MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

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Technical Proposal

IS-695 FROM IS-70 TO MD 43 TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS

Contract No. BA0065172

September 22, 2020

CONCRETE GENERAL, INC. *in association with* RK&K

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Section 2

Part-Time Shoulder Use

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CGI TEAM SOLUTION OVERVIEW

The CGI Team lives and breathes I-695. Many of our key staff suffer through the existing congestion. We've dreamed of providing the solution outlined in this proposal, which will **eliminate delay today** and promises **performance life beyond 2040**. Our project will provide $4.8B in annual congestion and safety benefits to Marylanders. It's a solution that the CGI Team and MDOT SHA will be proud to deliver.

The Solution

Nearly 40 Miles of Part Time Shoulder Use (PTSU)	• I-70 to MD 43 (37.3 miles) + • Outer loop extension within I-70 interchange (0.5 miles) • Inner loop extension to Lillian Holt Drive (1.8 miles) • Extended operational hours from 6 AM–10 AM and 2 PM–7 PM
Navtech Radar-Based AID System	• 80 devices vs. competing systems' 390 devices • True all-weather performance • Accurate debris detection as small as 2'x2'x2' • Automated incident detection on PTSU/GP lanes
Incident Response	• Complete CCTV coverage for PTSU/GP lanes • Outside shoulder for emergency response
Safety Upgrades	• 15 miles of upgraded concrete median barrier • 1,000 new drainage inlets reduce spread for PTSU
Pavement Enhancements	• 12 lane miles of pavement rehabilitation • 168 lane miles of pavement resurfacing
Highly Adaptable Systems	• Connected vehicle ready corridor • 21 miles of new fiber optic cable network
Maintenance and Operations	• $370K in annual reduced maintenance and operation costs over similar systems for I-695 TSMO

The Performance

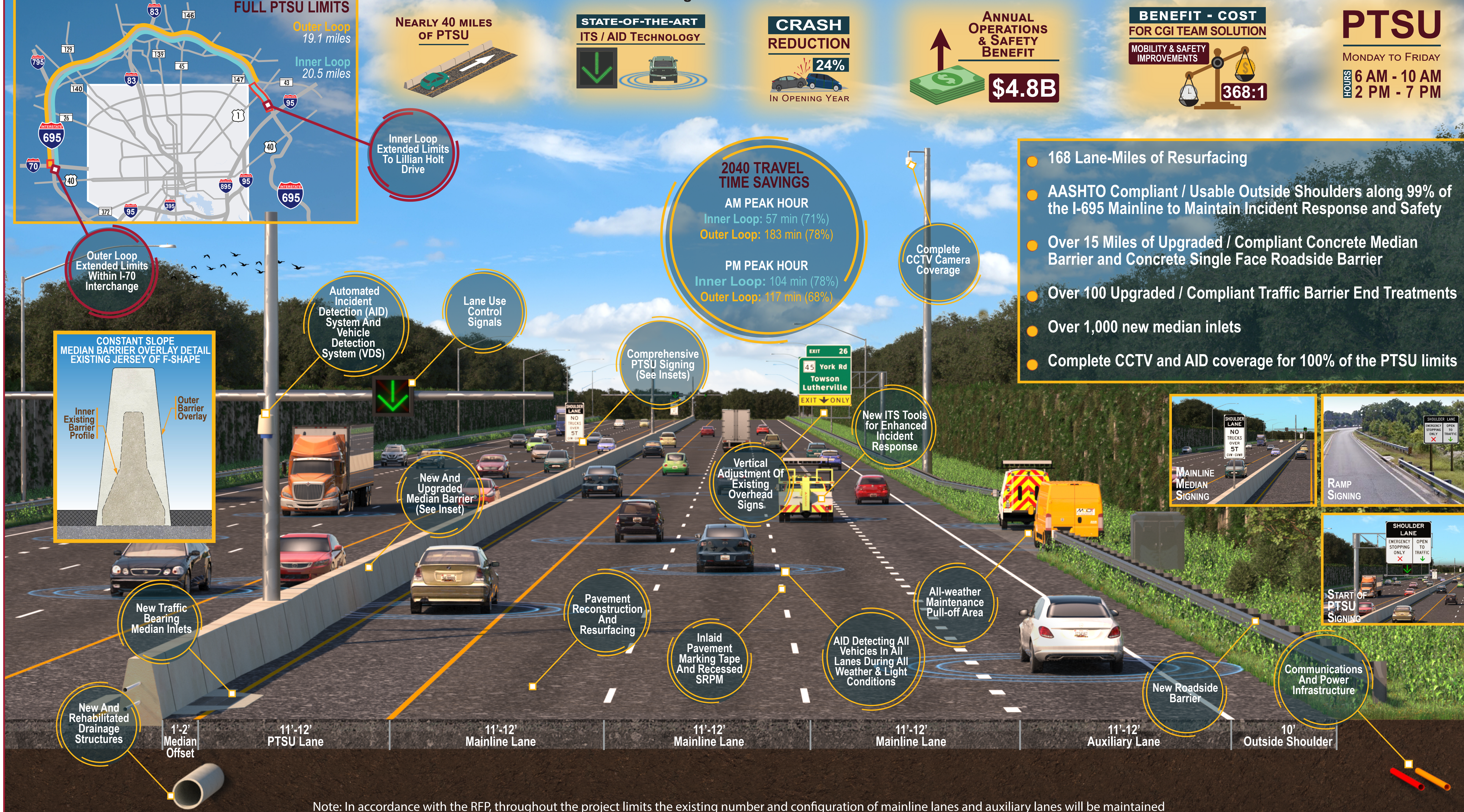
Existing	• 59% free flow traffic • Average speed as low as 23 MPH • Travel time up to 57 minutes
Opening	• 96% free flow traffic • Average speed 58 MPH / 57 MPH • Travel time 23.1 min / 23.5 min
2040	• 74% free flow traffic (96% with future projects*) • Average speed 51 MPH / 29 MPH (52 MPH w/future projects*) • Travel time 26.6 min / 47.2 min (26 min with future projects*)

All Statistics: Inner Loop Peak Period/Outer Loop Peak Period
**MDOT SHA planned improvements at I-70 and US 40*

Numbers don't lie. There is no better solution than free flow traffic in the opening year. In fact, our PTSU solution is so good that other improvements add little value now, or in the future. There are no impacts to arterial roadways, minimal environmental impacts, and safety is enhanced.

We understand that the devil is in the details. The remainder of this section will demonstrate exactly how the CGI Team's solution will maximize the amount of PTSU to increase vehicle throughput and minimize vehicle travel times along I-695 between I-70 and MD 43. Refer to **Figure 2.1** for a graphic of our solution.

Figure 2.1: CGI Team Solution



i. LOCATIONS, LIMITS & TYPICAL SECTION OF STATIC-DYNAMIC MEDIAN PTSU

Our team performed a systematic approach to determine the **limits, locations, predetermined hours of operation and typical sections of the Static-Dynamic PTSU** based on FHWA guidance. Acknowledging that this is a TSMO approach (intention of TSMO is to use existing facilities with minimum capital investment) and considering the Fixed Price/Best Value nature of the contract, we also incorporated a feasibility/ capital investment component to our analysis. Our approach to choosing limits and locations for PTSU is described below.

CGI Team Proposed PTSU Limits, Locations & Predetermined Hours

The CGI Team has determined that providing PTSU for the entire RFP limits and additional extensions on the inner and outer loop provides more benefit that any other combination of solutions resulting in a benefit cost ratio of 368:1 with an average **annual operations and safety benefit of $4.8B** to Marylanders. Our selected limits are shown in **Table 2.1**. The proposed predetermined hours **of operation for the PTSU are 6 AM-10 AM** and **2 PM-7 PM** to provide benefit throughout the peak periods now and in 2040. **Figure 2.2** shows the improvement in speeds corridor-wide proposed by these limits.

Four segments of I-695 within the project limits are on the list of Top 5 Most Congested Freeway Sections in Maryland—**Our solution will resolve congestion in all of them**

Table 2.1: CGI Team Proposed PTSU Limits and Locations

I-695 Inner Loop	**I-70 to Lillian Holt Drive (east of MD 43)**
I-695 Outer Loop	**MD 43 to I-70 (approximately 1,900 feet south of I-70 triple bridges)**

The following section will discuss how we chose these limits, locations, predetermined hours of operation and typical sections using operations and safety analysis; and the engineering elements required to achieve these limits.

Existing Operations & Safety Conditions Used to Choose PTSU Locations

Our team chose the locations and limits of PTSU by identifying the key areas where PTSU would provide the most benefit. Locations with significant bottlenecks and poor safety performance were identified as leading candidates for static-dynamic PTSU implementation. Bottlenecks were identified using the VISSIM model provided by MDOT SHA with both existing (2018) and 2040 volumes and other sources such as the MDOT SHA Mobility Report and RITIS. Safety performance was identified using existing crash data provided by MDOT SHA for 2015-2017 and geometric analysis.

Bottleneck Locations

MDOT SHA's Mobility Report ranks 4 segments of I-695 within the project limits on the list of top 5 Most Congested Freeway Sections in Maryland, as shown in **Table 2.2**. During the AM peak hour (8-9 AM), **three of the top 5 most congested freeway sections in Maryland** are within this corridor, and **one of the top 5 most congested freeway sections during the PM peak is within the project area.** Each has a Travel Time Index (TTI) greater than 2, signifying travel times are more than twice what they are when congestion is not present.

Table 2.2: Most Congested Freeway Segments along I-695 from Mobility Report—2018

Segment No.	Direction	Peak Period	Location	TTI	State Rank
1	OL	AM	US 1 to Cromwell Bridge Rd	2.85	#2 in AM
2	OL	AM	MD 129 to US 40	2.35	#4 in AM
3	IL	AM	MD 140 to I-83	2.33	#5 in AM
4	IL	PM	MD 139 to Cromwell Bridge Rd	3.19	#2 in PM

CONGESTION ELIMINATED

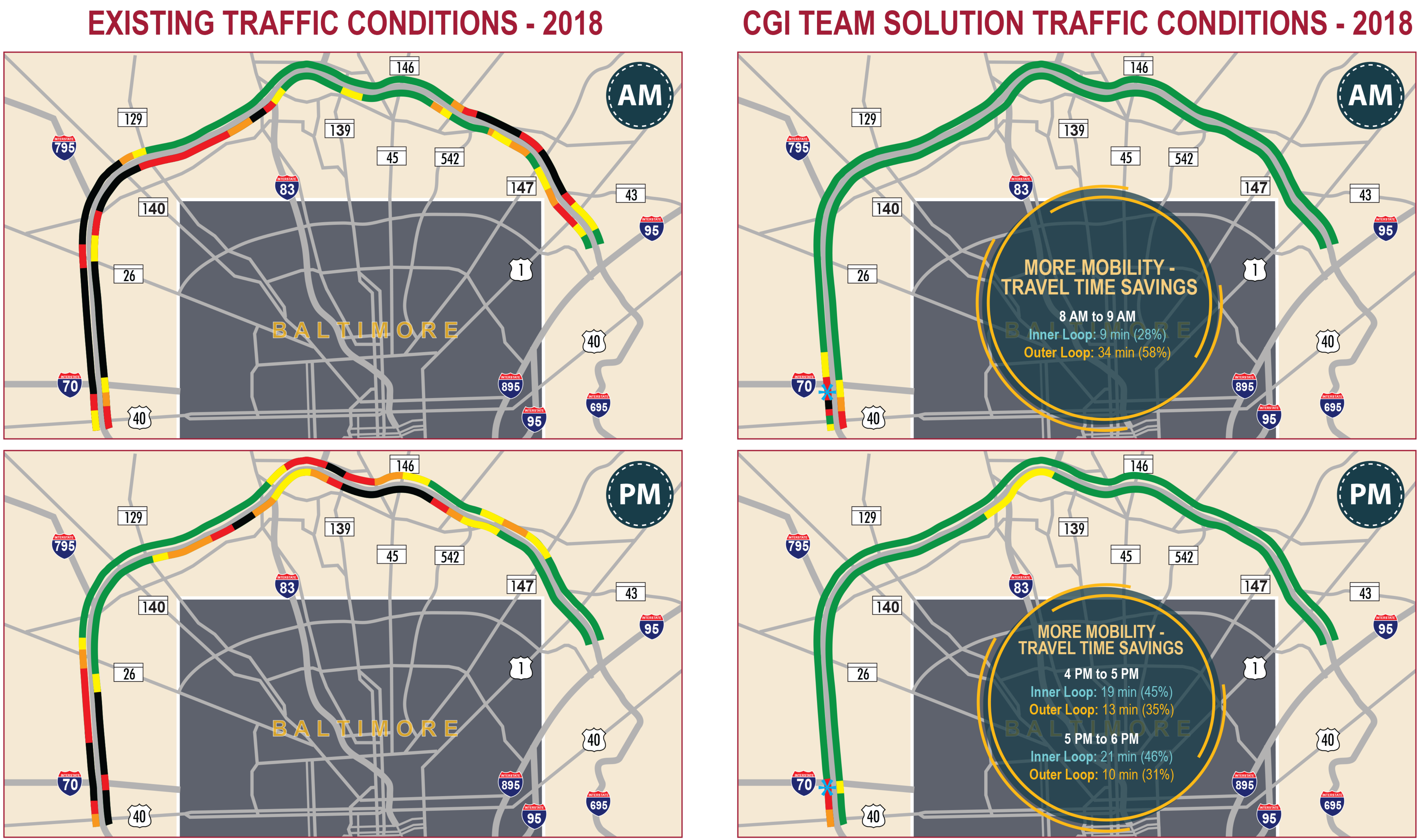


Figure 2.2: Speed Map of Existing and Proposed Conditions on I-695 in Peak Hour

SPEED LEGEND: 55 MPH 40 MPH 30 MPH 20 MPH

* Bottleneck Outside Limit Eliminated By Future Projects (I-70 at I-695 and I-695 at US 40)

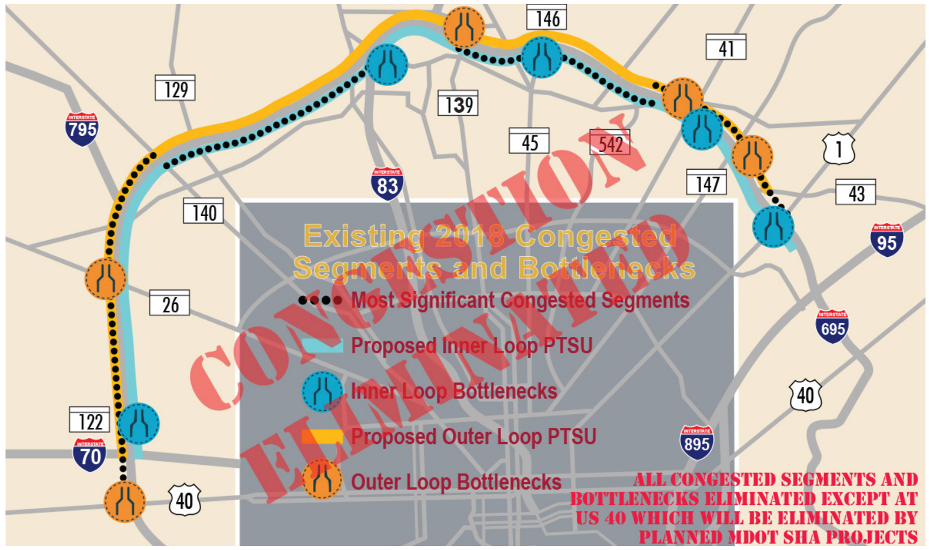
Note: 8-9 AM and 4-5 PM Speeds Shown

I-695 experiences significant congestion today with 53% to 73% of segments operating at Level of Service E or worse during the AM and PM peak hours on the inner and outer loop. This causes segments to break down and extensive queuing from downstream bottlenecks. The major bottlenecks are identified in **Figure 2.3**.

Our solutions provide a **91% reductio**n of LOS E/F segments immediately

Our team identified that when the bottleneck and congested segments were overlaid between AM and PM peaks, as shown in **Figure 2.3**, nearly the entire length of I-695 within the project limit is in need of improvements. Addressing these bottlenecks using PTSU will resolve much of the congestion on I-695, reduce crashes and improve incident response.

Figure 2.3: Existing Bottlenecks & Most Significant Congested Segments



Safety Hot Spots

The CGI Team performed a safety analysis of the data provided by MDOT SHA and determined that rear end crashes, which are heavily correlated with congestion, are the highest crash type in the project area and are up to **318% higher than the statewide average** in some segments. The inner loop locations with high crash experience include segments near MD 26, Greenspring Road, I-83 (Jones Falls Expressway), I-83 (Harrisburg Expressway), and MD 41. Corresponding high crash segments on the outer loop are near MD 26 and MD 122. Adding PTSU to the limits and locations of these safety hot spots to eliminate congestion will reduce crashes and improve safety.

Operations and Safety Analysis of Potential PTSU Limits and Locations

The CGI Team has developed our solution with the primary goal of **reducing recurring congestion,** eliminating bottlenecks and improving safety in the most effective manner. We used the existing bottleneck locations and safety hot spots to establish potential locations, limits and predetermined hours of PTSU to achieve optimal mobility and safety improvements. Preliminary engineering efforts determined feasibility and capital cost of providing median PTSU in those areas. The combined traffic analysis, safety analysis and preliminary engineering results determined our Team's **ability to provide PTSU for the entire RFP limits and additional limits on the inner and outer loops.**

Traffic Operations Analysis – Limits and Locations of PTSU

Using the VISSIM models provided by MDOT SHA, our team initially modeled independent segments of PTSU focusing on the congested areas and bottlenecks, but found that **if a discontinuous PTSU network is proposed, it will create a new significant bottleneck within the project limit**. Based on this modeling, the CGI Team determined that the only responsible solution is to **provide PTSU with the full project limits from I-70 to MD 43**. Furthermore, after modeling that scenario, we determined that congestion remained on the inner loop between MD 147 and US 1, due to the bottleneck located near the US 1 weave. On the outer loop, congestion remained from the US 40 bottleneck. A PTSU lane provides the most benefit when extended beyond an existing bottleneck as compared to ending before a bottleneck. The CGI Team proposes to **extend the PTSU lane on the inner loop and outer loop** to address recurring congestion now and in 2040.

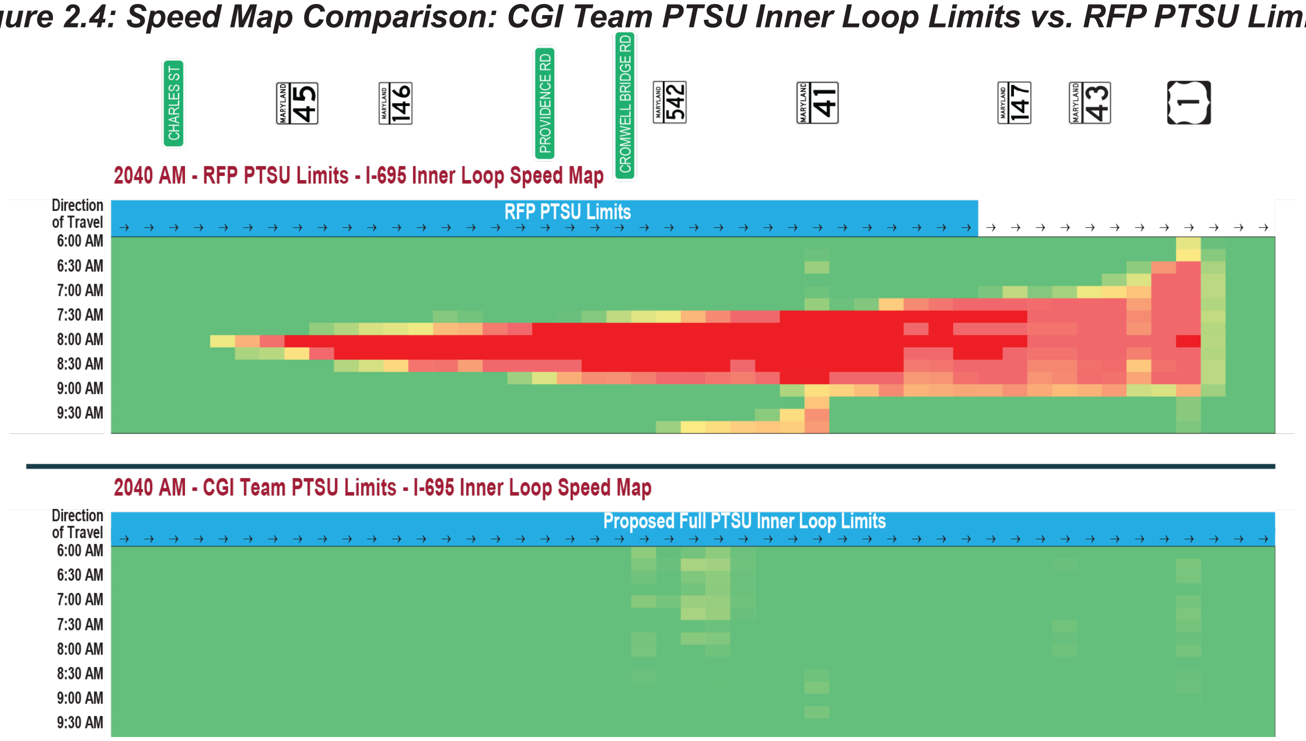
Eastern Inner Loop Termini: Providing additional inner loop PTSU limits from MD 43 to Lillian Holt Drive (documented in **ATC 23R1**) will **reduce inner loop travel times by an additional 13 minutes in 2040** (compared to PTSU which ends at MD 43) and ensures that the project limits will achieve **near free flow conditions in 2040, providing a performance life beyond 2040**. VISSIM traffic operations and predictive crash analysis indicate that the segment from MD 43 to I-95 will operate at an acceptable level of service and safety, including vehicles wishing to make lane changes from the PTSU lane to access I-95. The CGI Team's proposed solution includes additional signing for the I-95 interchange along the inner loop to provide additional advanced notification. **Implementing PTSU from I-70 to Lillian Holt Drive will eliminate all bottlenecks within the project limits.** A speed map comparing the RFP PTSU limits (I-70 to MD 43) and the proposed limits proposed (I-70 to Lillian Holt Drive) is shown in **Figure 2.4**.

Southwestern Outer Loop Termini: Implementing PTSU from MD 43 to I-70 will eliminate all bottlenecks within the project limits. The remaining outer loop bottleneck which impacts the project limits, located at US 40, will be addressed by separate future planned MDOT SHA projects (I-70 at I-695 interchange reconstruction and I-695 over US 40 bridge replacement).

As documented in ATC 37, the CGI Team proposes to establish PTSU on the outer loop from MD 43 to I-70, **south of the Triple Bridges but north of merge from the I-70 ramps.** The additional outer loop limits will **reduce outer loop travel times by an additional 30 minutes in the AM peak and an additional 69 minutes in the PM peak in 2040.** These additional outer loop limits will help to **extend the performance life of our improvements** and provide MDOT SHA with a decade to complete the I-70 at I-695 and I-695 over US 40 projects which would further improve travel times on the outer loop.

When our project is combined with future MDOT SHA projects, the outer loop experiences **free flow in 2040** through the entire project area from MD 43 to I-70. **Our goal with the outer loop extended PTSU limits is to ensure that we can tie into the planned improvements at the I-695 at I-70 interchange improvements seamlessly, resulting in the greatest enhancements in future mobility for I-695**. We will coordinate the design of the PTSU termini with the I-70 at I-695 project.

Figure 2.4: Speed Map Comparison: CGI Team PTSU Inner Loop Limits vs. RFP PTSU Limits



To summarize from a traffic operations standpoint, the focal point of our solution is the addition of **PTSU for the entire limits** of the project area and the **extension of PTSU along the inner loop and outer loop**. Maximizing the PTSU limits allows for a safe and effective increase in capacity during the peak periods and will effectively address the root causes of congestion in the most critical segments. The limits proposed by the CGI Team, including the entire RFP limits and extensions on the inner and outer loop, result in a highly effective solution that eliminates the extremely congested segments from the Mobility Report as shown in **Figure 2.6**.

> Our solution will reduce crashes in all high crash locations within the project area

Safety Analysis – Limits and Locations of PTSU

Overall crash rates on I-695 are up to 211% higher than the statewide average. Providing PTSU for the entire project limit with additional extensions on the inner and outer loop will **reduce fatal/injury crash rates throughout the project limits to within 30% of the statewide average. This will also reduce the total number of crashes on I-695 by up to 24% (a reduction of 268 crashes per year - more than 1 per weekday),** by deploying PTSU to reduce congestion while ensuring that the proposed geometry does not compromise safety. **All high crash rate locations are within the limits of the proposed CGI Team PTSU lanes, which will reduce congestion related crashes.**

Proposed PTSU Time of Operations

> **PTSU**
> MONDAY TO FRIDAY
> HOURS **6 AM - 10 AM**
> **2 PM - 7 PM**

Hours of PTSU Operation Evaluation: A very important element of a PTSU program is the hours of operation. MDOT SHA has chosen to implement PTSU on a static-dynamic basis. The static portion will be operated on a fixed schedule to coincide with time periods that experience recurring congestion. The dynamic portion will be implemented at any time to respond to non-recurring congestion caused by roadway incidents, construction, weather, or other events. The CGI Team proposes to implement static PTSU based on periods of recurring congestion. We evaluated travel speeds in the corridor from existing year RITIS data to define these operational periods and further tested these operational periods using the existing (2018) and 2040 VISSIM models. Refer to **Figure 2.5** for a summary of RITIS data and proposed predetermined PTSU hours of operation and limits.

Figure 2.5: CGI Team PTSU Limits and Hours on Existing RITIS Speed Map

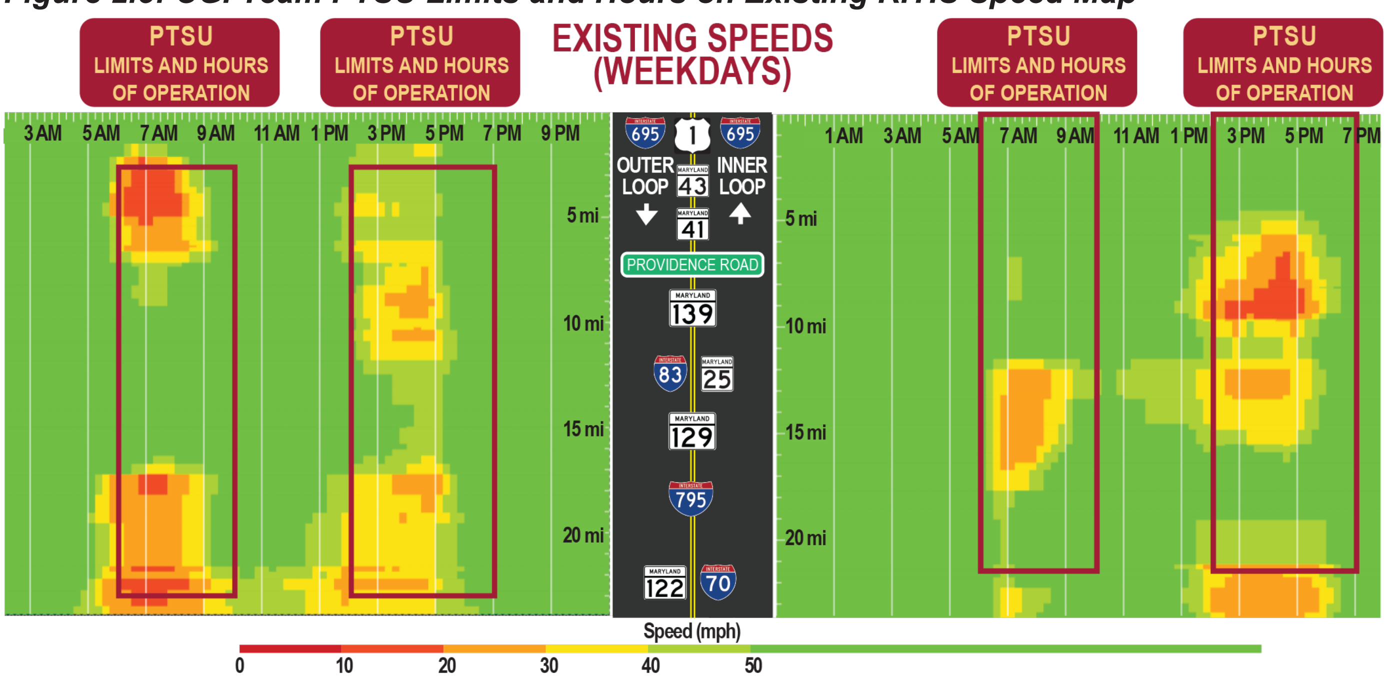
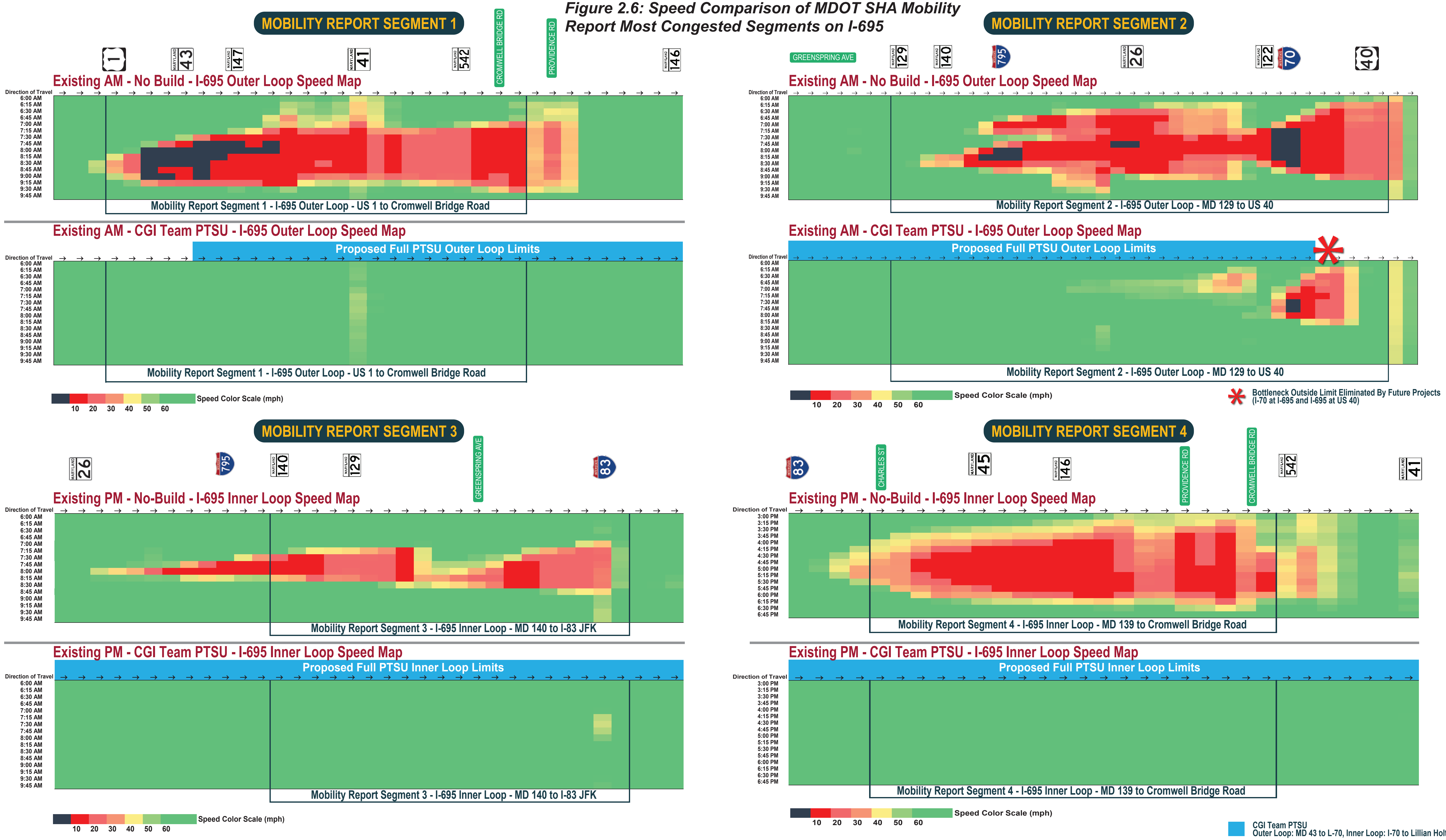


Figure 2.6: Speed Comparison of MDOT SHA Mobility Report Most Congested Segments on I-695



Although the congestion is not present throughout the entire limits, operating PTSU in a discontinuous manner is not recommended by FHWA and would create driver expectation issues which could negatively affect safety and congestion. In some locations, congestion becomes severe in the 3 PM hour very quickly, indicating that volumes start building in the 2 PM hour. For an average Friday, congestion starts in the 2 PM hour in a number of locations. After development of the static PTSU hours of operation using RITIS data, the VISSIM models provided by MDOT SHA were used to model the PTSU lane from 6 AM-10 AM and 3 PM to 7 PM. The CGI Team completed a supplemental analysis in VISSIM for the 2-3 PM hour. **The CGI Team determined that operating the PTSU lane from 6 AM to 10 AM and 2 PM to 7 PM would result in the most benefit to motorists traveling along I-695, including travel time savings of up to 25% during the 2-3 PM hour.** Recurring congestion is not present on the weekend, so predetermined operating hours are not proposed during this time, but the system can be configured to open on the weekend due to non-recurring congestion.

