ACCELERATED INNOVATION DEPLOYMENT DEMONSTRATION

Notice of Funding Opportunity Number: 693JJ324NF-AIDDP

"Enhancing Roadway Responder Safety through Innovative Debris Clearance and Collection"

US Department of Transportation
Federal Highway Administration

May 28, 2024

Volume I – Technical Approach

MARYLAND DEPARTMENT OF TRANSPORTATION
Taking you places!
STATE HIGHWAY ADMINISTRATION

Accelerated Innovation Deployment Demonstration

NOFO 693JJ324NF-AIDDP

COVER PAGE	
Entity Type	State DOT
Organization Name	Maryland Department of Transportation State Highway Administration
Subrecipient Name	N/A
Project Name	Enhancing Roadway Responder Safety through Innovative Debris Clearance and Collection
Innovation(s)	Next Generation Traffic Incident Management
Is the innovation listed above an EDC Innovation?	Yes
Previously Incurred Project Cost	$ 0
Future Eligible Project Cost	$ 1,140,000
Total Project Cost	$ 1,140,000
AID Demonstration Funding Request	$ 912,000
Total Federal Funding (including AID)	$ 912,000
Is the project currently programmed in one of the following? • Transportation Improvement Program • Statewide Transportation Improvement Program • Metropolitan Organization Long Range Transportation Plan • Long Range State Transportation Plan • Tribal Transportation Improvement Plan	Yes; The 2040 Maryland Transportation Plan (MTP) calls for investment in technology to facilitate 24/7 roadway clearance and public information of incidents through the Coordinated Highways Action Response Team (CHART) (pg. 28)
State in which the project is located	Maryland
Project location (latitude/longitude)	Statewide
Congressional District of Project Location	2401, 2402, 2403, 2404, 2405, 2407, & 2408
Has the applicant previously received an AID Demonstration grant?	No

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PROJECT DESCRIPTION

The Coordinated Highways Action Response Team (CHART) is responsible for clearing debris from nearly 2,000 miles of patrolled highways throughout the state of Maryland. This task poses significant safety risks to CHART responders—workers exit their vehicles to collect and dispose of debris, which exposes them to high-speed traffic on highways and freeways. The safety risks are exacerbated during low visibility conditions (i.e., nighttime and inclement weather). The **Enhancing Roadway Responder Safety through Innovative Debris Clearance and Collection** project (“Project”) seeks to implement Next Generation Traffic Incident Management (NextGen TIM) through the implementation of lane clearing technology that has been demonstrated successfully in an operational environment.

SHA Office of Transportation Mobility and Operations (OTMO) employs more than 40 Emergency Response Technicians (ERTs) to help broken-down motorists and assist with traffic incident management 24 hours a day, seven days a week to improve highway efficiency, safety, mobility, and reliability. Average daily traffic on Maryland’s highways is 19,400 vehicles per day (2018 data) – ERTs assist motorists every 16 minutes and prevent 225-250 secondary incidents each year by clearing the roadway and managing traffic.

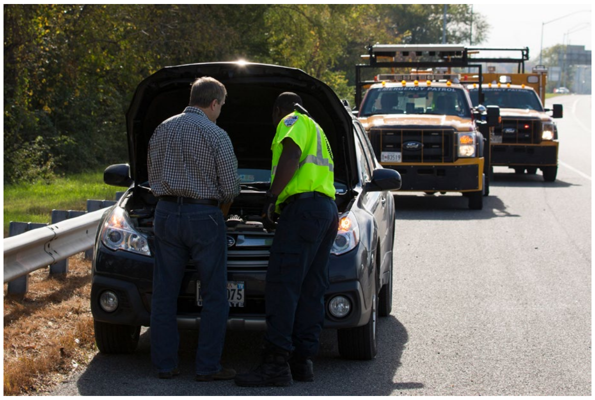


Figure 1 (top): CHART ERT Assists Broken-down Motorist

Figure 2 (middle): CHART ERT Manages Traffic

Figure 3 (bottom): CHART ERT Communicates with Motorist

Technology Readiness Level (TRL) for Proposed Innovation: Debris clearance technology, such as the J-Tech LaneBlade product, is aimed at reducing negative outcomes for roadway workers by providing safe and efficient debris removal without endangering lives. The technology has been implemented at 20 agencies in the United States and Canada. The technology currently stands at a TRL of 8. This is evidenced by the successful demonstration of the technology in a relevant environment, specifically through field evaluations conducted by SHA and the University of Maryland (UMD).

IMPLEMENTED AT
20 AGENCIES

Background and State of Knowledge to Support Deployment: Debris removal systems are defined by Federal Highway Administration (FHWA) as "truck-mounted devices to help agencies remove roadway debris without exposing individuals to the hazards of live traffic". They are considered Next-Generation Traffic Incident Management technology and are included on the EDC-7 Fact Sheet.

