National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY23FH010

FACTUAL REPORT OF INVESTIGATION

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A. CRASH

Location: Woodlawn, Baltimore County, MD
Date: March 22, 2023
Time: 12:36 p.m. EDT

B. FACTUAL REPORT OF INVESTIGATION GROUP

Group Chair / IIC	Robert Squire National Transportation Safety Board Washington, DC
Group Chair	Eric Gregson National Transportation Safety Board Washington, DC
Party Representative	Darien Manley Maryland State Highway Administration Hanover, MD
Party Representative	1st Sergeant Ronald Menchey Maryland State Police Westminster, MD

C. CRASH SUMMARY

For a summary of the crash, refer to the Crash Summary Report in the docket for this investigation.

D. INTRODUCTION

On March 22, 2023, about 12:36 p.m. EDT, six highway construction workers were struck by an errant passenger vehicle while working within a work zone along northbound Interstate 695 (I-695) north of Dogwood Road in Woodlawn, Baltimore County, Maryland. The work zone was a long-term closure of the left shoulder and was part of a project incorporating about 21.3 miles of I-695 between Interstate 70 and Maryland State Highway 43. The work zone occupied both left shoulders of the divided highway and used a series of concrete barriers to isolate workers from vehicles operating in the travel lanes.

The passenger vehicle that struck the workers was a 2017 Acura TLX, driven by a 54-year-old female driver. The Acura had traveled about 1.8 miles through the work zone when it collided with a 2017 Volkswagen Jetta, driven by a 20-year-old male. The

collision occurred in the far-left lane as the Acura moved leftward from the far-right lane and struck the Volkswagen. At the time of the crash, both vehicles were traveling at a high rate of speed in excess of the posted speed limit. As a result of the collision, the Acura was redirected through an access opening in the concrete barriers. After being redirected by the inside barrier, the Acura traveled through the work zone while overturning and struck miscellaneous construction materials and the six workers before coming to a stop.

E. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board (NTSB), Office of Highway Safety initiated a limited scope field investigation into the collision. Parties to the NTSB investigation include the Maryland State Highway Administration (MDSHA) and Maryland State Police (MSP). Relevant information was also acquired from the project contractor, Concrete General, Inc., and an engineering firm contracted by MDSHA for construction site inspection services, KCI Technologies, Inc. The NTSB investigation was conducted independent of, but concurrent with, the Maryland State Police crash investigation.

This report will primarily address elements of the highway work zone and crash events. Data and information presented herein is intended to address these areas of consideration for the NTSB investigation. Information regarding the involved vehicles and collision events are addressed by the NTSB Technical Reconstruction Group.

F. HIGHWAY PREFATORY DATA

1.0 Highway Background

Interstate 695 (I-695) is a 51.46-mile-long (82.82 km) auxiliary Interstate Highway that encircles the city of Baltimore.[1] Officially designated the McKeldin Beltway, the highway is colloquially known as the Baltimore Beltway. The two roadways comprising the highway are further identified as the inner- (nearest the city of Baltimore) and outer-loops. While the directional heading for this crash is designated as northbound, it occurred on the inner loop roadway.

The Baltimore Beltway was first planned by Baltimore County in 1949 and taken over by the state in 1956 as part of the Interstate Highway System. The full "beltway" was completed in 1977. During the intervening years various sections were completed or upgraded to interstate highway standards. Highway exit numbers are arranged consecutively clockwise starting at interchange 1, Quarantine Road, west of the Francis Scott Key Bridge, which crosses the Patapsco River. **Figure 1** depicts an overview of I-695 routing as it encircles the city of Baltimore.

[1] Auxiliary of Interstate 95.

The highway was functionally classified as an urban interstate with full access control.

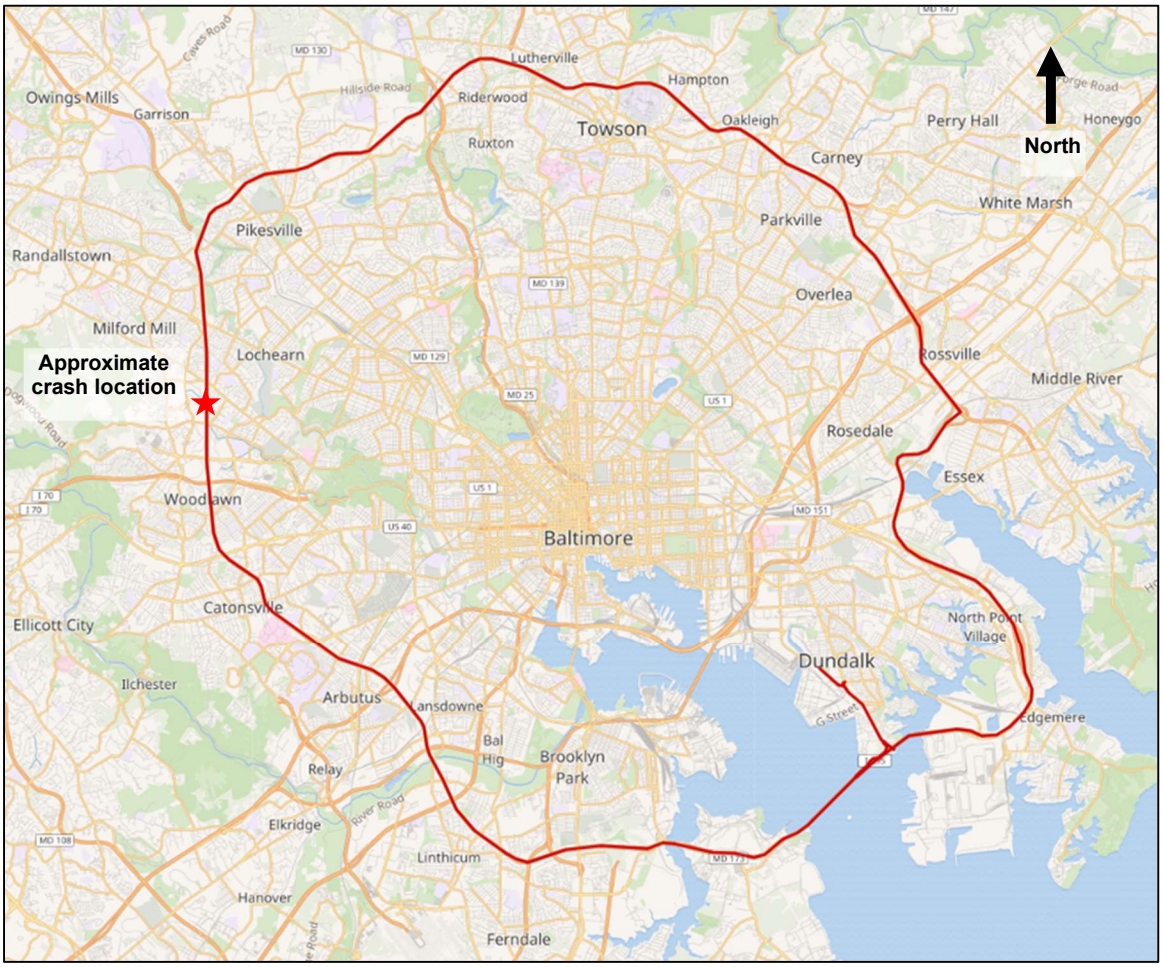

Figure 1: I-695 routing around the city of Baltimore with the red star designating the approximate area of the crash.