Operating the PTSU lane from 6 AM to 10 AM and 2 PM to 7 PM results in the most benefit to motorists

Preliminary Engineering for PTSU Locations and Typical Sections

The traffic analysis demonstrates that providing PTSU throughout the full project limits plus the noted extensions offers significant benefits. The CGI Team completed a detailed feasibility assessment to identify the roadway configuration and associated modifications that would provide for a safe and effective solution that also meets the requirements of the RFP. The CGI Team's solution uses MDOT SHA's project funds to maximize the project goals through an innovative and safe reconfiguration of I-695 within the proposed PTSU limits.

Horizontal Geometry. The CGI Team recognizes that MDOT SHA has limited funds for this project. **To provide PTSU throughout the proposed limits, the existing infrastructure must be used efficiently to avoid unnecessary impacts and their associated costs.** The CGI Team's approach includes a methodical, carefully considered process to fit the PTSU lane within the existing pavement to the greatest extent possible. At the same time, we are proposing widening where it is needed to maintain safe operations and a paved outside shoulder for incident response. This process is defined in the **Figure 2.7** and the proposed typical sections are shown in **Figure 2.8**.

Figure 2.7: CGI Team Approach to Implement PTSU:

A. Implement RFP-defined 12' PTSU with 2' offset in locations where adequate shoulder width is available. No modifications to other typical section elements.
B. Implement an 11' PTSU with 2' offset in locations where existing shoulder width cannot accommodate a 12' lane. No modifications to other typical section elements.
C. Implement an 11' PTSU with 2' offset and narrow general-purpose lanes to 11' (one at a time from left lane to right lane). Maintain existing outside shoulder.
D. Implement an 11' PTSU with 2' offset, narrow general-purpose lanes to 11', and maintain a 10' or 6' (adjacent to aux. lanes) outside shoulder.
E. Widen I-695 to accommodate PTSU in locations where staying within the existing roadway pavement is not feasible, while staying within ROW

The CGI Team's priority is to provide a 12-foot PTSU lane within the existing median shoulder without modification to any other typical section elements while providing at least a 2-foot offset from the median barrier (**Typical Section A**). However, within the project limits there is a relatively short segment along the northwest portion of I-695 from east of Stevenson Road to west of I-83 (JFX) where this is possible. Where a 12-foot lane is not possible, we would provide an 11-foot PTSU lane within the existing median shoulder without modification to any other typical section elements while providing at least a 2-foot offset from the median barrier

(**Typical Section B**). This approach, conditionally accepted in ATC 6, would be combined with the CGI Team's proposal to restrict trucks over 5 tons GVW/GVWR from using the PTSU lane.

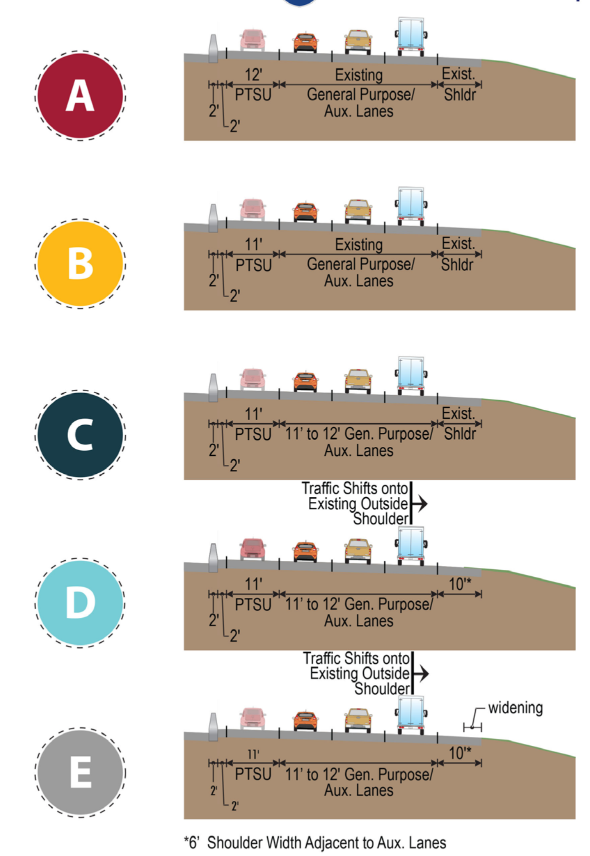
Where an 11-foot PTSU lane could not be provided within the existing shoulder, we would narrow mainline lanes to 11 feet to implement an 11-foot PTSU with at least a 2-foot offset from the median barrier (**Typical Section C**). **The outside shoulder would not be narrowed**. If possible, some mainline lanes, starting on the right side of the road, would be maintained at 12 feet, since large trucks mostly use the right lanes. This approach of narrowing freeway lanes follows the guidelines discussed in FHWA's *Use of Narrowed Lanes and Shoulders on Freeways: A Primer on Experiences, Current Practice, and Implementation Considerations*, 2016. In a limited number of locations, the outside shoulder will be narrowed (**Typical Section D**). This is in accordance with allowable widths in AASHTO's *A Policy on Geometric Design of Highways and Streets*. Narrowing mainline lanes and maintaining a full outside shoulder for maintenance and operations is in accordance with best practices identified by FHWA.

Where the above approaches are not feasible, our solution would include 11-foot PTSU and general-purpose lanes with roadway widening to maintain a full outside shoulder (**Typical Section E**).

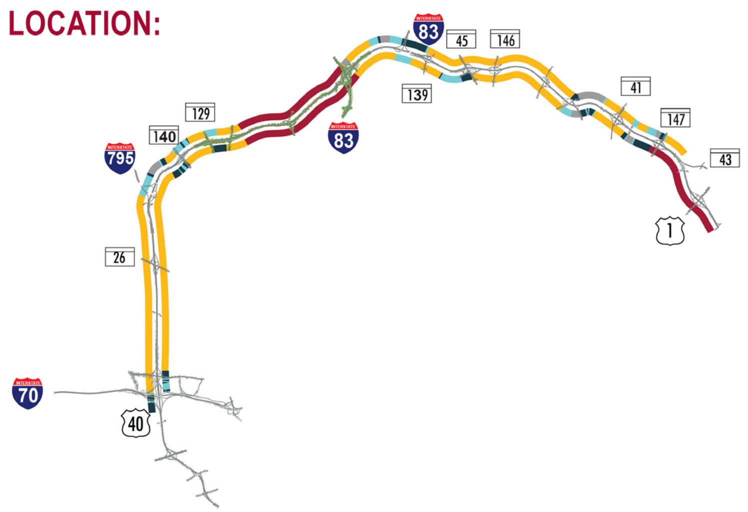
For all steps, a wider median shoulder/offset will be provided where needed to provide a minimum 55 mph sight distance around curves. This would be provided at 23 of the 25 relevant horizontal curves within the project limits. The only exceptions to this would be along the inner loop west of MD 45 and at the I-695 bridges over Cromwell Bridge Road and Loch Raven Boulevard. Neither of these bridges has existing width to accommodate the PTSU lane and offset to maintain 55 mph sight distance. The limits of these typical section approaches are summarized in **Figure 2.8**. Median offset widths less than two feet would only occur where the median barrier flares for ITS and sign structures.

Figure 2.8: Proposed Typical Sections

TYPICAL SECTION: 695 Outer & Inner Loop



LOCATION:



LENGTHS:

OUTER LOOP

	Miles	%
A	2.9	15%
B	11.5	60%
C	1.6	8%
D	2.0	11%
E	1.1	6%

INNER LOOP

	Miles	%
A	5.5	27%
B	11.3	55%
C	2.1	10%
D	1.3	6%
E	0.3	1%

The CGI Team recognizes that MDOT SHA's proposed project requires a design exception for the reduced median shoulder width during PTSU operation. The CGI Team's proposed improvements and roadway features will require design exceptions for reduced lane width in locations where lane widths would be less than 12 feet and for the reduced stopping sight distance in the PTSU. In addition, a design waiver will be needed for all locations where the median offset from the PTSU lane is less than 1.5 feet. The CGI Team will work closely with MDOT SHA and FHWA to develop approvable design exceptions, including acceptable mitigation for reduced lane width and reduced stopping sight distance. The CGI Team will work closely with MDOT SHA to develop approvable design waivers for the reduced horizontal offset from the PTSU lane. Examples of mitigation that will be provided include restricting large trucks from the PTSU lane and left mainline lane, upgrading the median barrier, implementing new pavement striping and recessed pavement markers, and advisory speed signing where SSD is less than 55 mph.

SSD in the PTSU lane of 55 MPH or greater would be provided for more than 98% of the project corridor.

99% of the corridor will have a full-time, full-width paved outside shoulder supporting maintenance emergency response.

Also, the proposed Automated Incident Detection system (see **Section 4**) will be able to detect debris/blockages in the PTSU and allow for fast closure of the PTSU if a blockage is detected. Further, during all non-PTSU operating hours there will be a full median shoulder provided. Finally, in accordance with best practices, MDOT SHA is implementing PTSU on a commuter facility during commuting periods with a high percentage of familiar drivers.

The percentage of the total lanes and shoulder mileage for various proposed widths within the project limits is presented in **Table 2.3**.

90% of general-purpose lanes within the project limits will be 12 feet wide.

Table 2.3: Proposed Lane and Shoulder Widths as a Percentage of the Corridor

Width		Inner Loop							Outer Loop						
		SHLDR	AUX	GP4+	GP3	GP2	GP1	PTSU	PTSU	GP1	GP2	GP3	GP4+	AUX	SHLDR
Lanes	Ex. or 12'	n.a.	98%	97%	92%	86%	81%	15%	22%	85%	87%	91%	96%	98%	n.a.
	11'		2%	3%	8%	14%	19%	85%	76%	15%	13%	9%	4%	2%	
Shldrs.	Ex. or 12'	96%	**n.a.**												98%
	6'	**4%**													2%

The specific typical sections are presented in **Table 2.4**. This includes locations where the proposed typical section elements do not meet the guidelines in RFP section TC-3.08. Detailed concept drawings showing the proposed configuration for the full proposed limits are provided in **Appendix K**.

The approach of providing the PTSU lane within the existing typical section, including design exceptions for modified typical section elements, is consistent with performance-based practical design practice where improvements are implemented based on the proposed use and existing context. Further, this approach is supported by FHWA's guidance as presented in *Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating,* and Designing Part-Time Shoulder Use as a Traffic Management Strategy, 2016.

The CGI Team completed preliminary safety analysis to assess the combined effects of additional roadway capacity provided by the PTSU and the proposed reconfiguration of I-695 to accommodate the PTSU using ISATe. The results show that the predicted number of crashes for the CGI Team proposed improvements are virtually identical to the improvements that use the MDOT

Performance-Based Practical Design:

- Develop solution that meets the project purpose based on defined goals/objectives/ transportation needs.
- Utilize objective data and engineering judgment to inform decisions based on an examination of geometric and operational elements.
- Work within constraints to minimize impacts.
- Consider cost and benefit in the context of the system needs and priorities.
- Evaluate how the preliminary design compares to the applicable design standards and identify any design exceptions.

SHA RFP typical section. These results are discussed in detail in **Section 4: Safety**.

There are many examples of similar facilities around the country where additional lanes have been added within the existing typical section to provide additional capacity while controlling cost and impacts. Local examples with similar characteristics to I-695 include I-95 in Baltimore north of the Fort McHenry Tunnel, the I-270 ICM improvements from Montrose Road south to and on the west spur, and I-395 in Northern Virginia. According to FHWA's *Use of Freeway Shoulders For Travel Guide*, "Experience in the U.S. to date has not identified major safety issues with part-time bus, static, or dynamic shoulder use that led implementing agencies to discontinue part-time shoulder use due to poor safety performance."

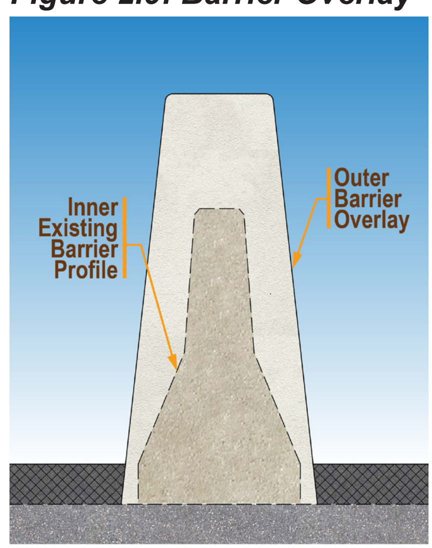
The CGI Team is confident that our approach to modify the existing I-695 typical section to accommodate PTSU follows best practices, includes appropriate mitigation approaches, and will improve operations and safety along I-695.

Vertical Geometry. The implementation of PTSU lanes in the existing median shoulders necessitates an evaluation of existing overpass bridges and overhead and cantilever sign structures to understand potential vertical clearance issues. Our approach, which will prohibit the use of the PTSU lane by large trucks, mitigates most vertical clearance concerns. Nevertheless, the CGI Team evaluated existing vertical clearance and has developed a proposed design that will maintain adequate vertical clearance under all overpasses. We will adjust sign panels or luminaire supports on 16 sign structures to provide the 17' 9" minimum clearance required by the RFP.

Cross Slope. Running a PTSU lane in the existing median shoulder will require adjustment of cross slopes to ensure the PTSU lane is not running in an adverse superelevation through curves and to ensure that cross slope breaks do not occur near wheel paths. The CGI Team proposes to adjust the cross slope to account for these items. At the same time, and consistent with AASHTO guidelines, our proposal would provide a 3% cross slope for the PTSU lane in normal sections to facilitate better drainage in the PTSU lane and support all-weather operations.

Drainage and Median Barriers. In support of PTSU operations and to ensure the proposed improvements meet the 4-foot maximum drainage spread requirements, the CGI Team will provide **over 1,000 additional inlets** along the median barrier for all-weather PTSU operation. All inlets that extend into the PTSU lane will include concrete collars to ensure they are traffic-bearing. Our proposed improvements will maintain existing drainage patterns by using existing storm drain systems crossing the I-695 travel lanes. The CGI Team will address the unstable outfalls noted in the RFP. Where identified after pipe inspections, the CGI Team will perform

Figure 2.9: Barrier Overlay



CONSTANT SLOPE MEDIAN BARRIER OVERLAY DETAIL
EXISTING JERSEY OR F-SHAPE

Table 2.4: Typical Section Adjustments

Outer Loop

Segment	MP Limits [1]	Outside Shoulder	Lanes 4–6	Lane 3	Lane 2	Lane 1	Median Shoulder	Comment
		Typical Section Element						
South of I-70 Entrance Ramp to I-70	6.7 to 6.9	MATCH EXISTING						Resurfacing MOT Shifts
	6.9 to 7.1	10' [2]	MATCH EXISTING				11'+2' [3]	Narrow PTSU lane with no other typical section adjustments
	7.1 to 7.5	10' [2]	11'	11'	11'	11'	11'+2' [3]	Reduce lane widths to provide additional room to widen median shoulder to 16' to meet required Stopping Sight Distance (55 mph)
	7.5 to 7.9	10' [2,4]	12'	12'	12'	12'	11'+2' [3]	
I-70 to East of I-795	7.9 to 10.6	10' [2]	MATCH EXISTING				11'+2' [3]	Narrow PTSU lane with no other typical section adjustments
	10.6 to 11.2	10' [2]	12'	12'	12'	12'	11'+2' [3]	
	11.2 to 11.4	10' [2]	MATCH EXISTING				11'+2' [3]	
	11.4 to 12.2	10' [2]	12'	12'	12'	12'	11'+2' [3]	
North of I-795 to South of MD 140	12.2 to 12.6	10' [2]	11'	11'	11'	11'	11'+2' [3]	Reduce lane widths to provide additional room to widen median shoulder to 16' to meet required Stopping Sight Distance (55 mph)
West of MD 140 to Stevenson Rd	12.6 to 14.4	10' [2]	12'	12'	12'	12'	11'+2' [3]	Includes narrowing of 2 left lanes from MP 12.9 and 13.3, left lane from 13.6 to 13.9
Stevenson Rd to I-83 S	14.4 to 17.5	10' [2]	MATCH EXISTING				12'+2' [3]	
I-83 S to West of Charles Street	17.5 to 18.2	10' [2]	12'	12'	12'	12'	11'+2' [3]	
	18.2 to 19.4	10' [2]	11'	11'	11'	11'	11'+2' [3]	
West of Charles St to West of Cromwell Bridge Road	19.4 to 23.1	10' [2]	12'	12'	12'	12'	11'+2' [3]	
West of Cromwell Bridge Road to East of Loch Raven Blvd.	23.1 to 23.9	10' [2]	11'	11'	11'	11'	11'+2' [3]	Reduce lane widths to provide additional room to widen median shoulder to 12' to meet required Stopping Sight Distance (55 mph)
East of Loch Raven Blvd to MD 43	23.9 to 25.9	10' [2]	12'	12'	12'	12'	11'+2' [3]	

Inner Loop

Segment	MP Limits [1]	Median Shoulder	Lane 1	Lane 2	Lane 3	Lanes 4–6	Outside Shoulder	Comment
		Typical Section Element						
I-70 to North of MD 122	7.3 to 7.8	11'+2' [3]	Match Existing				10' [2]	Narrow PTSU lane with no other typical section adjustments
North of MD 122 to East of I-795	7.8 to 12.6	11'+2' [3]	12'	12'	12'	12'	10' [2]	
North of I-795 to South of MD 140	12.6 to 13.0	11'+2' [3]	11'	11'	11'	11'	10' [2]	
West of MD 140 to Stevenson Road	13.0 to 14.4	11'+2' [3]	12'	12'	12'	12'	10' [2]	Includes narrowing of 2 left lanes from MP 13.7 and 14.1
Stevenson Road to I-83 S	14.4 to 17.5	12'+2' [3]	Match Existing				10' [2]	
I-83 S to East of Charles St	17.5 to 19.9	11'+2' [3]	12'	12'	12'	12'	10' [2]	
East of Charles Street to York Road	19.9 to 20.6	11'+2' [3]	11'	11'	11'	11'	10' [2]	Reduce lane widths to provide additional room to widen median shoulder to 9' to improve Stop-ping Sight Distance. SSD will be 50 mph.
York Road to West of Cromwell Bridge Road	20.6 to 23.1	11'+2' [3]	12'	12'	12'	12'	10' [2]	
West of Cromwell Bridge Road to East of Loch Raven Blvd.	23.1 to 23.8	11'+2' [3]	11'	11'	11'	11'	10' [2]	Reduce lane widths to provide additional room to widen median shoulder to 4-8' to improve Stopping Sight Distance over Bridges. SSD will be 45 mph.
East of Loch Raven Blvd to West of Old Harford Road	23.8 to 24.7	11'+2' [3]	12'	12'	12'	12'	10' [2]	
West of Old Harford Road to MD 147	24.7 to 25.3	11'+2' [3]	11'	11'	11'	11'	10' [2]	
MD 147 to MD 43	25.3 to 26.2	12'+2' [3]	Match Existing				10' [2]	
MD 43 to Lillian Holt Drive	26.2 to 27.9	12'+2' (3)	Match Existing				10' [2]	

Legend: XX – feature that meets RFP requirements; XX – feature that require design exception/waiver

- (1) Milepoints (MP) as specified in the 2016 Highway Location Reference for Baltimore County
- (2) Shoulders adjacent to Auxiliary Lanes are a minimum of 6'.
- (3) 2-foot minimum offset to median barrier except at localized obstruction (i.e. foundations for overhead sign structures, LUCS, light poles, etc.).
- (4) Outside shoulder under triple bridges is 6', requiring a Design Exception as noted in ATC No. 37.

pipe rehabilitation. All stormwater management (SWM) requirements resulting from pavement reconstruction, roadway widening, and pavement shifts associated with typical section changes will be provided within the proposed limits of the project corridor.

To accommodate cross slope adjustments and drainage improvements, **over 15 miles of median barrier will either be fully reconstructed or overlaid** (new concrete and reinforcement over the existing barrier as shown in **Figure 2.9**) to ensure that a safe, structurally sound barrier will be provided. W-beam will also be upgraded as necessary along the outside of I-695.

Pavement. The CGI Team developed pavement design for shoulder reconstruction, outside widening, patching, wedge/level, and resurfacing based on the RFP, including the proposed operational periods of the PTSU lanes. The proposed pavement design will meet or exceed the RFP requirements. Traffic data for the pavement evaluation and design was from the RFP and historical traffic counts available from the Maryland Internet Traffic Monitoring System (ITMS).

This evaluation was completed for all segments along I-695 within the project limits. Opening Year Part-Time Shoulder Use traffic volumes were estimated from the anticipated static hours of operation and adjusted (lower) capacity for the PTSU lane. A performance period of 15 years was used to calculate the total traffic over the performance period for the pavement design. The CGI Team interpreted and reduced the Falling Weight Deflectometer (FWD) data provided in the project RFP using PCASE software and methodologies. The Ground Penetrating Radar (GPR) data provided in the RFP was used for pavement layer thicknesses and initial moduli at each FWD test point.

Noise. The CGI Team solution will not result in a noise impact. The CGI Team's noise evaluation will be in accordance with MDOT Noise Policy, MDOT SHA Highway Noise Policy and Highway Noise Policy Implementation Guidelines and the Department of Transportation Federal Highway Administration Code of Federal Regulations (23 CFR Part 772) Procedures for Abatement of Highway Traffic Noise and Construction Noise. In particular to these documents is Appendix K of the MDOT SHA Implementation Guideline which provides policy for the evaluation of noise resulting from PTSU. The proposed roadway improvements are not exempt from noise analyses, and a Type I noise analysis is required. The CGI Team developed loudest hour traffic volumes based on the information provided in Addendum No. 2. Our loudest hour traffic analysis resulted in a shift from the existing condition loudest hour of 1 PM to 7 AM for the proposed condition, resulting in an approximate 55% increase in traffic volume from existing to design year. However, in consideration of the MDOT SHA's PTSU policy, the CGI Team proposed solution will not result in a noise impact. An impact is defined for PTSU projects as the design year build condition peak hour noise level at or above the appropriate FHWA defined Noise Abatement Criteria (NAC) level and there must be a perceptible increase in peak hour noise level (at least 3 dBA) from the existing condition to the proposed build condition in the design year. While there will be design year build noise levels above the NAC, there will not be a perceptible increase in peak hour noise of 3 dBA from existing to design year.

The elements of the CGI Team's solution and the proposed engineering approach will allow for PTSU to be implemented along I-695 for the full limits of the project and the noted extensions.

ii. REDUCTION IN RECURRING CONGESTION

A significant benefit of implementing part-time shoulder use is the **reduction of recurring congestion**. Both the inner loop and outer loop of I-695 operate under congested conditions in many segments of the project area. Our proposed PTSU solution and the operational results are described below and result in **over $4.8B in annual operational and safety benefits to I-695 users with congestion essentially eliminated now and in the future**.

The reduction in recurring congestion achieved by the CGI Team in 2018 and 2040 showed that maximizing the PTSU limits was more effective at meeting the goals of the project than any other combination of strategies. As shown in **Table 2.5**, our PTSU solution **reduces travel times by up to 58%** (further highlighted in **Figure 2.10**), **reduces delay by up to 62%** immediately; improves intersection operations by **reducing LOS E/F intersections by 44%**; and **improves density** reducing the number LOS E/F segments by up to **91%.**

Our PTSU solution also increases vehicle throughput during the peak hour such that nearly **all peak hour demand is accommodated**. The duration of congestion is also significantly reduced – any reduction in vehicle speed due to recurring congestion is anticipated to occur in the peak two hours (7 AM – 9 AM and 4 PM – 6 PM).

Figure 2.10: I-695 Outer Loop AM Peak (8–9 AM)—2018

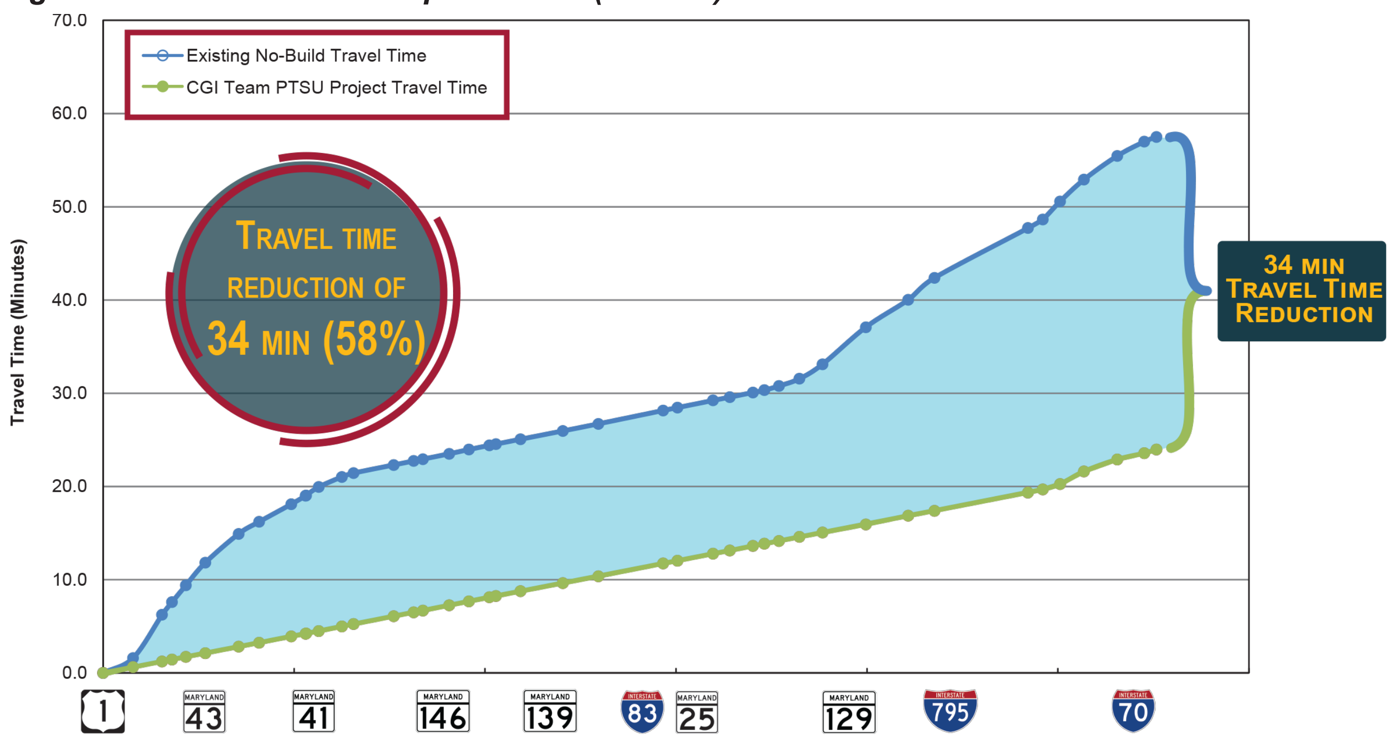
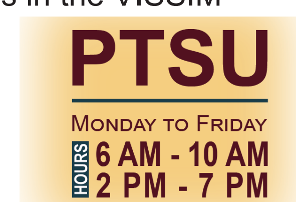


Table 2.5: Recurring Congestion Improvements, Existing (2018) No-Build vs. 2018 CGI PTSU

	Improvement Type	Details
AM Peak	**Travel Time Reduction:** (8AM to 9AM)	• Inner loop: **9-minute** (28%) • Outer loop: **34-minute** (58%) • Nearly **free flow** conditions (23 min average travel time)
AM Peak	**Vehicle Network Performance:**	• Network-wide: **50% reduction** in Average Delay per Vehicle
AM Peak	**Vehicle Throughput Increase:**	• Over **95%** of I-695 demand volume serviced during demand hour.
AM Peak	**Vehicle Density:**	• Inner loop: **83% reduction** in LOS E/F segments • Outer loop: **86% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed Increase:** (8AM to 9AM)	• Inner loop: **40%** from 42 MPH to 59 MPH • Outer loop: **140%** from 23 MPH to 55 MPH
AM Peak	**Connecting On-Ramp Queues:**	• **Eliminated** due to free flow conditions on mainline • One location with queue contained within existing ramp storage
AM Peak	**Intersection Operations and Arterial Performance:**	• 44% reduction in LOS E/F intersections • **No LOS F intersections** • No on-ramps causing arterial spill back
PM Peak	**Travel Time Reduction:**	• Inner loop: **21-minute** (46%) from 5 PM–6 PM • Outer loop: **13-minute** (35%) from 4 PM–5 PM • Nearly **free flow** conditions (24 min average travel time)
PM Peak	**Vehicle Network Performance:**	• Network-wide: **62%** reduction in Average Delay per Vehicle
PM Peak	**Vehicle Throughput Increase:**	• Over **95%** of I-695 demand volume serviced during demand hour
PM Peak	**Vehicle Density:**	• Inner loop: **89% reduction** in LOS E/F segments • Outer loop: **91% reduction** in LOS E/F segments
PM Peak	**Vehicle Speed Increase:**	• Inner loop: **85%** from 29 MPH to 53 MPH (5 PM-6 PM) • Outer loop: **54%** from 36 MPH to 56 MPH (4 PM-5 PM)
PM Peak	**Connecting On-Ramp Queues:**	• Essentially **eliminated** due to free flow conditions on mainline.
PM Peak	**Intersection Operations and Arterial Performance:**	• **50% reduction in LOS E/F intersections** • One remaining LOS F intersection • No on-ramps causing arterial spill back

With the CGI Team PTSU in place congestion will only remain in two locations in the VISSIM models (2018 and 2040) within the project limits:



- *Outer loop approaching US 40 bottleneck:* This **congestion will be eliminated** by future planned MDOT SHA projects including I-70 at I-695 and I-695 over US 40. Congestion **only impacts the project limits in the 2040 models**.
- *Inner loop in the PM peak between Greenspring Avenue and I-83 HBX:* This congestion appears to be caused by an over-reporting of congestion in the PM VISSIM model due to very conservative driver behaviors. This was documented in ATC 14; however, the CGI Team **did not** change calibration parameters to eliminate the congestion due to impacts to the No-Build. In practice **we anticipate this area will not be a source of congestion after opening** as it is not one of the most congested freeway segments identified in the MDOT SHA Mobility Report. This area accounts for as much as 3 minutes of travel time increase in the PM peak model.

