Advanced Transportation Technologies and Innovative Mobility Deployment (ATTIMD) Program

Notice of Funding Opportunity Number: 693JJ322NF00010

"Rural Opportunities to Use Traffic Technology Enhancements (ROUTE) on US 50"

US Department of Transportation
November 18, 2022

Volume I

MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

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MDOT
MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

Project Name	Rural Opportunities to Use Traffic Technology Enhancements (ROUTE) on US 50
Eligible Entity Applying to Receive Federal Funding	Maryland Department of Transportation (MDOT) State Highway Administration (SHA)
Total Project Cost (all sources)	$14,918,750
ATTAIN Request	$11,935,600
Are matching funds restricted to a specific project component?	No. 20% of state dollars will be spread across the lifespan of the project.
State	Maryland
Is the project currently programmed in the: » Transportation Improvement Program » Statewide Transportation Improvement Program » MPO Long Range Transportation Plan » State Long Range Transportation Plan	Yes. » Maryland Statewide Transportation Improvement Program (STIP), see page 70 "Rural Projects for Areawide Congestion Management." » The Transportation Systems Management and Operations Master Plan is referenced in the Maryland Consolidated Transportation Plan under the "CHART funding for TSMO" and is the Long-Range Transportation Plan for ITS.
Technologies proposed to be deployed (briefly list)	» Machine Learning Traffic Prediction » Signal Timing DSS: Q^2 Inverse Traffic Responsive, Incident Signal Timing, Adaptive Traffic Signal Control, and ATSPMs » Travel Information via DMS, Travel Time Signs, web sites, and push notifications for rental apps » Connected Vehicle SPaT and Curve Warning » Traffic Sensors » TMC and ATMS integration » Freeway Incident Traffic Management
Will the project use connected vehicle technologies? If so, which technologies will be used?	Yes. Connected vehicle technologies will utilize CV2X over 5.9GHz. The traffic detectors, vehicle re-identification detectors using WiFi and Bluetooth, and CCTV cameras will use 4G.
Will the project use automated driving system technologies?	No
Rural Considerations: a) Is the project serving a rural area? b) If yes, how much ATTAIN funding is being requested to be put toward serving the rural areas?	Yes. The project services multiple rural areas. 82% of the corridor traverses areas with populations less than 50,000 residents according to the 2010 Census. Accordingly, 82% of ATTAIN funding will be put toward rural areas for a total of $12,233,375.

Project Summary

The Rural Opportunities to Use Traffic Technology Enhancements (ROUTE) on US 50, called ROUTE 50 throughout this application, is an innovative and unique approach to dynamically managing traffic. ROUTE 50 focuses on improving safety, travel time reliability, mobility and quality of life in the rural communities along the 113-mile US 50 corridor between the oceanside resort areas and the Baltimore-Washington metro area. Seasonal congestion on US 50 creates a barrier that divides communities, impairs emergency responder response time and mobility, restricts the movement of freight and farm-to-market deliveries, and limits economic development. This project will help return economic vitality to a historically disadvantaged region.

Introduction

The ROUTE 50 project technologies address safety, travel time reliability, mobility and quality of life in four areas: 1) incident and event management, 2) traffic management, 3) traffic monitoring and performance, and 4) traveler information, as described in *Figure 1*, below.

Incident & Event Management

- Q^2 Inverse Traffic Responsive Pattern Selection (TRPS) Signal System
- Machine Learning Traffic Prediction
- Incident Signal Timing Plans
- Freeway Incident Traffic Management (FITM) Plans

Traffic Management & Safety

- Adaptive Signal Control Technology (ASCT)
- Connected Vehicle Systems: Curve Warning & Signal Timing Phasing & Timing (SPaT)

Traffic Monitoring & Performance Management

- Automated Traffic Signal Performance Measures (ATSPM)
- Traffic Sensors: CCTV, Volume & Speed Detectors, Origin-Destination & Travel Time Detectors
- TMC & ATMS Integration

Traveler Information

- Alternative Route Travel Time Signs
- Dynamic Message Signs (DMS)
- Travel Information Via Web Sites
- Push Notifications for Hotel & popular online Vacation Rental Platform Apps

Figure 1: ROUTE 50 ITS Strategies and Technologies

Geographic Area Description

The 113-mile ROUTE 50 project is within the geographic area of Maryland's Eastern Shore, as shown in *Figure 2* on the following page. It traverses 93 miles of rural topography, constituting 82% of the project. There are five counties in the project area: Queen Anne's, Talbot, Dorchester, Wicomico, and Worcester, which are among the most rural counties in the state. Major towns/population centers along this route include Ocean City, Salisbury, Cambridge, Easton, Queenstown, and Kent Island (unincorporated). Only Ocean City, which is a tourism area, and Kent Island, adjacent to the

Chesapeake Bay Bridge, are not rural. ROUTE 50 is part of the National Highway Freight Network through Kent Island, and a designated MDOT Critical Rural Freight Corridor to east of Salisbury.

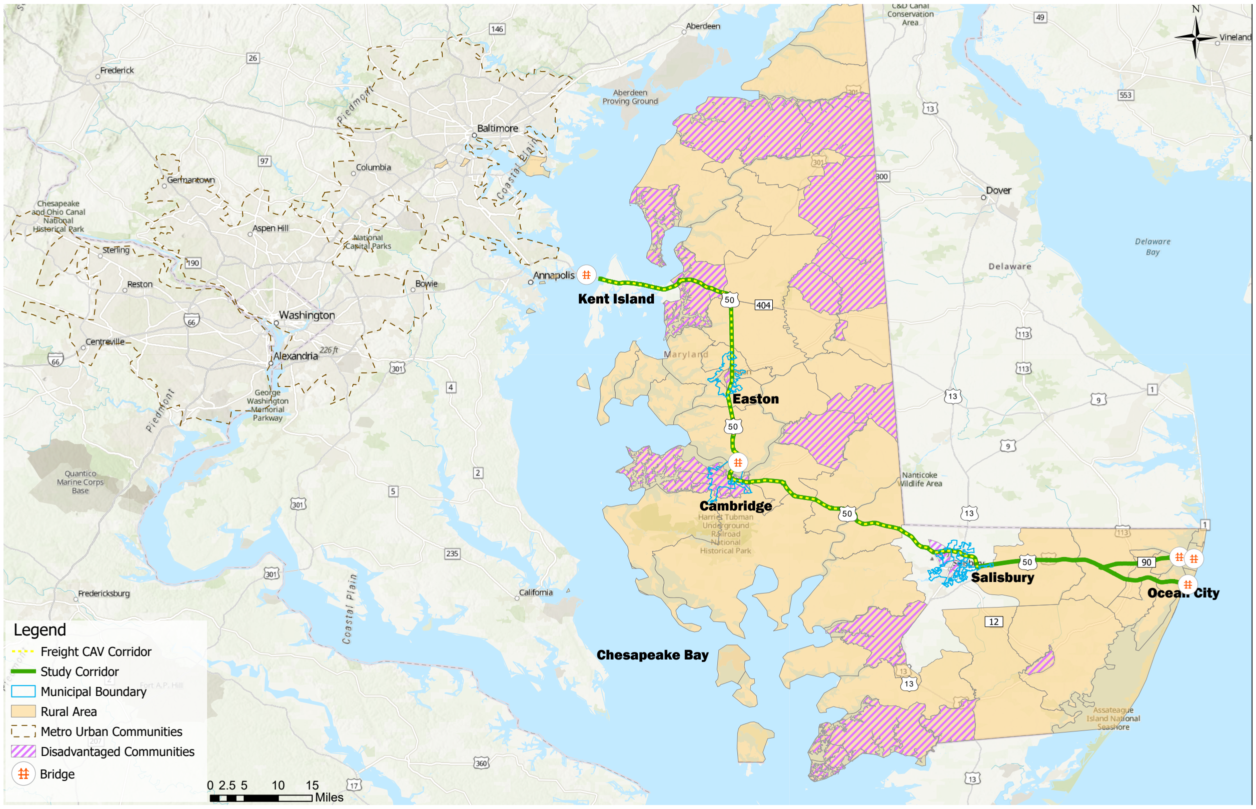


Figure 2: ROUTE 50 Project Area Map

US 50 is a lifeline link for businesses and communities on the eastern shore to gain access to jobs, send and receive goods from major points of warehouse and distribution across the Chesapeake Bay into the metro areas of Baltimore and Washington DC, as well as the key route for seasonal vacation and tourism travel between the metro areas and the Atlantic Ocean. The corridor is critical to the Eastern Shore's farming and tourism economies and supports both Maryland and the greater metro region economies.

All major cities along the Route 50 Corridor classify as disadvantaged communities[1] according to the USDOT Transportation Disadvantaged Census Tracts[2]. Additionally, per the same source, the towns/population centers of Cambridge, Queenstown, and Salisbury are designated as Historically Disadvantaged, and Cambridge, Salisbury, and Easton are listed as Economically Disadvantaged. The ROUTE 50 project far exceeds the department's 40% goal targeting resources and benefits towards low-income communities, disadvantaged communities, communities under-served by affordable transportation, or overburdened communities.

