MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

INTERSTATE 695

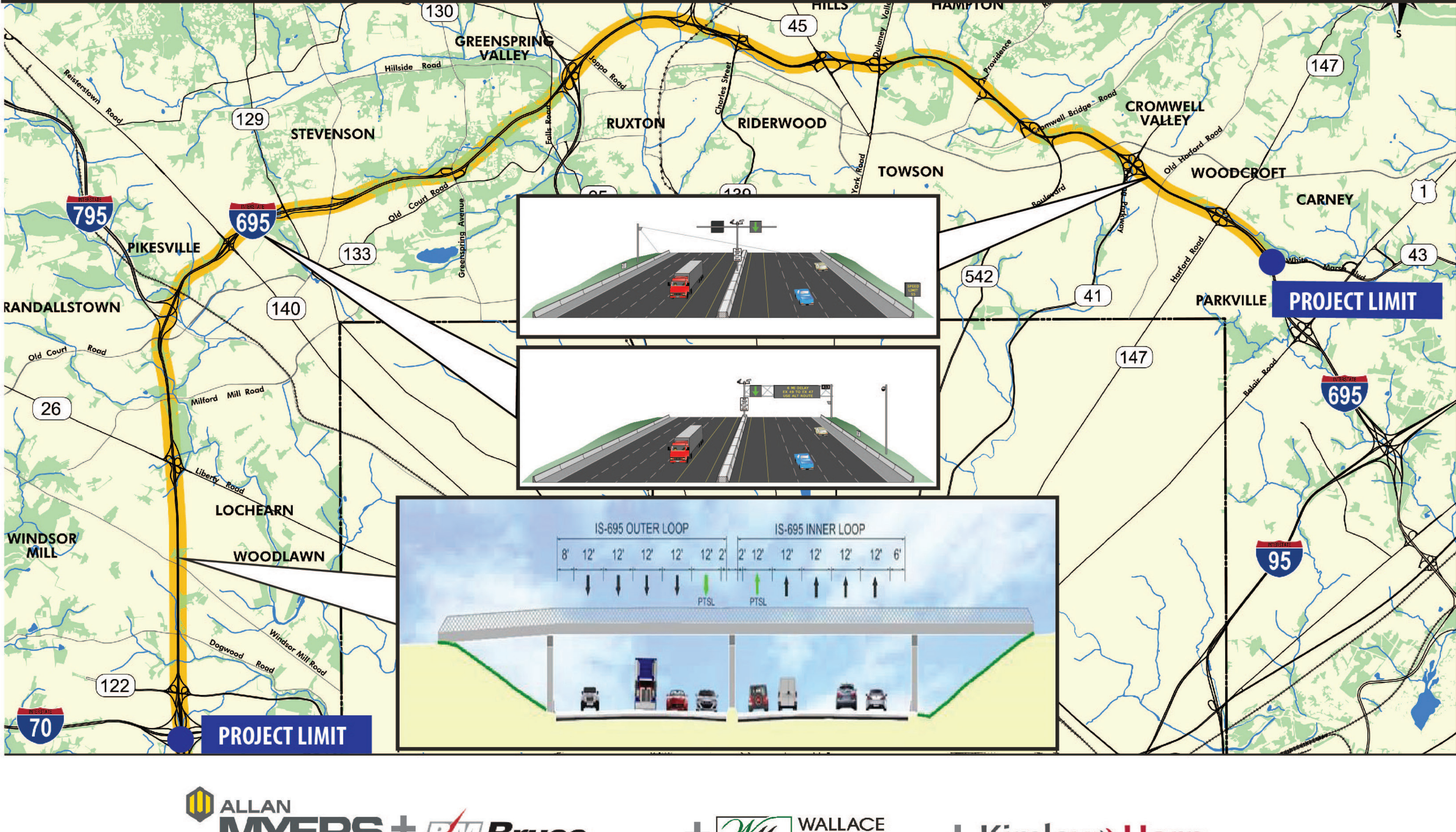
PHASE TWO -
TECHNICAL PROPOSAL
DESIGN-BUILD

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

Baltimore County, MD

Contract No. BA0065172

F.A.P. No. AC-NHPP-695-6(385)N



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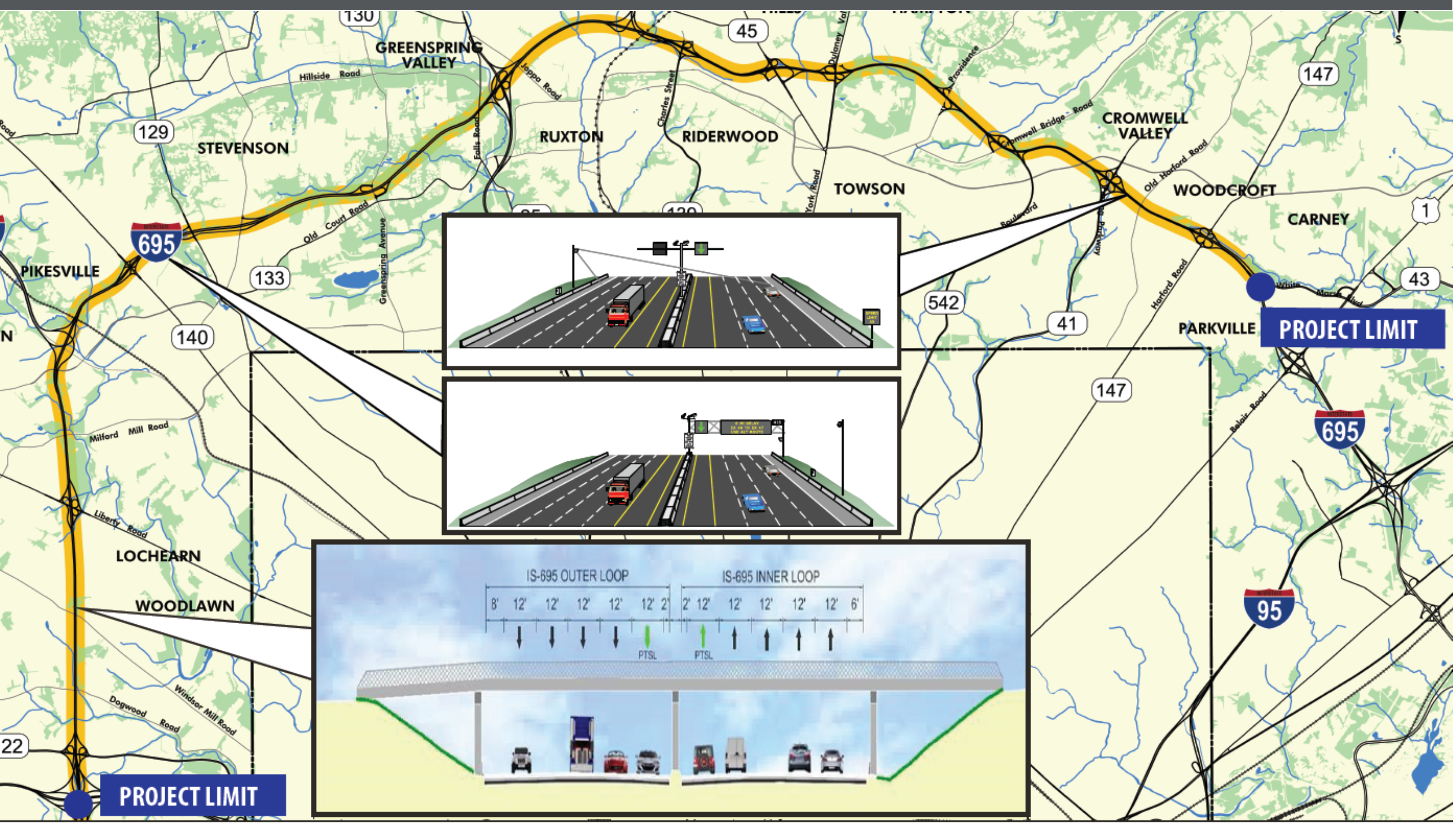

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2.09.02 PART-TIME SHOULDER USE

Maximized PTSU

The Myers Team will provide a continuous, static-dynamic median PTSU lane from north of IS-70 to west of MD 43 on both the Inner Loop and Outer Loop in order to maximize vehicle throughput, reduce travel times, and minimize congestion/delays.

The Myers Team understands the importance to both MDOT SHA and the Governor to operate a part-time shoulder use (PTSU) lane over the entire length of the Inner and Outer Loops. Our Team provides a multi-faceted approach that includes PTSU, Transportation Systems Management and Operations (TSMO) Technology Strategies, roadway and bridge improvements, and other operational improvements between IS-70 and MD 43.

Our Team will maximize congestion reduction, improve travel times, and minimize additional ITS maintenance/operation efforts by converting the IS-695 median shoulders to PTSU lanes from IS-70/MD 122 to MD 147/MD 43. The PTSU lanes will be developed within the existing pavement and/or right-of-way footprint to accommodate peak period travel demands, manage traffic during non-recurring events, and minimize rear-end collisions and friction between mainline and at interchange junctions. Our Team will provide the following improvements to accommodate the PTSU:

- Median barrier reconstruction, asphalt wedge/leveling, and resurfacing median shoulder to provide proper PTSU lane superelevation along seven miles of IS-695 curved roadway alignment;
- Deck/parapet reconstruction of the Inner Loop (IL) over Thornton Rd bridge's median shoulder;
- IS-695 median closed system drainage upgrades to meet roadway runoff spread requirements;
- Outside roadway widening and shoulder strengthening/reconstruction to shift IS-695 mainline;
- Widening of the bridges over Cromwell Bridge Rd, Loch Raven Blvd, and Perring Pkwy;
- Full-depth all-weather pull-off areas to accommodate ITS maintenance and emergencies;
- Outside shoulder concrete barrier along the Outer Loop (OL) between IS-795 and Reisterstown Rd;
- Outside shoulder concrete barrier along the IL between Charles St and York Rd, Cromwell Bridge Rd and Loch Raven Blvd bridges, and approaching the Harford Rd Interchange off-ramp;
- A comprehensive ITS system utilizing ActiveITS by SwRI to accommodate the PTSU, consisting of:
  - Electronic lane use control signals (LUCS) at $^1/_4$-mile spacing for lane availability;
  - AID cameras at $^1/_4$-mile spacing to monitor PTSU for incidents or debris presence;
  - Microwave vehicle detection (MVD) at $^1/_4$ to $^1/_3$ spacing to monitor mainline and shoulder speeds;
  - Additional pan-tilt-zoom (PTZ) cameras to provide continuous coverage;
  - Full-size and small DMS to display queue warning and PTSU information; and
  - Dynamic Speed Advisory (DSA) signs for five sections with limited sight distance and congestion;
- IS-695 pavement milling, resurfacing and restriping for the PTSU and as necessary to restore the IS-695 general-purpose mainline lanes and outside shoulders; and
- Roadway resurfacing, striping, and signing to improve the merge between SB IS-83 and IL & OL ramps.

i. LOCATIONS AND LIMITS OF PART-TIME SHOULDER USE

PTSU Project Lengths

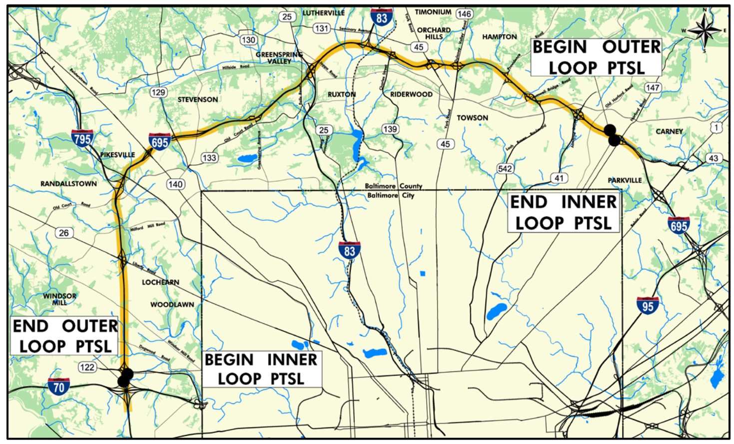
Total Length of PTSU Lanes = ***35.36 miles***

17.71 miles on the Inner Loop

17.65 miles on the Outer Loop.

The Myers Team proposed design maximizes the amount of static-dynamic median PTSU to maximize vehicle throughput and minimize vehicle travel times and delay along the Inner and Outer Loops of IS-695. The ***Inner Loop PTSU Lane*** begins 1,100 ft south of the on-ramp from Security Blvd (mile point (MP) 7.67 in the 2018 Highway Location Reference) and ends at the existing left exit lane for MD 43 located 600 ft west of the Harford Rd overpass (MP 25.38). The total length of the PTSU lane on the Inner Loop is 17.71 miles. The ***Outer Loop PTSU Lane*** begins 1,800 ft west of the Harford Rd overpass (MP 25.15) and begins to taper approximately 500 ft beyond the exit ramp to IS-70 (MP 7.50), for a total length of 17.65 miles as shown in *Figure 2.1* on page 2. SU-30 trucks and smaller vehicles will be permitted to use the lane during the predetermined hours of operation, and when deemed necessary by MDOT SHA based on emergency need or non-recurring traffic conditions. Our Project will maintain existing IS-695 mainline and ITS interchanges operations and lane assignments. Our Team is committed to providing this continuous PTSU lane to vastly reduce the traffic congestion along IS-695 during both the AM and PM peak hours. According to the 2019 Mobility Report, some segments experience congestion only during the morning peak, others only in the afternoon, and some during both time intervals.

Figure 2.1: Proposed PTSU Limits for IS-695 IL & OL



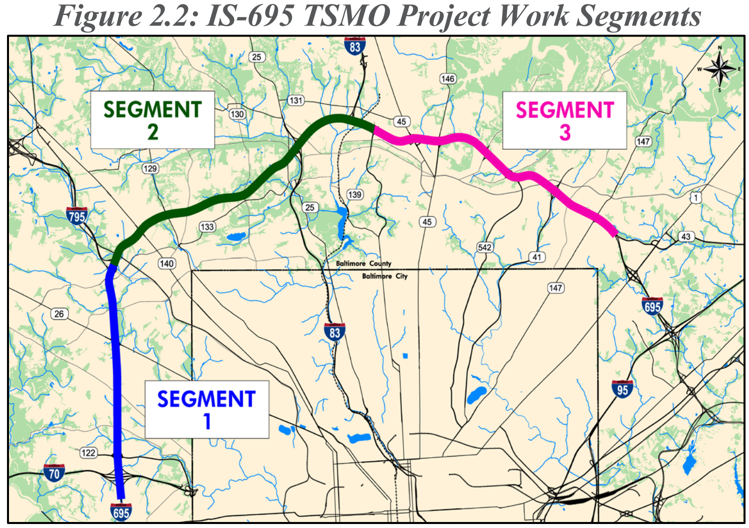
During the AM peak, three of the top 10 congested segments statewide are within the Project limits: (1) IS-695 Outer Loop between US Route 1 and Cromwell Bridge Rd; (2) IS-695 Outer Loop between IS-795 and US Route 40; and (3) IS-695 Inner Loop between IS-795 and IS-83. ***During the PM peak,*** the Inner Loop between IS-83 and MD 43 is the most congested freeway segment in the state (according to the 2019 Mobility Report), and entering traffic from IS-70 creates congestion on the Inner Loop all the way to IS-95.

Traffic volume is not the only issue creating recurring congestion; there are also steep grades, curves, and closely spaced interchange ramps that create friction and slowdowns. Short weaves at cloverleaf-style ramps contribute to congestion on the Inner Loop at MD 26, Falls Rd, and MD 41, and on the Outer Loop at MD 147 and MD 41. Multi-lane merges also create slowdowns. Traffic entering from Charles St on the Inner Loop, and at Harford Rd, MD 140, and Charles St on the Outer Loop, must merge across two lanes over short distances to continue on IS-695. While PTSU does not directly address these short weave segments and multi-lane merges, it does provide more gaps in the traffic to accommodate entering vehicles. Enhanced ITS improvements will advise motorists of speed differentials in these segments.

Segments

Our Team partitioned the corridor into three segments as shown in *Figure 2.2*: (1) IS-70 to IS-795, (2) IS-795 to Charles St, and (3) Charles St to MD 43. Traffic characteristics vary in each segment, as well as along the Inner Loop vs. Outer Loop, over the course of a typical day. Segment 1 and 2 improvements will provide significant benefits to system performance; however, we anticipate the work in Segment 3 from Charles St to MD 43 will provide the greatest benefit to maximize vehicle throughput, reduce travel times, and improve reliability on the Inner and Outer Loops.

Figure 2.2: IS-695 TSMO Project Work Segments

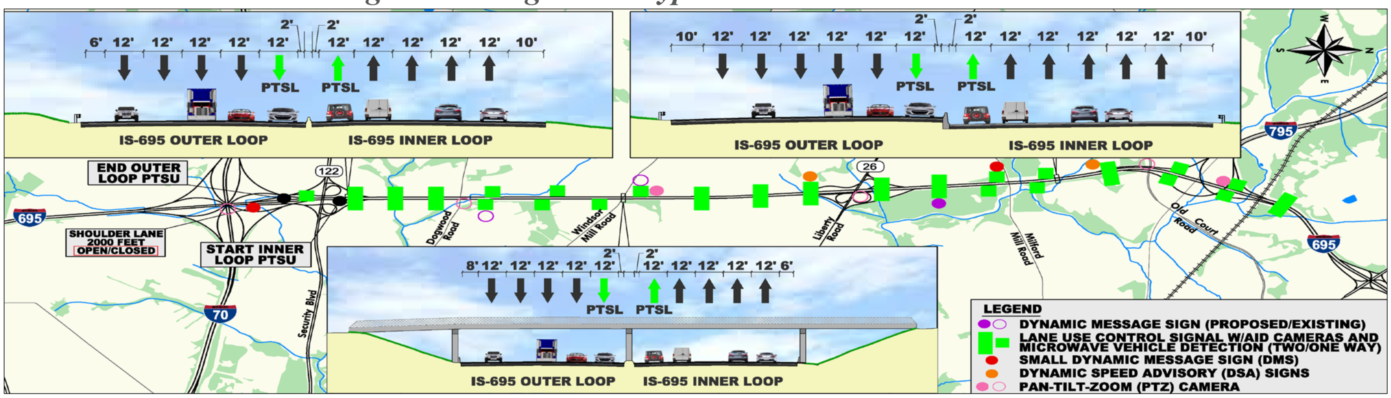


SEGMENT 1: IS-70 TO IS-795

Inner Loop: The Inner Loop from IS-70 to IS-795 is a critical segment during both the morning and the afternoon peak travel times, and traffic levels are expected to increase with the future replacement of the IS-70 interchange. We are implementing PTSU in this segment to provide lane balance during times of peak demand, where the three lanes entering from the Inner

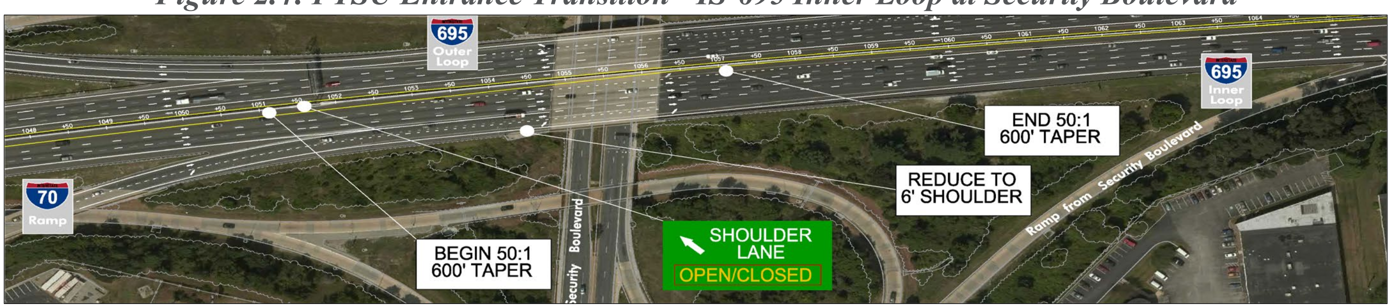
Loop to the south and the two lanes from IS-70 may continue northward as five lanes. The existing reduction from five lanes to four, coupled with a long upgrade with stop-and-go traffic beyond IS-70, creates queues south of the Project area that extend back to IS-95 during the afternoon peak. Select roadway typical sections showing the PTSU lanes and the ITS devices that will support PTSU and roadway operations within Segment 1 are included on *Figure 2.3*.

Figure 2.3: Segment 1 Typical Sections & ITS Devices



Starting PTSU as a fifth peak hour lane prior to the IS-70 merge allows mainline drivers to enter the median lane, creating gaps for merging traffic from IS-70 and reducing inter-vehicle friction in this area. The fifth lane also provides flexibility and will improve throughput when the future IS-70 interchange work is underway. Signs placed one mile and 2,000 ft prior to the PTSU lane entrance advise drivers that the lane is ahead on the left and if it is open or closed. The Inner Loop entrance taper begins 150 ft south of the striped gore of the IS-70 on-ramp and extends 600 ft northward, developing into a full-width PTSU lane just beyond the bridge over Security Blvd (*Figure 2.4*).

Figure 2.4: PTSU Entrance Transition - IS-695 Inner Loop at Security Boulevard



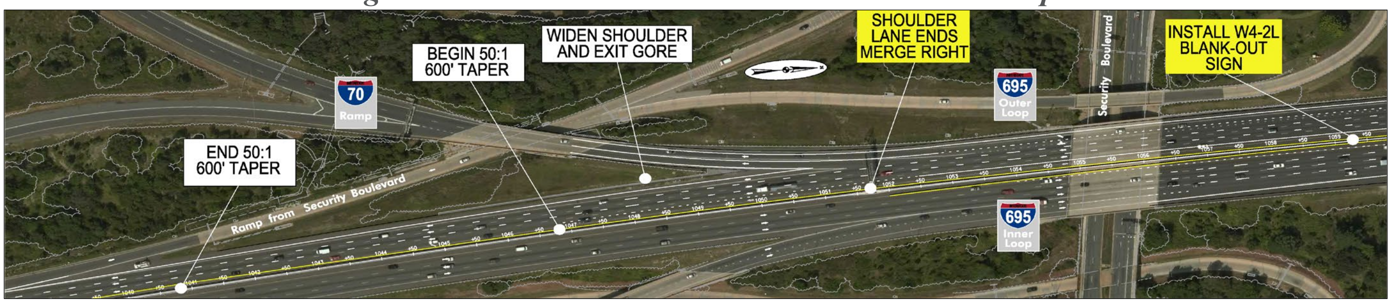
During off-peak times, the entrance to the median lane is closed and the roadway will operate just as it does today, reducing driver confusion and the likelihood of incidents. Lane use control signals (LUCS) spaced such that two are visible at any given time will advise drivers if the lane is open, is closing, or is closed. Signs will advise that the median shoulder may be used for emergency stopping only while the red "X" is lit.

Our Team will widen the outside shoulder prior to the on-ramp from MD 122 to create a 12-ft wide shoulder for maintenance and emergencies. North of this point, the existing median shoulder is typically 14 ft or more, providing space to support a 12-ft PTSU lane and 2-ft offset to the median barrier, while maintaining 10-ft outside shoulders. There is a single constrained section at Windsor Mill Rd (ATC #1) where the lanes must shift toward the outside shoulder for the PTSU lane, reducing it to 6 ft.

Outer Loop: The Outer Loop between IS-795 and IS-70 is a desirable segment to provide PTSU, as it is identified in the Top 10 most congested corridors during the morning peak (2019 Mobility Report) and is congested in the afternoon as well. The congestion results from constraints to the south, the narrow IS-70 bridge, and IS-695 segment near US Route 40. The Outer Loop currently reduces from four-lanes to three within the IS-795 interchange, and two lanes enter from IS-795. Five lanes continue for 1,800 ft before the right lane from IS-795 ends. The PTSU will continue from Segment 2 north of IS-795, creating additional capacity to handle peak hour demand and better accommodate the merging traffic from IS-795. Recent work at the MD 26 interchange and Milford Mill Rd bridge includes enough pavement width for the PTSU lane and full width inside and outside shoulders, but requires shifting the lanes toward the outside shoulder. South of MD 26, space is available to provide the 12-ft PTSU lane and 2-ft offset to the median barrier while maintaining adequate outside shoulder, except at Windsor Mill Rd (ATC #1).

The PTSU transition at the southern Project limit near IS-70 (*Figure 2.5*) requires a lane drop. Our Team proposes to widen the Outer Loop pavement to the outside beyond the IS-70 off ramp to provide space to continue the PTSU lane 400 ft beyond the striped exit ramp gore to IS-70, followed by a 600-ft taper. Extending PTSU beyond the IS-70 exit limits the friction between drivers merging right from the median lane at the same time that drivers are merging right from the exit only lane for IS-70 to remain on IS-695.

Figure 2.5: PTSU Exit Transition - IS-695 Outer Loop



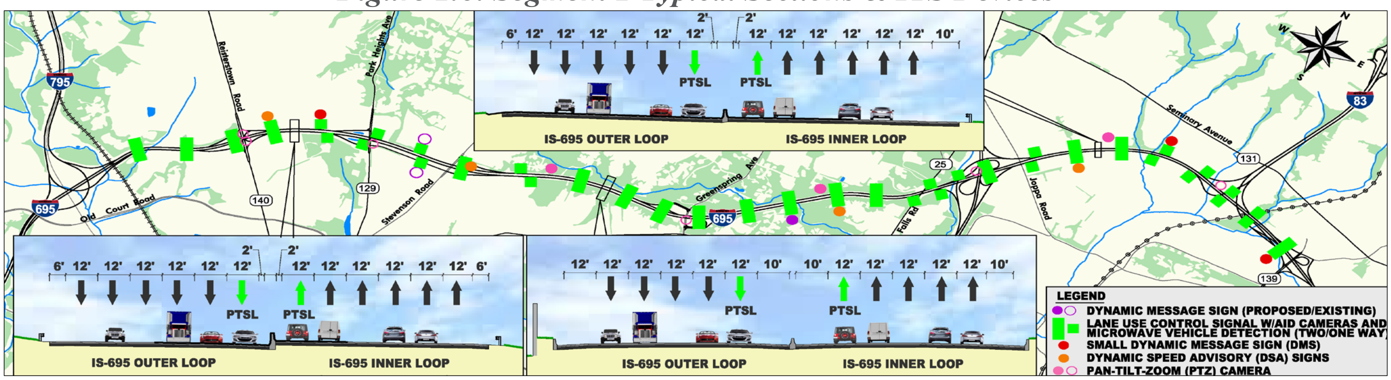
Advance warning signage will advise drivers that the shoulder lane is ending. We will use blank-out W4-2L signs ½ mile and 1,500 ft prior to the merge point, plus a static "SHOULDER LANE ENDS" sign mounted on the sign bridge at the IS-70 exit. To reduce crashes, we are incorporating TSMO technology strategies including: Queue Warning (QW), Dynamic Speed Advisory (DSA), enhanced PTZ CCTV camera coverage, continuous vehicle detection, enhanced traveler information, and mainline incident detection algorithms throughout the corridor to enhance safety, mobility, and overall operations.

SEGMENT 2: IS-795 TO CHARLES STREET

Inner Loop: The Inner Loop between IS-795 and the exit to IS-83 NB is a high priority segment to implement PTSU, as it is included in the Top 10 congested freeway segments statewide during the morning peak. Heavy volumes entering from IS-795, destined for Towson and downtown Baltimore, as well as horizontal curves and steep grades on IS-695, cause recurring congestion. PTSU will aid in meeting the demand to the IS-83 interchange during both the AM and PM peak periods. Currently three lanes enter from the mainline in Segment 1, and two lanes enter from IS-795. The rightmost lane on IS-795 becomes an auxiliary lane and ends at the MD 140 exit. The next lane becomes a choice lane and continues north as a fourth lane. The median PTSU lane continues as a peak-hour fifth lane from Segment 1, and our Team is providing a 12-ft wide PTSU lane with at least a 2-ft offset to the median barrier throughout the entire segment. From Stevenson Ln to IS-83, much of the roadway infrastructure (pavement, lighting, etc.) is already in place for PTSU while maintaining minimum width outside shoulders, except at the MD 129 and Stevenson Ln overpasses (ATC #2) and the overpass from IS-83 to the Inner Loop (ATC #3). Typical sections and ITS devices to be placed in this segment to support the PTSU lanes and enhance operations in the corridor appear in *Figure 2.6* on page 5.

Outer Loop: The Outer Loop between Charles St and IS-795 is heavily congested during the afternoon peak, as commuters return to residential areas to the north and west. Entering Segment 2 at Charles St, there are currently five lanes; three from the Outer Loop and two that are added from the two exit ramps at Charles St. We are providing a continuous 12-ft wide PTSU lane with minimum 2-ft offset to the median barrier throughout this entire segment that will continue westward from Segment 3 as an added lane on the Outer Loop during peak periods. Much of the infrastructure to provide the PTSU lane and full width inside and outside shoulders is already in place along this segment between the IS-83 South interchange and Stevenson Ln. We are able to provide the PTSU lane and minimum 2-ft offset to the median barrier while maintaining the minimum outside shoulder width at all locations except at the auxiliary lane from Charles St and IS-83 North (ATC #14); the bridge pier cap at the ramp from IS-83 North (ATC #3); the bridges over IS-83 North (ATC #8) and Thornton Rd (ATC #9); and the Stevenson Ln and Park Heights Ave overpasses (ATC #2). The curve between MD 140 and IS-795 currently has stopping sight distance for 50 mph in the left lane; our PTSU design (ATC #11) increases the left lane sight distance to meet 55 mph, but the PTSU lane will only meet 45 mph, requiring a design exception.

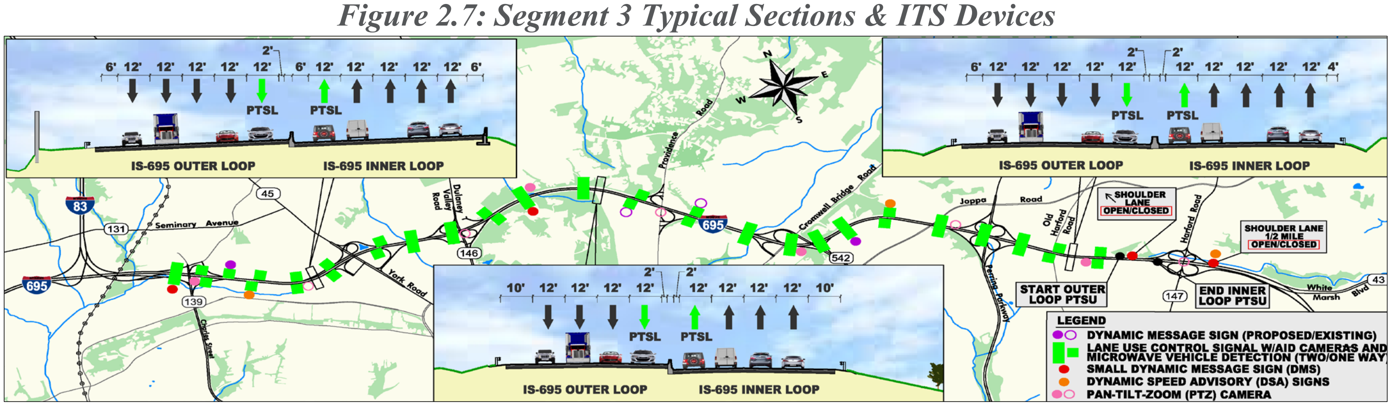
Figure 2.6: Segment 2 Typical Sections & ITS Devices



SEGMENT 3: CHARLES STREET TO MD 43

Inner Loop: The Inner Loop between Charles St and MD 43 is a crucial segment to provide PTSU; it is the State's No. 1 most congested corridor during the PM peak and is heavily traveled in the AM as well. The existing demand created by motorists bound for MD 43 and IS-95 to reach their homes to the north and east is over 7,700 vehicles, more than the three lanes can handle. Entering Segment 3, there are currently four lanes: three from the Inner Loop and one from IS-83 North that continues as an auxiliary lane to York Rd. Beyond York Rd, there are only three continuous lanes. Our Team will provide a 12-ft wide PTSU lane and minimum 2-ft offset to the median that continues from Segment 2 and extends all the way to the start of the existing left-exit lane for MD 43, approximately 500 ft west of Harford Rd, as shown in *Figure 2.7*.

Figure 2.7: Segment 3 Typical Sections & ITS Devices

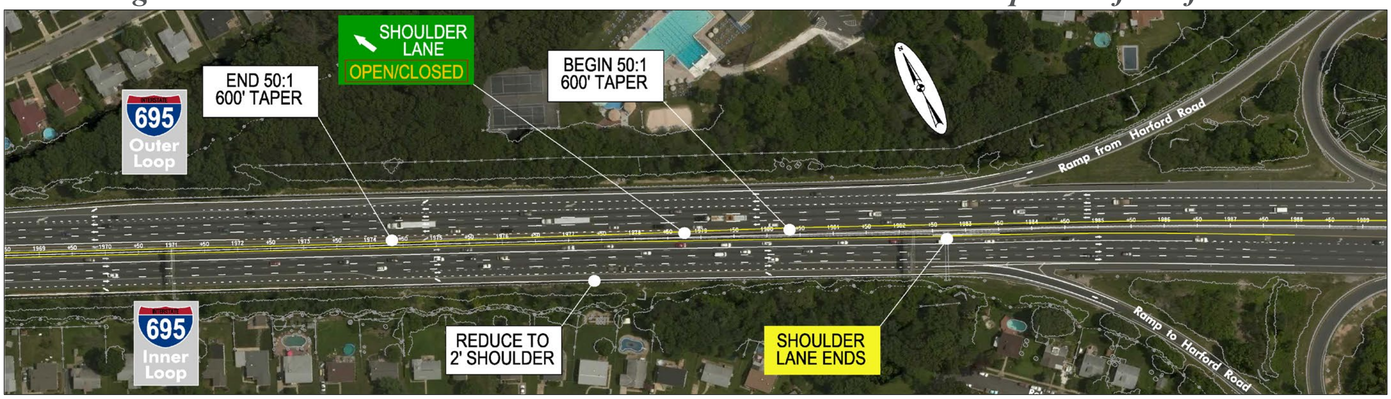


This segment is very constrained; to provide PTSU and maintain existing outside shoulder widths, we must widen the bridge over Cromwell Bridge Rd by 6 ft, MD 542 by 5.5 ft, and MD 41 by 2-ft. Our work resolves many existing design exceptions, however additional design exceptions will be required for substandard outside shoulders between MD 146 and Providence Rd (ATC #15) and between MD 41 and MD 147 (ATC

#16). Our improvements between Charles St and MD 45 require reducing the outside auxiliary lane shoulder to 2-ft and using a 50-mph PTSU design speed on the horizontal curve (ATC #12), require a design exception.

The Inner Loop transition at the end of the PTSU lane (*Figure 2.8*) is straightforward. The MD 43 exit is a left exit, and the PTSU lane simply continues into the current taper for the exit lane. We will place static signage on the last two gantry supports advising drivers of the approaching end of the lane. Drivers wishing to continue on IS-695 have a half-mile to merge right, while those exiting at MD 43 simply stay in the lane. Lane markings will transition from the solid to the short-skip lane markings that indicate an exit only lane.

Figure 2.8: PTSU Entrance and Exit Transitions - IS-695 Outer Loop west of Harford Rd



<u>Outer Loop</u>: Providing a PTSU lane on the IS-695 Outer Loop is most challenging along the segment between MD 43 and Charles St; however, it provides a significant reduction in recurring congestion. Queues during the morning peak typically extend beyond US 1 due to the four mainline lanes reducing to three at the exit to MD 41. Horizontal curves and steep grades exacerbate the congestion. While the greatest benefit of providing a PTSU lane is seen in the morning, this segment also benefits from having the lane open in the afternoon peak as the demand exceeds the capacity of the existing three lanes at both times.

On the Outer Loop, the 12-ft PTSU lane and 2-ft offset to the median is introduced to the west of the Harford Rd overpass (*Figure 2.8*) and continues from there through to Segment 2. Providing the PTSU lane entrance as an added peak hour lane east of Harford Rd maintains the existing conditions during off-peak times. During peak periods, the PTSU lane will reduce queues in this area considerably. There is already excess capacity between MD 43 and Harford Rd, and drivers currently use the right lane that ends at MD 41 as a queue jump, waiting until the last minute to merge into the three mainline lanes beyond the exit. Providing the PTSU lane entrance east of Harford Rd maintains the peak hour lane balance of four lanes approaching and four lanes continuing beyond the MD 41 interchange.

Static signage will advise drivers well before the lane begins, at one mile and ½ mile prior to the lane start, with a dynamic "OPEN/CLOSED" sign placed at the PTSU entrance. The entrance taper begins 1,000 ft west of the Harford Rd overpass and extends for 600 ft, where the full width PTSU lane begins.

This segment is very constrained, We must widen the bridges over MD 41 by 1.5 ft and Cromwell Bridge Rd by 2.5 ft to provide the 12-ft PTSU lane and minimum 2-ft offset to the barrier while maintaining existing outside shoulder widths. New design exceptions are required to reduce the outside shoulder at Old Harford Rd (ATC #4) and between Providence Rd and MD 146 (ATC #13), as well as for stopping sight distance on the curve between the MD 41 and MD 542 interchanges (ATC #10).