Current Organizational/Institutional Experience with Innovation: SHA engaged UMD to conduct a literature review, survey current operations, design an evaluation plan, conduct a field evaluation, and develop a final report and guidelines for implementation. Debris clearance truck modifications have been field-tested and evaluated for effectiveness and safety. Experiments conducted on October 16 and November 17, 2023 at SHA facilities demonstrated its capability in various scenarios, including handling different types of debris and operating conditions. These tests have shown that the truck innovations can effectively clear debris such as stones, dirt, tires, wood, and heavy metal objects, under both dry and wet conditions.

Potential Scope of Impact of Innovation on Conventional Practice: The deployment of debris removal technology can revolutionize debris clearance practices by significantly reducing manual labor, enhancing safety for CHART responders, and improving traffic flow and road safety. Its ability to clear various types of debris efficiently makes it a versatile tool for roadway maintenance, potentially setting a new standard for debris removal operations.

Future Deployment as Standard Practice: Post-evaluation, debris removal technology is anticipated to be adopted widely as a standard practice within SHA and potentially by other state highway agencies. Training programs and operational guidelines will be developed to facilitate its integration into current roadway maintenance and emergency response protocols.

Context and Other Investments: This Project aligns with broader investments in transportation safety and efficiency. It complements ongoing efforts by SHA and other transportation agencies to innovate in traffic incident management and roadway maintenance. The support through AID Demonstration funding will not only bolster this specific project but also contribute to the overarching goal of advancing sustainable and safe transportation practices.

PROJECT LOCATION

Maryland's highway system is divided into four regions: National Capital Region, Baltimore Region, Western Region, and Eastern Region. Multiple Census tracts surrounding the highways are identified as areas of persistent poverty and/or recognized by USDOT as disadvantaged, particularly in the Baltimore and Eastern regions. The highways are used by multiple local transit services as well as Metrobus (connects Maryland, DC, and Virginia). SHA proposes deploying enhanced debris-removal trucks in three locations that represent both urban and rural areas: adjacent to Washington, DC, around the City of Baltimore, and in the Eastern region. **Figure 4** presents the suggested pilot deployment areas as well as the routes serviced by CHART ERTs and surrounding Census tracts that USDOT recognizes as inequitable. The average daily traffic on the freeways is 19,400 vehicles per day (2018 data), and there were 1,607 events related to obstructions in 2022.

19,400
VEHICLES PER DAY (2018)