↗ Issues & Challenges

The dominant issues and challenges are the lack of mobility due to extreme traffic congestion and safety. The corridor has both general, corridor-wide issues and challenges, and those specific to smaller systems. We first describe the challenges and issues within each system followed by issues and challenges throughout the 113-mile route.

[1] Per the https://usdot.maps.arcgis.com/apps/dashboards/d6f90dfcc8b44525b04c7ce748a3674a , transportation access disadvantage identifies communities and places that spend more, and longer, to get where they need to go

[2] https://usdot.maps.arcgis.com/apps/dashboards/d6f90dfcc8b44525b04c7ce748a3674a

→ System Issues & Challenges

The ROUTE 50 project is classified into three systems: Nos. 4, 8, and 16 as defined in MDOT SHA's Transportation Systems Management & Operations Master Plan[3].

Figure 3: Chesapeake Bay Bridge. Under "normal" conditions, two eastbound lanes and three westbound lanes are provided. Under peak eastbound conditions, however, (including many weekday PM peak periods and extended periods on Fridays / Saturdays during the summer months), one of the westbound lanes is reversed to provide a third eastbound lane

System 4 includes US 50 from the Bay Bridge to US 301; a 10-mile, 6-lane, divided, full control of access highway through Kent Island. MD 18 is a two-way, two-lane undivided arterial parallel route that accommodates spill over traffic and regularly bottlenecks the community during from May to October. The dominant transportation feature immediately west of the project area is the Chesapeake Bay Bridge (see *Figure 3*), operated as a toll facility by the Maryland Transportation Authority (MDTA).

System 16 includes US 50 from US 301 to Salisbury, MD, and runs through Easton and Cambridge. US 50 is a signalized, 4-lane, divided arterial for most of this segment. There is a full control of access highway bypassing the town of Salisbury. In the Easton area, local roadways, including MD 322, are used to bypass US 50 when the latter roadway is congested. Similarly, to the north of Easton, MD 662 and MD 213 are used for diversion. This is particularly true on summer Sundays, when seasonal traffic is returning to the Western Shore.

System 8 includes US 50 and MD 90. US 50 is the primary artery, but MD 90 provides an important alternate access to Ocean City. The dominant physical feature of System 8 is the Assawoman Bay/ Isle of Wight Bay, the body of water immediately to the west of Ocean City. While US 50 is above this body of water for a comparatively short distance (less than 0.5 mile), part of that distance includes a drawbridge, which, when planned for opening or when requiring maintenance, has extensive impacts on US 50. MD 90 does not have a drawbridge but has a significantly longer traverse of the Bay – approximately 1.5 miles.

> ...periods of congestion have resulted in major delays...this is particularly troubling since it provides vital access for emergency services, patient transports, and fire response as well as to medical, car, resident's place of employment and the homes of their family and friends.
>
> *County Council of Dorchester County, dated 1 February 2022*

→ Corridor Issues and Challenges Addressed by Proposed Technology

The table below summarizes how the ROUTE 50 technology deployments address the goals of the ATTAIN program. A discussion of each of the technologies is presented in Project Systems & Services, and the quantitative benefits are presented in Quantifiable Mobility Benefit Projections and Quantifiable Safety & Environmental Benefit Projections.

[3] https://www.roads.maryland.gov/OPPEN/TSMO_Master_Plan.pdf

ATTAIN Goal	Q^2inverse TRPS	ML Prediction	Incident Signal Timing	FITM	ASCT	Connected Vehicle Systems	ATSPM	Traffic Sensors	TMC & ATMS Integration	Travel Time Signs & DMS	App Push Notifications
Improve Mobility	x	x	x	x	x	x	x	x	x	x	x
Optimize Existing Capacity	x	x	x	x	x	x	x	x	x	x	x
Environmental Benefits	x	x	x	x	x	x	x	x	x	x	x
Measure & Improve Operations	x	x			x		x	x	x		
Reduce Number & Severity of Crashes	x		x	x	x	x	x		x		
Real-Time Travel Information								x	x	x	x
Economic Benefit (delays, throughput, safety, reliability)	x	x	x	x	x	x	x	x	x	x	x
V2I Technologies						x					
Integration	x	x	x	x	x	x	x	x	x	x	x
Demonstration & Evaluation	x	x				x					x

Disproportionately High Fatality Rates. | The fatality rate in Wicomico and Worcester counties (47 miles, or 42% of the entire corridor) is 20% higher than the statewide rate for the 4-year period from 2018 to 2021. There were a total of 34 fatalities in the corridor during this period. V2I technologies will address the high fatality rates and high-speed traffic signals and tight horizontal curves.

Crashes. | Annually there are nearly 1,500 reported crashes and hundreds of events such as disabled vehicles that exacerbate recurring congestion or cause non-recurring congestion in the ROUTE 50 corridor. 30% of all crashes are rear-end type – which is an indication of the congestion in the corridor – and 20% are intersection related. The Q^2 TRPS signal timing technology will reduce queues lengths and thereby reduce the 15% rate of secondary crashes[4] occurring in these long queues, which are typically rear-ends. During vacation travel months (April to October) even a minor crash results in extraordinary backups which causes motorists to divert to alternate routes. Studies within the Kent Island community, have shown that when crashes occur approximately 25% of traffic attempts to bypass congestion on US 50 (see *Figure 4* for a snapshot of a Local News Vlog[5]). Incident signal timing and FITM plans will improve mobility, reduce delays and improve quality of life in rural towns along the Eastern Shore impacted by diverting traffic.

Figure 4: Gridlock near the Bay Bridge on Kent Island is severely impacting the quality of life.

[4]FHWA defines secondary crashes as those within a queue or incident scene that occur after the primary incident.
[5]https://www.youtube.com/watch?app=desktop&v=ys4RPQsF4jw

Congestion. | ROUTE 50 is plagued by heavy to severe congestion with a Travel Time Index (TTI)[6] ranging from 1.3 to over 2.5 in the Kent Island, Easton, Cambridge, Salisbury and greater Ocean City communities during the travel season. The portions of US 50 between the communities are ranked as moderately congested (TTI from 1.15 to 1.2). There are no non-congested sections per the TTI methodology. Congestion is most severe for westbound travel on Sundays between May and October as shown in *Figure 5*. The figure shows the congestion that occurs in the communities of Cambridge, Easton and Kent Island. Note that as time moves forward the slog of traffic moves westbound and then gets stuck at the Bay Bridge. It is not just a wall of cars from the beach; traffic builds gradually. One of the benefits of the Q^2 TRPS signal timing technology is that by metering traffic throughout the 113-mile corridor, throughput actually increases at the Bay Bridge (see the Appendix for the technical discussion). The technology will reduce delays and improve travel time reliability by optimizing existing capacity.

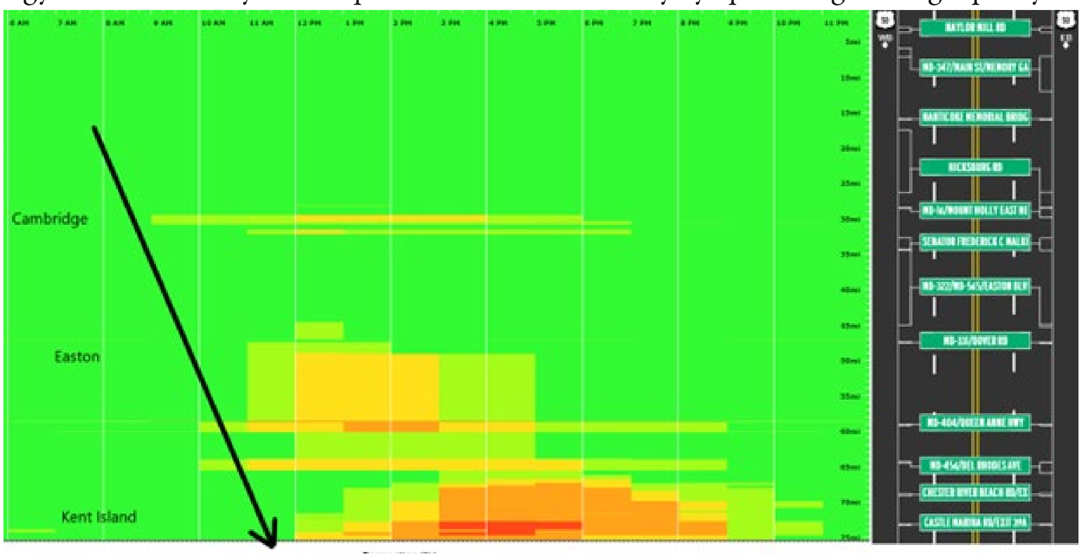


Figure 5: Average congestion on WB US50 on Sundays from May to September 2019. The horizontal axis is time, and the vertical axis is distance from the Bay Bridge. Red = severe congestion; orange = heavy congestion; yellow = moderate congestion. Note that the congestion in Kent Island occurs most of the day on Sunday (noon until 8 PM) and extends 10 miles back from the Bay Bridge. Moderate to heavy congestion can be observed in the figure in Easton and Cambridge. Note that these occur earlier in the day (noon to 3 PM). Queue lengths in Easton and Cambridge are shorter than in Kent Island, but still range extend several miles in length.