TSMO Technology Strategies to Support PTSU

The TSMO technology strategies that our Team is proposing to support PTSU will aid in reducing recurring and non-recurring congestion. Strategies include active ITS devices that manage traffic by advising drivers of current conditions, and passive ITS devices that operate in the background, gathering the data to detect and monitor conditions. Solutions that directly support PTSU include:

- **Lane Use Control Signals (LUCS)**, which are overhead-mounted LED signs to advise drivers that the shoulder lane is either open for use, closing, or closed to traffic except for emergency stopping only. LUCS are placed such that drivers can see two of them at any given time, per the RFP.
- **Automated Incident Detection (AID)** and Debris Detection System includes video cameras and video analytics software to continuously monitor PTSU lanes to detect stopped vehicles or obstructions that could impact PTSU operations, alerting TOC-4 of a potential incident. The AID system will have a false alarm rate of less than one per 10 true alarms per the RFP. Incident and debris detection improves mobility via enhanced situational awareness and reduced response times. Studies have estimated an average benefit to cost ratio for camera systems of 12:1 (SCDOT, 2007).
- **Microwave Vehicle Detectors (MVD)** will provide TOC-4 with real-time traffic flow conditions. MVD are currently operational at some locations along the corridor; our Project will provide full vehicle detection at $^{1}/_{3}$-mile spacing. In addition to collecting important volume and occupancy data, MVD will be used to determine the extent and duration of PTSU operation during non-recurring incidents.
- **Dynamic Message Signs (DMS)** provide real-time driver information regarding congestion or incidents, weather, or the current operation of the PTSU. New DMS along the corridor will be integrated with the existing CHART ATMS and operated as existing ones are today.
- **Dynamic Speed Advisory (DSA) Signs** will adjust recommended speeds to prevailing conditions and, coupled with the existing and proposed DMS, serve as an integrated queue warning system to reduce incidents in chronically congested areas. FHWA has reported the queue warning systems similar to our proposal have shown an average of 5% reduction of travel time as a result of reduced incidents.
- **New CCTV Cameras** supplement existing cameras to provide full corridor coverage, eliminating blind spots. This will improve safety on the corridor and PTSU by providing operators with additional surveillance capabilities to monitor traffic conditions, verify incidents or debris, and detect incidents.

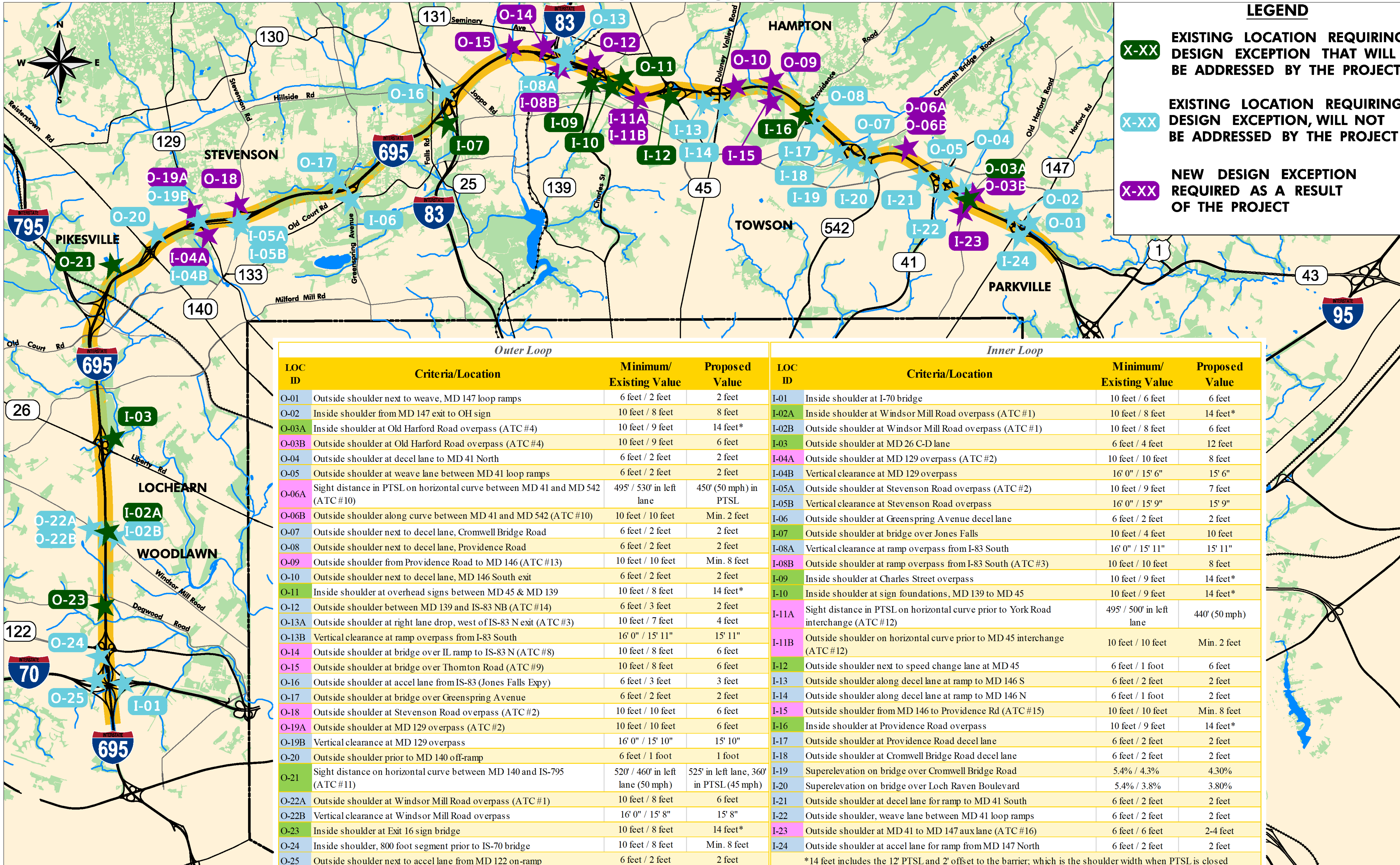
The Myers Team will prepare a Concept of Operations to document corridor deficiencies, define required functionality, describe operational scenarios, and detail system interfaces. The rules, decisions, and processes described in our proposal will be confirmed and further developed through stakeholder workshops to memorialize how the IS-695 TSMO system will integrate and operate with MDOT SHA CHART. Additional details of the Concept of Operations process is found on Page 46.

Design Exceptions and Alternative Technical Concepts

IS-695 is on the National Highway System (NHS) and must meet the 10 controlling criteria identified in the Federal Register (May 5, 2016 edition) as well as the RFP criteria, as outlined in *Table 2.1* on page 9. Our Team understands that any instance where the controlling criteria are not met must have an approved design exception (DE) per TC 3.05.05. We have identified 43 existing instances where the controlling criteria are not met within the Project limits; 20 on the Inner Loop and 23 on the Outer Loop. Our efforts focused on resolving existing DEs and minimizing new DEs required for the Project; resulting in 48 required DEs for the Project as shown on *Figure 2.9* on page 8. We identified both existing and proposed design exceptions within the Project area and developed proposed mitigation measures for each type.

> ***Limiting DEs Required***
> *The Myers Team reviewed the existing 43 design exceptions on IS-695 and focused our improvements to resolve as many existing DEs as possible while minimizing the need for new DEs. The proposed improvements require only **five** additional DEs.*

Figure 2.9: Design Exceptions



Outer Loop

LOC ID	Criteria/Location	Minimum/ Existing Value	Proposed Value
O-01	Outside shoulder next to weave, MD 147 loop ramps	6 feet / 2 feet	2 feet
O-02	Inside shoulder from MD 147 exit to OH sign	10 feet / 8 feet	8 feet
O-03A	Inside shoulder at Old Harford Road overpass (ATC #4)	10 feet / 9 feet	14 feet*
O-03B	Outside shoulder at Old Harford Road overpass (ATC #4)	10 feet / 9 feet	6 feet
O-04	Outside shoulder at decel lane to MD 41 North	6 feet / 2 feet	2 feet
O-05	Outside shoulder at weave lane between MD 41 loop ramps	6 feet / 2 feet	2 feet
O-06A	Sight distance in PTSL on horizontal curve between MD 41 and MD 542 (ATC #10)	495' / 530' in left lane	450' (50 mph) in PTSL
O-06B	Outside shoulder along curve between MD 41 and MD 542 (ATC #10)	10 feet / 10 feet	Min. 2 feet
O-07	Outside shoulder next to decel lane, Cromwell Bridge Road	6 feet / 2 feet	2 feet
O-08	Outside shoulder next to decel lane, Providence Road	6 feet / 2 feet	2 feet
O-09	Outside shoulder from Providence Road to MD 146 (ATC #13)	10 feet / 10 feet	Min. 8 feet
O-10	Outside shoulder next to decel lane, MD 146 South exit	6 feet / 2 feet	2 feet
O-11	Inside shoulder at overhead signs between MD 45 & MD 139	10 feet / 8 feet	14 feet*
O-12	Outside shoulder between MD 139 and IS-83 NB (ATC #14)	6 feet / 3 feet	2 feet
O-13A	Outside shoulder at right lane drop, west of IS-83 N exit (ATC #3)	10 feet / 7 feet	4 feet
O-13B	Vertical clearance at ramp overpass from I-83 South	16' 0" / 15' 11"	15' 11"
O-14	Outside shoulder at bridge over IL ramp to IS-83 N (ATC #8)	10 feet / 8 feet	6 feet
O-15	Outside shoulder at bridge over Thornton Road (ATC #9)	10 feet / 8 feet	6 feet
O-16	Outside shoulder at accel lane from IS-83 (Jones Falls Expy)	6 feet / 3 feet	3 feet
O-17	Outside shoulder at bridge over Greenspring Avenue	6 feet / 2 feet	2 feet
O-18	Outside shoulder at Stevenson Road overpass (ATC #2)	10 feet / 10 feet	6 feet
O-19A	Outside shoulder at MD 129 overpass (ATC #2)	10 feet / 10 feet	6 feet
O-19B	Vertical clearance at MD 129 overpass	16' 0" / 15' 10"	15' 10"
O-20	Outside shoulder prior to MD 140 off-ramp	6 feet / 1 foot	1 foot
O-21	Sight distance on horizontal curve between MD 140 and IS-795 (ATC #11)	520' / 460' in left lane (50 mph)	525' in left lane, 360' in PTSL (45 mph)
O-22A	Outside shoulder at Windsor Mill Road overpass (ATC #1)	10 feet / 8 feet	6 feet
O-22B	Vertical clearance at Windsor Mill Road overpass	16' 0" / 15' 8"	15' 8"
O-23	Inside shoulder at Exit 16 sign bridge	10 feet / 8 feet	14 feet*
O-24	Inside shoulder, 800 foot segment prior to IS-70 bridge	10 feet / 8 feet	Min. 8 feet
O-25	Outside shoulder next to accel lane from MD 122 on-ramp	6 feet / 2 feet	2 feet

Inner Loop

LOC ID	Criteria/Location	Minimum/ Existing Value	Proposed Value
I-01	Inside shoulder at I-70 bridge	10 feet / 6 feet	6 feet
I-02A	Inside shoulder at Windsor Mill Road overpass (ATC #1)	10 feet / 8 feet	14 feet*
I-02B	Outside shoulder at Windsor Mill Road overpass (ATC #1)	10 feet / 8 feet	6 feet
I-03	Outside shoulder at MD 26 C-D lane	6 feet / 4 feet	12 feet
I-04A	Outside shoulder at MD 129 overpass (ATC #2)	10 feet / 10 feet	8 feet
I-04B	Vertical clearance at MD 129 overpass	16' 0" / 15' 6"	15' 6"
I-05A	Outside shoulder at Stevenson Road overpass (ATC #2)	10 feet / 9 feet	7 feet
I-05B	Vertical clearance at Stevenson Road overpass	16' 0" / 15' 9"	15' 9"
I-06	Outside shoulder at Greenspring Avenue decel lane	6 feet / 2 feet	2 feet
I-07	Outside shoulder at bridge over Jones Falls	10 feet / 4 feet	10 feet
I-08A	Vertical clearance at ramp overpass from I-83 South	16' 0" / 15' 11"	15' 11"
I-08B	Outside shoulder at ramp overpass from I-83 South (ATC #3)	10 feet / 10 feet	8 feet
I-09	Inside shoulder at Charles Street overpass	10 feet / 9 feet	14 feet*
I-10	Inside shoulder at sign foundations, MD 139 to MD 45	10 feet / 9 feet	14 feet*
I-11A	Sight distance in PTSL on horizontal curve prior to York Road interchange (ATC #12)	495' / 500' in left lane	440' (50 mph)
I-11B	Outside shoulder on horizontal curve prior to MD 45 interchange (ATC #12)	10 feet / 10 feet	Min. 2 feet
I-12	Outside shoulder next to speed change lane at MD 45	6 feet / 1 foot	6 feet
I-13	Outside shoulder along decel lane at ramp to MD 146 S	6 feet / 2 feet	2 feet
I-14	Outside shoulder along decel lane at ramp to MD 146 N	6 feet / 1 foot	2 feet
I-15	Outside shoulder from MD 146 to Providence Rd (ATC #15)	10 feet / 10 feet	Min. 8 feet
I-16	Inside shoulder at Providence Road overpass	10 feet / 9 feet	14 feet*
I-17	Outside shoulder at Providence Road decel lane	6 feet / 2 feet	2 feet
I-18	Outside shoulder at Cromwell Bridge Road decel lane	6 feet / 2 feet	2 feet
I-19	Superelevation on bridge over Cromwell Bridge Road	5.4% / 4.3%	4.30%
I-20	Superelevation on bridge over Loch Raven Boulevard	5.4% / 3.8%	3.80%
I-21	Outside shoulder at decel lane for ramp to MD 41 South	6 feet / 2 feet	2 feet
I-22	Outside shoulder, weave lane between MD 41 loop ramps	6 feet / 2 feet	2 feet
I-23	Outside shoulder at MD 41 to MD 147 aux lane (ATC #16)	6 feet / 6 feet	2-4 feet
I-24	Outside shoulder at accel lane for ramp from MD 147 North	6 feet / 2 feet	2 feet

*14 feet includes the 12' PTSL and 2' offset to the barrier; which is the shoulder width when PTSL is closed

Table 2.1: Controlling Criteria for the Project

Criteria	Sources	Minimum Required Value(s)
Design Speed	RFP Section TC 3.09.04.01	55 mph
Lane Width	RFP Section TC 3.09.05; AASHTO Policy on Design Standards – Interstate System	12 ft
Shoulder Width	AASHTO Policy on Design Standards – Interstate System; AASHTO Policy on Geometric Design of Highways and Streets	Inside and Outside Shoulder – 10 ft; Outside Shoulder Adjacent to Speed Change or Auxiliary Lane – 6 ft
Horizontal Curve Radius	AASHTO Policy on Geometric Design of Highways and Streets	1,060 ft at full 6.0% superelevation
Superelevation	RFP Section TC 3.09.04.01	6.0% maximum
Stopping Sight Distance	AASHTO Policy on Geometric Design of Highways and Streets	495 ft – Level Roadway; 520 ft – 3.0% Downgrade; 469 ft – 3.0% Upgrade
Maximum Grade	RFP Section TC 3.09.04.01; AASHTO Policy on Design Standards – Interstate System	6.0% maximum (5.0% maximum for rolling terrain, with 1.0% added for Urban Interstate)
Cross Slope	AASHTO Policy on Design Standards – Interstate System	1.5% to 2.0% (within lanes); 2.0% to 6.0% (shoulders, non-PTSU); 8.0% maximum rollover
Vertical Clearance	RFP Section TC 3.11.05.01; AASHTO Policy on Design Standards – Interstate System	16 ft 9 in – Per the RFP; 16 ft 0 in – Per AASHTO
Design Loading Structural Capacity	AASHTO Policy on Design Standards – Interstate System)	Designed in accordance with *AASHTO LRFD Bridge Design Specifications*

OTHER APPLICABLE CRITERIA – The AASHTO interstate standards note for roads where design hourly truck volumes are greater than 250 per hour, as on IS-695 today and in the future, a 12-ft inside and outside shoulder "should be considered". Our Team interprets the 10-ft width, and not the 12-ft, as the minimum requiring a design exception. Another design feature that is not *controlling criteria* for the Project but important to the design is the minimum offset to median barrier while PTSU is active. There is median barrier over the full Project limits, with no space in the median to construct PTSU lanes. The AASHTO interstate standards note that on "depressed interstates in urban areas…which may need retaining walls and bridge piers to be placed within the clear zone…should be at least 2 ft beyond the outer edge of shoulder". FHWA's *Use of Freeway Shoulders for Travel: Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy* (February 2016) recommends a "minimum 1.5-ft offset between the edge of the PTSU lane and the face of the median barrier" based on the AASHTO Roadside Design Guide. ***Our proposed solution uses a continuous 12-ft wide PTSU lane as well as a minimum 2-ft wide offset to the barrier face, which during off-peak times provides a 14-ft wide usable inside shoulder.*** A design exception is required for the full limits of the PTSU lanes for this condition. The wider 14-ft inside "shoulder" results in outside shoulders less than the required minimum values in many locations.

ALTERNATIVE TECHNICAL CONCEPTS (ATC) – We submitted 23 ATCs to identify how we will incorporate PTSU lanes in the existing right of way in constrained conditions. ATCs 1-4 and 8-16 all require a design exception as shown on page 10. Mitigation methods include ITS devices (dynamic message and speed advisory signs, enhanced vehicle and speed detection, queue warning) and physical improvements (pavement design, emergency pull-offs) to lessen safety and operational risks involved with the design exception.

Median Treatments to Support PTSU (ATC #22) – IS-695 has several superelevated curves. The existing median shoulders are typically 10-12 ft wide and "roll over" to have cross-slopes counter to the roadway superelevation. The PTSU lane requires wedge/level to match the existing roadway surface several inches higher than existing at the median barrier, reducing its height to less than 42 in. There are over seven miles of these superelevated curves where bifurcated median barrier will be less than 42 in. Our Team proposes to retrofit the existing barrier with a straight-slope, 9.1-degree barrier face that is attached to the existing barrier to bring it into compliance. The straight slope retrofit is a value-engineered solution used on other PTSU projects to reduce the amount of time that motorists are impacted by the work.

Improved Lane Balance on IS-83 SB (ATC #23) The exit from the Inner Loop to the Jones Falls Expy (JFX) is a single lane ramp where demand exceeds capacity during peak periods. Ramp traffic merges into the two-lane ramp from the Outer Loop that is also near capacity. Our Team proposes to repurpose the lanes where the single lane from the Inner Loop and the two lanes from the Outer Loop continue as the three through lanes southward, maintaining the interstate-to-interstate connection and improving operations.

ATCs Incorporated into the Project

- *ATC #1 IL & OL, Reduce OS at Windsor Mill Rd*
- *ATC #2 IL & OL, Reduce OS at Stevenson Rd & Park Heights Ave*
- *ATC #3 IL & OL, Reduce OS at Ramp fr SB IS-83 to IL*
- *ATC #4 IL & OL, Reduce OS at Old Harford Rd*
- *ATC #8 OL, Reduce OS at Ramp fr IL to IS-83 NB*
- *ATC #9 OL, Reduce OS at Thornton Rd*
- *ATC #10 OL, Reduce OS on Ltd Sight Distance Curve fr MD41 to MD542*
- *ATC #11 OL, Reduce OS on Ltd Sight Distance Curve fr MD140 to IS-795*
- *ATC #12 IL, Reduce OS on Ltd Sight Distance Curve fr MD139 to MD45*
- *ATC #13 OL, Reduce OS from Providence Rd to MD146*
- *ATC #14 OL, Reduce OS from MD139 to IS-83*
- *ATC #15 IL, Reduce OS from MD146 to Providence Rd*
- *ATC #16 IL, Reduce OS from MD41 to MD147*
- *ATC #18 Truck Factors for Pavement Design*
- *ATC #22 Median Barrier Expansion Using 9.1-Degree Straight Slope Barrier*
- *ATC #23 Improve Lane Balance at IS-695 & IS-83 SB/ MD Route 25A Interchange*

**All ATCs Listed are Conditionally Approved*

ii. RECURRING CONGESTION REDUCTION FROM PTSU IMPROVEMENTS

The Myers Team is very familiar with the IS-695 corridor and its geometric constraints, vertical and horizontal curvature, heavy merge and weaving volumes, and environmental factors that result in significant recurring congestion during peak periods. In many locations, bottleneck conditions form due to heavy volumes, while in some locations the existing lane capacity is reduced due to various geometric and environmental constraints.

Figure 2.10 on page 11 shows heat maps of the existing conditions and hot spot locations along the Inner and Outer Loops for the AM and PM peak periods from the MDOT SHA existing conditions VISSIM models. The IS-695 map shows the average travel speeds during the worst AM peak hour (8 a.m. to 9 a.m.) and PM peak hour (5 p.m. to 6 p.m.). The inside box shows a congestion diagram for the entire AM peak period (6 a.m. to 10 a.m.) and PM peak periods (3 p.m. to 7 p.m.). These congestion diagrams show how the congestion builds up, how far the queues extend, and how the congestion dissipates in the corridor.

The congestion diagrams show there are multiple bottlenecks in the Project limits that make both the Inner and Outer Loops unreliable to travel during weekday peak periods. Along the Outer Loop during the AM peak period there is significant congestion approaching the Dulaney Valley Rd interchange and then at the IS-70 and US 40 interchanges. Along the Inner Loop during the PM peak period there is congestion at the IS-70 and Security Blvd merge, the IS-83 south diverge, and approaching the Perring Pkwy interchange. The key to improving travel time reliability is to address the cause of the recurring congestion. One of the most effective ways to provide additional capacity is a PTSU lane during peak periods to increase throughput. Most of the congestion occurs due to a surge in demand for a short period of time when demand exceeds capacity. Providing PTSU creates additional throughput capacity at these bottleneck locations, carrying the additional demand downstream to manage the additional throughput, which will eliminate most of the congestion in peak periods. Detailed results of the VISSIM models and supporting files are provided in *Appendix D*.

Figure 2.10: IS-695 Corridor Average Speeds and Congestion Diagrams (2018 VISSIM model results) – AM and PM Peak Existing Conditions and with PTSU-Only Build Conditions

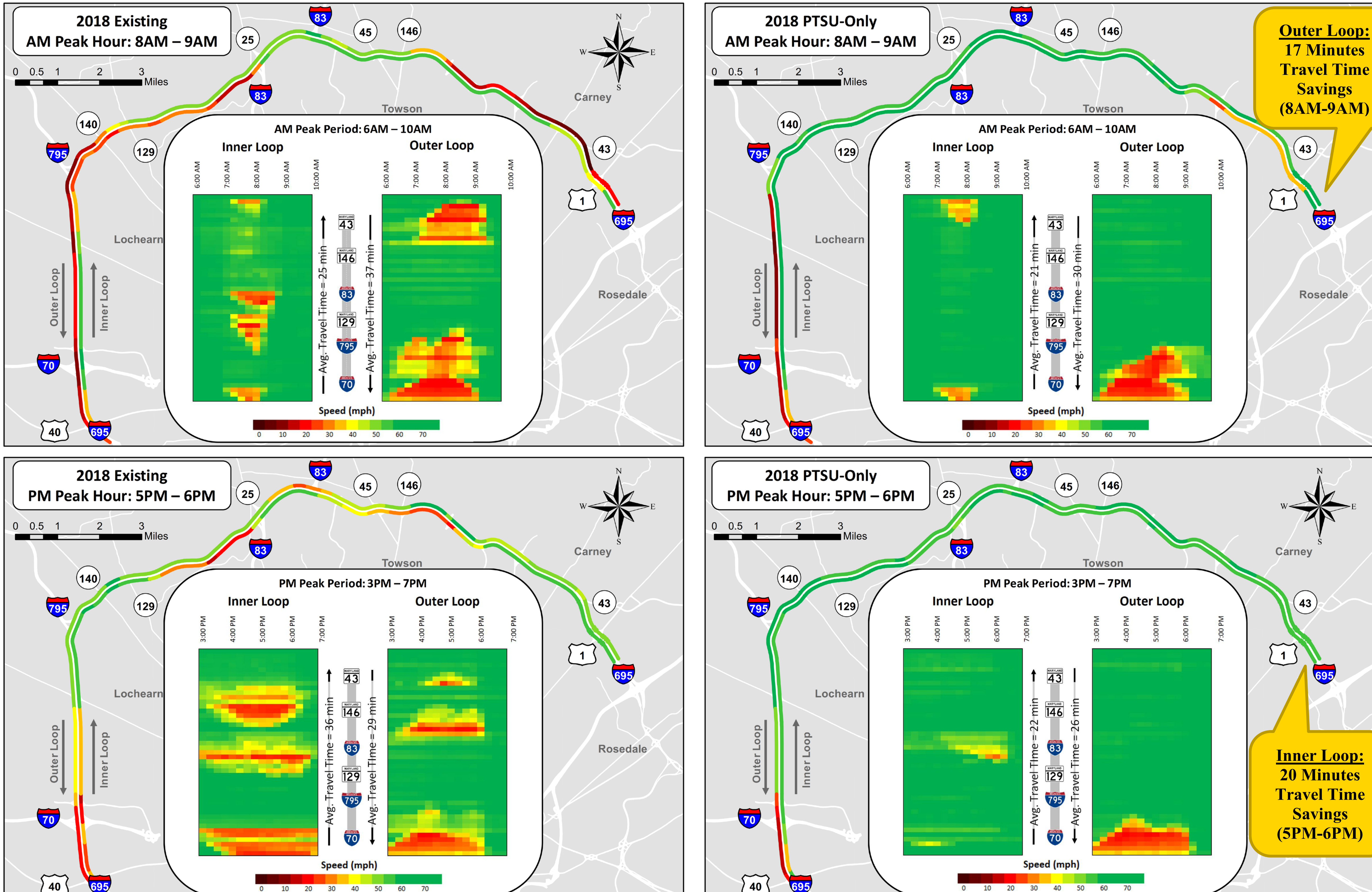


Figure 2.10 on page 11 also shows how the PTSU lanes will reduce the congestion in the worst peak hour as well as during the entire peak period along the corridor. The congestion relief provided by the proposed PTSU accounts for 17 minutes of travel time improvement in the AM peak hour along the Outer Loop between US 40 and US 1 and a 16 minute improvement between IS-70 and MD 43. Along the Inner Loop, there is more than 20 minutes of travel time improvement in the PM peak hour between US 40 and US 1 and a more than 19 minute improvement between IS-70 and MD 43. As summarized in *Table 2.2*, this equates to an average speed improvement of almost 42% in the AM peak hour along the Outer Loop and an 80% savings in travel time during the PM peak hour along the 19-mile segment of the Inner Loop between IS-70 and MD 43. The limited congestion that remains in the corridor results from constraints outside the Project limits.

Recurring Congestion Reduction with PTSU

Corridor Travel Time Reduction

- *Outer Loop (AM Peak Hour) =* ***17 mins***
- *Inner Loop (PM Peak Hour) =* ***20 mins***

Corridor Speeds Improvement

- *Outer Loop (AM Peak Hour) =* ***42%***
- *Inner Loop (PM Peak Hour) =* ***80%***

Freeway Density Improvement (Peak Hour)

- *Outer Loop (**72%** - AM | **82%** - PM)*
- *Inner Loop (**77%** - AM | **85%** - PM)*

Network Performance (Avg. Delay/Vehicle)

- *AM Peak Hour =* ***31%*** *reduction*
- *PM Peak Hour =* ***54%*** *reduction*

Table 2.2: Travel Time Savings along IS-695 with Proposed PTSU

Segment	**US 40 to US 1**		**IS-70 to MD 43**	
IS-695 Outer Loop [8–9 AM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	17 minutes	42%	**16 minutes**	**42%**
IS-695 Inner Loop [5–6 PM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	20 minutes	79%	**19 minutes**	**80%**

IS-695 Outer Loop

The Outer Loop segment of IS-695 between MD 43 and IS-70 experiences two congestion hot spots in the AM peak period and three congestion hot spots in the PM peak period as seen in *Figure 2.10* on page 11.

AM PEAK – The Outer Loop of IS-695 between MD 43 and IS-70 has significant congestion in the AM peak at two main locations: (1) between the merge from Cromwell Bridge Rd and the diverge to Providence Rd interchange and (2) at the IS-70 interchange. Between the merge from Cromwell Bridge Rd and the diverge to Providence Rd interchange, demand volumes exceed the capacity of this three-lane segment of the Outer Loop around the 7 a.m. timeframe during typical traffic conditions. As the queues from this congestion start to build, additional congestion starts to form at that same time between the on-ramp from Harford Rd and the off-ramp to Perring Pkwy. This worsens the congestion profile and extends queues past the US 1 interchange along the Outer Loop. This congestion lasts for most of the peak period and only starts to dissipate after 9 a.m., when the demand volume entering the Outer Loop drops below the capacity of this segment of IS-695. As seen in *Figure 2.10* on page 11, the PTSU segment proposed by our Team along the Outer Loop provides the additional capacity to process the unserved demand in the AM peak with the bottleneck not only eliminated, but the resulting increased throughput also processed downstream with the continuous PTSU in the corridor.

IS-695 Outer Loop – AM Peak

Overall, with the PTSU there is an improvement of more than ***16 minutes*** *of travel time and an improvement of* ***42%*** *increase in average speed along this stretch of the Outer Loop during the 8 a.m. to 9 a.m. time frame.*

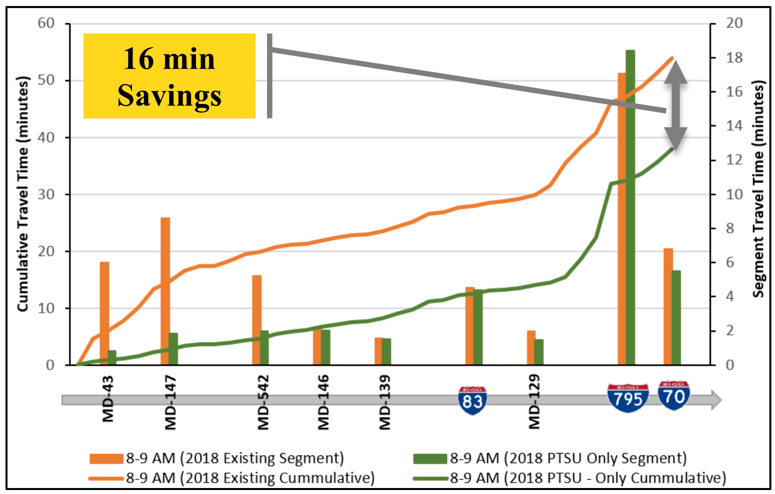
Along the Outer Loop past the IS-70 interchange, a congestion bottleneck location outside of the Project limits creates backup and queues which spill into the study area very early in the AM peak. There is additional friction from the on-ramp at the Liberty Rd interchange along with the heavy demand coming in from IS-795 that also adds to the congestion. Our proposed PTSU limits reduce the length of the queue spillback, but it does not eliminate this backup since the cause of the queueing is occurring outside of the Project limits. However, the increased throughput from the PTSU does help get vehicles through this network and resolves the secondary congestion that takes place at Liberty Rd.

PM PEAK – In the PM peak, the congestion at US 40 and Liberty Rd interchanges is observed but is much less intense when compared to the AM peak. The other congestion in the PM peak occurs at the IS-83 interchange and spills back to the Providence Rd interchange. This congestion is mainly caused due to the heavy on-ramp volumes entering the network from Dulaney Valley Rd, York Rd, and Charles St interchanges along with the lane drop past the IS-83 NB off-ramp. As seen in *Figure 2.10* on page 11, the proposed PTSU improvement in this segment eliminates most of the PM peak period congestion between MD 43 and IS-70, with the exception of the congestion that occurs at US 40 outside of the Project limits.

> ***IS-695 Outer Loop – PM Peak***
>
> *Overall, with the PTSU there is an improvement of more than* ***4.5 minutes*** *of travel time on average during the 4 p.m. to 5 p.m. time frame.*

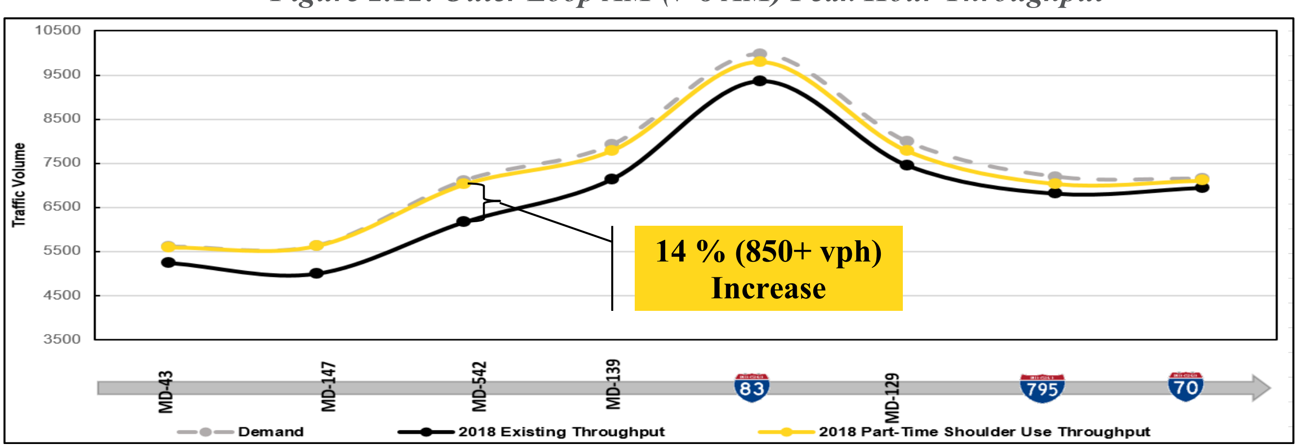
TRAVEL TIME – The resulting travel time benefits along the Outer Loop during the AM peak is shown in *Figure 2.11,* where the greatest benefit in travel time can be seen before the MD 146 interchange and the travel time is close to free flow conditions up to the IS-795 interchange. The congestion from US 40 results in traffic slowing down past IS-795, however, the travel time with the proposed PTSU is still better compared to the existing conditions between IS-795 and IS-70. In the AM peak hour, the proposed PTSU provides almost 16 minutes of travel time savings for vehicles traveling from MD 43 to IS-70. The greatest benefit along the Outer Loop in the PM peak is from Harford Rd to the IS-83 NB interchange. Due to the increase in throughput, downstream congestion that spills back from outside the Project limits increases travel times in the downstream segments. However, overall there is an improvement of 4.5 minutes in travel time in the PM peak hour.

Figure 2.11: Outer Loop AM Peak Hour Travel Time



VEHICLE THROUGHPUT – *Figure 2.12* shows how the proposed improvement will increase the throughput in the corridor compared to the existing conditions and will serve demand in the corridor along the

Figure 2.12: Outer Loop AM (7-8 AM) Peak Hour Throughput

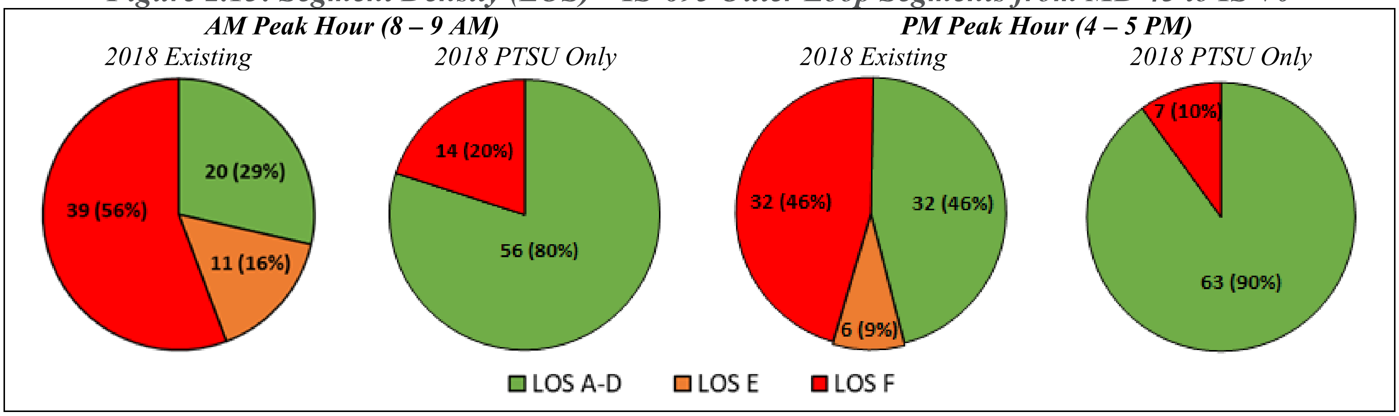


Outer Loop in the most constrained AM peak hour (7 a.m. to 8 a.m.). In some segments of the Outer Loop, our concept will relieve congestion and see a resultant increase of more than 850 vehicles throughput in the AM peak hour, compared to the existing conditions. In the PM peak, our design results in similar throughput benefits.

DENSITY – Along the Outer Loop between MD 43 and IS-70 there are a total of 70 different segments in the VISSIM network out of which 32 are basic freeway, 14 merges, 12 diverge, and 12 are weave segments. As seen in *Figure 2.13*, during the AM peak hour from 8 a.m. to 9 a.m., the proposed PTSU improvement reduces the number of segments operating at LOS E and F from 50 to only 14 segments. All other segments operate at an acceptable LOS D or better. ***That is an approx. 72% improvement for segments operating at LOS E and F that will operate under an acceptable LOS D or better with the proposed PTSU***. In the PM peak hour from 4 p.m. to 5 p.m., as seen in *Figure 2.13*, the number of segments operating at LOS E and F are reduced from 38 under existing conditions to only 7 segments with the proposed PTSU. ***That is an almost 82% improvement in segments that are operating at LOS E and F under existing conditions that will improve to LOS D or better with the proposed PTSU.***

> ***Outer Loop LOS Improvements***
> *In the AM and PM Peak Hours, with the PTSU improvements there is an approx.* ***72%*** *and* ***82% reduction****, respectively, in segments operating at an unacceptable LOS E and F, per the VISSIM model.*

Figure 2.13: Segment Density (LOS) – IS-695 Outer Loop Segments from MD 43 to IS-70



QUEUES – Along the Outer Loop during the AM peak, the average queues along the on-ramp from MD 43 back up to almost 4,000 ft during the 8 a.m. to 9 a.m. period. With the proposed PTSU improvements, this queue is eliminated during the entire AM peak period. Similarly, in the PM peak, under existing conditions the maximum queue on the on-ramp from IS-83 backs up to more than 1,485 ft during the 5 p.m. to 6 p.m. period. With the proposed PTSU improvements, the queues on this ramp are eliminated. ***With the proposed PTSU, there are no other ramps in the corridor where the average queues back up in the PM peak periods.***

IS-695 Inner Loop

Along the Inner Loop of IS-695 between IS-70 and MD 43 there is one main congestion hot spot in the AM peak and three distinct congestion hot spots in the PM peak period as seen in the peak period congestion diagram in *Figure 2.10* on page 11.

