lane. Our team determined congestion in this area is due to bottlenecks along IS-695 within the project limits.

During the PM Peak period, along the Outer Loop, congestion is due to the end of auxiliary lane between MD 45 and MD 139 as traffic positions to exit at IS-83 northbound, and the end of the weave between the IS-83 interchanges. Volume balance between IS-695 and IS-83 southbound creates a bottleneck for IS-695. Both locations experience congestion due to bottlenecks along IS-695.

During the PM Peak period along the Inner Loop, congestion is caused by the end of auxiliary lane between IS-83 southbound and MD 45/MD 45 weave, the high volume merge from MD 146 ramps, the high volume weave between Cromwell Bridge Road and MD 542 and the ramp from MD 542 northbound on significant grade. The last bottleneck is at the end of auxiliary lane between MD 41 northbound and MD 147 prior to development of exit lane to MD 147.Congestion on the Inner Loop, east of IS-83 is due to bottlenecks along IS-695.

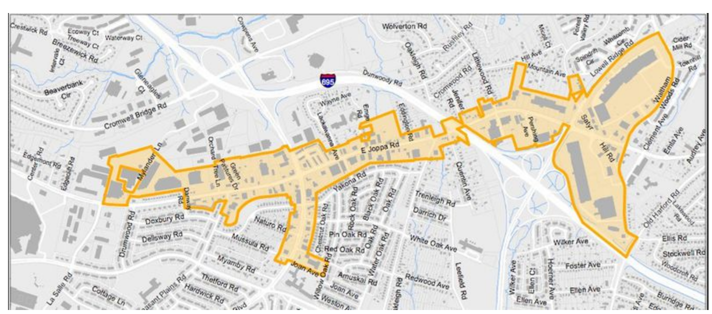
This stretch of IS-695 has two sections of roadway listed as the top five most congested freeway segment during the AM Peak Hour and one section during the PM Peak Hour and contains the highest volume to capacity sections within the study area:

- IS-695 Inner Loop after the MD 25 ramps, between MD 146 and Providence Road, MD 542 and MD 41, and within the MD 147 interchange.
- IS-695 Outer Loop between Providence Road and MD 146, after the MD 139 off-ramp and after the ramp to IS-83 southbound/MD 25.

Diversion to the local roadway network to avoid IS-695 congestion is a known issue and could be proven by analyzing Origin-Destination data or analyzing Google top travel routes during the peak hours. This section of IS-695 is so congested that many motorists use alternative routes, which primarily include local and county roads. Waze will often tell motorists to use lower functioning roadways such as Kenilworth Avenue, Fairmount Avenue, Putty Hill Avenue and Joppa Road, and other county roads as diversion routes and, as a result, there are high traffic volumes through residential areas and many of the intersections along this corridor to fail and Baltimore County left responsible to manage volumes, which should be using IS-695.

There are no practical alternative east/west routes to IS-695 between IS-83 and MD 43 and improving this section of IS-695 would help keep motorists on IS-695 and reduce the volume on neighborhood streets.

Reducing diversion from the Beltway to local roads could help economic development in underserved areas. County Councilman David Marks has been working with MDOT SHA to revitalize Joppa Road in east Towson and construct a roundabout at the Joppa Road / MD 542 intersection. The study location is shown in the figure below. He also wants to improve safety and promote walkability. Reducing the cut through volume through this area would help achieve these goals.



Safety: Crash data was evaluated on IS-695 for the four-year period, from January 1, 2015 through December 31, 2018, between Stevenson Road (MP 14.29) and MD 43 (MP 26.25). There were 2,570 crashes with the major crash types being rear-end (59%), single vehicle (23%) and sideswipe (14%). Analysis of top five IS-695 crash rates between IS-70 and MD 43 showed that the highest crash rate segments are located between Stevenson Road and MD 43. This analysis includes top five total crash rates, rear end crash rates and peak period only crash rates. Highest crash rate segments from Stevenson Road to MD 43 include IS-83 South (Jones Falls Expressway) interchange (ranked 2nd total crash rate and 2nd peak period crash rate), Charles Street interchange (ranked 3rd total crash rate, 2nd rear-end crash rate and 1st peak period crash rate), MD 146 interchanges (ranked 4th rear-end crash rate and 3rd peak period crash rate), and MD 41 (ranked 1st total crash rate, 1st rear-end crash rate and 5th peak period crash rate). MD 41 has highest percentage of rear end crashes (71%). Stevenson Road to MD 43 was identified as Priority CSIS from 2013 to 2018 based on crash severity index.

There are other nontangible safety benefits to improving operations along IS-695 between IS-83 and MD 43. As previously discussed, many motorists are diverting to the local roadway network. These roads become less safe because many motorists may not be aware of the character of the roadway and may travel at speeds higher than the posted speed limit. Higher volumes increase pedestrian and bicycle level of stress and discourages multimodal travel.

Constraints: The Lane/JMT team identified several constraints within this section of the project, Stevenson Road to MD 43. These constraints were analyzed and evaluated as part of our team's decision matrix. The impacts and project costs associated with each of these constraints were weighed against the operational and safety benefits provided by incorporation of PTSU within that roadway segment. The following identifies several of the major constraints within this section of the project limits and the cost-drivers that were considered as a result:

- Existing Bridges Carrying IS-695 Traffic – These existing bridges do not accommodate the required IS-695 typical section width required for a PTSU lane and would need widening to accommodate the PTSU lane.
    - Cromwell Bridge Road
    - MD 542 (Loch Raven Boulevard)
- Existing Horizontal Curvature – To accommodate the stopping sight distance requires for the PTSU lane, the entire roadway will need to be shifted to the outside in the following locations:
    - Outer Loop between the IS-83s
    - Inner Loop west of MD 45*
    - Outer Loop east of MD 45
    - Inner Loop under 146
    - Outer Loop west of Providence Road
    - Inner Loop west of MD 542*
    - Outer Loop east of MD 542
    - Inner Loop under Old Harford Road

*The stopping sight distance (SSD) constraint along the Inner Loop west of MD 45 will require widening within a constrained right of way. A proposed steepened slope will likely be required to keep the proposed grading within the existing right of way. The SSD constraint along the Inner Loop west of MD 542 will result in the need to widen the existing bridges over Cromwell Bridge Road and over MD 542 (Loch Raven Boulevard). These bridge widenings may require utility impacts, in particular, the overhead communications line that runs under the existing Cromwell Bridge Road bridge carrying IS-695 traffic.

- Existing Median Barrier and Drainage Replacement – Many roadway segments within this section will require removal and reconstruction of the existing median barrier and drainage system to accommodate the RFP requirements for replacement of the existing median barrier and drainage spread within the PTSU lane. However, there is a long stretch between Stevenson Road and IS-83 JFX, and between Old Harford Road where it is anticipated that the existing barrier can be maintained.

As with the section of the project between IS-70 and Stevenson Road, the Lane/JMT team went through a process to identify the constraints, estimate the costs and construction impacts, evaluate potential alternative and innovative solutions, propose potential ATCs to avoid/minimize the impact of the constraint, and then incorporate an optimized design to develop the potential costs of each of these roadway segment to evaluate the benefits against the goals and costs.

Other Considerations: This section contains the only six lane freeway in the study area, with three mainline lanes in each direction east of IS-83 South (Jones Falls Expressway) to MD 43. There are four mainline lanes in each direction west of IS-83 South except for within the IS-795 interchange where volumes are greatly reduced. There are also significant roadway vertical grades along this section, particularly between MD 146 and MD 41, which causes reduced capacity. The section between MD 542 to MD 41 has the steepest grade of any section in the study area. In previous Consolidated Transportation Programs, only our improvement section was slated for widening from a six lane to an eight-lane freeway. The proposed improvements specific to this section were replaced in the 2018 Consolidated Transportation Program with this current project.

FINAL PTSU DETERMINATION

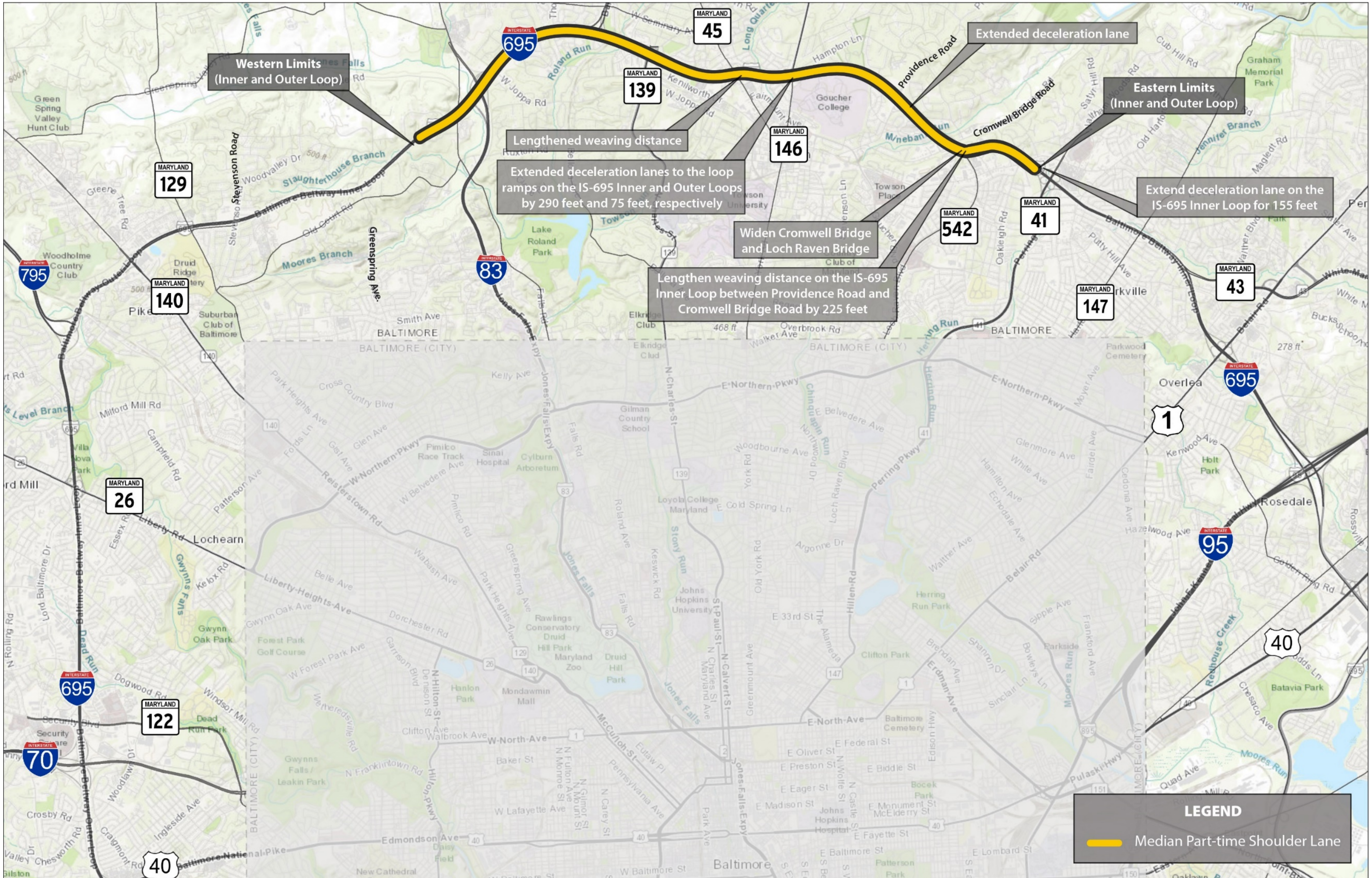
A summary of the operational, safety and geometric constraints in shown in Table 3. A comparison of the two sections showed that the Stevenson to MD 43 section, or some portion of this section, would see greater benefits from the implementation of a PTSU lane than the IS-70 to Stevenson section. After detailed geometric and cost analysis, our team determined it was not possible to complete the full limits of this preferred section.

Our team determined the maximum benefit, which balanced the most effective operational benefits of PTSU against the constraints and key issues would be between Greenspring Avenue and MD 41.

The proposed improvements are shown in Figure 2, **40,000 LF (7.6 miles)** of PTSU lane provided between Greenspring Avenue and MD 41. Ideally, the optimal solution would be to provide PTSU to MD 43, especially on the Inner Loop during the PM Peak Hour, however it was not possible, within the project budget constraints. We determined this section provides the most benefit for the project budget.

Table 3. Operation and Safety Summary	I-70 to Stevenson Road		Stevenson Road to MD 43			
Mobility Report Ranking	#4 AM OL – MD 129 to US 40 None in PM Peak		#2 AM - OL US 1 to Cromwell Bridge Rd #5 AM – OL MD 140 to I-83 #2 PM MD 139 to Cromwell Bridge Road			
Freight Mobility from Port to IS-795 and IS-83	Tolled Route through Tunnel or Bridge		No Toll or Tunnel Restrictions			
2040 Highest Volume per Lane	2,551 Outer Loop north of MD 122		3,093 Inner Loop MD 146 to Providence Rd			
CSIS Segments	3		4			
Total Number of Crashes	2,073		2,570			
Rear-End Percentage	60%		59%			
Single Vehicle Percentage	21%		23%			
Sideswipe Percentage	16%		14%			
Total Crash Rate	4th - MD 140	5th - MD 26	1st - MD 41	2nd - IS-83 (JFX)	3rd - Charles St	
Rear-End Crash Rate	3rd - MD 26	5th - IS-70/MD 122	1st - MD 41	2nd - Charles St	4th - MD 146	
Peak Period Crash Rate	4th - MD 140		1st – Charles St	2nd – IS-83 (JFX)	3rd – MD 146	5th – MD 41
Constrained Overpasses	3		2			
Sight Distance Constraint Points	3		8			

Figure 2. Proposed Improvements



ii. IMPROVEMENTS

HOURS OF OPERATION AND LOUD HOUR

The hours of operation will remain static daily and will need to be extended between the opening year and future years. The PTSU is proposed to operate during the weekday AM and PM peak periods and during the peak period on Saturday. Many people may only associate PTSU with weekday mobility, however, PTSU, should also be considered for the weekend. Today on Saturdays, there are failing freeway operations along IS-695 and PTSU should be provided during the peak period.

In the 2018 Opening Year, hours of operation are proposed to be weekdays 6 AM to 10 AM and 3 PM to 7PM and Saturday 11 AM to 4 PM. Saturday operations on the IS-695 Outer Loop will only be needed from IS-83 North to the western terminus.

In 2030, hours of operation are extended and proposed to be weekdays 6 AM to 10 AM and 2 PM to 7 PM and Saturday 11 AM to 5 PM. Saturday operations will also be extended to the full limits on the IS-695 Outer Loop.

In the 2040 Design Year, hours of operation are extended and proposed to be weekdays 6 AM to 10 AM and 2 PM to 7 PM and Saturday 10 AM to 5 PM.

The existing loud hour is from 1 PM to 2 PM. In the 2040 build condition, the loud hour will remain at 1 PM to 2 PM when the PTSU lane is not in use.

Our teams' median PTSU addresses the following key bottlenecks along the IS-695 Inner and Outer Loops:

AM PEAK OUTER LOOP

- High volume merge from MD 41 southbound ramp.
- High volume merge from MD 542/Cromwell Bridge Road on significant grade.

AM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound
- High volume weave at MD 25 loop ramps with heavy volumes destined to IS-83 northbound in right lane.

PM PEAK OUTER LOOP

- End of auxiliary lane between MD 45 and MD 139 as traffic positions to exit at IS-83 northbound.
- End of weave between the IS-83 interchanges. Volume balance between IS-695 and IS-83 southbound creates a bottleneck for IS-695.

PM PEAK INNER LOOP

- End of auxiliary lane between IS-83 southbound and MD 45/MD 45 weave.
- High volume merge from MD 146 ramps.
- High volume weave between Cromwell Bridge Road and MD 542.
- Ramp from MD 542 northbound on significant grade.

By addressing key bottlenecks, travel times are significantly reduced between IS-70 and MD 43. Our team's PTSU lane provides travel time reductions of up to 17.6% during the 2018 AM Peak and 39.5% during the 2018 PM Peak. **Travel time reductions increase by the year 2040 with reductions of up to 53.7% in the 2040 AM Peak and 75.2% in the 2040 PM Peak.**

By addressing key bottlenecks, throughputs along the IS-695 Inner and Outer Loops are improved in **2018 and 2040 with up to a 12% increase in the 2040 AM Peak and 21% increase in the 2040 PM Peak.**

TRAVEL TIME

Our project's PTSU will significantly improve mobility and address congestion by improving travel time and reliability through the study area.

Travel times are significantly reduced between IS-70 and MD 43 with reductions of 17.6% during the 2018 AM Peak and 39.5% during the 2018 PM Peak. **Travel time reduction increase by the year 2040 with reductions of up to 53.7% in the 2040 AM Peak and 75.2% in the 2040 PM Peak.** The VISSIM results showed the following travel time benefits between IS-70 and MD 43:

IS-70 to MD 43	2018 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	-1.2%	-6.2%	-12.7%	-1.1%
Outer Loop	-1.4%	-9.8%	-17.6%	-15.3%

IS-70 to MD 43	2018 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	-20.8%	-34.0%	-39.5%	-22.9%
Outer Loop	-7.1%	-14.0%	-17.4%	-5.7%

IS-70 to MD 43	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	-2.7%	-12.1%	-32.5%	-53.7%
Outer Loop	-0.8%	-4.1%	-18.5%	23.7%

IS-70 to MD 43	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	-42.9%	-62.2%	-68.7%	-75.2%
Outer Loop	-28.6%	8.7%	26.9%	67.2%

Cumulative travel times for notable time periods are shown below in Figures 3-10. Figure 3 shows that today, the southbound travel time significantly increase approaching the Towson stretch. Improving operations to near free flow conditions will allow travel times to increase linearly and will continue to increase linearly until motorists reach the I-695 SWOL construction, which will likely be finished prior to the opening year for this project. During the PM Peak, there is significant delay due to the mainline lane drop west of I-83. The PTSU provides additional capacity through this lane drop and improves speeds. Figures 5 and 6 show slowdowns approaching I-83 during the existing conditions. For the build conditions, the travel times are now linear and the benefits to the travel times are realized back to MD 140 for both time periods.

By the year 2040 conditions are expected to be considerably worse based on the forecasted volumes for this project. For the AM peak period, as shown in Figure 7, with improvements, the southbound travel times significantly decrease starting from the eastern limits of the project and the benefits are reduced near MD 146. During the PM peak, the benefits are realized again starting on the eastern end of the project and remain considerably lower compared to the no build conditions.

In the northbound direction, the AM peak hour benefits are realized far beyond the project limits and travel times improve all the way to I-70. During the PM peak hour, the travel time benefits begin at MD 140 and the slow downs between I-83 and MD 542 are significantly reduced.