Similar congestion patterns occur during holiday periods. Seasonal and holiday traffic congestion accounts for only about 650 hours a year. [7] However, these 650 hours account for 50% of the $78 million annual cost of congestion.[8] Incidents, weather, and works zones combined account for 8.5% of the cost of congestion in the study area. The incident signal timing plans on MD 18 in Kent Island will be designed for community mobility, not to provide throughput for travelers attempting to bypass US 50 (unless US 50 is closed).

Congestion also occurs throughout the year as shown in (*Figure 6*) on the next page. This graphic represents hourly costs of congestion from 2019 from the Integrated Transportation Information Systems (RITIS) platform. Red cells indicate severe congestion, and yellow cells indicate heavy congestion. The ROUTE 50 project is not just about vacation-related travel congestion but reinvesting in the community by implementing ASCT and ATSPMs in the traffic signal systems to improve safety and mobility all times of the year.

Congestion on US 50 is a barrier that divides communities. | Historically, MDOT SHA operated US 50 to maximize vehicular throughput to "Reach the Beach." The "Reach the Beach" program is highly influential in the historical development of Intelligent Transportation Systems (ITS) programs

[6] Travel Time Index (TTI) is the ratio of the measured average travel time during a specific time period to the travel time required to make that same trip at free-flow (e.g., typically at nighttime) speeds.
[7] 6 months (24 weeks) travel season, for 3 days per week for a total of 72 days per year for 8 hours each day. Total is 576 hours per year. There are approximately 10 holiday travel days for an additional 80 annual hours. The total is approximately 656 hours.
[8] RITIS Analysis of the 2019 causes of congestion for ROUTE 50.

in the United States. Although this approach served seasonal travelers from the metropolitan areas well, it negatively impacted the quality of life in the small, rural, disadvantaged communities along the route. The 113-mile US 50 "beach" route is capacity constrained by the Bay Bridge. The Chesapeake Bay Bridge has a peak capacity of about 4,000 vehicles per hour, but the observed traffic demand far exceeds the capacity during peak hours and weekends causing unbearable delays, summer weekend queues extending 10 to 15 miles, increased safety risks, more greenhouse gases, and delays to emergency response vehicle operations. As noted, traffic spills out and bottlenecks the local network as well as US 50. These conditions occur at the secondary bottlenecks in the towns of Easton, Cambridge, and Salisbury throughout the corridor. The Q^2 TRPS signal timing technology will keep queues out of these communities so that people can move about town freely, including getting across US 50 to get to the other side of town. Keeping the queues outside of town will lower GHGs and improve air quality. The Q^2 TRPS signal timing technology will reduce signal delay for local traffic intending to cross US 50.

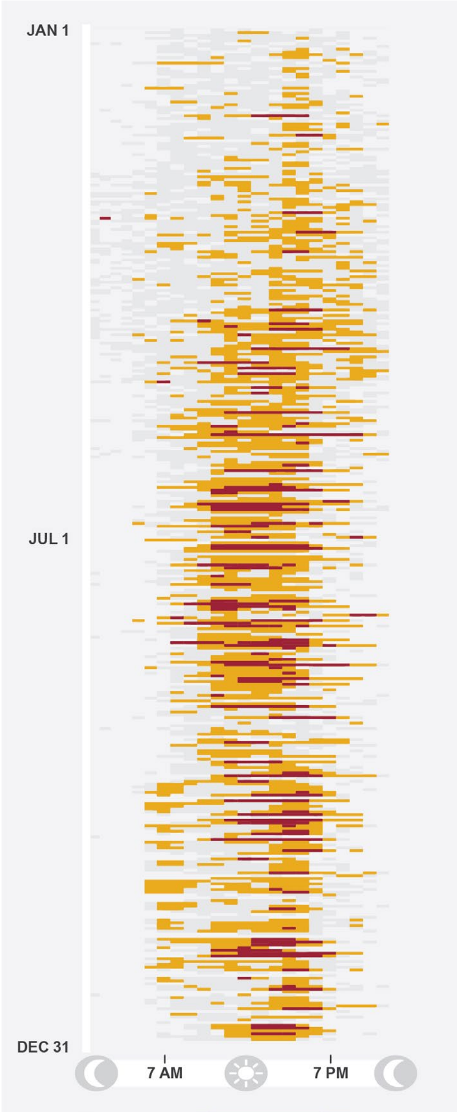


Figure 6: Illustrations of Hourly cost of Congestion for 2019

Access to Jobs. | Due to the rural nature and farming-based economy of the area, between 20 and 50% of the work force on the Eastern Shore travels out of the counties in which they live to a job. Many residents are dependent on the reliability of the US 50 corridor to gain access to the major job markets in the metropolitan areas and with that economic success. In addition to the time saving and crash reducing technologies mentioned, real and predicted travel information dissemination will improve travel reliability, improve mobility through data-driven travel choices, provide economic and environmental benefits.

Agriculture | The movement of crops to the major metropolitan areas is vital to the economic success of the Eastern Shore. One of the largest industries on the Eastern Shore is agriculture, accounting for $1 billion to the economy, $17 million in tax revenue, and over 3,700 jobs.[9] Traffic congestion along the corridor impairs the movement of harvesting equipment (see *Figure 7*) and impacts the economic vitality of the farming industry on the Eastern Shore. Many of the crops are time sensitive in that they need to be harvested within a tight window, thus the movement of the equipment to pick the crop can at times be critical and quite often will happen nearly around the clock, seven days a week. ROUTE 50, and the congestion that spills over into the arterials and local roads impacts harvesters' ability to gain access to the fields.

Figure 7 : Due to the high cost of the equipment, farmers borrow big machinery from the neighboring farms which require crossing congested roadways

Freight. | ROUTE 50 averages 10,000 trucks per day, which significantly increases during vacation travel months. According to Maryland Roadway Performance Tool (MRPT) 2019 data, the ROUTE

[9] https://lesmd.net/agriculture

50 corridor supports over $14 billion in commodity flow per year. Annual delays (see *Figure 8*) cost truckers over 107,000 hours which translates to $51 million in wasted fuel and time. This impacts productivity, jobs, and economic growth.[10] Freight movement and freight-related-industry-jobs support farm-to-market agricultural goods movement to supply the nation's food sources, and tourism on the Eastern Shore. Freight industries on the Eastern Shore supported by US 50 are extractive and important for the nation's food sources.

The ROUTE 50 corridor is the most direct route to major freight generating sources such as the Port of Baltimore, warehouse and distribution hubs in Laurel, Maryland, and other critical markets, particularly for the type of freight both needed on the eastern shore, the Delmarva peninsula and that which is exported to other markets. The beach areas are significant tourist draws requiring goods to support tourism, and the Delmarva peninsula is a top supplier of poultry and food processing products that typically ship by truck to major markets on the western shore. Another important need for ROUTE 50 is to support homeland security and advancing technology deployments related to Wallops Island in Virginia. This is a location important to space and technology. ROUTE 50 is the link between these facilities and military and technology industries on Maryland's western shore.

Seasonal traffic and congestion issues (as noted previously) present many problems for US 50. However, the agricultural growing and harvesting season, and the hurricane season create major problems. Agricultural production (which is higher in the summer season) means slower moving trucks and farm equipment, more frequent blocked grade crossings due to increased train movements, and other impacts not seen throughout the year. When hurricanes or bad weather occur, there are many washouts of rail equipment, which means that the trains must be replaced by trucks. This can mean a sudden injection of 1,000 trucks to cover train shipments that must move if the rail is out. The Route 50 V2I technologies for curve speed warning and Signal Phasing & Timing will directly benefit the trucking industry by reducing overturning type crashes in tight horizontal curves, and enabling Freight Signal Priroity to improve moblity.

Figure 8: Commecial Trucks Blocked, Stuck Amidst Hectic Bay Bridge Traffic, wboc.com

↗ Project System & Services

The ROUTE 50 project consists of both field infrastructure (hardware) and software as summarized below. A map of the proposed ITS infrastructure is shown in *Figure 9* on the following page.