AM PEAK – In the AM peak, the heavy off-ramp volume from the Inner Loop to IS-83 south (Jones Falls Expy) causes congestion. The volume in this diverge segment peaks and exceeds capacity around 7:30 a.m. and the queues spill back up to the IS-795 interchange. This congestion lasts through most of the peak period and only starts to dissipate towards the end of the peak when the demand volumes start to

> ***IS-695 Inner Loop – AM Peak***
> *Overall, with the PTSU there is an improvement of* ***7 minutes*** *of travel time along this stretch of the Inner Loop during the 8 a.m. to 9 a.m. time frame.*

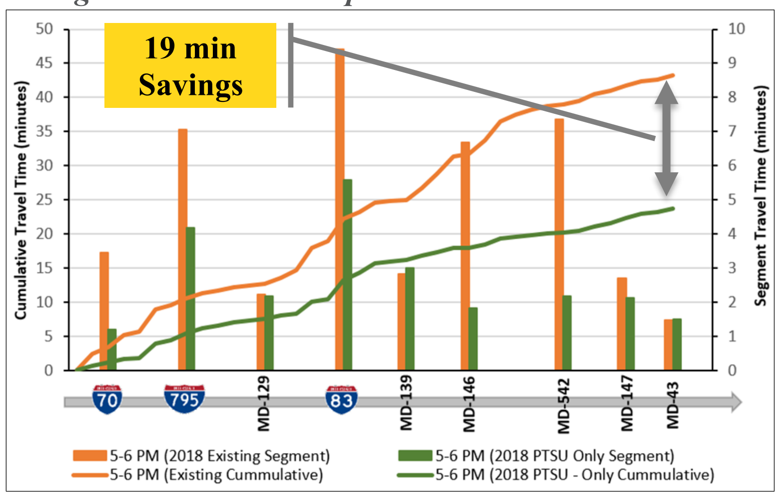
drop below the capacity. The PTSU proposed by the Myers Team along this segment of the Inner Loop will provide the additional capacity needed during the critical demand period. The additional capacity also creates gaps in the exit lane to improve the heavy off-ramp movement to IS-83 south. As seen in *Figure 2.10* on page 11, with the proposed PTSU improvement, the bottleneck is eliminated and the resulting increased throughput from the previously unserved demand is also processed downstream with the continued PTSU.

IS-695 Inner Loop – PM Peak
*Overall, with the PTSU there is an improvement of **19 minutes** of travel time and improvement of **80%** increase in average speed along this stretch of Inner Loop during the 5 p.m. to 6 p.m. peak hour. On an average, the travel time in the entire PM peak period from 3 p.m. to 7 p.m. improves by almost **14 minutes**.*

PM PEAK – There are three locations where congestion forms: (1) the diverge to IS-83 south, (2) between the on-ramp from Cromwell Bridge Rd and off-ramp to Perring Pkwy, and (3) due to consecutive merges from IS-70 and the Security Blvd (MD 122) on-ramp onto the Inner Loop. As seen in *Figure 2.10* on page 11, the proposed PTSU segment along the Inner Loop eliminates all three congestion bottlenecks with almost free flow conditions along the entire corridor during the PM peak.

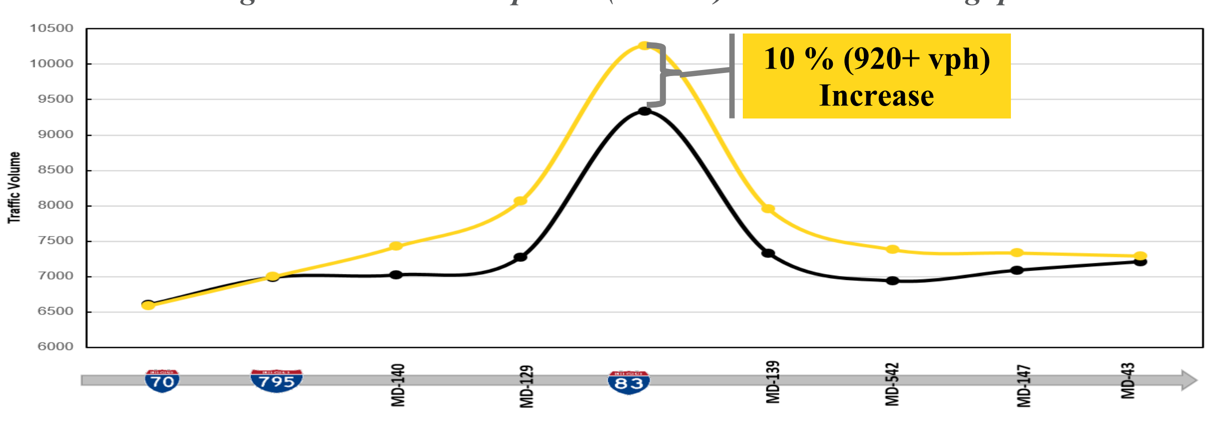
TRAVEL TIME – With the proposed PTSU, the resulting travel time benefits during the AM Peak Hour (8 a.m. to 9 a.m.), can be seen at the IS-83 interchange and the travel time is close to free flow conditions up to the Harford Rd interchange. The overall travel time with the proposed PTSU is still approx. ***24% better*** compared to existing conditions between the segment from IS-70 and MD 43. *Figure 2.14* shows the greatest benefit during the PM peak hour (5 p.m. to 6 p.m.) along the Inner Loop from IS-83 NB to the Harford Rd interchange. The overall travel time with the proposed PTSU is approx. ***44% better*** compared to existing conditions between the segment from IS-70 and MD 43.

Figure 2.14: Inner Loop PM Peak Hour Travel Time



VEHICLE THROUGHPUT – *Figure 2.15* shows how the proposed PTSU improvement and the added capacity will increase the throughput along the Inner Loop compared to existing conditions during the most constrained AM peak hour (7 a.m. to 8 a.m.). With the elimination of bottleneck congestion in the corridor

Figure 2.15: Inner Loops AM (7-8 AM) Peak Hour Throughput

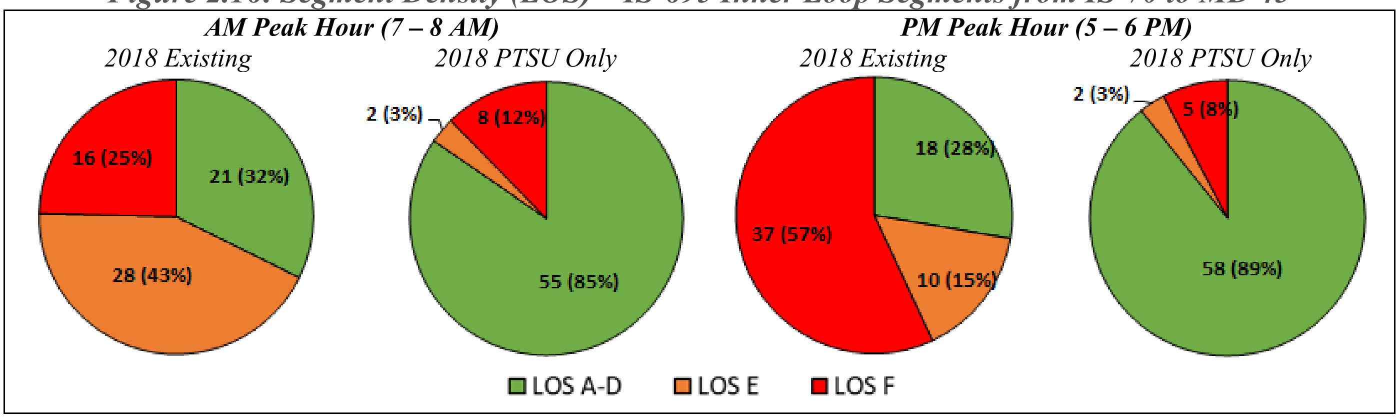


with the proposed PTSU, there is more throughput that is released downstream and is carried through the rest of the corridor without creating another downstream bottleneck. A similar increase in throughput is observed in the peak hours where congestion is reduced with the proposed design. For example, in the 4 p.m. to 5 p.m. peak hour we see an increase of more than 10% in throughput along the Inner Loop in segments where congestion is eliminated with the proposed PTSU.

DENSITY – As seen in *Figure 2.16*, out of the 65 different basic, merge, diverge, and weave segments along the Inner Loop between IS-70 and MD 43, in the AM peak hour between 7 a.m. and 8 a.m., there are 44 segments that are operating at LOS E or F. With the proposed PTSU improvement, this number is reduced to just 10 segments operating at LOS E or F while the remaining segments will operate at LOS D or better. That is nearly a 77% improvement of segments operating at LOS E or F under existing conditions. In the PM peak hour between 5 p.m. and 6 p.m., as seen in *Figure 2.16*, with the proposed PTSU improvement reduces the number of segments operating at LOS E and F from 47 to just 7, which is an improvement of almost 85% of segments. Almost 89% of all segments along the Inner Loop between IS-70 and MD 43 will operate at LOS D or better in the PM peak hour between 5 p.m. and 6 p.m.

Inner Loop LOS Improvements
In the AM and PM Peak Hours, the Total Project improvements provide an approx. ***77% and 85% reduction****, respectively, in segments operating at an unacceptable LOS E and F, per the VISSIM model.*

Figure 2.16: Segment Density (LOS) – IS-695 Inner Loop Segments from IS-70 to MD 43



QUEUES – Along the Inner Loop, the average queues on the on-ramp from IS-795 are about 50 ft in the AM peak between 7 a.m. and 9 a.m. With the PTSU segment proposed by the Myers Team in the corridor, this queue is eliminated during the entire AM peak period. There are no other ramps in the corridor where queues back up in the AM peak period. In the PM peak under existing conditions, there is significant queuing on the on-ramp from IS-70. Queues are beyond 4,900 ft at the beginning of the peak at 3 p.m. and go up to 16,280 ft by the end of the peak period at 7 p.m. ***With the proposed PTSU improvements, the queues on this ramp are eliminated.***

Intersection Operations

With the increased throughput provided by the proposed PTSU, the operations at the intersections within the study limits are maintained or in some instances improved. Vehicles on the mainline, however, are no longer constrained and will reach the ramp terminal intersections more quickly, likely requiring more time per signal cycle to clear the ramp. With signal timing optimization, the overall LOS of the intersections within the I-70 to MD 43 corridor either remains the same or is improved as compared to existing conditions in both the AM and PM peak periods.

Table 2.3, during the PM peak hours we see a similar performance of the intersections within the Project study limits. There is a slight improvement in the 6 p.m. to 7 p.m. hour, with the rest of the peak period intersections LOS remaining unchanged.

With the proposed improvements along this corridor, there is no degradation of operations along the arterials. The LOS and the queues at all the intersections along the arterials within the study limits remains equal to or better than existing conditions.

Table 2.3: LOS – PM Peak Period

LOS	A-D	E-F	A-D	E-F	A-D	E-F	A-D	E-F
Peak Hour:	**3-4 PM**		**4-5 PM**		**5-6 PM**		**6-7 PM**	
2018 Existing	39	0	37	2	36	3	35	4
2018 w/ PTSU	39	0	37	2	36	3	36	3

Networkwide Performance

The VISSIM microsimulation models also provide insight as to overall networkwide performance. One of the important parameters is the average delay per vehicle during the simulation period. As seen in *Table 2.4*, with the PTSU segment proposed by the Myers Team along the Inner Loop and Outer Loop, there is a significant decrease in the overall networkwide average delay per vehicle. In the ***AM peak there is a total reduction of 5% - 31%*** in the average delay per vehicle traveling through the network with the proposed PTSU improvements. In the ***PM peak we see even greater improvement, a reduction of 41% - 54%*** in average delay per vehicle in the network.

Table 2.4: Network Performance – Average Delay per Vehicle (AM and PM Peak Periods)

Average Delay per Vehicle	AM Peak				PM Peak			
	6-7 AM	7-8 AM	8-9 AM	9-10 AM	3-4 PM	4-5 PM	5-6 PM	6-7 PM
2018 Existing	80	180	213	93	123	195	199	146
2018 w/ PTSU	67	137	148	88	71	95	94	68
% Reduction	**17%**	**24%**	**31%**	**5%**	**42%**	**51%**	**52%**	**54%**

Connecting Ramps and Arterial Roadways

The Myers Team anticipates that PTSU improvements will considerably improve the existing entrance queues during the afternoon peak at the IS-70 ramp to the Inner Loop. ***There is also an improvement of almost 2 minutes in travel times for vehicles traveling from IS-695 ramps to IS-83 SB in both AM and PM peaks.*** In addition, during the afternoon peak there is 0.5 - 0.7 minutes of travel time saving for vehicles from IS-83 SB going to the Inner Loop. *Table 2.5* below and *Table 2.6* on page 18 show the summary of travel times improvements with the proposed PTSU in the AM and PM peaks, respectively. Detailed results of the VISSIM models are provided in *Appendix D-7.* These delay reductions are on the ramps movement before vehicles even reach the IS-695 Inner Loop, with additional travel time savings after they get on to IS-695 Inner Loop. ***The biggest improvement is for the vehicles traveling from IS-70 EB to IS-695 Inner Loop, a reduction of travel time ranging from 7.5 to 14.3 minutes in the PM peak period.***

Table 2.5: Ramp Movement Travel Times Reduction with PTSU Only (2018 AM Peak)

Movement	Improvement in Travel Times (Minutes) with PTSU Only				
	6-7 AM	7-8 AM	8-9 AM	9-10 AM	Average
IS-695 IL to IS-83 SB	0.0	0.6	**1.8**	0.0	0.5
IS-695 OL to IS-83 SB	0.0	0.0	0.0	0.0	0.0

Table 2.6: Ramp Movement Travel Times Reduction with PTSU Only (2018 PM Peak)

Movement	Improvement in Travel Times (Minutes) with PTSU Only				
	3-4 PM	4-5 PM	5-6 PM	6-7 PM	Average
IS-695 IL to IS-83 SB	2.2	1.9	0.4	0.3	0.7
IS-695 OL to IS-83 SB	0.4	0.6	0.6	0.2	0.4
IS-70 EB to IS-695 IL	7.5	**14.3**	13.9	10.7	11.4
IS-70 WB to IS-695 IL	1.0	1.7	1.5	1.0	1.3
IS-83 SB to IS-695 IL	0.0	0.5	0.7	0.0	0.3

iii. PERFORMANCE LIFE OF CONGESTION REDUCTION FOR PTSU

Each weekday along IS-695 through the Project limits, traffic steadily increases from about 6:00 a.m. onward. ***During the morning peak hours***, the most troublesome areas include the Outer Loop from MD 43 to MD 146, the Outer Loop from MD 140 to US Route 40, and the Inner Loop from IS-795 to IS-83 SB. Additional trouble spots are along the Inner Loop from IS-70 to IS-795 as well as the Outer Loop from IS-83 to Dulaney Valley Rd. ***During the afternoon peak hours***, traffic really begins to build by 3:00 p.m. The Inner Loop segment from Charles St to Loch Raven Blvd is the number one congested corridor statewide (2019 Mobility Report). Other trouble spots are the Outer Loop from IS-83 westward to IS-795, the Inner Loop from IS-70 to IS-795, the Inner Loop from IS-795 to IS-83, the Outer Loop from MD 43 to IS-83, and the Outer Loop segment from IS-795 to IS-70.

> ***PTSU Performance Life***
> *The Myers Team's proposed PTSU limits and predetermined hours of operations address AM and PM peak congestion areas and provide improvements that extend beyond 2040 for the majority of the IL & OL along the Project corridor.*

Predetermined Hours of Operation

Our Team analyzed the existing conditions data as shown in *Figure 2.10* on page 11 and recommends operating the PTSU lanes each weekday from ***6:00 a.m. to 10:00 a.m***. during morning peak period and from ***2:30 p.m. to 7:00 p.m.*** during the afternoon peak period. These time periods noted above include a 30-minute buffer before and after the peak traffic demand so that the PTSU lane opens before traffic builds to congested levels and closes after volumes have dissipated. Expanding the window of operation to include this buffer will delay the onset of recurring congestion. Toward the end of the peak period, congestion will dissipate faster when operating a part-time shoulder. As demand subsides at the end of the peak period, PTSU will increase corridor throughput and reduce the duration of congestion and the overall peak period.

Although traffic volumes vary by location, the Myers Team proposes to activate PTSU over the full Project limits at these preset times for operational consistency. For instance, if PTSU is operational on the Inner Loop between IS-70 and IS-795 during the afternoon peak, and not operational beyond IS-795, this would create a forced merge condition that would create conflict points and increase the likelihood of crashes.

The proposed operating hours are based on the existing conditions demand and congestion profile. As improvements are made along IS-695 to address congestion outside of our Project limits, there may be a need to reevaluate the operating times for the PTSU lanes. Our Team's proposed system is capable of adapting to the revised needs. The Myers Team anticipates that as the corridor experiences further traffic volume growth, these hours of operations may have to be extended.

While developing solutions to improve mobility and safety in the Project corridor, our Team implemented a Performance Based Practical Design (PBPD) assessment of design and use of PTSU to achieve MDOT SHA's performance objectives for the facility design and operations.

According to the FHWA guidance on use of PTSU, the term "part-time" does not require that the use of shoulders as a TSMO strategy is "short-term" and will be discontinued by some fixed date. Although PTSU may be used as an interim treatment while a conventional Project awaits funding or completion, it may also be used indefinitely. Our Team also understands that PTSU lanes are lower in capacity compared to the regular general-purpose lanes and are also restricted to passenger vehicles and single unit trucks only. While applying PTSU provides an immediate benefit to the corridor, it is important to know the anticipated performance life so that MDOT SHA can plan for other improvements to the corridor to address congestion and safety concerns.

Figure 2.17 on page 20 shows the 2040 congestion diagrams from the VISSIM modeling results for the corridor with the proposed PTSU as compared with the No-Build (Base) conditions for the AM and PM peak periods. It clearly shows that the proposed PTSU along the Inner Loop will continue to provide congestion relief benefits in the corridor beyond 2040. The congestion that exists in the corridor under existing conditions gets far worse under a No-Build scenario. However, with the provision of the PTSU along the Inner Loop during the AM and PM peak periods, most of the congestion in the corridor is eliminated. The resulting increase in throughput causes the existing queue at the end of the corridor to slightly worsen. This congestion is due to elements outside of the Project limits.

Along the Outer Loop of the IS-695 study corridor, the congestion that forms at the US 40 interchange to the south under existing conditions will exacerbate the bottleneck and result in a queue spill back that will eventually cover the entire Project corridor. By providing the proposed PTSU, the spill back can be contained up to the IS-83 interchange in the AM peak period. In the PM peak period however, due to heavy demand volumes entering the Outer Loop, this queue spills back through the entire corridor. With the PTSU, the magnitude and degree of congestion is greatly reduced compared to the No-Build conditions, but it shows that there will be a need for implementing other improvements in this corridor to fully address the congestion. *Appendix D* details the results of all the VISSIM analysis.

Performance Life

To understand when the congestion levels will return to the existing level, our Team analyzed the congestion at various segments along the Inner and Outer Loops. From the VISSIM models and the demand volumes provided by MDOT SHA, the Team identified the per lane capacity of the segments when they start to fail under existing conditions. This provides us a threshold of volume where operations along the freeway start to break down. We used the 2040 demand volumes provided by MDOT SHA to develop a growth rate between 2018 and 2040 and the FHWA recommended capacity was added for a PTSU lane to each of the segments. This helped us identify the year when demand will exceed the capacity threshold. *Table 2.7* shows that ***in most segments, the PTSU will help keep congestion levels below existing conditions far beyond 2040***. In the segment from IS-83 South to MD 43, the congestion will return to existing conditions congestion levels in the Inner Loop in the PM peak and in the Outer Loop in the AM peak by the year 2036. In the Outer Loop segment between IS-795 and IS-70 the congestion returns to existing conditions level in the AM peak by the year 2040. A detailed analysis is provided in *Appendix D*.

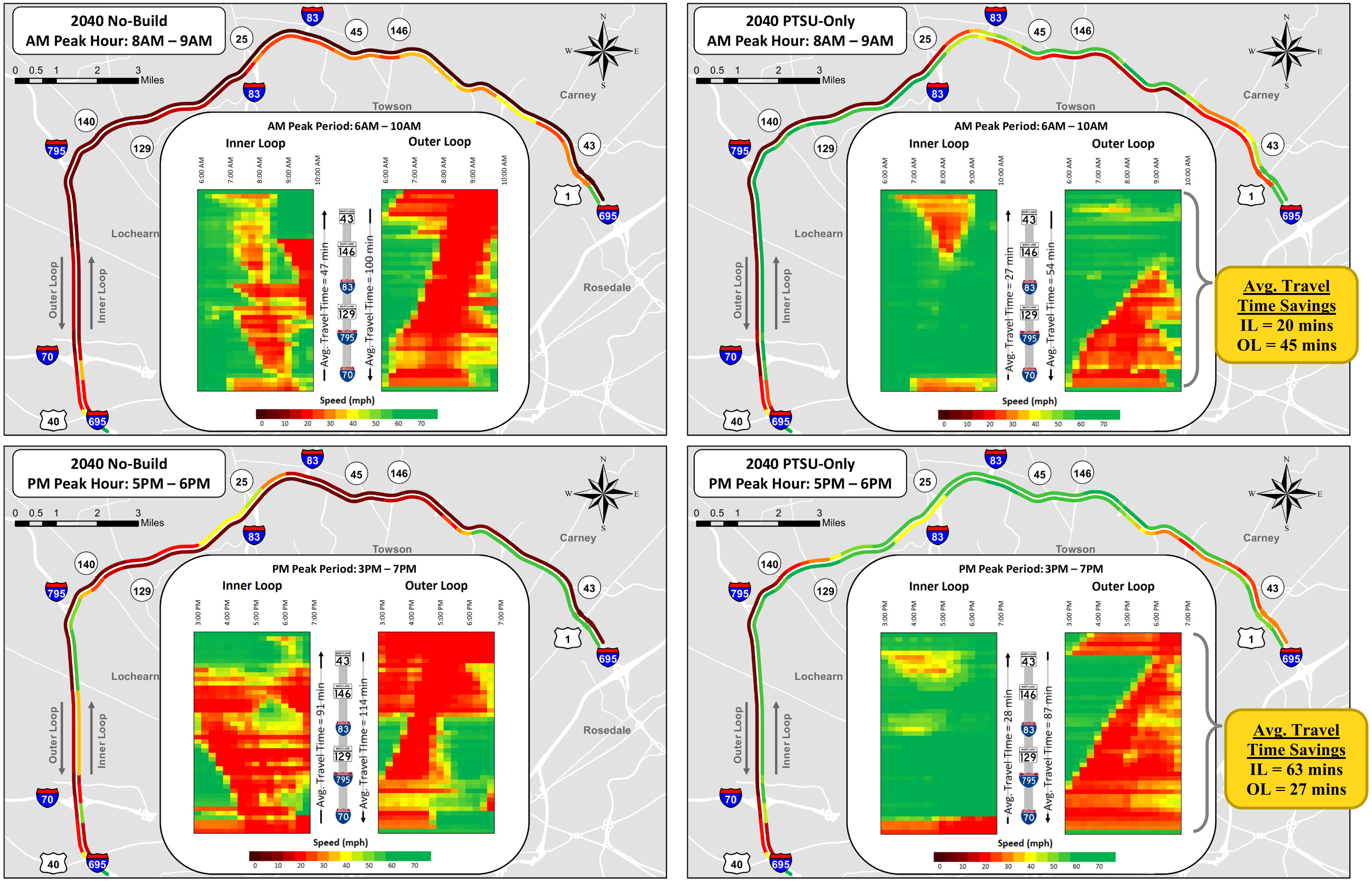
Hours of Operation

Determining ideal hours of operation is critical, and in many cases an iterative process; e.g. initial operating hours for the PTSU in Virginia approaching the American Legion Bridge were from 7-11AM and from 2-7PM on weekdays. After opening, AM traffic was building to the point where backups occurred before the lane opened. VDOT adjusted the opening time to 6AM.

Table 2.7: Performance Life of Network with PTSU Only

	Segment	Failing in Existing Condition?	Failure Year with PTSU Only
Inner Loop	IS-70 to IS-795	Yes, AM Peak	AM – 2042; PM – >2060
	IS-795 to IS-83 South	Yes, AM & PM Peaks	AM – 2043; PM – 2060
	IS-83 South to MD 43	Yes, PM Peak	AM - >2060; PM – 2036
Outer Loop	MD 43 to IS-83 North	Yes, AM & PM Peaks	AM – 2036; PM – 2052
	IS-83 North to IS-795	No	AM – >2060; PM – >2060
	IS-795 to IS-70	Yes, AM and PM Peaks	AM – 2040; PM – 2049

Figure 2.17: IS-695 Corridor Average Speeds and Congestion Diagrams (2040 VISSIM model results) – AM and PM Peak 2040 No-Build Conditions and with PTSU-Only Build Conditions

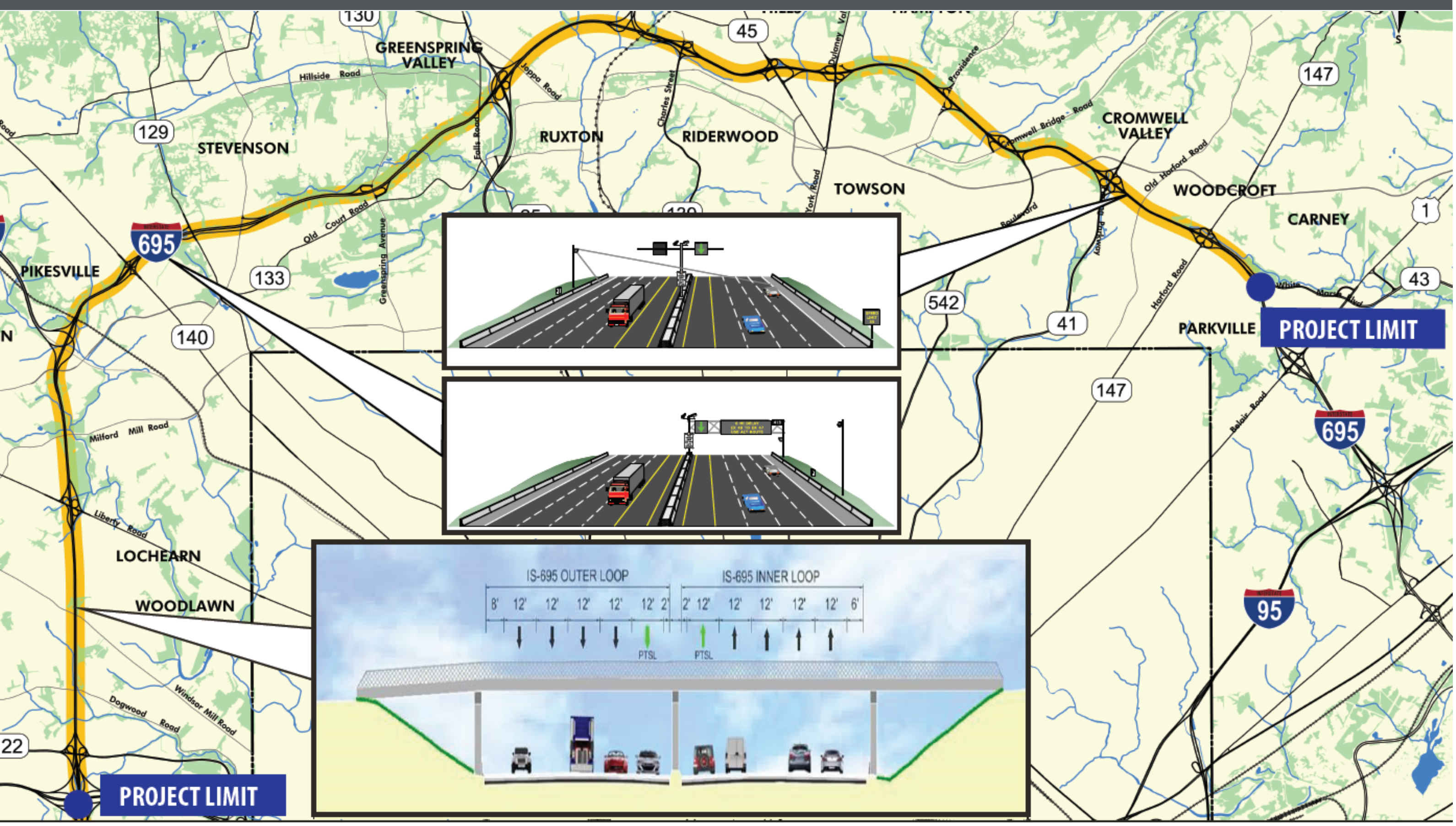


MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

INTERSTATE 695

2.09.03

MOBILITY



ALLAN MYERS + Bruce & Merrilees + WALLACE MONTGOMERY + Kimley»Horn

2.09.03 MOBILITY

Effective and reliable traffic flow along IS-695 is necessary for its function as a primary commuter route and for the vitality of economic development. The tableau of improvements proposed by the Myers Team maximizes vehicle throughput, minimizes vehicle travel times, and creates more reliable commuter trips between IS-70 and MD 43, as safely as possible, within the fixed budget.

Total Project Benefits

Inner Loop (2018 PM Peak Hour)

- *Travel Time Reduction =* ***20 mins***
- *Corridor Speed Improvement =* ***77%***

Networkwide (PM Network)

- *Avg. Delay/Veh =* ***54% Reduction***

Total PTSU miles added = ***35.36 miles***

- *Inner Loop =* ***17.71 miles***
- *Outer Loop =* ***17.65 miles***

Performance-Based Practical Design

Our Team's performance-based approach to decision-making focuses not just on the problem, but on the desired outcome. "Performance" is the ultimate objective measure of the system's ability to satisfy or exceed user needs and expectations, particularly relating to congestion, reliability, and safety. Understanding the factors affecting performance, and measuring those, will allow our Team and MDOT SHA to look beyond short-term solutions and take a longer-range view of system performance. By establishing performance objectives, a clear message is established during the planning and prioritization of projects with those same performance objectives, guiding the design and operations decisions further into the process. The performance objectives our Team considered for the Project include:

- **Mobility**: Improve corridor average speeds, throughput, and densities;
- **Reliability**: Reduce corridor and specific congested segment travel times and delays;
- **Safety**: Reduce corridor crash rates, secondary crashes, and debris clearance times (shoulder lanes);
- **Incident Management**: Reduce incident response times and delays; and
- **Maintenance**: Reduce lane closures and work zone crashes.

The Myers Team made use of quantitative tools, such as the MDOT SHA provided VISSIM models, as well as other qualitative measures, to test the projects to ensure the objectives are met and to determine which to prioritize.

i. IMPROVEMENTS OTHER THAN PART-TIME SHOULDER USE

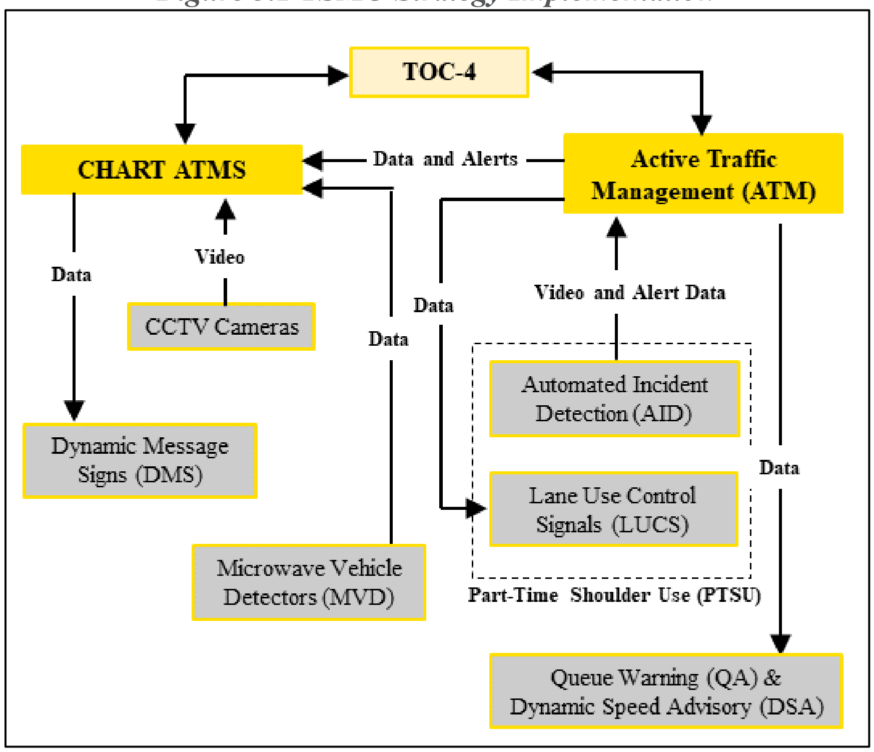
The Myers Team understands first-hand the challenges motorists face on IS-695 each day. Constructing continuous median PTSU lanes throughout the entire Project limits provides the most significant benefit to maximizing throughput, minimizing travel time, and improving reliability throughout the IS-695 Project area from IS-70 to MD 43. Our Team's best-value, performance-based practical design (PBPD) solution includes several other elements to complement PTSU, further enhancing mobility, reliability, and safety. We use an ITS "system of systems" that will seamlessly integrate with the current CHART ATMS to improve safety, streamline operations, and reduce incident identification and response times, while requiring only minor changes to CHART Standard Operating Procedures (SOPs). Geometric improvements include roadway widening to provide wider outside shoulder pull-offs for maintenance and emergency use as well as resurfacing and re-striping a section of IS-83 south to better accommodate entering traffic. Revisions to static signage and repairing areas where there is standing water and wet pavement crashes will further improve safety and reduce the effects of recurring and non-recurring congestion.

Our proposed best-value solution incorporates the PTSU, geometric improvements, ITS devices and technology to combat recurring and non-recurring congestion. We developed Transportation Systems Management and Operations (TSMO) technologies strategies to seamlessly integrate with the current CHART ATMS, streamline CHART Standard Operating Procedures (SOPs), and reduce incident response times.

TSMO Technology Strategies

Our Team is incorporating a variety of TSMO technology strategies and integrated solutions to provide an Active Traffic Management (ATM) system that interfaces with the existing CHART ATMS. The Southwest Research Institute (SwRI) software package, ActiveITS, will be the ATM system (ActiveITS ATM). To support the PTSU, this system includes enhanced detection, traffic management, and traveler information tools that increase existing CHART capabilities and improve safety and mobility along the corridor. We have reviewed our proposed enhancements with SwRI representatives. Our ActiveITS ATM and integrated solutions are scalable and adaptable to future changes in how the lanes are used (HOT or CAV-only) as well as for future projects in the MDOT SHA ITS long-range plan, such as deploying roadside infrastructure to support in-vehicle highway hazard alerts and in-vehicle highway signage systems (Long-Range Projects 3.9.6.1 and 3.9.7.1).

Figure 3.1 TSMO Strategy Implementation



As shown in *Figure 3.1,* the existing CHART ATMS system will integrate with the ActiveITS ATM to expand data collection and traffic monitoring; automatically detect incidents, disabled vehicles, and obstructions; and use strategic ITS devices to verify, respond, and support incident and traffic management processes to quickly clear incidents while optimizing the remaining capacity. The proposed technologies will interface through ActiveITS or through the existing CHART ATMS.

The primary benefit of ActiveITS ATM is improved incident management in the corridor. The ActiveITS ATM automatically recognizes a concern and notifies CHART staff at TOC-4. Once the Highway Operations Technician (HOT) confirms the incident, the event is created in the CHART ATMS with a recommended response plan selected based on the incident location and severity. The HOT can modify the incident details generated by the ActiveITS ATM and reflect actual conditions, including no response for false alarms or designation of additional resources for major incidents. ***We understand the pressure put on the HOTs and will ensure the number of false alarms is limited below the RFP maximum of one per 10 true notifications.*** The ActiveITS ATM is utilized to identify obstructions prior to opening the PTSU and notifies TOC-4 of any events that would prevent PTSU operations.

ConOps & SOP Development

The Myers Team will prepare a Concept of Operations to document corridor deficiencies; define required functionality; describe operational scenarios; and outline system interfaces along with updated SOPs to integrate into the existing MDOT SHA CHART system.

The proposed TSMO strategies described below will support PTSU in an integrated fashion. Each of these elements has numerous operational decisions rules, and parameters that will be agreed-upon with MDOT SHA to create a fully integrated and functional system. The proposed

ITS devices, as well as those currently in place in the corridor, are shown in relation to the PTSU lane typical sections on *Figures 3.2, 3.3, and 3.4*.