In addition to providing substantial mobility improvements over the existing no-build condition, the CGI Team PTSU improvements provide exceptional mobility improvements over the 2040 no-build condition including a **reduced travel time of 183 minutes (78%)** on the outer loop during the AM peak hour and a **reduced travel time of 104 minutes (78%)** on the inner loop during the PM peak hour with network-wide **throughput increase of 30%** and **60% reduction** in total network delay, as shown in **Table 2.6**.

Table 2.6: Recurring Congestion—2040 No-Build vs. 2040 CGI—PTSU

	Improvement Type	Details
AM Peak	**Travel Time Reduction:**	• Inner loop: **49-minute** (8 AM to 9 AM) and **57-minute** (9 AM to 10 AM) • Outer loop: **207-minute** (8 AM to 9 AM) with future planned projects (I-70 at I-695 and I-695 over US 40); **183-minute without future planned projects**
AM Peak	**Vehicle Network Performance:**	• Network-wide Delay: **58% reduction** • Latent Delay: **49% reduction**
AM Peak	**Vehicle Throughput Increase:**	• Network-wide: **23%**
AM Peak	**Vehicle Density:**	• Inner loop: **74% reduction** in LOS E/F segments • Outer loop: **50% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed:**	• Inner loop: —**323% speed increase** in critical MD 140 to I-83 segment (8 AM–9 AM) —**81% increase** from US 40 to Lillian Holt Dr (6 AM–10 AM) • Outer loop: —**893% speed increase** (5 MPH to 46 MPH) in critical US 1 to Cromwell Bridge Rd segment (8 AM–9 AM) —**119% increase** from Lillian Holt Dr to US 40 (6 AM–10 AM)
AM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged on-ramp queues at 90% of ramps locations with queues contained within existing storage at 94% of locations • Increased queues at MD 122 will be solved by future planned projects
AM Peak	**Intersection Operations and Arterial Performance:**	• **30% reduction** in LOS E/F intersections
PM Peak	**Travel Time Reduction:**	• Inner loop: **69-minute** (5–6 PM) and **104-minute reduction** (4–5 PM) • Outer loop: **146-minute** (5–6 PM) with future planned projects (I-70 at I-695 and I-695 over US 40); **117-minute without future planned projects**
PM Peak	**Vehicle Network Performance:**	• Network-wide Delay: **62% reduction** • Latent Delay: **53% reduction**
PM Peak	**Vehicle Throughput Increase:**	• Network-wide: **38%**
PM Peak	**Vehicle Density:**	• Inner loop: **73% reduction** in LOS E/F segments • Outer loop: **49% reduction** in LOS E/F segments
PM Peak	**Vehicle Speed:** (4 PM to 5 PM)	• Inner loop: **390% speed increase** (12 MPH to 59 MPH) in critical MD 139 to Cromwell Bridge Road segment • Outer loop: **863% speed increase** (6 MPH to 55 MPH) in US 1 to I-83 segment
PM Peak	**Connecting Ramps Queues:**	• Reduced or unchanged on-ramp queues at 84% of ramps locations with queues contained within existing storage at 96% of locations. • Once future planned projects (I-70 at I-695 and I-695 over US 40) resolve the US 40 bottleneck **all on-ramp queues will be contained within the existing on-ramp storage**
PM Peak	**Intersection Operations and Arterial Performance:**	• **41% reduction** in LOS E/F intersections

The specific benefits gained by implementing the full CGI Team PTSU solution would include travel time savings, increased vehicle speeds, less vehicles getting stuck at congested bottlenecks, and less dense highway operations (leading to more comfortable travel). Our solution will improve arterial operations in 2040 including up to a **41% reduction** in LOS E/F intersections and reduce on-ramp queues.

These benefits are quantified and supported by data included in **Appendix F** and **Appendix G**.

iii. PERFORMANCE LIFE

Performance life is defined as the time it will take for congestion levels to return to pre-construction levels. The **performance life of the CGI Team's PTSU, with predetermined hours of operation from 6 AM-10AM and 2 PM-7 PM**, is **beyond 2040** once future planned projects (I-695 at I-70 and I-695 over US 40) are completed. Without the future projects in place, the **performance life of the inner loop will be beyond 2040 during the AM and PM peak period**; and the performance life of the **outer loop will be beyond 2040 during the AM peak period**. The performance life of the outer loop in the PM peak is heavily influenced by the bottleneck located at US 40. The CGI Team estimates that congestion levels on the outer loop in the PM peak will return to pre-construction levels by 2030 without the future planned projects in place. This performance life is summarized in **Table 2.7**. This section discusses the details of the performance life evaluation including the basis for assessment.

The CGI Team's proposed PTSU improvements will provide **benefits over the No-Build condition to 2040 and beyond**. It is critical to consider what mobility benefit PTSU will provide relative to existing levels of traffic congestion. We completed an evaluation to understand when peak period congestion will return to existing levels on both the inner loop and outer loop during the AM and PM peak periods with our selected predetermined hours of PTSU operation. We have also summarized results for traffic operations during the horizon year (2040) as shown in **Table 2.7**.

Table 2.7: Performance Life Summary

AM Peak Hour	Inner Loop	✓ Beyond 2040
AM Peak Hour	Outer Loop	✓ Beyond 2040
PM Peak Hour	Inner Loop	✓ Beyond 2040
PM Peak Hour	Outer Loop	✓ Beyond 2040 *with Future Planned Projects**
PM Peak Hour	Outer Loop	**2030** *without Future Planned Projects**

**Planned projects (e.g. I-70 at I-695 and I-695 over US 40)*

Based on the existing and future congestion profile, the CGI Team PTSU solution includes proposed scheduled hours of operation of **6 AM to 10AM** and **2 PM to 7 PM** each weekday. These additional hours will provide added flexibility and **performance life through 2040** by allowing the hours leading up to and following the peak hour to be accommodated by the proposed PTSU lane. Significant travel time reductions are provided in each of the operating hours of the PTSU lane. In addition to the static operating hours, the PTSU lane may open at any time to response to incidents or congestion. The CGI Team also included provisions which would allow for the PTSU lane to remain open beyond the static scheduled PTSU closure time if congestion persists due to non-recurring congestion.

Performance Life of CGI's Proposed PTSU Improvements

This section demonstrates that the CGI Team's PTSU solution will operate exceptionally well in the future. The improvements were modeled using the 2040 No-Build network provided by MDOT SHA in the RFP. The VISSIM models provided by MDOT SHA as part of the RFP were used by the CGI Team as the **basis for assessment of performance for all improvements**. In accordance with the RFP, the **VISSIM calibration parameters were not changed** by the CGI Team.

The Team's PTSU improvements provide considerable mobility improvement when compared to the 2018 Existing No-Build in the AM and PM peak as shown in **Table 2.8**. The CGI Team improvements provide **21-32% reductions** in inner loop travel times during the AM and PM peak and network-wide **14% increase** in vehicle throughput during the AM and PM peak. The PTSU improvements proposed by the CGI Team are robust and provide **benefits for decades** into the future.

The CGI Team solution for **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond** on the inner loop. This exceptional performance life would be especially true of the inner loop during the AM and PM peak, as virtually all the relevant congestion measures indicate that the I-695 inner loop network with the CGI Team improvements performs better than under the existing (2018) conditions.

During the AM peak on the outer loop, **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond.** During the PM peak, **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond** once the I-695 at I-70 Interchange Reconstruction (BA0065272) and US 40 Bridge Replacement (BA0145180) planned projects eliminate bottleneck locations outside of the I-695 TSMO project limit. On the outer loop during the PM peak, the analysis results indicate that downstream bottlenecks outside of the project limit, which will be eliminated by current planned projects (I-695 at I-70 and I-695 over US 40), need to be corrected before 2030 to prevent congestion levels from returning to preconstruction levels. While the overall congestion levels on I-695 outer loop during the PM peak exceed current levels by 2040 with the US 40 bottleneck in place, the outer loop would accommodate a **17% increase** in throughput. The maximized PTSU limits provided by the CGI improvements would allow MDOT SHA to focus future spending on currently planned projects at I-70 and at US 40 to eliminate the bottleneck near US 40 and provide a **nearly free flow future network beyond 2040 on I-695 outer loop**.

To ensure performance of the inner loop PTSU improvements **beyond 2040**, the CGI Team is extending the PTSU lane, as described in ATC 23, east of US 1 to Lillian Holt Drive. Without this inner loop PTSU extension, the inner loop congestion conditions would degrade to preconstruction levels before 2040 in the AM peak period.

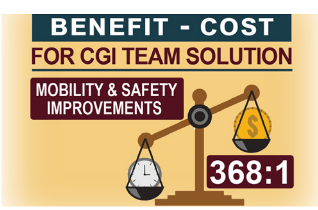
I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond on the inner loop

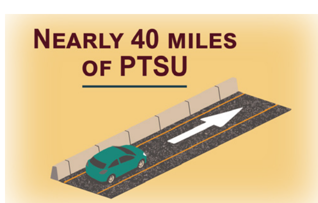
Table 2.8: Performance Life—Existing (2018) No-Build vs. 2040 CGI—PTSU

	Improvement Type	Details
AM Peak	**Travel Time Reduction:** (8 AM to 9 AM)	• Inner loop **7-minute** (21%) • Outer loop: **29-minute** (51%) with future planned projects (I-70 at I-695 and I-695 over US 40); 5-minute (8%) without future planned projects
AM Peak	**Vehicle Throughput Increase**	• Network-wide: **16%**
AM Peak	**Vehicle Density:**	• Inner loop: **40% reduction** in LOS E/F segments • Outer loop: **19% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed Increase:** (8 AM to 9 AM)	• Inner loop: **112%** in critical MD 140 to I-83 segment • Outer loop: **237%** in critical US 1 to Cromwell Bridge Road segment
AM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged at 67% of ramps locations with queues contained within existing storage at 94% of locations • Increased queues at MD 122 will be solved by future planned project (I-70 at I-695)
PM Peak	**Travel Time Reduction:** (5 PM to 6 PM)	• Inner loop: **15-minute** (32%) • Outer loop: **6-minute** (19%) with future planned projects (I-70 at I-695 and I-695 over US 40); 23-minute increase without future planned projects
PM Peak	**Vehicle Throughput Increase:**	• Network-wide: **13%**
PM Peak	**Vehicle Density:**	• Inner loop: **64% reduction** in LOS E/F segments • Outer loop: 16% increase in LOS E/F segments with US 40 bottleneck
PM Peak	**Vehicle Speed Increase:** (5 PM to 6 PM)	• Inner loop: **237%** (20–61 MPH) in critical MD 139 to Cromwell Bridge Rd segment • Outer loop: **43%** in US 1 to I-83 segment
PM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged on-ramp queues at 73% of ramps locations with queues contained within existing storage at 96% of locations • Once future planned projects (I-70 at I-695 and I-695 over US 40) resolve the US 40 bottleneck **all on-ramp queues will be contained within the existing on-ramp storage**

CGI TEAM SOLUTION SUMMARY

The CGI Team is proposing a solution that will maximize the amount of static-dynamic PTSU by **providing PTSU for the full limits of the project and extended limits along both directions**. This solution will result in nearly free-flow travel during the peak periods now and in the future. The CGI Team PTSU will **maximize vehicle throughput, minimize travel times and delay on I-695 and create a more reliable commuter trip** along I-695 from I-70 to MD 43. This is demonstrated by the up to 34 minutes (58%) travel time reduction upon opening and **183-minute (78%)** travel time reduction in 2040; Future **throughput increases of up to 51%**; **nearly free flow conditions** upon opening; **reducing delay by up to 62% reduction in average delay per vehicle;** and improving the operation of arterials roadways. This solution achieves MDOT SHA's goals of enhanced mobility along this vital corridor and provides a tremendous value for MDOT SHA's investment.





Section 3

Mobility

in association with

CGI TEAM SOLUTION OVERVIEW

The CGI Team lives and breathes I-695. Many of our key staff suffer through the existing congestion. We've dreamed of providing the solution outlined in this proposal, which will **eliminate delay today** and promises **performance life beyond 2040**. Our project will provide $4.8B in annual congestion and safety benefits to Marylanders. It's a solution that the CGI Team and MDOT SHA will be proud to deliver.

The Solution

Nearly 40 Miles of Part Time Shoulder Use (PTSU)	• I-70 to MD 43 (37.3 miles) + • Outer loop extension within I-70 interchange (0.5 miles) • Inner loop extension to Lillian Holt Drive (1.8 miles) • Extended operational hours from 6 AM–10 AM and 2 PM–7 PM
Navtech Radar-Based AID System	• 80 devices vs. competing systems' 390 devices • True all-weather performance • Accurate debris detection as small as 2'x2'x2' • Automated incident detection on PTSU/GP lanes
Incident Response	• Complete CCTV coverage for PTSU/GP lanes • Outside shoulder for emergency response
Safety Upgrades	• 15 miles of upgraded concrete median barrier • 1,000 new drainage inlets reduce spread for PTSU
Pavement Enhancements	• 12 lane miles of pavement rehabilitation • 168 lane miles of pavement resurfacing
Highly Adaptable Systems	• Connected vehicle ready corridor • 21 miles of new fiber optic cable network
Maintenance and Operations	• $370K in annual reduced maintenance and operation costs over similar systems for I-695 TSMO

The Performance

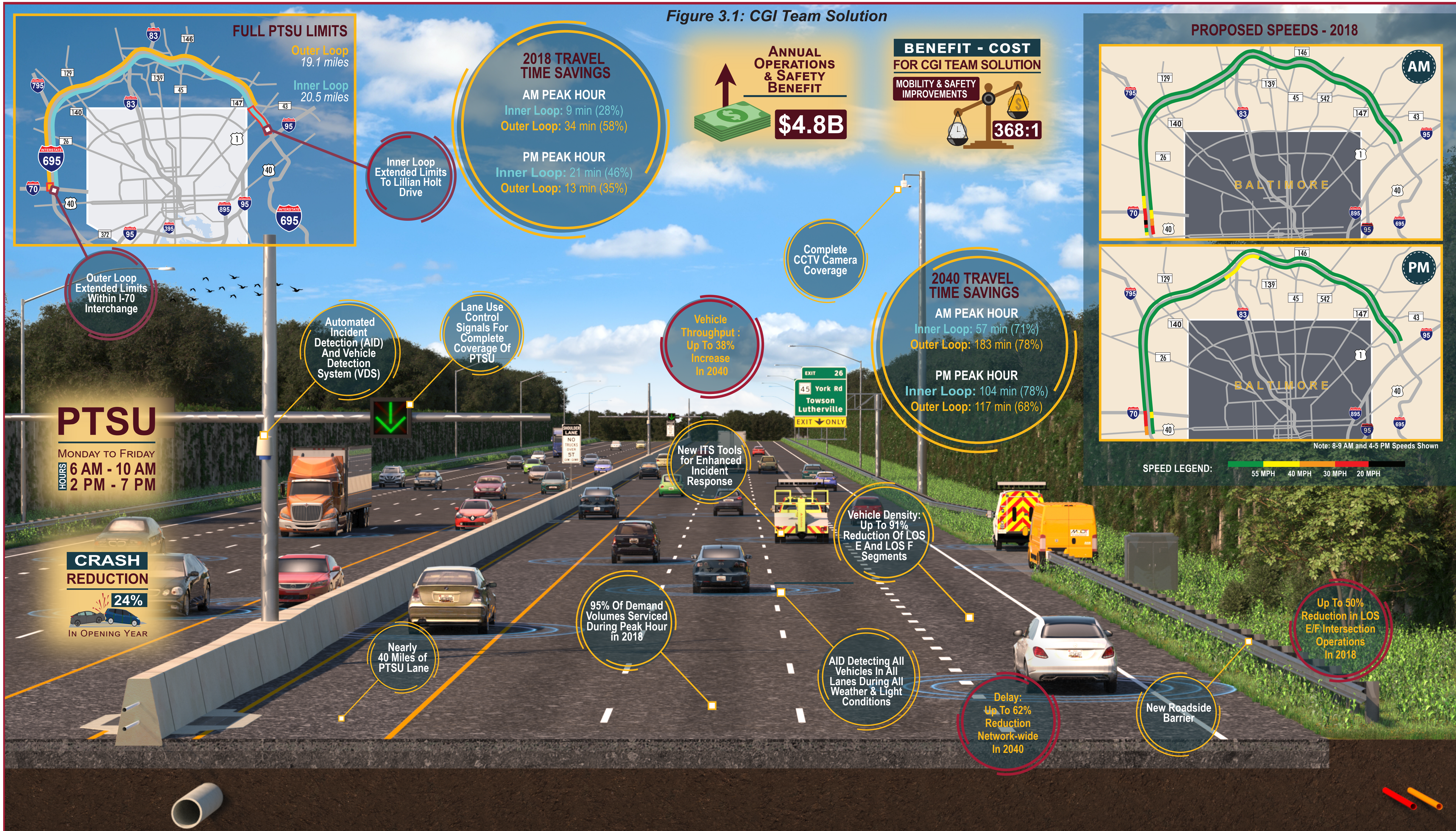
Existing	• 59% free flow traffic • Average speed as low as 23 MPH • Travel time up to 57 minutes
Opening	• 96% free flow traffic • Average speed 58 MPH / 57 MPH • Travel time 23.1 min / 23.5 min
2040	• 74% free flow traffic (96% with future projects*) • Average speed 51 MPH / 29 MPH (52 MPH w/future projects*) • Travel time 26.6 min / 47.2 min (26 min with future projects*)

All Statistics: Inner Loop Peak Period/Outer Loop Peak Period
**MDOT SHA planned improvements at I-70 and US 40*

Numbers don't lie. There is no better solution than free flow traffic in the opening year. In fact, our PTSU solution is so good that other improvements add little value now, or in the future. There are no impacts to arterial roadways, minimal environmental impacts, and safety is enhanced.

We understand that the devil is in the details. The remainder of this section will demonstrate exactly how the CGI Team's solution will provide additional improvements that maximize vehicle throughput, minimize vehicle travel times, and create a more reliable trip along I-695 from I-70 to MD 43. Refer to **Figure 3.1** for a graphic of our solution.

Figure 3.1: CGI Team Solution



i. OTHER IMPROVEMENTS TO MAXIMIZE VEHICLE THROUGHPUT AND MINIMIZE TRAVEL TIMES

The CGI Team investigated options to deliver the best, most cost effective solution for this project. **Our team found that maximizing static-dynamic PTSU within the project limit, with additional inner loop and outer loop PTSU extensions, was the best solution to accomplish the goals of the project which include maximizing vehicle throughput, minimizing vehicle travel times, and creating a more reliable commuter trip on I-695 from I-70 to MD 43.** Our PTSU system is combined with a comprehensive ITS system which includes Automated Incident Detection (AID) for all lanes of traffic to improve incident response time to create a more reliable commuter trip on I-695. The traffic analysis revealed that maximizing PTSU provided more benefit than any other combination of PTSU length within the project limits and other improvements, such as ramp metering, targeted interchange improvements, or Active Traffic Management.

Additional Project Limits for PTSU

Analysis identified that bottlenecks located just outside of the project area cause congestion to propagate back into the project area, degrading throughput and travel time results. By unlocking bottlenecks in the project area, these external bottlenecks are magnified due to the additional volume processed by PTSU in the project area. As such, the CGI Team sought to address these bottlenecks to achieve the **maximum benefits in the project area, increased throughput, and reduced travel times**. Our additional PTSU limits also reduce crashes by 24% on I-695 which **will reduce non-recurring congestion and create a more reliable commute trip**.

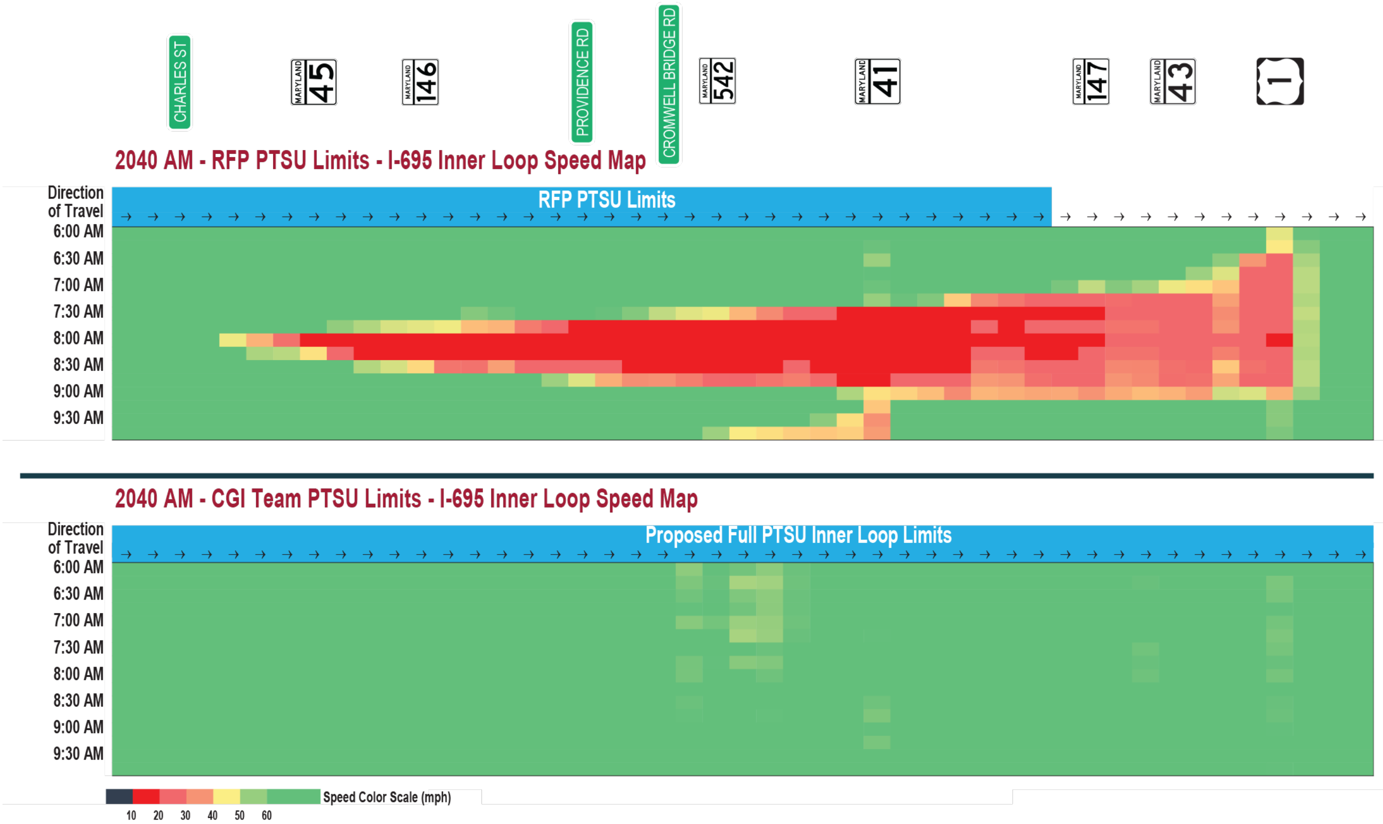
Inner Loop: On the inner loop, the external bottleneck impacting the project area is located at the I-695 at US 1 interchange. As described in the conditionally accepted ATC 23R, the CGI Team proposes to extend the limits of PTSU on the inner loop from the MD 43 interchange to east of US 1 (near Lillian Holt Drive). These additional limits will allow the PTSU lane to overlap with the five-lane section of I-695 east of US 1 where the deceleration lanes to I-95 have developed. As a result, the CGI Team proposes to provide PTSU on the inner loop between I-70 and Lillian Holt Drive. A speed map comparing the RFP inner loop PTSU ending (near MD 43) and the proposed CGI Team limits (I-70 to Lillian Holt Drive), which end near Lillian Holt Drive, is shown in **Figure 3.2**. **Signing improvements are included as part of extension to allow traffic to safely change lanes from the median PTSU lane to access the I-95 interchange.**

Outer Loop: On the outer loop, the external bottleneck impacting the project area is located at the I-695 at US 40 interchange. Two MDOT SHA projects (BA0065272 - I-70 at I-695 and BA0145180 – I-695 over US 40 Bridge Replacement) will be addressing the bottleneck to improve future operations. The CGI Team is proposing to extend PTSU limits on the outer loop to end the PTSU lane within the I-70 interchange. Knowing that the I-70 at I-695 project is planned, **our goal with the outer loop extended PTSU limits is to ensure that we can tie into the planned improvements at the I-695 at I-70 interchange improvements seamlessly, resulting in the greatest enhancements in future mobility for I-695**. **Table 3.1** provides a summary of benefits of our PTSU extensions.

Table 3.1: Additional PTSU Limits

Direction	Limits	Benefits Now and In Future
Inner Loop	MD 43 to Lillian Holt Drive	• **3 minutes of travel time savings** in AM Peak Hour immediately and **13 minutes** in 2040 • Inner loop performance life extends **beyond 2040** • Additional 2.2% reduction in crashes over RFP limits
Outer Loop	I-70 Interchange South of Triple Bridges	• **69 minutes of travel time savings** in 2040 PM Peak Hour • Outer loop performance life extends **beyond 2040** in AM • Allows tie-in to future MDOT SHA projects

Figure 3.2: Speed Map Comparison of CGI Team PTSU Inner Loop Limits and RFP PTSU Limits



Other Improvements Beyond Static-Dynamic PTSU

The CGI Team solution provides numerous enhancements to I-695 to **maximize throughput, reduce travel times and create a more reliable trip** along this vital primary commuter route.

Concrete Barrier Upgrades and Roadway Widening/Realignment to Meet Stopping Sight Distances: By realigning I-695 to meet stopping sight distance in 98% of locations along I-695 and upgrading 15 miles of barrier to meet current safety standards, safety benefits will be provided to motorists which contribute to the **24% reduction in total crashes** and a reduction in the injury crash rates. By providing a safer I-695 through roadway and geometric upgrades, non-recurring congestion will be reduced. Less non-recurring congestion due to less and shorter incidents will **create a more reliable trip and improve travel times** on I-695 by maintaining operations at free flow for most of the corridor.

Drainage: Our solution will install over 1,000 new median inlets to ensure that inlet spreads do not encroach into the general purpose lanes or more than 4 feet into the PTSU lane. These drainage upgrades will ensure the PTSU can **operate in all weather conditions**. By allowing all-weather operation by improving the drainage system, **the increased throughput (up to 51% increases) and minimized travel times (up to 58% reductions) provided by our total project will be realized every weekday.** This will create a more reliable trip on I-695, even in poor weather.

Complete CCTV Camera Coverage: Our solution will install new CCTV Cameras to provide MDOT SHA complete coverage of the PTSU lane and all general purpose lanes. By providing **enhanced situational awareness**, MDOT SHA can improve incident clearance times and reduce non-recurring congestion. By reducing non-recurring a more reliable trip will be created on I-695 with minimized travel times and increased throughput.

***Automated Incident Detection Across All Lanes:* The RFP requires an Automated Incident Detection (AID) system to support the static-dynamic PTSU lane system, including coverage for the entire limits of the PTSU system plus an additional distance for entry and exit. As described in conditionally accepted** PTC 1, the **CGI Team is providing an AID system which** exceeds the RFP requirements by providing AID functionality across all general-purpose lanes **as well as the PTSU lane**. **The CGI Team solution provides enhanced** situational awareness **and additional tools to respond to and manage events that cause non-recurring congestion. The PTSU and supporting ITS will improve detection, verification, response, roadway clearance and incident clearance times on I-695. By improving roadway clearance times, non-recurring congestion duration will be reduced and will result in a** more reliable commuter trip**. By reducing incident duration, the AID system will** maximize the vehicle throughput **provided by the PTSU lane and** minimize vehicle travel times.

Other Alternatives Eliminated from Consideration

This section contains other alternatives which were investigated and were eliminated from consideration because they were not as effective as maximizing the PTSU limits.

CGI Team is providing an AID system which exceeds the RFP with detection in all lanes to improve incident clearance times and create a more reliable trip.

Ramp metering is a great tool and effective method of maximizing vehicle throughput on a freeway by metering the rate that vehicles enter the freeway and is currently being deployed by the CGI Team on I-270. Ramp metering is most effective when bottlenecks are caused by platoons of traffic merging onto the freeway, such as was present under the I-270 ICM project. **By maximizing the PTSU limits to provide free flow conditions throughout most of the project limits at ramp termini**, the ramp metering strategy is not cost-effective at further reducing congestion on I-695. Ramp metering can also negatively impact arterial operations when sufficient storage is not present on entrance ramps. **Maximizing PTSU will improve arterial operations.** Since many I-695 ramps are short with high entry volumes, ramp queues could create issues from the inception of the project. In 2040, the demand far exceeds current capacity on I-695. In this situation, **maximizing PTSU to create additional capacity is a far more effective strategy** for I-695 than the demand management approach of ramp metering, which would be ineffective.

Active traffic management (ATM) is also effective in improving freeway operations. While FHWA considers PTSU as one element of ATM, this investigation focused on other ATM elements such as dynamic speed advisory signs, queue warning, and Dynamic Lane Control for all lanes. These ATM elements are effective at improving non-recurring congestion, which is an issue in the I-695 corridor. However, these **ATM elements provide marginal improvement for recurring congestion** and cannot adequately address all the goals of the I-695 TSMO project. Furthermore, **once the PTSU lane is in operation, recurring congestion is nearly eliminated, further negating the value of such a system**.

On I-66, VDOT noted that the Dynamic Lane Control over all lanes with ATM did not appear to consistently produce reductions in traveler delays—PTSU was their most effective strategy

Additional roadway improvements are other improvements which our Team investigated, including upgrades to the I-83 and MD 122 interchanges. However, these improvements only provided better traffic operations locally. Significant roadway improvements necessary to solve congestion issues of the entire corridor would be **costly and impactful** including impacts to Noise, ROW and protected resources and would not be in line with a performance-based practical design approach.