[10] Used Cost of Congestion in RITIS, www.ritis.org

Hardware	Software
» 9 CCTV Cameras » 8 Travel Time Signs » 8 Connected Vehicle Road Side Unit (RSU) Curve Warning Systems » 7 Traffic Sensors (Volume, Speed, Occupancy) with Vehicle RE-identification (WiFi & Bluetooth) Sniffers » 2 Dynamic Message Signs » 48 Traffic Signal Modifications to accommodate ASCT, ATSPMs & SPaT such as Advanced Transportation Controller, detectors and 4 full rebuilds of old signal » 48 Connected Vehicle Road Side Units (RSU) for Signal Phasing & Timing (SPaT)	» Machine Learning (ML) Traffic Prediction » Q^2 Inverse Traffic Responsive Pattern Selection signal timing » Incident Traffic Signal Timing Plans (configuration of existing software) » Adaptive Signal Control Technology (ASCT) » Automated Traffic Signal Performance Measures (ATSPM) » Integration of systems into RITIS, CHART ATMS, and MDOT SHA's centralized signal system Centracs » Freeway Incident Traffic Management (FITM) Plans (electronic plans integrated into CHART ATMS)

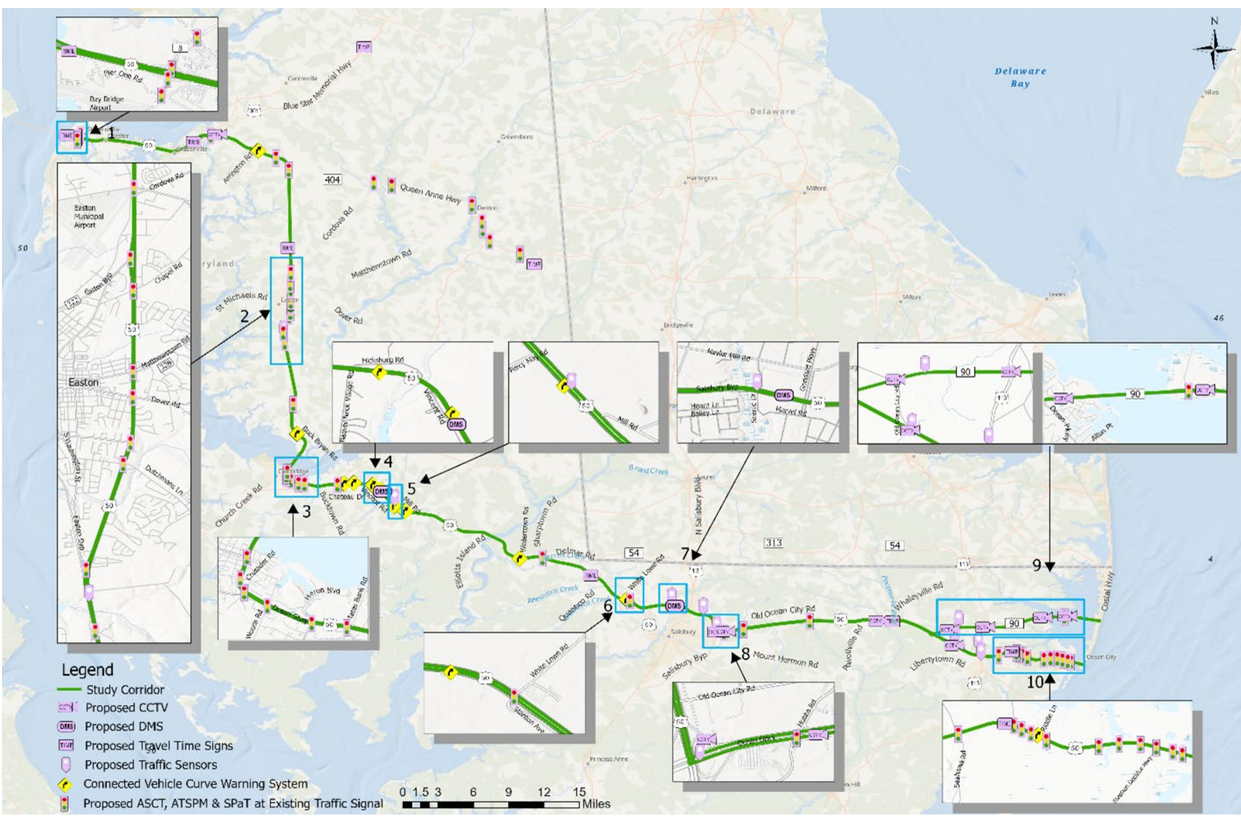


Figure 9: Proposed ITS Infrastructure

ROUTE 50 will add TSMO strategies using a combination of existing and proposed ITS infrastructure. The existing ITS infrastructure is shown in *Figure 10* on the following page. Due to the high density of ITS devices, a combined map of existing and proposed is not shown for clarity.

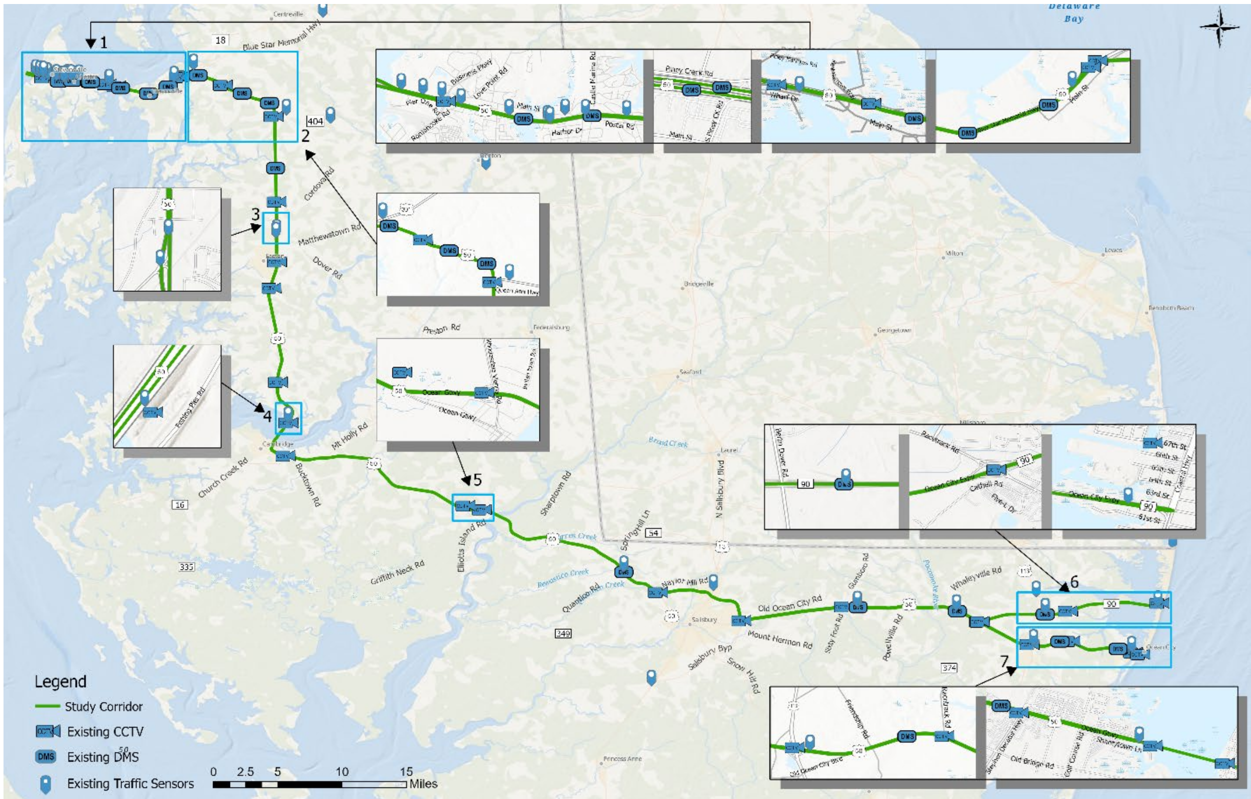


Figure 10 : Existing ITS Field Infrastructure

A description of each technology strategy presented in the Introduction is discussed in detail in the following paragraphs below.

Q² Inverse Traffic Responsive Pattern Selection (TRPS) signal system stands for two Q's - Quality of life and Queue management. This strategy will 1) reduce queues at the Bay Bridge so that traffic does spill out from the freeway to the local network; and 2) keep queues out of the communities of Easton and Cambridge so that traffic does not bottleneck the main arterial that runs through these towns. This strategy will improve the quality of life by removing the barrier that is a wall of cars on US 50 that divides these communities, improve mobility of emergency medical services, return economic vitality to the businesses that currently suffer economic hardships, and reduce GHG emissions in the areas where people live and work. The Q² Inverse TRPS signal system is a Decision Support System (DSS) that ingests region-wide traffic sensor data in real-time and the ML traffic prediction system to develop a signal timing strategy to accomplish its objectives over multiple corridors. This unique strategy is termed "inverse" because instead of increasing throughput as volumes increase, the signal system decreases throughput to meter traffic at key locations along the corridor (similar in concept to a ramp meter). MDOT piloted this traffic management approach over the last summer travel season on 4 signals along US 50 (without traffic sensor, CCTV or prediction data). ROUTE 50 will expand beyond this pilot to deploy the technology at 48 signals on ROUTE 50. The successful pilot showed positive results with shorter queues at the Bay Bridge, lower cycle lengths in the towns to improve mobility, and less spill over into the local community of Kent Island. Expanding an already successful pilot limits the risk inherent in innovation. An illustration of the improvements of the signal timing strategy is shown for the "homebound" trip in *Figure 11* where, currently, there is an average 6-mile queue at the Bridge on the WB approach when demand exceeds the Bridge capacity (nearly 4,000 veh/hr) during the afternoon peak period. The oversaturation condition (v/c of ~1.25) has been causing significant delays at the

Bridge, whereas there are relatively shorter delays and queuing upstream, i.e., WB US 50 at Easton, Cambridge, and Salisbury.