Figure 3.2: Segment 1 Typical Sections and ITS Devices

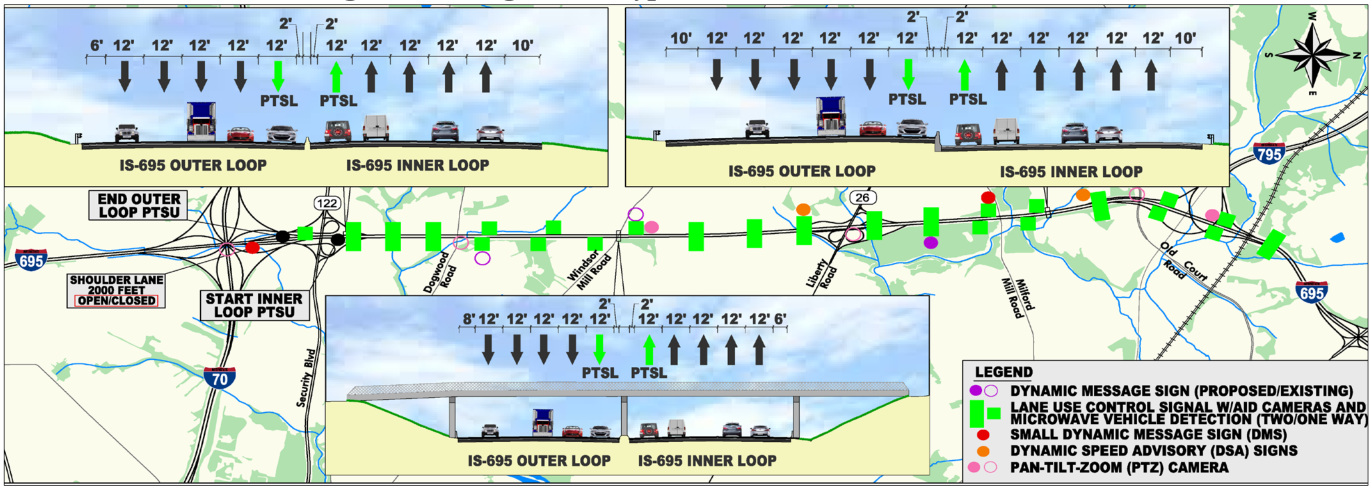


Figure 3.3: Segment 2 Typical Sections and ITS Devices

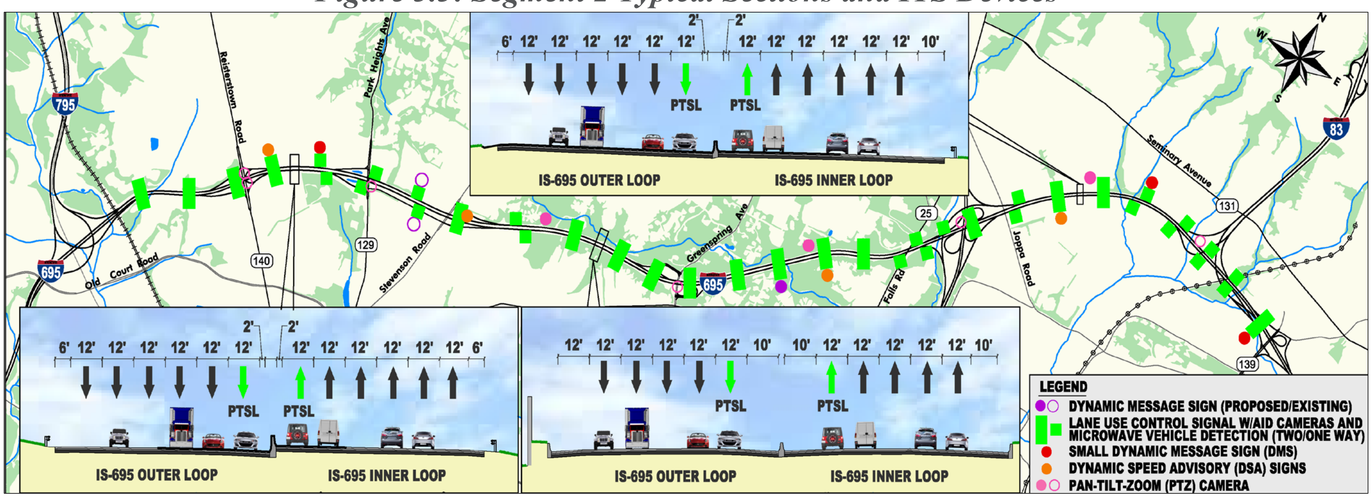
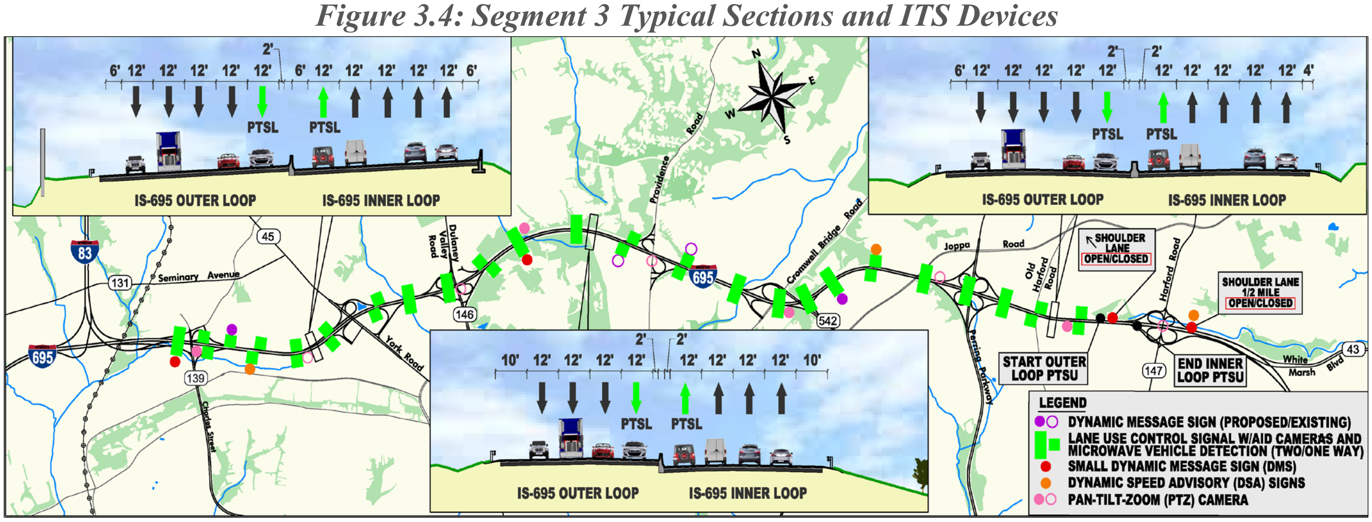


Figure 3.4: Segment 3 Typical Sections and ITS Devices



AUTOMATED INCIDENT DETECTION (AID) AND DEBRIS DETECTION SYSTEM – Video cameras and analytics software will enhance freeway operations. The system will continuously monitor the PTSU lane to detect stopped vehicles or obstructions that could impact PTSU operations. If an apparent incident has been detected, the Active ITS system will sound an alarm and create an event in the CHART ATMS. The HOT would then verify the incident using the PTZ camera system and either initiate the recommended response plan or modify it based on the circumstances. If an object is identified within the PTSU lane, the system will alert the HOT, who will confirm the obstruction and dispatch resources to clear debris. Once clear, the HOT will activate PTSU according to the appropriate strategy based on time-of-day and other activation parameters. This system will enhance incident response time and reduce the likelihood of an incident in the PTSU by sweeping the lane for debris or other obstacles in advance of opening. Continued monitoring by the AID video analytics also reduces the possibility of secondary crashes.

CONTINUOUS VEHICLE DETECTION – MVD will be installed throughout the corridor to provide HOTs with real-time traffic flow conditions. MVD are currently operational at some locations along the corridor; the Project will provide full vehicle detection at 1/4-mile spacing. In addition to collecting important volume, speed, and occupancy data, MVDs will also be used to identify incidents on the mainline and determine the extent and duration of PTSU operation in response to non-recurring congestion.

DYNAMIC MESSAGE SIGNS – Our Team is deploying full-size overhead and small pedestal-mounted dynamic message signs to complement the existing DMS within the corridor. DMS will be placed at key decision points along the corridor and at locations with a high potential for vehicle queues. The small DMS will be coupled with the DSA signs to increase driver awareness of rapidly changing conditions well in advance of an incident, to reduce the number and severity of crashes. The DMS are consistent with the Statewide ITS Architecture, and will complement CHART's current DMS on the Outer Loop at Providence Rd (#409), Stevenson Ln (#427), and Windsor Mill Rd (#407); and on the Inner Loop at Featherbed Rd (#405), Park Heights Ave (#408), Providence Rd (#4413), and east of MD 43 (#8471). The Myers Team will provide four new full-size and five smaller pedestal-mounted DMS to enhance traveler information and disseminate more information about queue warning and PTSU operation.

> ***DMS Travel Time Savings***
> *DMS support enhances traveler information and has been found to provide an average of **3 minutes** travel time savings when providing actionable information that is acted upon (TOPS-BC, FHWA).*

ENHANCED CCTV CAMERA COVERAGE – Our Team will provide additional coverage of pan-tilt-zoom (PTZ) cameras throughout the entire corridor to eliminate blind spots and provide enhanced traffic monitoring capabilities. This will improve safety on the corridor by providing operators with full surveillance capabilities to monitor traffic conditions, verify incidents or debris, and detect slowdowns. The enhanced visuals support the effective implementation of PTSU and other strategies such as Queue Warning and DSA signs. Camera feeds will be visible through the CHART ATMS, as existing cameras are today, enabling HOTs to quickly identify and verify incidents in the corridor. Enhanced cameras will provide full coverage of the Project corridor, increasing reliability of incident information, and reducing incident response conservatively by 20% (NTIMC, 2011).

DYNAMIC SPEED ADVISORY (DSA) AND QUEUE WARNING (QW) SIGNS – Use of existing and new DMS to display real-time warning messages and DSA signs showing reduced advisory speeds will inform travelers of downstream changes in travel speeds due to crashes or congestion. Advisory speed change is based on the detection of downstream congestion and is intended to smooth ("harmonize") upstream traffic flow and improve safety. It is intended to mitigate vehicles traveling at higher speeds from approaching an unexpected back of queue; as well as increase driver awareness of changing downstream conditions. DSA signs and QW information will be installed in five locations where sight distance is limited on curves, as well as through areas where traffic flow often breaks down as it reaches capacity. Specifically, these area are at the:

- Inner Loop at the IS-83 North merge
- Inner Loop prior to York Rd
- Outer Loop prior to Cromwell Bridge Rd
- Outer Loop prior to IS-795
- Outer Loop in advance of the southern terminus at IS-70

Studies have shown QW achieves a 14% reduction in queuing crashes and 11% reduction in injury crashes (IDOT). QW and DSA have also proven to provide significant mobility benefits through enhanced progression and reduced incidents; systems similar to that being recommended have shown an average of 5% reduction of travel time (FHWA, 2017) resulting from increased driver awareness of changing conditions, which has the potential to reduce the number and severity of crashes. As these segments demonstrate safety benefits, DSA signs can easily be expanded to other segments of the corridor.

ENHANCED TRAVELER INFORMATION STRATEGIES – Proactive deployment of traveler information strategies will reduce recurring congestion and the number and severity of incidents along IS-695. These strategies consist of traveler information messages about downstream conditions; alerting drivers that conditions are changing. These messages are displayed in real-time on DMS and pushed to 511 and other traveler information websites and alert services. Enhanced real-time information allows drivers to adapt, prepare, mitigate potential crashes, and avoid congestion.

MAINLINE INCIDENT DETECTION – With the enhanced MVD and CCTV camera deployments, HOTs will have more video feeds and traffic data along the corridor at their disposal. This data and video can also be used to identify anomalies (such as backups in non-typical locations or at non-typical times of the day) that could be the result of an incident along the IS-695 mainline. These systems operate in the background and only send alerts to operators when a significant anomaly is detected. We will conduct an initial evaluation of this system to maximize the effectiveness and usefulness to MDOT SHA operations.

Other Work Elements

REMEDIATION OF WET PAVEMENT – Our Team will resolve the existing drainage issues at the Inner Loop curve between IS-795 and MD 140 and near the bridge over Joppa Rd that were identified in the RFP. We will adjust the roadway cross-slope and repair the damaged frames and grates that contribute to the problems, and will resurface the roadway in these areas. We will also ensure that the standing water on the Outer Loop at MM 28.5 is addressed by the ongoing drainage project at Cromwell Bridge Rd.

MEDIAN BARRIER RETROFIT AND REPLACEMENT – The Myers Team will replace or retrofit approximately 10 miles of median barrier, of which much is substandard barrier because it is less than the required 42-in height, is a temporary barrier, is a modified barrier with W-beam, or is deteriorating. Seven miles of the median barrier will be retrofit with straight-slope median barrier built in to the existing barrier. The installation of DMS and LUCS, as well as drainage improvements in the median and replacement of damaged barrier identified in the RFP, will account for another three miles of replacements. We will remove broken and fractured concrete on existing median barrier to remain and repair it with non-shrink grout. We will patch spalls, remove delaminated areas, and patch them with non-shrink grout. Offset median sections, such as what exists between the IS-83 ramps, will be made flush with adjacent barrier.

LANE USE IMPROVEMENTS ON IS-83 SOUTH – The exit from the Inner Loop to the Jones Falls Expy (JFX) is a single lane ramp where demand exceeds capacity during peak periods. Traffic on this ramp currently merges into the two-lane ramp from the Outer Loop that is also near capacity. The two lanes entering on MD Route 25A from the north carry considerably less traffic than the single lane ramp from the Inner Loop, and one of the lanes continues southward as a through lane. Our Team proposes to repurpose the lanes where the single lane from the Inner Loop and the two lanes from the Outer Loop continue as the three through lanes southward, maintaining the interstate-to-interstate connection and improving operations. We will add “EXIT ONLY” to the existing overhead sign on southbound MD Route 25A at the ramp to the Inner

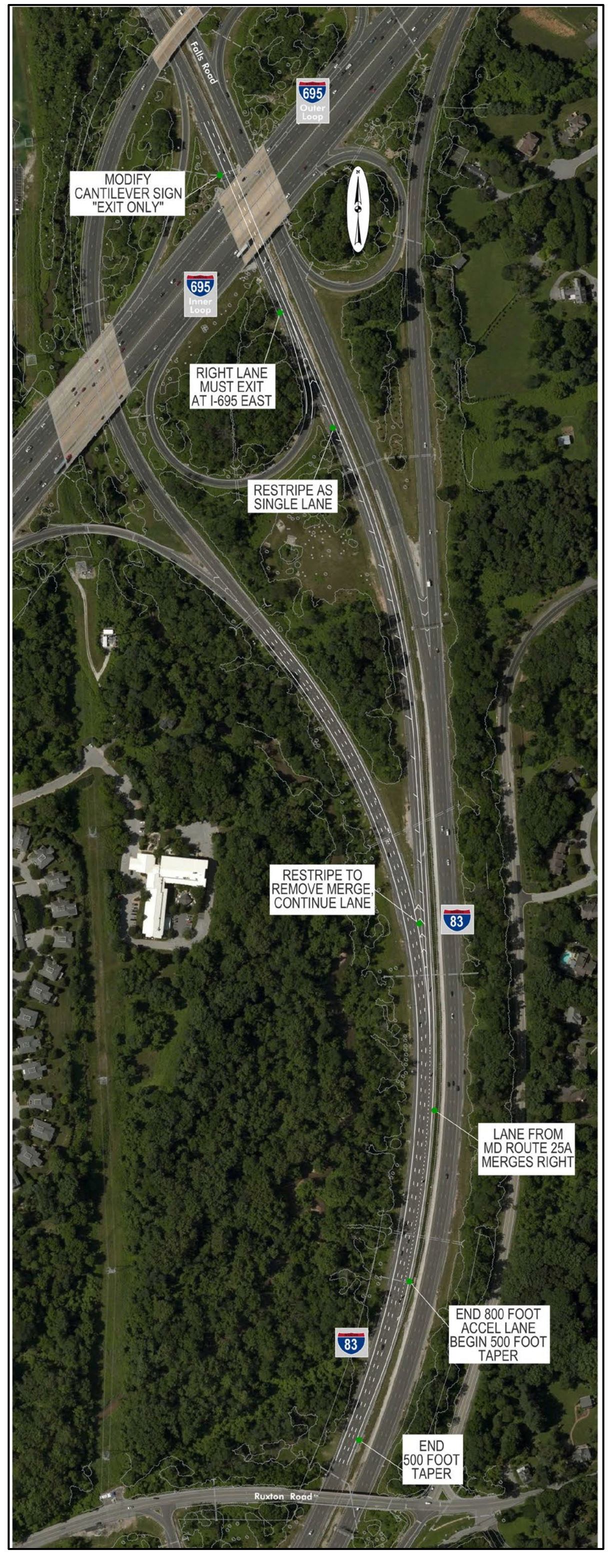
Loop and adjust the lane markings to carry a single lane beyond the ramp, as shown in *Figure 3.5*. We will also modify the lane markings on the ramp from IS-695 and perform pavement wedge/level at the entrance gore with MD Route 25A. Existing static signage will be removed, relocated, or replaced as needed.

DRAINAGE INLET RETROFIT AND REPLACEMENT – Drainage inlets are in poor condition at several locations in the corridor. The inventory notes that half of the 429 inlets along the median are in some sort of disrepair. Most of these inlets will be in the PTSU lane. Per RFP, our Team will repair the broken existing median inlets, replacing frames and grates that are cracked, fractured, or broken. We are also adding median inlets and drainage pipe to ensure that the two-year storm spread remains less than 4 ft adjacent to the PTSU lane per the RFP. We will inspect existing outfalls and perform improvements on pipe runs in areas where the hydrologic conditions are being modified.

SIGNAGE IMPROVEMENTS – Our Team will review the existing signage at all interchanges and recommend updates. For example, the existing guide signs for IS-795 on the Outer Loop are incorrect, as there are two lanes that may exit but only one "EXIT ONLY" lane is shown, leading to driver confusion and unnecessary sudden lane changes that likely contribute to the increased crash frequency at that location. We will modify the existing sign to indicate that both lanes may exit.

STORMWATER MANAGEMENT – Stormwater management (SWM) is required for this Project to account for the shoulder reconstruction, pavement widening, and drainage area shifts due to superelevation changes of the shoulders. Water quantity control for channel protection and 10-year peak discharge management must be provided at each point where runoff leaves the right-of-way. Water quality control may be provided anywhere within the same 6-digit watershed. SWM will be provided by first looking at opportunities to provide grass swales or bio-swales along the roadway within the existing right-of-way. Emphasis will be placed on avoiding impacts to steep slopes, natural resources, or utilities. Opportunities will be evaluated within interchanges for non-linear facilities such as micro-bioretention or bioretention facilities. There are several existing SWM facilities in the corridor. We will evaluate impacts to the hydrologic conditions of the facilities and ensure they still function as designed.

Figure 3.5: ATC 23 – IS-83 South



ii. RECURRING CONGESTION REDUCTION FROM THE TOTAL PROJECT

Recurring Congestion Reduction from Total Project

- *Corridor Travel Time Reduction*
  - *Outer Loop (AM Peak Hour) = **18 mins***
  - *Inner Loop (PM Peak Hour) = **20 mins***
- *Corridor Speed Improvement:*
  - *Outer Loop (AM Peak Hour) = **47%***
  - *Inner Loop (PM Peak Hour) = **77%***
- *Freeway Density Improvement (Peak Hour):*
  - *Outer Loop (**72%** - AM | **82%** - PM)*
  - *Inner Loop (**77%** - AM | **83%** - PM)*
- *Network Performance (Avg. Delay per Vehicle):*
  - *AM Peak Hour = **34%** reduction*
  - *PM Peak Hour = **54%** reduction*

Recurring congestion is most easily described as the "typical" roadway congestion experienced by drivers during the morning and afternoon peak hours as a direct result of the vehicle demand outpacing the available roadway capacity. According to the 2019 Mobility Report, recurring congestion accounts for 40% of the roadway congestion drivers experience statewide. Drivers will typically take these delays into account as part of their commutes. Non-recurring congestion, discussed in the next section, results from an atypical situation in which capacity is reduced while demand remains the same. It could be due to a crash, a weather event, work zone, or other emergency.

The proposed TSMO technology strategies that the Myers Team is proposing will contribute to reducing recurring congestion. PTSU will mitigate nearly all the existing recurring congestion through the corridor according to our modeling results, in some instances saving more than 20 minutes of travel time. Queue Warning (QW) and Dynamic Speed Advisory (DSA) signs have proven to provide significant mobility benefits by reducing the number of incidents in hot spot locations by alerting drivers of changing conditions. Systems similar to that being recommended have shown an average 5% reduction of travel time (FHWA, 2017). Full camera coverage offers significant mobility impacts through enhanced situational awareness, reduced response times, and improved incident management. Studies have estimated an average benefit-to-cost-ratio for camera systems of 12:1 (SCDOT, 2007). DMS messages support enhanced traveler information and have been found to provide an average of 3 minutes travel time savings when providing actionable information that is acted upon (TOPS-BC, FHWA). In addition, the Automated Incident Detection (AID) system and enhanced PTZ CCTV camera coverage will provide full coverage of the PTSU lane and mainline, increasing reliability of incident information. This has shown to reduce incident response conservatively by 20% (NTIMC, 2011). It is anticipated that the recommended strategies will, together, provide significant positive impact to mobility, reducing both recurring and non-recurring congestion.

Our Team used a variety of data sources to understand the recurring congestion in the Project area, including the provided VISSIM model, the 2019 Mobility Report, historic data from the Regional Integrated Transportation Information System (RITIS), INRIX data, and historical traffic counts. The recurring congestion on IS-695 within the Project area is variable, focused in "segments". In the morning, drivers from Westminster, Reisterstown, and other residential areas travel the Northwest Expy (IS-795) toward Baltimore and clog the Inner Loop on their way to the Jones Falls Expy (IS-83 South) as well as the Outer Loop heading toward IS-70 and IS-95. Similarly, drivers on the Harrisburg Expy (IS-83 North) travel the Outer Loop to remain on IS-83 into Baltimore, or travel the Inner Loop to get to Towson, the Baltimore County center of government. The congestion on the Outer Loop from IS-95, US 1, and points east of the Project area is some of the worst recurring congestion in the state. This recurring congestion is present from about 6:00 a.m. onward, and typically extends to 10:00 a.m each weekday. Implementation of the proposed median PTSU and other improvements on IS-695 are expected to result in great benefits based on the VISSIM modeling, during peak travel periods for reducing recurring congestion and improving travel time, vehicle throughput, density, and intersection operations within the corridor as described in this section. It is important to note that VISSIM software has limitations in what it can model. Using the models provided by MDOT SHA, it is possible to quantify the benefits of some of the proposed improvements, such as the PTSU and the IS-83 SB improvements during the average weekday AM and PM peak conditions. However, due to the limitations of the software, it is not possible to use these models to quantify benefits of other proposed ITS solutions such as AID, Full Camera Coverage, etc., or to quantify non-recurring congestion benefits. So the total benefits from all the improvements proposed by the Myers Team will be greater than what is quantified using the VISSIM models.

Quantitative Assessment of PTSU & IS-83 Improvements (Total Project Build)

Using Performance Based Practical Design (PBPD) criteria, the Myers Team has developed a set of innovative and practical solutions including providing a PTSU lane along the entire Project corridor and other roadway and technology solutions. *Figure 3.6* on page 29 shows a comparison of the existing conditions with the proposed Total Project Build conditions as calculated from the MDOT SHA provided VISSIM model results for the AM and PM peaks. *Figure 3.6* on page 29 and *Table 3.1* show the improvement in average speeds along the Project corridor during the heaviest peak hour as well as the entire peak period. They also show how the proposed Total Project improvements eliminate most of the bottlenecks and congestion within the Project limits and results in an almost free flow condition. With the elimination of recurring congestion, the reliability of the corridor will be significantly improved.

Figure 3.6 on page 29 shows heat maps of the existing conditions and hot spot locations along the Inner and Outer Loops for the AM and PM peak periods from the MDOT SHA existing conditions VISSIM models. The IS-695 map shows the average travel speeds during the worst AM peak hour (8 a.m. – 9 a.m.) and PM peak hour (5 p.m. – 6 p.m.). The inside box shows a congestion diagram for the entire AM peak period (6 a.m. – 10 a.m.) and PM peak period (3 p.m. – 7 p.m.). These congestion diagrams show how the congestion builds up, how far the queues extend, and how the congestion dissipates in the project area.

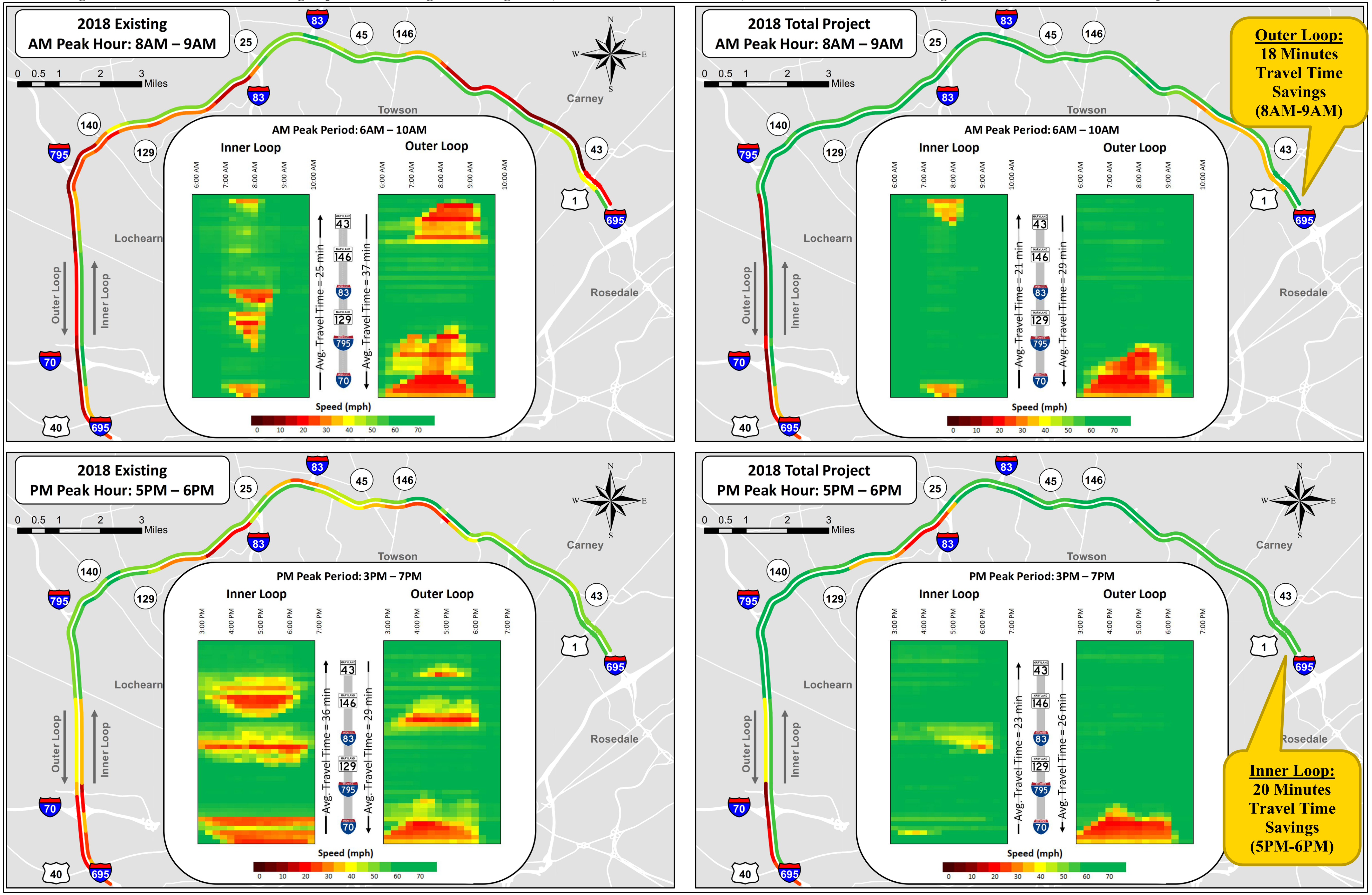
Looking at the congestion diagram of the IS-695 corridor in *Figure 3.6* on page 29 with the proposed Total Project Build, there is reduction in congestion in the worst peak hour as well as during the entire peak period in both the AM and PM peaks. The limited congestion that remains in the corridor results from constraints outside the Project corridor. This congestion relief provided by the proposed Total Project Build accounts for more than 18 minutes of travel time improvement in the 8 a.m. to 9 a.m. peak hour along the Outer Loop between US 40 and US 1 and over 17 minutes improvement between IS-70 and MD 43. Along the Inner Loop there is an improvement of more than 20 minutes of travel time in the 5 p.m. to 6 p.m. peak hour between US 40 and US 1 and approximately 19 minutes improvement between IS-70 and MD 43.

As shown in *Table 3.1*, this equates to an improvement in average speeds of almost 47% in the worst hour of the AM peak for vehicles traveling along the Outer Loop and more than 77% improvement in average speeds for vehicles traveling along the Inner Loop during the worst hour of the PM peak. Detailed results of the VISSIM models and support files are provided in *Appendix D*.

Table 3.1: Travel Time Savings along IS-695 with Proposed Total Project Build

Segment	US 40 to US 1		IS-70 to MD 43	
IS-695 Outer Loop [8-9 AM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	18 minutes	47%	**17 minutes**	**47%**
IS-695 Inner Loop [5-6 PM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	20 minutes	77%	**19 minutes**	**78%**

Figure 3.6: IS-695 Corridor Average Speeds and Congestion Diagrams (2018 VISSIM model results) – AM and PM Peak Existing Conditions and with Total Project Build Conditions



IS-695 Outer Loop

The Outer Loop of IS-695 between MD 43 and IS-70 experiences two heavily congested areas in the AM peak period and three in the PM peak period as seen in *Figure 3.6* on page 29.

> ***IS-695 Outer Loop – AM Peak***
> *Overall, with the Total Project build conditions, there is an improvement of more than **17 minutes** of travel time, an average speed of **47%** along this stretch of the Outer Loop during the 8 a.m. to 9 a.m. time frame.*

AM PEAK – The Outer Loop of IS-695 between MD 43 and IS-70 has significant congestion in the AM peak at two main locations. The first location where the congestion develops in the AM peak is between the merge from Cromwell Bridge Rd and the diverge to Providence Rd interchange. Around the 7 a.m. timeframe during typical traffic conditions, the demand volumes exceed the capacity of this three-lane segment of the Outer Loop. As the queues from this congestion start to expand, additional congestion starts to form at that same time between the on-ramp from Harford Rd and the off-ramp to Perring Pkwy. This worsens the congestion profile and extends queues past the US 1 interchange along the Outer Loop. This congestion lasts for most of the peak period and starts to dissipate after 9 a.m. when the demand volume entering the Outer Loop drops below the capacity of this segment of IS-695. The Total Project build conditions proposed by the Myers Team along the Outer Loop provides the additional capacity to process the unserved demand during the 7 a.m. to 9 a.m. critical demand time. As seen in *Figure 3.6* on page 29, with the proposed Total Build improvement, the bottleneck is not only eliminated, but the resulting increased throughput from the previously unserved demand is also processed downstream with the continued PTSU in the corridor.

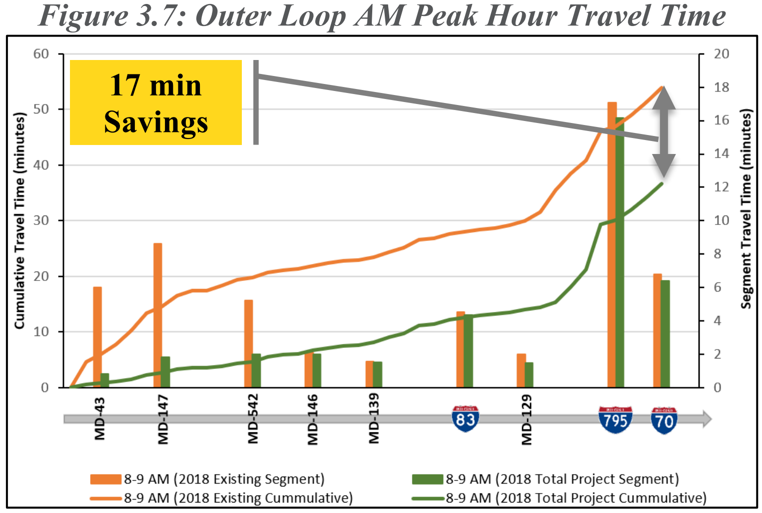
The second location where the congestion develops in the AM peak along the Outer Loop is past the IS-70 interchange located just outside of the Project limits. The backup and queues from this congestion spill into the study area very early in the AM peak. There is additional friction from the on-ramp at the Liberty Rd interchange along with the heavy demand from IS-795 that adds to the queue. Our Total Project build improvements reduce the length of the queue spillback, but it does not eliminate this backup since it is occurring outside of the Project limits. However, the increased throughput from the PTSU in this segment does help get vehicles through this corridor and resolves the secondary congestion that takes place at Liberty Rd.

> ***IS-695 Outer Loop – PM Peak***
> *Overall, with the Total Project build conditions, average travel time improvement of more than **4.2minutes** during the 5 p.m. to 6 p.m. time frame.*

PM PEAK – In the PM peak the congestion at IS-70 and Liberty Rd (MD 26) interchanges is observed but is much less intense when compared to the AM peak. The other congestion in the PM peak happens at the IS-83 interchange and spills back up to the Providence Rd interchange. This congestion is mainly caused due to the heavy on-ramp volumes entering the network from Dulaney Valley Rd, York Rd, and Charles St interchanges along with the lane drop past the IS-83 NB off-ramp. As seen in *Figure 3.6* on page 29, with the proposed Total Project build improvement in this segment of the corridor, most of the PM peak period congestion is eliminated with the exception of the congestion past the IS-70 interchange that occurs outside of the Project limits.

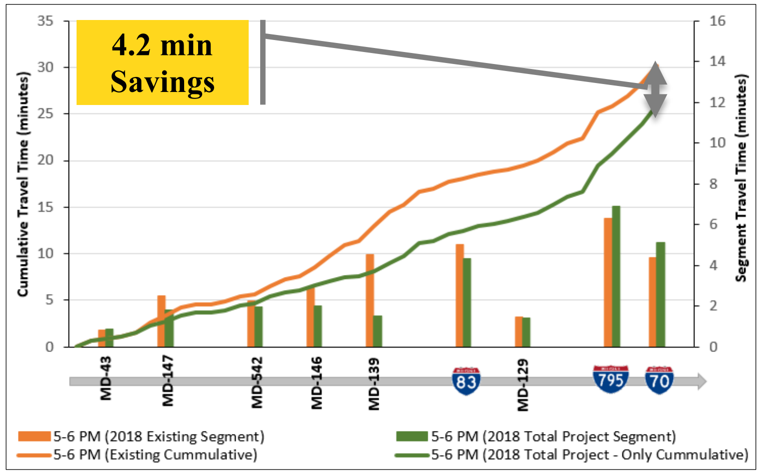
TRAVEL TIME – The resulting travel time benefits along the Outer Loop during the AM peak can be seen in *Figure 3.7* where the

Figure 3.7: Outer Loop AM Peak Hour Travel Time



greatest benefit in travel time can be seen before the MD 146 interchange and the travel time is close to free flow conditions up to the IS-795 interchange. The congestion from US 40 results in traffic slowing down past IS-795 however the travel time with the proposed Total Project is still better compared to the existing conditions between the segment from IS-795 and IS-70. In the 8 a.m. to 9 a.m. peak hour, the proposed Total Project improvements provide more than 17 minutes of travel time saving for vehicles traveling from MD 43 to IS-70, which amounts to a 32% reduction.