As a result, our team extended the PTSU rather than electing to add other features within the project limit. **Maximizing PTSU, with a resulting benefit-cost ratio of 368:1, is the best solution to address the goals of this project**. PTSU provides additional capacity for I-695 when it is needed, directly improving the ability to **maximize throughput, minimize travel time**, and create a more reliable trip. Maximizing PTSU provides **more mobility and safety benefit than any other combination of PTSU length within the project limits and other improvements now and in the future**. This project provides the benefits of an additional full-time travel lane without the tremendous capital cost of constructing an additional lane and without sacrificing safety.

ii. TOTAL PROJECT REDUCTIONS IN RECURRING CONGESTION (STATIC-DYNAMIC MEDIAN PART-TIME SHOULDER USE AND OTHER IMPROVEMENTS)

The CGI Team has developed our solution with the primary goal of **reducing recurring congestion, reducing travel time, and improving vehicle network performance along I-695 and on connecting ramps and arterial roadways** by eliminating bottlenecks. I-695 has long been plagued with recurring congestion as indicated by the MDOT SHA Mobility Report, as shown in **Table 3.2**. During the AM peak hour (8-9 AM), **three of the top 5 most congested freeway sections in Maryland** are key segments within this corridor, and **one of the top 5 most congested freeway sections during the PM peak is within the project area**. Each has a Travel Time Index (TTI) greater than 2, signifying travel times are more than twice what they are when congestion is not present. This has an everyday impact to Marylanders as, on average, a traveler must plan for up to six times the uncongested time through these segments to be confident in their arrival times – **adding roughly a half hour to their planned trips**.

Table 3.2: Most Congested Freeway Segments along I-695 from Mobility Report—2018

Segment No.	Direction	Peak Period	Location	TTI	State Rank
1	OL	AM	US 1 to Cromwell Bridge Rd	2.85	#2 in AM
2	OL	AM	MD 129 to US 40	2.35	#4 in AM
3	IL	AM	MD 140 to I-83	2.33	#5 in AM
4	IL	PM	MD 139 to Cromwell Bridge Rd	3.19	#2 in PM

CONGESTION ELIMINATED

We propose a highly effective solution that **eliminates these extremely congested segments** as shown in **Figures 3.3 and 3.4**. The focal point of our solution is the addition of **PTSU for the entire limits** of the project area and the **extension of PTSU along the inner loop and outer loop**. The maximization of these limits allows for a safe and effective increase in capacity for these segments during the times of day that warrant it and will most effectively address the root causes of congestion in the most critical segments. **Since capacity is the underlying issue, PTSU is the best solution to address the project goals and improve overall mobility and reduce recurring congestion on I-695**.

Our solution will eliminate the bottlenecks throughout the project limits, increasing the traffic volume traveling through these segments. The added volume to downstream segments could potentially increase congestion levels, but we factored that into our solution; by providing **more PTSU** for the **full project limit** and additional extensions, we have effectively minimized the "bottleneck shift" phenomenon allowing our improvements to be effective beyond 2040.

Providing PTSU for the entire limit and the extension would **eliminate all existing bottlenecks on the inner loop**. Providing PTSU for the entire limits along the outer loop, with an extension to tie-in within the I-70 interchange, leave only the US 40 bottleneck. **Figure 3.4** shows during the AM peak period, the bottleneck would remain, but it would be shorter and smaller than

> CGI Team solution will eliminate the bottlenecks throughout the project limits

EXISTING TRAFFIC CONDITIONS - 2018

CGI TEAM SOLUTION TRAFFIC CONDITIONS - 2018

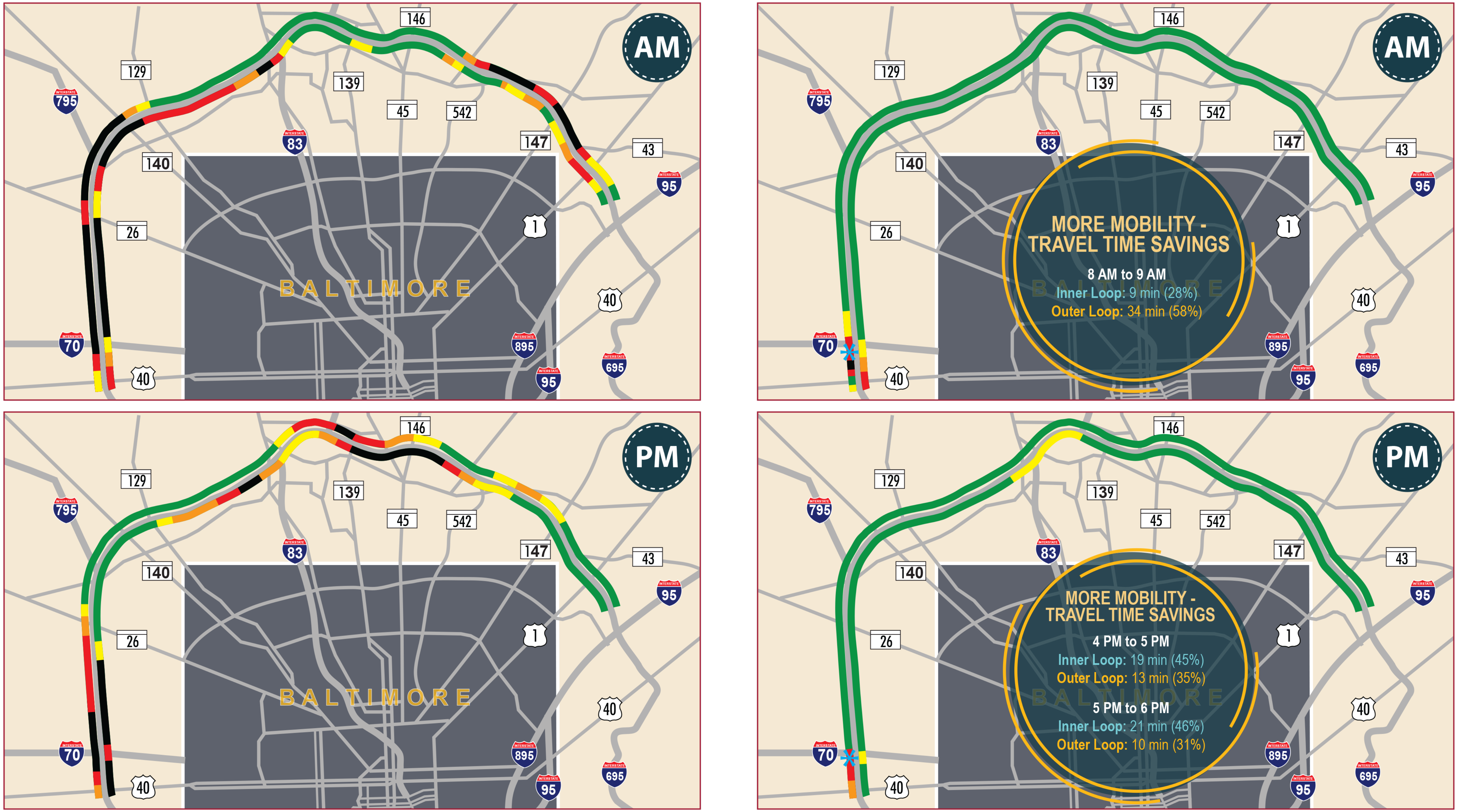


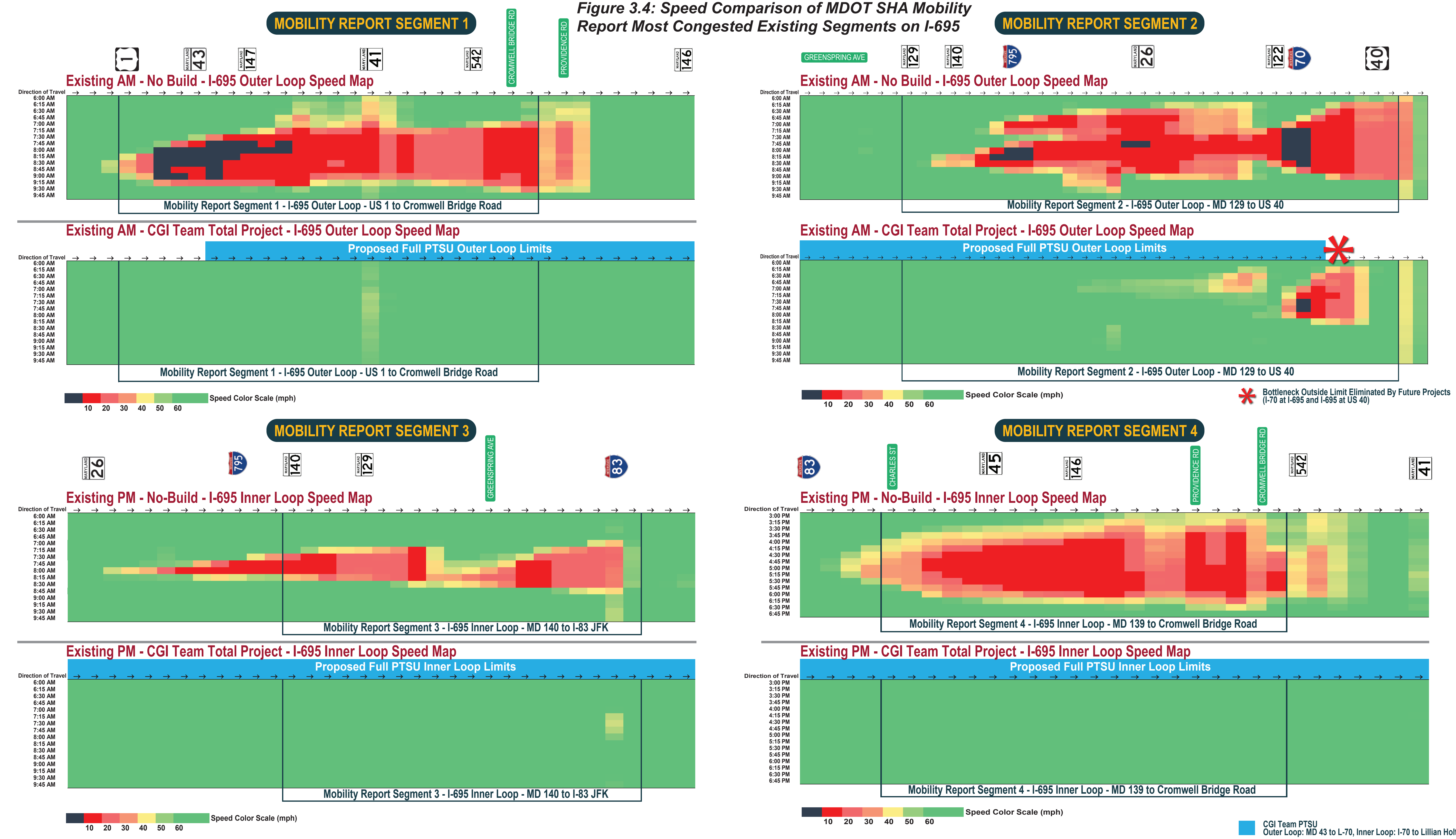
Figure 3.3: Peak Hour Speed Map - 2018

SPEED LEGEND: 55 MPH 40 MPH 30 MPH 20 MPH

* Bottleneck Outside Limit Eliminated By Future Projects (I-70 at I-695 and I-695 at US 40)

Note: 8-9 AM and 4-5 PM Speeds Shown

Figure 3.4: Speed Comparison of MDOT SHA Mobility Report Most Congested Existing Segments on I-695



the current bottleneck that plagues this segment. The CGI Team developed a PTSU approach that would be consistent with future MDOT SHA projects. We have extended our outer loop PTSU to I-70 to tie-in and coordinate with the I-695 at I-70 project rather than ending the PTSU lane early and causing a new bottleneck for the future. The future planned projects (I-70 at I-695 and I-695 over US 40) will eliminate downstream bottleneck at US 40 and allow our project to **provide free flow conditions throughout 96%** of the I-695 TSMO project limit **now and in 2040**.

Free flow conditions throughout 96% of the project limits now and in 2040

The CGI Team solution prioritizes PTSU, maximizes the PTSU limits, and provides significant tangible assets including state-of-the-art ITS (Navtech all-weather AID), complete CCTV camera coverage, adaptability, and a high level of operability for the benefit of MDOT SHA. As shown in **Table 3.3** below, our solution **reduces travel times by up to 58%, improves vehicle network performance by reducing delay by up to 62% along I-695** compared with the existing no-build in 2018; and reduces the number of I-695 highway segments at LOS E/F **by up to 91%.** Our solution also increases vehicle throughput during the peak hour such that nearly all peak hour demand is accommodated. The **duration of congestion is also significantly reduced**—as indicated by increased speeds throughout the peak period.

Table 3.3: Recurring Congestion Improvements, Existing (2018) No-Build vs. 2018 CGI Total Project

	Improvement Type	Details
AM Peak	**Travel Time Reduction:** (8AM to 9AM)	• Inner loop: **9-minute** (28%) • Outer loop: **34-minute** (58%) • Nearly **free flow** conditions (23 min average travel time)
AM Peak	**Vehicle Network Performance:**	• Network-wide: **50% reduction** in Average Delay per Vehicle
AM Peak	**Vehicle Throughput Increase:**	• Over **95%** of I-695 demand volume serviced during demand hour.
AM Peak	**Vehicle Density:**	• Inner loop: **83% reduction** in LOS E/F segments • Outer loop: **86% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed Increase:** (8AM to 9AM)	• Inner loop: **40%** from 42 MPH to 59 MPH • Outer loop: **140%** from 23 MPH to 55 MPH
AM Peak	**Connecting On-Ramp Queues:**	• **Eliminated** due to free flow conditions on mainline • One location with queue contained within existing ramp storage
AM Peak	**Intersection Operations and Arterial Performance:**	• 44% reduction in LOS E/F intersections • **No LOS F intersections** • No on-ramps causing arterial spill back
PM Peak	**Travel Time Reduction:**	• Inner loop: **21-minute** (46%) from 5 PM–6 PM • Outer loop: **13-minute** (35%) from 4 PM–5 PM • Nearly **free flow** conditions (24 min average travel time)
PM Peak	**Vehicle Network Performance:**	• Network-wide: **62%** reduction in Average Delay per Vehicle
PM Peak	**Vehicle Throughput Increase:**	• Over **95%** of I-695 demand volume serviced during demand hour
PM Peak	**Vehicle Density:**	• Inner loop: **89% reduction** in LOS E/F segments • Outer loop: **91% reduction** in LOS E/F segments
PM Peak	**Vehicle Speed Increase:**	• Inner loop: **85%** from 29 MPH to 53 MPH (5 PM–6 PM) • Outer loop: **54%** from 36 MPH to 56 MPH (4 PM–5 PM)
PM Peak	**Connecting On-Ramp Queues:**	• Essentially **eliminated** due to free flow conditions on mainline.
PM Peak	**Intersection Operations and Arterial Performance:**	• **50% reduction in LOS E/F intersections** • One remaining LOS F intersection • No on-ramps causing arterial spill back

The CGI Team improvements would provide mobility benefits for years to come. In 2040, the anticipated mobility improvements over the anticipated no-build conditions are staggering: **travel time reductions of 78%** during the PM peak hour – **over 3 hours (183 minutes)** for the outer loop and **over an hour and a half (104 minutes)** for the inner loop. More vehicles would be able to traverse the network, with a **throughput increase of 30%** and improvements in vehicle network performance including a **60% reduction** in total network delay, as shown in **Table 3.4**. When combined with the I-70 at I-695 interchange reconstruction and the I-695 over US 40 bridge replacement projects, the outer loop improvements are even more staggering as the travel time would be reduced by an additional 29 minutes as shown in **Figure 3.11**.

Table 3.4: Recurring Congestion—2040 No-Build vs. 2040 CGI—Total Project

	Improvement Type	Details
AM Peak	**Travel Time Reduction:**	• Inner loop: **49-minute** (8 AM–9 AM) and **57-minute** (9 AM–10 AM) • Outer loop: **207-minute** (8 AM–9 AM) with future planned projects (I-70 at I-695 and I-695 over US 40); **183-minute without future planned projects**
AM Peak	**Vehicle Network Performance:**	• Network-wide Delay: **58% reduction** • Latent Delay: **49% reduction**
AM Peak	**Vehicle Throughput Increase:**	• Network-wide: **23%**
AM Peak	**Vehicle Density:**	• Inner loop: **74% reduction** in LOS E/F segments • Outer loop: **50% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed:**	• Inner loop: —**323% speed increase** in critical MD 140 to I-83 segment (8 AM–9 AM) —**81% increase** from US 40 to Lillian Holt Dr (6 AM–10 AM) • Outer loop: —**893% speed increase** (5 MPH to 46 MPH) in critical US 1 to Cromwell Bridge Rd segment (8 AM–9 AM) —**119% increase** from Lillian Holt Dr to US 40 (6 AM–10 AM)
AM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged on-ramp queues at 90% of ramps locations with queues contained within existing storage at 94% of locations • Increased queues at MD 122 will be solved by future planned projects
AM Peak	**Intersection Operations and Arterial Performance:**	• **30% reduction** in LOS E/F intersections
PM Peak	**Travel Time Reduction:** (5 PM to 6 PM)	• Inner loop: **69-minute** (5 PM–6 PM); **104-minute reduction** (4 PM–5 PM) • Outer loop: **146-minute** (5 PM–6 PM) with future planned projects (I-70 at I-695, I-695 over US 40); **117-minute w/o future planned projects**
PM Peak	**Vehicle Network Performance:**	• Network-wide Delay: **62% reduction** • Latent Delay: **53% reduction**
PM Peak	**Vehicle Throughput Increase:**	• Network-wide: **38%**
PM Peak	**Vehicle Density:**	• Inner loop: **73% reduction** in LOS E/F segments • Outer loop: **49% reduction** in LOS E/F segments
PM Peak	**Vehicle Speed:** (4 PM to 5 PM)	• Inner loop: **390% speed increase** (12 MPH to 59 MPH) in critical MD 139 to Cromwell Bridge Rd segment • Outer loop: **863% speed increase** (6 MPH to 55 MPH) in US 1 to I-83 segment
PM Peak	**Connecting Ramps Queues:**	• Reduced or unchanged on-ramp queues at 84% of ramps locations with queues contained within existing storage at 96% of locations. • Once future planned projects (I-70 at I-695 and I-695 over US 40) resolve the US 40 bottleneck **all on-ramp queues will be contained within the existing on-ramp storage**
PM Peak	**Intersection Operations and Arterial Performance:**	• **41% reduction** in LOS E/F intersections

The specific benefits gained by implementing the full CGI Team solution would include travel time savings, increased vehicle speeds, less vehicles getting stuck at congested bottlenecks, and less dense highway operations (leading to more comfortable travel).

With the CGI Team Total Project in place congestion will only remain in two locations in the VISSIM models (2018 and 2040) within the project limits:

- *Outer loop approaching US 40 bottleneck:* This **congestion will be eliminated** by future planned MDOT SHA projects including I-70 at I-695 and I-695 over US 40. Congestion **only impacts the project limits in the 2040 models**.
- *Inner loop in the PM peak between Greenspring Avenue and I-83 HBX:* This congestion appears to be caused by an over-reporting of congestion in the PM VISSIM model due to very conservative driver behaviors. This was documented in ATC 14; however, the CGI Team **did not** change calibration parameters to eliminate the congestion due to impacts to the No-Build. In practice **we anticipate this area will not be a source of congestion after opening** as it is not one of the most congested freeway segments identified in the MDOT SHA Mobility Report. This area accounts for as much as 3 minutes of travel time increase in the PM peak model.

These benefits are quantified below and are supported by data included in **Appendix F** and **Appendix G**.

Segment Density / Freeway Level of Service

This **CGI Team solution would provide nearly the same peak period benefits of an additional full-time travel lane**, by delivering added I-695 capacity only when the added capacity is needed. Delivering PTSU for the entire project area and the extended limits provides the additional capacity needed to improve operations through the bottleneck locations that cause the critical I-695 segments to register amongst the most congested statewide. Perhaps the best metric that illustrates that added capacity are the improvements in segment density. This measure indicates how many vehicles would be present in any given lane, with higher densities indicating increased congestion. Level of service (LOS) for each segment is a common method to express the density, with a letter grade from LOS A to F assigned to the segment based on the density value. LOS E and F are generally representative of segments with unacceptable operations including a high level of driver frustration and delay.

The implementation of the CGI Team solution would reduce segment density for nearly the entirety of I-695 during periods that PTSU would be open. The existing year (2018) VISSIM model runs show substantial reductions in segment density, significantly increasing mobility. **Table 3.5** shows that the **reduction of segments that are at capacity (LOS E) or above capacity (LOS F) would range from 75% to over 90%**. Reviewing these critical LOS E and LOS F segments that remain, the implementation of the CGI Team solution would **reduce the density for those segments, in some cases by as much as 91%.** A few segments would result in increased density – those segments are all located on the I-695 outer loop between MD 122 and US 40 at the end and downstream of the PTSU limits. This increase would be due to additional vehicles arriving at these segments during the peak hours in conjunction with the existing bottlenecks located outside the project limits. The future MDOT SHA projects at the I-70 interchange and the US 40 bridge replacement would address this increase in density.

Table 3.5: I-695 Segment Density (Level of Service) Improvements

			Existing 2018 Segments	Full CGI Solution 2018 Segments	% Reduction (2018)	Full CGI Solution 2040 Segments	% Reduction (2040)
Inner Loop	AM Peak	LOS E	52	6	**88%**	24	**54%**
		LOS F	36	9	**75%**	29	**19%**
	PM Peak	LOS E	49	9	**82%**	16	**67%**
		LOS F	136	12	**91%**	51	**63%**
Outer Loop	AM Peak	LOS E	50	12	**76%**	41	**18%**
		LOS F	116	11	**91%**	94	**19%**
	PM Peak	LOS E	30	2	**93%**	27	**10%**
		LOS F	87	9	**90%**	109	**-25%***

**Density is increased in this segment due to the US 40 bottleneck which will be eliminated by future planned projects (I-70 at I-695 and I-695 over US 40)*

The **reduction in density would be substantial and long-lasting**, with the number of segments at or above capacity in 2040 reduced from today's conditions for the both the inner loop and the outer loop. The one exception would be the outer loop during the PM peak, with additional segments operating over capacity, with the congestion from the end of the PTSU limit spilling back into additional segments by 2040. The compatibility that the CGI Team solution provides with the future planned projects (I-695 at I-70 and I-695 over US 40) would further reduce the number of these segments once those projects are complete.

Travel Time Savings

The increased mobility provided by the CGI Team solution is perhaps best captured by the anticipated travel time savings. The drastic reductions in travel times and improvements in travel speeds are a direct result of capacity provided by the added PTSU lane. Under existing year (2018), the implementation of our proposed solution is anticipated to provide an average of **11 minutes of travel time savings (31%) for both directions of the entire corridor length** across the 8-hour AM and PM peak period **with travel time saving of up to 34 minutes (58%) on the outer loop and up to 21 minutes (46%) on the inner loop during the peak hour**. These savings are a result of anticipated **nearly free flow** traffic conditions, as the average travel time is within 2 to 3 minutes of free flow travel time for the peak hours.

Table 3.6 below shows significant travel time reductions expected in 2018 during the peak two hours and throughout the peak period in 2040 with up to **183 minutes of travel time savings (78%)**.

Table 3.6: Travel Time Reductions—2018 and 2040

Travel Time Reduction (Existing 2018)					Travel Time Reduction (2040)				
2018	Inner Loop		Outer Loop		2040	Inner Loop		Outer Loop	
Hours of Travel	Min	%	Min	%	Hours of Travel	Min	%	Min	%
6-7 AM	1	3%	3	11%	6-7 AM	2	7%	9	23%
7-8 AM	**7**	**22%**	**17**	**38%**	7-8 AM	16	39%	50	51%
8-9 AM	**9**	**28%**	**34**	**58%**	**8-9 AM**	**49**	**66%**	**183**	**78%**
9-10 AM	1	3%	8	28%	**9-10 AM**	**57**	**71%**	**142**	**79%**
2-3 PM	7	25%	4	15%	2-3 PM	48	66%	62	60%
3-4 PM	10	30%	6	20%	3-4 PM	51	66%	65	60%
4-5 PM	**19**	**45%**	**13**	**35%**	**4-5 PM**	**104**	**78%**	**101**	**61%**
5-6 PM	**21**	**46%**	**10**	**31%**	**5-6 PM**	**69**	**69%**	**117**	**68%**
6-7 PM	10	30%	3	11%	6-7 PM	75	71%	59	58%

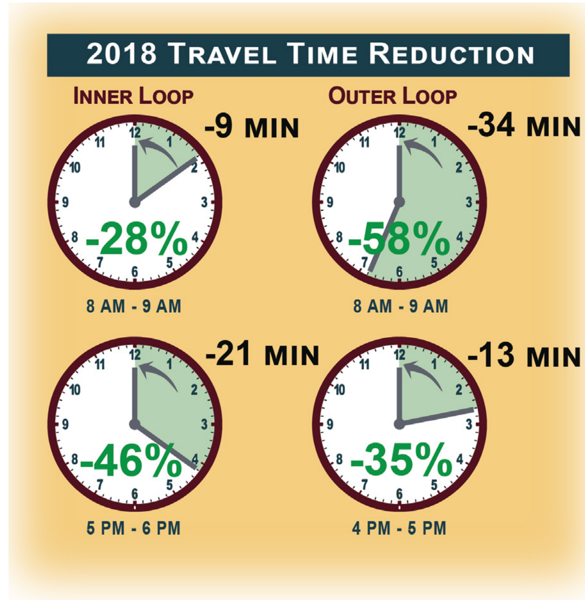
Travel time savings in 2018 along the I-695 outer loop during the peak hour (8-9 AM) is 34 minutes – a nearly **60% reduction** during the most congested hour along the outer loop in the project area as shown in **Figure 3.5**. Similarly, the inner loop experiences **travel time reductions of 19 to 21 minutes** during the peak two hours of the afternoon peak (4 to 6 PM) – a reduction of

45-46%. **These results show that providing PTSU for the entire project limits and the extended inner and outer loop limits would provide increased mobility at a level that approximates the level of improvements to be gained by full-scale widening of I-695.**

Relieving the congestion at the segments previously identified as the most congested segments in Maryland's 2019 Mobility Report is at the heart of the relief that providing PTSU for the entire corridor provides. The VISSIM results shown in **Figure 3.6** indicate that the **total project improvements would not cause travel time spikes anywhere along I-695**. This would result in stable, nearly free-flow conditions along I-695 during the peak hour, reducing the travel time for the entire corridor by 34 minutes.

Travel time savings resulting from the CGI Team solution are expected to benefit all I-695 users, not just those traveling through the most congested sections. Most travelers along I-695 do not travel the entirety of the I-695 project area. By providing PTSU for the entire project limits, travel time savings are expected for each quadrant of I-695 through the project area – assuring that **all I-695 users through the corridor will see some benefit**.

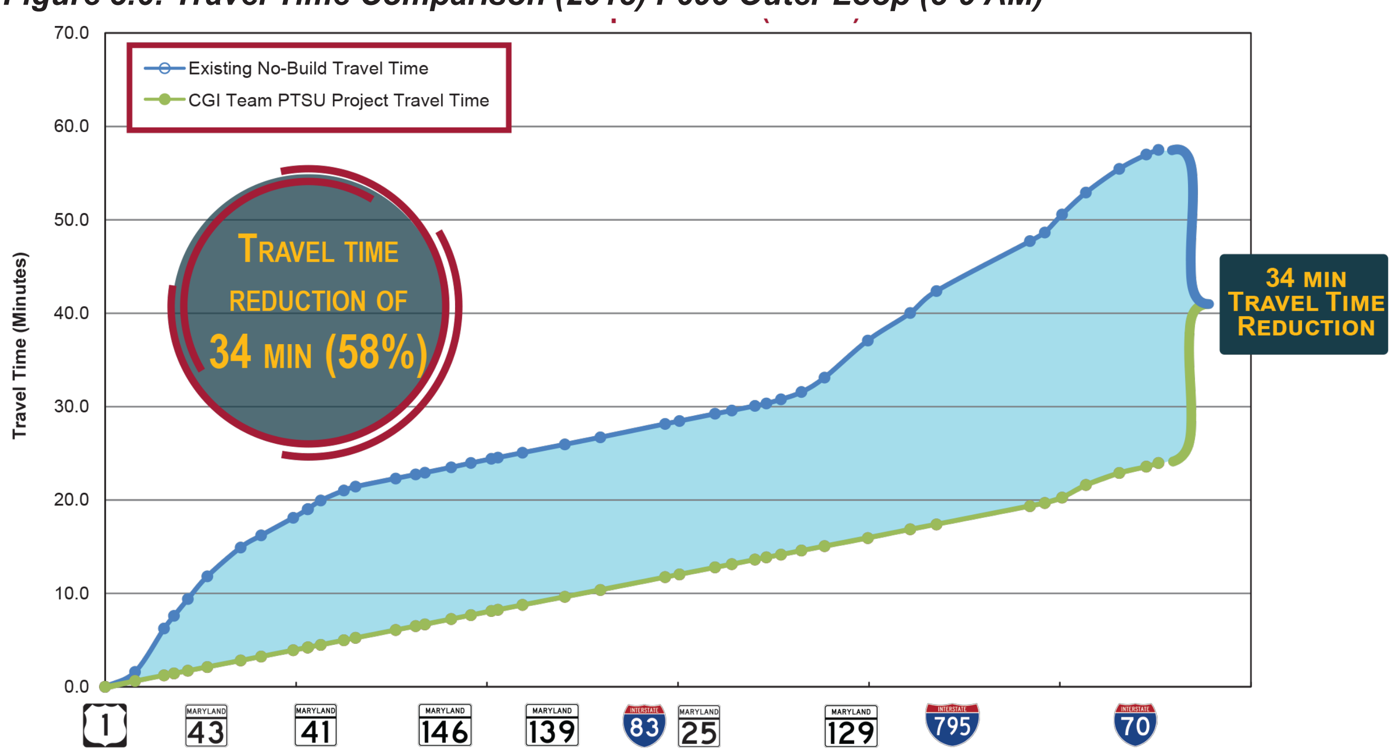
Figure 3.5: Peak Hour Travel Time Reduction (2018)



Travel Speed

The travel time improvements anticipated in the corridor are due to the increases in travel speeds that would result from the implementation of PTSU for the entire project limit and extend to Lillian Holt Drive. Travel speeds in the existing year (2018) would be at nearly free flow conditions for most of the I-695 project area for most of the time period that PTSU would be open. Along both the

Figure 3.6: Travel Time Comparison (2018) I-695 Outer Loop (8-9 AM)

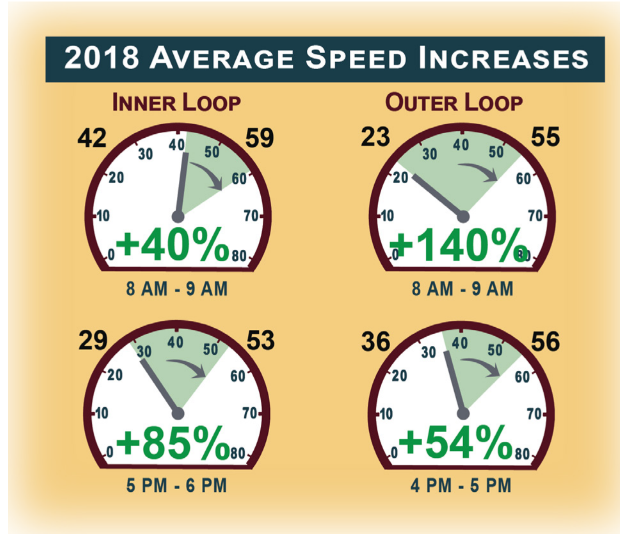


inner loop and outer loop, **speeds would increase by 40% to as much as 140%** during the peak hours when the PTSU would be opened, with an average speed of 57 MPH during the entire period when the PTSU lane is open to traffic, as shown in **Figure 3.7**.