1,607
OBSTRUCTIONS IN 2022

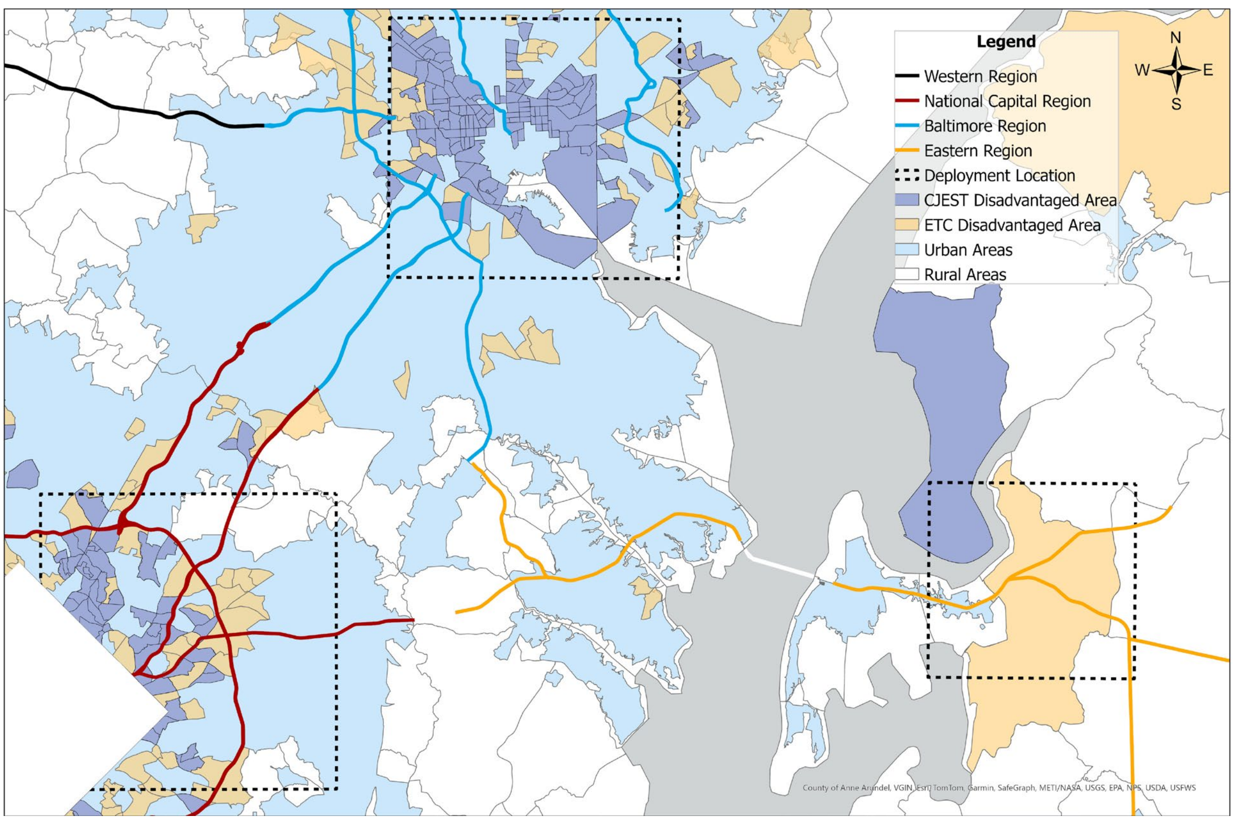


Figure 4: Map of Proposed Deployment Areas

The rough geospatial data for the three deployment areas are listed in **Table 1.**

Table 1: Geospatial Data for Pilot Deployment Areas

Region	Long_Lat_A	Long_Lat_B	Long_Lat_C	Long_Lat_D
Baltimore	39°22’12.0”N 76°42’12.0”W	39°22’12.0”N 76°27’29.0”W	39°11’35.0”N 76°27’29.0”W	39°11’35.0”N 76°42’12.0”W
National Capital	39°2’54.8”N 77°1’35.1”W	39°2’54.8”N 76°45’69.7”W	38°50’37.0”N 76°45’69.7”W	38°50’37.0”N 77°1’35.1”W
Eastern	39°2’86.7”N 76°14’25.6”W	39°2’86.7”N 76°3’33.1”W	38°54’71.7”N 76°3’33.1”W	38°54’71.7”N 76°14’25.6”W

The Project will be monitored for its effects on congestion. Roads are typically divided highways, varying between two and five lanes in each direction. Currently, traffic must be stopped to allow debris removal from the roadway. Lane closures lead to congestion, which can cause secondary accidents and increase greenhouse gas emissions due to idling vehicles.

PROJECT PARTIES

The Maryland **State Highway Administration** (SHA) will be responsible for pilot demonstration, implementation, and reporting to FHWA. They have experience with receipt and expenditure of Federal-aid highway program funds under Title 23 USC. While Maryland has never received an AID award, it has been selected for several State Transportation Innovation Council (STIC) Incentives since 2014 and was recognized with an Excellence Award for embracing innovation in 2020. Successful EDC implementations can be found on FHWA’s State Innovation Accomplishments.

The A. James Clark School of Engineering at the **University of Maryland** (UMD) has partnered with SHA to test capabilities of truck-mounted debris removal systems. Their work includes a literature review, information gathering and survey, development of an evaluation plan, two field evaluation tests, and development of a final report and guidelines.

PROJECT OUTCOME CRITERIA

Project Impact, Monitoring, and Innovation Effectiveness

The implementation of the debris-removal technology pilot program is anticipated to have a significant beneficial impact on roadway maintenance and traffic management. By systematically evaluating the performance of the innovation-equipped vehicles, SHA and UMD expect to see tangible improvements in the speed and efficiency of debris clearance.

The Project directly contributes to lessening commute times by improving debris clearance efficiency and reducing traffic congestion. This is particularly crucial for underserved communities, where residents often rely on road transportation for access to essential services and employment opportunities. Furthermore, efficient debris clearance leads to smoother traffic flow, which in turn contributes to a reduction in vehicle emissions. This aspect aligns with the environmental goals of the Justice 40 Initiative, as it aids in decreasing greenhouse gas emissions and improving air quality. Thus, the debris removal pilot program not only enhances roadway safety and efficiency but also supports the broader objective of promoting environmental justice and equity in transportation infrastructure.

The pilot program for assessing the debris removal solution aims to establish key parameters for monitoring and improving debris clearance efficiency and traffic flow restoration. Through this program, vehicles equipped with GPS tracking will accurately measure the performance in real-world scenarios. This initiative will enable evaluation of the solution’s impact on roadway safety and congestion mitigation.

Quick analysis, covering a 10-year period starting in 2026, examines the impact of this technology in reducing additional vehicle hours traveled (VHT) on Maryland freeways.

The analysis utilizes an average daily traffic volume of 19,400 vehicles/day, sourced from the Maryland government’s data for 2018. This conservative figure serves as the basis for calculating potential travel time savings.