2.0 Roadway-Crash Location

The initial impact between the Acura and Volkswagen occurred in the far-left lane of the I-695 inner loop approximately 0.2 miles north of the Dogwood Road overpass. At this location, the I-695 inner is comprised of four travel lanes, measuring approximately 12-feet in width. Left and right paved shoulders, exhibited similar 12-foot widths, are contiguous with the travel lanes. The collision area was located approximately 0.68 miles into a tangent segment exhibiting a 1.9 percent ascending vertical grade. Travel lane and left shoulder cross slope grades descend approximately two- and three percent toward the appropriate road edges, respectively.

Through this area the inner and outer loops of I-695 are separated by a 42-inch-high rigid, F-shape, concrete barrier system.[2] In addition, the inner loop roadway is elevated about five feet above the outer loop roadway.

The posted speed limit is 55 miles per hour.

3.0 Environmental Conditions

Weather and road conditions at the time of the crash were mostly cloudy skies, dry conditions, light winds (8 mph), and an ambient temperature of 62-65°F. The roadway travel surface was dry with no observed deficiencies.

No driver sightline obstructions or visibility impairments were noted.

4.0 AADT vehicle classification

As referenced in the MDSHA construction contract (2022) the annual daily traffic (ADT) volume on I-695 was 213,225 vehicles with about nine percent (7% D.H.V.) of vehicles classified as trucks.[3]

5.0 General Location Crash Data

General crash data over the most recent complete five-year period (2018-2022) was acquired for the area (preceded the construction project). The data focused on a three-mile stretch of I-695 between the interchanges of Interstate-70 and Maryland Route 26. In summary, the study area exhibited a total of 536 crashes involving 1,221 traffic units. Approximately 72% of the involved vehicles could be classified as light duty (<10,000 lbs. GVWR) with about three-quarters of that total defined as a passenger car. Of the total crashes approximately 77% were classified as either rearend (52%) or sideswipe (25%) configuration impacts. Approximately 80- and 85-percent of the total crashes occurred on dry road surfaces and during clear/cloudy weather conditions, respectively. Fifty percent of the total crashes occurred during daylight hours. Of the total crashes approximately 10.9% identified a speed-related probable cause, defined as either speed "too fast for conditions" (10.3%) or "exceeded speed limit" (0.6%). Crashes having identified "improper lane change" as a probable cause were infrequent at 4%.

[2] For reference see Maryland Department of Transportation State Highway Administration Book of Standards for Highway and Incidental Structures, standard MD-648.44-01.

[3] D.H.V. or Design Hourly Volume, also known as average peak hour trips, is an evaluation of the amount of traffic seen on the busiest hour.

Of the total 536 crashes, only one resulted in a fatal occupant injury. That fatality occurred in September 2020 and involved a collision between two passenger vehicles on the inner loop of I-695.[4] One vehicle was disabled from an earlier collision and partially occupied the left travel lane during hours of darkness. That vehicle was struck by the second as it attempted to swerve. The operator of the disabled vehicle was ejected and subsequently struck by other passing vehicles.

Otherwise, approximately 73% of the total crashes resulted in property damage only. Approximately 27% resulted in a reported injury.

Certain crash data are presented in **Tables 1-4**.

Table 1: Five-year count of traffic unit type involved in all crashes.

Vehicle Type Involvement	Total Count	
Motorcycle	1	0.08%
Passenger Vehicle	652	53%
SUV	156	13%
Pick-up	67	5%
Truck (2-3 axle)	27	2%
Combination	17	1%
Bus-Passenger	1	0.08%
Emergency Vehicle	6	0.49%
Other	294	24.08%

[4] The location of the fatal crash is estimated to have been about 0.4 miles north of the subject crash area. The fatally injured occupant was classified as a pedestrian for reporting purposes. Alcohol use was cited as a contributing factor. At that time, no work zone was established.

Table 2: Five-year crash severity count by collision configuration.

Collision Type	Fatal	Injury	Property Damage	Total	Percent
Rear End		74	206	280	52%
Sideswipe		36	97	133	25%
Parked Vehicle	1	4	9	14	3%
Other		4	21	25	5%
Guardrail/Barrier		21	43	64	12%
Embankment		2	3	5	1%
Fence			1	1	<1%
Light Pole		1	2	3	1%
Sign Pole			4	4	1%
Tree/Shrub		2	2	4	1%
Construction Barrier		1	1	2	<1%
Crash Attenuator		1		1	<1%
	1	**146**	**389**		

Table 3: Collision configuration by percent per calendar year.

Collision Type	2018	2019	2020	2021	2022
Rear End	52%	56%	28%	48%	63%
Sideswipe	23%	25%	33%	26%	18%
Parked Vehicle	3%	3%	4%	3%	1%
Fixed Object	16%	14%	23%	11%	14%
Other	4%	2%	8%	6%	4%
Backing	1%	0%	0%	0%	0%
Animal	2%	0%	5%	4%	0%
Fire	0%	1%	0%	0%	1%
Overturned	0%	0%	0%	2%	0%
Night	37%	41%	46%	45%	44%
Day	63%	59%	54%	55%	56%
Wet Surface	27%	15%	15%	12%	14%
Dry Surface	73%	85%	85%	88%	86%
Alcohol Related	3%	3%	9%	6%	5%
Truck Related	7%	8%	6%	9%	8%
Total Trucks	3%	4%	4%	5%	4%

Table 4: Five-year count of crash probable cause.

Probable Cause	Total Count	
Influence Drugs	9	2%
Influence Alcohol	24	4%
Influence Combined	5	1%
Physical/Mental	1	0%
Fell Asleep	10	2%
Fail to Give Attention	209	39%
Fail Drive Single Lane	29	5%
Fail Yield ROW	1	0%
Exceeded Speed Limit	**3**	**1%**
Using Cell Phone	2	0%
Stopped in Roadway	2	0%
Too Fast Conditions	**55**	**10%**
Following Too Close	30	6%
Improper Lane Change	**21**	**4%**
Other/Unknown	135	25%

G. CONSTRUCTION PROJECT AND WORK ZONE

6.0 Project Background

The crash occurred within a highway work zone that had been established as specified in the traffic management plan (TMP) for a long-term highway construction project. The project objective was to design and upgrade the median (far-left) shoulders for part-time traffic use for congestion management.[5,6,7] The project was designated as a Transportation System Management and Operation (TSMO) strategy to address recurrent congestion, increase traffic throughput and improve safety.[8,9] The entire project covers about 21.3 miles of I-695 inner and outer loops between Interstate-70 and Maryland Route 43. As noted in the project documents, as of 2015, the project limits encompassed six of the top fifteen most congested roadway

[5] For reference see MDSHA contract number BA0065172

[6] For reference see Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy; Federal Highway Administration FHWA-HOP-15-023; January 2016

[7] Also see Appendix A for additional information.