Nearly every congested segment along both the I-695 inner loop and outer loop would have significant travel speeds increases, with most segments anticipated to be at or above 55 MPH. In fact, during the existing year (2018), the number of segments operating at free flowing conditions (55 MPH or greater) during the peak period would increase by 45%, with **nearly 96% of segments operating at free flow conditions**.

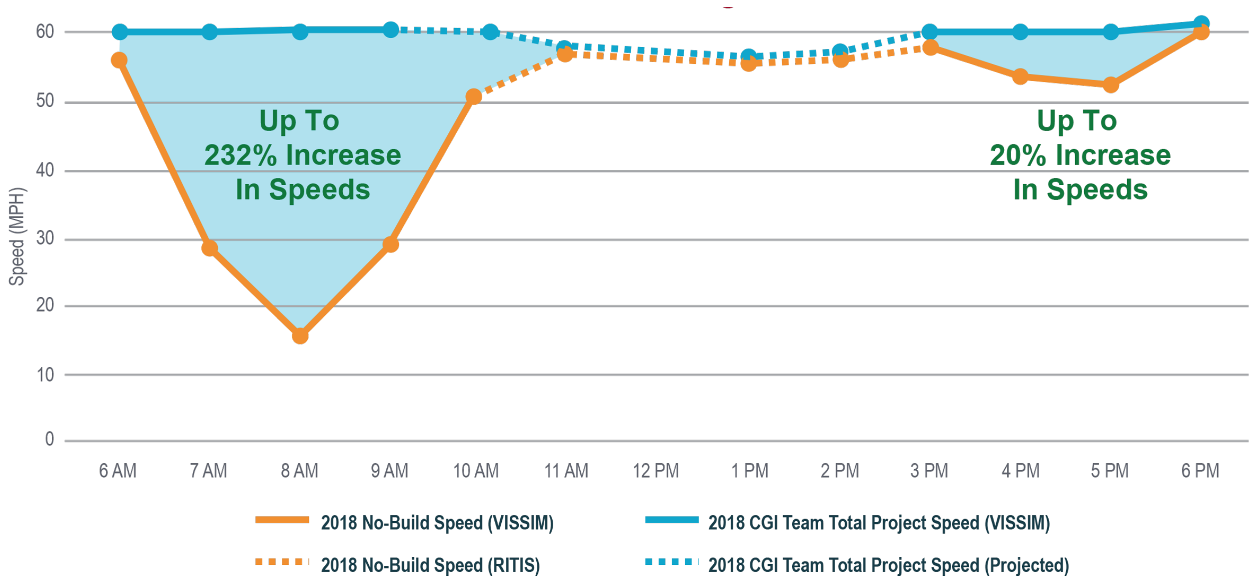
The long-lasting nature of the capacity improvements provided by the CGI Team solution would result in travel speed increases being anticipated well beyond the opening year. The 2040 model indicates that the overall average travel speed along the inner loop would be 18% higher than today's conditions. **In 2040, nearly 74% of all I-695 segments in the project area would be expected to travel at free flow speeds during the peak periods, an increase of 15% from today's conditions. Once current planned MDOT SHA projects are completed the percentage of free flow segments would increase to 96% in 2040.** This would be a significant improvement from the projected conditions, as without the CGI Team solution implemented, the anticipated outer loop travel speeds would be approximately 12 MPH. Without this project, just 16% of I-695 segments would operate at free-flow, at any time during either peak period. Based on crash analysis for our solution, the reduction in recurring congestion and the increased vehicle speeds will reduced total crashes by 24%. The resulting injury crash rate will be within 30% of the statewide average for the entire project corridor after completion.

Figure 3.7: Peak Hour Average Speed Increases (2018)



The travel speed increases are most pronounced at what today are the most congested segments along I-695. **Figure 3.8** illustrates the improvements in travel speeds along the I-695 in the most

Figure 3.8: Outer Loop Average Speed—US 1 to Cromwell Bridge Road (2018)



congested segment along the I-695 outer loop, between US 1 and Cromwell Bridge Road. During the AM peak, speeds currently deteriorate, and do not recover to free flow conditions at the end of the AM peak period. With the PTSU lane open for travel during the peak, travel speeds in this segment would be near free-flow conditions. Similar travel speeds improvements would be anticipated for inner loop travel in both peaks.

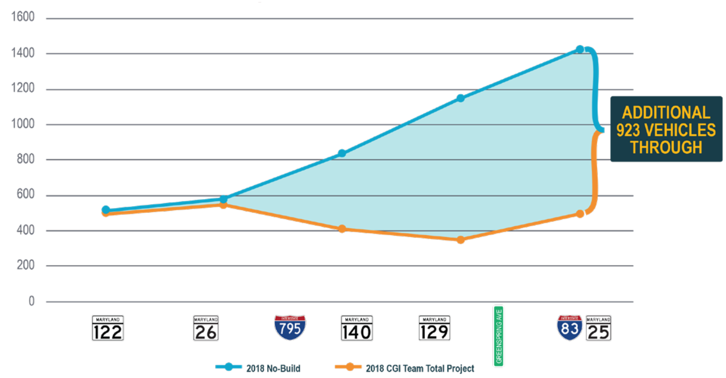
Vehicle Throughput

Under today's travel conditions, I-695 experiences congestion through critical peak hours but generally returns to near free-flow conditions by the end of the peak periods (10 AM, 7 PM). Implementing the CGI Team solution would increase vehicle throughput along I-695, however, that is not expressly noted for the full four-hour peaks in the existing year (2018) VISSIM model. We believe that two things would occur, supported by the modeling efforts:

- More vehicles would be able to travel through I-695 during the **peak hour**, particularly during the AM peak from 7 AM – 8 AM.
- Additional volume may be absorbed by I-695, **as evidenced by the high level of performance the CGI Team solution provides as I-695 traffic demand increases**. Our improvements have the potential to improve Baltimore County congestion on a systemwide level including improvements along the arterial network because I-695 can handle more traffic during the peak periods.

The ability of the system to process more volume would result in much lower unmet demand during those critical hours, particularly for the most congested segments. **Figure 3.9** illustrates how the CGI Team solution significantly reduces unmet demand. The ability for I-695 to process vehicular demand during the arrival period leaves less vehicles for the system to process in future hours, further improving operations in subsequent hours.

Figure 3.9: I-695 Inner Loop Unmet Demand—AM Peak Hour (2018)



One key component of the CGI Team solution is to **open the PTSU lane at 2 PM for daily weekday operations**. Our analysis has shown that opening the PTSU lane prior to the traffic volumes reaching the point of congestion would ultimately process more vehicles along I-695 sooner. This would further reduce the unmet demand volume and will have a significant impact in reducing congestion. Similarly, our solution provides SHA with the field technology and a Decision Support System that is ready to incorporate dynamic PTSU operation, allowing for similar applications at any time that MDOT SHA and CHART would need it to increase throughput.

Arterial Performance and Intersection Operations

The implementation of the CGI Team solution will provide increased mobility for I-695 travelers and improve the arterial network by allowing more vehicles to use I-695 during the peak periods. During the existing year (2018) AM peak, the number of anticipated intersections in the studied area operating at or above capacity (LOS E/F) would be reduced from 9 to 5, with **no LOS F intersections during any of the four hours during the AM peak**.

Similarly, intersection operations would be improved during the PM peak, with the number of anticipated intersections in the studied area operating at or above the capacity (LOS E/F) being

reduced 50% from 10 to 5. This would include one remaining intersection operating at LOS F, MD 41 (Perring Parkway) at Putty Hill Road, approximately 2,000 feet south of the ramps to/from the I-695 inner loop is the only intersection anticipated to remain at LOS F operations during the 5-6 PM peak hour. The full CGI Team improvements would only result in a 2.7 second increase in average delay at this intersection because more traffic will be arriving at this intersection due to less delay on I-695 during the peak period. Since congestion will be greatly reduced on I-695, motorists will be **less likely to use arterials which run parallel to I-695** to avoid congestion and has the potential to **greatly improve traffic operations on those arterial roadways**.

Greatly improve traffic operations on arterial roadways by eliminating delay on I-695

Connecting Ramps and On-Ramp Queuing

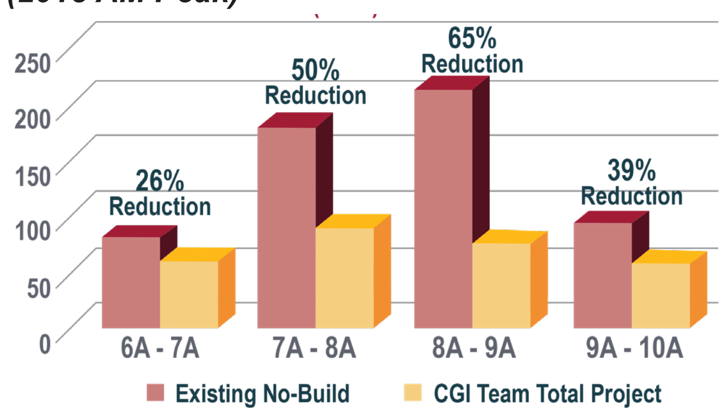
Maximizing PTSU has allowed the CGI Team to essentially **eliminate on-ramp queues** by providing free flow conditions in most locations along I-695. Queues on major interchanges entering I-695 such as I-70, I-795, and I-83, have generally been eliminated or reduced in most locations by providing **full PTSU limits** in 2018. Any remaining on-ramp queues can be accommodated by existing ramp storage.

During the AM peak, at the MD 122 on-ramp to I-695 outer loop, the congestion resulting at the end of the I-695 outer loop, due to the US 40 bottleneck, results in constrained entry for vehicles from the MD 122 on-ramp and resulting queues. The VISSIM model notes that this queue would extend up to a maximum of 1,125 feet during the AM peak hour (7 AM – 8 AM) which can be easily accommodated by the existing ramp length without impacting MD 122 operations. On-ramp queuing at the MD 122 ramp will be eliminated by the future I-70 at I-695 interchange reconstruction and I-695 over US 40 bridge replacement projects.

Vehicle Network Performance

The CGI Team solution, prioritizing PTSU, maximizing PTSU limits, and providing adaptability and a high level of operability is anticipated to provide MDOT SHA with significant network-wide benefits. For both AM and PM peak periods in the existing year (2018), our solution **reduces travel times by up to 58%** and **reduces delay by up to 62%**. Network-wide, these delay reductions are most pronounced during the peak periods. **Figure 3.10** shows that average delay per vehicle is most significantly reduced during the peak AM two hours (7 AM – 9 AM). Average delay per vehicle is reduced for all four hours during the AM peak.

Figure 3.10: Average Travel Delay Per Vehicle (2018 AM Peak)



Systemwide improvements in vehicular throughput, without sacrificing arterial operations, result in AM peak latent demand being **reduced by 82%** during the peak AM period from 6–10 AM and **reduced by 92%** during the peak PM period from 3–7 PM.

Reliable Commuter Trip

Travel Time Index (TTI) was calculated for each segment of I-695 based on the outputs from the traffic simulation model. TTI quantifies the average travel time and congestion levels during the peak periods, as it is a ratio between actual travel time and free-flow travel time. TTI also serves as a proxy for the Planning Time Index (PTI), which is used to estimate travel time reliability due to the strong correlation between PTI and TTI. Roadways with a lower TTI typically have some reserve capacity to absorb the disruption caused by non-recurring congestion (and generally have a lower PTI), while roadways with high TTI values are more likely to be impacted by minor incidents (and generally have a higher PTI).

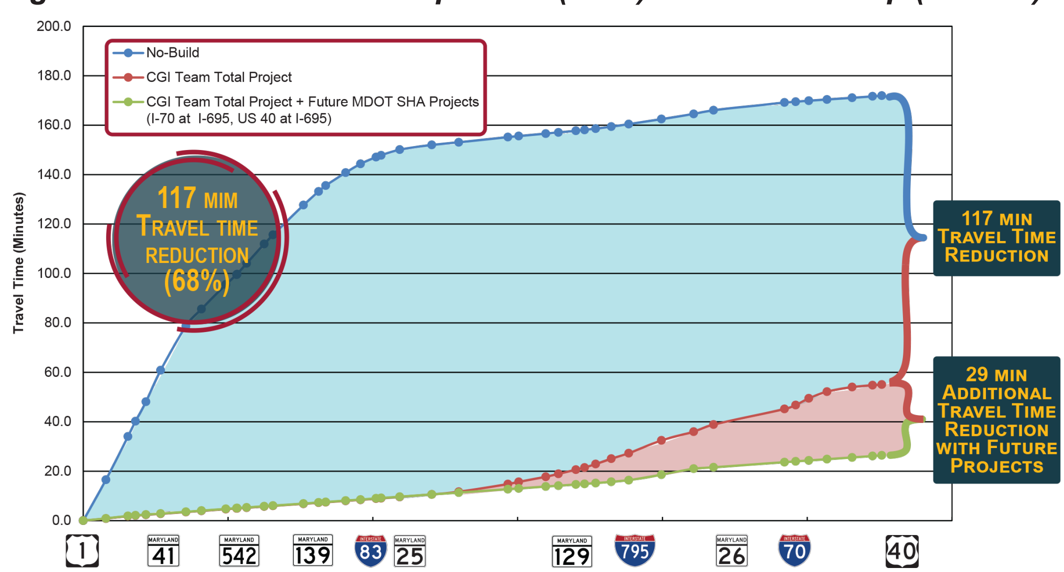
Using the VISSIM models, our team calculated an estimated TTI that would result from recurring congestion. The implementation of the CGI Team improvements would result in the reduction of existing year (2018) TTI along the entire I-695 project area from 1.6 (Heavy) to 1.1 (Uncongested). By 2040, the TTI with the CGI Team improvements would be anticipated as 1.8, a slight increase over today's conditions, and a significant reduction from the anticipated TTI without the CGI Team improvements of 5.2. The 2040 TTI for the I-695 inner loop would be most improved, with an average TTI due to recurring congestion of 1.3.

Travel reliability along any given highway is influenced by both recurring and non-recurring congestion. In addition to the reliability benefits during recurring congestion, the **anticipated 24% reduction in crashes** will improve reliability on I-695 resulting from non-recurring congestion. Additionally, since the PTSU system planned by the CGI Team has the ability to provide additional capacity during off-peak hours to respond to incidents and emergencies, the travel time reliability during hours outside the scheduled PTSU operating window will also be improved. Finally, the CGI Team proposes to open the PTSU lane at 2 PM to provide additional capacity before congestion begins to build now and, in the future, to improve reliability along I-695. **Travel time reliability on I-695 will be greatly improved by providing a solution which reduces crashes, provides an operational strategy to respond to incidents, reduces recurring congestion and reduces the Travel Time Index**. The CGI Team anticipates I-695 will operate with a PTI below 1.5 after completion of the PTSU project.

Compatibility with Future Projects

While our goal is to reduce recurring congestion on I-695 today, we want to be sure our improvements are compatible with future MDOT SHA planned projects including I-695 at I-70 interchange reconstruction and the I-695 over US 40 bridge replacement project. Carrying the PTSU limits south of the I-70 triple bridges will allow this project to tie in seamlessly with future projects resulting in the greatest enhancements in future mobility of I-695. **Figure 3.11** shows the minimum anticipated additional travel time reduction due to this project improvements, once the bottleneck at US 40 is removed from the outer loop.

Figure 3.11: Travel Time Comparison (2040) I-695 Outer Loop (5–6 PM)



iii. TOTAL PROJECT PERFORMANCE LIFE (STATIC- DYNAMIC MEDIAN PART-TIME SHOULDER USE AND OTHER IMPROVEMENTS)

Performance life is defined as the time it will take for congestion levels to return to pre-construction levels. The **performance life of the CGI Team's Total Project is beyond 2040** once future planned projects (I-695 at I-70 and I-695 over US 40) are completed. Without the future projects in place, the **performance life of the inner loop will be beyond 2040 during the AM and PM peak period**; and the performance life of the **outer loop will be beyond 2040 during the AM peak period**. The performance life of the outer loop in the PM peak is heavily influenced by the bottleneck located at US 40. The CGI Team estimates that congestion levels on the outer loop in the PM peak will return to pre-construction levels by 2030, without the future planned projects in place. This performance life is summarized in **Table 3.7**. This section discusses the details of the performance life evaluation including the basis for assessment.

The CGI Team's proposed improvements will provide **benefits over the No-Build condition to 2040 and beyond**. It is critical to consider what mobility benefit the proposed improvements will provide relative to existing levels of traffic congestion. We completed an evaluation to understand when peak period congestion will return to existing levels on both the inner loop and outer loop during the AM and PM peak periods with our selected predetermined hours of PTSU operation. We have also summarized results for traffic operations during the horizon year (2040) as shown in **Table 3.7**.

Table 3.7: Performance Life Summary

AM Peak Hour	Inner Loop	✓ **Beyond 2040**
	Outer Loop	✓ **Beyond 2040**
PM Peak Hour	Inner Loop	✓ **Beyond 2040**
	Outer Loop	✓ **Beyond 2040** *with Future Planned Projects**
		2030 *without Future Planned Projects**

**Planned projects (e.g. I-70 at I-695 and I-695 over US 40)*

In addition to relating how our proposed improvements will perform over time, it is important to understand that elements from our solutions have been chosen specifically because of the **flexibility they offer MDOT SHA to help manage traffic in the decades ahead**. Finally, the CGI Team knows that the I-695 project is important not only for the millions of drivers who use the Baltimore Beltway each year, but also for how MDOT SHA can best use funding for future improvements across the state and in the I-695 corridor.

Based on the existing and future congestion profile, the CGI Team solution includes proposed scheduled hours of operation of **6 AM to 10 AM** and **2 PM to 7 PM** each weekday. These additional hours will provide added flexibility and **performance life through 2040** by allowing the hours leading up to and following the peak hour to be accommodated by the proposed PTSU lane. In addition to the static operating hours, the PTSU lane may be opened at any time in response to incidents or congestion. The CGI Team also included provisions which would allow for the PTSU lane to remain open beyond the static scheduled PTSU closure time if congestion persists due to non-recurring congestion.

PTSU

MONDAY TO FRIDAY

HOURS **6 AM - 10 AM**
2 PM - 7 PM

Basis for CGI Team's Assessment of Performance for All Improvements

The CGI Team's Total Project will operate exceptionally well in the future as demonstrated in this section. The improvements were modeled using the 2040 No-Build network provided by MDOT SHA in the RFP. The VISSIM models provided by MDOT SHA as part of the RFP were used by the CGI Team as the **basis for assessment of performance for all improvements**. In accordance with the RFP, the **VISSIM calibration parameters were not changed** by the CGI Team.

Performance Life of CGI Team Solution

During both peak periods, the Team's Total Project improvements provide considerable mobility improvement when compared to the 2018 Existing No-Build as shown in **Table 3.8**. The **21–32% reductions** in inner loop travel times during the AM and PM peak and network-wide **14% increase** in vehicle throughput during the AM and PM peak exhibit this. The PTSU improvements proposed by the CGI Team are robust and provide benefits for decades into the future.

The CGI Team solution for **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond** on the inner loop. This exceptional performance life would be especially true of the inner loop during the AM and PM peak, as virtually all the relevant congestion measures indicate that the I-695 inner loop network with the CGI Team improvements performs better than under the existing (2018) conditions.

During the AM peak on the outer loop, **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond**. During the PM peak, **I-695 would not be expected to return to the same levels of congestion as today until 2040 or beyond** once the I-695 at I-70 Interchange Reconstruction (BA0065272) and US 40 Bridge Replacement (BA0145180) planned projects eliminate bottleneck locations outside of the I-695 TSMO project limit. On the outer loop during the PM peak, the analysis results indicate that downstream bottlenecks outside of the project limit, which will be eliminated by current planned projects (I-695 at I-70 and I-695 over US 40), need to be corrected before 2030 to prevent congestion levels from returning to preconstruction levels. While the overall congestion levels on I-695 outer loop during the PM peak, exceed current levels by 2040 with the US 40 bottleneck in place, the outer loop would accommodate a **17% increase** in throughput. The maximized PTSU limits provided by the CGI improvements would allow MDOT SHA to focus future spending on currently planned projects at I-70 and at US 40 to eliminate the bottleneck near US 40 and provide a **nearly free flow future network beyond 2040 on I-695 outer loop**.

The CGI Team evaluated numerous TSMO strategies for I-695 outer loop using the 2040 model and determined that strategies such as ramp metering and active traffic management were ineffective in managing the congestion and queuing which results from the US 40 bottleneck. The CGI Team identified that extension of the PTSU lane through the US 40 interchange, as described in ATC 35, or an additional through lane associated with BA0145180 and BA0065272 would eliminate congestion on the outer loop beyond 2040.

To ensure performance of the inner loop PTSU improvements beyond 2040, the CGI Team is extending the PTSU lane, as described in ATC 23, east of US 1 to Lillian Holt Drive. Without this inner loop PTSU extension, the inner loop congestion conditions would degrade to preconstruction levels before 2040 in the AM peak period.

Table 3.8: Performance Life—Existing (2018) No-Build vs. 2040 CGI—Total Project

	Improvement Type	Details
AM Peak	**Travel Time Reduction:** (8 AM to 9 AM)	• Inner loop **7-minute** (21%) • Outer loop: **29-minute** (51%) with future planned projects (I-70 at I-695 and I-695 over US 40); 5-minute (8%) without future planned projects
AM Peak	**Vehicle Throughput Increase:**	• Network-wide: **16%**
AM Peak	**Vehicle Density:**	• Inner loop: **40% reduction** in LOS E/F segments • Outer loop: **19% reduction** in LOS E/F segments
AM Peak	**Vehicle Speed Increase:** (8 AM to 9 AM)	• Inner loop: **112%** in critical MD 140 to I-83 segment • Outer loop: **237%** in critical US 1 to Cromwell Bridge Rd segment
AM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged at 67% of ramps locations with queues contained within existing storage at 94% of locations. • Increased queues at MD 122 will be solved by future planned project (I-70 at I-695).
PM Peak	**Travel Time Reduction:** (5 PM to 6 PM)	• Inner loop: **15-minute** (32%) • Outer loop: **6-minute** (19%) with future planned projects (I-70 at I-695 and I-695 over US 40); 23-minute increase without future planned projects
PM Peak	**Vehicle Throughput Increase:**	• Network-wide: **13%**
PM Peak	**Vehicle Density:**	• Inner loop: **64% reduction** in LOS E/F segments • Outer loop: 16% increase in LOS E/F segments with US 40 bottleneck
PM Peak	**Vehicle Speed Increase:** (5 PM to 6 PM)	• Inner loop: **237%** (20–61 MPH) in critical MD 139 to Cromwell Bridge Rd segment • Outer loop: **43%** in US 1 to I-83 segment
PM Peak	**Connecting On-Ramps Queues:**	• Reduced or unchanged on-ramp queues at 73% of ramps locations with queues contained within existing storage at 96% of locations. • Once future planned projects (I-70 at I-695 and I-695 over US 40) resolve the US 40 bottleneck **all on-ramp queues will be contained within the existing on-ramp storage**.

CGI TEAM SOLUTION SUMMARY

The CGI Team Total Project will **maximize vehicle throughput, minimize travel times, and create a more reliable commuter trip** along I-695 from I-70 to MD 43. The CGI Team solution provides better mobility benefits than any other combination of PTSU and other improvements. This is demonstrated by up to 34 minutes (58%) in travel time reduction upon opening and **183-minute (78%)** travel time reduction in 2040, future **throughput increases of up to 51%**, **nearly free-flow conditions** upon opening, while improving the operation of arterial roadways. Our solution will provide a more reliable commuter trip by providing MDOT SHA enhanced ITS tools including a PTSU lane that can be opened to provide additional capacity, when needed, to **eliminate recurring and non-recurring congestion**. Our solution will **create a more reliable trip by reducing the number of crashes on I-695 by 24%**, resulting in less delays for motorists due to incidents. The duration of incidents will also be reduced by the AID, PTSU lane, and complete camera coverage provided by our project. The impact to the **vitality of economic development of our project is best demonstrated by the $4.8B in average annual operations and safety benefit to Marylanders who travel I-695**. This represents a **benefit-cost of 368:1**. Our solution will provide a primary commuter route that performs with nearly free-flow conditions now and has a **performance life beyond 2040 in the future**.

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Section 4

Safety

CONCRETE GENERAL, INC.

in association with

RK&K

CGI TEAM SOLUTION OVERVIEW

The CGI Team lives and breathes I-695. Many of our key staff suffer through the existing congestion. We've dreamed of providing the solution outlined in this proposal, which will **eliminate delay today** and promises **performance life beyond 2040**. Our project will provide $4.8B in annual congestion and safety benefits to Marylanders. It's a solution that the CGI Team and MDOT SHA will be proud to deliver.

The Solution

Nearly 40 Miles of Part Time Shoulder Use (PTSU)	• I-70 to MD 43 (37.3 miles) + • Outer loop extension within I-70 interchange (0.5 miles) • Inner loop extension to Lillian Holt Drive (1.8 miles) • Extended operational hours from 6 AM–10 AM and 2 PM–7 PM
Navtech Radar-Based AID System	• 80 devices vs. competing systems' 390 devices • True all-weather performance • Accurate debris detection as small as 2'x2'x2' • Automated incident detection on PTSU/GP lanes
Incident Response	• Complete CCTV coverage for PTSU/GP lanes • Outside shoulder for emergency response
Safety Upgrades	• 15 miles of upgraded concrete median barrier • 1,000 new drainage inlets reduce spread for PTSU
Pavement Enhancements	• 12 lane miles of pavement rehabilitation • 168 lane miles of pavement resurfacing
Highly Adaptable Systems	• Connected vehicle ready corridor • 21 miles of new fiber optic cable network
Maintenance and Operations	• $370K in annual reduced maintenance and operation costs over similar systems for I-695 TSMO

The Performance

Existing	• 59% free flow traffic • Average speed as low as 23 MPH • Travel time up to 57 minutes
Opening	• 96% free flow traffic • Average speed 58 MPH / 57 MPH • Travel time 23.1 min / 23.5 min
2040	• 74% free flow traffic (96% with future projects*) • Average speed 51 MPH / 29 MPH (52 MPH w/future projects*) • Travel time 26.6 min / 47.2 min (26 min with future projects*)

All Statistics: Inner Loop Peak Period/Outer Loop Peak Period
**MDOT SHA planned improvements at I-70 and US 40*

Numbers don't lie. There is no better solution than free flow traffic in the opening year. In fact, our PTSU solution is so good that other improvements add little value now, or in the future. There are no impacts to arterial roadways, minimal environmental impacts, and safety is enhanced.

We understand that the devil is in the details. The remainder of this Section will demonstrate exactly how the CGI Team's solution will provide a safer I-695 corridor and increase MDOT SHA's ability to reduce, detect, verify, respond, and manage non-recurring congestion causes. Refer to **Figure 4.1** for a graphic of our solution.

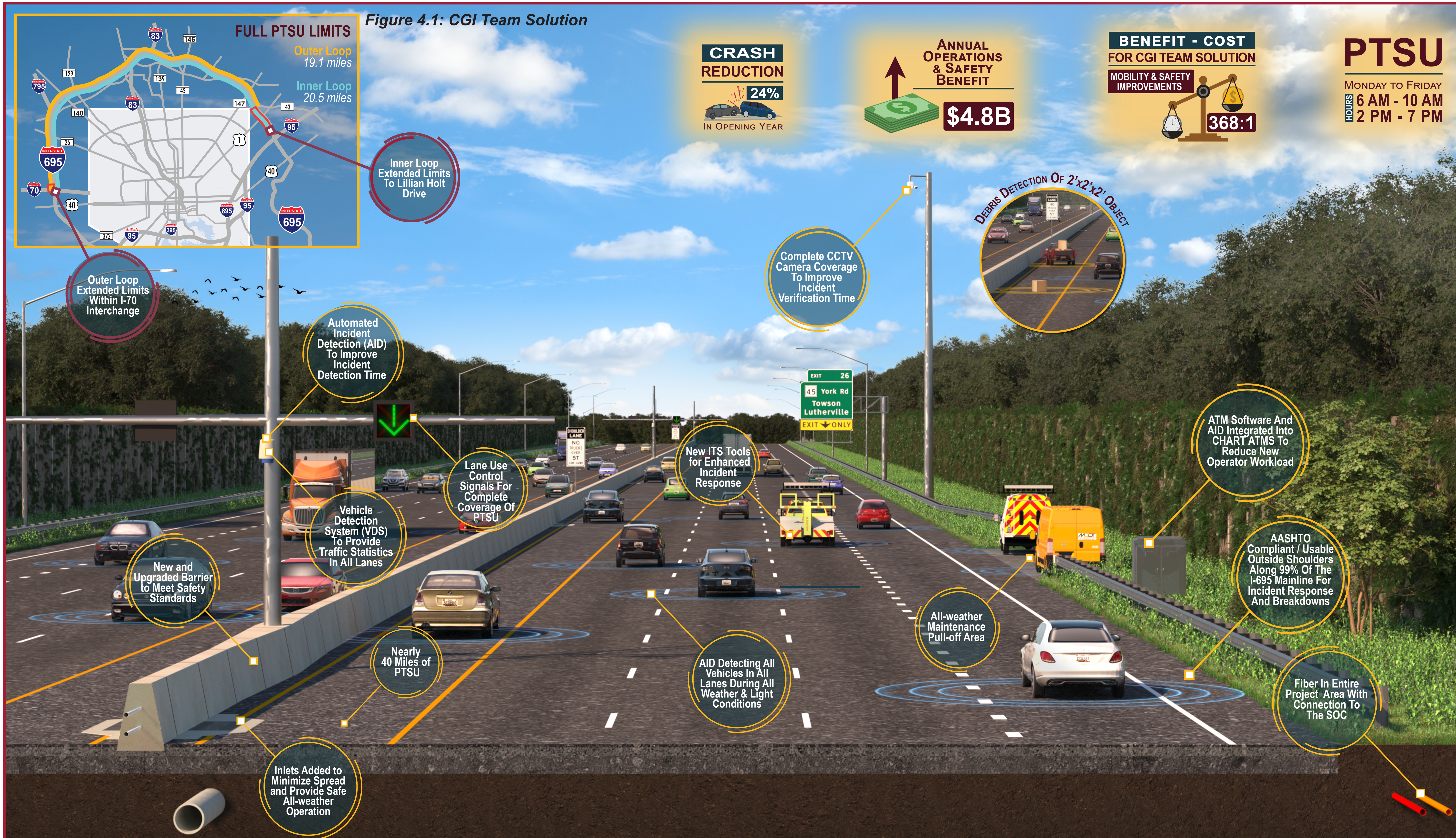


Figure 4.1: CGI Team Solution

I-695 SAFETY

Safety analyses examining the crash history on I-695 indicate that approximately **60% of all crashes involve rear-end collisions**. Since rear-end crashes generally occur due to congestion, the CGI Team solution will improve safety in addition to reducing recurring congestion. **Another aspect of safety for this project is the operation of PTSU lane**. FHWA has stated that PTSU facilities must have a method of ensuring that shoulders designated for PTSU operation are free of obstructions, thereby not compromising safety for the traveling public. The CGI Team's ITS Solution, detailed below, provides for **safe operation of PTSU**. Our complete solution also improves overall safety, resulting in a **crash reduction of 268 annual crashes** (163 inner loop and 105 outer loop). Our solution provides a **24% reduction in total crashes the opening year**, when compared with the existing crash reports between 2015 and 2017. The CGI Team solution will **reduce the injury crash rate on I-695 to within 30% of the statewide average for the entire project limit** and **50% of the segments will have crash rates less than the statewide average**. Refer to **Section iv** for additional details of reduction of non-recurring congestion.