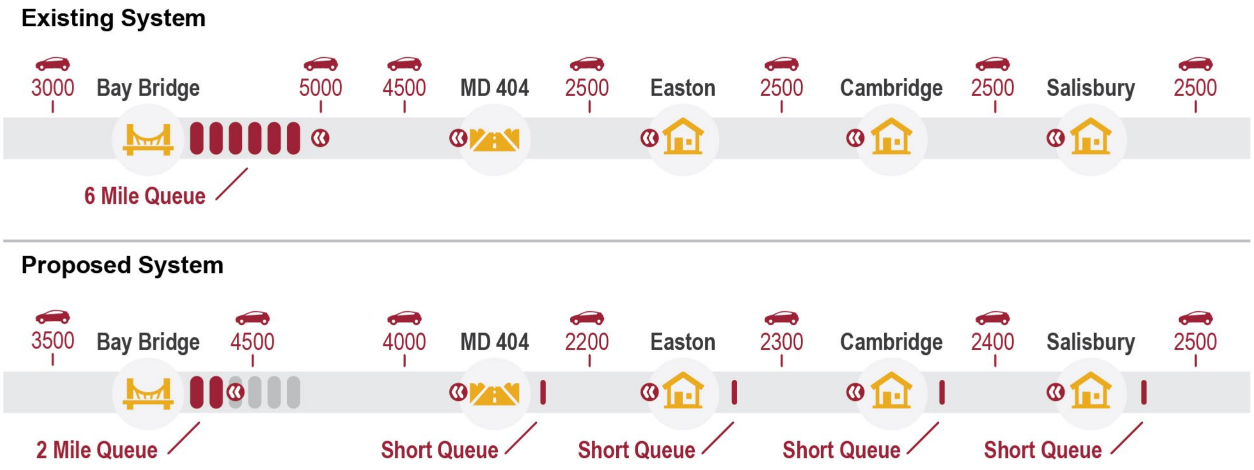


Figure 11: Q^2 Inverse Traffic Responsive Pattern Selection illustration of the changes in queues over the 113-mile corridor. The numbers under the cars are approximate hourly traffic volumes on a Sunday during the summer. Note that the throughput is reduced (intentionally) prior to the towns of Easton and Cambridge to improve the quality of life within these communities. By metering traffic at these towns, upstream of the Bridge, the net effect is an increase in throughput at the Bay Bridge and a reduction in queue length in Kent Island (the community adjacent to the bridge). The technical reason (see section 2.8) for the improvements at the Bay Bridge is that this system is on the supersaturated side of the volume-density curve, so as we decrease density, throughput increases.

Machine Learning Traffic Prediction. | Code, not concrete, is at the core of this unique and innovative strategy. We are turning a reactive strategy into a proactive strategy by predicting traffic volumes into the future using Machine Learning. Predicted traffic data will feed into multiple technologies in the project including: Q^2 Inverse Traffic Responsive signal system; Push Notifications for Hotel & Online Vacation Rental Platforms Apps; Alternative Route Travel Time Information Signs; and provide predicted and real-time travel time information to motorists, and local residents regarding the tidal wave of traffic that might be heading towards their communities.

Code is the New Concrete

A prediction system based on machine learning is the future of traffic management and a key component of this project to drive the traffic management and real-time traveler information decisions.

Prediction provides the peace of mind to local residents by reducing the anxiety of not knowing if you will get stuck at the shopping center and not be able get home; it informs famers and factories to better schedule freight movements and provides a better and more efficient means of scheduling deliveries; it also helps vacation travelers on deciding when to travel, selecting between alternative routes – and encouraging them to stay on the arterials and expressways and off of the local roads.

ML Predication is an advanced transportation technology, aligned with the research areas described in Section 6503 of Title 49. | Predicting traffic is innovative and evolving technology solution. Again, MDOT has been on the leading edge of ITS in America with a traffic prediction project already underway and currently being implemented in the vicinity of the Chesapeake Bay Bridge. In other words, we're managing the risk of innovation by integrating two proven, piloted projects into this grant application: ML Traffic Prediction and the Q^2 inverse traffic responsive. This project will expand the existing research and development work to the entire Eastern Shore of Maryland.

Incident signal timing plans will be used throughout the corridor and where previously noted on MD 18 in Kent Island; in Easton on MD 322, MD 662 and MD 213 (see discussion in System Issues & Challenges) to change signal timings to accommodate increased volumes diverting from US 50 due to roadway closures and major incidents. Incident signal timing plans will be pre-developed and based upon: a) location of an incident along the roadway segment and detour routes, b) time of year, time of day, day of week of the incident, c) expected duration, and d) full or partial roadway closure. It is anticipated that over 100 different signal timing plans will be developed! This technology includes more than static signal timing plans; it is an Integrated Corridor Management (ICM) decision support system (DSS). There is limited time to act: incident signal timing plans must be implemented within the first few minutes of a crash, or the controller transition period could make things worse, and there are limited expert resources, along with the trouble identifying which unique code corresponds to the plan that should be implemented. Clearly, some level of automation is necessary. This is where the DSS comes in. The DSS will include a matrix of "rules" or "case-based scenarios" that initially "expert" staff will follow to determine if an incident signal timing plan should be implemented and, if so, which plan and which signals, as based on the Freeway Incident Traffic Management plan.

Freeway Incident Traffic Management (FITM). | ROUTE 50 is managed by the regional Eastern Shore Traffic Operations TMC where 80% of all incidents occur off-peak and 67% of all crashes occur on the weekends. Therefore, detection, response, and traffic recovery (a.k.a. equipping technologies) are vital performance indicators associated with an incident management program that will be optimized with the FITM plans. FITM plans are pre-planned traffic detour plans that will be implemented when an entire direction of US 50 is closed such as due to a crash or weather event. Traffic will be detoured to alternate roadways. The TMC will monitor and manage ITS devices and traffic signal operations along the alternative routes. Plans will be developed using local incident response agency feedback as well as understanding and balancing different needs for all participating agencies. FITM and Incident Signal Timing Plans are integrated into the CHART ATMS for a comprehensive incident management strategy that reduces the incident timeline to reduce delays and secondary crashes and improve mobility.

Adaptive Signal Control Technology (ASCT) does not, in general, adapt well for large changes in traffic volumes such as those due to incidents or events (i.e. non-recurring congestion). However, it's perfect for improving day-to-day mobility in the signal systems within the small, rural towns along US 50. The ROUTE 50 project will deploy a variety of signal timing strategies depending upon the traffic congestion "battle" we're fighting.

- To combat the queues that gridlock our communities, we'll use two different strategies powered by a Decision Support System with ML Prediction: Q^2 Inverse Traffic Responsive for seasonal and holiday congestion periods, and Incident Signal Timing Plans would operate on US 50 during major incidents, work zones and weather events that block lanes and alternate routes such as MD 404.
- Adaptive Traffic Signal Control (ATSC) would operate in the signal systems in the towns during the "normal" weeks – sometimes during the summer and then of course during the fall and winter. ATSC would operate about 20% of the hours of the year.
- Ten (10) of the 48 signals in the project normally operate as fully actuated, isolated (not in a signal system) – commonly referred to as "free" operations. Also, the signals in system operate "free" during overnight and low volume periods. This mode of operation won't change. However, what will change is the 10 isolated signals will be put into a signal system during Q^2 or Incident programs to manage system-wide traffic operations.

Connected Vehicle (CV) Systems: Curve Warning & Signal Phasing & Timing (SPaT). MDOT SHA is committed to deploying connected vehicle technologies to advance Maryland's vision to uphold and enhance a Safe, Efficient, and Equitable transportation future by delivering collaborative, leading-edge Connected & Automated Vehicle (CAV) solutions. Signal Phase & Timing (SPaT) will be deployed as part of this project to support the following applications to be developed by automobile Original Equipment Manufacturers (OEMs) or others. This deployment will allow for additional applications, such as the Intelligent Traffic Signal System (I-SIG), to be implemented by MDOT SHA in the future when CAV market penetration increases.

- Eco-Approach and Departure at Signalized Intersections improves vehicle efficiency when approaching/departing from signaled intersection reducing emissions and improving the environment.
- Freight Signal Priority modifies coordination signal operations to provide preferential treatment to freight vehicles to reduce emissions, fuel consumption and freight costs. It also improves freight travel time reliability and reduces impacts to pavement conditions.
- Red Light Violation Warning (RLVW) application warns of impending red light violations, reduces fatal and serious injury crashes, and is based on the SPaT data communicated to the in-vehicle device.

Curve Speed Warning will be deployed at 8 horizontal curves (refer back to Figure 9 for locations). Curve Speed Warning is a CV application where alerts are provided to the driver who is approaching a curve at a speed that may be too high for safe travel through that curve. This application has the potential to correct unsafe speed through curves, roadway departure crashes, distracted driving and rollover related crashes. **Curve warning systems are technologies consistent with DOT's ROUTEs Initiative Focus Area.**

It should be noted that our safety analysis did not identify any opportunities to deploy V2X technologies for Vulnerable Road Users. This is a symptom of the nature of US 50 as a barrier to community mobility – very few people walk across US 50 (even though pedestrian crosswalks, signals and amenities exist) or bike along US 50, and there are no transit systems in operation.