Various clearance times for debris removal are considered in the no-technology scenario, ranging from 15 to 60 minutes. In contrast, the technology implementation scenario assumes a 75% reduction in clearance time due to the new equipment. This substantial decrease in clearance time is expected to facilitate quicker return to normal traffic flow, thereby significantly reducing travel time costs.

The economic benefits are calculated in constant 2021 dollars, adhering to USDOT BCA guidance. Non-carbon costs and benefits are discounted at a 3.1% rate to present value terms, ensuring a comprehensive and accurate economic evaluation.

NO-TECHNOLOGY:
15 to 60 minutes

TECHNOLOGY IMPLEMENTATION:
75% reduction in time

Table 2 demonstrates the computation of these travel time cost savings for a scenario with a 30-minute clearance time in the no-technology state. The analysis details how the reduction in clearance time translates into considerable cost savings over the 10-year analysis period.

Table 2: 2025 Travel Time Cost Savings

Input			Value	Units
a	Number of Events Related to Obstructions in 2022		1,607	
b	Clearance Reduction Rate with New Equipment		75%	
c	No-Build Clearance Time		30	Minutes
Daily Obstructions Clearance Time				
d	No-build	**(a*c)/(365*60)**	2.2	Hours/Day
e	Build	**d*(1-b)**	0.55	Hours/Day
f	Avoided Clearance Time	**d-e**	1.65	Hours/Day
g	The Volume Related to the Obstruction Clearance	**19,400*(d/24)**	1,779	Autos
h	Reduced Vehicle Hours Traveled (VHT)	**f*g*365**	1,072,335	VHT/Year
i	Average Vehicle Occupancy		1.67	Persons/ Automobile
j	Recommended Hourly Values of Travel Time Savings		19.6	2021$/Person-hour
k	**Value of Travel Time Savings Benefit**	**h*i*j**	**35.1**	**in Millions**
l	*10 Years Benefits after 3.1% Discount*		*651.75*	*in Millions*

Obstructions Event Data Source: https://ritis.org/traffic/

Volume Data Source: https://data.imap.maryland.gov/datasets/maryland::maryland-annual-average-daily-traffic-annual-average-daily-traffic-sha-statewide-aadt-lines/explore

Table 3: Key Performance Indicators provide information regarding how the debris-removal pilot will be monitored for its effectiveness. When proven to be effective, efficient, and resulting in better outcomes for roadway users, the technology will be added to additional ERT vehicles and used throughout the CHART response area.

Table 3: Key Performance Indicators

KPI	Description
Debris Clearance Time (DCT)	Time from debris detection to complete clearance.
Roadway Clearance Time (RCT)	Time taken to restore traffic flow to normal post-clearance.
Volume of Debris Cleared	Quantitative measure of the amount/type of debris cleared.
Secondary Accident Incidences	Number of accidents occurring during/after clearance.
Traffic Congestion Metrics	Changes in traffic patterns and congestion levels.

↗ **Data Collection Methods:** To enable KPI development, SHA will focus on implementing robust data collection methods. Currently, all incidents are logged, tracked, and monitored using the RITIS (Regional Integrated Transportation Information System) platform. By integrating RITIS data with GPS locations from debris removal-equipped vehicles, SHA can correlate the duration of each debris clearance operation with traffic flow changes. Alongside this, SHA will catalog the types of debris encountered during each operation. This dual approach of combining RITIS data with GPS tracking will provide a comprehensive understanding of the solution's impact on incident management and traffic flow efficiency.

Project Description and Pilot Deployment

The overall goal of the Project is to improve outcomes for all roadway users and workers in circumstances where debris needs to be removed from the roadway. The debris-clearing technology has been implemented successfully in other jurisdictions and performed well during two SHA/UMD experiments conducted in 2023. The technology readiness is level 8 or greater. The Project's alignment with FHWA's Technology and Innovation Deployment Program goals is described in **Table 4: Project Alignment with TIDP Goals.**

TECHNOLOGY READINESS LEVEL

8

Table 4: Project Alignment with TIDP Goals

TIDP Goal	Alignment with SHA's Pilot Project
Accelerate Adoption of Innovative Technologies	The Project is focused on introducing a NextGen TIM technology for roadway debris clearance, exemplifying the rapid adoption of innovative technologies in surface transportation.
Leadership and Incentives for State-of-the-Art Technologies	The Project demonstrates and promotes new technology in highway operations. It aims to set new performance standards in roadway safety, efficiency, and operational quality.
Improve Highway Efficiency, Safety, Mobility, Reliability, Environmental Sustainability	The Project enhances highway efficiency and safety by automating debris removal and collection, thus ensuring quicker clearance and safer roadways. It also has potential environmental benefits by reducing idling times during debris clearance.
Develop and Deploy New Tools and Practices	The Project represents the development and field application of a novel tool in highway maintenance, potentially setting a new standard in debris removal practices.

Project Readiness

The Project will be ready to authorize within six months of award. Refer to the Project Schedule for a detailed timeline.