CGI Team ITS Solution

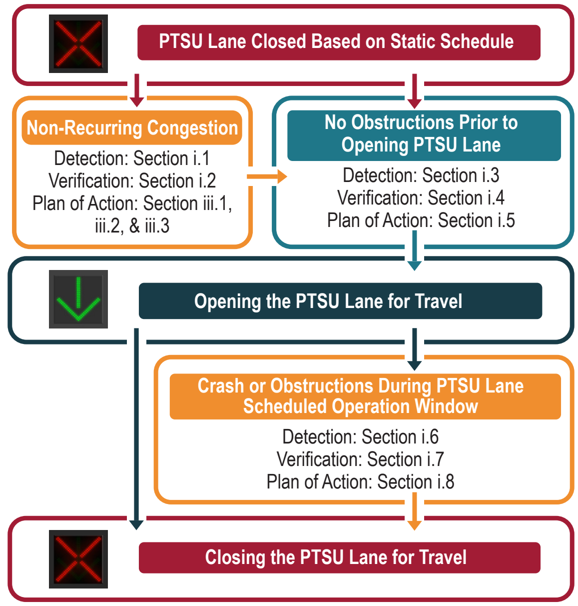
Our ITS solution is described in **Table 4.1** and highlights the safety aspects of our system. **Brian Grandizio** will serve as the CGI Team Systems Engineer, with a minimum of 10 years of proven experience in systems engineering for ITS projects. He will assist with system concept development, architecture development, design, construction, and implementation.

Table 4.1: CGI Team Solution Safety Benefit

Element	Safety Benefit
Navtech Radar ClearWay AID (Navtech AID)	• Improves detection and verification times • Detect non-recurring congestion, debris, and obstructions in **all lanes and PTSU** during all weather and light conditions • Meets RFP requirement for Vehicle Detection System • Will detect **debris** as small as 2' x 2' x 2' • Primary **Detection** Device for the PTSU system; also used for **verification**
Integration	• System will detect incidents and provide alarms within 30 seconds • Allows CHART operators to work within ATMS for quick response • Controlling PTSU lane from CHART ATMS **reduces new operator workload**
Lane Use Control Signals (LUCS)	• Visible at all locations along PTSU lane to indicate if a driver is permitted to drive in the PTSU lane to control opening and closing of PTSU • 24" symbols enhance visibility and exceed MUTCD minimums
Southwest Research ActiveITS ATM Software (ActiveITS)	• Decision Support System to automate some incident management tasks for quick response • AID and VDS data enables well-informed decisions • Improves response times • Adaptable to fully dynamic opening and closing of PTSU in future
Fiber Optic Network	• Real time data allows quick, effective response • High reliability allows effective response at critical times
DMS	• Existing DMS to better inform drivers for decision-making
CCTV Cameras	• Complete coverage of all lanes and PTSU; maximize surveillance verification • Provides view of all LUCS for verification of proper operation • Primary **Verification** Device for the PTSU system • Increased Situational Awareness

Our use of Navtech Radar ClearWay Automated Incident Detection (Navtech AID), CCTV cameras, lane use control signals (LUCS), and Southwest Research (SwRI) ActiveITS ATM software (ActiveITS) for the PTSU lane allowed our team to achieve adding nearly 40 miles of PTSU lane for Marylanders, while ensuring safe operations and avoiding installation of an excessive number of ITS devices. The heart of the CGI Solution is PTSU for the entire project limit plus two extensions. **Static operations for the PTSU lanes will be Monday through Friday from 6-10 AM and 2-7 PM**. The opening and closing of the PTSU lanes must be done safely to achieve all project goals. While the RFP requests information about various operating conditions and system details, covered later in this section, the CGI Team thinks it is noteworthy to define the opening and closing of the PTSU lane during normal static operations. This is the first implementation of PTSU in Maryland. The CGI Team recognizes the unique challenges which are presented when implementing innovative solutions for the first time in Maryland. As we did for the I-270 ICM project, which included the first implementation of ramp metering in Maryland, we will work in **close partnership with MDOT SHA** to implement a successful PTSU lane project.

Figure 4.2: PTSU Operational Flow Chart and Index



The CGI Team, with coordination and approval of MDOT SHA, will develop a step-by-step process that CHART operators will follow to advance changes of PTSU system operations (opening and closing). The CGI Team has defined a draft step-by-step process for the plan of action for various operating scenarios. Refer to **Appendix J** for draft Concept of Operations Flow Charts for various PTSU operations. Details are also provided in this section.

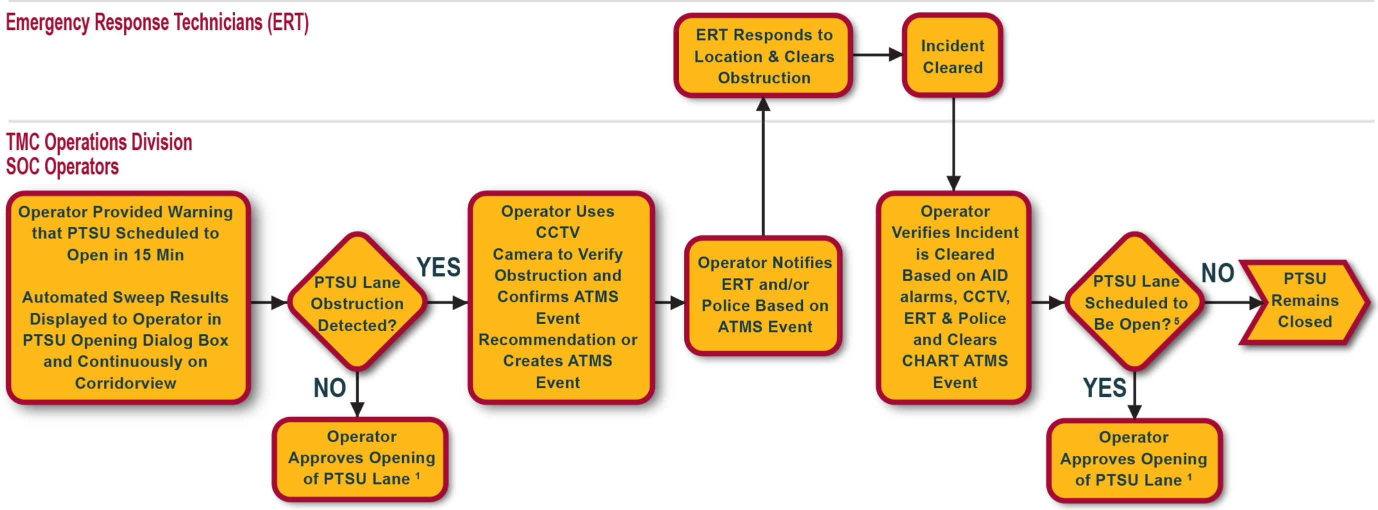
A major focus of the ITS solution is to provide for safe operations of the PTSU lane. This means that the system must not allow PTSU operations if an obstruction is in the PTSU lane. Since the PTSU lane can be opened at scheduled times and outside the scheduled operating window to respond to emergencies, our approach checks for obstructions under both conditions. **Figure 4.2** illustrates our proposed approach to account for these situations, with subsection references. The following sections discuss Opening and Closing the PTSU lane which apply to all operational scenarios.

Opening the PTSU Lane

Opening a PTSU lane is not an instantaneous process. It requires collection of real time data, transmission of data to the Statewide Operations Center, processing of the data, a decision by an Operator or Decision Support System (DSS) to initiate/approve opening activities, automated sweep activities to inspect the shoulder and, lastly, a second decision after the sweep to change lane use control signal displays to indicate that the shoulder is open. Interviews with other agencies with PTSU facilities indicated that opening the PTSU takes up to 15 minutes. In other words, a decision needs to be made to open the PTSU lane 15 minutes before it actually opens.

The plan of action illustrated in **Figure 4.3** will be followed to safely open the PTSU lane. The proposed system will be **adaptable to open with or without requiring CHART Operator approval**. We expect CHART will want operators to approve opening of the system initially, but once they are familiar with the system, technology may allow the PTSU to open without requiring operator intervention, while keeping safety of motorists' paramount. The process to open the lane is also described in **Table 4.2**.

Figure 4.3: Process to Open PTSU Lane



Note:
[1] System is capable of automated PTSU opening without operator action. It is anticipated operator action will be required initially when the system is deployed but will be automated after MDOT SHA is comfortable with the system operations.

Table 4.2: Plan of Action to Open PTSU Lane

Step No.	Actions
Step 1	• CHART Operator notified PTSU lane is scheduled to open in 15 minutes (warning notification time is configurable) • Details of automated sweep results are provided to Operators with warning
Step 2	• If no obstructions detected, Operator may accept notification or take no action —Taking no action allows the PTSU to open depending on selected configuration • If an obstruction or crash is detected, the PTSU will not open —Plan of action in **Section i.5** will be followed to clear obstruction, if detected
Step 3	• ActiveITS issues command to LUCS to displays green arrow, **Figure 4.4**
Step 4	• ActiveITS and CHART ATMS gets confirmation that green arrow is displayed and PTSU is open—LUCS and AID alarm/status continuously communicated between field devices and CHART ATMS

Closing the PTSU Lane

A command to close the PTSU will likely be as the result of: End of Static Operating Window; Obstruction/Crash Detected in PTSU lane; termination of a response plan for a qualifying incident; or manual control (such as for maintenance). In most of those situations, operator intervention is not needed to close the PTSU lane. Our system can recommend that the PTSU lane remain open beyond the scheduled operating window due to congestion using the DSS, should CHART desire to implement this function. Closing of the PTSU lane or segment includes steps in **Table 4.3**.

Figure 4.4: PTSU Lane Open

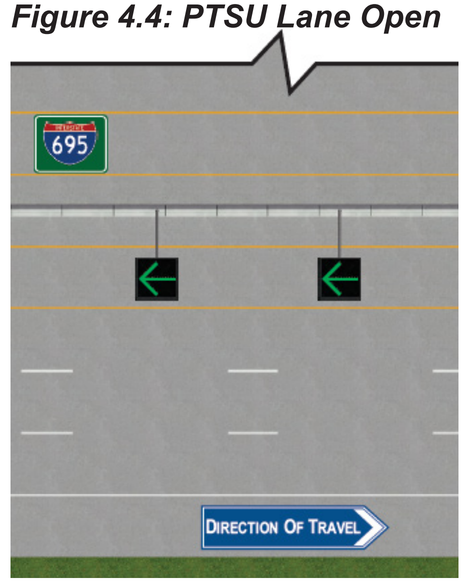


Table 4.3: Plan of Action to Close PTSU Lane

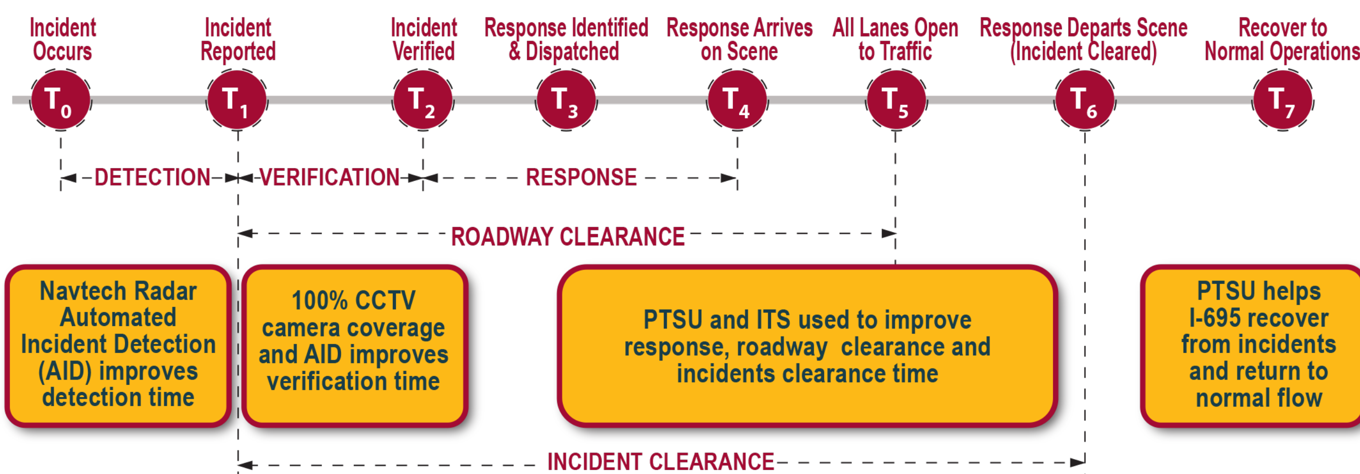
Step No.	Actions
Step 1	• Command to close PTSU lane originates from DSS, operator (manual override) or scheduler
Step 2	• CHART Operator notified PTSU lane is to close via ATMS
Step 3	• Operator may accept notification or take no action —Operator action not required to close PTSU
Step 4	• ActiveITS issues command to LUCS to displays Yellow 'X' for a predetermined period • ActiveITS and CHART ATMS gets confirmation that Yellow 'X' is displayed
Step 5	• ActiveITS issues command to LUCS to displays Red 'X' for a predetermined period • ActiveITS and CHART ATMS gets confirmation that Red 'X' is displayed

In situations where a portion of the PTSU lane is closed beyond an open segment, a yellow 'X' will be displayed on a minimum of two LUCS in advance of the closure location to warn motorists that the PTSU is closed ahead. The final advanced warning scenario will be approved by MDOT SHA.

i. DETECTION, VERIFICATION AND PLAN OF ACTION FOR NON-RECURRING CONGESTION, CRASHES AND OBSTRUCTIONS

Non-recurring congestion is caused by various events along I-695 including crashes, disabled vehicles, adverse weather, or other emergency events. According to RITIS, in 2018, I-695 in the project limits had over 1,800 incidents which closed one or more lanes for more than 5 minutes (an average of 5 per day) with 48% lasting more than 30 minutes and 4% (**once per week**) **lasting more than 2 hours**. **Figure 4.5** shows a typical incident timeline with notes about how the CGI Team's comprehensive solution will improve safety by providing **enhanced incident management** to help MDOT SHA **reduce the overall incident response timeline,** including detection, verification, response, roadway clearance, incident clearance, and return to normal flow.

Figure 4.5: Incident Timeline

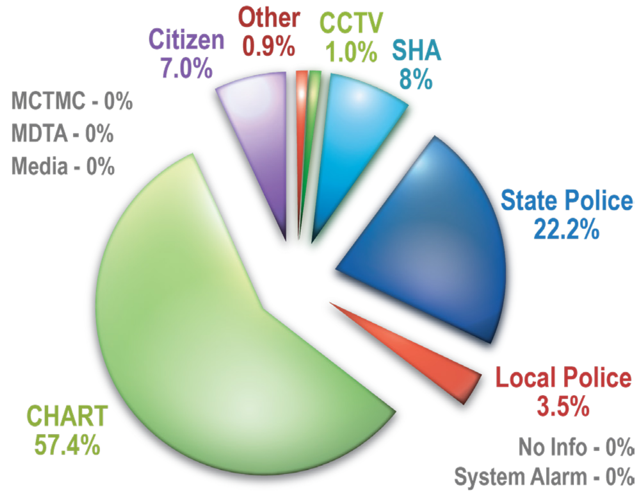


i.1 Detection of Non-Recurring Congestion

Today, detection and verification of non-recurring congestion on I-695 can take **up to 15 minutes**, with detection typically performed by CHART Emergency Response Patrol vehicles. This is indicated in **Figure 4.6**, which shows the existing detection sources for disabled vehicles and incidents for TOC 4, which includes I-695. The CGI Team will provide new ITS tools for detection of non-recurring congestion which will significantly reduce detection time of incidents by providing **AID alarms to ActiveITS and CHART ATMS software within 30 seconds**.

Navtech Radar and **ClearWay software** will be installed for the **Automated Incident Detection** (Navtech AID) System, which uses a combination of roadside radar units and centralized software to **detect non-recurring congestion**. The Navtech AID system includes rules (triggers) which are configured and fine-tuned for each detection type to **reduce false alarms**. The AID system will provide anomaly detection algorithms to analyze anomalies affecting roadway traffic and generate alarms when conditions are met. **Table 4.4** shows how radar AID is far superior to other products on the market.

Figure 4.6: Existing Detection Sources CHART TOC4



Navtech AID is deployed on over 1,500 miles of roadway in 15 countries and has become the standard in Norway, Sweden and the UK for safety of roadways. As the first US installation, we are providing a world class solution for I-695

Table 4.4: Advantages of CGI Team Navtech Radar AID over Video or Thermal AID

Design Parameter	CGI Team Solution: Navtech Radar AID	Video or Thermal
All-Weather & All Lighting Conditions	**Unaffected by rain, snow, smoke, fog, shadows or darkness**	Detection reduced in rain, snow, fog and darkness for video
Debris Detection	**Yes - Object as small as 2’x2’x2’**	Not Recommended by vendor for video 350 foot spacing required for thermal
Detection in All Lanes	**Yes - without adding more sensors**	More cameras needed to cover all lanes
Spacing	**1,500 Feet with Debris Detection**	350 Feet to 1,000 Feet (***without Debris Detection***)
Maintenance	**Less Preventative Maint: Lower Mount Height, Fewer Sensors**	Routine cleaning needed
Sensors Needed	**76**	>300
Vehicle Detection System	**Meets RFP requirements without any additional devices**	More cameras would be required to cover all lanes or reduced spacing

Navtech’s AID system deploys highly accurate radar technology and is proposed in **all lanes** (100% coverage including PTSU lanes) and will provide stopped vehicle, slow vehicle, wrong way driver and queue detection. Pedestrian and debris detection is provided with 99% coverage in the PTSU lane and all general purpose lanes with accuracy and

All Weather, All Light Conditions AID can see through: Darkness, Rain, Snow, Fog, Smoke, Fire coverage area shown in **Table 4.5** and **far exceeds the RFP requirements**. The AID provides **full situational awareness for all lanes of I-695**. The Navtech AID has a proven track record having been deployed in the most demanding situations and conditions, while functioning in all-weather, 24-7, around the world. For example, Navtech is installed on Swedish roadways for AID which get extreme snowfall and experience white-out conditions. Navtech is installed in many Norwegian tunnels where fire or smoke from a crash would eliminate visibility all together. Navtech AID was able to perform AID functions without issue in both scenarios.

Navtech AID will be configured to meet the integration requirements for I-695 TSMO, including integration with the ActiveITS ATM and the CHART ATMS. All AID alarms and traffic statistics will be communicated from the AID system to ActiveITS to the CHART ATMS through integration proposed under the project. **CHART Operators can view AID alarms and traffic statistics at their work-stations, without having to leave the CHART ATMS software interface**.

Table 4.5: Navtech AID Coverage & Accuracy

AID Type	Minimum Coverage (PTSU & General Purpose Lanes)	Minimum Accuracy[1]
Stopped Vehicle Detection	100%	**95%**
Slow Vehicle Detection	100%	**95%**
Wrong Way Driver Detection	100%	**95%**
Queue Detection	100%	**95%**
Pedestrian Detection	99%	**95%**
Debris (2'x2'x'2 Min) Detection	99%	>90%

[1] *Minimum accuracy represents the minimum true alarm percentage which meets RFP require-ments. For example, a minimum accuracy of 90% represents one false alarm per 10 true alarms.* ***Bold*** *indicated accuracy which* ***exceeds*** *RFP requirements for false alarm rates.*

Navtech AID also provides traffic statistics (volume, occupancy, speed, classification) within the AID area which exceeds the RFP requirement for the Vehicle Detection System (VDS). The traffic statistics will also be used to identify non-recurring congestion by identifying locations where speeds have dropped suddenly. Detection zones will be provided at minimum spacing of 1/3 mile. Minimum accuracy is shown in **Table 4.6**.

24 hours per day, 7 days per week, 365 days per year the AID will be active and available to CHART for detection of non-recurring congestion

Table 4.6: Navtech AID Vehicle Detection System Traffic Statistics Accuracy

Traffic Data Type	Minimum Accuracy[1]
Volume (Count)	**97%**
Speed	**98%**
Classification (Length Based)	**80%**
Occupancy	**>90%**

[1] *Minimum accuracy represents the minimum true data rate.*

Navtech has developed an accurate AID system which keeps roadways safe around the world. With over 50 deployments, totaling over 1,500 miles of roadway in 15 countries, Navtech has been tested in real life conditions and is ready for deployment in Mary-land. The Federal Communications Commission **(FCC) issued a Grant of Equipment Authorization for the Navtech** device to be used on US roadways in June 2020. The CGI Team will obtain the FCC site license for the installation of the devices during final design. Preliminary inves-tigation indicates that the frequency used by the Navtech AID system is available in the I-695 corridor for use, so obtaining the site license during design will be a simple process.

Navtech obtained FCC Grant Approval License in June 2020

The Navtech AID system meets the RFP requirement of less than one false alarm per 10 true alarms for debris and pedestrian detection, and it **exceeds the RFP requirements for all other AID**. The system will detect incidents and provide alarms to the ATM software in less than 30 seconds through the ClearWay software. Compared to other AID systems (e.g., CCTV, thermal), ClearWay provides superior accuracy and coverage while reducing the number of sensors required.

i.2 Verification of Non-Recurring Congestion

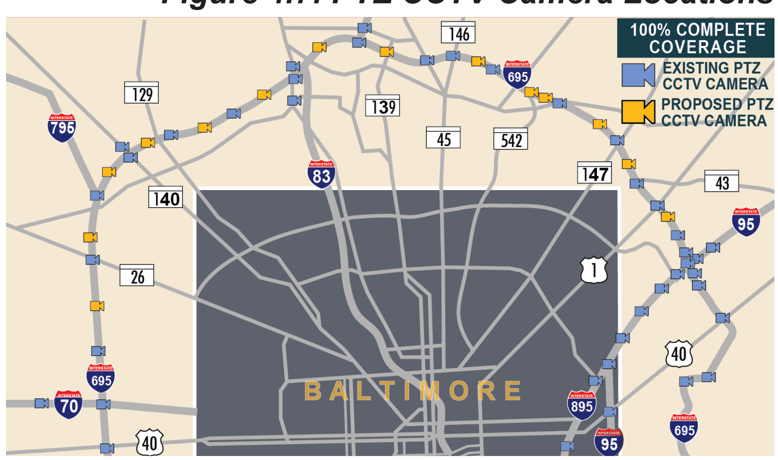
Section 3.1.2 of the *MDOT SHA CHART Traffic Management Center Operations – Standard Operating Procedures* states that CCTV camera coverage is the primary "reliable source" used to verify incidents and non-recurring congestion. The CGI Team proposal will enhance the current ITS systems and allow MDOT SHA CHART Operators to more quickly verify Non-Recurring Congestion including incidents, crashes, disabled vehicles, adverse weather or other emergency events by expanding the coverage area. Our solution will deploy additional CCTV cameras to **provide 100% coverage of the PTSU lane** using Pan-Tilt-Zoom CCTV cameras, as shown in **Figure 4.7**. **CCTV cameras installed by the CGI Team will be the primary tool for verification for the project**. General purpose lanes within the limits of PTSU and at the entry and exit transitions will be provided with 99% coverage. The limits of the CCTV camera coverage are from US 40 (southwest corner) to I-95 (northeast corner). By increasing CCTV camera coverage along I-695 for verification of non-recurring congestion, the CGI Team proposal will provide an **overall efficiency and benefit to MDOT SHA through savings in expenditure of resources** by allowing incidents and congestion to be verified using CCTV cameras rather than by notifying ERT.

> 100% CCTV Camera Coverage of PTSU Lane and 99% CCTV Camera Coverage of all general purpose lanes from US 40 to I-95

> Detection and verification time could be reduced from as much as 15 minutes to as little as 1 minute, a 93% reduction

The proposed Navtech AID (radar-based) system will also assist with verification of incidents by indicating the area where the AID alarm has occurred. The AID area alarm will help to identify which CCTV cameras are nearby to assist with quick verification of the obstruction. Our proposed software integration allows AID alarms to be shown in the CHART ATMS. INRIX/RITIS data is typically used to verify the length of queues. The Navtech AID can also provide supplemental information for verification of non-recurring congestion using traffic statistics. The AID and ATM Software can be integrated to automatically create ATMS Events based on AID alarms, if desired by MDOT SHA, further improving incident verification time. The CGI Team proposed solution will **significantly improve incident verification time along I-695 using complete CCTV camera cover and Navtech AID**. The incident detection and verification time could be **reduced from as much as 15 minutes to as little as 1 minute** based on the use of our solution.

Figure 4.7: PTZ CCTV Camera Locations



i.3 Detection of No Obstructions Prior to Opening PTSU Lane

The Navtech AID system, discussed in **Section i.1**, with 100% coverage of the PTSU lane will detect anomalies in traffic flow such as stopped vehicles, slow vehicles, and "other obstructions" that are within the AID coverage area from east of Lillian Holt Drive (east of MD 43) to south of I-70. The Navtech AID system will

provide automated segment or corridor sweeps of the PTSU lane before opening the PTSU lane to detect if any obstructions are present.

As noted previously, the CGI Team has defined “other obstructions” as **dropped objects or debris** with a **minimum size of 2 feet by 2 feet by 2 feet**, as shown in **Figure 4.8**. The **Navtech AID is the only system on the market which can accurately detect debris with a minimum size of 2’ while reducing the number of devices required for the system by over 200.** The AID will work in all light and weather conditions which far exceeds vision or thermal systems. Debris size of 2 feet by 2 feet by 2 feet was chosen based on AASHTO which states objects 2 feet in height is representative of the smallest object that involved risk to drivers. **Objects below 2 feet in height are seldom involved in crashes.**

Figure 4.8: PTSU Obstruction Detection

i.4 Verification of No Obstructions Prior to Opening PTSU Lane

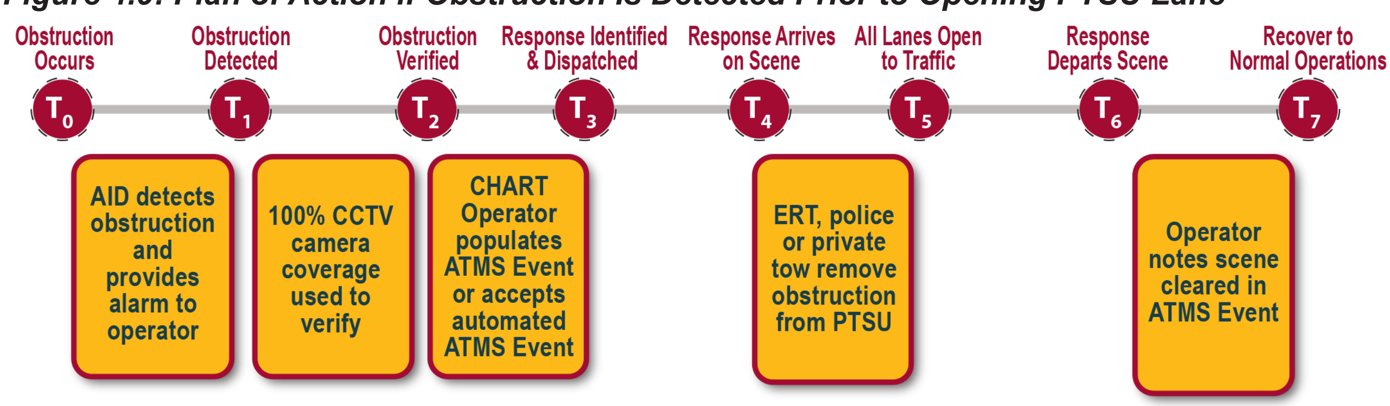
The comprehensive ITS solution proposed by the CGI Team for this project will protect against the PTSU lane segments being opened if there is an active AID alarm detected in the segment. If an AID alarm is detected in the PTSU lane, the system described in **Section i.2** will be used for verification of the obstruction including the results of **the continuous sweep with the AID** and **complete CCTV Camera coverage**. Both the AID and CCTV would be utilized by the CHART Operator to verify if there is an obstruction in the PTSU lane prior to opening. If an obstruction is detected, the plan of action discussed in **Section i.5** would be followed to clear the obstruction before the PTSU lane is opened.

Since the **proposed system can automatically sweep the PTSU lane continuously, our solution is adaptable to fully dynamic opening and closing of the PTSU lane in the future**. In the near term, it is anticipated that the lane will be permitted to open with some operator oversight using the continuous automated sweeps and integration between systems.

i.5 Plan of Action if Obstruction is Detected Prior to Opening PTSU Lane

The AID system provides automated segment or corridor sweeps of the PTSU lane limits and the complete CCTV camera coverage is used to verify obstructions within the PTSU lane as discussed in **Sections i.1** and **i.2**. An Incident Timeline if an obstruction is detected prior to opening the PTSU lane is shown in **Figure 4.9**. The PTSU lane should never be opened upstream of a PTSU lane blockage but the PTSU may be opened downstream of a PTSU lane blockage.

Figure 4.9: Plan of Action if Obstruction Is Detected Prior to Opening PTSU Lane



The CGI Team recognizes that the PTSU lane may be opened at any time for emergency reasons. Incident Events within the CHART ATMS are reserved for events which result in any unplanned closure of travel lanes and warrant the highest level of response, as shown in **Figure 4.10**. All obstructions in the PTSU are anticipated to be classified as ATMS Incident Events with appropriate response schedules based on the next anticipated opening of the PTSU lane. Today, disabled vehicles or debris on the shoulder are not classified as CHART Incident Events, as shown in **Figure 4.10**. Since the PTSU is a travel lane which could be opened at any time, disabled vehicles or debris in the PTSU lane should be categorized as CHART Incident Events with appropriate responses to clear the obstruction as soon as possible. Coordination with MDOT SHA through the systems engineering process may determine that a new event type, possibly called a PTSU Obstruction event, may be beneficial. A draft step-by-step process, is shown in **Table 4.7**, for responding to obstructions in the PTSU lane consistent with CHART procedures.