[8] TSMO is a set of strategies that focus on operational improvements that can maintain and even restore the performance of the existing transportation system before extra capacity is needed. The goal is to get the most performance out of the transportation facilities that already exist (Federal Highway Administration).

[9] Also see Appendix A for additional information.

segments in the state. In general, the project called for upgrading of the pavement surface, drainage, and the installation of overhead electronic lane use control signage.

The crash occurred about 1.85 miles north of the southern project limit. The project section where the crash occurred was designated 1B, a 12.1-mile segment between Interstates-70 and 83. At the time of the crash the current phase of work involved trenching and installation of pre-cast 48-inch-long polymer concrete drains along the outer edge of the median shoulder.

MDSHA described the project delivery process as a Design-Build project as opposed to a (more traditional) Design-Bid-Build project (**Figure 2** depicts the project delivery flow chart as presented in the MDSHA Design Build Manual). The *MDSHA Design-Build Manual* conveys that preliminary engineering and preparation of plans for Design-Build projects differ considerably from Design-Bid-Build projects.[10] For Design-Build, advertisement of the project is prepared by MDSHA and consists of Conceptual Plans with basic geometric information and an Invitation for Bids. The Conceptual Plans and Invitation for Bids are used by the bid team to establish a bid that includes both construction and final engineering. The Design-Build team is responsible for the development and delivery of the final engineering details, plans, and permits that might normally be completed by MDSHA with a typical Design-Bid-Build project. The Design-Build team has the "primary responsibility for controlling and managing the work, including management, design, and construction" and "may also include full responsibility for quality control as defined in the contract documents." MDSHA remains the Project Owner and will continue to oversee the design and construction of the project. Once the project contract is awarded, the MDSHA District office where the project is located assumes the MDSHA management role.

[10] See https://roads.maryland.gov/OHD2/SHA_Design-Build_Manual.pdf

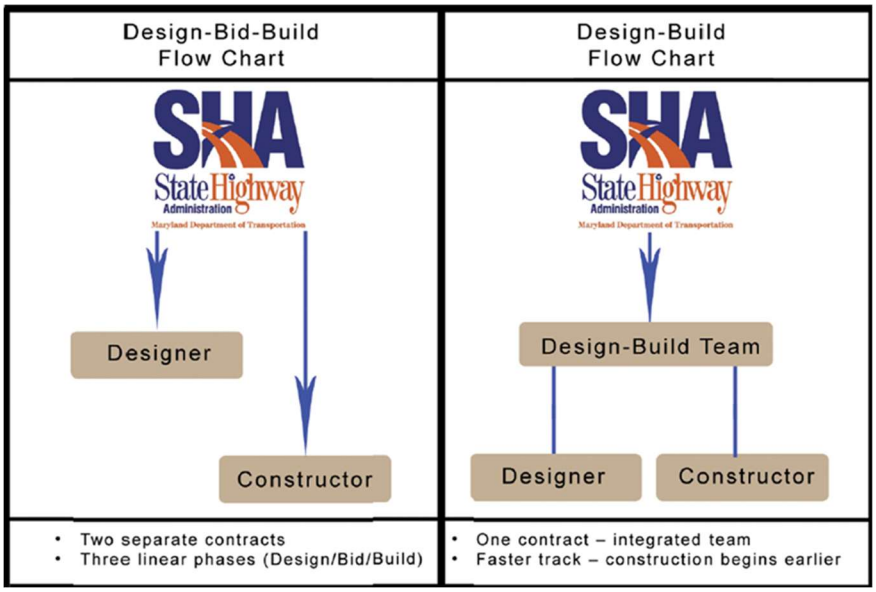

Figure 2: Project delivery flow chart as depicted in the MDSHA Design Build Manual.

As conveyed in *Design-Build Manual*, the "Design-Build contractor is the designer as well as the constructor, which means that they are responsible for problems, issues or changes to their design." The MDSHA Construction Project Engineer does remain involved in tracking the submittal, acceptance and subsequent field changes in design made by the contractor. MDSHA project management still have the responsibility to inspect the work and ensure compliance with project plans and specifications with respect to quality and workmanship.

The MDSHA Construction Project Management is responsible for the inspection of the work and ensuring that the work is built in accordance with the approved plans and specifications, although the contractor is responsible for the design and construction. All work on the project must conform to the *MDSHA Standard Specifications for Construction and Materials* in addition to other MDSHA reference documents and standards.[11]

Maintenance of Traffic (MOT) plans are not developed by MDSHA for Design-Build projects, although a Transportation Management Plan (TMP) is prepared up to the "Red Flag Summary".[12] Maintenance of traffic and construction phasing plans are prepared by the Design-Build team and reviewed with the MDSHA District office and other appropriate divisions. The development and review of these plans serve as a basis for defining project constraints such as work restrictions, lane restrictions, specific phasing requirements, etc. Final roadway plan sheets are submitted by the Design-

[11] See https://roads.maryland.gov/mdotsha/pages/Index.aspx?PageId=65

[12] Red flags are meant to identify locations that may entail additional study coordination; creative management, design, or construction approaches; or increased right-of-way or construction costs.

Build team for MDSHA review and acceptance. Construction notes such as proposed barriers, end treatments, drainage, etc. are included in the plan sheets.

MDSHA held an industry informational meeting in April 2019 to introduce the construction project, identified as *IS-695 from IS-70 to MD 43 Transportation Systems Management and Operations*.[13,14] In May of 2019 a Request for Qualifications (RFQ) was advertised, wherein the Maryland Department of Transportation sought the services of a qualified Design-Builder for the contract.[15] A project overview and goals summary was provided in the RFQ document. This was the first of two phases in the Competitive Sealed Proposals process. The second phase entailed a Request for Proposals. In 2021, Concrete General, Inc. (CGI) was awarded the construction contract. Five of the six highway workers killed in this crash were employed by CGI. The sixth worker killed was an employee of KCI Technologies, Inc (KCI), an engineering firm contracted by MDSHA to provide construction inspection services at the site.

7.0 Work Zone Configuration

The work zone configuration involved a closure of the median (left) shoulder and isolation of the work area by a continuous linking of prefabricated concrete barriers. Installation of the barriers was initiated October 18, 2022, and was completed October 22, 2022. The barrier system design, component requirements and work zone configuration required adherence to several state and federal specifications and standards. Such specifications and standards included, but were not limited to: *Maryland Manual on Uniform Traffic Control Devices for Streets and Highways* (MDMUTCD), *Maryland SHA Book of Standard for Highways, Incidental Structures and Traffic Control Applications*, AASHTO/FHWA *Manual for Assessing Safety Hardware* (MASH) or NCHRP Report 350: *Recommended Procedures for the Safety Performance Evaluation of Highway Features* (for existing systems) and AASHTO *Policy on Geometric Design of Highways and Streets*.[16] Additional requirements and information were referenced on the Temporary Traffic Control Plan (TTCP) sheets within the project plan documents.