Figure 3. 8 AM-9AM Existing Southbound Travel Times

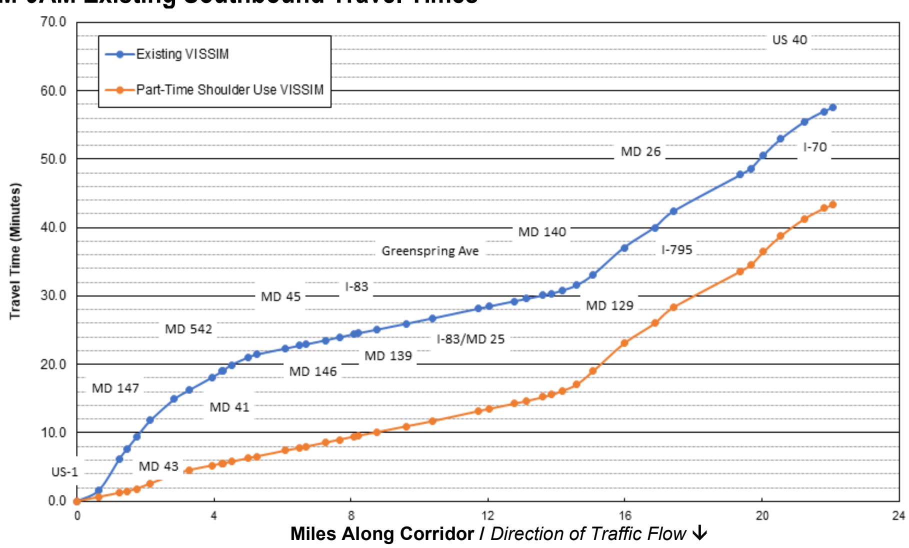


Figure 4. 5 PM-6PM Existing Southbound Travel Times

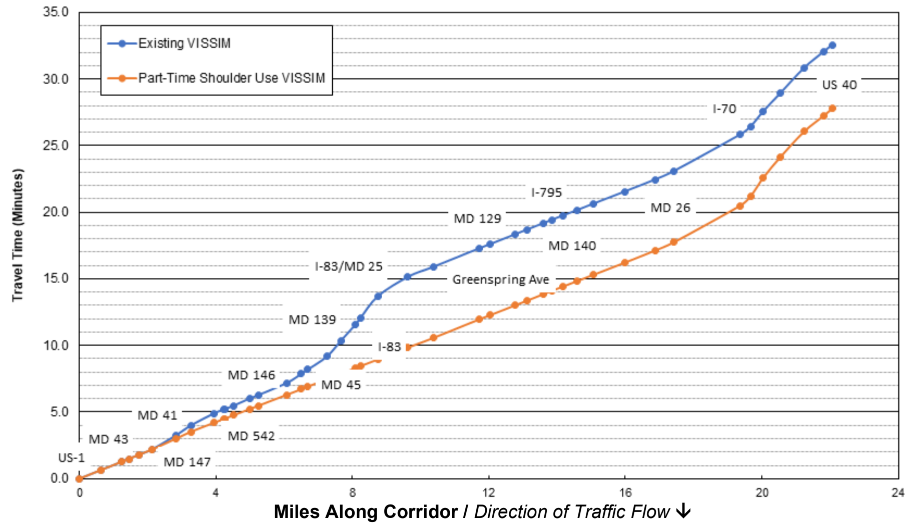


Figure 5. 8 AM-9AM Existing Northbound Travel Times

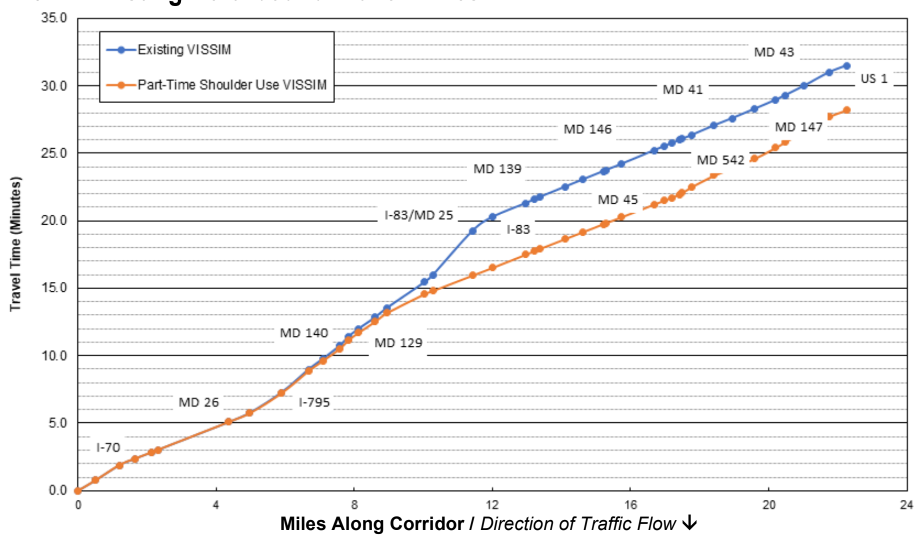


Figure 6. 4 PM-5PM Existing Northbound Travel Times

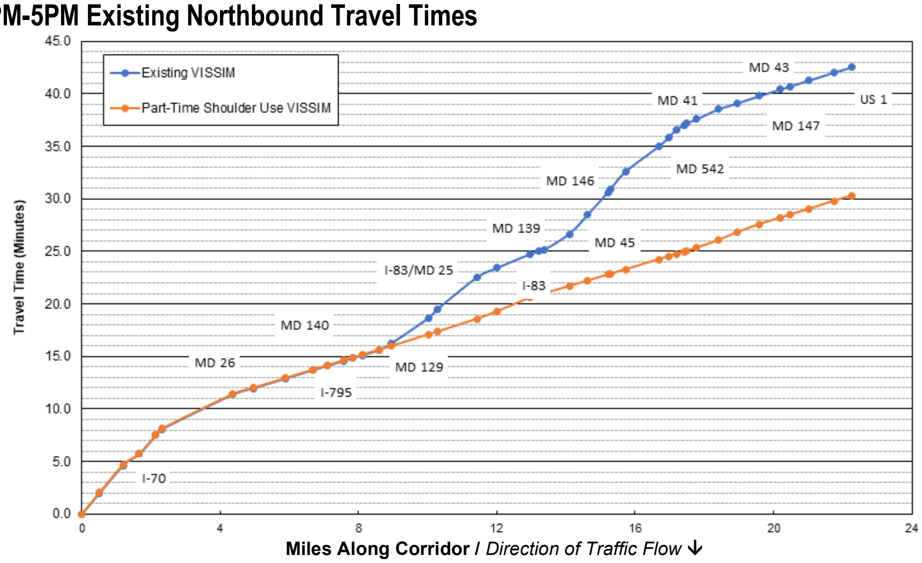


Figure 7. 8 AM-9AM Year 2040 Southbound Travel Times

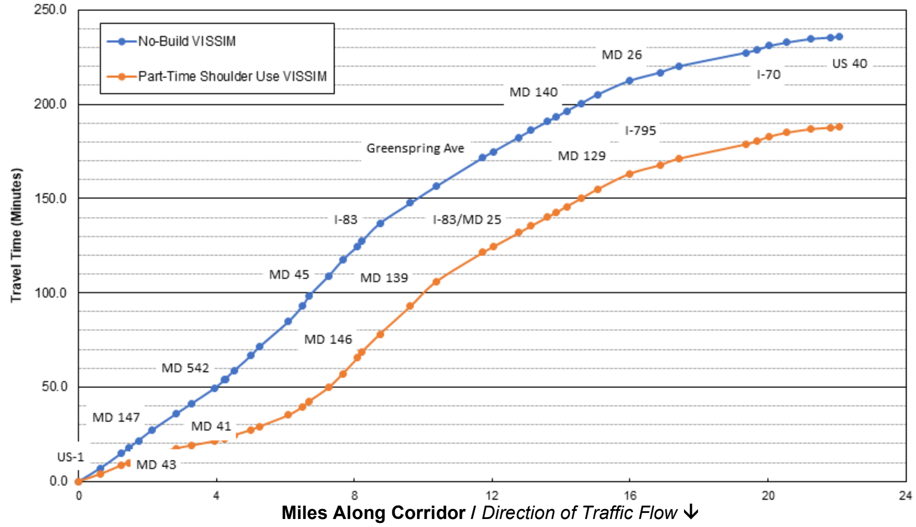


Figure 8. 3 PM-4PM Year 2040 Southbound Travel Times

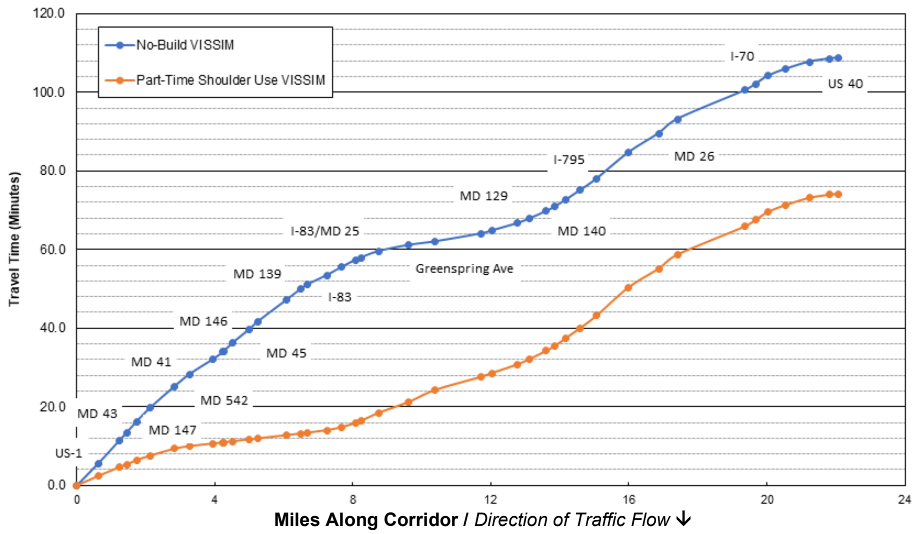


Figure 9. 8 AM-9AM Year 2040 Northbound Travel Times

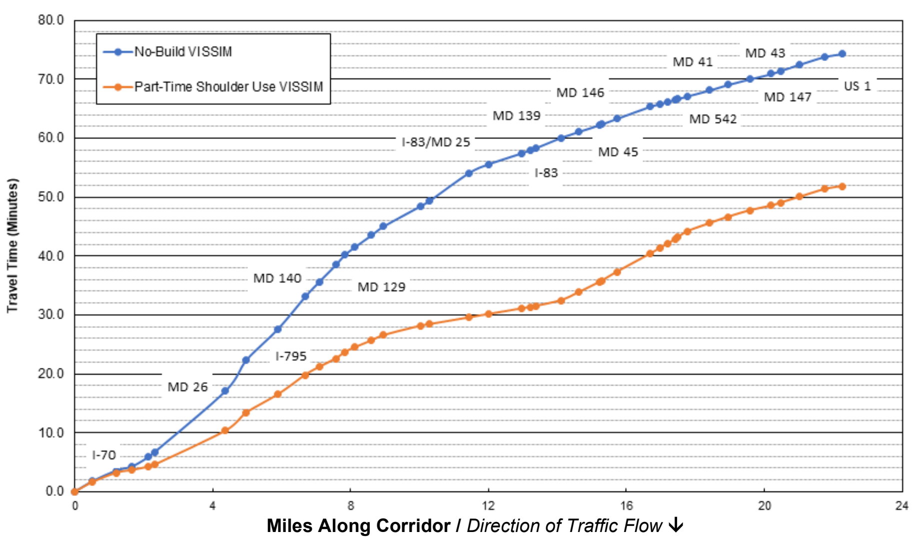
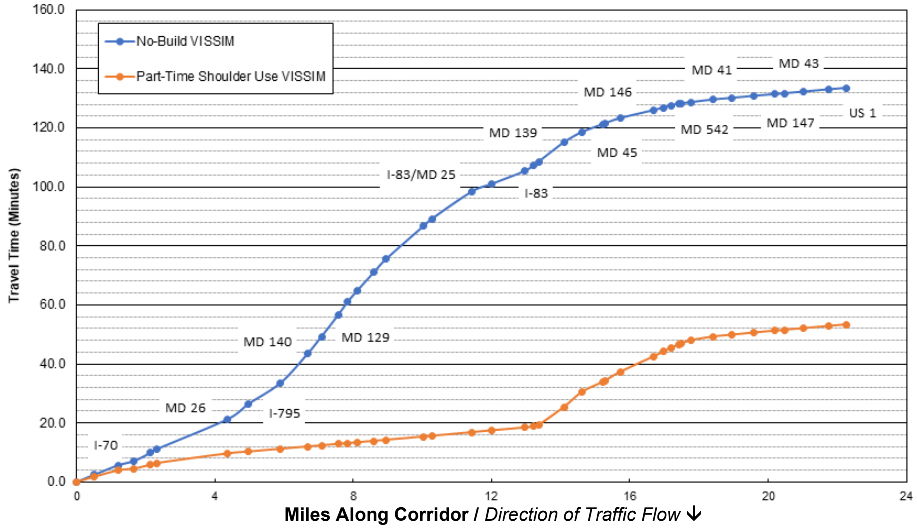


Figure 10. 4 PM-5PM Year 2040 Northbound Travel Times



Travel times along the IS-695 Outer Loop in 2040 are significantly impacted by downstream constraints at IS-70 and resultant queuing due to bottlenecks outside the study area. Since we are addressing bottlenecks along I-695, and not sending the bottleneck downstream, our project PTSU provides the most significant travel time reductions between IS-83 and MD 43 with 30.7% increase in speeds during the AM peak hour along the Inner Loop and 67% along the Inner Loop during the PM Peak hour.

MD 43 to IS-83 S.	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Outer Loop	-3.3%	-19.9%	-30.7%	25.6%

MD 43 to IS-83 S.	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Outer Loop	-61.0%	-4.5%	2.5%	22.5%

Reliability will be significantly improved with our proposed improvements. The TTI values in the Mobility Report are based on INRIX data, which is based on real world conditions. The TTI values from the model are not in line with existing conditions, so to make a fair comparison, the VISSIM Existing and Build conditions are compared below to determine the change in reliability. Our solution improves the travel time index to acceptable ranges and every section would no longer rank as one the worst operating section in the State. The Outer Loop will experience the greatest improvement in reliability and would operate at near free flow speeds.

	Mobility Report	2018 No-Build	2018 PTSU
AM PEAK 7-8 AM			
IS-695 Outer Loop US 1 to Cromwell Bridge RD – 2nd	2.85	2.43	1.47
IS-695 Inner Loop MD 140 to I-83 – 5th	2.33	1.85	1.43
PM PEAK 5-6 PM			
IS-695 Inner Loop MD 139 to Cromwell Bridge Road – 2nd	3.19	3.62	1.00

VEHICLE THROUGHPUT

By addressing key bottlenecks, vehicle throughputs are improved in 2018 and 2040 with up to a 12% increase in the 2040 AM Peak and 21% increase in the 2040 PM Peak. Our teams' median PTSU lane addresses the following key bottlenecks along the IS-695 Inner and Outer Loops and provides the following throughput benefits at these locations:

AM PEAK OUTER LOOP

- High volume merge from MD 41 southbound ramp – up to an 8% increase 2040 (Throughputs increase to over 100% in later hours due to cleared downstream queues)
- High volume merge from MD 542/Cromwell Bridge Road on significant grade – up to an 8% increase 2040 (Throughputs increase to over 100% in later hours due to cleared downstream queues)

AM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound – up to a 18% increase 2040
- High volume weave at MD 25 loop ramps with heavy volumes destined to IS-83 northbound in right lane – up to a 18% increase 2040.

PM PEAK OUTER LOOP

- End of auxiliary lane between MD 45 and MD 139 as traffic positions to exit at IS-83 northbound – up to a 33% increase in 2040.

PM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound – up to a 72% increase 2040.
- End of auxiliary lane between IS-83 southbound and MD 45/MD 45 weave – up to a 33% increase in 2040.
- High volume merge from MD 146 ramps – up to a 7% increase in 2040.
- High volume weave between Cromwell Bridge Road and MD 542 – up to a 7% increase in 2040.
- Ramp from MD 542 northbound on significant grade. – up to a 6% increase in 2040.

The VISSIM results showed the following vehicle throughput benefits along the IS-695 Inner and Outer Loops:

	2018 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	0.1%	0.8%	-0.8%	0.0%
Outer Loop	0.1%	2.8%	2.3%	-6.1%

	2018 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	1.5%	1.4%	-0.2%	-3.5%
Outer Loop	1.1%	0.3%	0.0%	-1.7%

	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	0.3%	2.2%	11.0%	1.3%
Outer Loop	0.0%	3.1%	12.4%	-2.8%

	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	10.6%	20.5%	12.7%	7.1%
Outer Loop	17.5%	11.8%	-5.0%	9.5%

DENSITY

Freeway density has a direct impact on safety because shorter headways can increase the chances of rear end collisions. Reduced gaps also make it harder for motorists to change lanes, leading to frustration and driver aggression. By addressing key bottlenecks, our teams' median PTSU lane greatly reduces vehicle density along the IS-695 Inner and Outer Loops in 2018.

During the 2018 AM Peak, IS-695 Inner Loop Level of Service (LOS) is improved to LOS E or better from Stevenson Road to MD 542/Cromwell Bridge for the duration of the AM Peak. IS-695 Outer Loop LOS is improved to LOS E or better from MD 41 to Stevenson Road.

During the 2018 PM Peak, IS-695 Inner Loop LOS is improved to LOS E or better from MD 26 to MD 41 for the duration of the PM Peak, except for between 5 and 6 PM at the Greenspring Avenue diverge and between the IS-83 interchanges. IS-695 Outer Loop LOS is improved to LOS E or better from MD 41 to MD 26.

During the 2040 AM Peak, IS-695 Inner Loop LOS is maintained at LOS E or better from Stevenson Road to IS-83 for the duration of the AM Peak. During the 2040 PM Peak, IS-695 Inner Loop LOS is maintained at LOS E or better from MD 26 to IS-83 for the duration of the PM Peak.

QUEUES AND INTERSECTION OPERATIONS

Our teams' median PTSU lane greatly reduces the queuing along the ramps to IS-695 and spillback into ramp terminal intersections. The greatest reduction is seen along the ramp from MD 43 westbound to the IS-695 Outer Loop where the queues of up to a mile are eliminated in the 2018 AM Peak and the 2040 PM Peak.

VEHICLE NETWORK PERFORMANCE

By addressing key bottlenecks, the vehicle network performance is significantly improved. Total delay and average delay per vehicle are reduced up to 23% in the 2018 AM Peak and 30% in the 2018 PM Peak. By 2040, total delay and average delay per vehicle in reduced by 9% in the AM Peak and 27% in the PM Peak with large reductions of latent delay of 12% and 24% in the AM and PM Peak, respectively. The VISSIM results showed the following network delay benefits:

	2018 AM % Change			
Metric	6-7	7-8	8-9	9-10
Total Delay	-3.5%	-10.3%	-23.6%	-21.5%
Average Delay Per Vehicle	-3.4%	-10.2%	-23.0%	-20.3%
Total Travel Time	-0.6%	-3.0%	-10.5%	-7.9%
Latent Delay	0.0%	3.7%	0.9%	1.0%

	2018 PM % Change			
Metric	3-4	4-5	5-6	6-7
Total Delay	-21.2%	-26.6%	-30.5%	-13.4%
Average Delay Per Vehicle	-20.9%	-25.8%	-29.4%	-12.0%
Total Travel Time	-5.9%	-11.2%	-13.7%	-6.45%
Latent Delay	-20.9%	13.7%	6.0%	-2.5%

	2040 AM % Change			
Metric	6-7	7-8	8-9	9-10
Total Delay	-1.6%	-5.6%	-8.9%	-5.7%
Average Delay Per Vehicle	-1.5%	-5.7%	-12.7%	-3.4%
Total Travel Time	-0.5%	-2.7%	-5.3%	-4.3%
Latent Delay	0.7%	-0.1%	-8.0%	-12.1%

	2040 PM % Change			
Metric	3-4	4-5	5-6	6-7
Total Delay	-26.6%	-20.0%	-14.3%	-18.5%
Average Delay Per Vehicle	-27.7%	-21.6%	-18.9%	-22.7%
Total Travel Time	-15.3%	-14.0%	-9.5%	-11.9%
Latent Delay	-19.0%	-24.3%	-24.5%	-24.0%

INCIDENT DETECTION

While the PTSU lane will derive most of its benefits from additional vehicle capacity related to additional lane use, ITS and software components deployed to detect obstructions to traffic flow will support improved incident management. The Lane/JMT team proposes to extensively equip the PTSU corridor with vehicle detector stations, using detector density exceeding three stations per mile. Automated Incident Detection software provide as part of the ActiveITS package will constantly monitor the detection station data. The ActiveITS software, integrated with the CHART software, will provide a rapid and reliable source of incident identification. With the improved incident detection, traffic incidents will be able to be managed more promptly, restoring full roadway capacity, and limiting related delays. This improvement in incident detection will always be available, not only when the PTSU is in operation.

TRAVELER INFORMATION

In addition to incident management improvements, improved traveler information provided by related ITS devices will also aid in reduction of delays. The Lane/JMT team proposes to place three additional Dynamic Message Signs (DMS) in each direction prior to and within the PTSU corridor. The DMSs can be used to provide advanced warning of PTSU operation. The DMS can also be used to inform travelers of upcoming conditions such as incidents and travel time information. **Individual travelers, armed with this information, can make individual choices related to route and schedule to avoid delays.** These DMSs will be integrated into CHART software.

iii. PERFORMANCE LIFE

Our team's PTSU solution addresses the most congested segments and bottlenecks, which results in the greatest reduction in travel time and increase in vehicle throughput. Our team identified constraints that impact the PTSU operations outside the study limits. Since congestion within our team's section is due to bottlenecks along IS-695 within the project limits rather than outside the study area, our team can provide the longest performance life.