All CV deployments will also be secured through the Maryland Security Credential Management System (SCMS). This platform helps to provide cybersecurity to messages sent and received by passing vehicles. **This approach is aligned with the USDOT's advanced transportation technologies deployment programs outlined in Section 6503 of Title 49.**

Automated Traffic Signal Performance Measures (ATSPMS) will show real-time and a historical performance at signalized intersections. The various measures will evaluate the quality of progression of traffic along the corridor and display any unused green time to enable signal retiming efforts based directly on actual performance without dependence on software modeling or expensive, manually collected data. This information also will inform traffic engineers and technicians of vehicle and pedestrian detector malfunctions, measures vehicle delay and lets us know volumes, speeds and travel time of vehicles. The measures will be used to optimize mobility and manage traffic signal timing and maintenance to reduce congestion, save fuel costs and improve safety.

> ***Traffic Equipping vs. Enabling Strategies.*** | *The next two strategies are equipping technologies The equipping technologies – in and of themselves – do not provide direct improvements but form the necessary foundation for the enabling technologies to "do the work" of improving the quality of life for people in, around, and travelling on ROUTE 50. For example, CCTV cameras (along with other sensor data) only equip other technologies to provide benefits such as when the TMC staff uses them to improve incident management and response, or when the signal timing engineers use them to fine tune incident signal timing plans. In this example, the CCTV cameras indirectly save the agency*

time and expenses from deploying staff on-site, enable MDOT SHA to optimize their response to events and incidents that save people time and money (reduced fuel, reduction in crashes and the costs thereof) and improve the environment (lower GHGs) and the quality of life for the residents in the area. However, what provides benefits are the various signal timing, FITM, CV, ML Prediction and traveler information strategies.

Traffice Sensors: CCTV, Volume & Speed Detectors & Origin-Destination / Travel Time Detectors. | The eyes and ears of the project is infrastructure deployment to measure real-time traffic data to provide situational awareness to the Transportation Management Center (TMC), feed the Machine Learning Traffic Prediction System, provide information to travelers, and implement traffic management plans, ICM, and DSS. The infrastructure includes microwave radar traffic detectors to measure lane-by-lane volume, speed and occupancies; WiFi/Bluetooth vehicle re-identification "sniffers" / detectors to measure travel time and origin-destination pairs; and CCTV cameras to view traffic operations. These devices are enabling technologies to empower the other strategies.

TMC & ATMS Integration. | The MDOT SHA's TMCs – the Eastern Shore Traffic Operations is a seasonal TMC responsible for this area – will monitor, coordinate, document, manage, and perform traffic management activities using the ITS infrastructure and real-time telecommunications, technology, and software constructed for this project through the Coordinated Highway Action Response Team (CHART) Advanced Traffic Management System (ATMS). The ASCT and Q^2 Inverse Traffic Responsive signal timing will be integrated into the state's Centracs ATMS system. TMC and ATMS integration of the traffic sensors, CCTVs, travel time detectors, ATSPMs will enable remote monitoring, enhance situational awareness, and provide for the remote management of traffic signals, DMS, travel time signs to improve incident, event and day-to-day traffic management. Traffic data will be made available to FHWA via MDOT SHA's big data repository site RITIS to further advance the objectives of this program.

Figure 12: Traveler Information Dissemination

Alternative Route Travel Time Information Signs & Dynamic Message Signs | will provide real-time and predicted travel-time traveler information signs at key decision points throughout the corridor. According to the Federal Highway Administration (FHWA), "travel time messages not only provide useful information to the motorists it also assists them in planning their routes. This planning can cause a small number of drivers to divert away from the congested highway. Thus, posting travel time messages provides critical additional capacity and assists in the management of congestion."[11] For the US 50 corridor, the use of dedicated travel time signs, which are an economical alternative to traditional DMS (approximately 25% of the cost), would allow the TMC to concurrently inform motorists of the travel conditions, while using traditional DMS to provide more specific roadway and travel advisories. See *Figure 12* for an illustration of the signs and sample messages.

Travel Information via Websites and Push Notifications for Hotel and Online Vacation Rental Platform Apps. | MDOT SHA and MDTA have used their website and social media feeds to try to influence pre-trip planning but have only experienced moderate shifts in travel behavior. Traveler information, including travel times and delays, will be enhanced through the deployment of traffic sensors and the ML Traffic Prediction. This will include work to integrate the real-time and predicted

[11] https://ops.fhwa.dot.gov/travelinfo/practices/practices.htm

data into RITIS, CHART ATMS travel time modules, and the MDOT web sites. As part of the community outreach initiative, we will target Vacation Rental By Owner (VRBO), Airbnb, major hotel chain apps (e.g. Marriott Bonvoy, etc.) to provide push notifications via a JSON feed to smart phones. The push notifications would be correlated with check-out times and dates. At the ocean resorts, many vacation rentals are week-to-week. Over the years, as congestion exacerbated, the property managers have spread out weekly vacation rentals to different starting days to minimize traffic congestion. For example, Friday-Friday, Saturday-Saturday, or Sunday-Sunday. Push notifications will provide real-time and predicted travel time information integrated with check-in and check-out times (see *Figure 13*).

Figure 13. Application Push Notifications Integrated with Vacation Rental Check-in & Check-Out Times

Web users will be able to enter an estimated departure time and be provided with an approximate travel time for the most common routes between Annapolis area (US 50, MD 404, US 13 and US 113 through Delaware) and the Ocean City area. The predicted traveler information will also benefit the local communities and travelers will shift travel times to avoid the most-congestion times of day, and predicted travel and real-time incident and event information will help plan routine activities as illustrated in the use-case study, below.

> *Sunday is going to be a torrential downpour at the beach. The weekly visitors would normally check out at 10 AM and head to the beach for one last full day in the sun. But, this Sunday, there's no reason to go to the beach so everyone leaves in the morning. The residents in Cambridge, Easton and Kent Island usually plan their activities on Sunday around the expected onslaught of traffic to be back at home before noon where they'll shelter from the "traffic raid." But today is different because the vacationers leave early and the army of cars from Ocean City congests the Cambridge community. It could be different...and it will be with better and targeted traveler information included in the ROUTE 50 project.*

↗ Deployment Plan

MDOT SHA has a mature TSMO Program that has already made the cultural shift into operations and maintenance of advanced transportation technologies within each of AASHTO's six dimensions of capability and maturity. This program will minimize risk and achieve implementation costs for ROUTE 50. The ROUTE 50 technologies will be deployed and integrated into MDOT SHA's well-developed organizational infrastructure for planning, designing, constructing, operating and maintaining the agency's ITS technologies. MDOT SHA has identified a project team consisting of our vendors, contractors, and on-call consultants, with whom we have contracts that last through the life-cycle of the 3.5-year project. Refer to the schedule in section 2.12 for high-level work breakdown structure of the 3.5-year project. Our on-call consultants will prepare the preliminary engineering and final engineering design; our vendors and contractors will perform the software development and deployment, and our on-call "areawide" contractors will perform the infrastructure construction. We also have on-call contracts for field infrastructure and software maintenance (preventative and emergency). MDOT SHA includes increases in funding for ITS deployment maintenance and operations on an annual basis. These technologies would be operated and maintained through these programmatic funds. Monthly CHART Board meetings with senior leadership that are open to all stakeholder agencies and partners provide a transparent reporting structure on both projects and asset management. Refer to the organizational chart for a discussion of individual roles and responsibilities among the project team, including specific contacting mechanisms.

ROUTE 50 is perfectly aligned with FHWA's published Policy on Using Bipartisan Infrastructure Law Resources to Build a Better America[12], as it will improve the condition and safety of existing infrastructure within the right-of-way without adding new general purpose travel lanes serving single occupancy vehicles. Additionally, ROUTE 50 is part of the National Highway System and as such its bridges and pavement are covered by the certified DOT-required Maryland Transportation Asset Management Plan (TAMP)[13]. This means all partner owners of NHS assets (US 50 included) have agreed to a maintain the system in a state of good repair as guided by the TAMP. MDOT SHA has lifecycle management plans in place for ITS, traffic signals and software assets along the US 50 corridor.

↗ Challenges & Obstacles

There are no challenges in the regulatory, legislative or institutional environments to deployment. We note that supply chain concerns may rise across the United States due to Buy America requirements, but that no other obstacles are expected for the successful deployment of this project.

↗ Quantifiable Mobility Benefit Projections

The benefits and improvements from the equipping technologies are summarized in the following tables. The appendix contains a more detailed summary of the tools, assumptions, calculations and methodological approach. As shown below, the ROUTE 50 project will pay for itself within two years; namely, the sum of 1+ year 2 benefits is about equal to the project cost.

Technology	Annual Improvement	Annual Benefit
Q^2 TRPS: US 50	267,897 hours	$5,290,953
Q^2 TRPS: Side Street in Towns	1,066 hours	$21,054
Travel Information	552,434 hours	$10,910,128
Incident Signal Timing Plans	48,000 hours	$948,000
FITM, TMC, ATMS	1,648,800 hours	$32,000,000
ASCT	12,439 hours	$245,670
ATSPM	437,468 hours	$8,640,000
Annual Benefit	**2,968,104 hours**	**$58,055,808**

↗ Quantifiable Safety & Environmental Benefit Projections

Similar to the Quantifiable Mobility Benefit Projections discussion, the appendix contains a more detailed summary of the tools, assumptions, calculations, and methodological approach.