Requirement for continuous barrier – During the preliminary project design stage an engineering analysis is conducted to assess the primary functions of a barrier system that include prohibiting motor vehicles from entering work areas; separating and protecting workers from motor vehicle traffic; and shielding construction

[13] See Industry Informational Meeting, April 12, 2019 (https://www.roads.maryland.gov/ohd2/BA0065172_IndustryPres.pdf)
[14] See Design-Build Projects database https://roads.maryland.gov/mdotsha/Pages/Dsbinfo.aspx?PageId=873
[15] See Request for qualifications (overview) https://www.roads.maryland.gov/ohd2/BA0065172_RFQ.pdf
[16] AASHTO - American Association of State Highway and Transportation Officials. FHWA - Federal Highway Administration

elements. Other factors are also considered (e.g., roadway classification, traffic volume, work zone access, type of operation, roadway geometry, exposure, duration, etc.). Ongoing assessments throughout project activities can warrant changes in barrier and work zone protection strategies. Note that the transition zone (including taper, buffer space, etc.) to the longitudinal barrier system was observed but is not further addressed in this report.

For this project, a continuous line of flexible (energy absorbing through deflection) F-shape, 12.8-ft-long, 32-in-high pre-cast concrete barriers was used. The individual panels were linked with loop and pin connectors and required a minimum offset from travelway of six inches.[17] The barrier requires a MASH test level (TL) 3 certification.[18]

As depicted in the **Figure 3** photograph, the Volkswagen was forced into contact with the flexible concrete barrier during the initial contact between the two vehicles. No substantial movement of the barrier was observed.

Figure 3: Photograph depicting evidence of Volkswagen contact with flexible concrete barrier (Maryland State Police – cropped).

[17] See Maryland SHA Book of Standard for Highways, Incidental Structures and Traffic Control Applications standards MD-104.01-53, MD-104.01-54 and Temporary Traffic Control Plan included in construction plan. Note - The difference is that the F-shape barrier features a side that slopes 10 inches above the pavement, while the Jersey barrier has a 13-inch slope. This three-inch difference allows the F-shape barrier to better absorb proportional impacts from smaller vehicles.

[18] Manual for Assessing Safety Hardware (MASH) TL-3 generally requires impact testing using a passenger vehicle (2420 lbs.) and light truck (5000 lbs.) at a speed of 62 mph and up to a 25° angle.

For work zone access and per the project construction plan, the Contractor provided openings in barrier system. The barrier openings were placed at the contractor's discretion as noted in the temporary traffic control plan. The crash occurred at the 3rd inner loop opening from beginning of barrier system. Separation distance between first five to six access openings was estimated at about 0.5-0.6 miles. The length of the barrier opening where the crash occurred was estimated to be 149 feet. The barrier system provided for a work zone area approximately 11 feet in width.

The upstream end (facing oncoming traffic) of the barrier opening required the installation of a crash attenuating end-treatment. Maryland standards required the installation of a two-sided (TS), non-gating (NG), type-E (MDSHA designated TS-NG, Type-E) – energy absorbing system certified to MASH TL-3 standards.[19]

Figure 4 depict images of the F-shape barrier and end-treatment system.

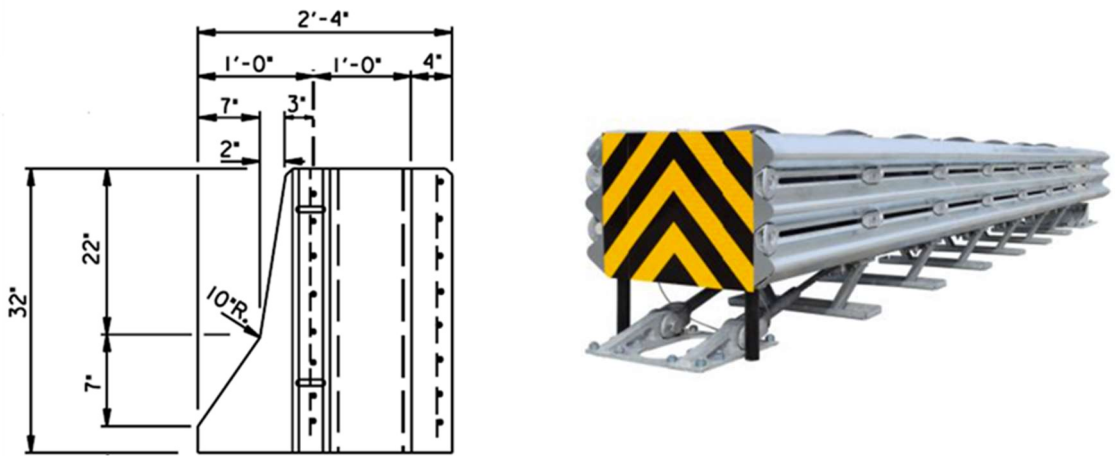

Figure 4: Images depicting F-shape concrete barrier section (left) and two-sided end treatment system (right).

The inner and outer loops of I-695 are divided by a 42-inch-high F-shape rigid concrete barrier system.[20] This barrier exhibited superficial surface damage after having been impacted by the Acura after it was redirected through the work zone access opening, as depicted in **Figure 5**. **Figure 6** depicts an aerial photograph

[19] See Maryland SHA Book of Standard for Highways, Incidental Structures and Traffic Control Applications standards MD-605.12. Non-gating attenuators do not allow the vehicle to pass through when impacted.

[20] See Maryland SHA Book of Standard for Highways, Incidental Structures and Traffic Control Applications standards MD-648.44-01.

(courtesy MSP sUAS flight) of the northern end of the work zone access opening where the collision occurred. The upstream barrier opening end-treatment is visible.

Figure 5: Impact damage to median barrier following Acura contact. (Maryland State Police (cropped))

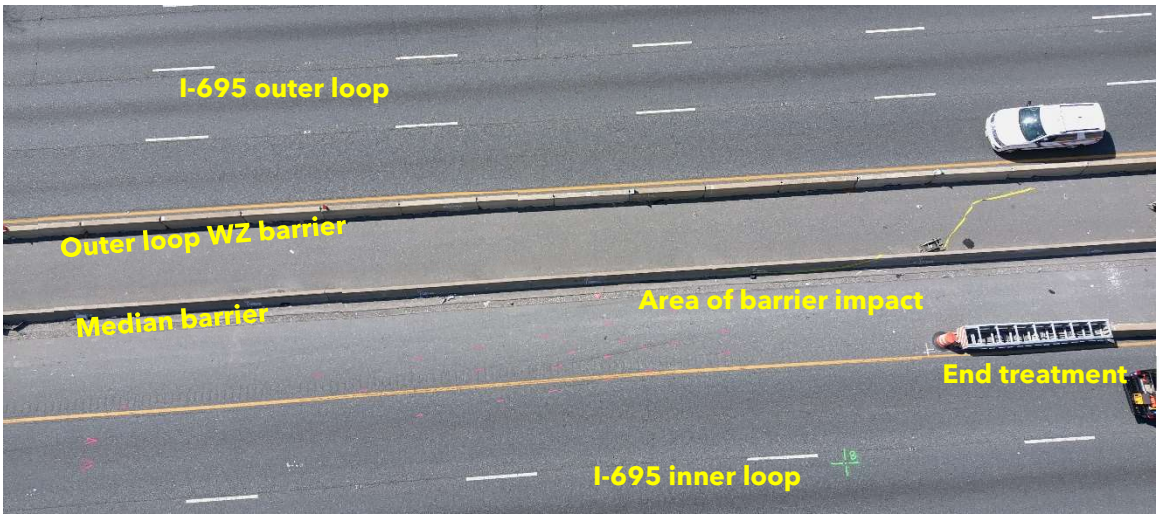

Figure 6: Aerial photograph depicting the northern end of the barrier opening (Maryland State Police and annotated by NTSB).