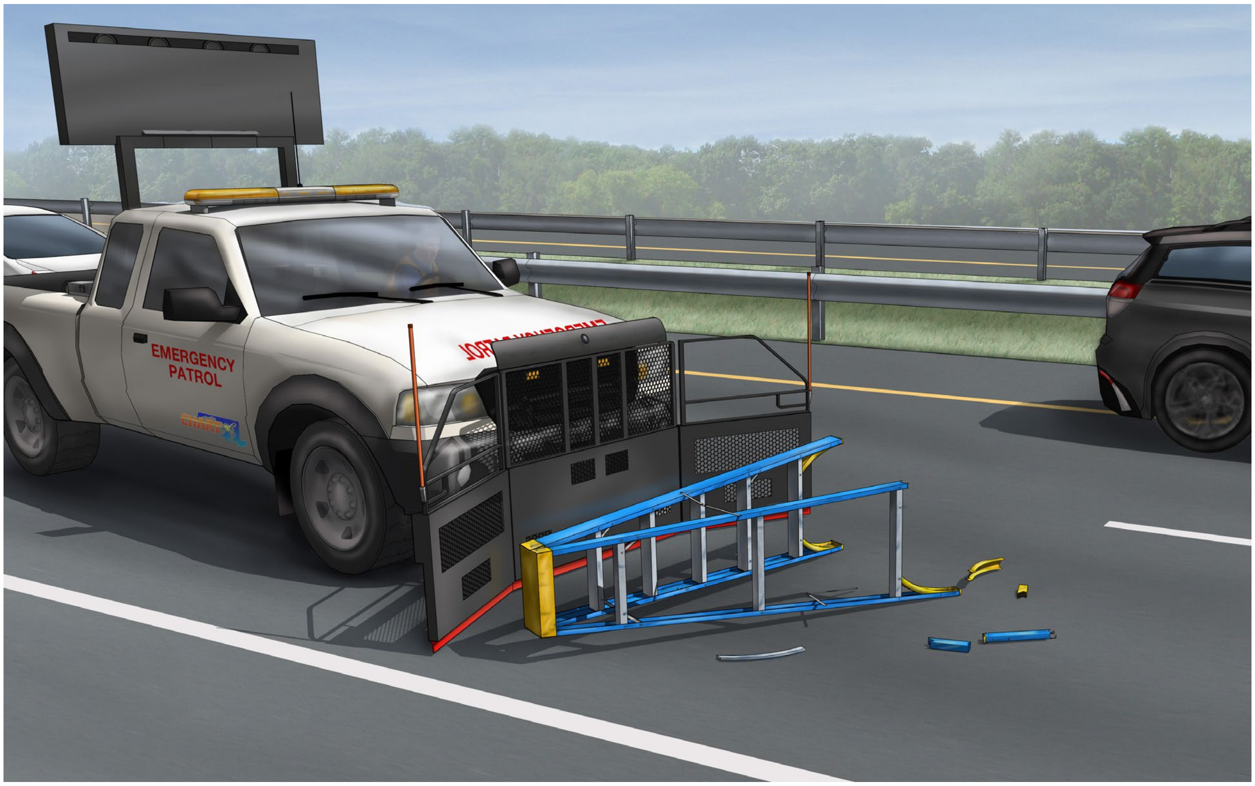
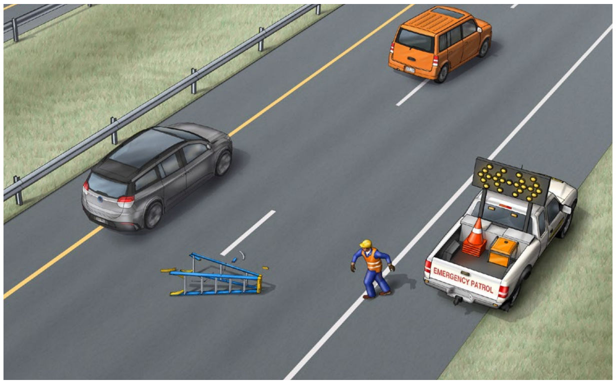


Figure 5: Emergency Response Truck Collects Debris

Administration Goals

↗ **Safety:** Clear roadways are critical to safety, and debris removal is a key element of clear roadways. As part of a Traffic Incident Management System, debris-removal vehicles offer safer methods of removing items from roadways. Workers are able to stay in vehicles and not endanger themselves by entering traffic. FHWA's Public Roads – Winter 2023 publication includes debris-removal vehicles, a next-generation TIM innovation.