Figure 3.8: Outer Loop PM Peak Hour Travel Time



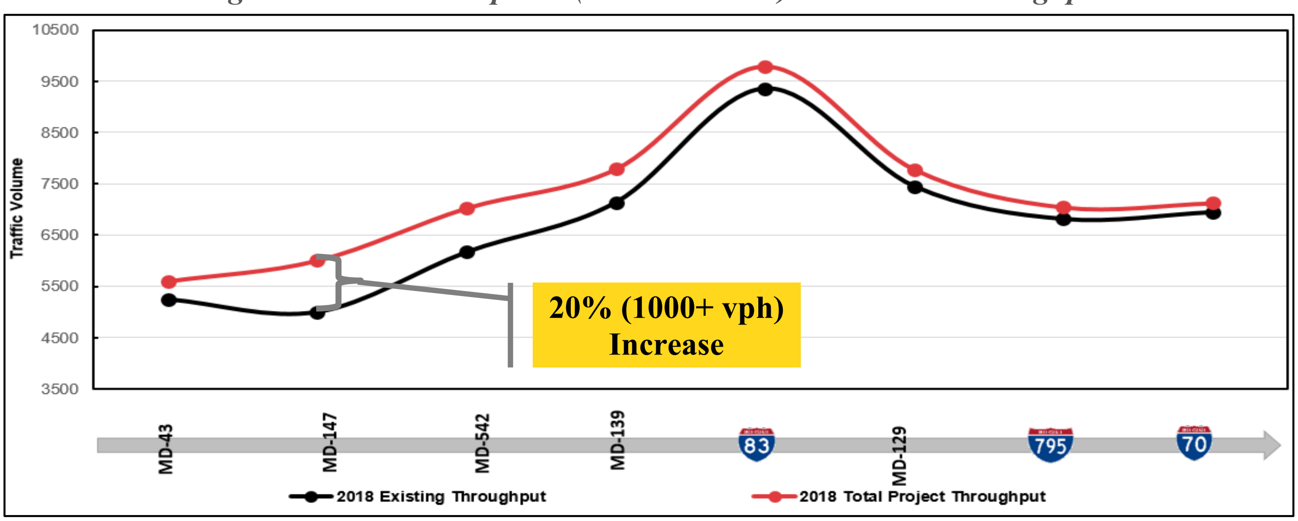
Looking at *Figure 3.8*, the greatest benefit in the PM peak from 5 p.m. to 6 p.m. along the Outer Loop can be seen from Harford Rd to the IS-83 NB interchange. Due to the increase in throughput the downstream congestion that spills back from outside the Project limits increases travel times in the downstream segments. However, overall there is still **more than 4 minutes of improvement in the travel time** in the corridor, which amounts to a **14 percent reduction.**

Outer Loop LOS Improvements

In the AM and PM Peak Hours, the total Project improvements provide an approx. ***72%*** *and* ***82%*** *reduction, respectively, in segments operating at an unacceptable LOS E and F, per the VISSIM model.*

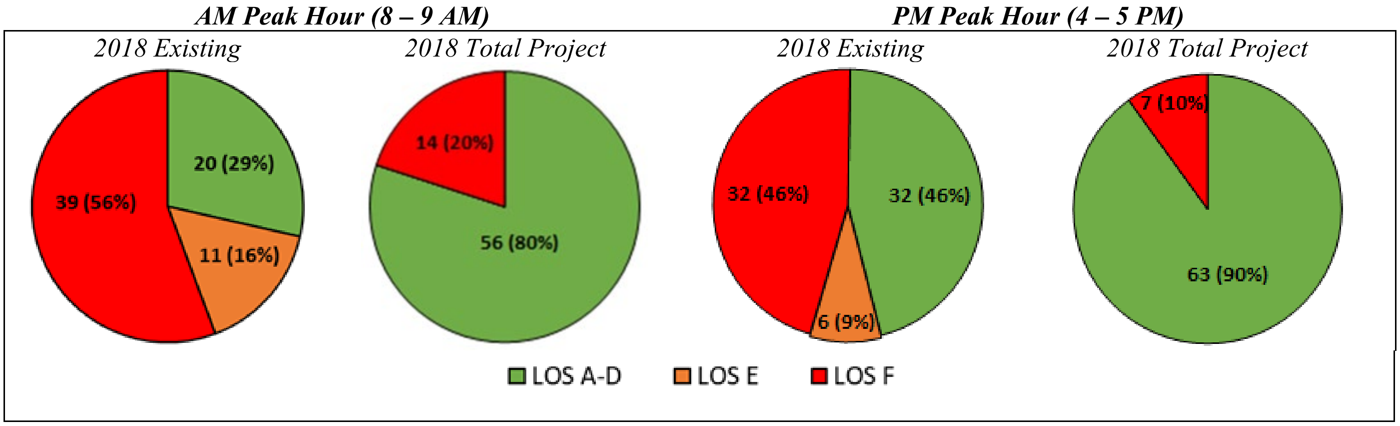
VEHICLE THROUGHPUT – *Figure 3.9* shows how the proposed Total Project improvement and the added capacity with the PTSU will increase the throughput in the corridor compared to the existing conditions and will be able to serve demand in the corridor up to IS-795 along the Outer Loop in the most congested AM peak hour (7 a.m to 8 a.m). In some segments of the Outer Loop, the Myers Team concept will be able to process an additional 1,000 vehicles per hour more than the existing conditions without breaking down. A similar increase in throughput is also observed in the PM peak period where congestion is reduced with the proposed improvements.

Figure 3.9: Outer Loop AM (7 a.m. – 8 a.m.) Peak Hour Throughput



DENSITY – Along the Outer Loop between MD 43 and IS-70 there are a total of 70 different segments in the VISSIM network out of which there are 32 basic freeway, 14 merge, 12 diverge, and 12 weave segments. As see in *Figure 3.10*, during the AM peak hour from 8 a.m. to 9 a.m., the proposed Total Project improvement reduces the number of segments operating at LOS E and F from 50 to only 14 segments. All other segments operate at an acceptable LOS D or better. In the PM peak hour from 4 p.m. to 5 p.m., the number of segments operating at LOS E and F are reduced from 38 under existing conditions to only 7 segments with the proposed Total Project.

Figure 3.10: Segment Density (LOS) – IS-695 Outer Loop Segments from MD 43 to IS-70



QUEUES

Along the Outer Loop, in the AM peak the average queues on the on-ramp from MD 43 back up almost 4,000 ft during the 8 a.m. to 9 a.m. period. With the proposed Total Project build conditions, this queue is eliminated during the entire AM peak period.

Similarly, in the PM peak, under existing conditions the queues on the on-ramp from IS-83 backs up to more than 1,485 ft during the 5 p.m. to 6 p.m. period. With the proposed Total Project improvements, the queues on this ramp are eliminated. ***With the proposed Total Project improvements, there are no other ramps in the corridor where queues back up in either the PM peak periods.***

IS-695 Inner Loop

Along the Inner Loop of IS-695 between IS-70 and MD 43 there is one major congested area in the AM peak and three in the PM peak as seen in the peak period congestion diagram in *Figure 3.6* on page 29.

AM PEAK

The heavy off-ramp volume from the Inner Loop to IS-83 south (JFX) causes the AM peak congestion. The volume in this diverge segment peaks and exceeds capacity around 7:30 a.m. and the queues spill back to the IS-795 interchange. This congestion lasts through most of the peak period and only starts to dissipate towards the end of the peak when the demand volumes start to drop below the capacity. The Total Project improvements proposed by the Myers Team along this segment of the Inner Loop, as well as repurposing the lanes on IS-83 south, will provide the additional capacity needed during the critical demand period. The additional capacity also frees up some gaps in the exit lane to improve the heavy off-ramp movement to IS-83 south. As seen in *Figure 3.6* on page 29, with the proposed Total Project improvement, the bottleneck is eliminated and the resulting increased throughput from the previously unserved demand is also processed downstream with the continued PTSU in the corridor.

> ***IS-695 Inner Loop – AM Peak***
> *Overall, with the Total Project there is an improvement of* ***7.2 minutes*** *of travel time along this stretch of the Outer Loop during the 8 a.m. to 9 a.m. time frame.*

PM PEAK

There are three locations where congestion regularly occurs during the PM peak: 1) on the east side near the IS-70 and MD 122 on-ramps; 2) the ramp to IS-83 south (similar to the AM peak); and 3) between the on-ramp from Cromwell Bridge Rd and the off-ramp to Perring Pkwy. The demand exceeding the available lane capacity factors into all three locations, while the consecutive merges from IS-70 and MD 122 and the short weave segment at the cloverleaf ramps at MD 41 contribute as well. As shown in *Figure 3.6* on page 29, our proposed Total Project improvements removes all three of these major bottlenecks along the Inner Loop during the PM peak period, with nearly free-flow conditions along the entire segment from IS-70 to MD 43.

IS-695 Inner Loop – PM Peak
Overall, with the Total Project there is an improvement of ***19 minutes*** *of travel time and an average speed of approx. 50 mph along this stretch of the Inner Loop during the 5 p.m. to 6 p.m. peak hour. On an average, the travel time in the entire PM peak period from 3 p.m. to 7 p.m., improves by* ***13.5 minutes****.*

TRAVEL TIME

As seen in *Figure 3.11*, with the proposed Total Project the resulting travel time benefits during the AM peak hour (8 a.m. to 9 a.m.) can be seen at the IS-83 interchange and the travel time is close to free flow conditions up to the Harford Rd interchange. The proposed Total Project improvements provide a **7 minute travel time savings** which is approximately **24% better** compared to the existing conditions for vehicles traveling from IS-70 to MD 43 along the Inner Loop.

Figure 3.12 shows the greatest benefit in the PM peak (5 p.m. to 6 p.m.) along the Inner Loop is from Harford Rd to the IS-83 NB interchange. There is an overall **travel time saving of 19 minutes** with the proposed Total Project improvements, which is approximately **44% better** compared to the existing conditions for vehicles traveling from IS-70 to MD 43 along the Inner Loop.

Figure 3.11: Inner Loop AM Peak Hour Travel Time

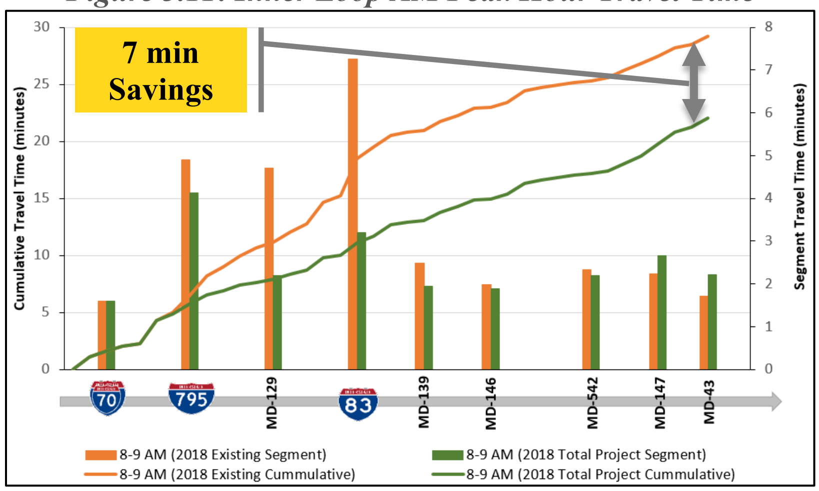
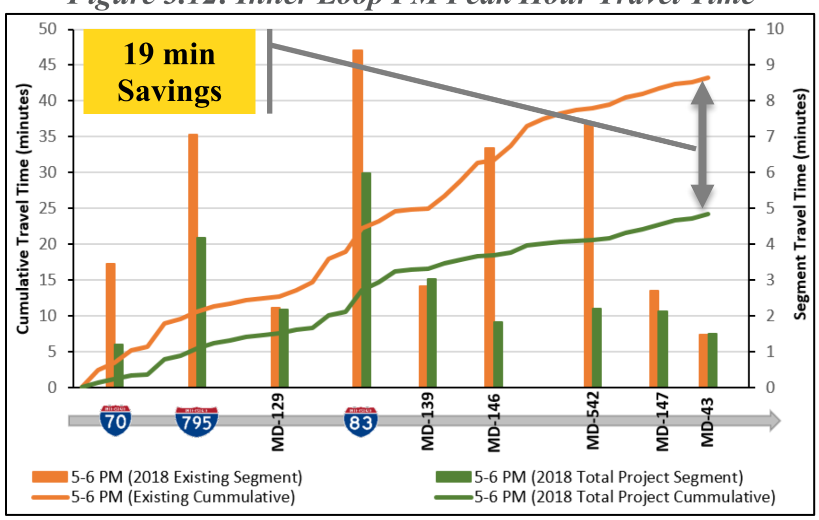


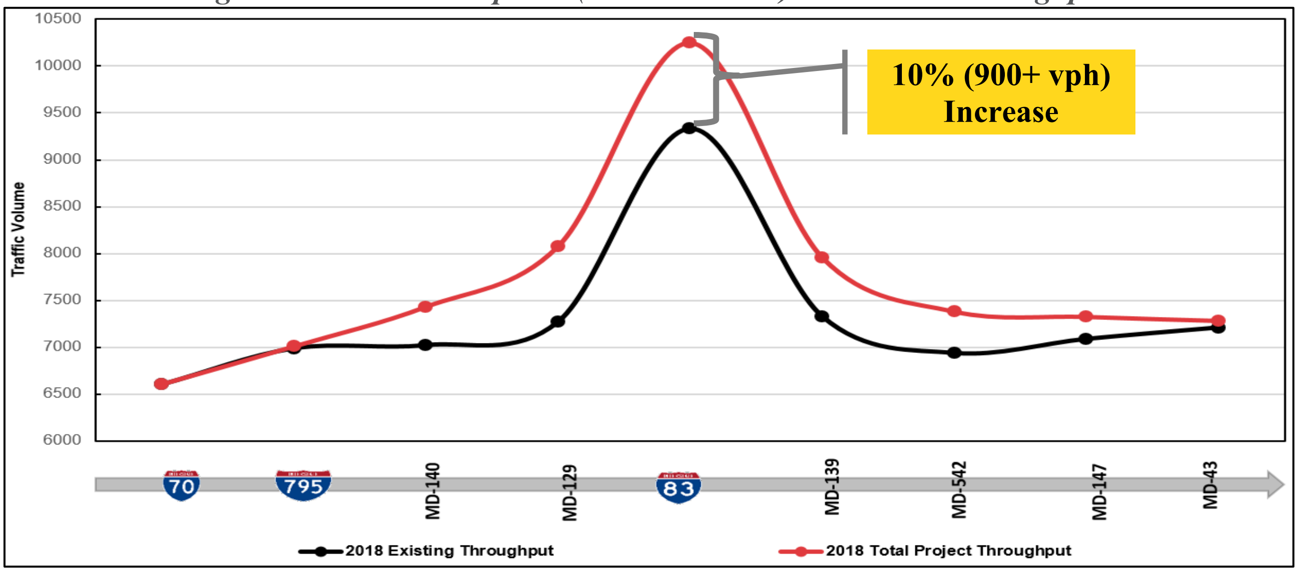
Figure 3.12: Inner Loop PM Peak Hour Travel Time



VEHICLE THROUGHPUT

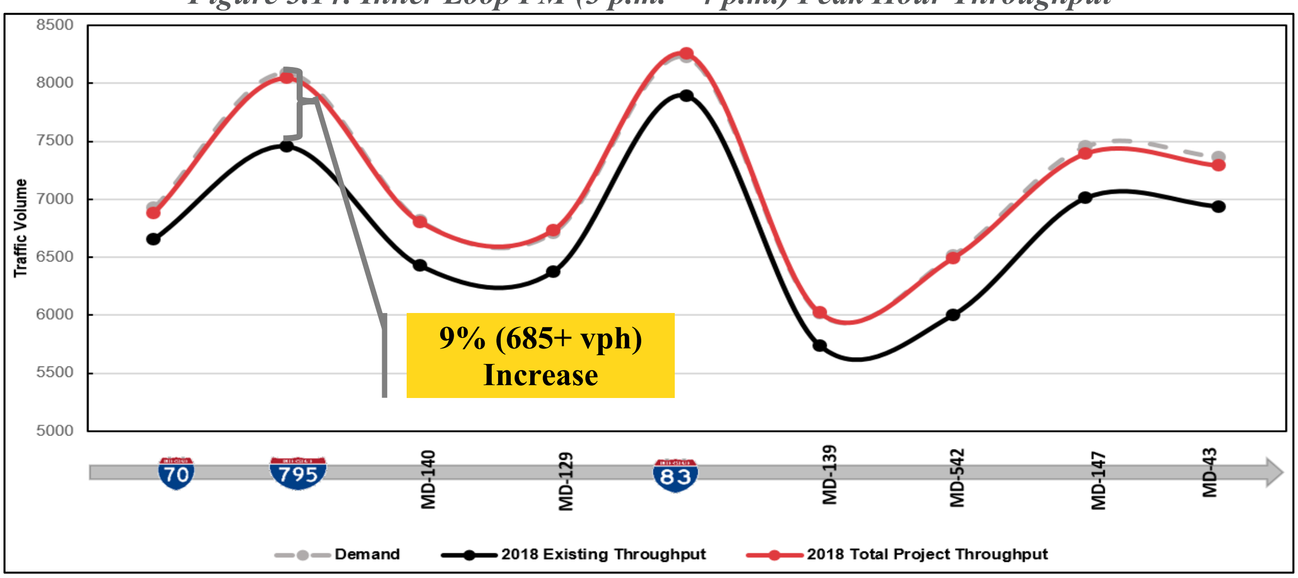
Figure 3.13 shows how the proposed Total Project improvements and the added capacity with the PTSU will increase the throughput in the corridor compared to the existing conditions and will be able to serve much more demand in the corridor up to MD 43 along the Inner Loop in the most constrained 7 a.m. to 8 a.m. peak hour. In some segments of the Inner Loop, the Myers Team concept will be able to process an additional 900 additional vehicles per hour. With the elimination of bottleneck congestion in the corridor, there is more throughput that is released downstream and is carried through the rest of the corridor without creating another downstream bottleneck.

Figure 3.13: Inner Loop AM (7 a.m. – 8 a.m.) Peak Hour Throughput



In the PM peak, similar increase in throughput is observed in the most constrained peak hour (3 p.m. to 4 p.m.) where congestion is reduced with the proposed improvements and almost all the demand gets processed throughout the corridor as seen in *Figure 3.14*.

Figure 3.14: Inner Loop PM (3 p.m. – 4 p.m.) Peak Hour Throughput

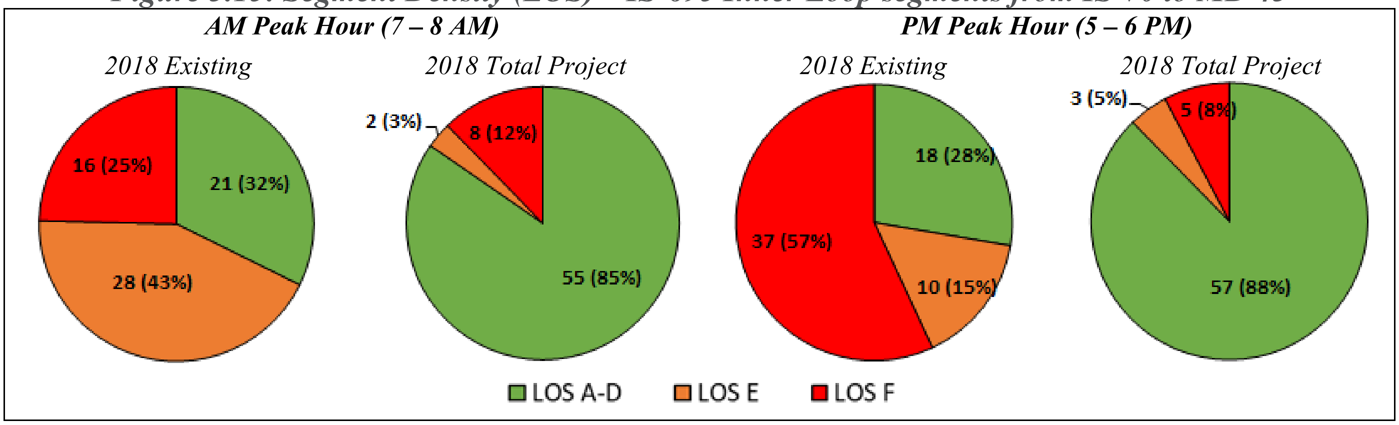


DENSITY

As seen in *Figure 3.15*, out of the 65 different basic, merge, diverge, and weave segments along the Inner Loop between IS-70 and MD 43, in the AM peak hour between 7 a.m. and 8 a.m., there are 44 segments that are operating under LOS E and F. With the proposed Total Project improvements, this number is reduced to just 10 segments. All other segments operate at a LOS D or better along the Inner Loop. In the PM peak hour between 5 p.m. and 6 p.m., as seen in *Figure 3.15*, with the proposed Total Project improvement, the number of segments operating at LOS E and F are reduced from 47 to just 8. All other segments operate at a LOS D or better along the Inner Loop in the PM peak hour between 5 p.m. and 6 p.m.

> ***Inner Loop LOS Improvements***
> *In the AM and PM Peak Hours, the Total Project improvements provide an approx.* ***77%*** *and* ***83%*** *reduction, respectively, in segments operating at an unacceptable LOS E and F, per the VISSIM model.*

Figure 3.15: Segment Density (LOS) – IS-695 Inner Loop segments from IS-70 to MD 43



QUEUES

Along the Inner Loop, in the AM peak the average queues on the on-ramp from IS-795 are about 50 ft during 7 a.m. – 9 a.m. ***Our Total Project improvements eliminate this queue, and there are no other ramps on the Inner Loop where queues back up in the AM peak period.*** In the PM peak, under existing conditions there is significant queuing on the on-ramp from IS-70 where queues are beyond 4,900 ft at the beginning of the peak at 3 p.m. and go up to 16,280 ft by the end of the peak period at 7 p.m. ***With the proposed Total Project improvements, the queues on this ramp are eliminated.***

Intersection Operations

With the Total Project improvements proposed by the Myers Team in this corridor there is an increase in throughput along the freeway and reduction in spill back from ramps on to the arterials. Vehicles on the mainline, however, are no longer constrained and will reach the ramp terminal intersections more quickly, likely requiring more time per signal cycle to clear the ramp. With signal timing optimization, the overall LOS of the intersections within the I-70 to MD 43 corridor either remains the same or is improved as compared to the existing conditions in both the AM and PM peak periods.

Networkwide Performance

During the afternoon peak hour workers leave the primary employment centers in Baltimore City, Towson, and Woodlawn to travel home to locations outside of the Beltway. The Inner Loop between IS-70 and IS-795, according to the 2019 Mobility Report, experiences the worst congestion in the state every afternoon. The VISSIM microsimulation models provide an insight on the overall networkwide performance. One of the important parameters in the networkwide performance is the average delay per vehicle during the simulation period. As seen in the *Table 3.2*, with the Total Project improvements proposed by the Myers Team along the IS-695 Inner Loop and Outer Loop, there is a significant decrease in the overall networkwide average delay per vehicle. In the AM peak there is a reduction of 18% - 34% in the average delay per vehicle traveling through the network with the proposed Total Project improvements. In the PM peak we see even more improvement between 41% to 54% reduction in average delay per vehicle in the network.

Table 3.2: Network Performance – Average Delay per Vehicle (AM and PM Peak Periods)

Average Delay per Vehicle	**AM Peak**				**PM Peak**			
	6-7 AM	7-8 AM	8-9 AM	9-10 AM	3-4 PM	4-5 PM	5-6 PM	6-7 PM
2018 Existing	80	180	213	93	123	195	199	146
2018 Total Project	66	137	141	72	72	96	95	68
% Reduction	**18%**	**24%**	**34%**	**22%**	**41%**	**51%**	**52%**	**54%**

Connecting Ramps

The Total Project improvements are anticipated to eliminate the existing recurring congestion on the IS-695 mainline once built. These improvements are anticipated to considerably improve the existing entrance queues during the afternoon peak at the IS-70 ramp to the Inner Loop. There is also an improvement of almost 2 minutes in travel times for vehicles traveling from IS-695 ramps to IS-83 SB in both AM and PM peaks. In addition, during the afternoon peak there is a 0.5 - 0.7 minutes of travel time saving for vehicles from IS-83 southbound going to the Inner Loop.

Table 3.3 and *Table 3.4* below show the summary of travel times improvement with the proposed Total Project in the AM and PM peaks, respectively. Detailed results of the VISSIM models are provided in *Appendix D-7*. These delay reductions are on the ramps movement before vehicles even reach the IS-695 Inner Loop with additional travel time savings after they get on to IS-695 Inner Loop. ***The biggest improvement is for the vehicles traveling from IS-70 eastbound to IS-695 Inner Loop which see a reduction of travel time ranging from 7.5 to 14.3 minutes in the PM peak period.***

Table 3.3: Ramp Movement Travel Times Reduction with Total Project (2018 AM Peak)

Movement	**Improvement in Travel Times (Minutes) with Total Project**				
	6-7 AM	7-8 AM	8-9 AM	9-10 AM	Average
IS-695 IL to IS-83 SB	0.0	0.7	1.9	0.0	0.5
IS-695 OL to IS-83 SB	0.1	0.0	0.0	0.0	0.0

Table 3.4: Ramp Movement Travel Times Reduction with Total Project (2018 PM Peak)

Movement	**Improvement in Travel Times (Minutes) with Total Project**				
	3-4 PM	4-5 PM	5-6 PM	6-7 PM	Average
IS-695 IL to IS-83 SB	2.2	1.8	-0.4	-0.2	0.7
IS-695 OL to IS-83 SB	0.5	0.6	0.6	0.2	0.5
IS-70 EB to IS-695 IL	**7.5**	**14.3**	**13.9**	**10.7**	**11.4**
IS-70 WB to IS-695 IL	1.0	1.7	1.5	1.0	1.3
IS-83 SB to IS-695 IL	0.0	0.5	0.7	0.0	0.3

The improved mainline operations on IS-695 also require re-assessing the ramp terminal intersections on arterial roadways, as the entrance queues are significantly reduced, and more motorists arrive at these intersections during each signal cycle with the improved throughput.

Arterial Roadways

With the significant reduction in congestion on the mainline IS-695 Inner Loop as well as along the Outer Loop, there is an increase in the throughput along the corridor. This results in more demand from the freeway reaching destination arterials and vice-versa. However, with just optimization of the signal timing and phasing, it is possible to process this increased throughput sufficiently. With the proposed improvements along this corridor, there is no degradation of operations along the arterials. The LOS and the queues at all the intersections along the arterials within the study limits remains equal to or better than the existing conditions.

IS-695 Inner Loop to IS-83 Southbound – Under existing conditions, the exit from the Inner Loop to IS-83 SB is a one-lane off-ramp that serves between 1,375 to 1,720 vehicles per hour during the morning peak from 6 a.m. to 10 a.m. The volume on the Inner Loop going through at this diverge is also close to the three-lane segment capacity at the same time. Furthermore, this is a low speed exit ramp with a 30-mph speed limit with a tight curvature which merges with the heavy volume coming from the IS-695 Outer Loop ramp going to IS-83 SB. This creates friction along this diverge segment of the Inner Loop. Our improvements will not only address the merge between the two ramps from IS-695, but will also improve the operations along the IS-83 SB. This simple restriping improvement is based on providing the most optimal capacity based on the demand volumes from each direction. As seen from the results of the VISSIM models at this location, along with the proposed improvement through this corridor, there is a noticeable difference in the congestion and travel times in the 2040 conditions. Under the existing conditions, the proposed improvements with the Total Project through this segment provides additional capacity and relief for this diverge segment. But that will eventually start to deteriorate with the growth in demand on the volumes along the two ramps from IS-695 as can be seen in the 2040 No Build VISSIM results as shown in *Figure 3.16* on page 39.

As seen in *Table 3.3* on page 36, there is a reduction in travel time for vehicles traveling from the Inner Loop to IS-83 SB of almost 1.9 minutes in the AM peak hour of 8 a.m. to 9 a.m. and an improvement of 2.2 minutes in the 3 p.m. to 4 p.m. time period. For the vehicles traveling from the Outer Loop to IS-83 southbound there is an improvement of more than 0.5 minutes in most of the PM peak hour shown in *Table 3.4* on page 36. In 2040 these improvements are significantly increased as shown in *Table 3.5*. From the 2040 VISSIM models, with the Total Project, in the AM peak hour from 8 a.m. to 9 a.m., there is more than 3 minutes of travel time savings for both the Inner and Outer Loop ramps to IS-83 SB. In the PM peak hour from 4 p.m. to 5 p.m. the travel time savings for the Inner Loop ramp to IS-83 southbound is almost 8.6 minutes and for the Outer Loop ramp to IS-83 SB the savings is more than 3.8 minutes with the proposed Total Project improvements. Detailed results of the VISSIM models are provided in *Appendix D-7*.

Table 3.5: Ramp Movement Travel Times Reduction with Total Project (2040 Peak)

Segment	2040 AM Peak	2040 PM Peak
	8-9 AM	4-5 PM
IS-695 IL to IS-83 SB	3.3	9.4
IS-695 OL to IS-83 SB	3.4	3.8

iii. PERFORMANCE LIFE OF CONGESTION REDUCTION FOR THE TOTAL PROJECT

Using the Performance Based Practical Design approach, the Myers Team developed solutions that are most efficient to improve the mobility and safety in this IS-695 corridor. This includes providing PTSU through the entire corridor as well as other improvements that in the earlier sections. *Figure 3.16 on page 39* shows the 2040 congestion diagrams from the VISSIM modeling results for the corridor with the Total Project (including PTSU). Along the Inner Loop, the congestion in most places remains below existing condition levels even in 2040. In the Outer Loop, the congestion levels return to existing condition levels mainly due to the spill back from the external bottlenecks. *Table 3.6* shows the total benefits in the year 2040 as calculated from the VISSIM models with the Total Project improvements. The results show that by the year 2040, the congestion in the IS-695 corridor from IS-70 to MD 43 will be so high that with our Team's proposed Total Project improvements will provide a travel time saving of 149 minutes along the Outer Loop in the AM peak hour (8 a.m. to 9 a.m.) and 105 minutes along the Inner Loop in the PM peak hour (4 p.m. to 5 p.m.).

Table 3.6: 2040 Travel Time and Speed Improvements with Total Project Improvements

Segment	**US 40 to US 1**		**IS-70 to MD 43**	
IS-695 Outer Loop [8–9 AM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	156 minutes	11 mph	**149 minutes**	**10 mph**
IS-695 Inner Loop [4–5 PM Peak Hour]	Travel Time Savings	Average Speed Improvement	Travel Time Savings	Average Speed Improvement
	106 minutes	39 mph	**105 minutes**	**38 mph**

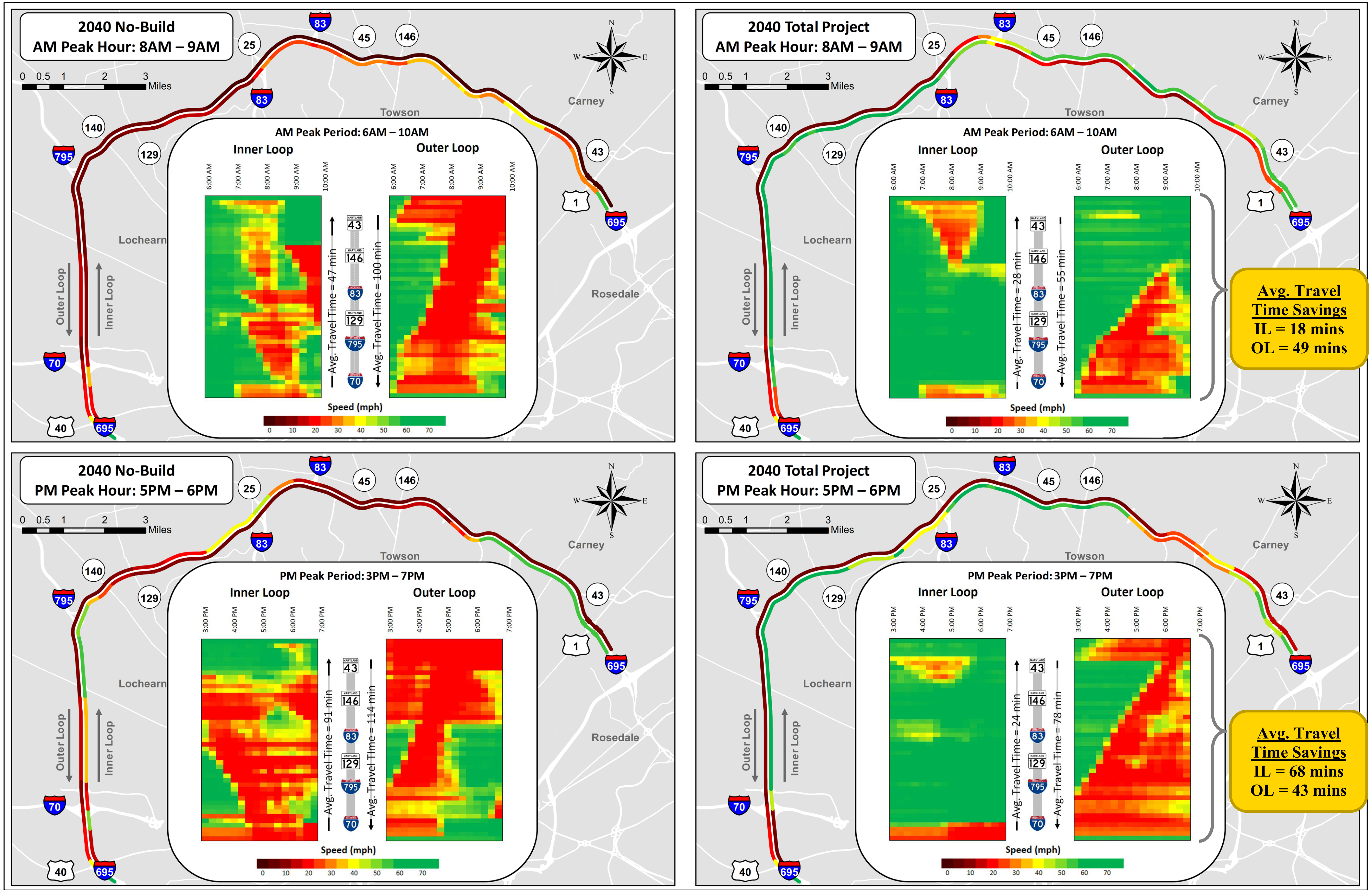
To understand when the congestion levels will return to existing conditions level for the Total Project, we analyzed the congestion at various segments along the Inner and Outer Loops. From the VISSIM models and the demand volumes provided by MDOT SHA, we identified the per lane capacity of the segments when they start to fail under existing conditions. Using this as a threshold of volume where operations along the freeway start to breakdown, we projected when the demand volumes will exceed the capacity threshold.

Table 3.7 shows that in most segments, ***our proposed Total Project Build, the congestion levels will remain below existing conditions far beyond 2040***. In the segment between IS-83 South to MD 43, the congestion will return to existing conditions congestion levels in the Inner Loop in the PM peak and in the Outer Loop in the AM peak by the year 2036. In the Outer Loop in the segment between IS-795 and IS-70 the congestion returns to existing conditions level in the AM peak by the year 2040. The detailed analysis is provided in *Appendix D-8.* With this understanding that the benefits from the performance of the PTSU in not just significant in the existing conditions but also in the future, our Team focused on maximizing the PTSU segment along the Inner and Outer Loop of the corridor. It is apparent from the performance benefits that PTSU provides the maximum benefit to reduce recurring congestion as well as address non-recurring congestion, thus improving the travel time reliability of the corridor.

Table 3.7: Performance Life of Network with Total Project Improvements

Segment		**Failing in Existing Condition?**	**Failure Year with Total Project**
Inner Loop	IS-70 to IS-795	Yes, AM Peak	AM – 2042; PM – >2040
	IS-795 to IS-83 South	Yes, AM & PM Peaks	AM – 2043; PM – 2064
	IS-83 South to MD 43	Yes, PM Peak	AM - >2040; PM – 2036
Outer Loop	MD 43 to IS-83 North	Yes, AM & PM Peaks	AM – 2036; PM – 2052
	IS-83 North to IS-795	No	AM – >2040; PM – >2040
	IS-795 to IS-70	Yes, AM and PM Peaks	AM – 2040; PM – 2049

Figure 3.16: IS-695 Corridor Average Speeds and Congestion Diagrams (2040 VISSIM model results) – AM and PM Peak 2040 No-Build Conditions and with Total Project Improvements

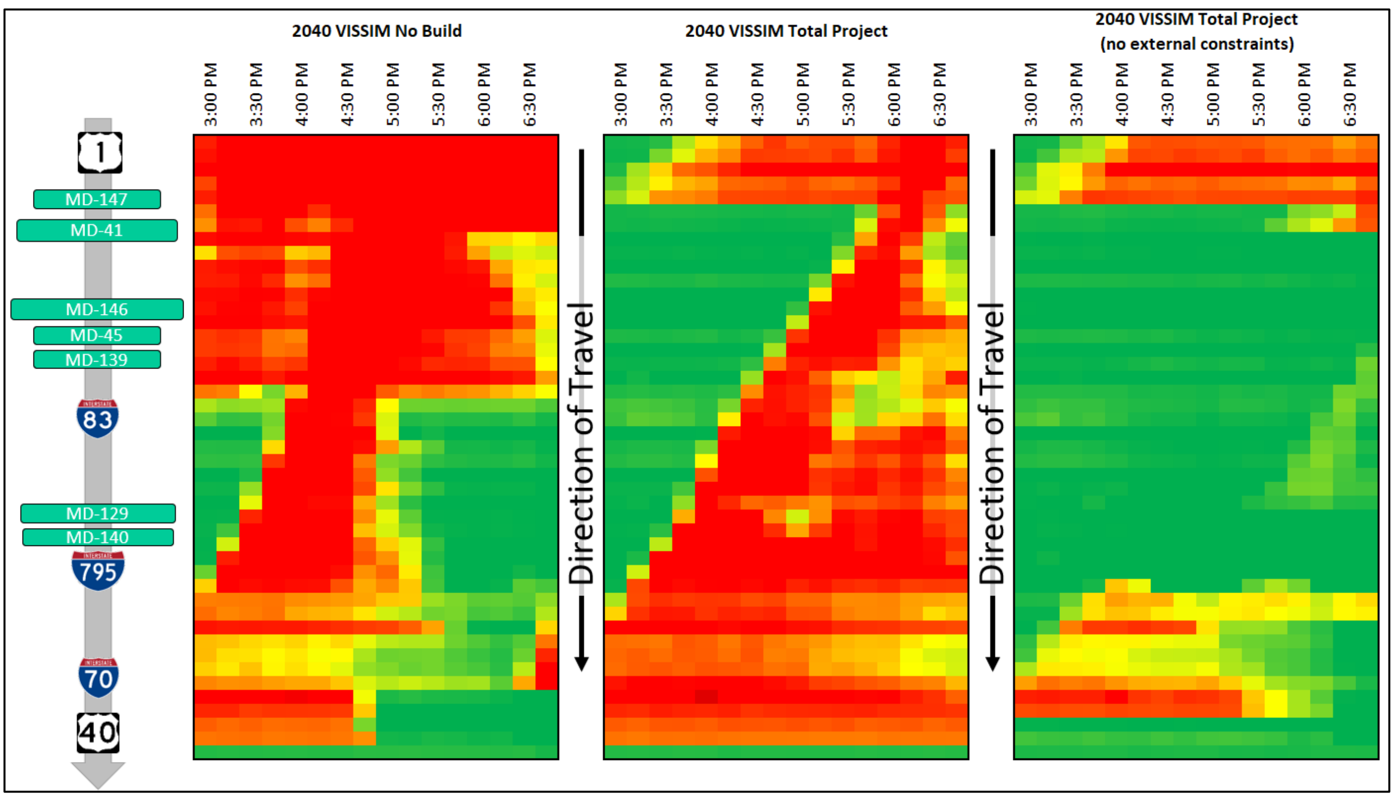


Additional Outer Loop Congestion Improvements

It is important to note that with the reduction in congestion within the Project limits, there is an increase in throughput downstream and the backup from outside of the Project limits – beyond IS-70 on the Outer Loop and beyond MD 43 on the Inner Loop gets worse. This congestion is due to elements outside of the Project limits and if addressed in a future project, would eliminate the congestion.