By addressing the bottlenecks on the IS-695 Inner Loop at IS-83 / MD 25, MD 45, and Cromwell Bridge Road / MD 542 our team can provide a performance life of at least 2040 for the IS-695 Inner Loop from MD 129 (Park Heights Avenue) to IS-83 during the full AM Peak period and from MD 26 to IS-83 during the full PM Peak period. During the 2040 AM Peak, IS-695 Inner Loop LOS is maintained at LOS E or better from Stevenson Road to IS-83 for the duration of the AM Peak. During the 2040 PM Peak, IS-695 Inner Loop LOS is maintained at LOS E or better from MD 26 to IS-83 for the duration of the PM Peak.

Addressing the bottleneck at IS-83 / MD 25 provides significant performance life outside the limits of the PTSU by maximizing the effectiveness of the existing IS-695 Inner Loop section. The IS-695 Inner Loop section between I-83 and Cromwell Bridge Road will have a performance life of approximately 2030 in the AM and PM Peaks after which it is impacted by queuing from the US 1 and MD 41 interchanges.

By addressing the bottlenecks on the IS-695 Outer Loop at the MD 41 southbound ramp, MD 542 / Cromwell Bridge Road, MD 139, and at IS-83 southbound, our team can provide a performance life of at least 2040 for the IS-695 Outer Loop from MD 41 to MD 139 during the full PM Peak period and from 6-8 AM. After 8 AM, this section is impacted by the existing AM Peak bottleneck at IS-70 outside the study area which queues to IS-795 in 2018 and extends to MD 43 by 2040. The section between MD 41 and IS-83 JFX / MD 25 will have an approximate performance life of 2030 for the full AM Peak period.

The performance life of IS-695 between MD 41 and MD 43 can be improved by a future reconfiguration of the MD 41 interchange. By reconfiguring some or all the existing loop ramps into a diamond or diverging diamond interchange configuration, the existing auxiliary lanes between MD 41 and MD 147 / MD 43 can be fully utilized. The MD 41 interchange reconfiguration would also better facilitate the ability to extend the IS-695 Inner Loop median PTSU lane to the ramp to MD 43 in the future.

2.09.03 **Mobility**

A Design-Build Team

2.09.03 MOBILITY

BENEFITS OF THE LANE/JMT TEAM

- Pavement marking adjustments improve operations and increase safety
- Increase of 21% in 2040 PM Peak Hour (4PM-5PM) vehicle throughput
- Up to 75% travel time improvement during the 2040 PM peak (6PM-7PM)
- Improved merging and diverging operations
- Resurfacing will improve travel speeds, visibility, and rideability
- Lower travel times and increased trip reliability will reduce diversions to local arterial roadways
- Provides 7.6 continuous miles to improve operations and safety
- Addresses 10 out of 15 bottlenecks within the project limits
- Proven PTSU operational methods to improve mobility and safety
- Solution meets all RFP roadway geometric requirements
- Provide traffic conditions to CHART for advance warning to motorists through DMS signs
- Able to provide 6 hours of operation without noise impacts
- Fulfills 2017 Consolidated Transportation Program (CTP) goals for eight lanes of capacity during weekday and Saturday peak periods
- Performance life of LOS E or better in 2040

i. MAXIMIZING THROUGHPUT

The Lane/JMT team developed an initial baseline mobility suite of innovative solutions that focused on the system as a whole (system of systems) - a combination of strategies, technologies, roadway improvements, and partnerships to take full advantage of the network, optimize traffic flow, and improve safety. These solutions were evaluated using VISSIM as part of a data driven process to evaluate goals for maximizing vehicle throughput, minimizing vehicle travel times, and creating a more reliable commuter trip by evaluating potential treatments such as ramp metering, interchange improvements, extension of ramp acceleration and deceleration lanes, additional auxiliary lanes, capacity improvements, better traveler information, and use of TSMO and ITS solutions to minimize the amount of time to detect capacity reduction.

Freight movement and reliability is important for the state's economic welfare. Our proposed improvements provide relief to the direct routes from the Port of Baltimore to IS-83 and IS-795.

Diversion to the local roadway network to avoid IS-695 congestion is a known issue and could be proven by analyzing Origin-Destination data or analyzing Google top travel routes during the peak hours. The section of IS-695 from IS-83 to MD 43 is so congested that many motorists use alternative routes, which primarily include local and county roads. Waze will often tell motorists to use lower functioning roadways such as Kenilworth Avenue, Fairmount Avenue, Putty Hill Avenue and Joppa Road, and other county roads as diversion routes and, as a result, there are high traffic volumes through residential areas, causing many of the intersections along this corridor to fail, leaving the MDOT SHA and Baltimore County left responsible to manage volumes on the local arterial street network that should be using IS-695.

There are no practical alternative east/west routes to IS-695 between IS-83 and MD 43 and **improving this section of IS-695 would help keep motorists on IS-695 and reduce the volume on neighborhood streets.**

IMPROVEMENTS

As the median Part-Time Shoulder Use (PTSU) provides the most significant increases to vehicle throughput and minimizes travel times, project funds should be used to maximize the use of PTSU throughout the study area.

Any improvements that are "not directly related to creating a PTSU lane and thus the clauses in Appendix K of the MDOT SHA Noise Policy would not apply for any required Type 1 noise analysis for the full limits of the approved National Environmental Policy Act (NEPA) document for this project." Given this and the administration's concern that there is a "high potential risk of these improvements alone causing the need for that Type 1 noise analysis", our team removed from consideration all additional improvements beyond the creating median PTSU lane and any additional improvements realized as a result of accommodating the PTSU lane.

As part of the restriping and resurfacing needed to accommodate the median PTSU, improvements can be provided at minimal cost through adjusting the existing pavement markings. These improvements are limited in scope and does not risk the need for the Type 1 noise analysis:

- Lengthened weaving distance on the IS-695 Inner Loop between the MD 45 loop ramps by 100 feet.
- Extended deceleration lanes to the MD 146 loop ramps on the IS-695 Inner and Outer Loops by 290 feet and 75 feet, respectively.
- Extended deceleration lane to Providence Road on the IS-695 Outer Loop by 140 feet.
- Lengthened weaving distance on the IS-695 Inner Loop between Providence Road and Cromwell Bridge Road by 225 feet.
- Lengthened weaving distance on the IS-695 Inner Loop between Cromwell Bridge Road and MD 542 by 80 feet.
- Extended deceleration lane to MD 41 on the IS-695 Inner Loop for 155 feet.

These improvements are also noted on Figure 1.

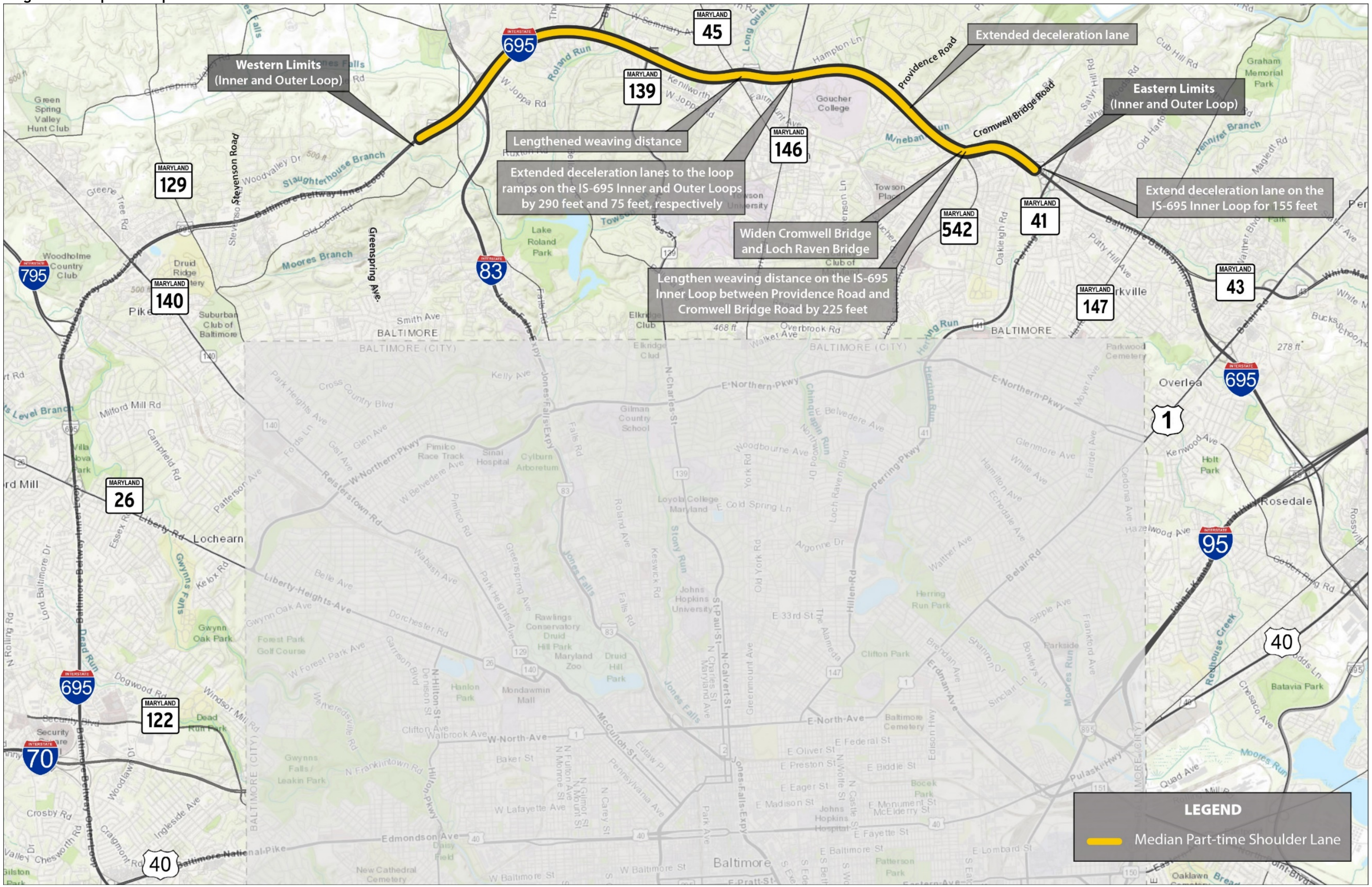
MAXIMIZING THE THROUGHPUT/ MINIMIZING VEHICLE TRAVEL TIMES

Our team identified constraints that impact the PTSU operations and evaluated additional low-cost improvements to address these constraints. These improvements were ultimately not included as they alone risk causing the need for a traditional Type 1 noise analysis for the entire project limits. These improvements included:

- Addressing the failing weaving section on the IS-695 Inner Loop at the US 1 ramps by lengthening the weaving distance on the IS-695 Inner Loop between the US 1 loop ramps by 200 feet.
- Addresses the failing weaving section on the IS-695 Inner Loop at the MD 25 ramps by extending the MD 25 southbound ramp acceleration distance by 750 feet. This reduces the speed differential for the traffic merging from MD 25 southbound into high volumes destined to IS-83 northbound.
- Addressing the failing merge along the ramps from IS-695 to IS-83 southbound by extending the lane from the IS-695 Inner Loop to the MD 25 ramp gore. This eliminates the AM Peak queuing along the ramps from IS-695 that spills back onto the IS-695 Outer Loop between the IS-83 interchanges.

Ramp metering was also evaluated within the IS-70 to MD 43 limits. It was determined that ramp metering provided minimal improvement and risked causing the need for a traditional Type 1 noise analysis as it is "not directly related to creating a PTSU lane."

Figure 1. Proposed Improvements



ii. REDUCING **CONGESTION**

Using a Performance Based Practical Design mindset, our team used the best resources provided and optimized the static-dynamic median part time shoulder use on the IS-695 Inner and Outer Loops to a 7.6-mile section between Greenspring Avenue and MD 41. We utilized relevant objective data to make an informed decision and provide the best solution for MDOT SHA. To maximize the effectiveness of the PTSU operations, our team developed additional low-cost improvements.

TRAFFIC OPERATIONS

Our team's total project addresses the most congested segments, which results in the greatest reduction in travel time and increase in vehicle throughput. According to the 2019 Maryland Mobility Report, IS-695 has several sections of roadway that rank as the most congested segments statewide. The IS-695 Outer Loop has two sections of roadway and the Inner Loop has one section of roadway listed in the top five most congested AM Peak freeway sections:

2018 AM PEAK MOST CONGESTED FREEWAYS (BY RANKING)

AM Rank	Roadway	Limits	TTI
1	IS-495 Outer Loop	IS-95 to MD 97	3.89
2	**IS-695 Outer Loop**	**US 1 to Cromwell Bridge Road**	**2.85**
3	US 50 WB	MD 410 to Washington D.C. Line	2.46
4	**IS-695 Outer Loop**	**MD 129 to US 40**	**2.35**
5	**IS-695 Inner Loop**	**MD 140 to IS-83**	**2.33**

During the PM Peak, there is one section of roadway along the Inner Loop within the project limits that has been identified as one of the top five most congested sections of roadway in the state.

2018 PM PEAK MOST CONGESTED FREEWAYS (BY RANKING)

PM Rank	Roadway	Limits	TTI
1	IS-495 Inner Loop	Virginia State Line to IS-270 West Spur	3.55
2	**IS-695 Inner Loop**	**MD 139 to Cromwell Bridge Road**	**3.19**
3	IS-95/IS-495 Inner Loop	IS-95 to MD 201	2.66
4	IS-495 Inner Loop	IS-270 East Spur to MD 97	2.64
5	IS-695 Inner Loop	IS-95 to IS-70	2.41

This stretch of IS-695 has two sections of roadway listed as the top five most congested freeway segment during the AM Peak Hour and one section during the PM Peak Hour and contains the highest volume to capacity sections within the study area:

- IS-695 Inner Loop after the MD 25 ramps, between MD 146 and Providence Road, MD 542 and MD 41, and within the MD 147 interchange.
- IS-695 Outer Loop between Providence Road and MD 146, after the MD 139 off-ramp and after the ramp to IS-83 southbound/MD 25.

This section contains the only six lane freeway in the study area, with three mainline lanes in each direction east of IS-83 South (Jones Falls Expressway) to MD 43. There are four mainline lanes in each direction west of IS-83 South except for within the IS-795 interchange where volumes are greatly reduced. There are also significant roadway vertical grades along this section, particularly between MD 146 and MD 41, which causes reduced capacity. The section between MD 542 to MD 41 has the steepest grade of any section in the study area. In previous Consolidated Transportation Programs, only our improvement section was slated for widening from a six lane to an eight-lane freeway. The proposed improvements specific to this section were replaced in the 2018 Consolidated Transportation Program with this current project.

Congestion within our team's section is due to bottlenecks within the project limits rather than outside the study area. Our team's total project addresses the following bottlenecks:

AM PEAK OUTER LOOP

- High volume merge from MD 41 southbound ramp.
- High volume merge from MD 542/Cromwell Bridge Road on significant grade.

AM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound
- High volume weave at MD 25 loop ramps with heavy volumes destined to IS-83 northbound in right lane.

PM PEAK OUTER LOOP

- End of auxiliary lane between MD 45 and MD 139 as traffic positions to exit at IS-83 northbound.
- End of weave between the IS-83 interchanges. Volume balance between IS-695 and IS-83 southbound creates a bottleneck for IS-695.

PM PEAK INNER LOOP

- End of auxiliary lane between IS-83 southbound and MD 45/MD 45 weave.
- High volume merge from MD 146 ramps.
- High volume weave between Cromwell Bridge Road and MD 542.
- Ramp from MD 542 northbound on significant grade.

Our project's PTSU and additional improvements will significantly improve mobility and address congestion by improving travel time and reliability through the study area.

TRAVEL TIME

Travel times are significantly reduced between IS-70 and MD 43 with reductions of 17.6% during the 2018 AM Peak and 39.5% during the 2018 PM Peak. **Travel time reduction increase by the year 2040 with reductions of up to 53.7% in the 2040 AM Peak and 75.2% in the 2040 PM Peak.** *Note: The Total Project VISSIM models are affected by model noise caused by extensive queuing and oversaturated conditions between IS-795 and IS-70. The model results show unrealistic differences in traffic operations when the mobility improvements are included since intuitively, improved merge and weave operations would occur.*

The VISSIM results showed the following travel time benefits between IS-70 and MD 43:

IS-70 to MD 43	2018 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	-1.3%	-6.6%	-13.3%	-1.1%
Outer Loop	-1.2%	-10.5%	-17.9%	-14.4%

IS-70 to MD 43	2018 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	-21.0%	-34.0%	-39.2%	-22.4%
Outer Loop	-7.2%	-14.3%	-17.8%	-5.3%

IS-70 to MD 43	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	-2.2%	-11.8%	-32.8%	-54.8%
Outer Loop	-1.2%	-4.1%	-18.7%	26.4%

IS-70 to MD 43	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	-42.9%	-61.0%	-66.6%	-74.3%
Outer Loop	-29.2%	8.7%	29.3%	84.4%

Cumulative travel times for notable time periods are shown below in Figures 2-9. Figure 2 shows that today, the southbound travel time significantly increase approaching the Towson stretch. Improving operations to near free flow conditions will allow travel times to increase linearly and will continue to increase linearly until motorists reach the I-695 SWOL construction, which will likely be finished prior to the opening year for this project. During the PM Peak, there is significant delay due to the mainline lane drop west of I-83. The PTSU provides additional capacity through this lane drop and improves speeds. Figures 4 and 5 show slowdowns approaching I-83 during the existing conditions. For the build conditions, the travel times are now linear and the benefits to the travel times are realized back to MD 140 for both time periods.

By the year 2040 conditions are expected to be considerably worse based on the forecasted volumes for this project. For the AM peak period, as shown in Figure 6, with improvements, the southbound travel times significantly decrease starting from the eastern limits of the project and the benefits are reduced near MD 146. During the PM peak, the benefits are realized again starting on the eastern end of the project and remain considerably lower compared to the no build conditions.

In the northbound direction, the AM peak hour benefits are realized far beyond the project limits and travel times improve all the way to I-70. During the PM peak hour, the travel time benefits begin at MD 140 and the slow downs between I-83 and MD 542 are significantly reduced.