Technology	Safety Improvements	Fatality Reduction
Q^2 TRPS	Significant. Not estimated	-
CV Curve Warning	2 per year	-
CV SPaT	22 per year	0.33 per year
ASCT	15 per year	-
Q^2 TRPS	6 per year	-
All Others	45 per year	1 per year
TOTAL	**90 per year**	**1.33 per year**
Annual Benefit	**$331,380 per year**	**$1.86M per year**

[12] https://www.fhwa.dot.gov/bipartisan-infrastructure-law/docs/building_a_better_america-policy_framework.pdf
[13] https://maryland.maps.arcgis.com/apps/MapJournal/index.html?appid=e99ba9fdd5e34598a491750f2e557d36

Technology	Environmental Improvements	Annual Benefit
FITM, TMC, ATMS	HC 9.6 ton, CO 220.4 ton, NO 9.4 ton, CO2 3,203.8 ton	$1,660.779
Travel Information & Q^2 TRPS: Emissions	CO 47.1 ton NO 10.3 ton VOC11.4 ton	$432,506
ASCT: Emissions	Significant; not estimated	
Emission Total	-	$2.09 Million per year
Travel Information & Q2 TRPS: Fuel Savings	675, 573	$2,026,718
FITM, TMC, ATMS: Fuel Consumption	.34 million gallons	$0.81 Million
Fuel Savings Total	gallons	$2.84 Million per year
FITM, TMC, ATMS: Fuel Consumption	0.34 million gallons	$0.81 Million
Fuel Savings Total	Gallons	$2.84 Million per year

↗ Vision Goals & Objectives

Our Vision for the ROUTE 50 project is that it improves the quality of life in the rural communities along the 113-mile US 50 corridor between the oceanside resort areas and the Baltimore-Washington metro area. We see a future where traffic stays on US 50 and doesn't spill out into the local Kent Island community; where queues approaching the Bay Bridge are only a few miles and don't extend through multiple interchanges, thus allowing the community to go about normal weekend activities; where travelers and freight traffic can reliably travel on the corridor between the Eastern Shore and metro areas, making informed data driven travel decisions – so that if they get stuck in traffic they expected it; where emergency medical, police and fire and rescue services can reliably and quickly serve their communities within Cambridge, Easton, and Salisbury and not get stuck in traffic on US 50 trying to save a life; where rural residents trying to cross the barricade that is called US 50 don't have to wait 8-10 minutes at a traffic signal every weekend for 6 months of the year...to get to the other side of the road; and the high-severity car-crashes at our high-speed traffic signals and tight horizontal curves are significantly reduced though Connected Vehicle technologies.

> Backups on both [The US 50] corridor and along all parallel community roads...dramatically impacts the health, safety, livability, and economy of the communities...on boths sides of the Chesapeake Bay
>
> *Queen Anne's County Resolution 21-17, Dated 29 September 2021*

Goals. | The ROUTE 50 project is a component the TSMO program, which has a goal to maximize the efficiency and safety of the surface transportation system through the application of ITS technologies and operational strategies. TSMO does not include large-scale changes to the physical roadway network but implements technology and operational strategies that improve mobility, improve safety and provide information to travelers. More specifically, TSMO relies on ITS field devices (to collect and disseminate information), telecommunications systems (to allow those field devices to be operated in real time), and decision support systems (to allow collaboration among agencies and efficiency in implementation).

Objectives are to a) improve situational awareness throughout the corridor for improved incident and event response; b) reduce congestion on US 50 within the communities of Kent Island, Cambridge, and Easton so that US 50 is not a barrier that divides communities and restricts EMS mobility; c) implement holistic signal timing strategies using a DSS, that are appropriate for the operational objective and congestion patterns throughout all times of year with both the corridor and the community in mind; d) reduce trucking and freight delays on US 50; e) quicky implement traffic incident management plans to reduce incident duration and secondary crashes; f) reduce the number and severity (specifically including a reduction of the high fatality rate) at crashes at traffic signals and high-speed curves; and g) disseminate real and predicted travel information including events and travel times for traveler's to make improved decisions and travel choices including times of day, route-choice, in-trip, and pre-trip planning. The table below maps the objectives to the technology strategies.

Vision	Improve the Quality of Life									
ROUTE 50 Goals	Improve Mobility				Improve Safety				Travel Information	
Objectives	a) Situational Awareness	b) Reduce Congestion in Communities	c) Signal Timing : Q^2 TRPS & ASCT	d) Improve Freight Mobility	e) Reduce Incident Timeline	f) Reduce Traffic Signal & Curve Crashes	e) Reduce Secondary Crashes	f) Reduce Fatalities	g) Real and Predicted Travel Time	g) Traffic Event Information
CCTV Cameras	X	X		X	X		X			
Traffic Sensors	X	X	X	X	X		X		X	
Travel Time Detectors	X	X		X	X		X		X	X
TMC & ATMS Integration	X	X	X	X	X		X		X	
4G Comm to Signals	X	X		X	X					
ATSPMs	X	X		X						
ATSC		X	X	X		X				
CV SPaT						X		X		
CV Curve Warning						X		X		
DMS				X	X		X			X
Travel Time Signs		X		X	X				X	
App Travel Notifications		X			X				X	X
FITM Plans		X		X	X		X			
Incident Signal Timing		X	X	X	X		X			
Q^2 Inverse TRPS		X	X	X	X		X			
Travel Time Prediction	X	X	X	X	X				X	

↗ Optimizing Existing Advanced Transportation Technology

In one sense, this entire document describes how the ROUTE 50 project will add and expand technologies using the solid foundation of existing local and regional advanced transportation technology. MDOT SHA will integrate the ROUTE 50 technologies into existing operations and maintenance systems. MDOT SHA has an integrated platform for ITS monitoring and reporting through CHART ATMS, Centracs ATMS and the MDOT big data repository site RITIS. The current CHART ATMS includes a complex Decision Support system, which helps the operator manage traffic event response plans, where technology deployments as proposed in this grant will help further support the institution's situational awareness of the transportation ecosystem. MDOT SHA has demonstrated its commitment to constantly optimizing both functional and operational capacity of Advanced Transportation Technology through building and improving the CHART program by building and improving the CHART ATMS, developing institutional arrangements, and investing in the University of Maryland-led RITIS platform, among other efforts.

It should also be noted that this project is well planned – as documented in the TSMO Strategic Plan and CAV Strategic Plan, which demonstrates the strong framework in which the ROUTE 50 project will operate. These plans outline future investments in TSMO and CAV technologies, tracking and analytic systems, and performance management.

↗ Schedule

The ROUTE 50 project will be deployed and tracked over a period of three and a half years, as shown in the schedule in *Figure 14*. We have assumed an April 1, 2023 award notification date. Annual Budget Review and Program Plan Reporting (not shown in the schedule) will be submitted annually. Note that the final report will include a before/after study to demonstrate, quantify, and evaluate of the impact of these advanced technologies, strategies, and applications towards improved safety, efficiency, equity, and sustainable movement of people and goods. As noted in Volume II, this will be funded from the MDOT SHA Capital budget arterial operations budget and is not part of this grant request.