For example, the congestion that forms along the Outer Loop past the IS-70 interchange near the US 40 interchange under existing conditions will exasperate the bottleneck by 2040 and result in a queue spill back that will eventually cover the entire Project corridor as shown in *Figure 3.17* under the No-Build congestion diagram. With the Myer Team's proposed Total Project Build, the spill back can be contained up to the IS-83 interchange in the AM peak period. In the PM peak period however, due to heavy demand volumes entering the Outer Loop, this queue spills back through the entire corridor. With the proposed Total Project Build, the magnitude and degree of congestion is greatly reduced compared to the No-Build conditions, but it shows that there will be a need for implementing other improvements outside of this Project corridor to address the congestion. *Figure 3.17* shows that if the bottleneck at US 40 were to be addressed by another project, then the improvements proposed with the Total Project Build along will sustain the operations in this corridor through 2040. *Appendix D-6* details the results of the VISSIM analysis for the Inner and Outer Loop for this scenario.

Figure 3.17: IS-695 Outer Loop Corridor Congestion Diagrams (2040 PM Peak VISSIM Model Results No-Build vs. Total Project vs. Total Project with no External Constraints)



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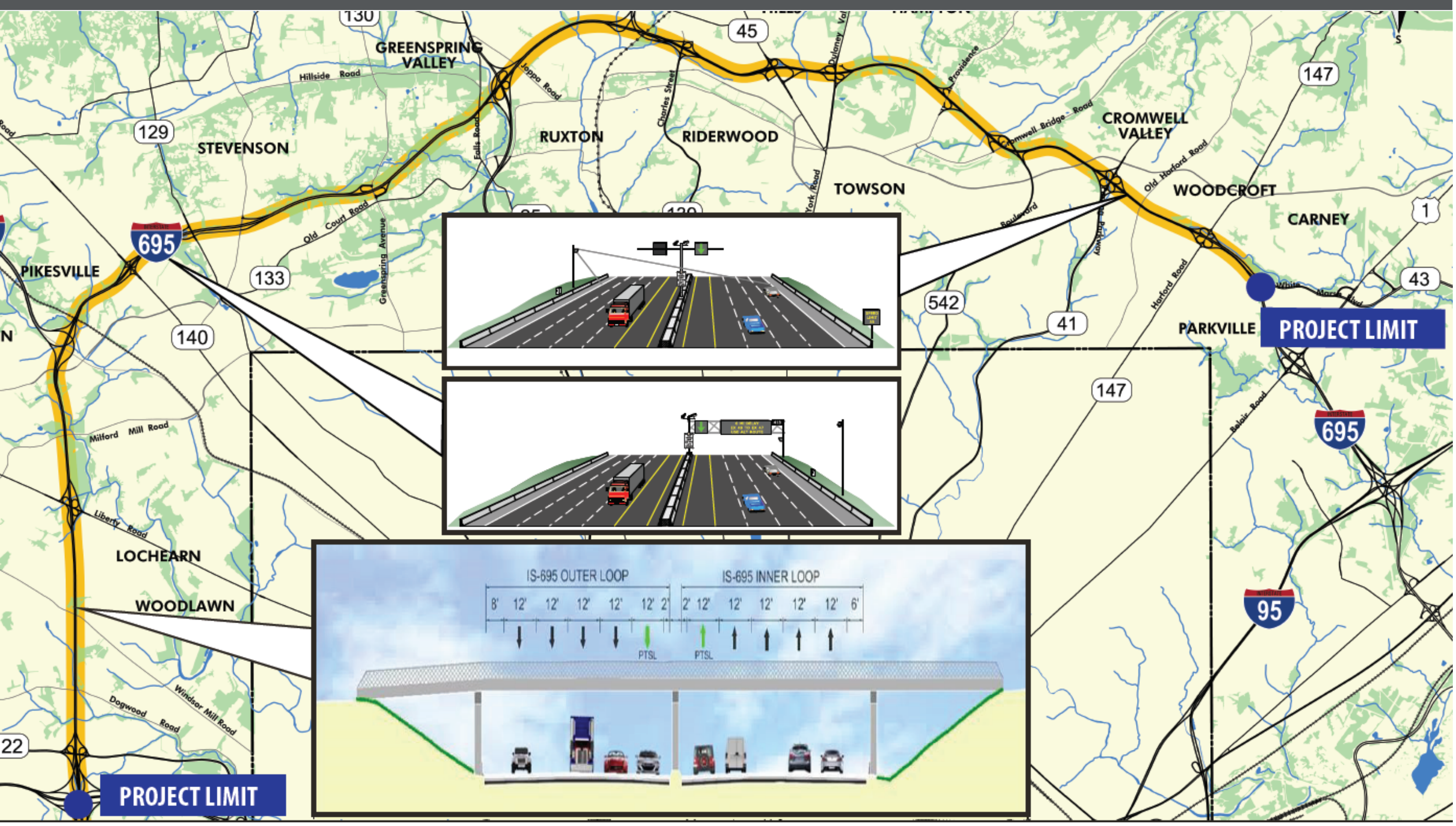
2.09.04

SAFETY



ALLAN MYERS + Bruce & Merrilees + WALLACE MONTGOMERY + Kimley»Horn

2.09.04 SAFETY

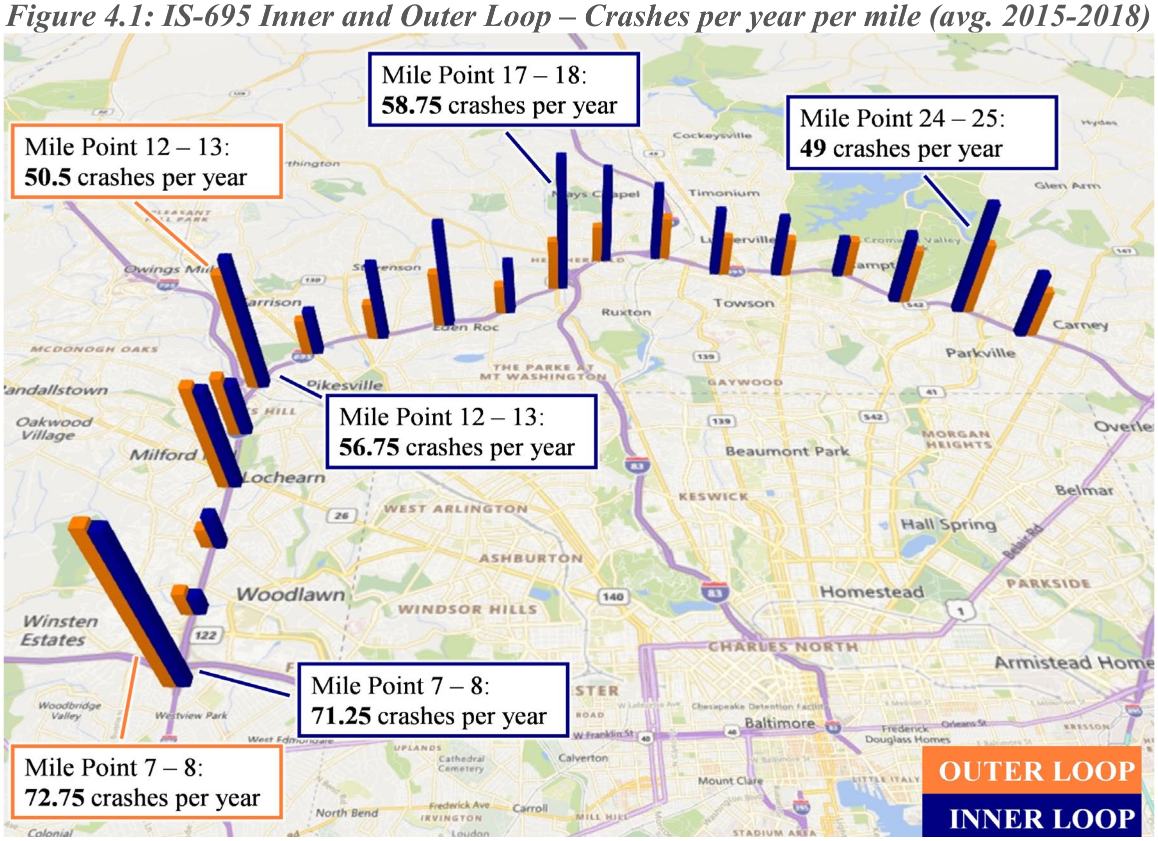
Congestion along the IS-695 corridor in the region leads to reduced mobility and increased incidents such as stalled vehicles, major and minor crashes, and spilled freight loads. Non-recurring congestion accounts for 60% of all delays on the highway system in Maryland. The average yearly crash rate on the IS-695 corridor is 35 crashes per mile on the Inner Loop and 23.5 on the Outer Loop (2015-2018 data), and secondary crashes represent more than 20% of all crashes and 18% of fatalities on interstates (FHWA, 2010).

Improving Crash Clusters
Our Project will implement DSA signs in advance of the five most severe crash clusters to reduce the frequency and severity of crashes at these locations. The DSA signs coupled with the DMS for queue warning will reduce speeds and alert drivers of adverse weather conditions such as ice or fog.

There are several crash "clusters" along the Inner and Outer Loop of IS-695. In 2018, a significant number of crashes occurred on the Inner Loop at the IS-70/MD 122 interchanges, between IS-795 and MD 140, between the Greenspring Ave and Falls Rd interchanges, prior to the exit to IS-83 North and Charles St, and within the interchanges at Cromwell Bridge Rd and Perring Pkwy. IS-695 approaching IS-83 is also particularly susceptible to crashes as a result of sun angle and ice in the morning. Crash clusters on the Outer Loop occur at the Perring Pkwy interchange, between the Charles St and IS-83 North on-ramps, between the MD 140 and IS-795 interchanges, within the MD 26 interchange, and at the MD 122/IS-70 interchanges.

The IS-695 Inner Loop from IS-70 to MD 43 has a total of 655 crashes per year (average 2015-2018), which is almost 50% higher than crashes on the Outer Loop as shown in *Figure 4.1*. In 2018, there were seven crashes on IS-695 between IS-70 and MD 43 that resulted in fatalities. Using this data, it was also found that over 40% of the crashes were rear-end crashes, implying that variances in speed was a primary cause of crashes within the corridor.

Figure 4.1: IS-695 Inner and Outer Loop – Crashes per year per mile (avg. 2015-2018)



i. NON-RECURRING CONGESTION DETECTION AND VERIFICATION

The implementation of part-time shoulder use (PTSU) and other TSMO strategies throughout the IS-695 Project will contribute to improving overall corridor safety by reducing stop-and-go conditions, reducing queuing, and raising driver awareness of downstream conditions during both recurring and non-recurring conditions (e.g., disabled vehicles, crashes, emergency events, or adverse weather). To provide the greatest safety improvements on IS-695, the Myers Team proposes the following TSMO strategies for the IS-695 corridor:

- PTSU with Automated Incident Detection (AID) and Lane Use Control Signs (LUCS)
- Continuous microwave vehicle detection (MVD) system
- Expanded PTZ CCTV Camera coverage
- Full-size Dynamic Message Signs (DMS) and Small DMS
- Dynamic Speed Advisory (DSA) Signs and Queue Warning (QW)

Figure 4.2: ITS Features Typical

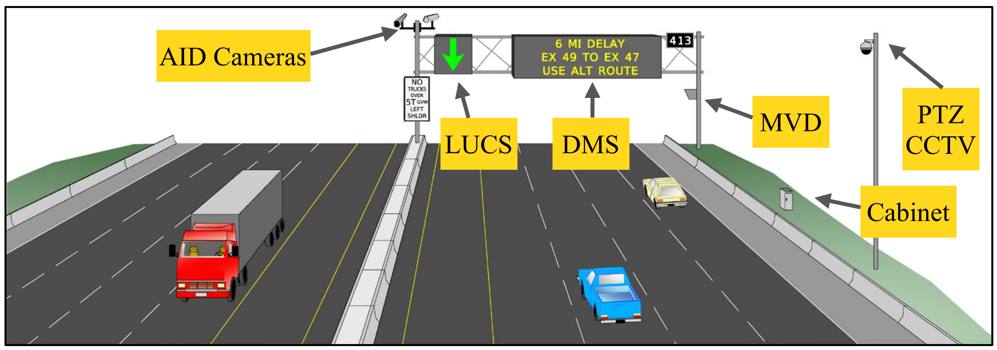
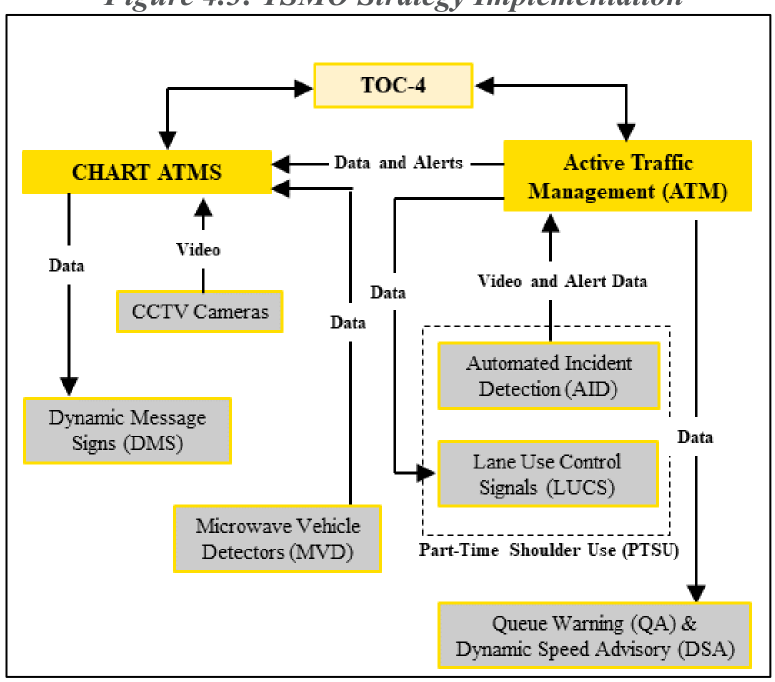


Figure 4.2 shows where these devices will typically be located along IS-695, and *Figure 4.3* illustrates how they will be implemented and integrated into an active traffic management (ATM) system. The ATM will seamlessly link with the CHART ATMS and be fully controllable by the Highway Operations Technicians (HOTs) at the District 4 Traffic Operations Center (TOC-4). Safety benefits are difficult to model in VISSIM due to the variability and modeling assumptions influenced by driver behavior, incident characteristics, and prevailing traffic conditions. Anticipated safety benefits for TSMO strategies are typically supported by references to benefits that are seen in similar deployments around the country.

Figure 4.3: TSMO Strategy Implementation



Expanded PTZ CCTV camera coverage and the ***automated incident detection (AID) system*** provides enhanced situational awareness, reduced response times, and improved incident management. Studies have estimated on average, a 40% reduction in secondary crashes when a traffic incident management system includes enhanced camera coverage (USDOT, 2007). Expanded camera coverage and AID system will provide full coverage of the mainline and

PTSU lanes of the corridor, increasing reliability of incident information and has shown to reducing incident response conservatively by 20% (NTIMC, 2011) by alerting HOTs sooner of an incident or debris. In outside shoulder segments that have less than standard shoulder widths, the PTZ cameras will be useful tools to monitor the presence of debris or disabled vehicles.

Proven safety benefits of ***Queue Warning (QW)*** and ***Dynamic Speed Advisory (DSA) signs*** combined provide an average of 8% reduction of the number and severity of crashes (FHWA, 2017).

Microwave Vehicle Detection throughout the corridor will provide complete corridor performance information, enabling proactive alerts and response to degrading traffic conditions.

Full-size and small DMS will be used in conjunction with PTSU operation during recurring and non-recurring congestion to display queue warning and traveler information. DMS support enhances traveler information and has been found to provide an average of 3 minutes travel time savings when providing actionable information which is acted upon (TOPS-BC, FHWA).

DMS Benefits
DMS support enhances traveler information and provides an average of ***3 minutes*** *travel time savings.*

Automated Incident Detection (AID) and Debris Detection System

The key to successful operation of the PTSU is to quickly detect incidents or debris along the roadway and immediately initiate a response to address them. Time is of the essence, and our AID system of cameras and video analytics software automatically detects obstructions and debris in the PTSU lane, works through the local ActiveITS ATM to create an event and sound an alarm in the CHART ATMS, and then the CHART ATMS recommends a response plan based on the geographic location of the incident. The HOT may then make a visual confirmation and decide to either override the system (e.g., if the debris is within the 2-ft buffer between the barrier and striped PTSU lane) or carry out the recommended response plan. The AID system is also used to confirm that the entire length of the PTSU lane is clear of debris and obstructions prior to opening; if all clear, HOTs confirm and activate PTSU. If debris or obstruction is identified, an event is created in the CHART ATMS and the HOT may elect to open or send a Field Operations unit or Emergency Response Technician (ERT) to the location. The AID cameras provide safer PTSU by quickly detecting obstructions and incidents, allowing HOTs to immediately verify them and initiate response plans.

AID System Benefits
*Automated Incident Detection systems have shown to improve incident response conservatively by 20% (*NTIMC, 2011) *Fixed thermal-imaging cameras will improve incident detection and produce few false alarms.*

The AID system uses video analytics software to continuously monitor the shoulder lane (or other areas defined within the view of the camera) to detect stopped vehicles or larger objects that could obstruct vehicular traffic. Implementation of the system will include a software interface at the SOC or TOC-4 that integrates directly with the ActiveITS ATM. The primary goal of the software is to monitor alarms coming from the AID system fixed cameras. The AID system we are proposing meets the requirements or the RFP by using fixed thermal imaging cameras to improve detection at night and other light-sensitive situations such as oncoming headlights and sunlight in the camera's view.

PTSU systems require high availability and uptime to be most effective, and the AID system must also have AID cameras that are hot-swappable to for ability to swiftly change out a failed AID camera with a spare camera and minimize the time the shoulder must be closed.. If one AID camera is offline at any time, the remainder of the corridor can still operate the PTSU lane, but losing incident and debris detection coverage for a portion of the PTSU lane could introduce a dangerous situation if the shoulder lane cannot be opened to traffic or is not providing consistent information. Operating the AID system at 100% availability will provide the most benefit to the corridor. PTSU systems require high availability and uptime to be most effective. The AID system includes AID cameras that are hot-swappable to swiftly change out a failed camera with a spare and reconfigure it prior to the next use of the PTSU lane. The required amount of availability (100% of devices or otherwise) will be defined during the Concept of Operations (ConOps), and will influence maintenance responsibilities, particularly with respect to responsiveness and repair time.

Detecting/Verifying PTSU Lane Non-Recurring Congestion

The full video coverage of the PTSU lanes will utilize a series of fixed thermal-imaging cameras with built-in video analytics. Fixed cameras ensure the AID system is always aimed at the shoulder and prevent the possibility of PTZ cameras being moved away from the shoulder lane and not returning to the original position. Fixed cameras allow the detection zones to be drawn on the shoulder lane during setup and will not require adjustment.

Thermal-imaging cameras provide improved detection performance over conventional visual cameras by detecting infrared radiation emitted from both organic and inorganic objects in all weather and lighting conditions. This creates a more reliable AID system for continuous operations and will produce fewer false alarms.

Figure 4.4 AID System Alert Sent to SOC

There are two options for housing the algorithms that process the video feeds: inside the camera (at the "edge") or inside a computer server at the SOC (at "central") or TOC-4. Our Team has chosen an edge architecture with video analytics built into the cameras, which requires significantly less bandwidth and decreases demand on the communications network.

With a central architecture, the video from all cameras is continuously sent to the SOC for processing, which is not recommended for the Project due to limited bandwidth. With the recommended edge architecture, the system can be configured so that only alarms and status information from the cameras are sent to the SOC, with video available on-demand as shown in *Figure 4.4*. Other benefits of the edge architecture include minimal equipment installed at the SOC and system redundancy of the AID system for the corridor, resulting in less equipment to maintain.

Detecting/Verifying Mainline Non-Recurring Congestion

With AID focused solely on the PTSU lanes, we will utilize other technology solutions to detect incidents and non-recurring congestion on the mainline. We will provide **microwave vehicle detectors** (MVD) every ¼ mile to continuously monitor volume and speed within all of the travel lanes; when speeds within a lane along a roadway segment drop to below a threshold speed, an event will be initiated in the CHART ATMS and the HOT may then quickly zoom into the location with the **expanded network of CCTV pan-tilt-zoom (PTZ) cameras** to confirm the cause. The expanded network of MVD and the full CCTV coverage within the coverage within the corridor will reduce the incident detection time considerably, whereas today HOTs often rely on multiple sources of varying reliability to confirm the location, and then must either zoon in to the area or get an ERT to check the site.

Consistent Monitoring with Fewer False Alarms

Fixed cameras ensure that the AID system is always actively monitoring the shoulder lane for anomalies. Thermal-imaging capabilities improve detection to produce fewer false alarms. Video analytics built into the cameras reduces bandwidth requirements and requires less equipment to maintain.

The incident detection for mainline IS-695 includes the installation of a new ***incident detection application platform*** as a demonstration deployment at the Statewide Operations Center (SOC). The incident detection application will integrate with the existing CHART ATMS and operate within the new ActiveITS ATM implemented as part of the Project, as well as integrate with the existing RITIS data hub. The incident detection platform will monitor traffic data, including vehicle detector data, live CCTV camera feeds, and incident reports and will also ingest third-party data sets (as determined by MDOT SHA), such as weather data, travel times, MSP CAD, alerts from navigation apps, and other sources.

Using these real-time data sources, the incident detection platform uses advanced processing to apply typical traffic behavior to quickly detect anomalies. The platform will proactively assess conditions and predict when anomalies are likely to occur, allowing TOC-4 to more quickly detect, respond, and manage traffic incidents. Historic data will allow HOTs to identify specific locations where traffic management strategies utilizing the Project devices can be utilized to prevent traffic incidents. The system data outputs provide robust data sources that can feed into the incident management processes. The Myers Team will evaluate deploying a pilot or demonstration of this system for a period of six months throughout the corridor to evaluate its effectiveness and usefulness to MDOT SHA operations.

Plan of Action for MDOT SHA if an Obstruction or Accident is Detected

An operator in TOC-4 will use the AID system in two main scenarios: (1) confirmation that the PTSU is ready to be opened to traffic; and (2) continuous monitoring during PTSU operation. According to the FHWA guide Use of Freeway Shoulders to Travel (*February 2016*), it is a best practice in operations to "sweep" the lanes before opening by either driving the facility or utilizing a technology such as the AID system. The proposed full camera coverage will save field resources by sweeping digitally from the CHART workstation, rather than a physical sweep of the entire PTSU corridor.

During PTSU operation, the camera coverage of the AID system will detect an incident or debris faster than waiting for the obstruction to be reported. If an object is identified within the defined boundaries, a web browser-based graphical user interface will show a representation of the PTSU corridor with color-coded symbology of the status and alarm state of each camera. HOTs can select a camera to see the live video and process any alarms for stopped vehicles or debris. Once debris is confirmed by an operator using camera feeds, the operator can dispatch appropriate resources to clear the debris. The HOT can then move quickly to close the PTSU lane by accepting the updated ATMS-recommended response plan or by creating a custom response based on the situation to reduce the risk of secondary crashes. Full and consistent monitoring of the PTSU using continuous thermal camera coverage saves resources, increases PTSU effectiveness, and increases activation time of the PTSU. This process is described in more detail below for different conditions.

PRIOR TO OPENING THE SHOULDER

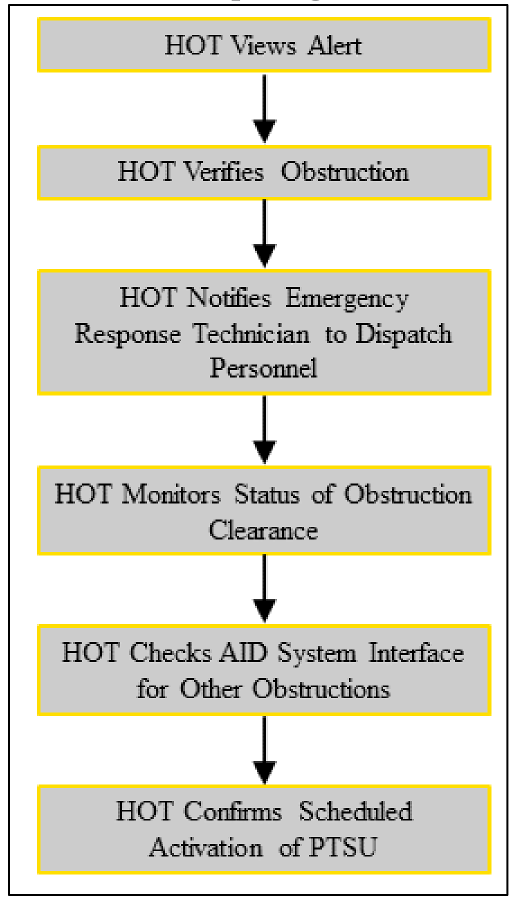
Before the PTSU lane is opened to traffic, either during the set peak period times or in response to an incident, the AID system will be scanning the PTSU lane for the presence of an obstruction (e.g., stalled vehicle or other debris). Based on the operational procedures for PTSU, the operator will receive AID alerts in real-time and be able to respond and clear the shoulder at any time, rather than waiting to confirm just in advance of opening the shoulder lane to traffic.

Figure 4.5 on page 46 describes the actions taken by TOC-4 if an obstruction is detected prior to opening PTSU:

1. HOT **views alert** on AID system interface in ActiveITS.
2. HOT **verifies obstruction** using AID cameras and/or PTZ CCTV cameras.
3. Upon positive verification, HOT **notifies Emergency Response Technician to dispatch personnel**

4. to clear obstruction. If debris is in the 2-ft offset between the lane and barrier, the HOT may choose “no action”.
5. HOT **monitors status of obstruction clearance** using AID cameras and/or PTZ CCTV cameras.
6. Upon successful clearance, HOT **checks AID system interface for other obstructions**, and repeats prior steps if necessary.
7. If all obstructions are clear, HOT will **confirm scheduled activation of PTSU**, which will activate signs and notifications to drivers.

Figure 4.5: Operator Process Prior to Opening PTSU



This system will enhance TOC-4’s response time, and reduce the likelihood of an incident in the PTSU lane by sweeping the lane for debris or other obstacles in advance of opening. Continued monitoring by the video analytics reduces the possibility of secondary crashes by alerting CHART Operators to an incident so PTSU operations can be adjusted.

DURING THE PTSU SCHEDULED OPERATING WINDOW

Figure 4.6 on page 47 illustrates when the AID system detects an obstruction in the shoulder (e.g., crash) while the PTSU lane is in operation. An event is created in CHART ATMS, initiating an alarm. The HOT confirms the incident, initiates the recommended response plan (or custom response if warranted), and notifies appropriate MDOT, CHART, and stakeholder forces. The following actions should be taken by CHART Operators if an obstruction is detected during PTSU operation:

1. HOT **views alert** on AID system interface in ActiveITS.
2. HOT **verifies obstruction** using AID cameras and/or PTZ CCTV cameras.
3. Upon positive verification, HOT will **initiate closure of PTSU** in advance of the obstruction (minimum of two PTSU signs). The downstream PTSU signs may remain in operation through the rest of the corridor. The HOT may override the recommended response plan if warranted.
4. HOT **displays DMS message** if PTSU will be unexpectedly closed for an extended period of time.
5. HOT **notifies Emergency Response Technician to dispatch personnel** to clear obstruction.
6. HOT **monitors status of obstruction clearance** using AID cameras and/or PTZ CCTV cameras. The MVD will continuously monitor speeds and queues on both the Inner and Outer Loops.
7. Upon successful clearance, HOT **checks AID system interface for other obstructions**, and repeats prior steps if necessary.
8. If all obstructions are clear, HOT will **re-activate the PTSU elements** that were de-activated and continue to monitor overall operations.

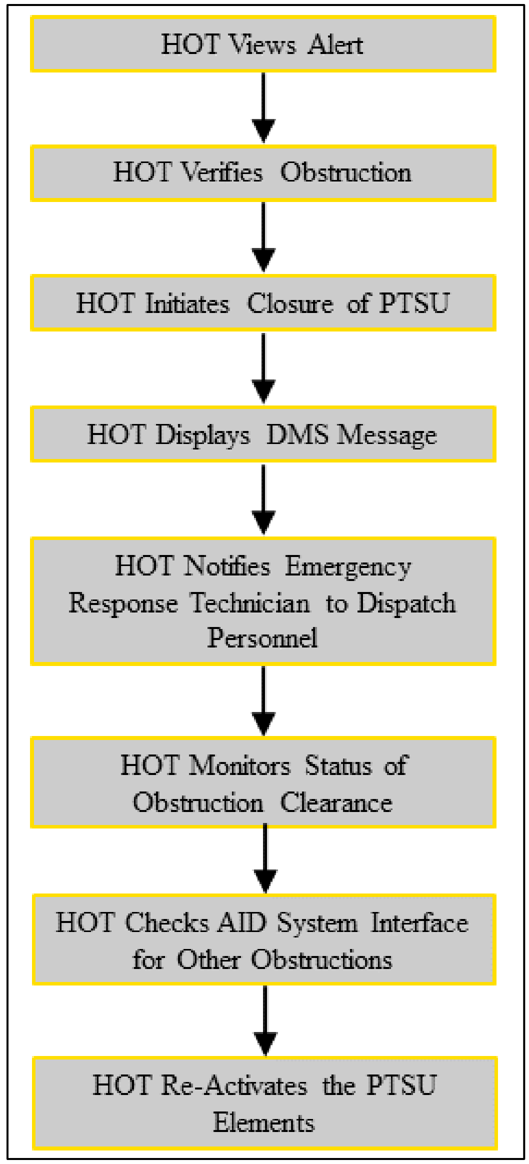
Specific details of these actions will be further documented in the ConOps and updated in the CHART Standard Operating Procedures.

CONCEPT OF OPERATIONS

While several aspects of system functionality can be described in this proposal, the Myers Team will develop a Concept of Operations (ConOps) to create a framework for an integrated ITS network in accordance with the RFP requirements and FHWA guidelines.

Implementation of the PTSU has numerous operational decisions, rules, and parameters that need to be agreed upon by stakeholders to create a fully integrated and functional system that meets the needs of MDOT SHA. The Myers Team will conduct multiple workshops to gather information from stakeholders, and solidify the specific parameters and procedures to be implemented for the Project. Each of these decisions will be documented in the ConOps to memorialize how the system will operate under different conditions. The resulting functionality will be a set Use Case Scenarios and Functional Requirements to guide PTSU implementation throughout the Project corridor. Additionally, the ConOps will identify new and updated Standard Operating Procedures (SOPs) that will be developed so support effective operations once the system is active. Some examples of parameters, considerations, and decision points include:

Figure 4.6: Operator Process During PTSU Operating Window



- ***Standard Operating Window:*** Our initial recommendation is for the PTSU lanes to be operational during AM and PM peak periods to provide the greatest benefit to the corridor. MDOT SHA CHART may desire flexibility in which portion of the corridor will be activated at any given time.
- ***Incident Management*:** PTSU should be activated under certain conditions or rules, such as only during major incidents or not in specific locations.
- ***Process for Opening and Closing PTSU:*** The recommended process for opening and closing PTSU lanes is in this section; it describes a step-by-step process for verifying an incident, activating PTSU, providing traveler information, monitoring an incident, and deactivating PTSU.
- ***Updating CHART ATMS Response Plans:*** The existing CHART ATMS has pre-programmed response plans for various incidents based on the type of incident and its geographic location. Our more robust ITS network not only provides more tools to detect conditions, but also to convey real-time information to motorists and responders. Response plans, and even the public dashboard will need to be updated as we implement the PTSU Project. This effort requires close coordination with the CHART Systems Integration, Field Operations, and TMC Operations teams.

The high-level outline for the ConOps document provided below illustrates our Team's proven approach to developing the IS-695 TSMO Project around sound system needs and operational deficiencies:

I. ***Project Purpose, Goals, and Objectives*** – Define why the Project is being developed and overall objectives. The Project Purpose, Goals, and Objectives and Operational Needs Assessment will capture existing constraints and deficiencies, such as travel time unreliability, limited management capabilities, and a lack of existing infrastructure to effectively manage the IS-695 corridor.

II. ***Operational Needs Assessment*** – Capture current functionality and document system operational gaps.

III. ***Operational Scenarios*** – Define how the built-out system will operate under different operating conditions. The Operational Scenarios and System Functionality will illustrate how the corridor will operate with PTSU and other ITS subsystems, formulating the critical foundation for developing the system.

IV. ***System Functionality*** – Define system requirements, rules, and parameters in the environment of a complete integrated system.

V. ***Roles and Responsibilities*** – Define stakeholder activities, responsibilities, and agreements for operations and maintenance of the system. The Roles and Responsibilities will ensure operations and maintenance sustainability by clearly articulating the role each stakeholder and department plays in success of the Project.

ii. IMPROVEMENTS FOR MANAGEMENT OF NON-RECURRING CONGESTION

The Myers Team is committed to reducing the number, severity, and duration of incidents along the IS-695 corridor. We also share CHART's mission "*to improve mobility and safety for the users of Maryland's highways through the application of ITS technology and interagency teamwork.*"

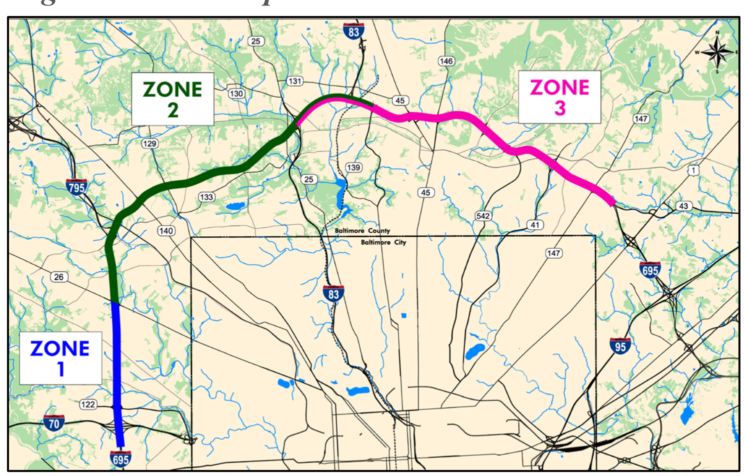
The AID System, MVD network, and 100% CCTV coverage provide the ability to quickly detect incidents to both the mainline and PTSU lanes, substantially increasing the reliability of incident information and reducing the time to identify the severity of and initiate a response to incidents. Systems similar to our proposed solution have shown to reduce response times by 20% (NTIMC, 2011). TOC-4 average response time was 13.2 minutes (2015); a 20% reduction equates to a reduced response time of 10.6 minutes, saving 2.6 minutes per incident. According to FHWA, each minute a lane is blocked can lead to four minutes of delay, which means a 2.6 minute quicker response time will have significant safety and mobility impacts.

Understanding of MDOT SHA CHART Existing Response and Management

When incidents, emergencies, weather events or other causes occur on IS-695 today, CHART's Traffic Management Center (TMC) Operations Division coordinates the response through the Statewide Operations Center (SOC) and the supporting Traffic Operations Centers (TOCs). The IS-695 Project area falls under the purview of TOC-4, located at the Golden Ring Barracks of the Maryland State Police (MSP). TOC-4 is now staffed 24 hours a day and handles all operations within the Project area. There is a "Ravens TOC" that provides traffic management for football games and other special events that occur at the M&T Bank Stadium. As needed, the SOC is available to provide back-up support.

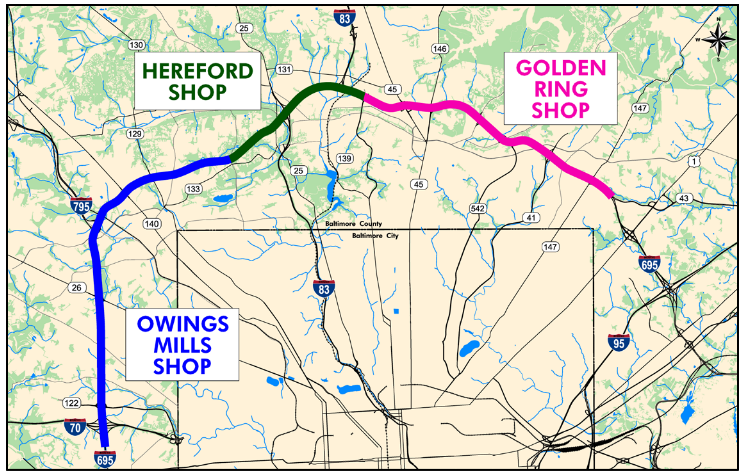
The SOC and TOCs are staffed by HOTs who use the CHART ATMS and the various ITS devices to monitor traffic conditions, respond to incidents, disseminate information to travelers, and coordinate among the various stakeholder agencies and emergency services. HOTs follow the latest version of the CHART SOP to create and manage incidents in the ATMS. This includes entering the incident information, initiating the response, coordinating the response, and monitoring the prevailing roadway conditions. Based on the verified situational awareness, the HOTs will coordinate with District and Shop staff to dispatch resources and personnel to support on-scene management of the incidents. The Project falls within three Field Operation Patrol Routes, as shown in *Figure 4.7*,

Figure 4.7: Field Operations Patrol Routes on Corridor



which are responsible for responding to incidents. TOC-4 is also responsible for dispatching Emergency Traffic Patrol (ETP) drivers from the SHA Shops. The Project falls within three different Shop ETP zones as shown on *Figure 4.8*. ETP vehicles operate 24/7 along the Beltway and are often the first responder to an incident. They are responsible for diverting traffic around an incident; reporting on-site conditions to the HOT at TOC-4/SOC; and (together with the HOT) identifying the need for emergency services, environmental clean-up, and other responders. For major incidents, an estimated time to clear is entered into the ATMS.