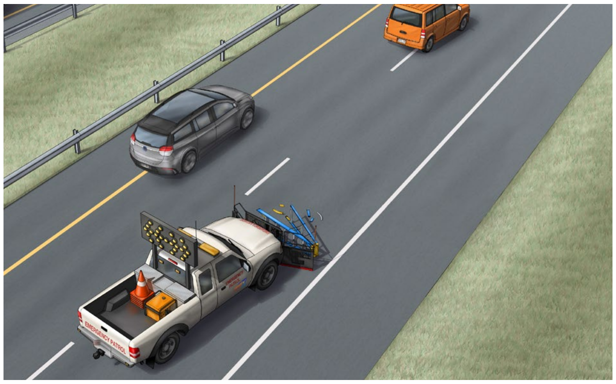


Figure 6 (left): CHART ERT Exits Vehicle and Removes Debris

Figure 7 (right): CHART ERT Stays in Vehicle and Removes Debris

THE VEHICLES ARE EXPECTED TO RESULT IN THE FOLLOWING POSITIVE OUTCOMES:

- Reduce secondary crashes
- Improve road user safety
- Improve responder safety
- Improve transportation systems resiliency
- Improve trip reliability
- Reduce mortality and morbidity rates related to injury crashes
- Reduce greenhouse gas emissions

The technology, tested during the 2023 SHA experiments, is similar to the debris-removal devices implemented by the Pennsylvania Turnpike Commission. The International Bridge, Tunnel and Turnpike Association (IBTTAA) awarded the Commission with a 2023 Toll Excellence Award for Safety, providing evidence of the technology's maturity and improved safety outcomes.

↗ **Climate Change and Sustainability:** This Project will positively impact greenhouse gas emissions and avoid adverse environmental impacts. Implementation of debris-removal vehicles is expected to reduce the time for clearing incidents from roadways, which directly impacts fuel consumption and vehicle emissions. In 2022, [CHART responded to 28,972 incidents] throughout Maryland highways; the total number of recorded incidents was 38,957.[1] CHART interventions reduced the time required to clear an incident or roadway debris. CHART intervention reduced the average time for clearing incidents from 39.04 minutes to 27.67 minutes. This resulted in a reduction of more than 70,000 metric tons of CO2 emissions in 2022. CHART's direct benefits to highway users in 2022 resulted in $2.03 billion (combined savings includes reductions in emissions, fuel consumption, and value of delay time).

CHART'S DIRECT BENEFITS TO HIGHWAY USERS:
$2.03 BILLION in combined savings

Implementation of debris-removal technology on CHART vehicles is expected to reduce incident clearance time by 75%. The shorter clearance time will further reduce greenhouse gas emissions from delays and idling vehicles, and result in fewer gallons of gasoline consumed by road users.

↗ **Equity:** As shown in Figure 1, there are multiple disadvantaged Census tracts within the planned deployment areas – 43% of the total population is considered disadvantaged. These vulnerable communities will benefit from expedient response to incidents that will prevent extended traffic disruptions. Reducing incident-related congestion improves safety for responders and the public as well as enhances overall traffic flow. Based on FHWA's Traffic Incident Management Performance Measurement report, improving incident clearance time results in increased driver and responder safety (including a reduction in secondary accidents, fatalities, injuries, and property damage), congestion relief, better preparation for large-scale emergencies, better use of public resources, and reduced emissions. Equipping SHA vehicles with debris-clearing technology will improve safety outcomes in disadvantaged communities by reducing the time that travelers spend on unsafe roadways.

Table 5: Population in Deployment Areas

Deployment Area	Congressional District	Disadvantaged Population	Total Population
Baltimore	2, 7, & 3	476,105	835,261
National Capital Region	8, 4, & 5	329,156	1,029,574
Eastern	1	5,152	13,549

[1] *Refer to page 9 of CHART 2022 Performance Report*

- **Workforce Development, Job Quality, and Wealth Creation:** MDOT Secretary's Office (TSO) has ongoing partnerships with the Community College of Baltimore County (CCBC), Anne Arundel Community College, Morgan State University, University of Maryland Baltimore County, University of Maryland Global Campus, and Stevenson University for training and tuition reimbursement programs. In March 2023, SHA successfully registered an Apprenticeship program through the Apprenticeship Maryland Program (AMP) for Heavy Equipment Maintenance Technicians. SHA is currently selecting mentors for the program and evaluating locations to host apprentices. There are two additional programs in early development at SHA for Diesel Mechanics and Facility Maintenance Technicians.
- **Previous Awards:** Maryland has not previously been granted an AID Demonstration award. This would be the first.

PROJECT READINESS AND ENVIRONMENTAL RISK

Technical Feasibility

Technical feasibility of the debris removal innovation was observed through two Proof of Concept events conducted in the fall of 2023. The first set of experiments was conducted on 10/16/2023 at an abandoned SHA facility (2333 W Joppa Rd, Timonium, MD 21093). The second set of experiments was conducted on 11/17/2023 at an SHA facility (10615 Falls Rd, Timonium, MD 21093).