The work zone area did not intrude into the roadway travel lane and the posted speed limit was unmodified at 55 miles per hour. The work zone configuration and barrier system appeared compliant with relevant standards and guidance as required.

NTSB investigators noted two concerns regarding certain signage did arise following a site examination and review of the TTCP. Investigators noted a "*Shoulder*

Closed" sign (MDMUTCD W21-5), as designated in the Temporary Traffic Control Plan, had been toppled. This sign was installed adjacent the right shoulder, approximately 1260 feet in advance of the work zone area. CGI responded that the sign had recently been struck by a motorist and was scheduled for reinstallation. The TTCP also indicated the placement of "*Trucks Entering Highway*" signs (MDMUTCD W11-10(1) as optional) in advance of, and at the work zone openings.[21] While these signs were not present at the time of the crash, CGI responded that the proximity of the travel lane and limited clearance of any sign erected on the barrier necessitated that the signs be displayed using *Windmaster*® portable sign stands when the openings were being accessed by vehicles. MDSHA similarly responded that the signs were displayed on portable stands when the access openings were to be used. The TTCP provided guidance stating that the "location of temporary traffic control signs and other temporary traffic control devices may be adjusted by the contractor to account for unforeseen field conditions" (TTCP Note 15).[22] **Figure 7** depicts an illustration of the W11-10 "*Trucks Entering Highway*" sign.

Figure 7: MD MUTCD Trucks Entering Highway sign.

8.0 Highway Workers

Six highway workers were inside the work zone and within the errant vehicle's path of travel. All six workers were fatally injured. Five of the six were employed by the principal contractor, CGI, and the sixth by a MDSHA consultant, KCI. The age and gender of the workers were identified as:

- 43-year-old male (CGI)

[21] Maryland MUTCD Section 6F.36 Motorized Traffic Signs (W8-6, W11-10)
Option: (01) Motorized Traffic (W8-6, W11-10) signs may be used to alert road users to locations where unexpected travel on the roadway or entries into or departures from the roadway by construction vehicles might occur. The TRUCK CROSSING (W8-6) word message sign may be used as an alternate to the Truck Crossing (W11-10) symbol sign (see Figure 6F-4) where there is an established construction vehicle crossing of the roadway.
[22] Use of this sign is also presented in the MDSHA Book of Standards for Highways and Incidental Structures, General Notes MD 104.00-13.

- 52-year-old male (CGI)
- 52-year-old male (CGI)
- 30-year-old male (CGI)
- 46-year-old female (KCI)
- 46-year-old male (CGI)

9.0 Work Zone Activity and Inspection

At the time of the crash the current phase of work involved trenching and installation of pre-cast concrete drains along the outer edge of the median shoulder. At the time of the crash the workers were located within the work zone and had been further separated from the access opening by construction material stored within work zone. As noted by CGI and observed in MSP photographs, three pallets of prefabricated polymer concrete trench drain, each weighing approximately 2,240 pounds were linearly positioned between the opening and the likely location of the workers. Other material including lumber and steel rebar were also stacked within about 150 feet from the upstream barrier end treatment. The three pallets were located at distances of about 147, 177, and 201 north of the barrier end treatment. Movement of the Acura through the work zone displaced these pallets and destroyed many of the drains. In addition, a large steel job box, measuring approximately three by three by five feet was also struck and destroyed. Steel rebar rods were displaced into the outer loop shoulder work zone and adjacent travel lanes. At their positions of final rest, the Acura and Volkswagen were approximately 218 and 387 feet north of the upstream barrier end treatment.

Figure 8 is a photograph depicting exemplar pallets of the drain segments positioned within the work zone in a manner similar to that near the access opening.

Figure 8: Photograph depicting exemplar storage of drain pallets within the work zone. (Maryland State Police – cropped)

CGI reported that workers were assigned to specific work areas daily, although their movement within the assigned work area was unrestricted. The median work zone location required daily coordination with all personnel working in the area. Space constraints restricted personnel to their assigned areas including break periods.

CGI reported that safety assessments are performed daily by the Project team at the management and foremen level. Foremen also hold daily pre-work briefings with their crews to discuss the daily work assignments. The Project Superintendent inspects the site daily in addition to a review and discussion of the ongoing and future work with foremen. Current and future safety concerns are also topics of discussion. CGI foremen also host with their crews weekly safety "toolbox talks" prepared by the company's safety department. These talks provide additional guidance to personnel on a broad range of safety-related topics.

The Project Superintendent holds daily conversations with the MDSHA Project Engineer by phone every morning before start of day shift during which future/upcoming work activities are discussed. Regarding specific work zone and traffic safety inspections, CGI stated that daily maintenance of traffic (MOT) inspections was performed by the company's MOT foreman and Project Superintendent along with MDSHA staff. CGI provided copies of their daily MOT inspection reports from January 1 through March 21, 2023.

Review of the daily reports identified no significant issues in the days before the crash. In general, the reports appeared to have pre-established inspection areas such as signs, barricades, arrow panels, pavement condition and an area for comments. Each report contained an AM and PM "time checked" entry.

CGI's Project Superintendent and all foremen working onsite that day held certifications in Maryland DOT Temporary Traffic Control Manager (TCM) and OSHA 30-hour safety and health programs.[23] Similarly most of CGI's hourly employees receive the OSHA 10-hour safety and health training. MDSHA requires at least one individual onsite have a valid MdDOT Temporary Traffic Control Manager certification.

In general, MDSHA stated the contractor must comply with all applicable State and federal requirements governing work zones. Among those requirements are to have onsite staff holding certifications as - Temporary Traffic Control Manager; American Traffic Safety Services Association (ATSSA) Maryland Flagger Certification; Erosion & Sediment Control Manager – Responsible Person Course and Erosion & Sediment Control Certification (formerly Yellow Card).

The MDSHA District office assigns inspectors to the project including a dedicated maintenance of traffic (MOT) inspector having the responsibility to inspect maintenance of traffic set up and review/follow up with the contractor's daily MOT inspection report. The district office also has a Quality Assurance MOT inspector who visits the job site once a week on average.