Figure 4.8: Chart Emergency Traffic Patrol (ETP) Routes



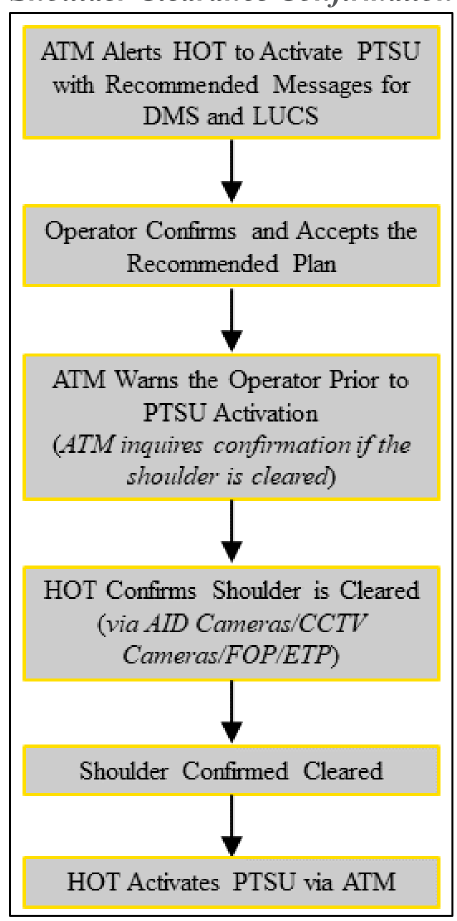
Improved MDOT SHA CHART Response and Management of Non-Recurring Congestion

The enhanced incident management strategies on the Project will maximize the safety benefits and enhance the functionality and ability for HOTs to effectively and proactively. monitor and respond to traffic conditions throughout the entire corridor. When the IS-695 TSMO technology strategies are integrated into the ATMS, CHART staff will have several new tools and expanded existing tools for managing recurring and non-recurring congestion and implementing management strategies. These new features will require new and updated SOPs which are anticipated to include the following:

- **Automated Incident Detection (AID)** and Debris Detection System – A new SOP will inform HOTs of operations for the AID system. HOTs will receive alerts if an object is identified within the defined boundaries on the PTSU and validate the occurrence of an incident, a crash, or the existence of a foreign object.
- **PTSU System** – A new SOP will inform HOTs of the procedures for determining and implementing PTSU lane under recurring and non-recurring scenarios (separate SOPs).
- **PTSU Lane Clearance Confirmation** – A new SOP for PTSU will include procedures for verifying the shoulder is available for use during non-recurring conditions. This would also involve new SOPs for Field Operations and ERT personnel to respond and clear debris from the shoulder.
- **Queue Warning (QW)** – A new SOP will inform HOTs of QW operations that could be utilized during recurring and non-recurring congestion.
- **Dynamic Speed Advisory (DSA) Signs** – A new SOP will inform HOTs of DSA operations that could be utilized during recurring and non-recurring congestion.

In order to activate the PTSU and open the lane to traffic, the HOT must confirm that the lane is free of incidents or debris. *Figure 4.9*

Figure 4.9: New SOP for PTSU – Shoulder Clearance Confirmation



provides a flowchart of the procedures that will be integrated into a new SOP specific to Shoulder Clearance Confirmation. This process includes alerts to the HOT and use of surveillance via CCTV cameras, FOP, and ETP to identify potential threats to safe usage of the PTSU. After the HOT receives the notification of a response plan that includes the ***recommendation to activate the PTSU***, the HOT will ***confirm and verify*** any outstanding alerts or potential concerns in the PTSU. Once the shoulder is ***confirmed as clear*** by the PTSU, the HOT can ***activate PTSU via the ATMS***. The process outlined in *Figure 4.9* on page 49 may also be set to run fully automated with the AID system initiating an alarm if an obstruction is detected in the PTSU lane.

HOTs will have complete monitoring capability through the entire corridor, enhanced vehicle detection/AID that will alert HOTs of possible incidents on the freeway; and an AID system to alert Operators that an obstruction has been detected on the PTSU lane. These functionalities will enable HOTs to respond to incidents and manage incident congestion in a proactive, timely manner compared to current activities today, requiring less incident response planning and limited additional personnel involvement. These functions will be provided through Southwest Research Institute (SwRI) software package, ActiveITS that will be the ATM system (ActiveITS ATM) and integrated with the CHART ATMS to optimize the adoption within existing operations, while increasing CHART's responsiveness to non-recurring congestion.

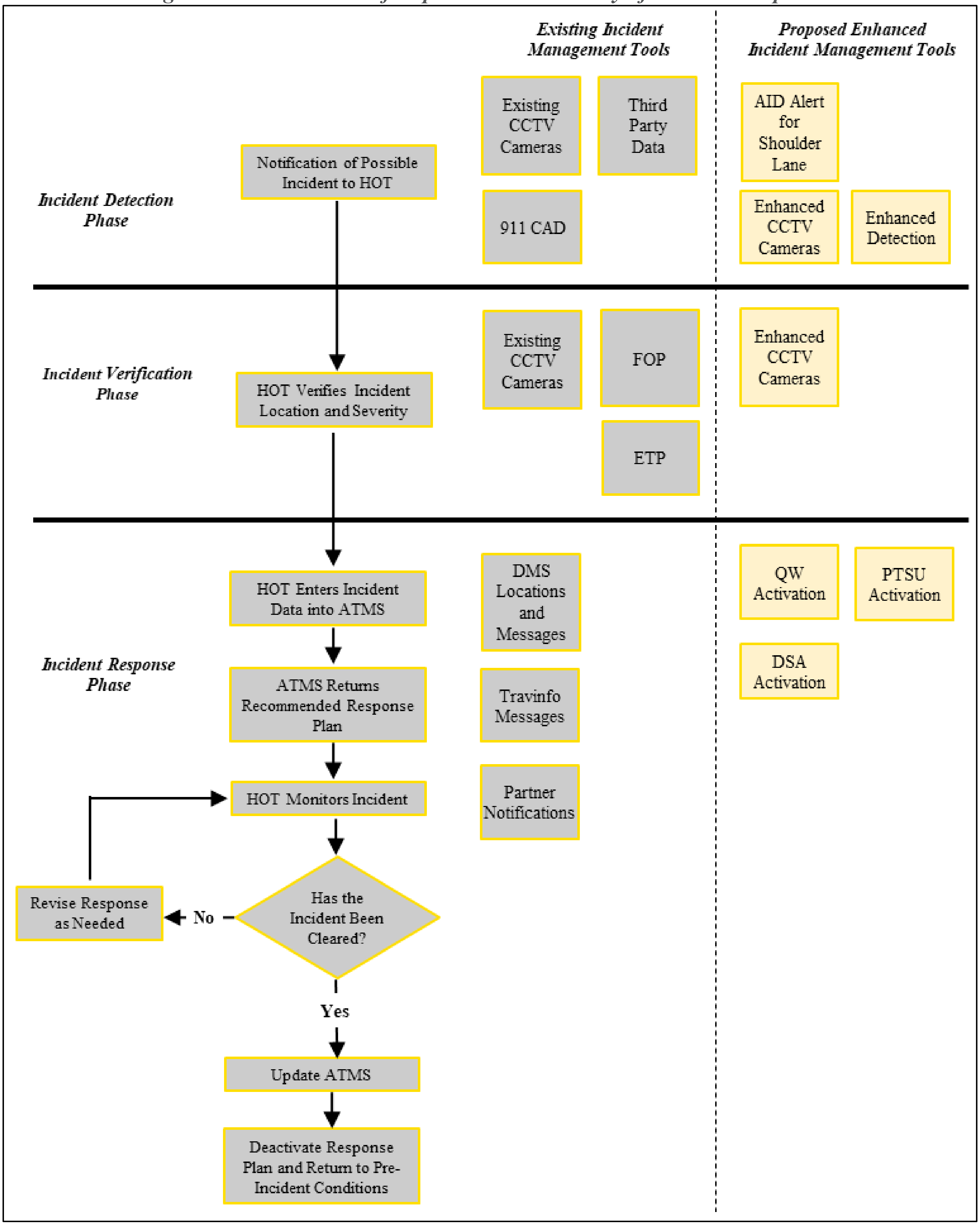
The flowchart shown in *Figure 4.10* on page 51 demonstrates the existing and additional functionality that would be available to support responsibilities related to incident management. The flowchart illustrates a response to non-recurring congestion and can be applied at any time during the day (peak or off-peak) based on the prevailing traffic conditions and anticipated impact to travel reliability. The additional tools noted in the second column provide an expansion to the operators' incident management capabilities and will decrease the response time and resulting incident clearance times for incidents. For example, during the first phase of the incident response flowchart, operators will be able to receive notifications or identify incidents using all seven of the existing and proposed tools. CHART has well established and mature operational procedures. The improved functionality of the incident response builds on those existing processes and will seamlessly integrate the new strategies into the baseline operations as show in *Figure 4.10* on page 51. SOPs and response plans will be revised so incident response can be optimized by effective use of the proposed strategies. All phases of the incident response will be revised to reflect the new technologies and application of the traffic management strategies including PTSU, DSA, and QW.

The Myers Team will prepare a Concept of Operations to document corridor deficiencies; define required functionality; describe operational scenarios; and outline system interfaces. The rules, decisions, and processes described in our proposal will be confirmed and further developed through stakeholder workshops to memorialize how the IS-695 TSMO system will integrate and operate with the MDOT SHA CHART environment.

> ***Decreased Incident Response Time***
> *Enhanced camera coverage and AID system will provide full coverage of the mainline and PTSU lanes of the corridor – increasing reliability of incident information and has shown to reduce incident response conservatively by 20% (NTIMC, 2011).*

In addition to modifying the SOPs used by CHART, it will be important to also revise and expand the response plans to include the new roadway configuration inclusive of the PTSU lane and the application of the new strategies. HOTs will continue to use the ATMS to access CCTV cameras and monitor real time freeway conditions relative to the incident, and will have new technologies and ITS devices available within the system. Our Team will work with CHART to ensure all of the revised response plans appropriately integrate all of the devices and effective traffic management applications. Response plans within the ATMS will recommend specific devices and actions to support the incident response including posting DMS messages, activating highway advisory radios, and disseminating notifications to 511 and social media. Incidents involving disabled vehicles or injuries may recommend additional messaging and implementation such as Dynamic Speed Advisory (DSA) and Queue Warning (QW) specific to the situation.

Figure 4.10: Flowchart of Improved Functionality of Incident Response



iii. PTSU ACTIVATION OUTSIDE OF THE SCHEDULED OPERATING WINDOW

Major incidents have the biggest impact on freeway performance, causing more than 50% of the delay that drivers experience. Utilizing PTSU outside the scheduled operating windows can have significant positive impacts on congestion reduction, enhanced safety, and overall corridor performance by making more capacity available during times of constricted operations. According to FHWA, an incident that blocks two of four freeway lanes causes a 75% capacity reduction. As PTSU effectively creates an additional through lane, this same incident now effectively blocks only two of five freeway lanes, resulting in the capacity reduction of only 60%. While PTSU is limited to passenger vehicles and light trucks, it does provide a level of additional throughput capacity that can be realized with PTSU outside of scheduled operating windows.

Plan for MDOT SHA to Determine if PTSU Should Be Activated

MDOT SHA HOTs will have the ability to proactively monitor conditions and activate PTSU operations as frequently as possible to optimize corridor capacity, mobility, and safety. Proactive operations during an incident will minimize or eliminate congestion and traffic impacts that occur outside of the scheduled operating windows (typically AM and PM peak periods).

The proposed plan of action for utilizing PTSU outside of the scheduled operating window involves the consideration of incident characteristics, incident location, shoulder availability, and time of day related to scheduled operating windows. HOTs apply these incident characteristics to define the acceptable scenarios and conditions that can benefit the most from PTSU. HOTs will consider the following factors to determine if PTSU should be activated outside of the schedule operating window (in order of importance):

- ***Incident Accessibility for Emergency Vehicles*** – Before PTSU can be utilized, HOTs must confirm that emergency vehicles can access the incident scene. The incident or incident clearance activities could also block the PTSU lane. Rapid and efficient incident response and clearance is paramount before PTSU can be considered.
- ***Event Severity and Duration*** – PTSU will be most effective for intermediate and major incidents, where the normal flow of traffic is impeded for more than 30 minutes. This level of severity will have substantial throughput reduction and will warrant the additional capacity. Activation of PTSU should be consistent with deployment of other incident management strategies focused on managing non-recurring congestion, such as displaying traveler information messages on DMS and issuing notifications to partner agencies.
- ***Event Location*** – The incident location with respect to other geometric constraints, including narrow shoulders, interchanges, and lane drops, will influence if HOTs will activate PTSU. Drivers will need sufficient advanced warning of an available PTSU lane for effective use, so proximity to the PTSU lane terminus or a lane drop/add could influence if PTSU is activated. If the incident is located on the left side of the roadway, the PTSU should remain closed and available for emergency use. For more severe incidents near the median, the PTSU should also be closed on the opposite side of IS-695 as emergency responders typically approach from both directions.
- ***Current Conditions in Adjacent Segments of the Corridor*** – Traffic conditions along the corridor at the time of an incident will influence if PTSU is activated for a particular segment. If PTSU is already in operation along part of the corridor due to an incident, it may not be appropriate to create inconsistent conditions by having disjointed PTSU lane segments (or PTSU activations). Alternatively, the specific scenario could warrant the extension of existing PTSU implementation to encompass a longer segment.
- ***Concurrent Work Zones*** – If a major incident occurs during a time when traffic control is already in place in the vicinity of the incident, it may be appropriate to activate PTSU. Some situations may allow for PTSU to be used in a work zone scenario, or be adapted to include incident situations. MDOT SHA could also consider whether PTSU could actually be used as a work zone traffic control tool even without an incident.

- ***Time of Day*** – At the time a major incident occurs, traffic demand will be trending higher or lower toward the next peak or off-peak period. If traffic is trending higher toward a peak period, PTSU activation should also consider incident severity and proximity to the next scheduled operating window. An incident that occurs in the time before and after a scheduled operating window will influence if PTSU is activated. A major incident that occurs prior to a scheduled operating window will likely cause PTSU to be activated for the major incident, then extended to the scheduled operating window if the entire corridor is being activated. This will avoid disruption and confusion associated with turning the PTSU off and on. If traffic is trending lower toward a non-peak period, PTSU may not be extended beyond the scheduled operating window due to lower traffic demand that will not cause substantial queuing. A major incident that occurs after a scheduled operating window may result in turning the PTSU back on, but it will also be dependent on prevailing demand and other factors described above. An incident that occurs in the middle of the night may not even justify activating PTSU. Specific parameters and thresholds will need to be established as part of the SOP to define how PTSU is utilized during non-peak periods.

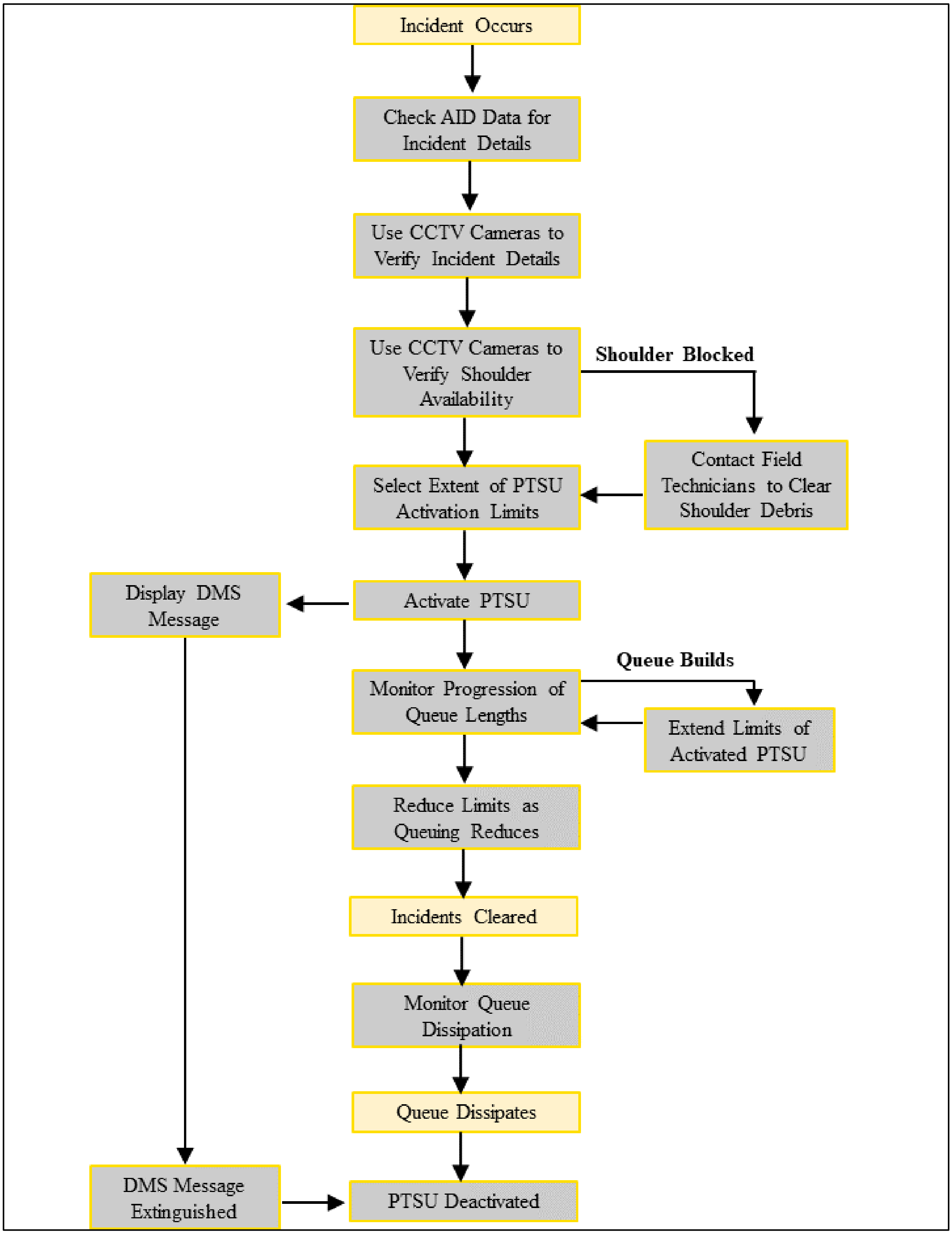
When an incident meets a pre-determined criterion, HOTs will confirm the recommended PTSU limits and activate the PTSU strategy for operation. *Figure 4.11* on page 54 illustrates the Plan of Action for MDOT SHA to determine if the PTSU should be activated when an event occurs. Each event will have multiple factors that influence the decision to activate PTSU. The ConOps will describe the specific thresholds for each of these, so the CHART Operator can rely on a pre-determined database of strategies rather than evaluate each incident as it occurs. The ConOps will describe how the system is to be operated during different scenarios (i.e., Incident during Non-Peak Period) and which stakeholders have responsibilities for each event. The Functional Requirements will define how the system will accommodate action requests and activation of field equipment.

Plan for MDOT SHA to Determine What Portion of the PTSU Should be Used

The portions of the PTSU lane to activate during an event will be influenced by several factors, including those described in the previous section. Parameters and conditions for activating the PTSU will be detailed in the ConOps, as well as in the updated Standard Operating Procedures (SOP). An MDOT SHA CHART HOT will consider the following factors to determine what portion of the PTSU should be activated:

- ***Begin in Advance of Queue*** – When a major incident occurs, a queue will quickly develop upstream of the incident on the order of one mile per minute. The beginning of PTSU activation should be selected based on where the back of the queue is expected to reach at the time the PTSU is implemented, which could require the inclusion of an additional mile or more in advance of the incident location.
- ***Advanced Notice to Drivers*** – When PTSU is activated, drivers need enough advanced warning to react to using the shoulder. Drivers typically need ¼-mile per typical lane change maneuver. In addition, drivers should view a second LUCS for confirmation that the lane is available. This means PTSU should be activated at least ¼-mile plus the distance from the back of queue to the second upstream LUCS.
- ***Consideration for Vertical and Horizontal Alignment*** – When PTSU is available, drivers need to see two consecutive signs in advance of using the lane. There are conditions along the corridor where vertical or horizontal alignment may require an additional LUCS notification to ensure drivers are well-informed of the PTSU activation. This may extend the starting point of the PTSU and will be accommodated within the programmed response plans
- ***Extend Beyond Incident Location*** – Downstream from the incident, the end of PTSU needs to continue beyond at least one LUCS to indicate to drivers the lane is ending. The second LUCS downstream from the incident should provide an indication (e.g., yellow) that the lane is ending, followed by the third LUCS indicating the PTSU is closed.

Figure 4.11: Flow Chart of Activation and Deactivation of PTSU



- ***Proximity to Corridor Terminus (Beginning or End)*** – When the extents of PTSU operation are determined by the previous criteria, the final element is considering the proximity to the beginning or end of the corridor. In some scenarios, the extents of PTSU may need to be extended or adjusted based on the beginning or end of the corridor (e.g., beyond the extents of PTSU LUCS, or extended to smooth corridor operations). In these scenarios HOTs will need to consider other factors described above to determine if PTSU can be safely and effectively utilized.

These factors will determine how much of the PTSU should be activated at different locations on the corridor and for different incident severity. The decisions and specific thresholds will be further defined as part of the Concept of Operations and Functional Requirements workshops to build the decision process into Standard Operating Procedures and the SwRI ActiveITS interface.

How MDOT SHA Opens and Closes the Shoulder

For activation and deactivation, our Team envisions that the TOC-4 HOTs will be responsible for confirming to open and close the PTSU lanes following the process described below, and in response to an AID-automated incident notification. The opening and closing processes noted may also be developed as response plans for an event in the CHART ATMS. The activation and deactivation of PTSU will utilize functions of the existing ATMS and the proposed SwRI ActiveITS ATM, and is illustrated in the flow diagram in *Figure 4.11* on page 54.

OPENING: When an incident occurs, the HOTs will receive an alert through the SwRI user interface that the AID cameras have detected a possible incident. The operators will also be notified from the same interface if the shoulder is “all clear” for PTSU activation. If debris is detected in the shoulder, HOTs will notify a Field Ops or an ERT to remove the debris. Operators will confirm and observe incident conditions using the AIM/CCTV cameras and MVD data feeds to verify an incident has occurred, and confirm the factors provided by the ATM that influence the decision to activate PTSU (e.g., severity, estimated duration, extents, time of day). Most parameters described above will be pre-determined based on data collected through the vehicle detection system, so HOTs can quickly validate that PTSU activation is appropriate.

Once shoulder clearance and limits have been confirmed, the HOT will activate the signs which advise drivers of the lane opening via DMS or static signs and change red X to green arrow at the same time throughout the corridor. All signs to be activated will be turned on at the same time, allowing access along any portion of the PTSU. As the PTSU lanes are in operation, HOTs will monitor traffic conditions using camera feeds through the ATMS. As conditions change, it may be necessary to adjust the limits of PTSU operation longer or shorter depending on the effectiveness of the initial activation. This will be part of the HOTs SOP for managing incidents.

CLOSING: Once the incident has been cleared, CHART Operators will continue monitoring dissipation of the residual queuing until the freeway returns to normal operating conditions. Depending on the time-of-day, actual and anticipated traffic demand, and rate of queue dissipation, the Operators will continue to operate the PTSU until traffic returns to normal conditions. Deactivating PTSU involves advising drivers via DMS that the lane is shutting down and to obey LUCS, changing the signs to a yellow X followed by a red X starting with the furthest upstream sign, and in sequence to the last downstream sign. This process must be followed to avoid trapping drivers in the shoulder. These actions will be completed through the ATM interface.

Turning on and off the PTSU LUCS will account for vehicle travel time between signs. For example, signs at ¼-mile spacing should be sequenced at 15-second intervals based on an assumed speed of 60 mph.

Examples of Incident Response

The use of our project improvements will vary depending on the location of the incident, its severity, and the time of day, among other factors. The following summarizes the response for two separate scenarios, one on the left side of the roadway and the other on the right.

Incident #1 – Three-Vehicle Crash on the Left Side of the Inner Loop While PTSU Active

The crash on the left side of the roadway may be detected by the AIM cameras if it is within or near the PTSU lane. If not, the closest MVD before the incident will quickly recognize the slowed traffic in the travel lane. For both instances, the ActiveITS ATM would initiate an event in the CHART ATMS that an incident has occurred. The HOT will utilize the AIM/CCTV cameras to verify the incident, estimate its severity and clearance time, and initiate the pre-programmed response plan (or override and initiate a custom plan). Notifications will go out to the CHART, MDOT SHA, emergency response, and/or other stakeholders. The response plan will recommend closing the PTSU in advance of the incident in both directions, as traffic will be diverted to the right on the Inner Loop and emergency vehicles will approach along the median shoulder from both directions. All of the LUCS in advance of the crash site will change from green arrow, to yellow X, to red X. The response plan will place messages on the DMS prior to the incident location, and the local ATM will modify the DSA signs to slow drivers approaching the incident. The response plan could be modified based on the severity of the crash entered in the ATMS; for more severe incidents, additional DMS devices farther away would provide messages to drivers with flashing beacons activated and alternate routes to convey urgency. The ActiveITS ATM will continually track vehicle queues in both directions and sweep for secondary incidents. As the incident is cleared and queues dissipate, the HOT will visually confirm that the AIM system is not identifying debris or disabled vehicles within the PTSU lane and initiate the sequence to open the PTSU lane to traffic.

Incident #2 – Two-Vehicle Crash on the Right Side of the Outer Loop While PTSU is Closed

Crashes occurring on the right side of the roadway would be less impactful to the traveling public if the PTSU lane were able to open. Emergency vehicles for crashes on the right side of the highway will typically approach from the same side of the highway and traffic is diverted to the left around the crash site. The median lane would provide additional capacity to reduce the overall delay impacts from the incident. The initial detection of an incident on the right side of the roadway would be identified by an MVD as traffic slowed below a speed threshold, so the response would not be as immediate as if an incident occurred in the PTSU lane (identified immediately by AID cameras). The slowed traffic would initiate an event in the CHART ATMS, and the HOT would confirm it using the PTZ CCTV cameras. Based on the location of the slowed traffic and the severity of the event, the pre-programmed response plan could include an option to open the PTSU lane. As with any incident once confirmed, notifications would go out to the appropriate CHART, MDOT SHA, emergency response, and/or other stakeholders per the CHART TMC Operations Standard Operating Procedures Manual. The response plan will include recommended messages on nearby ITS devices, and if the PTSU is activated, the LUCS will change from the red X to the green arrow to help keep queues to a minimum. The ActiveITS ATM will adjust the DSA signs prior to the incident, and will continually track vehicle queues in both directions and sweep for secondary incidents. As the incident is cleared and queues dissipate, the HOT will initiate the sequence to close the PTSU lane to traffic.

iv. NON-RECURRING CONGESTION REDUCTION

The PTSU is anticipated to be in service from 6:00 a.m. until 10:00 a.m. and from 2:30 p.m. until 7:00 p.m. each week day, and the ITS support devices will continuously function all day. Based on 2018 crash data, there were 794 reported crashes on the Inner Loop and 576 on the Outer Loop with over 40% of crashes being rear-end crashes. There were seven fatal crashes and 388 that resulted in injuries.

Impact of TSMO Technology Strategies on Non-Recurring Congestion

The Highway Safety Manual provides information, tools and guidance to practitioners such that design, and operational decisions can be made with an understanding and estimate of how safety will be impacted by a given propose strategy. Crash Modification Factor (CMF) is the estimated reduction in crash numbers expected after the implementation of a treatment. Multiplying the CMF value by the current observed crashes results in the estimated number of crashes in the same time period if the treatment had been applied. Therefore, the estimated crash reduction can be determined by the following formula:

Average crashes − (CMF∗Average crashes) = Crash reduction

For example, assuming that a corridor has 10 crashes per year, and the CMF for a treatment is 0.70.

$$10-(10*0.7) = 3 \text{ fewer crashes per year}$$

The specific TSMO technology strategies that are being implemented within the corridor focus on benefits from reduced crashes and improved safety, which will contribute to reducing non-recurring congestion. The strategies are described below along with applicable CMFs where available. It is important to note that CMFs are developed by contributing agencies who evaluate and provide data pertaining to a given deployment. Very few reliable CMFs are available for emerging technology strategies such as dynamic speed advisory signs and queue warnings. Furthermore, when deploying a combination of strategies, it is unlikely that a CMF will be available for the same combination of strategies and deployment type. The following sections provide a high-level review of anticipated safety benefits for the proposed strategies along this corridor; it is not expected that these benefits will be additive in nature but provides a conservative way to consider each strategy independently.

> ***PTSU Benefits***
> *PTSU will reduce congestion and increase throughput throughout the entire corridor during recurring and non-recurring congestion, improving overall corridor safety and mobility by reducing bottlenecks and stop-and-go conditions.*

PART-TIME SHOULDER USE (PTSU) – PTSU has proven to be an effective strategy to improve operations, reliability and safety, particularly during heavy congestion periods. The addition of a part-time shoulder lane is expected to reduce congestion-related crashes, which can be verified in a safety analysis using existing crash data, including crash type, time, and location. During peak hours, when the general-purpose lanes are congested or blocked by incidents, this strategy provides temporary additional capacity along the corridor, relieving congestion and reducing the probability of secondary crashes. PTSU is expected to reduce non-recurring congestion by increasing throughput, minimizing queuing, and reducing incident recovery time. Reduced safety benefits of PTSU occur primarily where the static-dynamic lane ends at a land drop, similar to the situation on the Outer Loop at IS-70. Our Team extended the merge point beyond the IS-70 split and incorporated DSA and additional DMS as a queue warning system to enhance safety within this segment.

AUTOMATED INCIDENT DETECTION (AID) AND DEBRIS DETECTION SYSTEM –The system will continuously monitor the PTSU lane to detect stopped vehicles or obstructions that could impact PTSU operations. This system will enhance the CHART response time, and reduce the likelihood of an incident in the PTSU by sweeping the lane for debris or other obstacles in advance of opening. Continued monitoring reduces the possibility of secondary crashes. Implementation of AID system increasing reliability of incident information and has shown to reduce incident response conservatively by 20 percent (NTIMC, 2011).

QUEUE WARNING (QW) – The Queue Warning (QW) treatment uses DMS to display real-time warning messages to inform travelers of downstream changes in travel speeds due to crashes or congestion. It is intended to mitigate vehicles traveling at free flow speeds from approaching an unexpected back of queue. Enhanced vehicle detection is coupled with QW to alert operators of changes in traffic flow to determine if QW should be implemented. ***QW will reduce congestion by mitigating the likelihood of crashes occurring by alerting upstream traffic of unexpected slowed or stopped queues downstream.***

Queue Warning Crash Reduction
From the CMF of 0.84 (rear-end) shown in Table 4.1 it is estimated that a QW implementation on the corridor could reduce crashes by 88 crashes per year (per 2018 crash data).

Table 4.1: Queue Warning CMF from CMF Clearinghouse

CMF	Quality	Crash Type	Crash Severity	Area Type	Reference
0.84	3/5	Rear End	Serious, Minor Injury	Urban	Elvik. R. and VAA, T., 2004

DYNAMIC SPEED ADVISORY (DSA) – Also referred to as Speed Harmonization, this treatment uses digital speed limit signs that can display advisory speed limits in response to real-time traffic conditions to smooth traffic flow across a longer portion of the corridor by minimizing the speed differential of vehicles approaching a slower or stopped platoon. DSA works well with queue warning and enhanced MVD and camera coverage to mitigate non-recurring congestion by reducing the frequency of primary and secondary collisions. Speed harmonization reduces the severity of crashes that do occur, which will reduce incident clearance times and further minimize non-recurring congestion. DSA will reduce congestion by normalizing mainline traffic flow, minimizing the speed differential and thereby decreasing the frequency of primary and secondary crashes.

DSA Crash Reduction
*From the CMF of 0.71 shown in Table 4.2 on page 59, it is estimated that a DSA implementation on the corridor **could reduce crashes by 397 crashes per year** (per 2018 crash data).*

Table 4.2: Queue Warning CMF from CMF Clearinghouse

CMF	Quality	Crash Type	Crash Severity	Area Type	Reference
0.71	4/5	All	All	Urban	Pu et al., 2017

ENHANCED CCTV CAMERA COVERAGE – Enhanced CCTV camera coverage supplements existing camera to provide continuous coverage of PTZ cameras to eliminate blind spots and provide continuous coverage of the entire corridor. This will reduce non-recurring congestion by allowing HOTs to quickly identify/verify incidents in the corridor and effectively implement PTSU and other strategies, such as Queue Warning and Dynamic Speed Advisory signs, to reduce the potential for secondary crashes.

> ***Enhanced CCTV Camera Crash Reduction***
> *On average, 20% of all crashes are secondary crashes. There is a 40% reduction in secondary crashes when a traffic incident management system includes enhanced camera coverage (USDOT, 2007). With implementation of full camera coverage on the corridor crashes* ***could reduce by 110 crashes per year*** *(per 2018 crash data).*

MICROWAVE VEHICLE DETECTORS (MVD) – By providing real-time traffic flow conditions, enhanced MVD capabilities will provide full vehicle detection at ¼-mile spacing and will be used to identify incidents on the mainline and determine the extent and duration of PTSU operation during non-recurring congestion. This additional detection will provide enhanced alerts to TOC-4 when traffic flow changes, and will support quicker incident detection and clearance data.

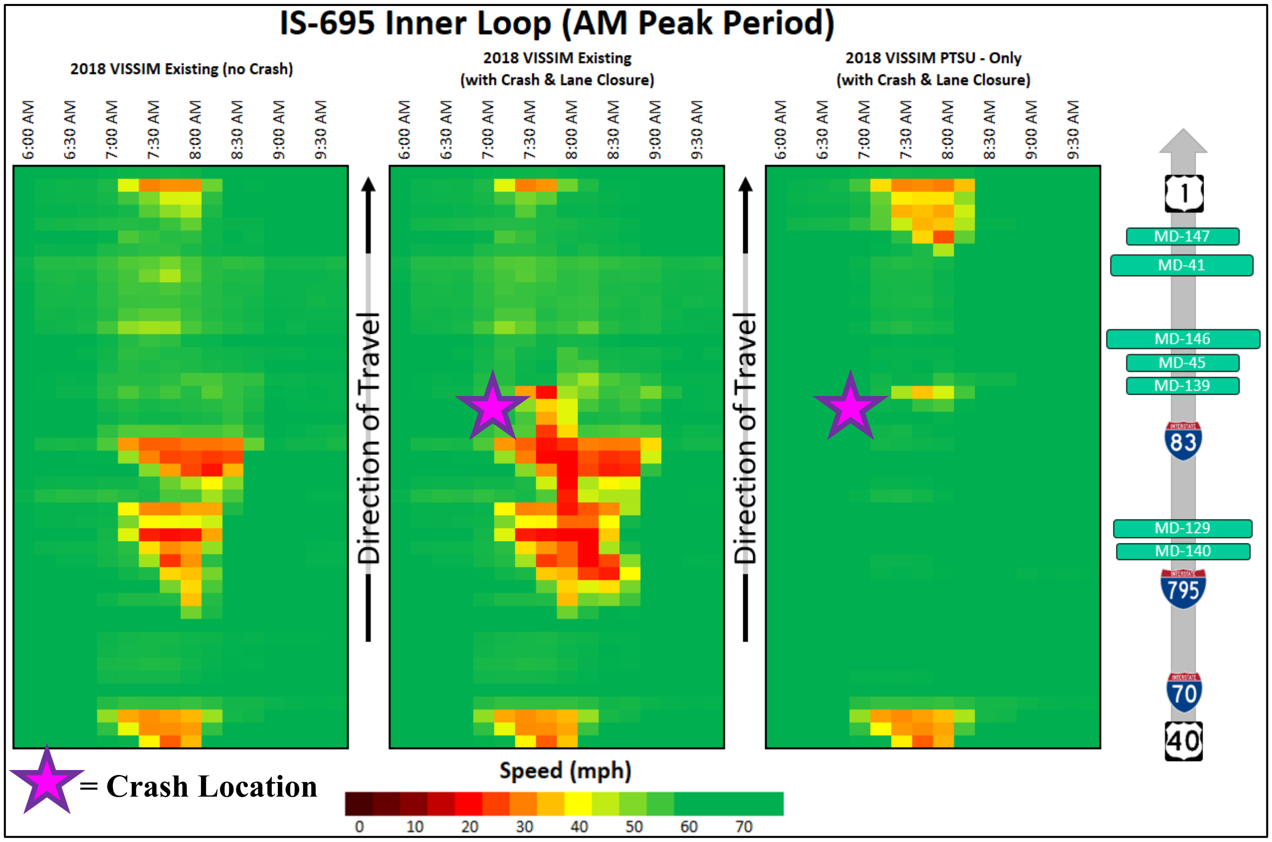
ENHANCED TRAVELER INFORMATION STRATEGIES – Proactive deployment of traveler information strategies will reduce the number and severity of incidents along IS-695. These strategies consist of traveler information messages about downstream conditions; alerting drivers that conditions are changing. These messages are displayed in real-time on DMS and pushed to 511 and other traveler information websites and alert services. More accurate real time information allows drivers to adapt, prepare and mitigate potential crashes, and avoid congestion. DMS support enhances traveler information and has been found to provide an average of 3 minutes travel time savings when providing actionable information which is acted upon (TOPS-BC, FHWA).