Figure 1. 8 AM-9AM Existing Southbound Travel Times

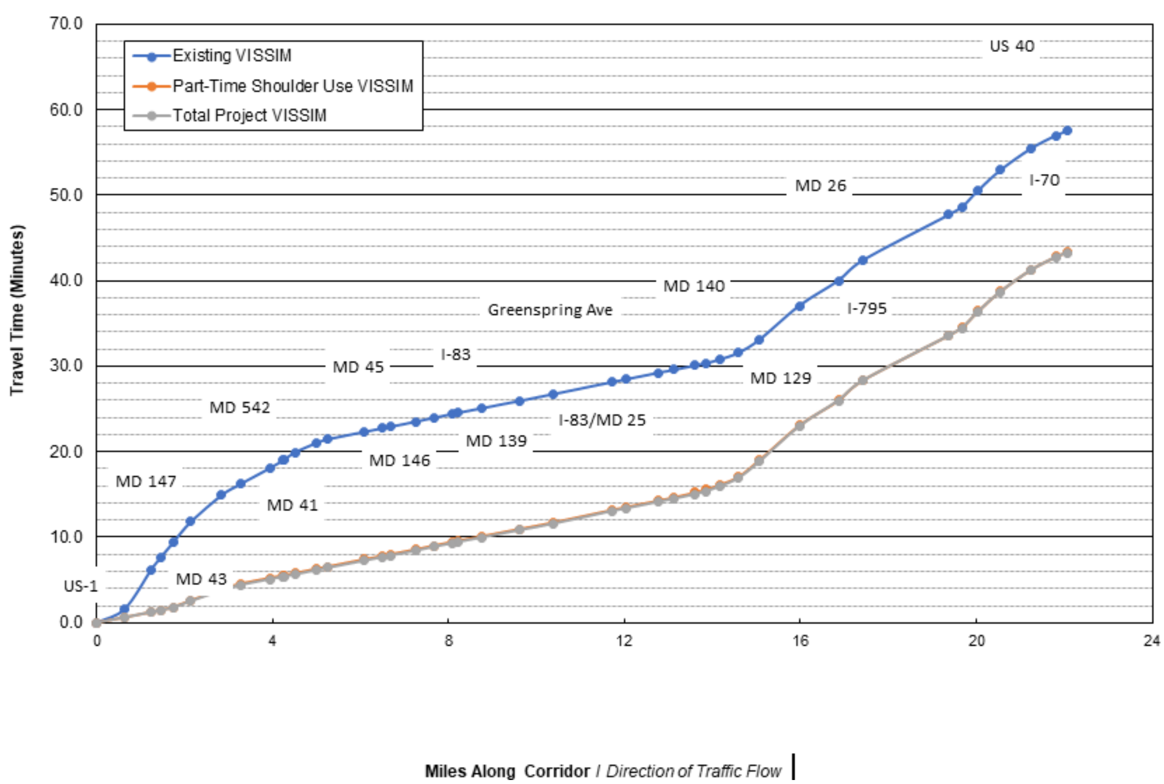


Figure 3. 5 PM-6PM Existing Southbound Travel Times

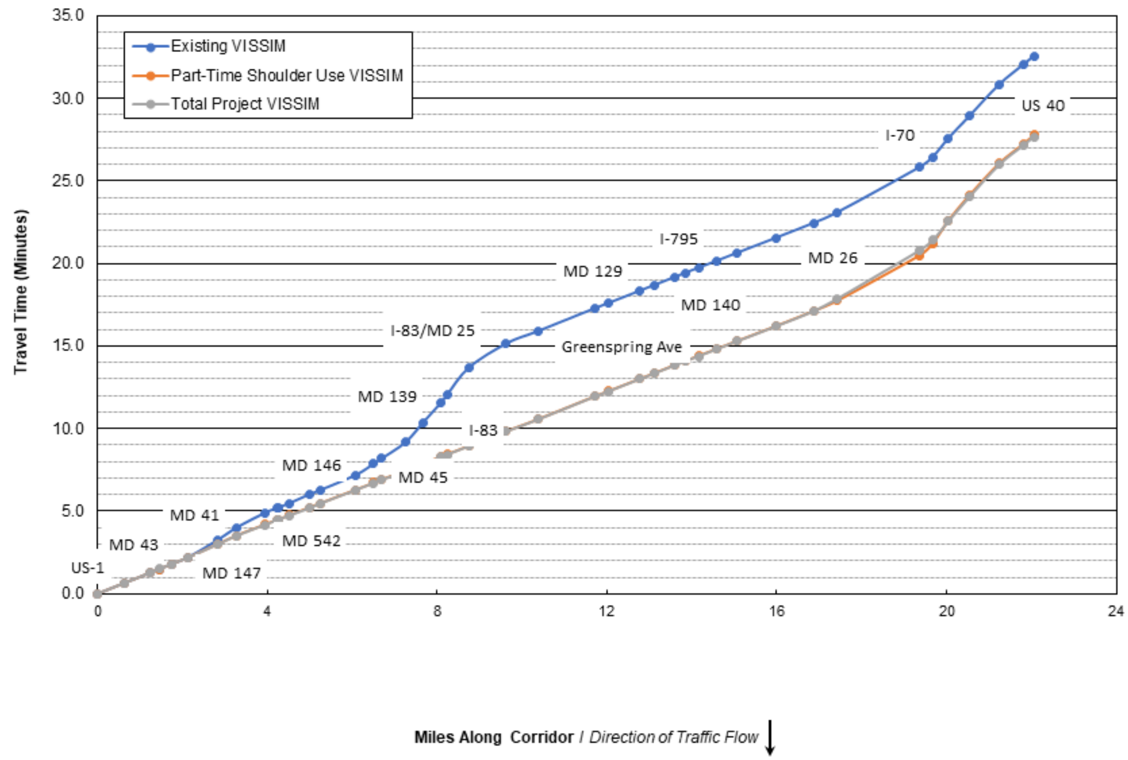


Figure 2. 8 AM-9AM Existing Northbound Travel Times

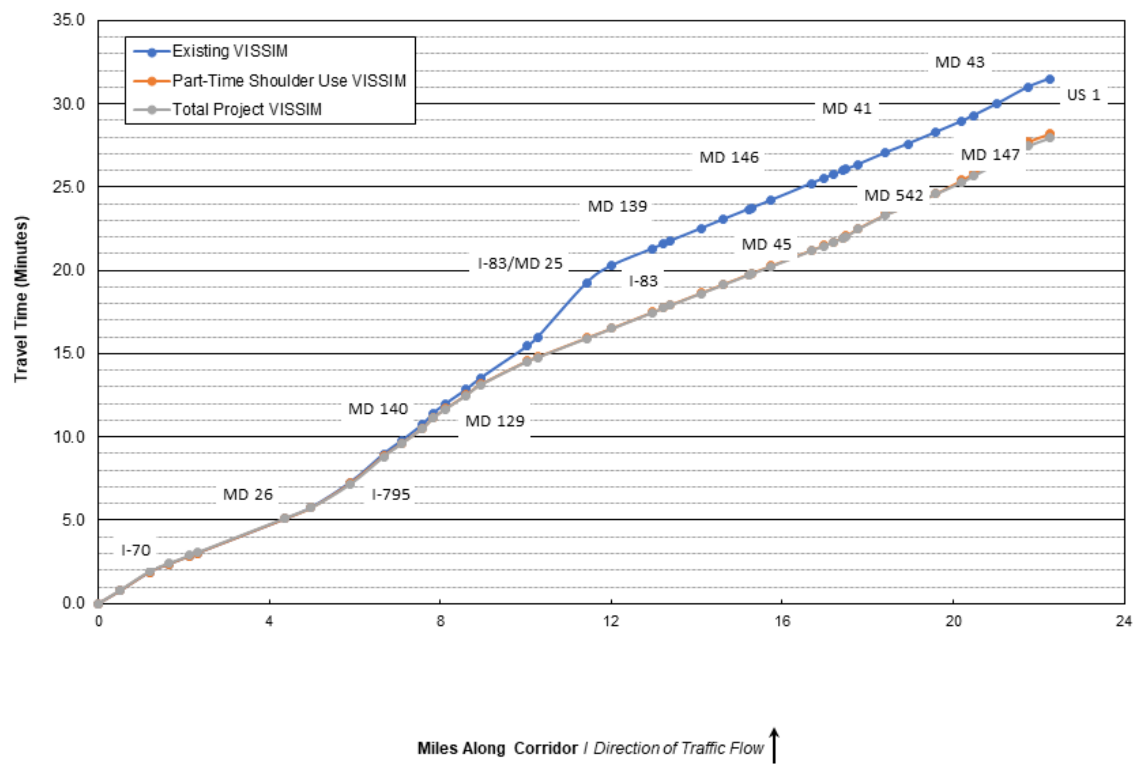


Figure 4. 4 PM-5PM Existing Northbound Travel Times

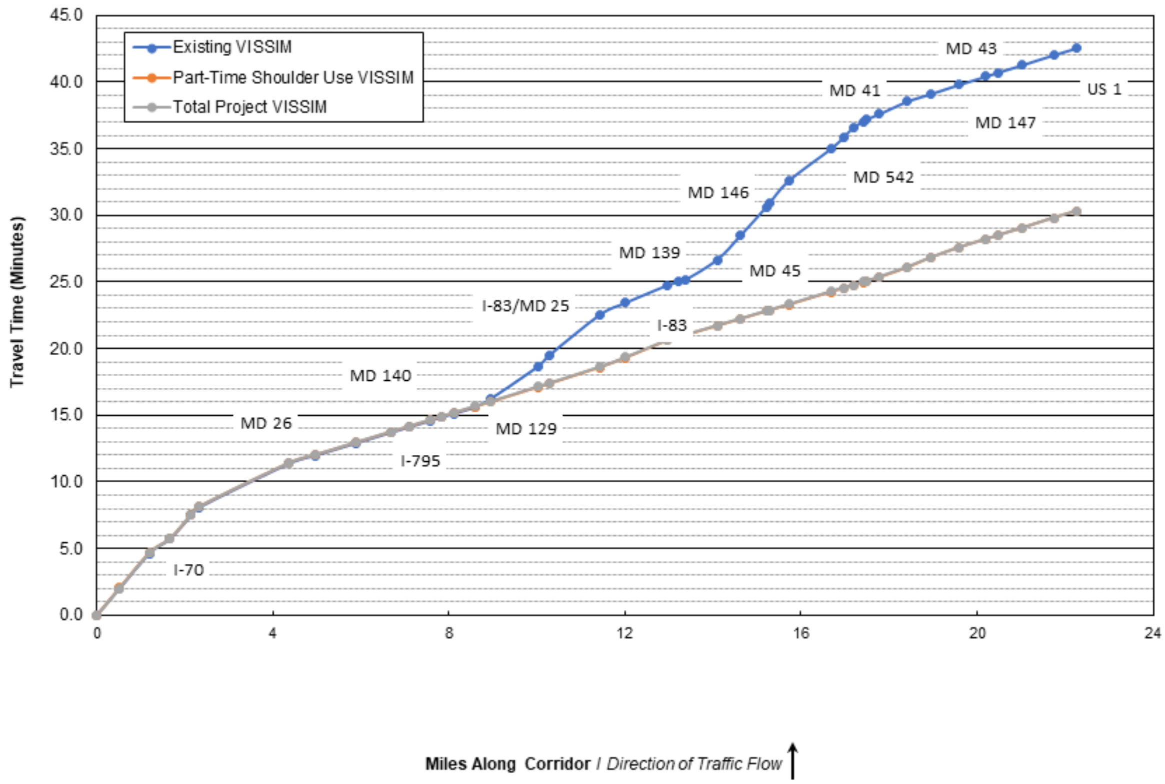


Figure 5. 8 AM-9AM Year 2040 Southbound Travel Times

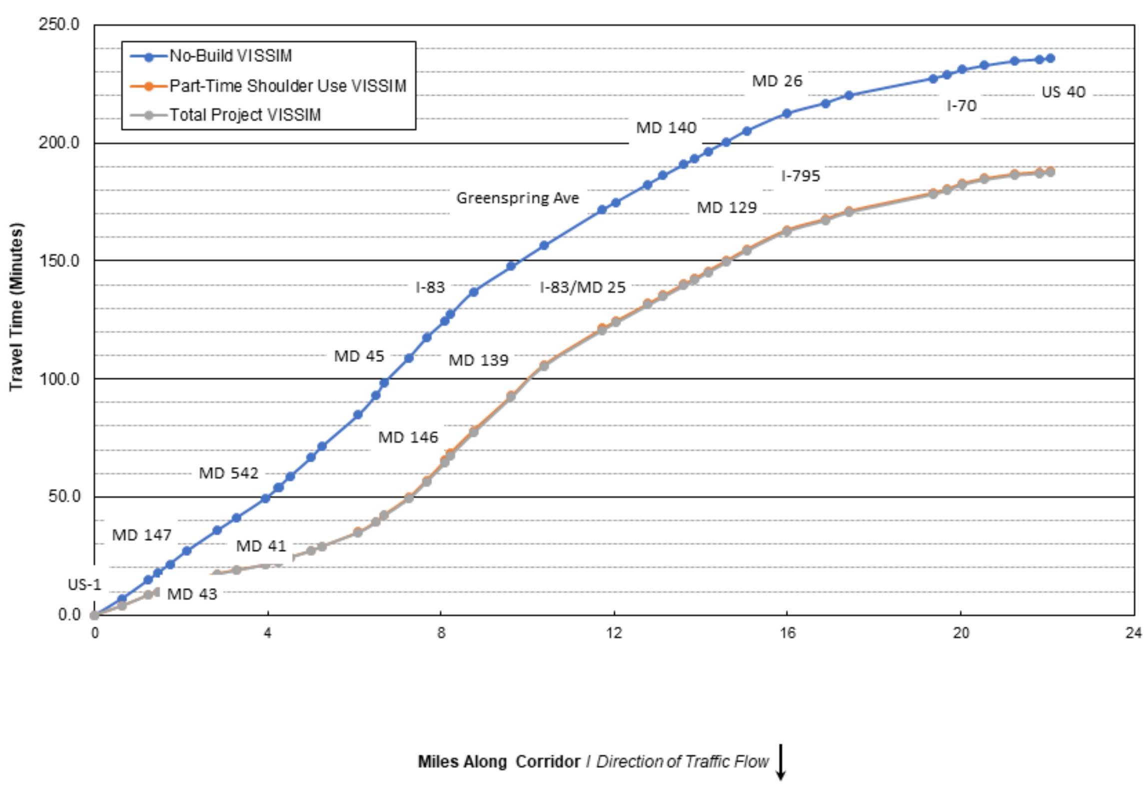


Figure 7. 3 PM-4PM Year 2040 Southbound Travel Times

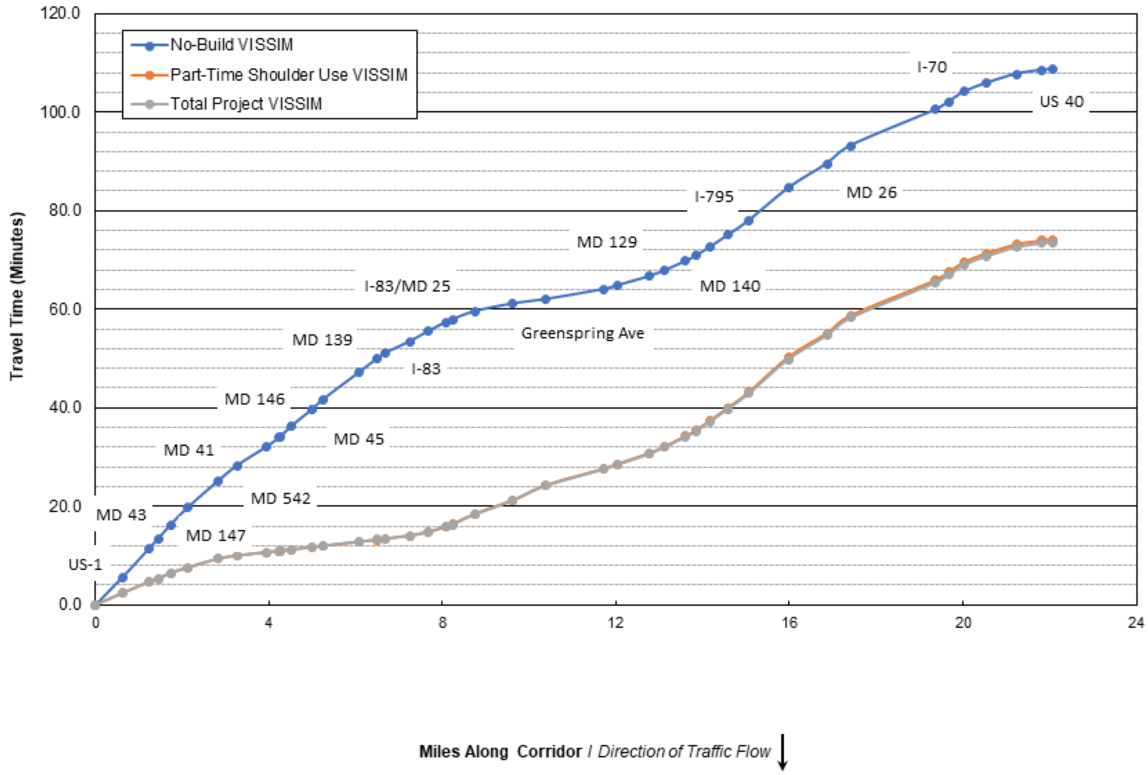


Figure 6. 8 AM-9AM Year 2040 Northbound Travel Times

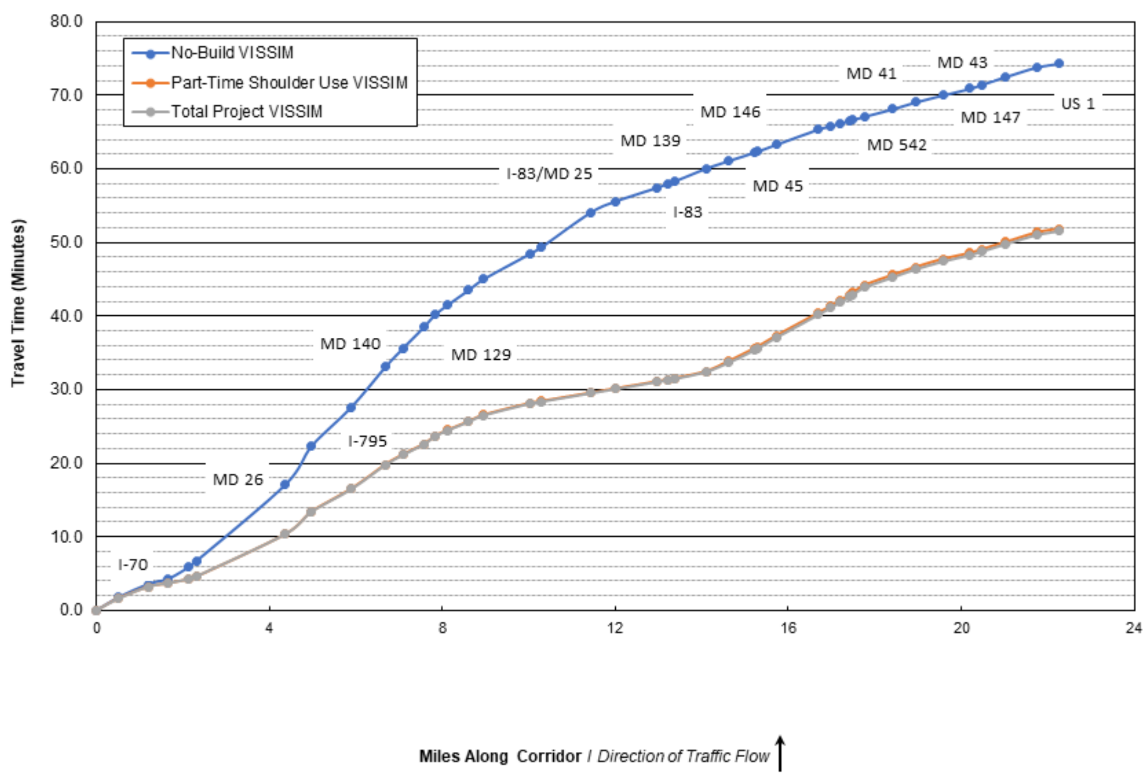
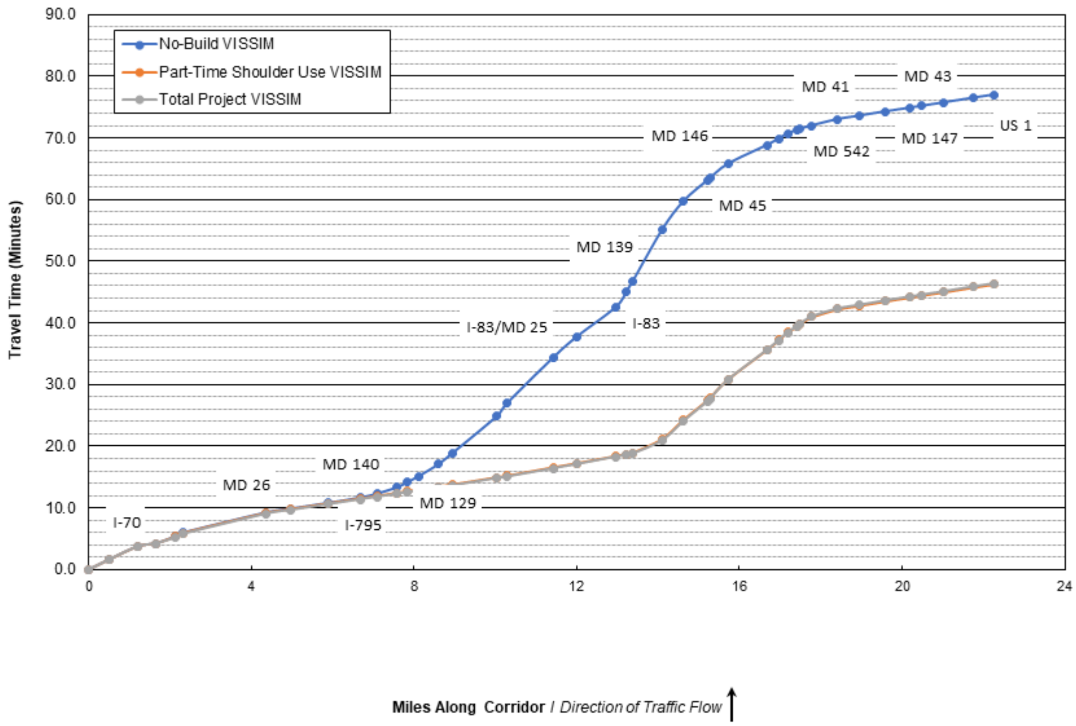


Figure 8. 3 PM-4PM Year 2040 Northbound Travel Times



Travel times along the IS-695 Outer Loop in 2040 are significantly impacted by downstream constraints at IS-70 and resultant queuing due to bottlenecks outside the study area. Since we are addressing bottlenecks along IS-695, and not sending the bottleneck downstream, our project PTSU provides the most significant travel time reductions between IS-83 to MD 43 with 30.7% increase in speeds during the AM peak hour along the Inner Loop and 67% along the Inner Loop during the PM Peak hour.