Figure 4.10: CHART ATMS Events

Incident: used to record information related to any unplanned closure of travel lanes

Disabled Vehicle: used to track information on disabled vehicles on the shoulder or NOT in the travel portion of the roadway

Action Event: used to log information on various activities that typically do NOT block a travel lane and require a TMC HOT to act (i.e., traffic signals, potholes, DMS testing, etc.)

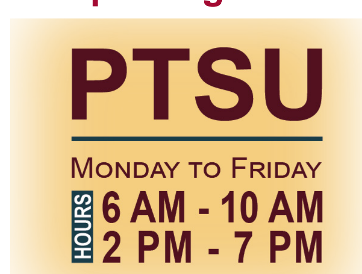
Table 4.7: Plan of Action if Obstruction is Detected in PTSU Lane Prior to Opening

Step No.	Actions
Step 1	• AID detects obstructions, provides alarms to operators, displays on ATMS map
Step 2	• CHART Operators verify obstructions using CCTV and AID
Step 3	• CHART Operators create a CHART Event and Response Plan based on DSS recommendations —ActiveITS can automatically create ATMS Events in the CHART ATMS through integration, if desired —PTSU closure may be initiated during this step based on MDOT SHA preferences
Step 4	• Emergency Response Technicians (ERT) notified, arrive at scene, and remove obstructions
Step 5	• ERT notifies CHART Operator scene has been cleared
Step 6	• AID alarm automatically cleared once obstruction is gone

If the PTSU is recommended to open based on the static schedule or in response to incidents using the ActiveITS DSS, the presence of an AID alarm or ATMS Event in the PTSU lane will prevent the opening of the PTSU lane when an obstruction is present.

i.6 Detection of Crash or Obstruction During PTSU Lane Scheduled Operating Window

The scheduled operating window proposed by the CGI Team is 6 AM to 10 AM and 2 PM to 7 PM. The AID & VDS system discussed in **Section i.1** and **i.3**, Navtech AID (radar-based) will be used to detect crashes or obstructions in the PTSU lane or general purpose lanes during the PTSU lane scheduled operating windows. The AID system has complete coverage of the PTSU lane and general purpose lanes. The proposed AID system will provide alarms to the ATM software and CHART ATMS within 30 seconds for a minimal detection time.



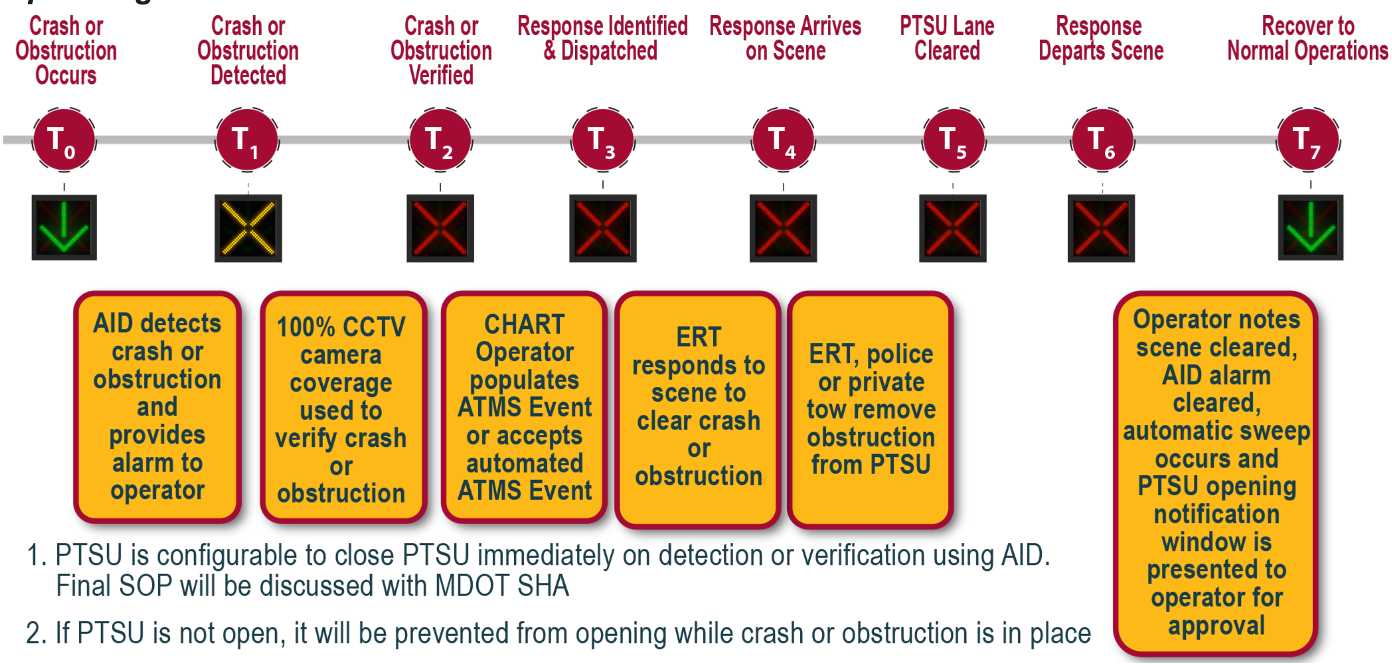
i.7 Verification of Crash or Obstruction During PTSU Lane Scheduled Operating Window

The complete CCTV camera coverage and Navtech AID system discussed in **Section i.2** and **i.4**, will be used for CHART Operators to verify crashes or obstructions during the PTSU lane scheduled operating window. The automated sweeps will also be a verification tool. Nearby Police and/or ERT will also be used for verification of obstructions in the PTSU lane. The Vehicle Detection System provided by the AID system will also provide additional verification of the impact of crashes or obstructions in the PTSU lane during the scheduled operating window.

i.8 Plan of Action if Obstruction or Crash is Detected During PTSU Lane Scheduled Operating Window

The Navtech AID system described in **Section i.1** and **i.3** provides **continuous automated sweeps** of the PTSU lane limits and the complete CCTV camera coverage is used to verify obstructions within the PTSU lane. It is anticipated that incidents or crashes in the general purpose lanes adjacent to the PTSU lane may require the PTSU lane to close. **Figure 4.11** illustrates the Incident Timeline if an obstruction is detected during the PTSU scheduled operating window.

Figure 4.11: Plan of Action if Obstructions Are Detected in PTSU Lane During Scheduled Operating Window



The proposed ITS system is configurable to close the PTSU lane, using Lane Use Control Signals, immediately on detection or verification of an obstruction in the PTSU lane using AID to ensure safe operations of the lane. The system is capable of closing a segment of any length based on various conditions, which will be preprogrammed as business rules in the DSS. The CGI Team recognizes that the PTSU lane is an active travel lane during the PTSU operating window. As discussed in **Section i.5**, incident Events within the CHART ATMS are reserved for unplanned closure of travel lanes and warrant the highest level of response. All obstructions in the PTSU lanes are anticipated to be classified as ATMS Incident Events with appropriate responses to clear the obstruction as soon as possible, so the PTSU lane can reopen. The PTSU system is split up into logical segments which may open or close based on incidents, obstruction or crashes. **Table 4.8** shows a draft step-by-step process for responding to obstructions in the PTSU lane during the scheduled operating window and is consistent with *MDOT SHA CHART Traffic Management Center Operations – Standard Operating Procedures* Section 3.1.2 and Section 3.2.

Table 4.8: Plan of Action if Obstruction or Crash is Detected During Scheduled Operating Window

Step No.	Actions
Step 1	• AID detects obstructions, provides alarms to operators, displays on ATMS —PTSU closure may be initiated during this step based on MDOT SHA preferences
Step 2	• CHART Operators verify obstructions using CCTV and AID
Step 3	• CHART Operators creates a CHART Event and Response Plan based on DSS recommendations —ActiveITS can automatically create ATMS Events in the CHART ATMS through integration, if desired —PTSU closure may be initiated during this step based on MDOT SHA preferences
Step 4	• Emergency Response Technicians (ERT) notified, arrive at scene, and remove obstructions
Step 5	• ERT notifies CHART Operator scene has been cleared
Step 6	• AID alarm automatically cleared once obstruction is gone
Step 7	• PTSU opening procedure is followed if: —More than 30 minutes (time is configurable) remaining in PTSU scheduled operating window —The incident recommending opening of the PTSU remains open

The ATM software is capable of **closing the PTSU lane (segment or entire corridor) immediately upon receipt of an AID alarm which indicates an obstruction/crash within the PTSU lane, or after verification of the alarm by an operator**. Under immediate closure operations, Yellow 'X' is displayed on LUCS upstream of the closed segment and Red 'X' is displayed on LUCS within the closed segment. The CGI Team will work with MDOT SHA to determine the preferred configuration of the system at initial deployment and for the future. It is anticipated the system may start as a verification-based closure but transition to a detection based closure over time once MDOT SHA is comfortable with the system, since the system will respond to the obstruction more quickly.

ii. RESPONSE AND MANAGEMENT OF NON-RECURRING CONGESTION

As discussed in **Section i**, The CGI Team solution provides enhanced **situational awareness** and additional tools to respond to and manage events that cause non-recurring congestion. The PTSU and supporting ITS, shown in **Figure 4.12**, will improve detection, verification, response, roadway clearance and incident clearance times on I-695. Retaining an AASHTO compliant outside shoulder on I-695 is viewed as critical to incident response and management by the CGI Team to allow space for out-of-service vehicles to be moved and to allow first responders room to access an incident site in heavy traffic. Our solution provides **usable full-time outside paved shoulder for 99% of the project corridor** for incident response and management.

Incident response times on I-695 in 2018 averaged 11 minutes, which is approximately 30% above the statewide average, due to congestion experienced each weekday. The full PTSU limits provided by the CGI Team solution will provide MDOT SHA with the **greatest flexibility for response**

> Outside paved shoulders are maintained along 99% (over 40 miles) of I-695 to aid with incident response and management

and management of non-recurring congestion by allowing MDOT SHA to **add capacity when required due to crashes** or other incidents in the general purpose lanes. Integration between our ActiveITS software and the CHART ATMS ensures **CHART Operators are provided a one stop shop in the CHART ATMS to operate the PTSU lane** for incident response and for management of the incident. **CHART Operators will not be required to detect, verify or respond to incidents using multiple software platforms.** The CGI Team considered ramp metering for this project, but it was not as effective as maximizing PTSU. One downside of ramp metering is that the Intelight ramp metering central software is a separate system from the CHART ATMS, which requires Operators to switch between two software programs to manage an incident. **The CGI Team will allow all proposed ITS to be managed from the CHART ATMS**.

The Navtech AID and complete CCTV camera coverage discussed in **Section i** will assist CHART Operators with response and management of non-recurring congestion events by providing **situational awareness of all lanes and PTSU lane** along I-695. Traffic statistics including volume, occupancy and speed will be provided in real-time which can assist with response and management of incidents by providing queue lengths and identification of secondary crashes caused by non-recurring congestion. The AID system will provide an all-weather view of the roadway, so if CCTV camera views are obstructed due to heavy snow or rain, the AID can provide situational awareness of the condition of the roadway through AID alarms and traffic statistics.

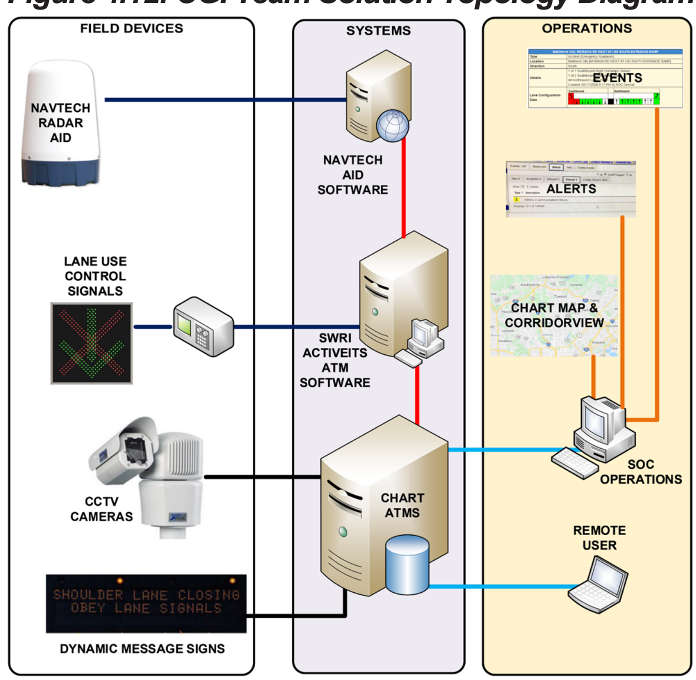
The LUCS portion of the comprehensive ITS solution will be used to manage and respond to incidents by opening or closing segments of PTSU due to non-recurring congestion. Weather events can be managed by opening or closing the PTSU. During significant winter storms, it would be expected that the shoulder could be closed to provide additional short term storage space for snow. Draft logical PTSU incident response segments are included in **Figure 4.16** and **Appendix L.**

The ActiveITS software is equipped with a Decision Support System (DSS) which will be populated with incident response plans. These response plans will be recommend to Operators when it is beneficial to open the PTSU lane due to incidents or non-recurring congestion. The system will also be capable of **dynamically opening the PTSU lane without operator intervention**, if desired by MDOT SHA in the future. In addition to the ATM software DSS, triggers can be created in the CHART ATMS for specific incident types to recommend opening of the PTSU lane.

Recommendations to open the PTSU lane will be integrated into the ATMS to **reduce new workload for CHART Operators**. It is anticipated that PTSU opening will be included in CHART ATMS Event response plans. It is anticipated that PTSU will be managed out of the Statewide Operations Center.

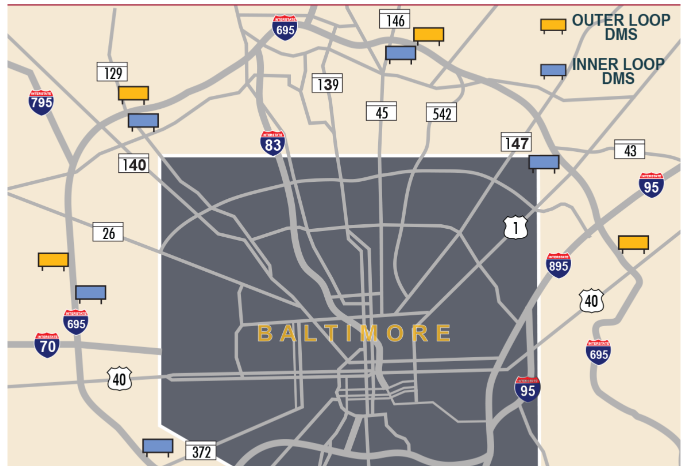
We anticipate MDOT SHA CHART will use existing DMS, shown in **Figure 4.13**, along I-695 to notify motorists of changes in the operational status of the PTSU, including when the PTSU is opened due to incidents or emergency situations.

Figure 4.12: CGI Team Solution Topology Diagram



The I-695 project is located in TOC-4 Patrol Zones 1, 2 and 3. It is anticipated that ERT will continue to complete Emergency Response Patrols (ERP) along I-695 and respond to non-recurring incidents in the same manner as described in the CHART *Field Operations Concept of Operations*. Over time, MDOT SHA may rely more on the AID system to **reduce workload of ERT and ERP** vehicles on I-695, potentially dedicating the resources elsewhere in the state. CHART will use the same fully functional ERP operated by ERTs to assist stalled vehicles, remove impediments in the roadway, and assist first responders with clearing incidents on I-695 including in the PTSU lane. MDOT SHA also has the option of using the PTSU lane to provide additional capacity during roadwork, if desired by MDOT SHA.

Figure 4.13: DMS Locations



iii. PLAN OF ACTION FOR USE OF PTSU LANE (STATIC-DYNAMIC MEDIAN PART-TIME SHOULDER) FOR INCIDENTS

The PTSU lane and ITS system proposed by the CGI Team provides MDOT SHA with the flexibility to open the PTSU lane to provide additional capacity to respond to incidents. There will also be situations where the PTSU lane should be closed due to an incident on I-695. Similar to the monthly ITS coordination meetings we held for I-270 ICM ATM, **we will work closely with MDOT SHA to determine which incidents qualify for opening or closing the PTSU lane.** Decisions on which incidents qualify for opening or closing the PTSU will be programmed as business rules into the ATM Software Decision Support System (DSS).

iii.1 Plan of Action to Determine if PTSU Lane Should Be Activated Outside Scheduled Operating Window During Incident

An Incident Timeline for activating the PTSU lane outside the scheduled operating window is shown in **Figure 4.14.**

Figure 4.14: Incident Timeline using PTSU Outside Scheduled Operation Window

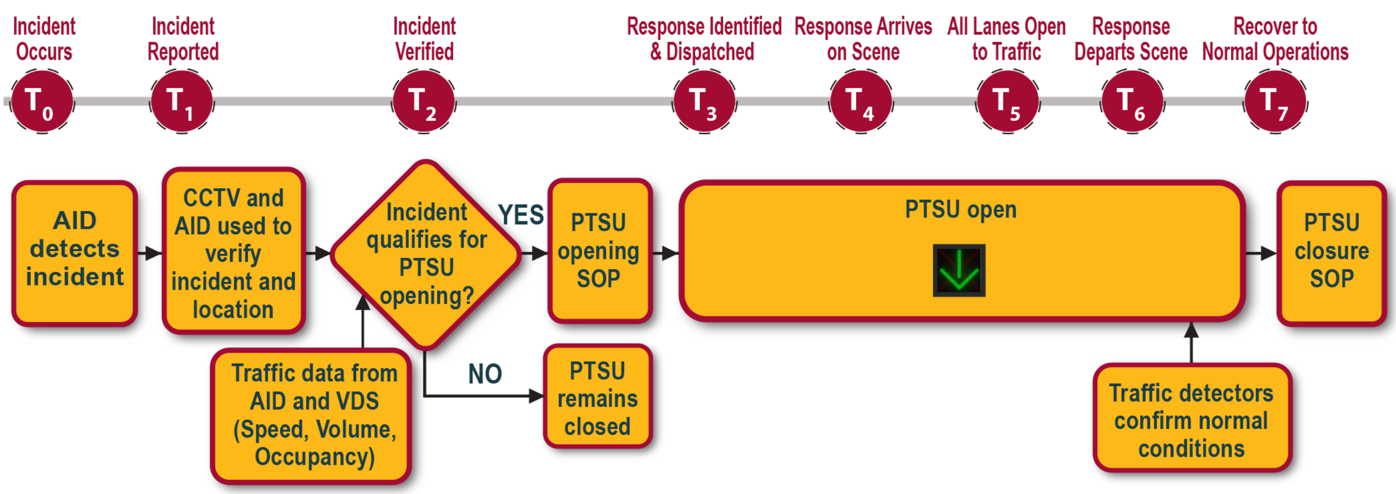


Table 4.9 includes the CGI Teams' proposed plan of action to determine if the PTSU lane should be activated outside the scheduled PTSU operating window during an incident.

Table 4.9: Plan of Action to Determine if PTSU Lane Should Be Activated Outside Scheduled Operating Window

Step No.	Actions
Step 1	• Operator creates ATMS Event after detection and verification of an incident —ActiveITS can automatically create ATMS Events in the CHART ATMS through integration, if desired
Step 2	• DSS will recommend incident response plan based on: —Incident severity/anticipated duration —Location in roadway —Impact to traffic/congestion —Longitudinal location on I-695 —Results of automated sweep by Navtech AID system
Step 3	• CHART Operator Activates PTSU from CHART ATMS based on DSS recommendation —Can be automated in future if SHA desires
Step 4	• PTSU opening procedure is followed

Figure 4.15: Operational Scenario for Crash in Right Lanes

An example of opening the PTSU to respond to a crash on the right side of the roadway, to manage and respond to non-recurring congestion, is shown in **Figure 4.15**, to manage and respond to non-recurring congestion. The PTSU lane will be opened upstream of the crash to provide additional capacity for vehicles to move beyond the crash, with LUCS displaying green arrows. Beyond the crash, the PTSU lane will remain open (with LUCS displaying yellow 'X') until reverting back to operating as a shoulder (red X on LUCS). Volume, Occupancy and Speed thresholds for recommendation to open PTSU lane will be developed by the CGI Team by using historical trends. The location of the incident within the PTSU corridor will impact the recommendation to activate the PTSU lane. Business rules will be developed by the CGI Team and approved by MDOT SHA for PTSU activation, which can be an automated process when CHART desires.

iii.2 MDOT SHA Operators Plan to Determine Portion of PTSU to Use for Incident

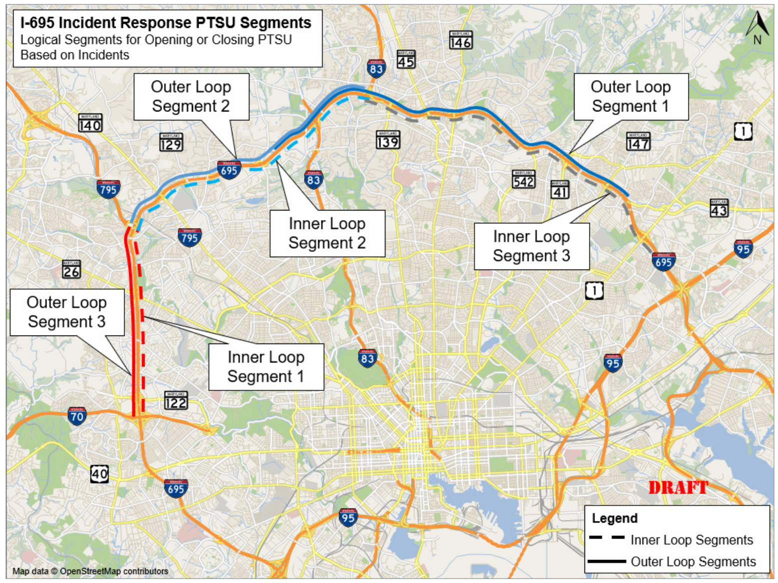
When using the PTSU lane for incident response, **logical segments are proposed of sufficient length to provide benefit and allow the ending point to occur at a safe location**. The CGI Team will **coordinate with MDOT SHA to develop business rules** to establish which segments should be opened during an incident and program the rules into the ActiveITS Decision Support System. These logical segment lengths and locations will be based on traffic volumes, traffic study, crash history, segment capacity and bottlenecks, incident history, sight distance, interchange spacing and the ability of traffic to safely merge into general purpose lanes from the PTSU lane. After verification of an incident, if the criteria discussed in **Section iii.1** is met, one or more **logical PTSU segments would be recommended for opening by the ActiveITS Software Decision Support System** or the CHART ATMS Incident Event. The information would be communicated to MDOT SHA CHART Operators through the CHART ATMS.

Since CHART Operators are not traffic engineers, we recognize the ability of the **ActiveITS software to recommend which PTSU segments to open for an incident** is critical to the success of using the PTSU lane for incident response. The proposed system is adaptable to **opening**

segments of any size if conditions require, however, the CGI Team will ensure the end of a PTSU incident response segment will be at **logical locations where merging can occur safely**. During the incident, the Vehicle Detection System portion of the AID system would be used to **monitor queuing and may recommend additional PTSU logical segments to be opened** upstream of the original PTSU incident response segment.

Our draft approach includes dividing the PTSU lane into three logical segments per direction, six in total, between major junction points. The draft segments are shown in **Figure 4.16** and **Appendix L**. Based on the anticipated incident duration, traffic conditions and other relevant site conditions, a sub-section may be recommended to open, rather than opening the entire incident response segment. Our solution is **adaptable to incident response segments of any length**.

Figure 4.16: Draft PTSU Incident Response Segments



iii.3 Plan of Action for MDOT SHA to Open and Close the PTSU Lane for Incident

The ActiveITS software proposed for this project can open and close the PTSU using the LUCS through manual operation, scheduling for static PTSU hours, activation through incident response plans, and automated activations using the ActiveITS Decision Support System (DSS), such as for incidents, if desired by MDOT SHA. MDOT SHA will have the ability to require operator approval or allow the PTSU lane to open automatically for incidents. The processes discussed below assume Operator approval will be required for the initial period of deployment.

Opening the PTSU Lane for Travel for Incidents

The plan of action for opening the PTSU to respond to an incident is similar to the process to open the PTSU for scheduled operation. The main difference is determining if the PTSU should open and the limits that should be opened as discussed in **Section iii.1** and **iii.2**. **Table 4.10** includes a draft step-by-step process to open the PTSU lane for incidents.

Table 4.10: Process to Open PTSU for Incidents

Step No.	Actions
Step 1	• Opening the PTSU is recommended to the Operator by the ActiveITS DSS through: —When creating an ATMS Event for an incident, the CHART Operator is presented with a recommended response plan —Notification based on recommendations from the ActiveITS DSS is displayed to Operator for confirmation —Details of automated sweep results are provided to Operators with warning —Length and location of PTSU opening is recommended by DSS but may be overridden by Operator

Step No.	Actions
Step 2	• If no obstructions detected, Operator may accept notification or take no action —Taking no action allows the PTSU to open depending on selected configuration • If an obstruction or crash is detected, the PTSU will not open —Plan of action in **Section i.5** will be followed to clear obstruction, if detected
Step 3	• ActiveITS issues command to LUCS to displays green arrow
Step 4	• ActiveITS/CHART ATMS gets confirmation that green arrow is displayed and PTSU is open —LUCS and AID alarm/status continuously communicated between field devices and CHART ATMS

The CGI Team solution is adaptable to fully dynamic opening of the PTSU lane in the future based on a determination of imminent flow breakdown, which is defined as the transition from non-congested conditions to congested conditions. This is typically determined by a measured speed drop accompanied by queue formation. FHWA's *Decision Support Framework and Parameters for Dynamic Part-Time Shoulder Use* provides recommendations for decision trees and threshold parameters. The CGI Team proposed ActiveITS software Decision Support System is compatible with fully dynamic operation.

Closing the PTSU Lane for Incidents

The plan of action for closure of the PTSU due to obstructions or crashes is described in **Section i.8** and would be the same for incidents adjacent to the PTSU lane. During an incident, the ActiveITS DSS will determine if the PTSU should remain open based on traffic statistics provided by the AID system and INRIX/RITIS queue length data provided by the CHART ATMS, if desired by MDOT SHA. It is anticipated the response plan which initiated the PTSU lane will remain active until the scene is cleared and the Operator indicates the incident as cleared within the ATMS. Once the Incident is cleared within the CHART ATMS, the ActiveITS DSS will monitor the AID traffic statistics to determine when flow on I-695 has returned to normal. Once flow has returned to normal, a notification will be provided to Operators that the DSS is recommending closure of the PTSU lane. The system will evaluate how much time is remaining before a PTSU scheduled operating window to avoid flipping between opened and closed within a short time period. The system can be configured to require Operator acknowledgment for closure of the PTSU after an incident or allow it to be automated. **Our solution is flexible to how MDOT SHA would like to operate the system now and in the future.**

iv. REDUCING NON-RECURRING CONGESTION

The CGI Team Solution reduces non-recurring congestion on I-695 in two ways: First, by reducing the number of incidents which cause non-recurring congestion, such as crashes; and second, by allowing MDOT SHA to detect, verify, respond to and clear incidents more quickly. Today, I-695 is plagued with congestion related crashes, as shown in **Figure 4.17**, with **rear-end crashes making up 60%** of all crashes on the inner loop and outer loop and are up to **318% higher than the statewide average** in some segments. This non-recurring congestion causes I-695 to be ranked as one of the most unreliable roadways in Maryland based on the 2019 *Mobility Report* with 4 segments being classified as Highly to Extremely Unreliable based on Planning Time Index.

The CGI Team solution will greatly reduce recurring congestion for the next 20 years. Crashes contribute significantly to non-recurring congestion on I-695 with over 3,168 crashes reported within the project limit over the three year period between 2015 and 2017. Based on an

Enhanced Interchange Safety Analysis (ISATe) safety analysis which follows the Highway Safety Manual concepts and methodology, the CGI Team solution results in a **crash reduction of 268 annual crashes** (163 inner loop and 105 outer loop) which represents a **24% crash reduction in the opening year** when compared with the existing crash reports between 2015 and 2017. The Empirical Bayes method was used to account for the existing crash rates into the ISATe analysis. The severity of crashes was also reduced by **reducing the number of fatality and injury crashes by 66 crashes** per year as shown in **Table 4.11**. The CGI Team solution will **reduce the injury crash rate on I-695 to within 30% of the statewide average for the entire project limit** and **50% of the segments will have crash rates less than the statewide average**.

Table 4.11: CGI Team Crash Reduction in Opening Year

Crash Reduction		2015–2017 Average	Opening Year Predicted Crashes*	Crash Reduction*	Crash Reduction %
Inner loop	Fatality+Injury	171	128	43	25%
	PDO	470	350	120	26%
Outer loop	Fatality+Injury	121	99	23	18%
	PDO	331	249	82	25%
Total		**1,093**	**825**	**268**	**24%**

**Values rounded from ISATe outputs to whole numbers*

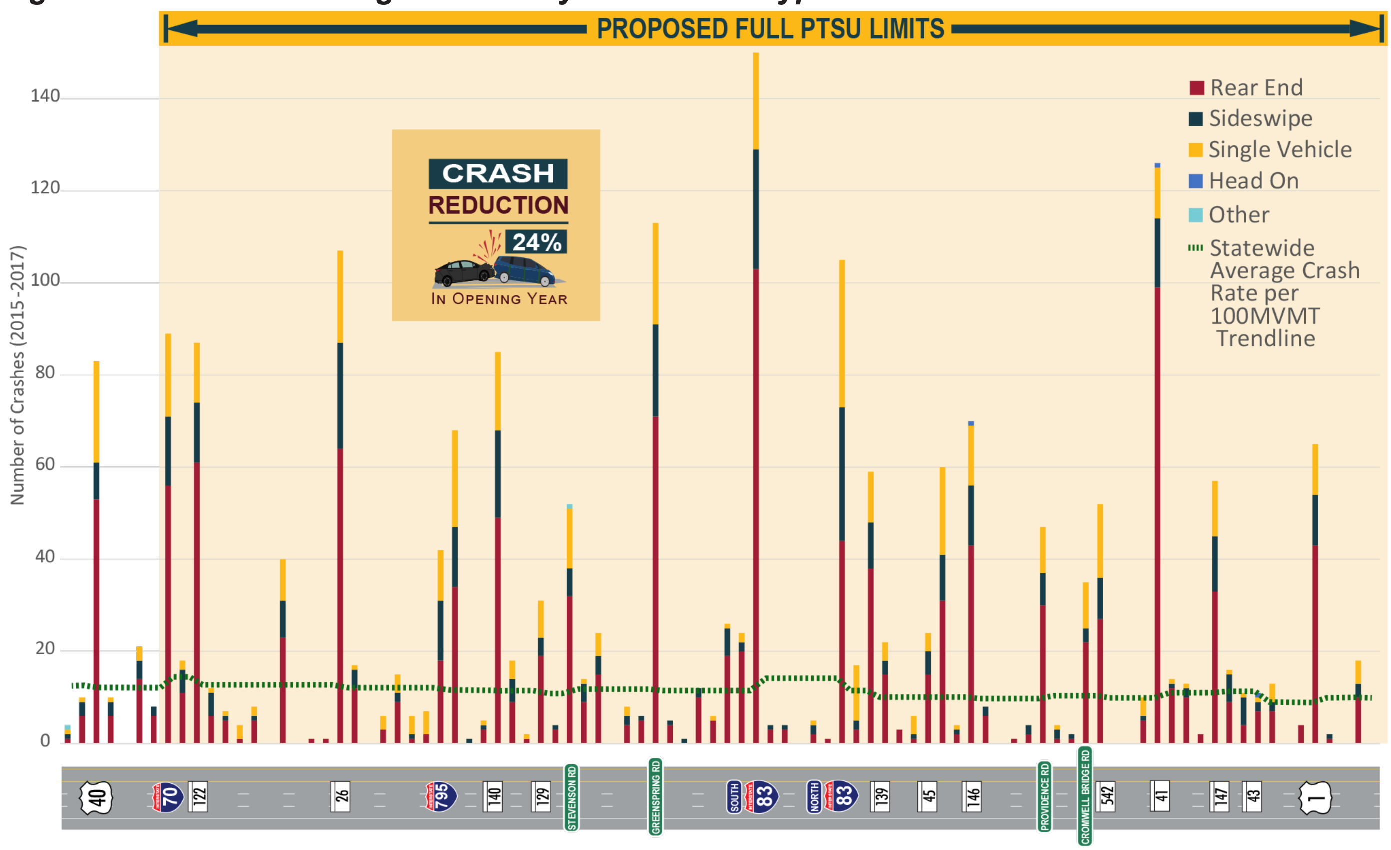
FHWA *Use of Freeway Shoulders for Travel: Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy* indicates that roadways with high Average Annual Daily Traffic, such as I-695, will realize significant crash reductions even if all general purpose lanes are narrowed to 11 feet. Our ISATe safety analysis indicates less than a 1% difference in crashes between our solution and a solution with no Design Exceptions (other than use of the median shoulder for travel). This analysis shows that the **CGI Team solution provides a geometric configuration which does not compromise safety.** The CGI Team choose to use reasonable Design Exceptions to maximize PTSU.