Two types of LaneBlade equipment were tested: one with a steel blade ("Steel LaneBlade") and the other with a rubber blade ("LaneBlade"). They were installed on two CHART emergency patrol vehicles, and the drivers of the trucks were CHART responder supervisors with over twenty years of working experience. During the experiments, the CHART responders were asked to clean the debris as if it were on the highways they patrol.

The first experiment included several types of debris, including stone (with sand), dirt, tires (two complete truck tires and one piece of tire debris), wood (three large and small pieces), metal debris (including a steel pipe), and signs (imitated by wooden plates).

Debris tested in the second experiment included stones, dirt, tires, wood (multiple pieces), heavy metal debris (a manhole cover), abandoned motorcycles, and abandoned cars. For stones, dirt, and wood, the debris was wet manually to imitate rainy weather.

The experiments were designed by a UMD research team and conducted by the CHART operations team. The debris was provided and prepared by an SHA maintenance shop. The SHA Office of Communications observed the experiments.

The experiments were considered successful and determined that the steel version of the product was more efficient and effective than the rubber model. CHART responders were able to move up to 3,000 pounds (similar to a passenger car) when vehicles were operated at five miles per hour.

MOVE UP TO
3,000 POUNDS

Figure 8: LaneBlade Equipment (from J-Tech, 2022)

Project Schedule

The Project will begin in October 2024 (Q4) and will extend through December 2026. SHA will develop an operational framework for procurement, deployment, and evaluation of the debris-clearance technology.

Project Coordination will be crucial, ensuring SHA and stakeholders concur regarding goals and timelines. **Grant Compliance and Execution** activities will ensure that the project adheres to the stipulations of the grant agreement and reporting requirements.

As the project progresses through 2025 and beyond, emphasis will be placed on **Progress Reporting** to maintain transparency and monitor the Project's advancement against its objectives. **Procurement and Contracting** will be initiated to secure the necessary resources and services for the technology's deployment.

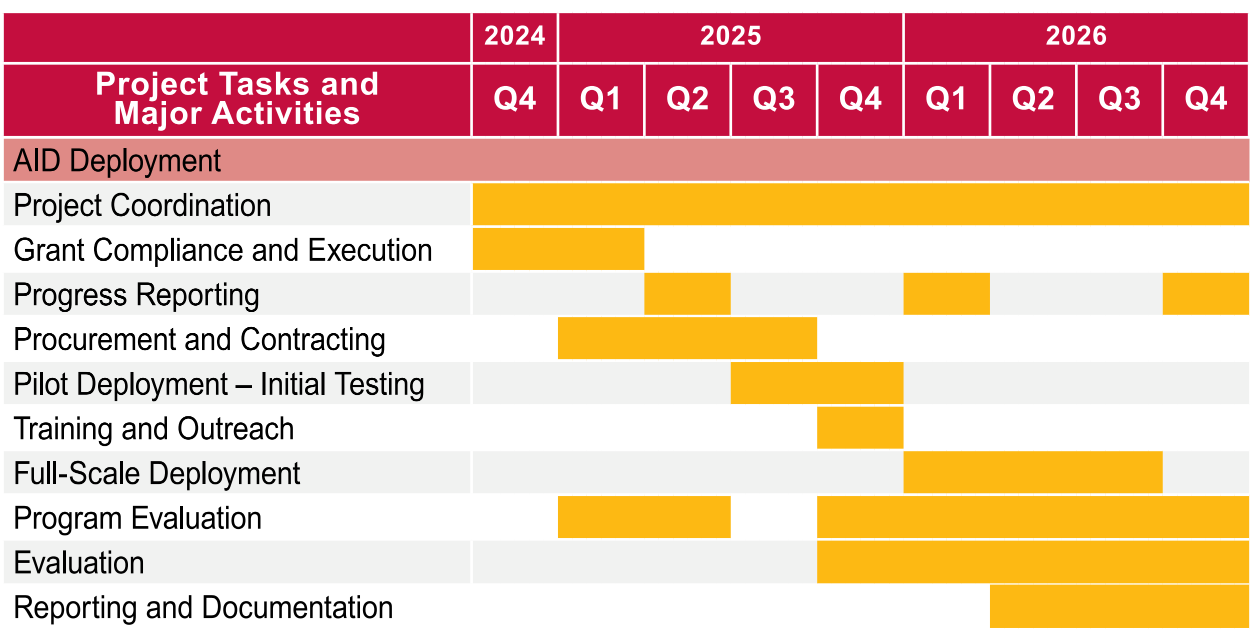
The second and third quarters of 2025 will be a pivotal period as the project transitions into the **Pilot Deployment and Initial Testing** phase. This stage is designed to test the technology in controlled scenarios to validate its functionality and effectiveness. The findings from this phase will inform the subsequent steps and any necessary adjustments to the deployment strategy.