MD 43 to IS-83 S.	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Outer Loop	-3.6%	-19.0%	-31.0%	27.5%

MD 43 to IS-83 S.	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Outer Loop	-61.2%	-8.7%	2.2%	36.5%

Reliability will be significantly improved with our proposed improvements. The TTI values in the Mobility Report are based on INRIX data, which is based on real world conditions. The TTI values from the model are not in line with existing conditions, so to make a fair comparison, the VISSIM Existing and Build conditions are compared below to determine the change in reliability. Our solution improves the travel time index to acceptable ranges and every section would no longer rank as one the worst operating section in the State. The Outer Loop will experience the greatest improvement in reliability and would operate at near free flow speeds.

	Mobility Report	2018 No-Build	2018 PTSU
AM PEAK 7-8 AM			
IS-695 Outer Loop US 1 to Cromwell Bridge RD – 2nd	2.85	2.43	1.47
IS-695 Inner Loop MD 140 to IS-83 – 5th	2.33	1.85	1.43
PM PEAK 5-6 PM			
IS-695 Inner Loop MD 139 to Cromwell Bridge Road – 2nd	3.19	3.62	1.00

The PM Peak Inner Loop is ranked as the second worst reliability section in the state and the improved travel times will drastically improve the TTI and PTI values.

VEHICLE THROUGHPUT

By addressing key bottlenecks, vehicle throughputs are improved in 2018 and 2040 with up to a 12% increase in the 2040 AM Peak and 21% increase in the 2040 PM Peak. Our team's median PTSU lane addresses the following key bottlenecks along the IS-695 Inner and Outer Loops and provides the following throughput benefits at these locations:

AM PEAK OUTER LOOP

- High volume merge from MD 41 southbound ramp – up to an 8% increase 2040 (Throughputs increase to over 100% in later hours due to cleared downstream queues)
- High volume merge from MD 542/Cromwell Bridge Road on significant grade – up to an 8% increase 2040 (Throughputs increase to over 100% in later hours due to cleared downstream queues)

AM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound – up to a 18% increase 2040
- High volume weave at MD 25 loop ramps with heavy volumes destined to IS-83 northbound in right lane – up to a 18% increase 2040.

PM PEAK OUTER LOOP

- End of auxiliary lane between MD 45 and MD 139 as traffic positions to exit at IS-83 northbound – up to a 33% increase in 2040.

PM PEAK INNER LOOP

- Lane drop at ramp to IS-83 southbound – up to a 72% increase 2040.
- End of auxiliary lane between IS-83 southbound and MD 45/MD 45 weave – up to a 33% increase in 2040.
- High volume merge from MD 146 ramps – up to a 7% increase in 2040.
- High volume weave between Cromwell Bridge Road and MD 542 – up to a 7% increase in 2040.
- Ramp from MD 542 northbound on significant grade – up to a 6% increase in 2040.

The VISSIM results showed the following vehicle throughput benefits along the IS-695 Inner and Outer Loops:

	2018 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	0.1%	0.9%	-1.0%	0.0%
Outer Loop	0.1%	2.9%	2.1%	-6.0%

	2018 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	1.6%	1.4%	-0.2%	-3.5%
Outer Loop	1.0%	0.4%	-0.1%	-1.7%

	2040 AM % Change			
Direction	6-7	7-8	8-9	9-10
Inner Loop	0.2%	2.2%	11.8%	2.8%
Outer Loop	0.1%	2.6%	12.4%	-5.1%

	2040 PM % Change			
Direction	3-4	4-5	5-6	6-7
Inner Loop	10.4%	20.2%	12.8%	3.9%
Outer Loop	17.6%	12.3%	-5.8%	5.1%

DENSITY

Freeway density has a direct impact on safety because shorter headways can increase the chances of rear end collisions. Reduced gaps also make it harder for motorists to change lanes, leading to frustration and driver aggression. By addressing key bottlenecks, our teams' median PTSU greatly reduces vehicle density along the IS-695 Inner and Outer Loops in 2018.

During the 2018 AM Peak, IS-695 Inner Loop Level of Service (LOS) is improved to LOS E or better from Stevenson Road to MD 542/Cromwell Bridge for the duration of the AM Peak. IS-695 Outer Loop LOS is improved to LOS E or better from MD 41 to Stevenson Road.

During the 2018 PM Peak, IS-695 Inner Loop Level of Service (LOS) is improved to LOS E or better from MD 26 to MD 41 for the duration of the PM Peak, except for between 5 and 6 PM at the Greenspring Avenue diverge and between the IS-83 interchanges. IS-695 Outer Loop LOS is improved to LOS E or better from MD 41 to MD 26.

During the 2040 AM Peak, IS-695 Inner Loop Level of Service (LOS) is maintained at LOS E or better from Stevenson Road to IS-83 for the duration of the AM Peak. During the 2040 PM Peak, IS-695 Inner Loop Level of Service (LOS) is maintained at LOS E or better from MD 26 to IS-83 for the duration of the PM Peak.

QUEUES AND INTERSECTION OPERATIONS

Our teams' median PTSU lane greatly reduces the queuing along the ramps to IS-695 and spillback into ramp terminal intersections. The greatest reduction is seen along the ramp from MD 43 westbound to the IS-695 Outer Loop where the queues of up to a mile are eliminated in the 2018 AM Peak and the 2040 PM Peak.

VEHICLE NETWORK PERFORMANCE

By addressing key bottlenecks, the vehicle network performance is significantly improved. Total delay and average delay per vehicle are reduced up to 23% in the 2018 AM Peak and 29% in the 2018 PM Peak. By 2040, total delay and average delay per vehicle in reduced by 9% in the AM Peak and 27% in the PM Peak with large reductions of latent delay of 12% and 24% in the AM and PM Peak, respectively. The VISSIM results showed the following network delay benefits:

	2018 AM % Change			
Metric	6-7	7-8	8-9	9-10
Total Delay	-3.0%	-11.3%	-24.2%	-19.5%
Average Delay Per Vehicle	-3.0%	-11.3%	-23.4%	-18.3%
Total Travel Time	-0.5%	-3.4%	-10.8%	-7.3%
Latent Delay	-0.4%	1.5%	-0.3%	-0.2%

	2018 PM % Change			
Metric	3-4	4-5	5-6	6-7
Total Delay	-21.4%	-26.9%	-28.6%	-13.4%
Average Delay Per Vehicle	-21.1%	-26.2%	-27.5%	-12.0%
Total Travel Time	-6.0%	-11.4%	-12.9%	-6.4%
Latent Delay	-21.8%	14.3%	2.1%	-2.5%

	2040 AM % Change			
Metric	6-7	7-8	8-9	9-10
Total Delay	-1.9%	-5.5%	-9.2%	-4.6%
Average Delay Per Vehicle	-1.9%	-5.5%	-13.2%	-2.4%
Total Travel Time	-0.6%	-2.7%	-5.4%	-3.4%
Latent Delay	2.6%	0.0%	-8.2%	-13.3%

	2040 PM % Change			
Metric	3-4	4-5	5-6	6-7
Total Delay	-26.4%	-20.0%	-12.7%	-14.8%
Average Delay Per Vehicle	-27.5%	-21.7%	-17.7%	-18.4%
Total Travel Time	-15.2%	-14.0%	-8.3%	-9.8%
Latent Delay	-17.4%	-23.8%	-24.7%	-23.4%

INCIDENT DETECTION

While the PTSU lane will derive most of its benefits from additional vehicle capacity related to additional lane use, ITS and software components deployed to detect obstructions to traffic flow will support improved incident management. The Lane/JMT team proposes to extensively equip the PTSU corridor with vehicle detector stations, using detector density exceeding three stations per mile. Automated Incident Detection software provide as part of the ActiveITS package will constantly monitor the detection station data. The ActiveITS software, integrated with the CHART software, will provide a rapid and reliable source of incident identification. With the improved incident detection, traffic incidents will be able to be managed more promptly, restoring full roadway capacity, and limiting related delays. This improvement in incident detection will always be available, not only when the PTSU is in operation.

TRAVELER INFORMATION

In addition to incident management improvements, improved traveler information provided by related ITS devices will also aid in reduction of delays. The Lane/JMT team proposes to place three additional Dynamic Message Signs (DMS) in each direction prior to and within the PTSU corridor. The DMSs can be used to provide advanced warning of PTSU operation. The DMS can also be used to inform travelers of upcoming conditions such as incidents and travel time information. **Individual travelers, armed with this information, can make individual choices related to route and schedule to avoid delays.** These DMSs will be integrated into CHART software.

iii. PERFORMANCE LIFE

Our team's median PTSU lane and additional improvements addresses the most congested segments and bottlenecks, which results in the greatest reduction in travel time and increase in vehicle throughput. Our team identified constraints that impact the PTSU lane operations outside the study limits. Since congestion within our teams' section is due to bottlenecks along IS-695 within the project limits rather than outside the study area, our team can provide the longest performance life.

By addressing the bottlenecks on the IS-695 Inner Loop at IS-83 / MD 25, MD 45, and Cromwell Bridge Road / MD 542 our team can provide a performance life of at least 2040 for the IS-695 Inner Loop from MD 129 (Park Heights Avenue) to IS-83 during the full AM Peak period and from MD 26 to IS-83 during the full PM Peak period. During the 2040 AM Peak, IS-695 Inner Loop Level of Service (LOS) is maintained at LOS E or better from Stevenson Road to IS-83 for the duration of the AM Peak. During the 2040 PM Peak, IS-695 Inner Loop Level of Service (LOS) is maintained at LOS E or better from MD 26 to IS-83 for the duration of the PM Peak.

Addressing the bottleneck at IS-83 / MD 25 provides significant performance life outside the limits of the PTSU by maximizing the effectiveness of the existing IS-695 Inner Loop section. The IS-695 Inner Loop section between IS-83 and Cromwell Bridge Road will have a performance life of approximately 2030 in the AM and PM Peaks after which it is impacted by queuing from the US 1 and MD 41 interchanges.

By addressing the bottlenecks on the IS-695 Outer Loop at the MD 41 southbound ramp, MD 542 / Cromwell Bridge Road, MD 139, and at IS-83 southbound, our team can provide a performance life of at least 2040 for the IS-695 Outer Loop from MD 41 to MD 139 during the full PM Peak period and from 6-8 AM. After 8 AM, this section is impacted by the existing AM Peak bottleneck at IS-70 outside the study area which queues to IS-795 in 2018 and extends to MD 43 by 2040. The section between MD 41 and IS-83 JFX / MD 25 will have an approximate performance life of 2030 for the full AM Peak period.

The performance life of IS-695 between MD 41 and MD 43 can be improved by a future reconfiguration of the MD 41 interchange. By reconfiguring some or all the existing loop ramps into a diamond or diverging diamond interchange configuration, the existing auxiliary lanes between MD 41 and MD 147 / MD 43 can be fully utilized. The MD 41 interchange reconfiguration would also better facilitate the ability to extend the IS-695 Inner Loop median PTSU lane to the ramp to MD 43 in the future.

2.09.04 Safety

LANE | JMT
A Design-Build Team

2.09.04 SAFETY

BENEFITS OF THE LANE/JMT TEAM

- Solutions based on successful experience implementing and operating similar systems
- Provides 100% video surveillance coverage with nearly 100% redundancy
- Provides comprehensive coverage of vehicle detection using greater density of Vehicle Detection System (VDS) devices than required by the RFP
- Implements Part Time Shoulder Use (PTSU) addressing the areas of greatest recurring congestion and crash experience
- Operates with no additional MDOT SHA staff

The Lane/JMT team approach to ensuring safety in the corridor will build on CHART's extensive operational experience managing incidents in the region and our team's experience managing PTSU and other managed lane facilities. Our proposed technical and operational enhancements to support safety in the PTSU corridor are consistent with ongoing MDOT SHA Transportation Systems Management and Operations (TSMO) initiatives. The enhancements expand on the systems and technology available to operate IS-695 in the PTSU corridor both with technologies deployed along the roadway and with expansion of system processing capabilities. Additional installation of existing technologies such as Dynamic Message Signs (DMS), VDS devices, and Closed Circuit Television (CCTV) Cameras and the deployment of Lane Use Control Signals (LUCS) increase the ability for MDOT SHA to address the TSMO goals of improving the reliability of travel times and improving the customer experience by significantly reducing delays throughout the corridor.

Our team's first-hand experience managing similar projects will be critical to the successful implementation and operation of PTSU. Iteris, our team's ITS designer, is currently managing the IS-680 express lanes for the Metropolitan Transportation Commission (MTC) in the Bay Area outside San Francisco and provides hands-on, day-to-day management of VDOT's statewide Transportation Operations Center (TOC) program and staffs two regional TOCs. Additionally, our team's proposed ITS Specialist has acted as VDOT's agent over the past five years supporting ATMS design and upgrades. Iteris has also managed the Hampton Roads TOC which included operations of shoulder use lanes on IS-264.

STANDARD OPERATING PROCEDURES

Standard Operating Procedures (SOPs) are provided in a formal document to provide for both routine operations and situations where events override routine or normal operations. The procedures will be maintained in some form – typically in an authorized notebook or series of checklists, which will be readily available in the CHART operations center. The document consists of both step-by-step procedures and summary tables. The situations necessitating closing (or opening) the lanes and the procedures to do so are followed as per their SOP. This document is reviewed and updated periodically. Sample excerpts from other SOPs are shown in Figure 1.

Figure 1. Sample excerpts from other SOPs

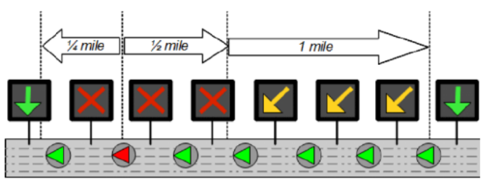
ID	Scenario	LOM Override Type*
1.1	CHP requests the Express Lane to be opened to all traffic	OPEN TO ALL
1.2	Roadway incident resulting in all General Purpose (GP) lanes blocked/closed for more than 5 min.	OPEN TO ALL
1.3	Roadway incident resulting in one or more GP lanes blocked/closed for more than 5 min. and the resulting traffic queue exceeds 50% of the length of the affected zone.	OPEN TO ALL
1.4	CHP requests the Express Lane to be closed	CLOSED
1.5	CHP has stopped/blocked all lanes of traffic as a result of a traffic break for more than 5 minutes	CLOSED
1.6	A traffic collision, traffic hazard, or CHP/EMS vehicle(s) are blocking the Express Lane or all lanes of traffic.	CLOSED
1.7	Roadway debris or other traffic hazard in the Express Lane are causing vehicles to swerve or make unsafe lane changes	CLOSED
1.8	Caltrans is performing roadwork in the Express Lane or an adjacent General-Purpose Lane	CLOSED - Roadwork
1.9	Caltrans is performing sweeping operations in the Express Lane	CLOSED - Sweeping
1.10	Caltrans or CHP closes the freeway for more than one hour for emergency roadway repairs or a catastrophic incident	CLOSED – Freeway**

Procedure

Planned and unplanned lane closures- Shoulder Lane

When the shoulder lane is blocked or closed, the incident Response Manager (IRM) dynamic plan rules for LCS devices will include:

- All LCS devices that are 1 and ½ miles upstream of the incident
- All LCS devices that are ¼ mile downstream of the incident (or extended to 2000 feet until at least one downstream LCS is found)



The intention of including downstream LCS devices in IRM plans is to provide an extra measure of safety for responders on the roadway.

SOPs for operating the PTSU will detail the actions to take and the needed coordination during specific situations. The initiation of a scheduled operation and subsequent routine operation will be performed per the applicable SOP. The scheduled termination of PTSU and subsequent routine operation will follow the standard closure procedure. SOPs will be developed to handle expected, routine operations as well as unusual or infrequent occurrences. It is expected that operational staff will need to reference the SOPs more and more infrequently after implementation, as the procedures will be performed daily.

i. DETECTING AND VERIFYING

The Lane/JMT team has designed procedures to provide proven, reliable detection of obstructions and incidents in the PTSU corridor prior to operation of the PTSU lanes, during operation of the PTSU lanes, and during the transition from PTSU. Our approach expands the number of devices already used throughout the corridor with the addition of LUCS to provide direction to drivers in the corridor.

Our approach limits the additional workload for MDOT SHA maintenance staff and CHART operational staff by leveraging the existing knowledge base and maintenance assets.

Our proposed solutions are based on experience in long-term operational settings. They have been proven over decades of use by shoulder-use implementations, managed lane implementations, and express lane implementations as well as general incident and traffic management operations.

Some roadway incidents will require operations staff to either close the PTSU during scheduled operating periods or open it when it is scheduled to be closed. Exceptional conditions causing a change to routine operations can cause a delayed opening, an expedited opening, or an expedited closing. Typical scenarios that will be developed related to PTSU operation are summarized in Table 1.

Table 1. Operating Scenarios.

ID	Scenario	Procedure
1	Opening on schedule	Standard Open
2	Closing on schedule	Standard Close
3	Obstruction detected during opening procedure	Delayed Open
4	Schedule shoulder-related roadwork/maintenance	Delayed Open
5	General purpose lanes partial blockage during off hours for over 5 mins and resulting queue exceeding ½ mile	Expedited Open
6	MSP requests opening during off hours	Expedited Open
7	Obstruction detected in operating shoulder lane	Expedited Close
8	MSP requests immediate closure	Expedited Close

All operation of PTSU will be controlled and monitored from a dedicated graphical user interface (GUI) to be integrated with CHART software and operated from existing CHART workstations. In keeping with project requirements, Automated Incident Detection (AID) system will be provided through enhancement of SWRI ActiveITS by the Lane/JMT team as part of its Active Traffic Management (ATM) capabilities. ActiveITS will be enhanced to provide AID via the system to support device control and status information regarding the devices used for PTSU. The interface with CHART will provide supervisory control and data acquisition capabilities for CHART operators with the new GUI allowing a corridor-wide approach to operation. While the CHART interface will provide detailed information related to corridor operation, the Lane/JMT team recommends maintaining a "human in the loop" to provide definitive verification of incidents detected by the system.

DETECTING OBSTRUCTIONS PRIOR TO OPENING

Incident verification will be performed using proven CHART ITS processes and procedures and will be enhanced and supplemented by the ITS systems deployed by our team. Prior to operation of the PTSU, the camera tour capability will be employed to cover the corridor for visual verification by operational staff that the roadway is free of obstruction. The tour will be displayed on video monitors available within the CHART Statewide Operations Center (SOC). In addition to the camera support, the CHART staff will have the support of Emergency Response Technicians (ERT) to perform a field verification of the condition of the roadway.

In concert with the camera coverage, the Lane/JMT team proposes to expand VDS device deployment along the corridor to improve availability of traffic detection. This VDS deployment not only forms the backbone of the Automated Incident Detection (AID) system but will also provide additional corridor information for action by CHART operators; to include providing valuable information to approaching drivers. The Lane/JMT team's approach will space the detectors at higher densities than the RFP requirements for one-third of a mile spacing, especially in crash prone areas. Traffic variables will be fed into the existing incident detection product offered from SwRI as part of ActiveITS. As with the cameras, the detector data will enhance CHART staff's ability to leverage its existing knowledge base and maintenance assets by deploying sensors compatible with the existing installed base. Any incident identified using the traffic sensors will be investigated as a potential obstruction or incident that may impact the ability or need to operate the PTSU. For example:

- The AID indicates potential incident in PTSU just prior to scheduled opening
- CHART operator verifies obstruction resulting in traffic queue using CCTV
- CHART operator implements SOP for lane blockage
- The LUCS display red "X" and opening is delayed as per SOP

DETECTING CRASHES AND OBSTRUCTIONS DURING SCHEDULED OPERATION

The Lane/JMT team proposes to enhance the CCTV deployment with additional cameras positioned to ensure 100% coverage of all lanes in our project limits, with nearly 100% duplicate coverage.

In preparation for PTSU operation, the cameras will traverse the corridor on a camera tour designed to provide visual verification that the condition of the roadway and shoulder is adequate for shoulder use. The tour capability of the cameras and switching system show the roadway images to the operational staff sequentially. Assessing the images from the CCTV cameras is a core competency of the CHART operational staff.