KCI Technologies, Inc., who employed one of the fatally injured workers, conveyed that they are under contract with MDSHA to augment onsite staff and provide construction inspection personnel having the expertise and training needed to perform inspection services (quality control). KCI reported that MDSHA assigns inspectors to portions of the project on a regular and, often, daily basis. KCI inspectors report to MDSHA routinely or daily to receive instructions for the day. MDSHA is responsible for providing the directions and day to day management of the Inspectors.

[23] MdDOT Temporary Traffic Control Manager program is an 8-hour course designed for field supervisors providing management training for temporary traffic control in work zones. OSHA (Occupational Safety and Health Administration) 30-hour provides training for supervisors and workers on safety and health risk in the field of construction and general industry.

Any limitations or restrictions to a work area or where Inspectors may take rest breaks would be identified by MDSHA or the contractor for the project.

All KCI staff are required to successfully complete the OSHA 10-hour safety certification, and MdDOT Temporary Traffic Control Manager training.[24]

9.1 Truck-Mounted Attenuator

Imagery of the crash location after the event depicted the presence of a truck-mounted attenuator (TMA) protection vehicle parked within the work zone at the downstream side of the barrier opening. CGI and MDSHA reported that truck (and trailer) mounted attenuators have specific applications and are used on this project when temporary lane closures are needed.[25] CGI reported that on the day of the crash after one of its flatbed trucks became disabled the TMA vehicle was being temporarily used as a delivery truck for materials from the laydown yard. At the time of the crash, it was parked and unattended.

For this project, and consistent with other references the TMA (protection vehicle) was used for temporary lane or shoulder closures to protect workers.[26] Guidance presented in the MDSHA Book of Standards (MD 104.00-12) requires that a protection vehicle be used when opening or closing a lane on highways with posted speed limits of 55 mph or more and mobile operations.[27] Typical TMA application provides a barrier temporary protection of exposed personnel or other hazards in slow-moving or stationary operations.

Truck and trailer mounted attenuators are certified to MASH Test Level 3, which generally requires impact testing to the attenuator using a passenger vehicle (2420 lbs.) and light truck (5000 lbs.) at a speed of 62 mph. Impact to the attenuator includes zero-degree angle full, and 1/3 vehicle width lateral offset and at a 15° angle.

10.0 Work Zone Crash History

In response to an NTSB request for work-zone crash history data that included the crash site, MDSHA identified a total of four crashes that occurred in the three-mile segment between I-70 and MD Route 26. All the crashes occurred during the month of

[24] OSHA 10-hour training teaches basic safety and health information to workers in construction and general industry.
[25] Mobile crash attenuators may be mounted on either a truck or trailer (TTMA). The vehicle/attenuator combination is typically referred to as a protection vehicle.
[26] Also see Transportation Research Record 1304, Guidelines for the Use of Truck-Mounted Attenuators in Work Zones (1991); FHWA Manual on Assessing Safety Hardware, Section 2.2.3, Truck- and Trailer-Mounted Attenuators and Portable Work-Zone Traffic Control Trailers.
[27] MDSHA Book of Standards for Highways and Incidental Structures, General Notes MD 104.00-12.

February 2023 and involved only property damage. A review of the specific crash reports identified that none were directly related to this construction project, and none were classified as a work-zone crash.

The crashes are summarized below.

- Vehicle sideswiped left-side barrier propelling debris that struck a second vehicle. Crash occurred ~0.4 mile south of crash site during daytime, under clear and dry conditions.
- Vehicle rearended slow moving traffic attributed to typical congestion. occurred ~0.7 mile south of crash site during darkness, under clear and dry conditions.
- Vehicle struck rear of TTMA while setting up a temporary left lane closure about 0.26 mile north of the crash site during darkness under clear and dry conditions.
- Vehicle slowing for traffic changed lanes to right striking rear of a second vehicle forcing both vehicles into the barrier and was attributed to typical congestion. Crash occurred near I-70 (estimated about 1.1 miles) south of the crash site during daytime under clear and dry conditions.

H. MARYLAND WORK ZONE AUTOMATED SPEED ENFORCEMENT PROGRAM

As codified in the Maryland Transportation Article (MD Annotated Code, Transportation §21-810, "Work Zone Speed Control System"), and colloquially named the Automated Speed Enforcement (ASE) program, the state may deploy automated speed enforcement cameras in highway work zones. The statute imposes certain requirements when ASE is considered for a work zone. Those requirements include:

- Deployed within a designated work zone,
- Deployed on an expressway or a controlled access highway,
- Minimum posted speed limit of 45 MPH,
- Conspicuously signed and the equipment operator present,
- Violations occur when the posted speed is exceeded by 12 mph or more,
- Enforcement results in citation issued to the registered vehicle owner and imposes a fine of $40.

MDSHA described several factors when considering ASE deployment, which can include a request from the (MDSHA) District, a review of the eligible projects, the duration of the project, the type of work zone, and the number of deployments available under the MDSHA ASE contract. MDSHA is currently working to expand the

coverage of the work zone types to include resurfacing, rehabilitation, and restoration projects and increase the number of available deployments under its ASE contract.

Shortly after the implementation of the ASE program in 2009, MDSHA observed a substantial reduction in work zone speed violations. **Figure 9** depicts a graph provided by MDSHA illustrating the percentage of vehicle exceeding the work zone enforcement speed after the introduction of ASE.

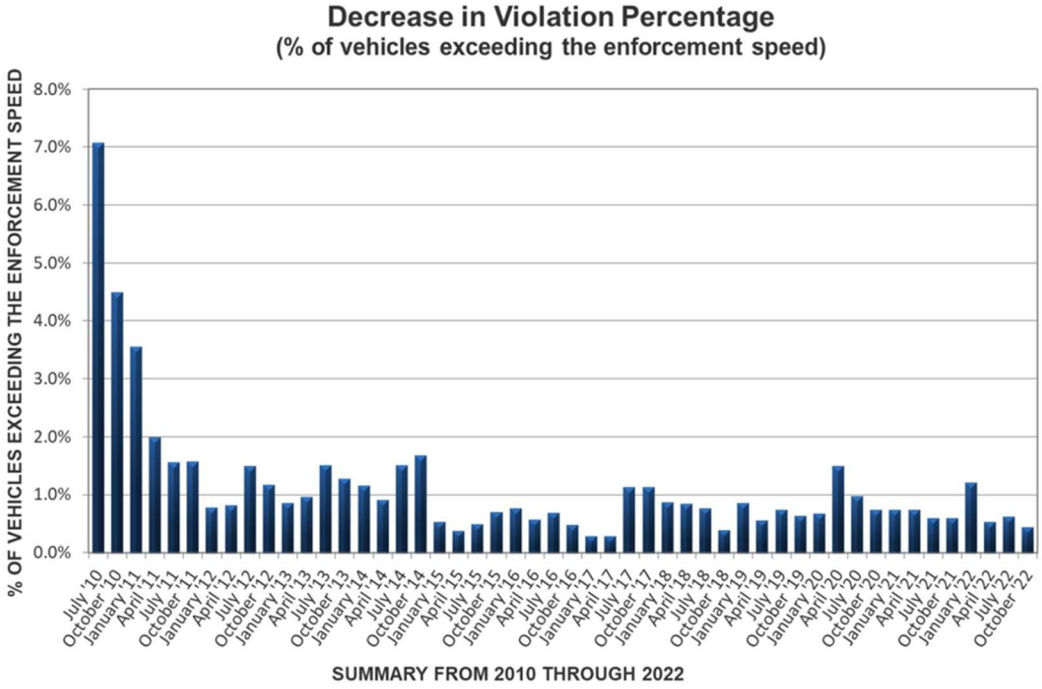

Figure 9: MD State Highway Administration graph illustrating the percentage of vehicles violating the work zone enforcement speed since the introduction of ASE. (MDSHA)

MDSHA commented that when determining whether a work zone area has a speeding issue, consideration is given to crash data from police reports that identify high speed as the cause of the crash, citizen concern, and/or the observation of MDSHA employees or representatives with traffic expertise.