The fixed budget of this project does not make it possible to provide a PTSU lane for the full project limits with no Design Exceptions (other than the DE for using PTSU in the median shoulder). **Our solution will result in improved safety, over a project which has no Design Exceptions, by achieving PTSU for the full RFP limits and extensions on the inner and outer loop.** The CGI Team has provided the perfect balance of safety and effective roadway design to provide a project which will improve safety on I-695 including crash reductions of 24% immediately. By providing the full PTSU, the CGI Team solution reduces congestion through 2040 on the inner loop which will reduce crashes for the next 16 years. Once downstream outer loop bottleneck at US 40 is eliminated by planned projects, I-695 between MD 43 and I-70 on the outer loop will be free flow. This elimination of congestion will further enhance safety.

Navtech all-weather Automated Incident Detection (AID) system will be deployed within the project limits for **all lanes of traffic and shoulders** to detect congestion, crashes, disabled vehicles and other causes of non-recurring congestion. **The CGI Team is providing tools to MDOT SHA to improve detection, verification, response, roadway clearance and incident clearances times throughout the corridor at all times of day, every day of the year.** By reducing incident clearance times, non-recurring congestion caused by the incident and secondary crashes will be reduced causing the roadway to recover to normal flow faster. Our solution will reduce delay and improve travel time reliability by clearing incidents more quickly and reducing the number of incidents MDOT SHA will respond to. The PTSU lane system proposed under this project will provide an operations tool to assist with incident response to lessen the impact of non-recurring congestion by providing additional capacity in the vicinity of an incident. The ATM software is equipped with a Decision Support System (DSS) which will recommend which PTSU lane segments should be opened to respond to an incident. This DSS will reduce response times and allow I-695 to recover to normal flow more quickly.

The CGI Team is providing solutions which will improve safety of MDOT SHA maintenance staff including **all-weather pull-off areas**, **traffic barrier to protect cabinets** and **maintaining the outside shoulder for 99% of the project limit**. Our Operability/Maintainability/Adaptability **Section 5** provides additional information for how our solution will keep MDOT SHA maintenance staff safe and reduce non-recurring congestion.

Figure 4.17: I-695 Existing Crashes by Location & Type



CGI TEAM SOLUTION SUMMARY

The CGI Team solution will improve safety on I-695 by reducing recurring congestion, reducing the number of crashes which occur each year, reducing the severity of crashes, and by providing MDOT SHA with new ITS (Navtech AID, complete CCTV Camera coverage and a full project length PTSU lane facility) to respond to and manage non-recurring congestion. In addition, we are providing the tools to help you safely maintain and operate the new PTSU lane. With a Benefit-Cost ratio of 368:1, our solution results in an average annual operations and safety benefit to Marylanders of $4.8B now and for decades into the future.

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Section 5

Operability/Maintainability/Adaptability

CONCRETE GENERAL, INC.

in association with

RK&K

CGI TEAM SOLUTION OVERVIEW

The CGI Team lives and breathes I-695. Many of our key staff suffer through the existing congestion. We've dreamed of providing the solution outlined in this proposal, which will **eliminate delay today** and promises **performance life beyond 2040**. Our project will provide $4.8B in annual congestion and safety benefits to Marylanders. It's a solution that the CGI Team and MDOT SHA will be proud to deliver.

The Solution

Nearly 40 Miles of Part Time Shoulder Use (PTSU)	• I-70 to MD 43 (37.3 miles) + • Outer loop extension within I-70 interchange (0.5 miles) • Inner loop extension to Lillian Holt Drive (1.8 miles) • Extended operational hours from 6 AM–10 AM and 2 PM–7 PM
Navtech Radar-Based AID System	• 80 devices vs. competing systems' 390 devices • True all-weather performance • Accurate debris detection as small as 2'x2'x2' • Automated incident detection on PTSU/GP lanes
Incident Response	• Complete CCTV coverage for PTSU/GP lanes • Outside shoulder for emergency response
Safety Upgrades	• 15 miles of upgraded concrete median barrier • 1,000 new drainage inlets reduce spread for PTSU
Pavement Enhancements	• 12 lane miles of pavement rehabilitation • 168 lane miles of pavement resurfacing
Highly Adaptable Systems	• Connected vehicle ready corridor • 21 miles of new fiber optic cable network
Maintenance and Operations	• $370K in annual reduced maintenance and operation costs over similar systems for I-695 TSMO

The Performance

Existing	• 59% free flow traffic • Average speed as low as 23 MPH • Travel time up to 57 minutes
Opening	• 96% free flow traffic • Average speed 58 MPH / 57 MPH • Travel time 23.1 min / 23.5 min
2040	• 74% free flow traffic (96% with future projects*) • Average speed 51 MPH / 29 MPH (52 MPH w/future projects*) • Travel time 26.6 min / 47.2 min (26 min with future projects*)

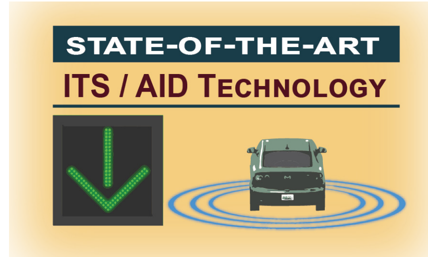
All Statistics: Inner Loop Peak Period/Outer Loop Peak Period
**MDOT SHA planned improvements at I-70 and US 40*

Numbers don't lie. There is no better solution than free flow traffic in the opening year. In fact, our PTSU solution is so good that other improvements add little value now, or in the future. There are no impacts to arterial roadways, minimal environmental impacts, and safety is enhanced.

We understand that the devil is in the details. The remainder of this Section will demonstrate exactly how the CGI Team's solution will minimize MDOT SHA operations and maintenance activities while being adaptable to future technological advancements. Refer to **Figure 5.1** for a graphic of our solution.

Figure 5.1: CGI Team Solution

CGI TEAM OPERABLE, MAINTAINABLE AND ADAPTABLE ITS SOLUTION



The CGI Team recognizes that installation of a PTSU lane on a Maryland roadway will expand operations and maintenance performed by MDOT SHA CHART. We have the expertise and knowledge to work with you to deploy this exciting new TSMO solution. The CGI Team solution provides a comprehensive PTSU system that delivers incredible mobility benefits without compromised safety. Our solution was carefully chosen to ensure that our decisions would **minimize MDOT SHA operations and maintenance activities while being adaptable to future transportation technological advancements**. **Table 5.1** highlights the operations and maintenance for our proposed ITS system. **Brian Grandizio** will serve as the **CGI Team Systems Engineer**, with a minimum of 10 years of proven experience in systems engineering for ITS projects. He will assist with system concept development, architecture development, design, construction and implementation.

Table 5.1: CGI Team Solution Operations, Maintenance and Adaptability Benefits

Element	Benefit
Navtech Radar ClearWay AID (Navtech AID)	• Detects non-recurring congestion, debris and obstructions in all lanes • Less than 80 sensors required (hundreds less than competing AID systems) • Can be maintained from shoulder • Meets RFP requirement for Vehicle Detection System and eliminates 120 additional traffic sensors
Integration	• CHART operators can control all elements of PTSU lane and AID from within CHART ATMS • No separate systems proposed for Operators to manage project
Lane Use Control Signals (LUCS)	• Controlled using LEDStar CTL-24 controllers, same as current MDOT SHA inventory for DMS signs • Less than 100 LUCS gantry location to cover all of PTSU limit • Can be maintained from shoulder • Only proposed over PTSU lane. **No proposed ITS devices on this project are installed over active general purpose lanes**. • Visible from proposed CCTV cameras to reduce maintenance workload
Southwest Research ActiveITS ATM Software (ActiveITS)	• Decision Support System to reduce new operator workload • Allows fully dynamic operation in the future • MDOT SHA access to source code for future CHART ATMS enhancements • Manual, scheduled,or automated opening/closing of PTSU to reduce new operator workload
Fiber Optic Network	• All new ITS devices will be installed on a fiber optic communication network • Substantial bandwidth for future devices
332D Cabinets	• Larger cabinets proposed to eliminate the need for multiple cabinets at each device, producing less maintenance needs • Space for future devices, including connected vehicle equipment
CCTV Cameras	• Complete coverage of all lanes and PTSU for enhanced verification

Our team carefully chose an Automated Incident Detection (AID) system to minimize operations and maintenance. **Table 5.2** summarizes benefits for choosing Navtech AID over competing solutions, such as CCTV camera or thermal camera based systems. Navtech AID requires less than half the number of devices and exceeds the requirements for the Vehicle Detection System. **Fewer devices mean less maintenance and lower long term costs for MDOT SHA** while exceeding the technology needs for the project.

Table 5.2: Comparison of Navtech Radar AID vs Camera-Based Technology

Design Parameter	*Our Solution:* Navtech Radar AID	Video or Thermal
All-Weather & All Lighting Conditions	**Unaffected by rain, snow, smoke, fog, shadows or darkness**	Detection reduced in rain, snow, fog and darkness for video
Debris Detection	**Yes - Object as small as 2'x2'x2'**	Not Recommended by vendor for video; 350 foot spacing required for thermal
Detection in All Lanes	**Yes - without adding more sensors**	More cameras needed to cover all lanes
Spacing	**1,500 Feet with Debris Detection**	350 Feet to 1,000 Feet (without Debris)
Maintenance	**Less Preventative Maintenance; Lower Mount Height; Fewer Sensors**	Routine cleaning needed
Sensors Needed	**76**	>300
Vehicle Detection System	**Meets RFP requirements without any additional devices**	More cameras would be required to cover all lanes or reduced spacing

i. MAINTENANCE OPERATIONS (SAFETY & MINIMIZING TRAFFIC IMPACTS)

Our proposed solution **maintains a paved full-time outside shoulder** along I-695, **for 99% of the project limit**, to allow for maintenance to be performed safely while minimizing impacts to the efficient flow of traffic on I-695. In addition to the outside shoulder, the CGI Team is proposing **all-weather maintenance pull off areas**, as shown in **Figure 5.2**, where 12-foot-wide outside shoulders are not available at proposed ITS device locations. Maintenance vehicles can use the pull off areas to get the vehicle off the roadway and be protected behind traffic barrier. The ability for maintenance vehicles to park behind traffic barrier will allow staff to meet the requirements of MDOT SHA policies including the 2016 *Protection Vehicle Usage Policy*, which requires the use of Protection Vehicles for maintenance work more than 15 minutes unless behind barrier. By providing pull-off areas, the CGI Team solution will result in fewer **protection vehicles than camera-based solutions to maintain ITS equipment**, which will **save CHART over $60,000 annually** on maintenance for the new system. Providing pull-off areas and widened outside shoulders allows maintenance to be completed safely, away from traffic, while keeping workers out of harm's way and minimizing impacts to the efficient flow of traffic. Since all maintenance work can be completed without active lane closures, **daytime maintenance work** can be performed, which reduces the risk of injury to workers and improves driver safety.

Figure 5.2: All-Weather Maintenance Pull Off Areas

Maintenance of lanes designated for PTSU is more similar to maintenance of general purpose lanes than maintenance of a shoulder. Based on the experience of other agencies, the CGI Team recommends that the PTSU lane be maintained at the same level as general purpose lanes. There is no need to clean the PTSU lane with street sweepers, as the presence of traffic on the shoulder removes small rubble, similar to a general purpose lane. Conducting maintenance in the median within PTSU segments requires maintenance vehicles to stop in the PTSU lane. Maintenance in the PTSU lane will require CHART Operators to close the PTSU to traffic and create an ATMS Event.

ITS Equipment

The CGI Team proposes to minimize the required maintenance, enhance safety and minimize the impact to efficient flow of traffic on I-695 by providing a **reduced number of devices**, when compared to other technologies, that needs to be installed and maintained and by **co-locating**

devices. The CGI Team solution will minimize the time maintenance staff from the ITS Division are exposed to traffic. ATC 2R1, 5 and 10R1 describe some of the decisions made to reduce the number of devices. As described in PTC 1, the CGI Team selected Navtech Radar based Automated Incident Detection because it requires less field sensors while still allowing **debris detection of objects as small as 2’x2’x2’**.

The sensors are mounted approximately 13 to 15 feet above grade, making them easy to maintain from a bucket truck or a ladder from within the closed PTSU lane. A comparable vision-based or thermal-based AID system would require over 300 cameras to maintain. Navtech AID eliminated the need for standalone Vehicle Detection System (VDS) sensors. Maintenance for Navtech AID includes checking internal components every 5 years.

All new ITS devices for this project are consistent with current MDOT SHA performance measures including operational percentage, work order resolution on first response and mean response time by device. ActiveITS will assist MDOT SHA with tracking of these performance measures for new devices.

No in-pavement sensors are proposed under our solution

The decisions made to reduce LUCS via ATCs and to choose an AID system which requires less sensors, reduce supporting infrastructure and eliminate a separate VDS system will **require over 400 fewer devices** and **reduce annual maintenance of the system by up to $210,000 per year** based on Texas Transportation Institute (TTI) *Guidelines for Funding Operations and Maintenance of ITS/ATMS.* Less devices will **reduce the exposure of maintenance staff** and the number of trips to the field—increasing safety.

The 12-foot-wide outside shoulder and maintenance pull-off areas, where shoulders are less than 12 feet, will be used to access ITS field equipment cabinets and proposed Pan-Tilt-Zoom CCTV cameras for maintenance. When the PTSU is not in operation, the median shoulder will be used to maintain equipment installed in the medians, including AID sensors and LUCS. All proposed **cabinet locations are protected by traffic barrier** or are located outside the Clearzone to **limit maintenance staff exposure to traffic**. It is anticipated that maintenance will use a Protection Vehicle, in accordance with MDOT SHA policy, to safely maintain ITS devices located in the median.

All proposed CGI Team **ITS devices can be maintained without requiring lane closures** in the general purpose lanes. Ramp metering and full gantry Active Traffic Management is not proposed for this project because they aren’t as effective as PTSU for meeting the project goals. Both strategies were also eliminated because they required devices over active ramp and general purpose lanes which require active lane closures to maintain devices. Based on allowable lane closure schedules for I-695, lane closures are only permitted during nighttime hours. By eliminating a full system of ramp metering from consideration, the CGI Team will **avoid maintenance costs to MDOT SHA of approximately $100,000 annually**, according to the TTI *Guidelines for Funding Operations and Maintenance of ITS/ATMS*, since there will be fewer devices to maintain. By reducing the equipment that needs to be maintained, our proposal will result in less disruptions to traffic, less exposure of maintenance staff to traffic and limit new personnel required. These items will **enhance maintenance personnel safety**.

ITS devices can be maintained without requiring lane closures

No proposed ITS equipment is located over an active general purpose travel lane. Only the Lane Use Control Signals (LUCS) are located over the PTSU lane, which would be closed for device maintenance. The CGI Team designed the LUCS system with maintenance in mind by locating the driver, power supply and all components except the LED elements themselves in the roadside cabinet. This approach will ensure that most **maintenance activities can be**

accomplished from behind traffic barrier on the outside of the roadway. Cameras on poles over 40 feet will be installed on lowering systems. If it is necessary to replace the LUCS located over the PTSU lane, the LUCS can be replaced in less than 20 minutes.

ITS Communications

Maintenance of ITS communications will be completed on the outside of the roadway Longitudinal fiber will not be installed in concrete barrier walls in the median to avoid the need for PTSU lane or general purpose lane closures to maintain fiber. Splices and switches will be accessible from widened outside shoulders or maintenance pull-off areas to reduce the impacts to traffic flow and minimize the potential for worker injury. Use of RSA fiber would follow current maintenance agreements between MCI and MDOT SHA. All proposed work will be in conformance with National Electric Code to ensure maintenance staff can easily identify communication infrastructure from electrical infrastructure.

> No proposed ITS equipment is located over an active general purpose travel lane or ramp

Snow Removal

The outside shoulder is maintained for storage of snow removed from active travel lanes. During record snowfall events, the PTSU lane can be closed and used for snow storage. The FHWA *Use of Freeway Shoulders for Travel* guideline states the PTSU lane is typically plowed after all general purpose lanes which usually has little effect on traffic operations due to reduced traffic volume during snow. The system is adaptable to keeping the PTSU lane open during snow events. In 4 lane sections, MDOT SHA generally plows snow into the median shoulder. Since the PTSU lane is located in the median shoulder, the CGI Team will work with MDOT SHA Office of Maintenance to implement a minor change to revise any necessary plow train SOPs to minimize the impact to efficient traffic flow. Based on our review, MDOT SHA can plow all snow to the outside of the roadway for normal storms. Snow plowing can be performed in accordance with typical procedure and can be completed safely.

> **CGI Team Solution:**
>
> - 400 fewer devices than other solutions
> - High MTBF ratings for products
> - Similar devices to current assets
> - Spare equipment provided
> - Cohu cameras
> - LEDStar controllers for LUCS

> MnDOT keeps PTSU open to spread salt in minor snow storms

Mowing

The Standard Operating Procedure for mowing along I-695 will not change from existing. Usable outside shoulders are provided along 99% of the project limits. Mowing maintenance staff will park safely on wide outside shoulders and all-weather maintenance pull-off areas. In many cases, mowing transportation vehicles can be parked behind traffic barrier on pull-off areas which will minimize the impact to efficient flow of traffic. Mowing is not required in the median from west of MD 43 to I-70.

ii. MAINTENANCE PERSONNEL AND EQUIPMENT REQUIREMENTS OF PROJECT (PERSONNEL & TRAINING)

The CGI Team proposes to minimize the required maintenance personnel and equipment by **reducing the quantity and type of devices that need to be installed and maintained** to provide a fully functional ITS system. Where possible, the CGI Team has proposed equipment which is already common to MDOT SHA CHART's inventory.

The CGI Team proposes to use PTZ CCTV cameras consistent with the current MDOT SHA inventory. Lane use control signals and radar-based AID sensors are new to MDOT SHA CHART but Lane Use Control Signals are common to MDOT SHA OOTS. The controller for LUCS is consistent with the existing CHART DMS controller. The CGI Team solution includes a business rule-based Decision Support System (DSS) to automate common tasks and reduce the personnel requirement to operate the system.

Personnel Requirements

MDOT SHA has made a commitment to TSMO projects which will expand the number of ITS devices throughout the state. Once the CGI Team solution becomes active, the system will be turned over to MDOT SHA for operations and maintenance. **The proposed non-ITS (roadway, drainage, etc) improvements will have no new personnel or equipment requirements for maintenance or operations**. The ITS portion of the CGI Team solution consists of electronic equipment including approximately 80 radar-based AID sensors, 165 Lane Use Control Signals and 20 new Cohu PTZ CCTV cameras to provide coverage from I-70 to east of MD 43. A new fiber optic cable network will be deployed within the project limit and the existing connected CCTV camera locations within the PTSU limit will be to the new fiber. The new fiber network will tie into the existing Resource Share Agreement fiber between I-70 and I-83.

Personnel Requirements:

- Similar skills and procedures for maintenance
- Current duties will apply
- Comprehensive training for new skills

Proposed non-ITS (roadway, drainage, etc) improvements will have **no new personnel** or equipment requirements for maintenance or operations.

Software maintenance and updates will **not require any additional MDOT SHA personnel or equipment**, as this will be provided via a software maintenance agreement with the vendors. It is anticipated that MDOT SHA would enter into maintenance agreements with SwRI and Navtech AID for the system. Maintenance for ITS is expected to be undertaken by personnel from MDOT SHA CHART ITS Division (Radio Shop) via State Forces or contractors.

Personnel will need skills to perform preventative, responsive and emergency maintenance for these devices in accordance with current MDOT SHA policy and procedures. The current regimens and procedures will apply to these new devices. In addition to maintenance, MDOT SHA CHART ITS Division is typically involved in construction inspection, equipment testing and acceptance tests for new ITS equipment. The **current Radio Shop duties** will apply to the CGI Team proposed ITS.

The devices proposed by the CGI Team are **similar or identical to existing MDOT SHA assets**, resulting in similar skills and procedures currently utilized. Field devices will be remotely accessible through proposed ATM and AID software. New skills are required for maintenance and programming of the AID radar sensors, lane use control signals and controllers. MDOT SHA CHART staff will receive comprehensive training for these new skills. All other ITS devices proposed are consistent with current MDOT SHA ITS assets and require no new skills.

Due to the quantity of equipment proposed on I-695 and current reduced maintenance staffing levels, the CGI Team estimates MDOT SHA CHART will need the equivalent of one new full time maintenance person (either state forces or contractor) to assist with maintenance of the I-695 PTSU ITS equipment. The CGI Team anticipates that the additional maintenance staff will also be available to assist the Radio Shop with maintenance activities for ITS devices on other roadways in the state, since the I-695 device workload will not occupy the new maintenance staff person full time every day, especially in the first few years of deployment.

Equipment Requirements

The CGI Team anticipates that the equipment required to maintain the CGI Team solution is **similar to the equipment required to maintain existing MDOT SHA ITS devices and infrastructure** including: bucket trucks to maintain LUCS and AID sensors, optical time domain reflectometers (OTDR) to maintain fiber optic cable network and laptops to access the ATM software and ATMS software. To complement the recommendation for one new maintenance person, it is recommended that new maintenance staff be outfitted with a leased bucket truck and other typical tools to allow for maintenance of the overhead lane use control signals. This new equipment could be procured using State or contractor forces. **Spare equipment will be provided by the CGI Team** for this project including 10% of the total number of CCTV cameras, AID sensors, LUCS, LUCS controllers, network switches and network routers. In addition, 5% of the total number of cabinets will be provided as spares to MDOT SHA CHART.

Training Program

Experience: Our team developed and executed a training program for I-270 ramp metering

We have done this for you before. The CGI Team has experience providing training sessions to MDOT SHA for deployment of new systems, including the I-270 ramp metering system. The CGI Team will arrange for a comprehensive training program for the project to be completed for maintenance (MDOT SHA CHART ITS Division - Radio Shop), operations (MDOT SHA CHART Traffic Management Center Operations Division) and managers. Prior to equipment being accepted for maintenance, our team (including vendors) will provide **operational and maintenance training for all ITS equipment**. Just like we did for I-270, **we will be side by side with MDOT SHA, attending each training to be a technical resource during this project and in the future**.

At a minimum, the training program will include how to configure, program, operate, maintain, replace, test, and troubleshoot the system. The CGI Team will submit training materials to MDOT SHA for approval 30 days prior to performing any training. All materials will be MDOT SHA approved before the training will be conducted. Copies of all approved training materials will be provided to all trainees. All training information will be bound in a 3-ring binder with an outside label on the binder cover and spine. A minimum of 5 additional copies of the training materials will be provided to MDOT SHA. All training materials will provide detailed step-by-step instructions for trainees. Standard off-the-shelf reference manuals will be used in addition to tailored step-by-step procedures and exercises to be provided during training to place emphasis on those features that will be utilized by MDOT SHA. Generic training will not be provided. The training will be specific to the equipment, configuration, and operation of the ITS proposed and constructed in this project.

The vendors for each product will be the primary trainers and will provide the most detailed and comprehensive training program possible. The CGI Team will ensure the quality of training materials, vet all trainers, facilitate training, attend all training and assist MDOT SHA with any follow up or questions which may arise. The CGI Team will supply copies of a maintenance manual complete with catalog cuts of all parts and components utilized within the system, including user manuals, and installation and configuration guides. Detailed procedures providing step-by-step instructions for configuring and maintaining the system will be provided along with the training materials.

In addition to training MDOT SHA staff, the CGI Team recognizes that a public outreach campaign will be required to educate drivers and the public, including videos, websites, or advertisements. We have done this for you for I-270 ICM. Outreach will be completed to train law enforcement, towing companies and first responders on the use of the PTSU lane and to avoid placing disabled vehicles or other obstructions within the lane, including meeting with each stakeholder individually to address questions.

Operations and Maintenance Training

The CGI Team operations training program will provide **separate training sessions for operator and administrator level staff**. Operator level staff include MDOT SHA Traffic Management Center (TMC) Operations Division Highway Operations Technicians (HOTs). Administrator level staff include TMC Operations Center Managers. Maintenance and engineering staff will also be invited to training. Based on feedback from MDOT SHA, HOT IVs (Supervisor) may be included in both operator and administrator level trainings. Efforts will include training materials and on-site training to MDOT SHA.

Training will be **provided to maintenance staff**, separate from operations, to ensure they can maintain new ITS equipment (preventative and emergency maintenance), complete equipment testing and acceptance tests for new ITS equipment and inspect construction for new ITS equipment. Training materials will be provided ahead of time and trainings will be completed on-site and in the field. Training will include how to configure, program, inspect/commission, operate, maintain (preventative, responsive and emergency), replace, test, and troubleshoot the following systems as shown in **Table 5.3**.

Table 5.3: Proposed Training Program

System	Operations (Operator & Administrator Level) and Maintenance Training Details
Navtech ClearWay Radar-Based AID	• Minimum of two on-site trainings and two virtual trainings • 45 days of remote fine tuning and monitoring which will involve working closely with MDOT SHA operations staff during initial deployment
Southwest Research ActiveITS ATM Software	• Minimum of two on-site training events by SwRI • Admin Ops training will include configuration of Decision Support System • SwRI engineers will be side-by-side with MDOT SHA staff for 30 days • Remote assistance available during the 90 day burn-in period • Daily Checks of the ATM software will be included for operations
CHART Advanced Traffic Management System ATMS Software	• Operations will be within the CHART ATMS • ATM training in the CHART ATMS coordinated with GDIT, formally CSRA • Status of AID, LUCS and ATM shown to staff • Error notifications and Daily Check of the ATMS
Cohu CCTV Cameras	• CCTV cameras proposed consistent with current MDOT SHA brands • Minimal CCTV camera operations training required. • Minimum of 1/2 half day training session
Lane Use Control Signal and Controller	• Minimum of two on-site training events by the vendor • Maintenance and programming of the LUCS and controllers • Staff familiar with LEDStar controller that we are using for LUCS control
Cisco Managed Network Switches	• Switches consistent with current MDOT SHA brands • Minimal training is anticipated but vendor training will be offered
Alpha UPS Backup System	• UPS consistent with current MDOT SHA brands • Minimal training is anticipated but vendor training will be offered

The CGI Team will provide content to MDOT SHA CHART to update the TMC HOT Training Manual. The I-695 TSMO systems will be deployed into the MDOT SHA CHART Training Environment, hosted at the Statewide Operations Center to provide users with a more realistic learning environment. In addition to the training environment, it is anticipated the ATM and AID software will be included in the CHART ATMS Production, Development/Testing, Pre-Release (for final systems test) and Backup Production (off-site) environments.

Since ramp metering, and other approaches with incompatible software, is not proposed for this project, it will reduce the training which must be provided for the project. **The deployment of a single system will improve maintenance and operations on the corridor** and avoid CHART versus OOTS management of freeway devices.

iii. ADAPTABILITY TO FUTURE TRANSPORTATION TECHNOLOGICAL ADVANCEMENTS

The FHWA *Decision Support Framework and Parameters for Dynamic Part-Time Shoulder Use* defines various levels of PTSU, including Level 4—fully dynamic PTSU capable of opening or closing shoulders based on real time traffic conditions. Based on the RFP, MDOT SHA anticipates operating the PTSU as Static-Dynamic for the initial deployment of the I-695 PTSU lane, however, the CGI Team is **deploying software and infrastructure capable of operating fully dynamic Level 4 PTSU** to allow maximum adaptability in the future.

The level of AID with VDS being installed by the CGI Team would be adaptable to deployment of additional Active Traffic Management strategies including dynamic speed advisory, variable speed limit, queue warning, dynamic lane assignment and dynamic shoulder lane. The detection, infrastructure and communication systems installed by our solution would also be adaptable to providing these additional ATM strategies.

The system being deployed by the CGI Team is **Connected Vehicle Ready**. The cabinets, fiber optic cable network and ITS structures being proposed for this project would allow MDOT SHA CHART CATS to install Roadside Units (RSU) for future connected vehicle applications without having to pay for power or communications. The structures proposed for the CGI Team solution are approximately 30 feet tall which is consistent with typical RSU height requirements. In addition, the average cabinet spacing for the CGI Team ITS solution is approximately 1,000 feet. Since maximum RSU range is approximately 1,500 feet, the CGI Team solution would provide optimal future RSU spacing for connected vehicle applications. The CGI Team infrastructure could provide full RSU coverage without the need for any new ITS structures. Additionally, the future CV system could communicate PTSU status to vehicles.

> Our solution makes I-695 connected vehicle ready

The CGI Team proposal is deploying a 1 Gbps fiber optic cable network with Cisco switches to feed the proposed ITS solution. By deploying a fiber network with cabinet spacing which averages 1,000 feet, this system would provide adaptability to any future transportation deployment. The CGI Team solution is proposing 332D cabinets and electrical services which will accommodate the deployment of future devices. The CGI Team proposal is consistent with automated vehicles by providing compliant pavement markings. Existing CCTV Cameras within the I-695 corridor will be connected to the new fiber optic cable network which will improve the resolution of the cameras.

CGI TEAM SOLUTION SUMMARY

The CGI Team solution will allow MDOT SHA to operate and maintain this important facility effectively, efficiently and safely. Our solution was carefully chosen to ensure that this system will **minimize MDOT SHA operations and maintenance activities while being adaptable to future transportation technological advancements**. Our solution will allow MDOT SHA to transform travel on I-695 and provide $4.8B of benefits to the Baltimore region.

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