During operation of the PTSU, the camera tour capability will be employed to cover the corridor on a continuous basis. The tour will be displayed on video monitors available within the CHART center. In addition to the corridor-wide tour, other cameras will focus on known "hotspots" - locations that experience a higher incidence of crashes, made possible through the Lane/JMT team's redundant coverage approach. The specific monitors and workstations to use in displaying the camera tours will be determined by CHART management and operational staff. **The Lane/JMT team's design will support safe operations using current staffing levels**

through this camera automation and hotspot approach.

In concert with the camera coverage, the Lane/JMT team proposes to expand microwave vehicle detector deployment along the corridor to improve availability of traffic detection. This VDS deployment not only forms the backbone of the AID system but will also provide additional corridor information for action by CHART operators; to include providing valuable information to approaching drivers. The Lane/JMT team's approach will space the detectors at higher densities than the RFP requirements for one-third of a mile spacing, especially in crash prone areas, to help increase CHART operators' situational awareness through improved traffic condition data resolution. Traffic variables will be fed into the existing incident detection product offered from SwRI as part of ActiveITS. As with the cameras, the Lane/JMT team's design will utilize Wavetronix SmartSenorHD devices similar to those already in use and maintained by MDOT SHA maintenance and contractor crews thereby leveraging device compatibility and existing knowledge base of MDOT SHA maintenance managers.

In addition to the technological processes assessing measured traffic conditions, the Lane/JMT approach accesses information from roadway users made available in several formats. ERTs following emergency services radios serve as initial sources and provide those to regional dispatchers. Alerts from roadway users provide eyewitness information as callers to cellular 911 centers. Crowd-sourced incident reports offer reporting through smartphone applications such as Waze and Google Maps to provide incident awareness from a limited menu of options. With the Connected Citizen program from Waze, MDOT SHA has a pipeline of recent eyewitness observations. These data are not as reliable as measurements from agency sensors but provide an expedited alert to operational staff who can then provide the detail and verification needed for operational decisions.

In the event of a crash or obstruction, CHART staff will utilize the CHART interface to provide instructions to the ATM devices at the supervisory level. The SOP will dictate impact to the shoulder usage. Based on the location and extent of the incident, the operational staff will be able to adjust parameters of the PTSU usage, including continuing to use the entirety of the PTSU, closing all of the PTSU to use, adjusting the location of the beginning or ending of the segment of the corridor where PTSU is allowed, or terminating use of the PTSU on an interior segment of the corridor. In the event that an interior segment of the corridor is prohibited, the PTSU would operate as two noncontiguous PTSU portions.

ii. RESPONDING AND MANAGING NON-RECURRING CONGESTION

One of the benefits of PTSU implementation is the ability to quickly and accurately detect incidents based on the additional video and traffic surveillance. During operation of the PTSU, the camera tour capability will be employed to cover the corridor on a continuous basis. The tour will be displayed on video monitors available within the CHART center. The tour will focus on locations that have a high crash experience. As previously mentioned, the Lane/JMT team proposes to expand microwave vehicle detector deployment along the corridor to improve availability of traffic detection. As with the cameras, the detectors will leverage the existing knowledge base and maintenance assets by deploying sensors compatible with the existing installed base.

Responding to non-recurring congestion will follow the detection and verification steps outlined in the previous section. The system will be used to reduce congestion by providing information to approaching drivers well upstream of the incident to allow them avoid lanes that are closed, be prepared to decrease speed (thereby reducing the risk of secondary collisions) or providing drivers the opportunity to choose alternative routes to maximize MDOT SHA's system of systems (thereby reducing queuing and clearance times).

In the event of a crash or obstruction, the SOP will dictate the impact to PTSU. If authorized for use, operation of the PTSU outside of the scheduled windows provides for significant potential capacity increase and related reduction in delay due to non-recurrent congestion.

Additionally, the proposed GUI will be implemented in conjunction with both the CHART software and CHART operational teams to assure the usability of the GUI in the CHART operational and technical environment. The utilization of the enhanced display and control interface provides a tool for improved situational awareness and corridor management even when the shoulder lanes are not in use for traffic.

As with the other operations of PTSU, the management of non-recurring congestion will be controlled and monitored from a dedicated GUI using existing CHART workstations. Operations will use the CHART software enhanced to integrate with ActiveITS software.

These approaches build on the procedures that have evolved with incident management practices industry-wide and within CHART. **The Lane/JMT team's design provides benefits to roadway users as well as support for operational staff to execute the procedures with a high level of confidence and a low error rate.**

iii. PROPOSED PLAN OF **ACTION**

ACTIVATING OUTSIDE SCHEDULE WINDOW

Opening and closing of the PTSU facility will proceed in a documented and methodical manner in all situations, including both scheduled openings and unscheduled operations (full/partial openings, full/partial closures). The primary requirements will address safe operation of the roadway while prioritizing efficient movement of traffic in compliance with regulations and operating procedures.

To operate outside of the scheduled window, the Lane/JMT team proposes a process to use new and existing devices to determine operation to be safe, beneficial, and in compliance with operational procedures and regulations. The newly installed devices for this project include CCTV cameras and vehicle detectors. The devices allow for improved situational awareness of CHART operators:

- Provide universal coverage with CCTV cameras
- Provide frequent traffic detection using vehicle detection system sensors

Detection of incidents that can have impacts to reduced PTSU operations can come from several sources. The primary sources will be CHART resources including project-installed incident detection functions using vehicle detection system data and camera surveillance. Alerts from cellular 911, local media, and crowd-sourced incident reports will be considered potential incidents. The verification will be performed visually by CHART staff using traditional ATM tools.

In the event of a crash or obstruction, SOP will dictate impact to the PTSU usage. Based on experience with similar projects, the Lane/JMT team proposes incorporating criteria into SOP to enable operation of the PTSU use in the area of the incident or obstruction, while prioritizing safety and the ability of emergency responders to manage the incident.

Our approach builds on the procedures that have evolved with incident management practices and within CHART:

- CHART staff will be able to respond to incidents in our project limits more rapidly and with higher level of confidence (both in PTSU and general-purpose lanes)
- The SOP along with local knowledge such as location and length of queue will determine proper portions of shoulder use
- DMS will provide drivers with improved information in advance of incident area to support safe maneuvering and reduce likelihood of secondary incidents
- LUCS will provide direction in advance of and through the area of use

DETERMINING PART-TIME SHOULDER PORTION

The Lane/JMT team has designed an approach to provide reliable detection of obstructions and incidents in the PTSU corridor. The extent of shoulder to be used to avoid impact from an incident will leverage detailed information related to the incident as well as the extent of the related blockage and queueing. For an obstruction that is localized, the function of the shoulder use will be to provide relief in the area of the bottleneck caused by the incident. In general, the shoulder will be authorized for use from the beginning of the resulting queue between ½ and 1 mile upstream from the incident to ¼ mile downstream regardless of the number of lanes impacted. If no queueing or delay results from the incident, shoulder use will not be authorized.

For an obstruction of significant linear extent, the function of the shoulder use will be to move vehicle traffic away from the obstruction, while still providing congestion relief if a bottleneck results. In general, the shoulder will be authorized for use from between ½ and 1 mile upstream of the beginning of obstruction to ¼ mile downstream regardless of the number of lanes impacted.

In both of these scenarios, the use of the shoulder will be coordinated with ERTs on site and the incident commander(s).

OPENING AND CLOSING THE SHOULDER

While the PTSU are not in operation, the LUCS will be indicating that the shoulder is closed for use by displaying a red "X". The red "X" is expected to be illuminated for a vast majority of the time, with the shoulder closed for 14-17 hours on a typical weekday. This situation is depicted in Figure 2. Additionally, vehicle detection systems and CCTV cameras will be reporting information to the CHART system, which will operate at all times.

Figure 2

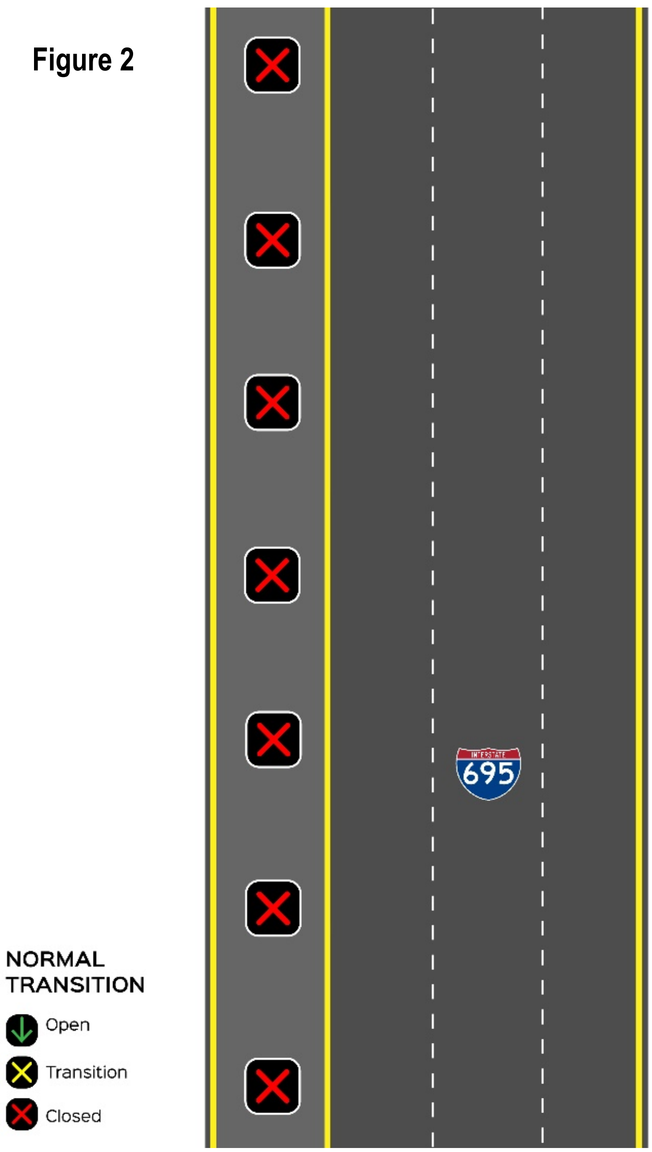
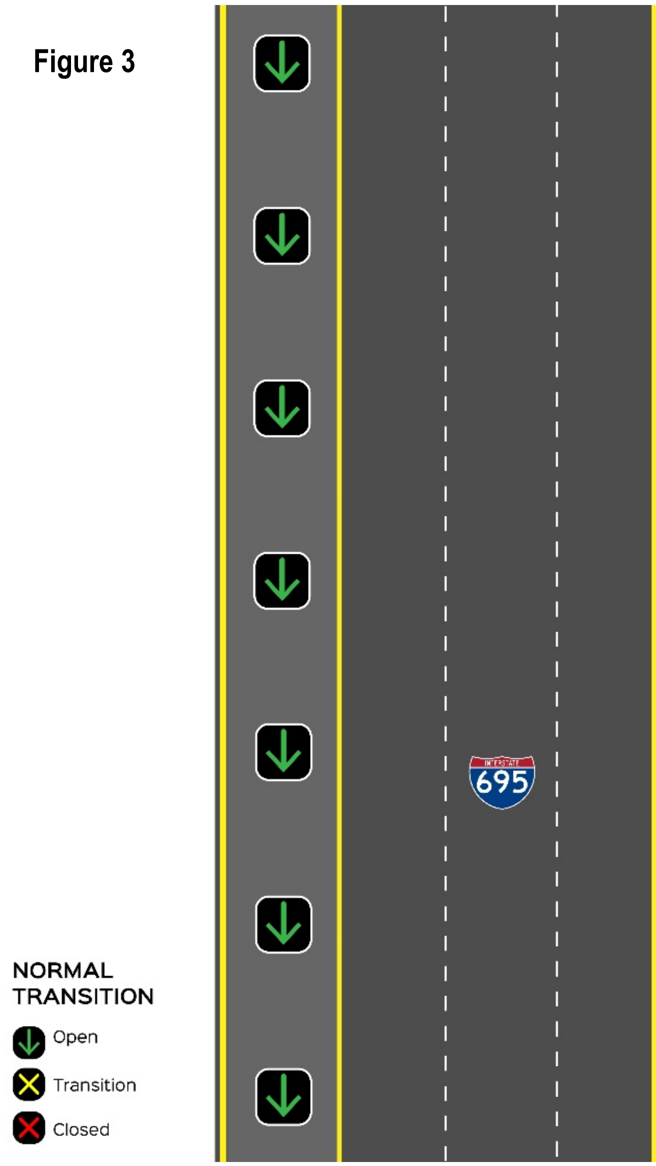


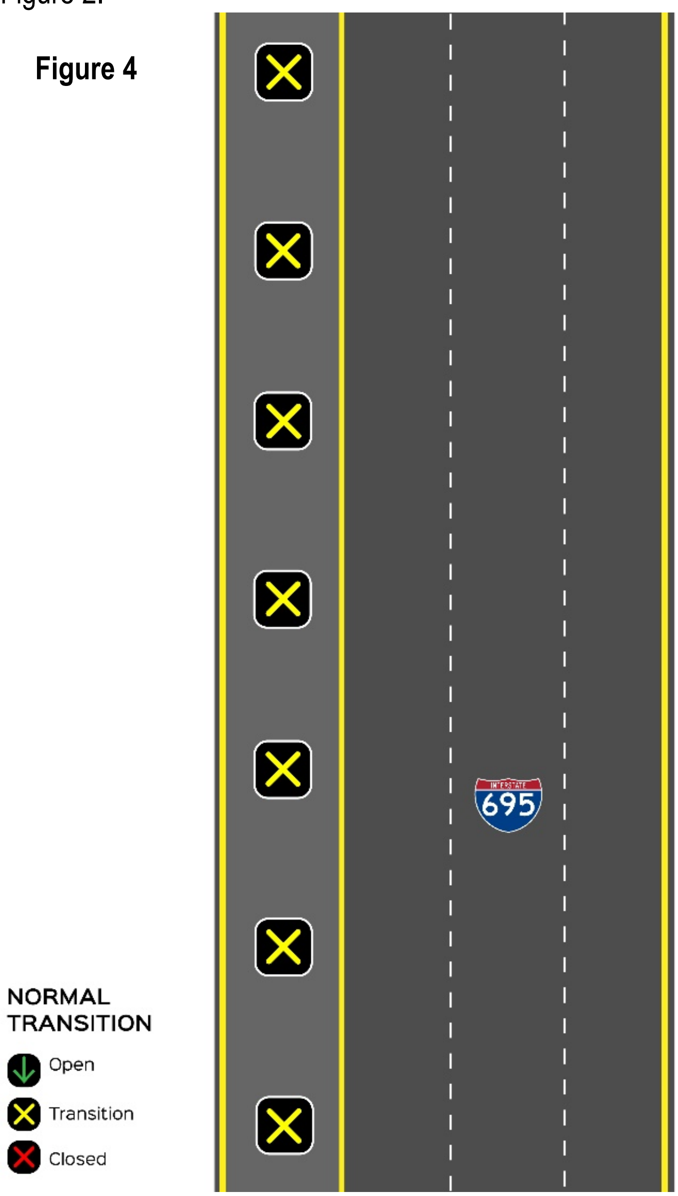
Figure 3



In preparation for transition to operation, CHART staff will assure that the shoulder lane is available and clear of obstruction by visual verification on CCTV cameras and coordination with field staff and Emergency Response Technicians. The transition to operation is immediate, with the LUCS transitioning from a red “X” to a green arrow. The green arrow indicates that the lane is available for use. This situation is depicted in Figure 3.

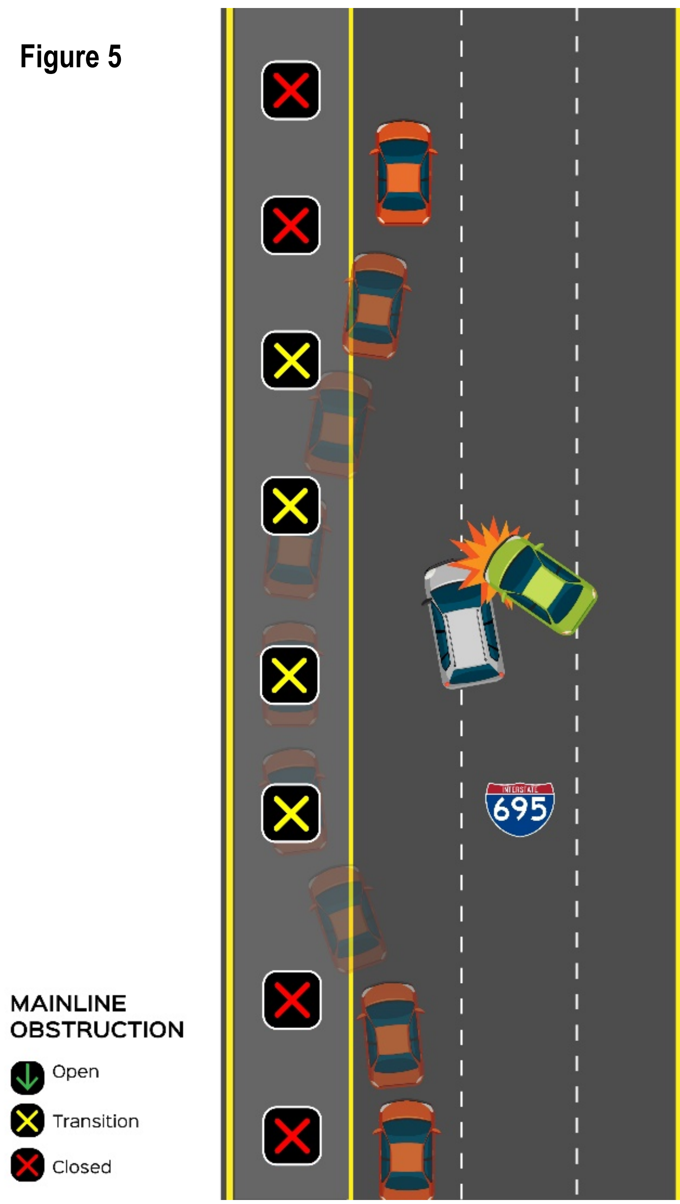
When the decision is made to terminate shoulder use, transition will be made to allow for users of the PTSU to leave the lane. The LUCS will first change to yellow “X” for a transitional period, as shown in Figure 4, and then changing to red “X” display as previously shown in Figure 2.

Figure 4



In the situation in which the shoulder may be used is during an incident in the through lanes occurs when the PTSU are not scheduled for operation, initiation of the shoulder use will be a single action to illuminate the involved LUCS with a yellow “X”. To reduce congestion and delay related to an incident, the shoulder may be available for use by traffic. If this is authorized for a specific incident, the LUCS in the area of the incident will be changed from red “X” to yellow “X”, indicating that the shoulder is available with caution in the area of the incident. All other LUCS will continue to indicate that the lane is closed by displaying a red “X”. This situation is depicted in Figure 5.

Figure 5



iv. REDUCING NON-RECURRING **CONGESTION**

Our PTSU design meets all the AASHTO requirements-sight distance, lane widths, spreads (drainage) and no lane width reductions or regulatory speed limit reductions are proposed, which will help maintain safe traffic operations during off peak periods. Based on the Highway Safety Manual, reducing the lane widths from 12 feet to 11 feet causes a 2% overall increase in crashes.

The hours of operation for the PTSU address crashes during congestion and balances the safety disbenefit of losing a shoulder for emergency use during these times. Through the use of static-dynamic lanes, the PTSU lane can be reverted back to a shoulder during emergency situations or maintenance or can be used as a travel lane during emergency evacuations.