MDSHA has issued guidance on decreasing speed limits within work zones. The guidance document, in part, states:[28]

[28] MD State Highway Administration Application Guideline No. 6-F1 - GUIDELINES ON REDUCED WORK ZONE SPEED LIMITS ON MARYLAND STATE HIGHWAYS, revised 11/07/2022.

The safest traffic conditions in a work zone generally occur when traffic is able to pass through the work site under normal operating conditions. Temporary traffic control through work zones should be designed to accommodate normal operating speeds to the extent practicable. There are circumstances, however, where it may be necessary to reduce the posted speed limit through the work zone. Reduced speed limits should only be used where it is imperative for drivers to reduce speeds in order to safely navigate through lane restrictions or other potential obstacles encountered in the work zone.

Conditions that may factor into the need for a reduced work zone speed limit include:

- *A full width shoulder that will be converted to a travel lane,*
- *Lane widths that will be reduced,*
- *Long-term stationary lane closures on urban freeways/expressways are proposed,*
- *The presence of major work activities immediately adjacent to the travel lanes,*
- *Work zone conditions that dictate a speed limit reduction for safe navigation, for example:*
  - *Work zone alignments (e.g., long-term median cross-over or traffic shift) that will have a design speed less than that of the existing roadway,*
  - *Adverse roadway geometry (below current design standards),*
  - *Sight distance restrictions due to grade or alignment changes*
- *The work zone eliminates usable shoulders,*
- *The crash rate for the roadway (prior to construction) is higher than the statewide average for similar roadways.*

When evaluating the need for a reduced work zone speed limit, other factors to consider include:

- *The length of the work zone (or section of the work zone) where the speed limit reduction is being considered.*
- *The duration of work.*
- *The type of work; and,*
- *The type of temporary traffic control devices to be used and their effectiveness.*

Where it may be necessary to reduce speed limits within a work zone, an engineering study will be conducted to include documentation or analysis of:

- *Traffic conditions during construction,*
- *A determination of the conditions that necessitate the reduced speed limit,*
- *A recommendation of the appropriate speed limit based on traffic conditions,*
- *A statement of the limits of the work zone where the temporary speed limit reduction is to be enforced,*
- *A statement of the times during construction when the temporary speed limit reduction is to be enforced (e.g., throughout all phases of construction, during phase 2 of construction only, etc.).*

Speed limit reductions should be in 5 mph increments with a maximum allowable speed limit reduction of 10 mph. A reduction of 15 mph may be considered for highways with a posted speed limit of 70 mph in special circumstances.

I. WORK ZONE SAFETY IMPROVEMENT AND STATE WORK ZONE SAFETY WORKING GROUP

Following the crash MDSHA and the project contractors, including CGI suspended work on the project. MDSHA then engaged with (and continues to participate with) industry groups and as partner in the Governor's Work Zone Safety Work Group.

11.0 Modification of Project Temporary Traffic Control Plan

MDSHA conveyed that work on certain segments of the project would resume no earlier than September 2023 following acceptance of several changes to the temporary traffic control plan (TTCP) developed by the design-build team. MDSHA provided a draft copy of the TTCP and summarized the proposed modifications as follows:

- *Work areas will include additional temporary daily lane closures next to the median of the inner and outer loops of I-695 between 9 a.m. and 3 p.m.* (the adjacent lane closure will occur when workers are present)
- *Increase use Automated Speed Enforcement (ASE) Systems*
- *Application of reduced variable speed limits through the area when workers are present (MDSHA notes that the VSL system will be implemented when all the components have been delivered and it has been tested).*

- *When workers are present, the speed limit through the work zone will be reduced by 10-mph to 45-mph. When no workers are present, the speed limit through the work zone will be 55-mph. Multiple Variable Speed Limit (VSL) signs will be set up throughout the pilot area on I-695 Inner and Outer loops mainline and ramps to clearly indicate the posted speed limit through the work zone as it changes between 55 mph and 45 mph.*
- *The TTCP also cites a provision that the contractor shall block the opening of access with a protection vehicle (i.e., TTMA) when work is taking place within the vicinity of the construction entrance. The contractor has the option of mounting signs on supports within the work area behind the concrete barriers in lieu of mounting on the barrier.*

MDSHA is also working on initiatives to increase driver awareness and further enhance work zone safety. MDSHA describes some of those initiatives as:

- *Enhancements to the work zone constructability review process of traffic control plans to incorporate recommendations in design or early phases of a project.*
- *Develop new or revised SHA guidelines or policies to supplement existing standards relating to law enforcement presence in the work zone, work zone inspection rating guidelines, protection vehicles, and the expansion of the types of work zones in which ASE is deployed and the number of deployments*

12.0 State of Maryland Governor's Work Zone Safety Work Group

In April of 2023 following this crash, the Maryland Governor announced the creation of a state-wide work group to address work zone safety. The group, chaired by the Lieutenant Governor, was comprised of individuals with expertise in transportation including law enforcement, labor, traffic engineering, highway safety, and workers with direct experience in work zones. The group met regularly between June and November to identify actions to improve work zone safety for roadway workers, law enforcement, and motorists. Group members were tasked with developing a set of recommendations and in November 2023 published a report that focused on recommendations for changing driver behavior, which was identified as the cause for the majority of all work zone crashes. The final report highlighted the work of two subcommittees – Driver Behavior and Roadway Operations – and the recommendations presented by those groups. Certain recommendations presented

by the subcommittees are summarized below. The full report is publicly available at https://governor.maryland.gov/leadership/ltgovernor/policy/Pages/work-zone-safety.aspx. Release of the final report was preceded by a public survey the results of which are referenced in the report and available at the web site noted above.