MAINLINE INCIDENT DETECTION – With the enhanced MVD and CCTV camera deployments described above, HOTs will have more video feeds and traffic data along the corridor at their disposal. This data and video can also be used to identify anomalies (such as backups in non-typical locations or at non-typical times of the day) that could be the result of an incident along the IS-695 mainline. These systems operate in the background and only send alerts to operators when a significant anomaly is detected. Our Team will conduct an initial evaluation of this system to assess the effectiveness and usefulness to SHA operations. The earlier identification of backups will allow HOTs to identify and respond to incidents quicker, which will help reduce the non-recurring congestion and secondary crashes.

Example of Congestion Reduction associated with PTSU

The potential benefits of using the PTSU can be quantified and illustrated using the VISSIM models provided by MDOT SHA. For example, in the AM peak, under existing conditions there is no congestion in the segment of the Inner Loop between IS-83 and MD 45 (York Rd). However, if an accident were to take place during the AM peak period just east of IS-83 and one lane (outside lane) were to be blocked for travel, it would quickly result in congestion and spill back as shown in *Figure 4.12* on page 60. The simulation assumed a crash occurring between 7 a.m. – 7:30 a.m. along the Inner Loop that will block the right-most travel lane.

Figure 4.12 – Congestion Diagram with Crash During AM Peak Period With and Without PTSU



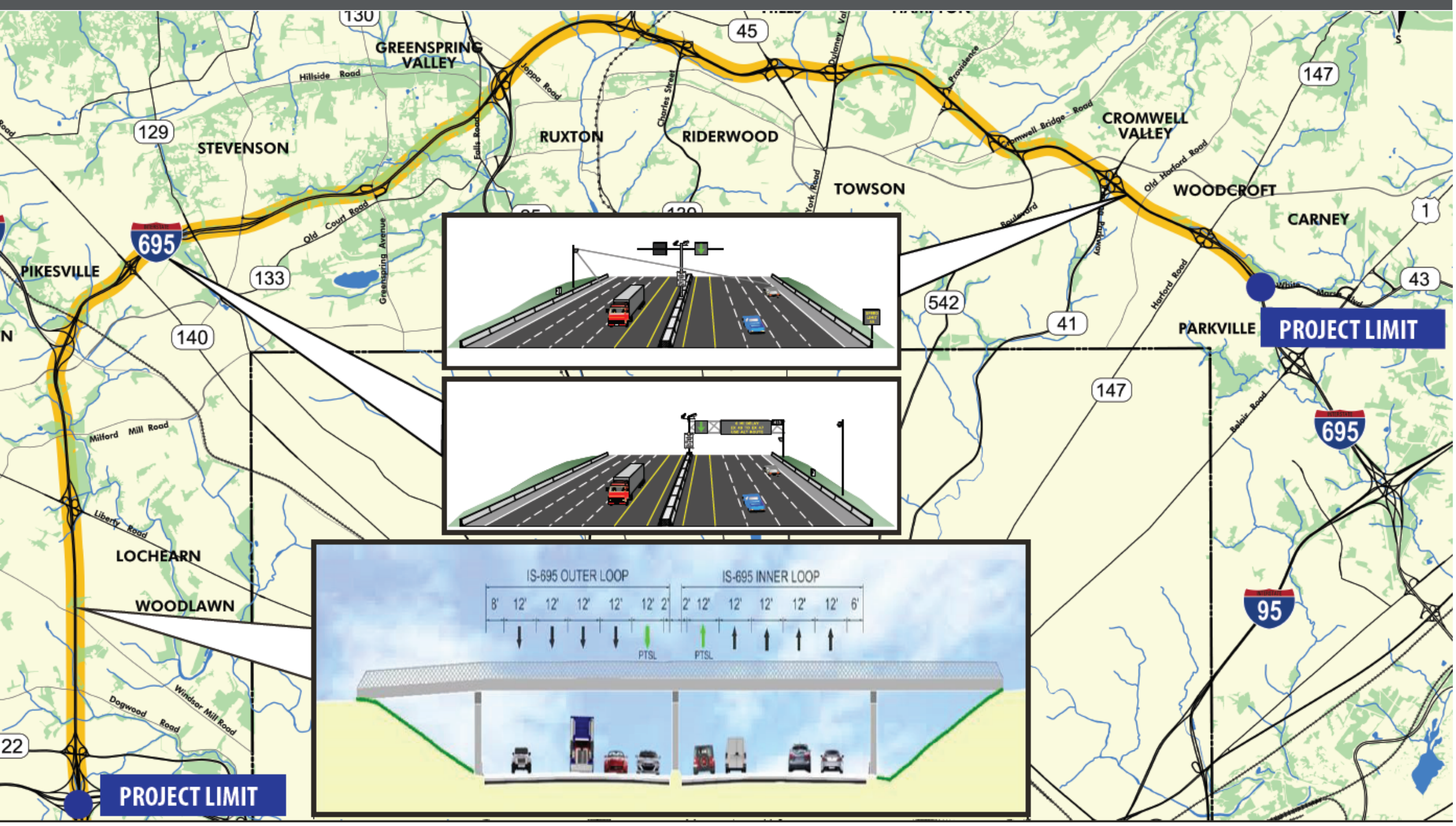
As shown in *Figure 4.12*, with the PTSU proposed by the Myers Team, this congestion would be eliminated compared to the existing conditions. As shown in the Travel Time savings summary in *Table 4.3* below, there is an average reduction in travel time delay of more than 6.6 minutes on the Inner Loop during the peak period with ***more than 18.6 minutes savings in the 8 a.m. – 9 a.m. peak hour***. The benefits and impacts will vary depending on the location and type of crash and blockage. However, PTSU clearly provides additional capacity to manage the congestion in the event of an incident. Detailed results of the VISSIM analysis for the Inner and Outer Loop for this scenario are provided in *Appendix D-5*.

Table 4.3: Travel Time Savings Along Inner Loop with PTSU and Crash During the AM Peak Period

Segment	Travel Time Savings (Minutes)				
	6-7 AM (Segment)	7-8 AM (Segment)	8-9 AM (Segment)	9-10 AM (Segment)	Average 6-10 AM
IS-695 IL (from US 40 to US 1)	0.1	6.0	18.6	1.1	6.6

2.09.05

OPERABILITY/MAINTAINABILITY/ ADAPTABILITY



ALLAN MYERS + Bruce & Merrilees + WALLACE MONTGOMERY + Kimley»Horn

2.09.05 OPERABILITY/MAINTAINABILITY/ADAPTABILITY

The Myers Team is focused on providing solutions that address the mobility goals of the IS-695 TSMO Project (the Project) while ensuring the safety of CHART and District 4 Maintenance staff, minimizing the need for additional operations and maintenance (O&M) staff, and being flexible to adapt to future technology. We understand the need to incorporate the new infrastructure required to operate the part-time shoulder use (PTSU) lanes and the ITS technology solutions as seamlessly as possible with the existing CHART ATMS and ITS architecture, as well as CHART's Standard Operating Procedures (SOPs). Most of our proposed strategies will require minor updates to existing SOPs, however our tableau of improvements will require extensive changes to the existing recommended response plans that are built into the CHART ATMS. The specific functionality, integration, and operations processes will be developed in the Concept of Operations (ConOps).

Our proposed Project solutions will achieve the following:

- Enable MDOT SHA and CHART staff to enhance IS-695 corridor performance by reducing congestion and improving travel time reliability;
- Minimize additional operational and maintenance responsibilities through compatibility with existing field equipment and integrating with existing SOPs; and
- Establish a framework and vision that positions MDOT SHA and CHART for future technology advancements as new equipment and new innovative strategies become available in the market.

Our Team's proposed Project improvements include both roadway and technological solutions to substantially improve safety and mobility in the IS-695 TSMO Project area:

- ***Roadway Improvements*** – Roadway and structure improvements to provide continuous PTSU between IS-70 and MD 147 on the Inner and Outer Loops, as well as pull-off areas for maintenance and emergency use; pavement wedge/level and restriping IS-83 South ramps to improve operations; retrofit of over 10 miles of median barrier; and drainage structure repair and replacement.
- ***Technological Solutions*** – ITS improvements to enhance safety and reduce non-recurring congestion, including additional full-size and small dynamic message signs (DMS), automated incident detection (AID) system, full coverage with pan-tilt-zoom (PTZ) cameras, continuous microwave vehicle detection (MVD) and dynamic speed advisory (DSA) signs; all of the ITS devices are connected to the local Southwest Research Institute Active ITS Advanced Traffic Management System (SwRI ActiveITS ATM), which is integrated with the CHART ATMS.

i. SAFE MAINTENANCE WHILE MINIMIZING TRAFFIC IMPACTS

Our Team incorporated the feedback received at the One-on-One meetings and involved former District Maintenance staff, SOC employees, and Emergency Response Technicians (ERTs) in developing the final plan for the IS-695 improvements. Our work includes additional field devices (MVDs, LUCS, and thermal-fixed cameras) and associated equipment, cabinets, and computer hardware to facilitate integrated operations and efficient deployment of operational strategies. Considering risks associated with conducting maintenance activities along the roadside, our design includes strategies that minimize the maintenance workers' exposure to live traffic by maximizing the activities that can take place remotely, providing wide shoulders at new and existing cabinets, using hot swappable units, in median, and ensuring that the areas near cabinets are well-lit. Fuses for the ITS units are located at ground level, as required by the RFP.

We also focused on ensuring that the median can operate during the expected peak hours to the fullest extent practicable, through the use of the AID thermal cameras, roadway design, and modifications to SOPs. The AID cameras operate 24/7, performing sweeps of the entire PTSU lanes from IS-70 to west of MD 43 and notifying CHART of any obstructions or debris in the lanes. Our PTSU design helps to minimize the number of incidents that would force the closure of the PTSU lanes as well. We maintain a two-foot offset from the median barrier throughout the Project limits, which still provides a space outside of the striped lane for debris and roadway runoff in the event of major rain events. The SOP could be established such that any debris that is located outside of the travel lane will not force the closure of the lane, and could be removed the next time the lane is closed.

Coordination with MDOT SHA CHART

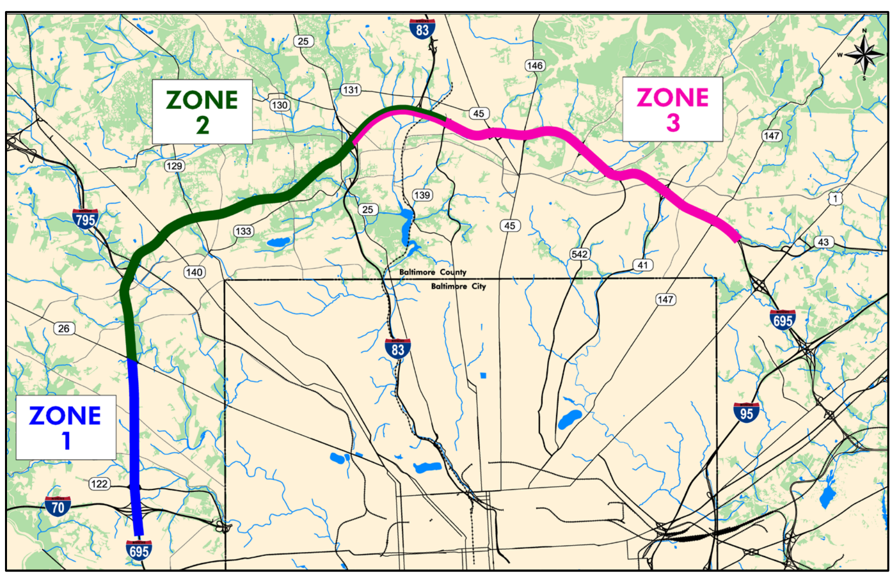
Implementing the proposed improvements will require coordination with the MDOT SHA and District 4 design and construction offices, but more extensively with the MDOT SHA Office of Traffic and Safety, District 4, and all of the CHART Divisions: Program, Planning and Development; Systems Integration; Field Operations; and TMC Operations. The success of the final improvements really rests on CHART's ability to keep the TSMO "system of systems" operating in the Project area (and beyond). Our Team's collaboration with CHART to ensure a successful Project is summarized in *Table 5.1*.

Table 5.1: Collaboration with MDOT SHA CHART

CHART Division	Primary Coordination Items
Program, Planning and Development	Integration with future projects and initiatives, setting performance criteria and tracking KPAs, input on ITS improvements
Systems Integration	Ensuring ITS functionality is consistent with CHART ATMS, maintaining and configuring ITS systems, integrating ActiveITS ATM into CHART ATMS, coordinating communications/notifications, reviewing ConOps and end-user training materials, data storage and distribution, modifying CHART SOPs
Field Operations	Modifying field response SOPs, preparing/performing emergency response training, reviewing ConOps for PTSU lane use (regular and incidents)
TMC Operations	Reviewing the ConOps, incorporating changes to the CHART ATMS (response ITS implementation), providing input to ActiveITS interface, providing input to SOP changes to accommodate new functionality, collaborating on end-use training modules.

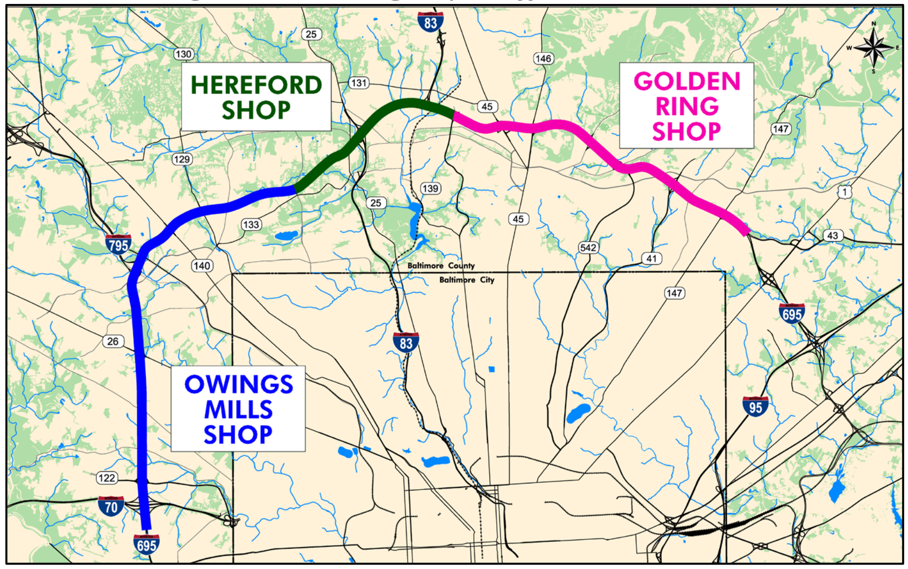
We understand CHART and the District Shops' role in providing on-the-fly operations to keep the IS-695 Project area safe, whether it is responding to and advising motorists of incidents, debris removal, or aiding disabled vehicles. CHART operations along the Project area are addressed and dispatched through the Highway Operations Technicians (HOTs) at the District 4 Traffic Operations Center (TOC-4) at the Golden Ring Maryland State Police barracks. Field operations are performed primarily by the Field Operation Patrols and the Emergency Traffic Patrols (ETPs) that are based in the nearby MDOT SHA Shops. Patrol zones for the Field Operation Patrols and ETPs are shown in *Figure 5.1* and *Figure 5.2* on page 63, respectively.

Figure 5.1: Field Operations Patrol Routes



ETPs typically travel IS-695 during peak hours and are often the first responder on scene. Trucks are equipped with battery chargers and fuel to help disabled vehicles, and also have mobile cameras, arrow panels, and flares to provide "eyes on the scene" and divert traffic around incidents. Field Operations Patrols are responsible for responding to incidents, working with emergency services (fire/EMT, police, environmental clean-up) as need to clear the incident as quickly as possible.

Figure 5.2: Emergency Traffic Patrol Routes



The CHART ATMS is used by HOTs to perform traffic management duties at the TOC. The CHART ATMS gives access to traffic management information (events, available ITS devices, communication logs) and the information is updated in real-time to ensure that team members get the appropriate responders to an incident, disseminate information to travelers and stakeholders, and communicates current conditions and estimated times to clear an incident.

Today, when an event that impacts traffic operations occurs on IS-695, the HOT must identify and verify the event (through CCTV, Emergency Response Technicians (ERTs), or reliable sources) and then create the event in the ATMS. Our local IS-695 ATMS will automate the ATMS event creation process, identifying incidents in the PTSU lanes using the AID camera network (debris, crashes, disabled vehicles) and microwave vehicle detection (MVD) units for queue detection on the mainline. The HOT will be able to zoom in quickly on the incident to confirm, identify the severity, and dispatch the required units. The new ITS devices – AID camera, DSA signs, and LUCS – will be added into the CHART ATMS inventory and as a result, will be incorporated into the pre-programmed recommended response plans. This integration requires a lot of work within the CHART ATMS and will be detailed in the ConOps document, but will save precious minutes of response time for every incident that occurs within the Project area, also reducing the likelihood of secondary incidents.

Expedited Incident Response Time
AID cameras, MVD, and CCTV cameras will reduce incident verification and response time by several minutes.

The Myers Team will prepare a Concept of Operations to document corridor deficiencies; define required functionality; describe operational scenarios; and outline system interfaces. The rules, decisions, and processes described in our proposal will be confirmed and further developed through stakeholder workshops to memorialize how the IS-695 TSMO system will integrate and operate with MDOT SHA CHART. We provide a detailed discussion of the Concept of Operations in Section 2.09.04 Safety starting on page 45.

Design Features that Support Safe Maintenance

The combined median offset and PTSU provide at least a **14-foot wide inside shoulder** for maintenance during non-PTSU hours, and our Team maintains a two-foot wide offset to the median barrier while the PTSU lane is active throughout the Project limits on both the Inner Loop and Outer Loop.

Cabinets for ITS devices are only located on the outside of the roadway per the RFP, and were prioritized for placement in the wide, flat areas within interchanges. Our Team minimized placing cabinets within merge and diverge areas to the fullest extent practicable, and the shoulders at existing and new cabinets are 12 ft minimum (with a wider shoulder at MD 26) for a distance of at least 150 ft long with 250-ft long entrance and exit tapers to provide space for the crew and a protection vehicle to safely pull off of the roadway and park when accessing the cabinet.

Maintenance Benefits of the Myers Team's Proposed Improvements

- *Wider inside shoulder when PTSU lanes are not active*
- *Wide outside shoulders at maintenance pull-offs may be used in emergencies*
- *All ITS cabinets are located on the outside of the roadway*
- *PTSU lane closure hours are consistent with permitted hours for maintenance work*
- *PTSU lanes may be used during off-peak times for incident management*
- *Minimal ITS items will be located over active traffic*

The PTSU scheduled operating window allows for maintenance activities along the median shoulder and PTSU lane between 10 a.m. and 2:30 p.m. each weekday, as well as night-time hours from 7 p.m. to 6 a.m. These time intervals are consistent with the times that shorter-term lane closures are currently permitted by District 4 on IS-695 for construction and maintenance.

The static-dynamic PTSU lanes have the flexibility to be opened or closed over individual roadway segments in the event of incidents, maintenance activities, or construction. The recommended open/closed segments, as well as the ITS devices that should be used to provide positive guidance to motorists, will be incorporated into the recommended response plans in the CHART ATMS. For example, if an incident occurs on the outside shoulder of the Inner Loop just to the north of the Liberty Road interchange, the updated response plan may recommend utilizing the new and existing DMS on IS-695 to the south to warn drivers of the incident, as well as activating the PTSU (changing the LUCS to the green arrow) prior to and for a short distance beyond the incident.

Maintenance Activities

ITS EQUIPMENT

The only new ITS devices proposed over the full-time active traffic lanes are full-size DMS. While some equipment will be installed in the median, such as AID cameras and PTSU LUCS; controllers and communications equipment will be installed in roadside cabinets on the outside shoulder of the freeway. Adequate pull-offs have been designed at existing and planned equipment cabinets along the corridor to provide ample area for maintenance staff to access the cabinets. ***These locations include 12 ft shoulders that can safely accommodate the maintenance vehicle and a crash truck protection vehicle intended to buffer the maintenance vehicle and staff from live traffic.*** The farther away from active traffic, the safer it is for maintenance personnel.

Developing New SOPs for Maintenance to Prevent Non-Recurring Congestion

On a recent Sunday afternoon, our Team spotted a broken crab pot, remnants from four blown tires, part of a cooler, and other litter along the median shoulder. A new beneficial SOP would have the Field Operations Patrols travel the Project limits every Sunday evening to remove all existing debris along IS-695 if the AID cameras detect it.

All of the proposed ITS devices will provide a notification to the TOC when they are not functioning properly. The HOT can then quickly create a repair notification in the ATMS and have the appropriate Field Operations or Systems Integration personnel address the repair. The system is designed such that when one element of the ITS system fails, the entire system can still function. The LUCS are placed such that two are visible to drivers at any given time; if one fails the lane can still operate. If a forward-facing AID camera fails, there is redundancy such that either the rear-facing camera on the next pole could cover or a PTZ camera could be directed to temporarily cover the area so that the HOT may maintain situational awareness until a replacement could be swapped out.

***Electronic Signs* –** The Project provides several new LED electronic sign types – full-size DMS, small DMS, LUCS, and DSA signs. All of these signs will be provided by the same sign manufacturer, which will streamline maintenance activities and the wiring/sign configuration protocols. LED sign panels are hot swappable, making it possible to have the same LED sign panel size for every sign on the Project.

***PTZ CCTV* Camera**s – CCTV cameras will have camera lowering systems per the RFP for efficient access and replacement of cameras, and are located along the outside shoulder throughout the Project limits. The CCTV cameras provide coverage in the Project area, and may be used to monitor the maintenance activities from the TOC as needed.

***LUCS* –** The mast arm at each LUCS extends over both the median lane and the adjacent travel lane, per the RFP, in the event that future construction or maintenance activities require a long-term PTSU lane shift. LUCS will be hot swappable to allow maintenance crews to swiftly change out failed LUCS with a spare sign and minimize the time the shoulder must be closed. There will be enough "slack" in the wiring to shift each LUCS to the next lane if needed. Repair activities on the failed LUCS can be safely conducted in the maintenance shop.

***MVDs* –** MVD will be installed on the outside of the roadway and capture vehicle data for both directions from a single unit. This will reduce the number of devices that will require routine preventive maintenance throughout the year. The MVD units are spaced closer together (every $^{1}/_{4}$-$^{1}/_{3}$ mile), so if one fails there are enough in place such that the ActiveITS ATM functionality is not sacrificed.

***Cabinets* –** Where feasible, ITS elements in the same area will share cabinets to reduce the number of access points and equipment that needs to be maintained. This includes PTSU equipment shared with CCTV camera and MVD controllers, or PTSU in both directions from the same cabinet. Each sign will be visible from the cabinet or from a local video feed for confirmation of accurate messages on the signs. This will reduce efforts in maintaining each device, and will reduce the number of cabinets and devices that could experience failure. Our cabinets are sized with additional space and airflow to accommodate future ITS equipment, such as vehicle-to-infrastructure (V2I) communications.

ITS COMMUNICATIONS

The Project will be adding approximately 8 miles of new fiber backbone connected to the existing fiber from IS-70 to IS-83. New fiber will be installed along the shoulder of one side of IS-695 to provide ease of access and an efficient layout. Laterals and splice points will be minimized to reduce the risk of communications failures. Junction boxes will be placed in areas that are near wide pull-offs, easily accessible by maintenance staff, and will be secured to minimize the risk of theft or unauthorized entry.

MOWING OPERATIONS

Mowing operations overall are improved. Our proposed design provides wider outside shoulders at all new and existing ITS cabinets that also serve as emergency pull-offs that could be utilized by landscaping crews with smaller, trailered equipment. Over most of the Project area, the outside shoulders will be at least 10 feet wide where boom mowers may easily maneuver to maintain sloped areas behind barriers. These types of operations are typically accomplished with safer maintenance practices such as afternoon lane closures or mobile MOT and will not be impacted with our proposed Project at the isolated areas identified in the ATCs where the proposed outside shoulders are reduced. The TOC could utilize the new DMS, as well as set a lower advisory speed, to supplement the portable signs that the landscaping crews will use to advise drivers of the work ahead. ***The PTSU could open during off-peak travel times within the limits of the mowing work to maintain lane balance and lessen the probability of queues developing.*** Landscaping teams will have a consistent, wide inside shoulder during non-PTSU hours to better facilitate weed removal. The additional cabinets and poles that support the new ITS devices, as well as the W-beam needed to protect them, will create a need for more smaller equipment to properly mow the areas around them. We have located as many of these devices near existing ITS poles and cabinets to maximize this need.

SNOW REMOVAL

Snow removal operations are also improved. The additional DMS and DSA signs may be used to advise drivers of snow removal operations and increase driver awareness. The location of the overhead LUCS in the median lane provide a "guide" for plow drivers to identify the location of the edges of lanes. There are isolated locations identified in the ATCs where the outside shoulders that are typically used for snow storage are reduced slightly with the proposed improvements. Most of these locations, however, are along existing superelevated curves where the roadway drainage flows toward the median, and current maintenance SOPs recommend removing the plowed snow entirely from the roadway to reduce the likelihood of it melting across the roadway and refreezing. ***Existing areas where there are no outside shoulders, such as on the Inner Loop adjacent to the speed change lane at York Rd, will now have a six-ft wide shoulder for snow storage.*** After large storm events, front-end loaders are often used to remove snow from the outside shoulders, requiring closure of one or two of the rightmost travel lanes. The PTSU could be activated to maximize the roadway capacity during these operations.

FUTURE CONSTRUCTION ACTIVITIES

Long-term and short-term construction activities are identified as events in the CHART ATMS, and our improvements will ultimately be incorporated into the CHART response plans for these activities. The DMS and dynamic speed advisory signs could be used to support construction and maintenance operations, and communicate to drivers when mobile MOT operations are underway or when there are temporary closures for bridge beam or overhead sign placement. DMS could also communicate when and where specific lane closures are in place. ***Our improvements ultimately provide additional tools in the CHART and District 4 toolbox to maximize vehicle throughput, reduce travel times, and maintain system reliability during construction events.***

ii. MAINTENANCE PERSONNEL, EQUIPMENT REQUIREMENTS & TRAINING

Our approach to developing the IS-695 TSMO Project solutions focuses on minimizing the impacts to staffing and equipment required to operate and maintain the system. Most elements align with existing MDOT equipment standards, the Statewide ITS Architecture, and SOPs, and all elements will be integrated with the existing CHART ATMS or SwRI ActiveITS ATM. Our design focuses on providing accommodations for safe and efficient maintenance activities for all devices. The Project will provide technologies that are generally new for the IS-695 corridor, but a majority of the field equipment is currently in use on other corridors around Maryland. We will be conducting training of the new functionality as part of activating the ActiveITS ATM. ***For this reason, we expect minimal training for expanded functionality or maintenance activities to accommodate the new IS-695 TSMO system.***

MDOT SHA Familiarity with Proposed Field Equipment

Our proposed IS-695 improvements includes the following field equipment:

- **Fiber Optic Communications:** The communications infrastructure designed for the corridor will meet MDOT SHA standard specifications and staff have experience in conducting maintenance for this infrastructure.
- **Dynamic Message Signs:** All new full-size and small DMS will meet MDOT SHA standard specifications and will be compatible with existing Daktronics DMS. Standard poles and foundations for pedestal DMS will be used where feasible, with modified "narrow" foundations for median installations. Standard overhead gantries and foundations will be used for full-size DMS. Staff has experience conducting maintenance for this device type.
- **Pan-Tilt-Zoom (PTZ) Closed Circuit Television (CCTV) Cameras:** All PTZ cameras will meet MDOT SHA standard specifications and be compatible with existing COHU cameras. Staff has experience conducting maintenance for this device type, and lowering devices are included as required by the RFP.
- **Microwave Vehicle Detection:** All detection stations will follow MDOT SHA standard specifications and staff have experience conducting maintenance for roadside detection. Microwave Vehicle Detectors (MVD), as shown on *Figure 5.3*, will be mounted on other ITS structures to the extent practicable, otherwise MDOT SHA standard poles will be used.
- **Lane Use Control Signals (LUCS):** All LUCS, as shown in *Figure 5.4* will follow the requirements of the MUTCD and MDOT SHA standard specifications. The user interface will be through the SwRI ActiveITS application. The LUCS units are new to MDOT SHA, and training will be provided for operations and maintenance staff.

Figure 5.3 – MVD

Figure 5.4 – LUCS

- **Automated Incident Detection (AID) Cameras:** AID thermal cameras on IS-695 will be the first installed in the state. Training will be provided for operations and maintenance staff. It is also recommended that a certain number of spares are maintained locally for replacement needs.
- **Dynamic Advisory Speed (DSA) Signs:** DSA signs will follow the requirements of the MUTCD and MDOT SHA standard specifications. Training and certification of maintenance staff will be included for effective operations.

No Additional Personnel Needed

Each of the devices proposed for the Project will require a minimal amount of preventative maintenance, generally on the order of once per year. As a result, we do not anticipate that MDOT will need to hire any additional staff for preventative maintenance. There are several factors that contribute to this expectation:

- The CHART Systems Integration team is responsible for maintenance of much of the ITS system, however this team has specialized expertise and knowledge of the Statewide ITS Architecture on which our system is designed and built. We will coordinate with Systems Integration (and other CHART division, Division 4, etc.) in developing the final design and ConOps, and as a result staff will gain the knowledge of the systems being built. We will also coordinate with Systems Integration and TMC Operations as we develop the training modules and O&M guidance for the various systems.

- There will be three different shops performing maintenance on the proposed devices. The division of work over the three shops will allow the additional maintenance responsibilities to be divided and not fall on one shop.
- MDOT SHA maintenance staff is currently supplemented with contracted staff to provide additional resources if there is an elevated need for emergency maintenance.
- By using equipment that is consistent and compatible with existing MDOT equipment, maintenance activities and spare equipment replacement can be completed efficiently since staff are already familiar with the processes.
- AID cameras and PTSU LUCS are located in the median and will be hot-swappable to allow maintenance crews to swiftly change out failed devices with a spare and minimize the amount of time required of maintenance crew.

Equipment Requirements

All field equipment designed for IS-695 will be based on specifications of equipment that are readily available and non-proprietary. The proposed equipment has been selected to avoid specialty or customized replacement equipment for the Project. Per the RFP, the Myers Team will provide spare equipment that includes the device, controller, encoders, power supplies, and other equipment directly associated with the device necessary for a complete (100%) repair installation of the device. For IS-695, this will include:

- AID fixed thermal cameras – 14 cameras
- PTZ CCTV cameras – 1 camera
- MVD units – 7 MVD
- PTSU LUCS – 14 signs
- Equipment cabinet – 6 cabinets
- Ethernet switches – 12 switches

Training of Maintenance Personnel to Operate & Maintain the Project Improvements

Since certain field equipment is only used in certain areas of the state, not all maintenance staff may be familiar with all field device types proposed for IS-695. Some equipment is also new to Maryland and therefore requires training for all maintenance staff on specific equipment. It is expected that some training will be required for the LUCS and all staff will require training on the AID cameras. We will work directly with the CHART Systems Integration and TMC Operations to develop the training modules and O&M guides for the various ITS equipment. The integration of the SwRI Active ITS ATM and the CHART ATMS will require extensive collaboration with Systems Integration, as will incorporating the changes to the response plans to incidents on IS-695. There are three different shops performing maintenance on the proposed devices on the corridor which will require training for all three shops. Additionally, some training will be required for the TOC-4 staff so they can provide first line troubleshooting for some devices.

We anticipate training occurring over three sessions, described below:

1. **Maintenance Shop** – Includes bench testing, troubleshooting, warranties, and spare equipment inventory.
2. **Field Maintenance** – Includes procedures for safe access to equipment; and routine preventative maintenance and equipment replacement activities.
3. **Software** – Includes graphical user interface, operational procedures, and incident management scenario exercises.

Each of these training sessions will be attended by representatives of each associated district and include training and maintenance material for staff.

iii. ADAPTABILITY TO FUTURE TECHNOLOGY ADVANCEMENTS

Transportation technology is the most rapidly evolving component of the transportation industry. To deploy a system that supports future technology advancements, it is critical to have a thorough understanding of the individual components of each system; how each system needs to work together for compatibility and full functionality; and how connected and autonomous vehicle technology (and other innovative solutions) will impact existing systems and operations. We developed our improvements with future projects in the MDOT SHA ITS long range plan in mind, such as deploying roadside infrastructure to support in-vehicle highway hazard alerts and in-vehicle highway signage systems (Long Range Projects 3.9.6.1 and 3.9.7.1).

The ITS staff on our Team are on national committees and high-profile innovation programs throughout the country, and is a founding member of ITS America. ***Our ITS Team members extensive emerging technology solutions and projects experience includes:***

- Activity Roadmap for North Carolina DOT and DMV in Preparation for Automated and Connected Vehicles
- NCHRP 20-24(98) AASHTO AV/CV Research Roadmap – Impacts of AV and CV Data Technologies on State and Local Government, Nationwide
- California Statewide Connected and Autonomous Vehicle Plan
- Connected Autonomous Shuttle Supporting Innovation (CASSI) Autonomous Vehicle, North Carolina
- USDOT Guidance on Impacts of Emerging Data Sources and Big Data Tolls on Transportation Systems Management and Operations of State and Local DOTs, Nationwide
- NCHRP 20-102: Implementation of AASHTO AV/CV Research Roadmap, Nationwide
- Impacts of CV Data on Traffic Management Centers, Virginia
- Florida DOT Automated Vehicle Initiative
- USDOT Guidelines for Applying the Capability Maturity Model for V2I Deployment, Nationwide
- CV Pilot Deployment Concept of Operations for Gateway Cities Region of Los Angeles County, CA

Industry Leaders in Future Transportation Technological Advancements
The Myers ITS Team members are at the forefront of emerging solutions that are woven into our solutions to future-proof projects for new technologies that can be integrated into the system without sacrificing functionality or performance.

Our Team is at the forefront of emerging design solutions that are woven into our innovative project improvements to future-proof the Project for new technologies that can be integrated into the system without sacrificing functionality or performance. This is accomplished by applying the following principles:

- Define System Concepts based on MDOT SHA Needs
- Understanding Component-Level Infrastructure
- Adhere to National Interoperability Standards
- Design and Implement Based on Full Buildout

Define System Concepts based on MDOT SHA Needs

The most successful ITS deployments result from deploying technologies and strategies that specifically address the needs of a corridor. For IS-695, that means reduce congestion, enhance mobility, improve safety, and minimize impacts to current operations and maintenance. The Systems Engineering guidelines defined by FHWA were established to ensure that project needs create the framework for system solutions. The Concept of Operations developed by the Myers Team will support MDOT SHA's vision outlined in this proposal; enabling CHART to realize increased functionality, enhanced responsiveness, and improved system performance well into the future.

Each function will trace back to achieving one or more of MDOT SHA's needs, and will not be a stand-alone function or module that does not contribute to the needs. For example, MDOT SHA has a need to enhance system performance on IS-695 through a reduction in congestion, increased throughput, and improved safety. PTSU is proposed as an innovative operational strategy that will address these needs. Other needs such as accommodating Connected Vehicle technology, establishing infrastructure to support Autonomous Vehicles, and promoting greater person throughput will be discussed and defined as part of the Concept of Operations. Details of an expanded network architecture with new subsystems and functionality will illustrate how the new functions and features will be integrated into the existing system. The architecture builds on CHART's current system and is built to adapt to innovative new technologies in a seamless manner.

Understanding Component-Level Infrastructure

A thorough understanding of component-level design is essential to preparing for and integrating future technology. Component-level knowledge is associated with understanding the communications format that is imported and exported to each field device; it is accounting for bandwidth needs of the existing equipment and planning for future expansion; and it is recognizing the critical elements of legacy compatibility when creating an integrated network of existing, proposed, and future technologies. The Myers Team understanding of component-level infrastructure and configuration will enable the IS-695 corridor to support roadside units for Connected Vehicle infrastructure; data sensor technology for Autonomous Vehicles; and data analytics software for performance measures. A future vision is necessary to ensure adaptability and seamless integration of future needs.

Adhere to National Interoperability Standards

Compatibility for integrating future solutions largely rests on following an open standard protocol. NTCIP is a widely adopted standard when developing and deploying transportation systems. Still, some solutions have been developed around proprietary standards and do not accommodate integration. We will avoid solutions that limit MDOT's ability to expand and integrate new system elements to build a solution that remains innovative and integrated well into the future.

Design and Implement Based on Full Buildout

When the overall system is developed during the Concept of Operations, we will identify interfaces and components that might be added in the future. During design and deployment, elements such as spare fibers, slack cable, cabinet space, Ethernet communication links, and central equipment rack space will be designed to accommodate future expansion that includes further coverage of current elements, as well as anticipation of future elements. This is necessary to minimize the impacts and costs associated with adding new elements later. As Connected and Autonomous Vehicle technology and deployments continue to expand and saturate the market, the median shoulder lane could be used in the future as a dedicated autonomous vehicle lane. Future technologies will be considered and incorporated into the Concept of Operations.

Following this critical guidance will ensure the IS-695 TSMO system will be developed in a manner that addresses the immediate congestion and safety needs of the corridor, ensures compatibility for integrating the Project elements into current CHART operations, and puts MDOT SHA in a position to deploy new innovative solutions as they emerge in the future.

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