Training and Outreach activities will also commence during the first half of 2025, equipping CHART responders with the knowledge and skills required to operate the new technology effectively. This stage is critical for ensuring user competency and fostering acceptance of the new system. SHA anticipates two training periods: one will prepare CHART responders for removing debris during the spring-summer-fall seasons and a second period to prepare for winter (snow, ice, sleet, etc.) weather.

Entering the second half of 2025, the project will move into **Full-Scale Deployment,** leveraging the insights from the pilot tests to implement the technology across a wider area. This broader application will provide a more comprehensive understanding of the technology's impact in various conditions and settings.

Throughout the entire project duration, **Program Evaluation** will be an ongoing activity, serving as the backbone for continuous improvement. Evaluation efforts will assess the effectiveness, efficiency, and user satisfaction with the technology, with the ultimate goal of enhancing the safety and operational capabilities of CHART responders.

By the end of the project in the fourth quarter of 2026, extensive **Reporting and Documentation** will capture the project's outcomes, challenges, and lessons learned. This comprehensive documentation will be vital for informing future decisions about the technology's potential wider adoption and for reporting back to the grantors and stakeholders involved in the project.



↗ Deliverables

DELIVERABLES WILL INCLUDE

1. **Final Project Schedule:** The deliverable will include detailed schedule, outlining key milestones, deadlines, and the sequence of activities planned for the project. It will include start and end dates for each task, dependencies between tasks, and may also indicate which team members are responsible for each task. This schedule will be crucial for tracking progress and ensuring that the project stays on track.
2. **Equity and Outreach Plan:** This plan would focus on ensuring equitable participation and benefits from the project, particularly for underrepresented or disadvantaged communities.
3. **Testing Plan:** This document would describe the procedures for testing the project's components, in this context, likely the effectiveness and efficiency of the proposed technology. It would cover test scenarios, criteria for success, methodologies for collecting and analyzing data, and risk management strategies during testing.
4. **Data Collection and Implementation Plan:** This deliverable would outline the methods for collecting, managing, and analyzing data throughout the project. The document will detail the types of data to be collected, data sources, collection frequencies, tools and technologies used. The plan would also describe how this data will be used to guide and adjust project implementation.
5. **Operation and Maintenance Plan:** This plan would detail how the project's implementation will be operated and maintained post-implementation. It includes schedules for regular maintenance, guidelines for operation, troubleshooting procedures, and plans for long-term sustainability.
6. **Semi-annual Project Progress Report (January 30, July 30):** These reports would provide updates on the project's progress, summarizing activities completed, milestones reached, any challenges encountered, and solutions implemented. It would also compare planned versus actual progress and may include financial reporting.
7. **Final Project Report (6 months after project completion):** This comprehensive document would summarize the entire project from start to finish. It would include an overview of the project, methodologies used, results of testing and data analyses, achievements versus initial goals, lessons learned, and recommendations for future related projects. It might also include case studies or specific instances to highlight particular successes or challenges.

Project Approvals

↗ Environmental Permits and Reviews

No environmental permits or reviews are required for the pilot deployment. Still need to talk about public engagement/comments.

↗ State and Local Approvals

No local approvals are required. Maryland's 2040 Transportation Plan calls for investment in technology to facilitate 24/7 roadway clearance via CHART (page 28).

Assessment of Project Risks and Mitigation Strategies

Table 6 identifies factors that could affect the successful implementation of the Project and provides a summary of the risk and mitigation strategies.

Table 6: Project Risks and Mitigation Strategies

Risk	Description	Mitigation Strategies
Procurement Delays	Delays in procuring equipment/services could delay the project.	• Establish relationships with multiple suppliers. • Develop contingency plans. • Monitor procurement processes. • Include buffer in schedule.
Pushback from Stakeholders	Resistance from communities or stakeholders could lead to delays.	• Proactive community outreach. • Establish open communication. • Incorporate stakeholder feedback. • Develop community benefit plans.
Technology Performance and Reliability	Issues with the performance or reliability of proposed technology.	• Conduct thorough testing under various conditions. • Maintain a close relationship with the technology provider. • Develop contingency plans for technological failures.
Training and Operational Challenges	CHART responders may face challenges in operating new technology.	• Implement comprehensive training programs. • Provide ongoing support and refresher courses. • Collect feedback for continuous improvement.
Inaccurate Data Collection	Risk of collecting data that is not accurate, leading to flawed analyses and decisions.	• Implement rigorous data validation and verification processes. • Use multiple data sources for cross-verification. • Regularly calibrate and maintain data collection and equipment.
Adoption of New Methodologies for Data Collection	New data collection methodologies may not be well understood or may not integrate well with existing systems.	• Conduct pilot tests for new methodologies. • Provide comprehensive training to personnel. • Ensure compatibility with existing systems before full implementation.