Driver Behavior Subcommittee recommendations summary:

- *Establish a Culture of Safety and Courtesy – motorists must acknowledge their responsibility to show respect for other road users, minimize distractions.*
- *Driver Manual improvements – the Maryland Motor Vehicle Administration (MVA) should strengthen language around automated speed enforcement and educate drivers that they may be cited without law enforcement present. The MVA should also expand the distracted driving sections that focus on work zone considerations.*
- *Education improvements – encouraging schools to teach young passengers to wear a seat belt and ensuring veteran drivers are aware of changes in Maryland law, such as the expanded Move Over law. Education shouldn't stop with the state-mandated Driver Education Program. This recommendation may also include changes to the existing curriculum and/or online training resources.*
- *Expand education around flashing green-lights – Motorists may recognize orange cones and orange barrels are related to work zones but may not be aware that flashing green lights on trucks relay a similar message. Along with the Roadway Operations Subcommittee, the state should improve the public's understanding of flashing green lights and its context. Authorized by legislation in 2022, highway maintenance vehicles may display flashing green lights in work zones. Prior law only permitted amber flashing lights to warn motorists about upcoming work zones.*
- *Aggressively partner with stakeholders – state agencies should work in partnership with industry stakeholders and safety advocates to seek and reach community groups. These partnerships may include crash simulations, demonstrations, and so forth.*
- *Promote partnership and common goals between the three branches of government.*
- *Improved notifications and signage entering work zones – research shows that alerting drivers of an upcoming work zone can reduce speeds by at least 25% and minimizes hard-braking that leads to*

secondary crashes. The work group recommends expanding SHA and industry's utilization of Alert Systems, such as safety alerts on navigation apps, to improve driver awareness about upcoming roadwork.

- *Automated Speed Enforcement – current Maryland law sets a $40 citation for work zone speed violations (which is the lowest in the nation, with zero points). The work group recommends increasing the citation fine amount and directing revenues towards road safety priorities.*

Roadway Operations Subcommittee recommendations summary:

- *Establish a Culture of Safety - based on the perspective that safety-related questions, feedback, and innovative ideas can be freely shared, discussed, and potentially implemented within state agencies and the contracting community. Develop a platform where broader questions, ideas, and feedback can be received and incorporated into current partnering structures for sharing and responding.*
- *Training and Certification - update current training to ensure the most up-to-date standards, guidance, and best practices are consistently being implemented statewide, by both public and private entities. Frontline workers, as well as drivers of Truck-mounted Attenuators (TMA), would be trained and certified to ensure the safest work zone possible.*
- *Buffer Lanes - review and update warrants and criteria to integrate national best practices for when and how buffer spaces can be implemented in a work zone, on a case-by-case basis. Criteria should take into account the project type, the location, and other contextual considerations.*
- *Worker Protection - propose requiring anyone performing state-approved work on an interstate to wear ANSI Class III leg gaiters or pants. Update guidance to take into account project context, such as temperature and time of day. Identify and implement currently available Personal Protection Equipment (PPE) to ensure maximum visibility as practicable.*
- *Temporary Traffic Control Inspection Program - review and update current MDSHA Work Zone Inspection program to include guidance with more focus on Maintenance of Traffic (MOT) inspection protocols and criteria. Document new resources needed to sustainably support the improved process and requirement for improved tools.*
- *Maintenance of Traffic (MOT) Reviews at Project Design - incorporate into the current Project Design and Delivery process a specific Action Item where the*

proposed Work Zone design and Maintenance of Traffic configurations are reviewed by project stakeholders for appropriateness and feasibility.

- *Contractual Requirements and Incentives for safe practices - develop an incentive structure for safe practices, with associated standards and contractual language. MDOT and its Industry partners would determine goals, criteria, and contract language to integrate into current practices.*
- *Annual Work Zone Safety Summit - establish commitment with partners that a work zone safety summit will be held annually. Each summit should have a specific theme and core audience as well as include introductions to innovations or other technologies not currently in use.*
- *Optimize Use of Current Resources - inventory current safety-related funding and grant opportunities and develop a plan to ensure they are being utilized.*

The employers of the injured workers, CGI and KCI, advised that they are participants with the Governor's Work Zone Safety Work Group.

J. DOCKET MATERIAL

Attachment: General highway plans and temporary traffic control plans
Attachment: General highway plans cross sectional data
Attachment: MD State Highway Administration reference and guidance material list
Attachment: Work zone daily inspection logs
Attachment: Automated Speed Enforcement Program summary
Attachment: MD State Highway Administration Work Speed Limit Guidelines

End of report ----------

Submitted by:

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APPENDIX

Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy

As described by Federal Highway Administration literature, "part-time shoulder use is a transportation system management and operation (TSM&O) strategy for addressing congestion and reliability issues within the transportation system. It is a strategy that may be used as part of a congestion management process (CMP). There are many forms of part-time shoulder use or "shoulder running"; however, they all involve use of the left or right shoulders of an existing roadway for temporary travel during certain hours of the day. Part-time shoulder use has primarily been used in locations where there is recurring congestion due to lack of peak period capacity through the corridor, particularly where other alternatives to peak period operations are infeasible or cost-prohibitive (at least in the near term). In such situations, TSM&O alternatives, including part-time shoulder use, may be most appropriate for cost-effectively reducing delays and improving travel-time reliability. Part-time shoulder use is a form of Active Traffic Management (ATM) and modifies roadway conditions and controls—in this case the number of lanes—in response to forecast or observed traffic conditions. It may be used in combination with other ATM strategies, such as overhead lane control signs, dynamic speed limits, and queue warning".

(See https://ops.fhwa.dot.gov/publications/fhwahop15023/ch1.htm)

Transportation Systems Management and Operations (TSMO)

As described in MDSHA literature "Transportation Systems Management and Operations or TSMO is MDOT SHA's integrated approach to planning, engineering, operating, and maintaining existing facilities to maximize their full-service potential, and ultimately improve the safety, security, and reliability of our transportation network. TSMO looks at performance from a system-wide perspective, not just one strategy, project, or corridor. Strategies are coordinated with others across multiple jurisdictions, agencies, and modes.

The TSMO Program provides an interface to other program areas like asset management, capital projects, planning and programming, maintenance, and construction inside MDOT SHA, with MDOT Transportation Business Units, and other stakeholders through ITS projects, telecommunications infrastructure, Advanced Traffic Management Systems, and data analytics and performance management".

(See https://www.roads.maryland.gov/mdotsha/pages/otmo.aspx?pageid=884)

Maintenance of Traffic Red Flag Summary

Early in the project, after the project corridor or study area is defined, the Project Manager in consultation with the TMP Team will identify maintenance of traffic issues that are present or should be considered during project development. Red flags are meant to identify locations that may entail additional study coordination; creative management, design, or construction approaches; or increased right-of-way or construction costs. Uncovering problem areas prior to developing engineering alternates could help reduce project costs and eliminate project delays. The maintenance of traffic red flag summary shall include an identification of existing barriers that may affect safety and mobility during construction. Identifying any major construction issues at this stage is important so that costly and complex conflicts can be avoided, or at a minimum identified, during the development of preliminary alternates. Before the Core Team field review, the Maintenance of Traffic Red Flag Summary chart shall be completed. Any red flags identified should be presented at the Scoping Meeting (and included in the Scoping Meeting Report).

(See www.roads.maryland.gov/OOTS/07MOTRedFlagSummary.pdf)