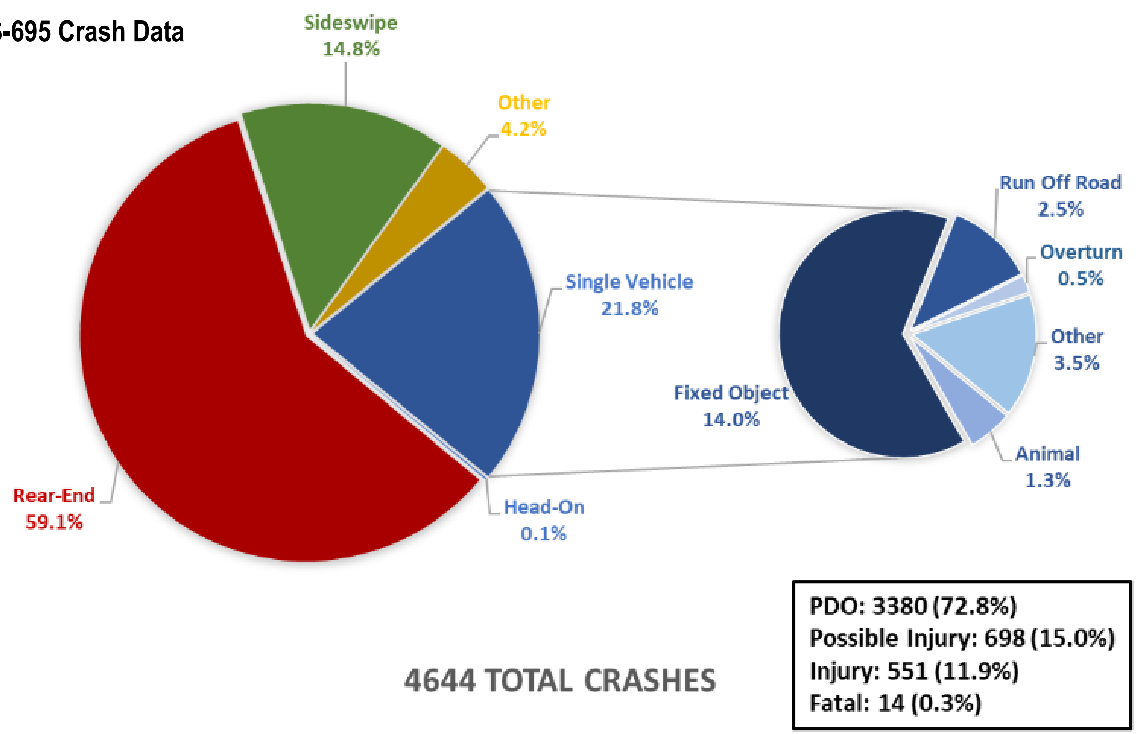
As part of the restriping and resurfacing needed to accommodate the median part-time shoulder lane, adjustments to the existing general purpose and auxiliary lanes are required, and in some locations, these adjustments provide increased weaving distances and acceleration lanes to improve safety along the IS-695 corridor. These improvements with associate Crash Modification Factors (CMF) include:

- Lengthened weaving distance on the IS-695 Inner Loop between the MD 45 loop ramps. – 0.91
- Extended deceleration lanes to the MD 146 loop ramps on the IS-695 Inner and Outer Loops. – 0.89/0.97
- Extended deceleration lane to Providence Road on the IS-695 Outer Loop. – 0.94
- Lengthened weaving distance on the IS-695 Inner Loop between Providence Road and Cromwell Bridge Road. – 0.96

CRASH ANALYSIS

Crash data was evaluated on IS-695 for the four-year period, from January 1, 2015 through December 31, 2018, between IS-70 (MP 6.80) and MD 43 (MP 26.25) to identify crash hotspots and crash causes. There were a total of 4,644 crashes with the major crash types being rear-end (59%), single vehicle (22%) and sideswipe (15%). The crash type distribution for IS-695 from IS-70 to MD 43 is depicted in Figure 6. Based on the crash type distribution, consideration should be given to increasing capacity and improving congestion, which leads to lower congestion-related crashes.

Figure 6. IS-695 Crash Data



When evaluating sections for PTSU, we aimed to identify those sections that had an increased number of crashes during the peak periods and would realize significant improvement in speeds and queue reductions. Analysis of top five I-695 crash rates between IS-70 and MD 43 showed that the highest crash rate segments are located between Stevenson Road and MD 43. This analysis includes top five total crash rates, rear end crash rates and peak period only crash rates. The top crash trends are noted in Table 2.

Table 2. Top Crash Trends

Crash Rate Type	I-70 to Stevenson Rd	Stevenson Rd to MD 43
Total Crash	4th - MD 140 5th - MD 26	1st - MD 41 2nd - IS-83 (JFX) 3rd - Charles St
Rear-End Crash	3rd - MD 26 5th - IS-70/MD 122	1st - MD 41 2nd - Charles St 4th - MD 146
Peak Period Crash	4th - MD 140	1st - Charles St 2nd - IS-83 (JFX) 3rd - MD 146 5th - MD 41

The 2040 No Build expected crash frequency was quantified for the Lane/JMT proposed segment using the FHWA Enhanced Interchange Safety Analysis Tool (ISATe). The quantitative methods used in ISATe are described in Part C of AASHTO Highway Safety Manual (HSM). As it is noted in FHWA Use of Freeway Shoulder for Travel, HSM freeway models are limited when conducting a predictive safety analysis of PTSU. Therefore, the 2040 Build condition crash frequency was calculated based on the 2040 No Build results, and by applying CMF described in HSM Part D to determine the expected number of crashes with PTSU.

A CMF is a multiplicative factor, available from the Crash Modification Factors Clearinghouse or the HSM, that estimates the potential change in expected crashes following a change in one specific condition. This change in a specific condition is reflected as a countermeasure, and can include design elements like narrowing lane widths, increasing lane numbers and corresponding volume variation, widening medians, lane change behavior, etc. CMFs for installing PTSU were developed based on a study that evaluated the safety benefits of IS-66 active traffic management with PTSU and the study results are available in the FHWA Crash Modification Factors Clearinghouse[1].

Table 3 summarizes the difference in expected crash frequency between the 2018 Existing and 2018 Build, along with 2040 No Build and 2040 Build conditions and the CMFs used for each crash severity.

Table 3. Expected Crash Frequency

	Severity Index [1]					
	Total	**K**	**A**	**B**	**C**	**O**
CMF	-	0.681	0.681	0.681	0.681	0.831
2018 Existing [2]	405.0	1.5	6.8	42.3	58.8	295.8
2018 Build	320.2	1.0	4.6	28.8	40.0	245.8
Number Reduction	-84.8	-0.5	-2.2	-13.5	-18.7	-50.0
Percent Reduction	-21%	-32%	-32%	-32%	-32%	-17%
2040 No Build	538.6	2.0	5.6	30.7	110.8	389.5
2040 Build	425.2	1.3	3.8	20.9	75.4	323.7
Number Reduction	-113.4	-0.6	-1.8	-9.8	-35.3	-65.8
Percent Reduction	-21%	-32%	-32%	-32%	-32%	-17%

[1] K = Fatal; A = Disabled; B = Injured; C = Possible Injury; O = Property Damage Only

[2] Expressed as average of four-year crash data (2015 to 2018)

Safety analysis results showed a reduction of 21% in the total number of crashes for the Lane/JMT proposed PTSU segment. It would reduce the 2018 Existing average crash rate in retained segments from 96.4 per 100 Million Vehicle Miles Traveled (100 MVM) to 76.2 per 100 MVM and would no longer be significantly higher compared to the statewide average (44.3 per 100 MVM). Since queues are reduced beyond proposed segment, the benefit is expected to extend at least one mile from the end of the PTSU. The Lane/JMT proposed segment accounts for 35% of all study area crashes and, therefore, the total number of crashes in the study area will be decreased by 7.5%.

[1] http://www.cmfclearinghouse.org/study_detail.cfm?stid=571

2.09.05 Operability / Maintainability / Adaptability

A Design-Build Team

2.09.05 OPERABILITY/MAINTAINABILITY/ADAPTABILITY

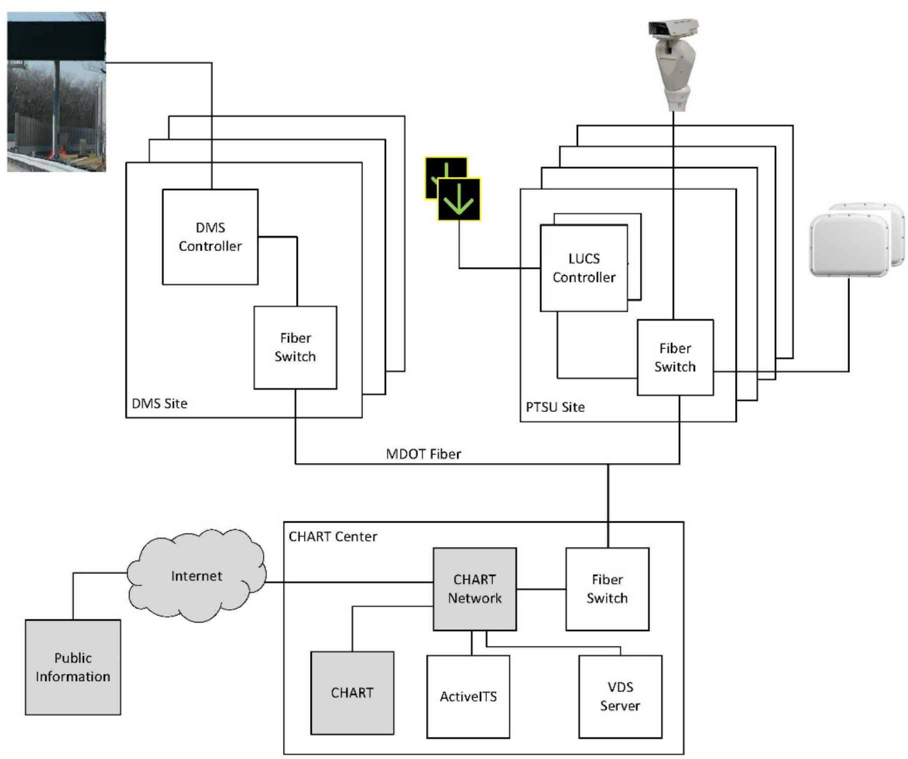
BENEFITS OF THE LANE/JMT TEAM

- Solutions based on successful experience implementing and operating similar systems
- Deploys device models that are already in use in CHART or compatible with CHART systems to simplify device maintenance
- Operates with no additional MDOT SHA staff
- Collocates access for Inner Loop and Outer Loop devices in a minimum of cabinets located on the Inner Loop shoulder

The Lane/JMT team will implement physical and electronic components enabling Part Time Shoulder Use (PTSU) along IS-695 in a robustly reliable and safe manner. Our team's PTSU limits will alleviate the most severe bottlenecks in the corridor. The physical implementation consists of providing the needed revisions to pavements, barriers, pavement markings, and drainage to provide for safe operation of a continuous median shoulder.

Implementation of electronic components offer operational control and surveillance of the limits from the existing CHART Statewide Operations Center (SOC), along with expanded driver information locations. The configuration of the proposed electronic components is shown at a high-level in Figure 1.

Figure 1



Our team's approach is to provide a system that mitigates impact to CHART maintenance and operations. We will accomplish this by building on CHART's extensive experience and optimizing the use of their existing infrastructure and procedures. In developing our solutions, we placed an importance on the compatibility with existing architecture and existing devices and the minimization of training needed for the equipment to reduce the cost of contracted device maintenance.

The proposed procedures to perform the physical maintenance in both winter and summer settings will build off existing MDOT SHA procedures. Infrastructure installed in the field, including communication equipment, ITS equipment, cabling, and roadway features will be selected and located with safety and convenience for the MDOT SHA staff and support contractors in mind.

Equipment selected for the project will be among the most reliable available in the industry. Equipment placed onto the roadway such as LUCS, CCTV, and Vehicle Detection System (VDS) will include features to simplify maintenance, including extensive diagnostic capability, modular equipment replacement design, and quick access features. Electronics to operate and power these devices will be housed in roadside cabinets that will be placed in easily accessible locations. This will ensure that the safety of the maintenance workforce is prioritized.

The ITS equipment and field equipment proposed by our team draws on the existing experience of MDOT SHA's staff and support contractors. Equipment will be selected to achieve compatibility with existing software, hardware, and institutional knowledge. Software and operational tools in the CHART SOC Traffic Operations Centers (TOC) will operate using the same workstations with a similar look and feel to the existing CHART capabilities and will be compatible as MDOT SHA migrates to an ONVIF architecture from its current NTCIP architecture. Field devices will use the same existing infrastructure manufacturers, to the extent possible, to allow for standardization in its device maintenance contracts. Using this approach, the Active Traffic Management (ATM), ITS, communication, and roadway maintenance will leverage the existing skill sets available to MDOT SHA which will minimize the need for additional costs spent on training.

i. MAINTENANCE

SAFE MAINTENANCE PERFORMANCE

As with all infrastructure investments, maintenance must include a reliable and ongoing program of preventive and reactive maintenance of not only the existing roadway infrastructure components but the supporting ITS hardware in the field and at CHART. With these two maintenance needs, there are also diverse groups of MDOT SHA offices involved in the operations and maintenance that include CHART, District 4, and Office of Maintenance. As this infrastructure uses existing roadway features and new technology it is likely that new approaches to maintenance activities and modifications to existing device maintenance contracts will be required. The advent of PTSU will impact the approach to device maintenance, snow removal, debris removal and potentially mowing operations in the PTSU section.

The ITS equipment and field equipment proposed by the Lane/JMT team draws on experience already existing within MDOT SHA and its support contractors. Equipment will be selected to achieve compatibility with existing software, hardware, and institutional knowledge. Where possible, existing products from existing vendors will be selected to simplify asset management, spare parts inventory, and maintenance contractor training requirements. The maintenance of the proposed PTSU is, on average, the same as maintenance of adjacent general-purpose lanes with some additional costs for maintenance that will include maintaining pavement markings, pavement surface, static signage, etc.

Maintenance vehicles required to stop on the PTSU and/or PTSU shoulder will need to consider closure of the PTSU and perform maintenance of features on the PTSU lane when it is closed to traffic. In general, PTSU lane maintenance should be maintained at the same level as general-purpose lanes. PTSU ITS devices are designed to minimize the number and duration of maintenance visits required, both for operational benefit and safety of maintenance staff.

Training of maintenance crews is essential when consideration is given to the PTSU lanes. The use and time of PTSU will need to be considered and existing maintenance activities will be impacted with additional maintenance activities being required as part of the implementation of the PTSU lanes into the system.

SNOW REMOVAL

The implementation of PTSU will require a new approach to snow removal operations along the stretch of IS-695 with PTSU. Although conventional anti-icing, deicing, and plowing methods can be employed during light snow or ice events, traditional snow removal operations during moderate or heavy snow events would push several lanes of snow to the median shoulder and several lanes of snow to the right shoulder. Leaving a windrow of snow on the median shoulder during moderate to heavy snow events would eliminate the ability to use the PTSU until such time as the snow in the median shoulder/PTSU melted. The majority of existing MDOT SHA and contractor snowplow equipment would not have the ability to move all the snow from the median shoulder and all travel lanes over to the right shoulder because of the weight and volume of snow. In order to safely perform snow removal operations and preserve the functionality of the PTSU, a different approach to snow removal operations would need to take place in the section of IS-695 with PTSU. The Lane/JMT team would recommend either the reintroduction of a previously used piece of equipment at MDOT SHA called the belt loader or a snow blower to remove the windrow on the median shoulder/PTSU. This belt loader would offer a more controlled disposal of the snow into the dump truck especially in the urban setting of IS-695. This operation using the belt loader or snow blower would be performed upon completion of the snow event to allow the use of the PTSU during the next peak period cycle. A benefit cost analysis should be performed to determine if MDOT SHA should purchase the equipment or the activity should be contracted out. A Protection Vehicle (PV) should be employed when performing this operation to ensure the safety of the maintenance personal and the traveling public.

During a snow emergency event, vehicles and trucks left on the shoulder are not afforded the 24-hour retrieval requirement based on current state law. During a declared snow emergency event, vehicles and equipment are subject to immediate towing on snow emergency routes (IS-695 is considered a snow emergency route). As is the case today, coordination between MDOT SHA and Maryland State Police (MSP) would be critical to ensure vehicles abandoned on the shoulders (especially the median/PTSU shoulder), are identified and their removal is coordinated between MDOT SHA, MSP (legal authority to tag and have vehicles removed) and the towing company that is removing the vehicle. The MSP maintains a list in coordination with the towing company to record where abandoned vehicles have been towed and by which towing company.

A joint outreach campaign should be developed to educate the public on these new approaches that would need to be employed to ensure the safe and effective operation of the PTSU and the maintenance forces performing these activities. If the activity is performed in-house, additional equipment training will be required for equipment that may be new for many of the existing maintenance forces.

DEBRIS REMOVAL

The introduction of the PTSU will require a different approach to the removal of roadway debris to ensure the safety of the maintenance forces and the traveling public. Current roadway debris removal operations related to the roadway element focus on the removal of "large litter" and sweeping in compliance with TMDL regulatory requirements.

The success and safe operations of the PTSU in the median shoulder will necessitate "sweeps" of the PTSU to remove any "large litter" that would impede traffic and pose a safety risk to PTSU users. This would need to take place twice daily during weekdays and once during Saturday operations of the PTSU. If existing MDOT SHA maintenance staffing levels do not support the ability to conduct this task, current maintenance or inmate labor contracts would need to be modified to alter the scope and the timing of this task. Given the uncertainty of the reliability of the inmate labor and the risk they may be unable to "report" on any given day, provisions should be developed for a backup plan if inmate labor crews are the primary resource to perform large litter sweeps of the PTSU lane during the sweeps. This would allow for debris removal of the PTSU to take place twice daily during weekdays and once during Saturday prior to the activation of the PTSU. Given the proximity of PTSU to the travel lanes, provisions should be included to ensure a PV is included as part of the maintenance of traffic (MOT) for this operation to ensure the safety of the maintenance personnel performing this task. The “large litter” removal efforts in preparation of the activation of the PTSU should be coordinated with the sweeping operations to comply with TMDL regulations. During the activation of the PTSU, CHART Emergency Response Technicians (ERT) personnel should be prepositioned in the area specifically to remove any large litter that impedes the operation of the PTSU that occurs after a preceding large litter removal operation. ERT vehicles that routinely patrol this section of IS-695 are properly equipped to safely manage the traffic while removing litter impediments that are present during actual PTSU operations.

ROUTINE MAINTENANCE/MOWING

Routine mowing activities will generally follow the existing standard operation procedures given that the area our team is proposing PTSU will not include areas with grass medians. Modifications in roadside mowing and trimming may require modifications to quantities in mowing/trimming contracts (if this section is contracted out for mowing) to account for the additional ITS device cabinets along the roadside which would result in additional trimming. **The additional cabinets will be placed roadside and will be behind traffic barrier or outside the clear zone to avoid creating a safety issue.**

Routine maintenance activities would continue to work within the hours of restrictions for this specific facility which may need to be altered depending on the hours of operation of the PTSU. Maintenance staff and contractors will need to be educated to any newly created pinch points and the potential need to modify temporary traffic control approaches throughout the area with PTSU to ensure the safety of the work zone and the travelling public. Maintenance forces will need to provide additional warnings and communication with CHART for DMS notifications of maintenance activities through pinch point as well as the entire PTSU section.

ITS EQUIPMENT

The ITS devices selected for this project represent some of the most durable and field-proven equipment in the industry. For a majority of the ITS devices, preventative maintenance is not required. Routine maintenance is not anticipated for structures used for ITS components.

In keeping with project requirements, a majority of the electronics are housed in the ITS cabinet, which is located at the roadside. Any need for maintenance of communication and control devices can be performed by the technician at the cabinet, which is located off of the roadway with the protections required by Maryland and Federal standards.

Most of the ITS devices are self-contained, only requiring a cable providing communication and power back to the Ethernet switch. Most equipment is connected to the Ethernet switch using Power over Ethernet standards, for both communication and power. The LUCS require more power than is available using PoE standards and are connected to a controller in the ITS cabinet by separate control and power leads.

The Lane/JMT team is proposing deployment of all ITS and communication equipment in locations easily accessible. Communication equipment will be universally located in roadside cabinets and consist of standard Cisco Ethernet products. Newly installed DMS will be located either on the outside shoulder or in the median. All other ITS devices used for the PTSU will be installed on poles in the median. All devices will be mounted at or below 30 feet above the roadway, making them readily available using easily available bucket trucks.

For the LUCS, product maintenance is performed to minimize the frequency and duration of lane and shoulder closures. **The limitation of roadway closures minimizes the traffic disruption as well as offering safety advantages to the technicians performing the maintenance.** LUCS housings offer face access for components placed over the roadway. LUCS maintenance is based on rapid replacement of modular components. This again is designed to minimize shoulder closures.

Other devices mounted in the median are designed for remote monitoring and firmware upgrade. **This approach limits median access to incidents where the entire device is to be replaced and also minimizes the frequency and duration of lane and shoulder closures.**

The Lane/JMT approach to providing communication to each site is based on a fiber connectivity with redundant paths to minimize single points of failure. Communication to each site will be accomplished using new or existing fiber infrastructure. The fiber-based communication system does not include any requirements for preventative maintenance. Restorative maintenance will be required when individual devices fail. The redundant character of the fiber network reduces the need for emergency restorative maintenance. Emergency maintenance will be required for traffic control devices, which in this configuration means the LUCS and the Layer 2 switch that it is connected to. In the event of a physical cut to the fiber bundle, significant sections of the devices along the corridor would become uncontrollable, necessitating the termination of operation for the affected portion of the corridor until the cable can be repaired.

The proposed communication devices represent durable and field-proven equipment. The Lane/JMT team proposes Industrial Ethernet products from Cisco Systems, including the IE 4000 and IE 5000 products. Use of these products allows for both reliable operation and extensive fault detection monitoring. When a fault is detected, the urgency of the restorative maintenance can be assessed. The network design reduces the likelihood of emergency service work. In the presence of faults that represent no degradation in performance, restorative work can be scheduled in keeping with standard procedures related to working hours and traffic impacts. While the need for emergency service has been minimized, the possibility still exists for a failure to cause traffic impact and require immediate repair regardless of cost or traffic impact.

All of the communication system elements are located within roadside cabinets. The Lane/JMT design places most of the ITS cabinets with related communication elements off of the outside shoulder of the Inner Loop. **This configuration allows for technicians to access to the communication elements with a minimum of traffic impact and exposure for the technician. Additionally, the cabinet placement simplifies the effort required if access to consecutive cabinets is required.**

In a few locations due to limited space availability near the Inner Loop, our team proposes to use ITS cabinets located off the outside shoulder of the Outer Loop. In these cases, the linear fiber infrastructure continues to be placed near the shoulder of the Inner Loop with a lateral fiber connection being made using a transverse conduit placement similar to those used to reach from the cabinet to ITS devices located in the median. The number of such placements has been kept to a minimum, as it entails complexity in device service and costs in installation.

LUCS maintenance will require shutting down the PTSU lane to service the overhead components as will CCTV maintenance. This work can still be performed with minimal impact to traffic. The devices are selected for rapid replacement of modular device components or replacement of complete devices It is anticipated that MDOT SHA would perform this maintenance work during off peak hours when the PTSU is not needed and traffic congestion is low.

Power distribution units and hardened computers were included in ITS cabinets to decrease maintenance response time. These components can be remotely controlled so ITS maintenance contractors can remotely access ITS equipment and will be able to troubleshoot problems without impacts to traffic operations and from within the office environment.

ITS COMMUNICATIONS

For the new infrastructure, communication to the roadside will be accomplished using a combination of trunk and distribution fibers. A diagram showing the structure of the fiber infrastructure is shown in Figure 2.

The Lane/JMT team proposes installation of a 96-strand bundle of trunk fiber reaching from the IS-695/IS-83 interchange to the end of our team's proposed project limits. Four of those fibers will be connected to a set of cabinets designated as node cabinets. Layer 3 switches housed in those cabinets will establish a collapsed ring with counter rotating connections. This configuration assures that the failure of a single port on this switch will not result in loss of capacity or communication to any field site.

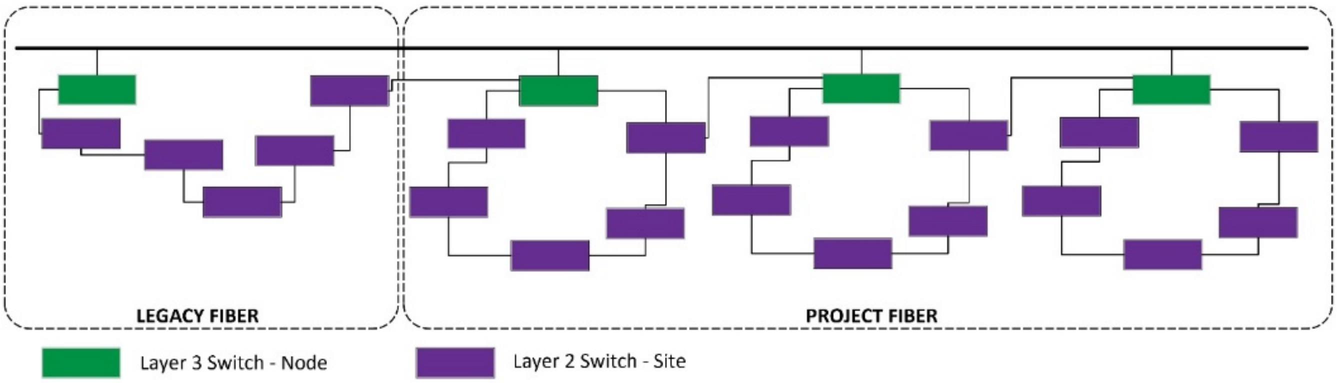


Figure 2. Fiber infrastructure

A parallel distribution bundle of 24 fibers will connect to each field location, with only six of those fibers planned for use on this project. Layer 2 switches will be installed in each ITS cabinet. These switches will be connected to fibers configured to provide a counter rotating collapsed ring for each cabinet connected to a specific node. Similar to the configuration for the trunk, this configuration assures that the failure of a single port on the switch will not result in the loss of capacity or communication to any field site. Similarly, the loss of function of any single switch will only result in the loss of communication to the field devices at that site. To further limit impact from potential Layer 3 switch failures, one Layer 2 switch in each distribution ring will connect to the Layer 3 switch an adjacent ring. This connection provides a pathway for communication from a ring connected to a failed Layer 3 switch to reach the Layer 3 switch of the adjacent ring.

For the existing fiber between the IS-695/IS-70 interchange and the IS-695/IS-83 interchange, the redundant design will be revised with the availability of only six fiber strands. In this configuration, the use of four strands will be retained for the trunk nodes. For the distribution cabinets, the Layer 2 switches will be connected in a linear manner, with each group of Layer 2 switches connected to adjacent Layer 3 switches. Power distribution units and hardened computers were included in ITS cabinets to decrease maintenance response time. **These components can be remotely controlled so ITS maintenance contractors can remotely access ITS equipment and will be able to troubleshoot problems without impacts to traffic operations and from within the office environment.**

CHART OPERATION – OPENING AND CLOSING PTSU FACILITY

Opening and closing of the PTSU facility will proceed in a documented and methodical manner in all situations, including both scheduled openings and unscheduled operations. The primary requirements will address safe operation of the roadway while prioritizing efficient movement of traffic in compliance with regulations and operating procedures.

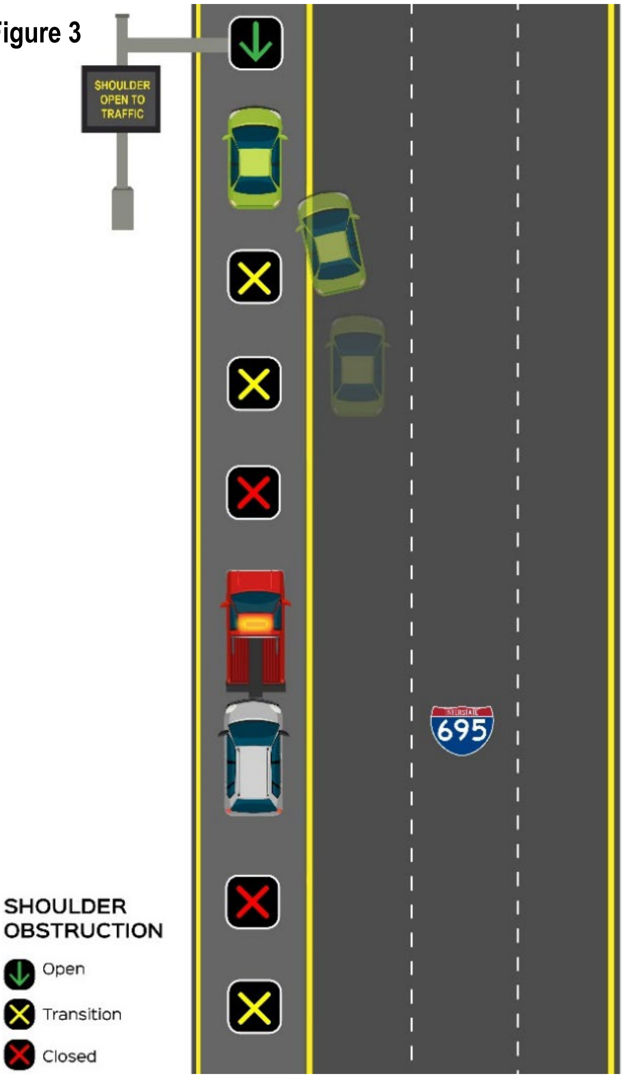
While the PTSU are not in operation, the LUCS will be indicating that the shoulder is closed for use by displaying a red “X”. The red “X” is expected to be illuminated for a vast majority of the time, with the shoulder closed for 14 - 17 hours on a typical weekday. Additionally, vehicle detection systems and CCTV cameras will be reporting information to the CHART system, which will operate at all times.

Prior to transition to operation, CHART staff will assure that the shoulder lane is available and clear of obstruction by visual verification on CCTV cameras and coordination with field staff and ERTs. The transition to operation is immediate, with the LUCS transition from a red “X” to a green arrow. The green arrow indicates that the lane is available for use.

When the decision is made to terminate shoulder use, transition will be made to allow for users of the PTSU to leave the lane. The LUCS will first change to yellow “X” for a transitional period and then change to red “X” display.

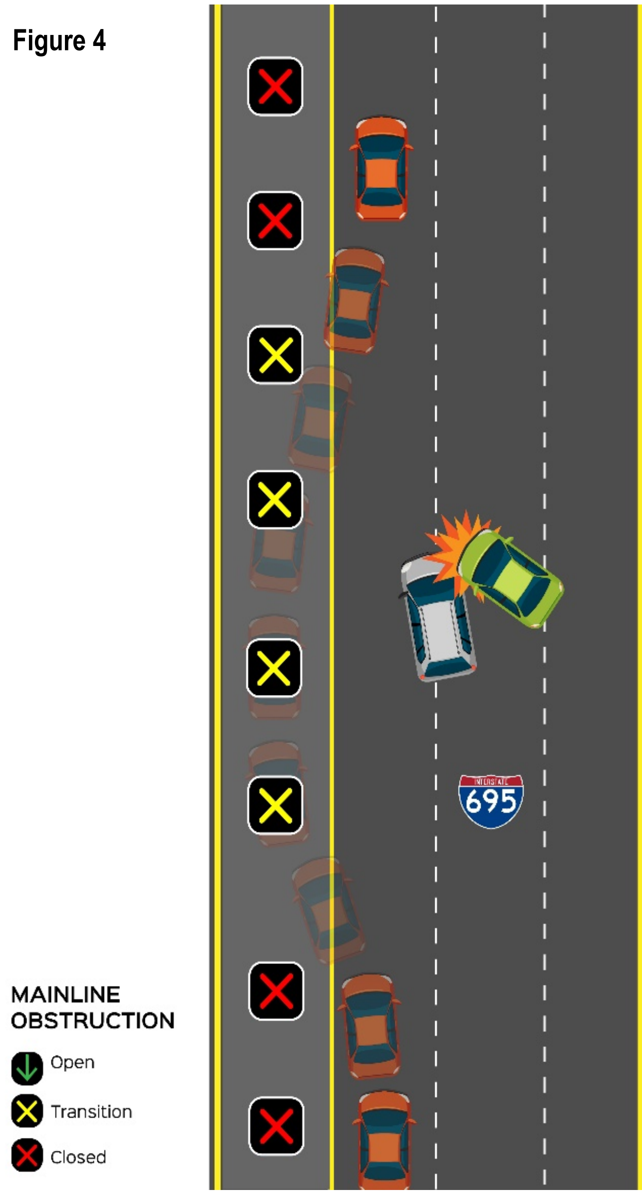
The transition from operation to partial or no operation will be adjusted in the event of an incident blocking the shoulder while the shoulder is in use. In this event, LUCS in the area affected by the incident will be immediately changed without a transitional period. The LUCS at the location of the incident will change to red "X" and the LUCS over the roadway approaching the incident will be changed to a yellow "X". If a portion of the roadway is unaffected by the incident, the shoulder use in that area can continue without interruption and the LUCS can continue to display a green arrow. An example incident is depicted in Figure 3.

Figure 3



An additional situation in which the shoulder may be used is during an incident in the through lanes when the PTSU are not scheduled for operation. To reduce congestion and delay related to an incident, the shoulder may be available for use by traffic. If this is authorized for a specific incident, the LUCS in the area of the incident will be changed from red "X" to yellow "X", indicating that the shoulder is available with caution in the area of the incident. All other LUCS will continue to indicate that the lane is closed by displaying a red "X". This situation is depicted in Figure 4.

Figure 4



ii. MAINTENANCE **REQUIREMENTS**

As referenced earlier, the advent of the PTSU will require a different approach to snow removal, debris removal, and mowing operations as well as create additional device maintenance responsibilities to ensure the safe and effective operation of the PTSU. Wherever possible, existing staff, tools, and techniques of maintenance will be used.

Conventional approaches to snow removal and existing staffing will be insufficient to meet the additional demands created by the introduction of the PTSU. To effectively use the PTSU, the snow accumulated during moderate to heavy events would need to actually be removed from the PTSU. This would be an effort that would be require a reevaluation by MDOT SHA of the resources currently committed to snow removal efforts along this section of IS-695. As previously mentioned, the Lane/JMT team recommends the addition of a belt loader or snow blower to allow for the removal of accumulated snow from the PTSU. The additional cost would result from the purchase of belt loader or snow blower (if a snow blower could not be permanently redeployed to serve this specific purpose). Once the operations moves to clean up activities, either existing MDOT SHA or contractor dump trucks could be deployed to the snow removal operations in the PTSU. If a decision is reached to purchase a belt loader or additional snow blower, additional training may be required by MDOT SHA forces and should be incorporated into Office of Maintenance's training program and Snow College curriculum.

Debris removal requirements associated with the PTSU will not entail the need for new equipment or additional training but will require a new approach to meet the twice daily weekday and once on Saturday needs to ensure the PTSU is free and clear of any large debris that could cause an impediment to the safe operation of the PTSU. Depending on the approach MDOT SHA takes to meet this requirement, additional cost will be incurred either through contractor labor and equipment cost, inmate labor cost (through agreements between MDOT SHA and Department of Corrections) or lost productivity cost if MDOT SHA personnel are dedicated to this activity which takes them away from other maintenance activities.

Although it is unlikely to result in the need for additional Office of Communications staff resources, cost will be incurred to develop a campaign to educate the public about the functionality of PTSU and the resulting changes to maintenance and CHART operations resulting from the implementation of the PTSU.

ITS devices were selected due to their field-proven durability. **This approach limits the number of additional staff members required to provide maintenance activities for ITS devices.** The decision on the need for additional maintenance staff/contract support staff will center around the number of staff members required to maintain the number of new devices, with no additional unique skills anticipated.

Our team proposes using equipment similar to existing communication and ITS devices to those already in use on freeways in Maryland. This includes using hardware from companies include Wavetronix, LEDStar, Cisco Systems, and Pelco. **This approach leverages the knowledge base already available within MDOT SHA staff.**

LUCS maintenance is based on rapid replacement of modular components. Since the LUCS are built on the technological foundation of Dynamic Message Signs (DMS), which have been deployed for decades, maintenance knowledge is available within the industry. Training for maintenance staff is included as part of the hardware procurement. An inventory of spare parts will be included in the initial hardware procurement.

The Lane/JMT team is proposing deployment of all ITS and Communication equipment in locations easily accessible. Communication equipment will be universally located in roadside cabinets and consist of standard Cisco Ethernet products. Newly installed DMS will be located either on the outside shoulder or in the median. All other ITS devices used for the PTSU will be installed on poles in the median. All devices will be mounted at or below 30 feet above the roadway, making them readily available using easily available MDOT SHA and contractor bucket trucks.

ITS maintenance can be performed using the inventory of spare parts and hand tools routinely available to all MDOT SHA or contractor maintenance staff. **No specialized equipment is anticipated to perform ITS maintenance.** In the event of damage to structures or cabinets, construction equipment similar to that used in the original installation will be required.

Communication equipment proposed is compatible with existing MDOT SHA equipment. All needed tools should already exist within MDOT SHA staff and support contractor inventories.

MAINTENANCE PERSONNEL/ADDITIONAL PERSONNEL NEEDED

For ITS and communication devices, no additional maintenance skills will be required beyond those required to support existing ITS infrastructure. With the increase in deployed electronics inventory, a corresponding increase in contracted staff hours is expected. Snow removal operations to clear the PTSU lane may require additional resources to operate the belt loader or snow blower to remove the windrow of snow on the PTSU lane during moderate to heavy snow events but we would recommend the use of contract resources to supplement MDOT SHA resources as is done for conventional snow removal operations. Additional resources will be needed for debris removal given the level of service required twice weekday plus once on Saturday debris removal for the PTSU lane. This would entail reallocating MDOT SHA staff from other activities to dedicate to debris removal functions for the PTSU lane or modifications to existing district sweeping, large litter contracts or agreements with Department of Corrections for inmate labor to meet the enhanced debris removal requirements. Mowing and trimming requirements would not require additional staffing but would entail some additional trimming around newly installed roadside cabinets to house ITS systems and would require modifications to quantities for trimming in mowing/trimming contracts in this section of the Beltway with PTSU.

MAINTENANCE EQUIPMENT

For ITS and communication devices, no additional maintenance tools will be required beyond those required to support existing ITS infrastructure. With the increase in deployed electronics inventory, a corresponding increase in contracted spare parts inventory and asset management is expected. Snow removal operations would require the addition of either a belt loader or snow blower to facilitate snow removal of the windrow in the median PTSU lane in advance of the activation of the PTSU lane. Existing MDOT SHA and contractor dump trucks would be employed in conjunction with the belt loader or snow blower to facilitate the hauling away of the accumulated snow on the PTSU lane. No new or additional equipment would be required to facilitate the increased cycle frequency and approach to debris removal on the PTSU lane. Mowing /trimming operations would not necessitate the need for any new equipment as part of our proposal.

TRAINING MAINTENANCE FORCES

For ITS and communication devices, training of maintenance forces will be limited to details of the specific devices and spare parts. No additional skill sets are anticipated.

Snow removal in the PTSU lane would require additional training in the use of or oversight of (if contracted out) the belt loader and perhaps the snow blower as many MDOT SHA maintenance staff may have no or little exposure and experience working with the belt loader and/or snow blower. Training should not only focus on the use and operation to remove snow from the PTSU lane but also the appropriate temporary MOT set up to ensure the safety of the work zone and the travelling public. Snow removal operations of the PTSU lane should be incorporated into the Office of Maintenance Snow College curriculum to ensure appropriate District staff are trained and aware of this type operation.

Modifications to the approach to debris removal and mowing/trimming operations would not require any additional training as the same procedures and temporarily traffic control set ups would be applicable with the advent of the PTSU lane as would be for the existing roadway/roadside network.

iii. FUTURE ADVANCEMENTS

The assets fielded to support PTSU operations provide significant infrastructure for future applications. The primary source for future accommodation of communication need along the corridor is the addition of significant spare fiber. The Lane/JMT team anticipates installation of a 96-strand bundle of trunk fiber reaching from the IS-695/IS-83 interchange to the end of our team's proposed project limits, with only four of those fibers planned for use on this project. A parallel distribution bundle of 24 fibers will connect to each field location, with only six of those fibers planned for use on this project. **The additional fiber infrastructure provides capacity to future applications with superior performance characteristics and security.** The fiber could be used in future applications such as:

- Connected Vehicles
- Automated Vehicles
- Express Lanes

Field infrastructure of cabinets and poles provide resources for additional field devices. The poles provide for mounting of Connected Vehicle Roadside Units (RSUs) in either a DSRC or C-V2X (5G) deployment scenario, although use in a C-V2X deployment scenario would be more limited. The cabinets provide protection for future equipment and communication devices, including the needed assets to support enhanced surveillance equipment such as lidar and edge computing resources.

The presence of ITS capability to support PTSU can be leveraged to support work zone management. Immediately following deployment, additional DMSs will become available to improve traveler awareness. Future development of work zone protocols can leverage additional communication resources either through use of fiber communication resources or temporarily deployed connected vehicle roadside units.

In addition to the incorporation of future technology, our team's design enables simplified extension of the PTSU corridor as future needs develop and funding becomes available. The devices proposed allow for deployment of sites incrementally, with a minimum integration cost. The communication design allows for installation of additional nodes, allowing for addition of devices without interference with existing sites or devices. The software and servers at the CHART center will be designed and sized to accommodate additional devices with only configuration changes.