↗ GHG Emissions Reduction, Climate Action Plans and Environmental Justice

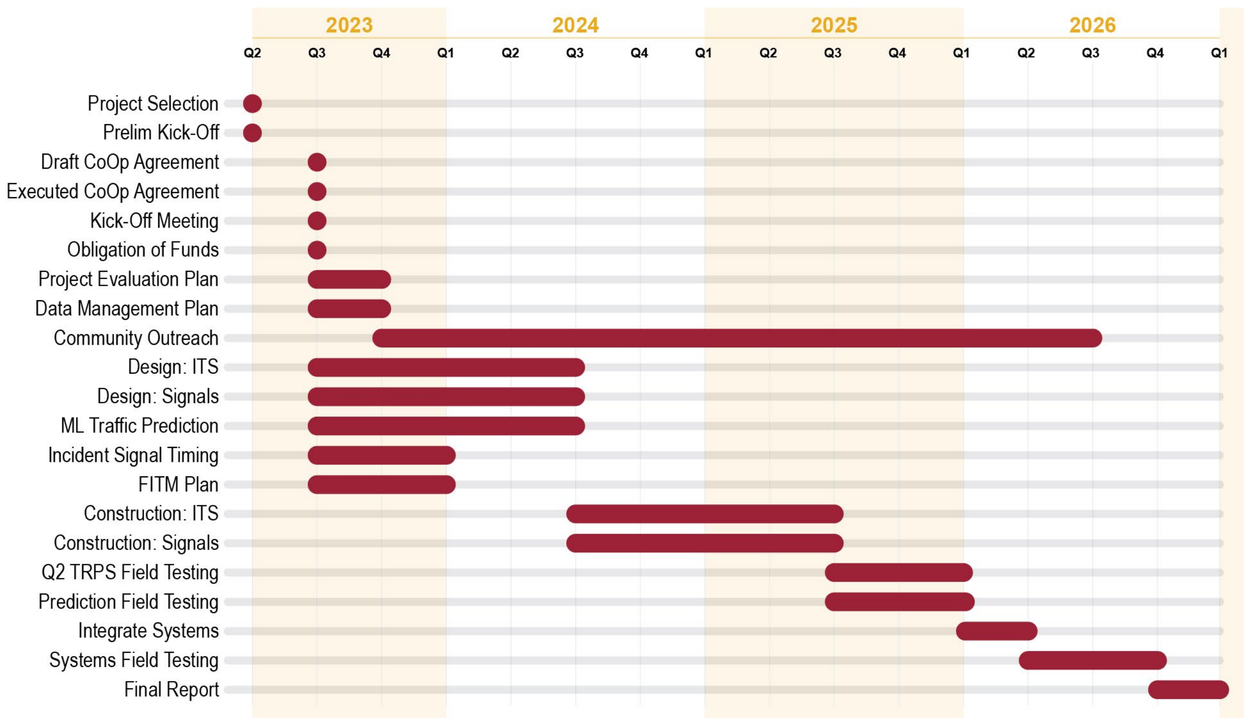


Figure 14: ROUTE 50 Project Schedule

Except with regard to incrementally reduced greenhouse gas emissions from improved traffic flows, this project does not address climate change or resiliency. Refer back to Quantifiable Safety & Environmental Benefit Projections for a discussion of the emissions reduction benefits.

↗ Racial Equity

There are three communities along the ROUTE 50 project with significant racial minorities: Cambridge, Salisbury, and near Queenstown. Equitable benefits to these communities are described in Criterion #3: Equity, Multimodal options, and Quality of Life.

Applications should be clearly address and explain if the proposed project can comply with the Buy America Act

Yes. All MDOT SHA contracts are compliant. However, more information from USDOT is required if USDOT wishes for certifications or verification of Buy America compliance.

↗ ITS Program Innovative Technology Initiatives

This project will support and leverage several USDOT ITS research areas, including emerging technologies, accelerating ITS deployment, and data access and exchanges.

- **Emerging technologies:** ML Traffic Prediction is an emerging and advanced technology aligned with the research areas described in section 6503 of title 49.
- **Accelerating ITS deployment: through ITS Evaluation:** This project will provide an ITS evaluation of the ML Traffic Prediction, Q^2 Inverse Traffic Responsive, and the travel information via web sites and push notifications for hotel and online vacation rental platforms applications strategies. The evaluation will contribute data and evaluation results to support evidence-based policy options for traffic information dissemination to accelerate national ITS implementation and best practices. The proposed technology deployment will provide evidence to decision-makers on the value of ITS deployment nationwide, such as efficiency and safety gains.
- **Data access and exchanges:** MDOT SHA will leverage our existing data exchange platform RITIS to share data gained through this project with DOT to demonstrate program performance and help inform future DOT investment decisions. MDOT SHA's real-time and archived operational data is mostly publicly available through TrafficView data APIs (which are part of RITIS). Any public or private sector individual can get free access to this API, and many already use this. It is an established system that we will use without having to create something new and waste resources. For the data that can't be shared with the public but should be shared with FHWA or other licensed users, we will leverage the RITIS platform GUI and API access which is secure and credentialed. This will enable US DOT to enable third-party research into the effectiveness of emerging ITS technologies.

↗ Proposed Technologies ATTAIN Goals & Focus Areas

Technologies	Implemented/Addressed by Application
1. Advanced traveler information systems	Yes
2. Advanced transportation management technologies	Yes
3. Advanced transportation technologies to improve emergency evacuation and response by Federal, State, and local authorities	Yes
4. Infrastructure maintenance, monitoring, and condition assessment	No
5. Advanced public transportation systems	No
6. Transportation system performance data collection, analysis, and dissemination systems	Yes
7. Advanced safety systems, including V2V and V2I communications, technologies associated with automated vehicles, and other collision avoidance technologies, including systems using cellular technology	Yes
8. Integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems	No
9. Integrated corridor management systems	Yes
10. Advanced parking reservation or variable pricing system or system to assist trucks locate available truck parking	No
11. Electronic pricing, toll collection, and payment systems	No
12. Technology that enhances high occupancy vehicle toll lanes, cordon pricing, or congestion pricing	No
13. Integration of transportation service payment systems	No
14. Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly and disabled individuals	No
15. Retrofitting DSRC technology deployed as part of an existing pilot program to C–V2X technology, subject to the condition that the retrofitted technology operates only within the existing spectrum allocations for connected vehicle systems	No
16. Advanced transportation technologies, in accordance with the research areas described in section 6503 of title 49	Yes

ATTAIN Goals	Implemented/Addressed by Application (Check all that apply)
1. Improvement in the mobility of people and goods;	Yes
2. Improvement in the durability and extension of the life of transportation infrastructure	No
3. Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity	Yes
4. Protection of the environment and delivery of environmental benefits that alleviate congestion and streamline traffic flow	Yes
5. Measurement and improvement of the operational performance of the applicable transportation networks	Yes
6. Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety	Yes

ATTAIN Goals	Implemented/Addressed by Application (Check all that apply)
7. Collection, dissemination, and use of real-time transportation-related information including, but not limited to work zone, weather, transit, and paratransit, to improve mobility, reduce congestion, and provide for more efficient and accessible, and integrated transportation, including access to safe, reliable, and affordable connections to employment, education, healthcare, freight facilities, and other services	Yes
8. Facilitating account-based payments for transportation access and services and integrate payment systems across modes	No
9. Monitoring transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair	Yes (real-time telecom to signals improves state of good repair via automatic alarm notification and remote monitoring)
10. Delivery of economic benefits by reducing delays, improving system performance and throughput, and providing for the efficient and reliable movement of people, goods, and services	Yes
11. Accelerated deployment of V2V, V2I, vehicle-to-pedestrian, and technologies associated with automated vehicle applications and other advanced technologies	Yes
12. Integration of advanced technologies into transportation system management and operations	Yes
13. Demonstration, quantification, and evaluation of the impact of these advanced technologies, strategies, and applications towards improved safety, efficiency, equity, and sustainable movement of people and goods	Yes
14. Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges	Yes
15. Incentivizing travelers— (I) to share trips during periods in which travel demand exceeds system capacity; or (II) to shift trips to periods in which travel demand does not exceed system capacity.	NO

Focus Areas	Implemented/Addressed by Application
1. State of Good Repair	No
2. Integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems	No
3. Advanced public transportation systems	No
4. Freight (or Port) Community Systems	No
5. ROUTES Initiative	Yes
6. Complete Trip Program	No
7. Data Availability	Yes

ROUTE 50 is a ROUTES Initiative "Poster Project!" The strategies address disproportionately high fatality rates on our rural transportation infrastructure, will improve emergency response services and traffic incident management, and deploy connected vehicle curve warning systems.

↗ Criterion #1: Economic Impacts, Freight Movement, and Job Creation

→ Job Creation

ROUTE 50 is an opportunity to showcase and extend MDOT SHA's commitment to supporting good paying jobs through public infrastructure investments and foster economic growth (see *Figure 15*). Historically, MDOT SHA's workforce development efforts in disadvantaged communities have been focused on the major metropolitan areas where there is a critical mismatch between skilled workers and employment opportunities. Development of this grant has highlighted the need to build a modern Maryland workforce in disadvantaged rural communities like Cambridge and Salisbury where wages are low and unemployment rates are high, especially among African American and Latino residents. MDOT SHA is committed to using the ROUTE 50 project as a platform to work with community partners like the Lower Shore Workforce Alliance, and institutions like Wor-Wic Community College, the University of Maryland Eastern Shore, and Salisbury University to upskill workers on the Lower Eastern Shore for technology-oriented jobs. These organizations are already working to upskill workers to support expanded broadband infrastructure; it would not take much more to extend training to cover the skills required for the installation and maintenance of intelligent transportation systems (ITS). The ROUTE 50 grant includes $100,000 in state matching funds to support an upskilling program to be determined among the workforce development partners.

To ensure that the workers trained locally have an opportunity to participate in projects being designed and built locally, MDOT SHA will also include a local hiring preference in the construction contract(s) for the ROUTE 50. As always, MDOT SHA is committed to free and fair choice to join a union in project construction and in ongoing operations and maintenance. Finally, achieving significant participation by Disadvantaged Business Enterprises on the Eastern Shore and in other rural areas has always been a challenge for MDOT SHA. Staff from the Office of Civil Rights will be engaged early in the project development process to conduct outreach and look for ways to increase the DBE participation goals for this project.

Figure 15: Businesses Impacted due to US 50 Congestion

→ Freight

Refer to Corridor Issues & Challenges Addressed by Proposed Technology for a discussion of the existing freight issues and challenges. ROUTE 50 will improve the movement of freight and foster economic growth to the region and the greater mid-Atlantic metro areas. Improving freight efficiency has a reach much longer than the Eastern Shore and Maryland itself. When freight is inefficient, the region suffers. US 301 traffic has increasingly influenced US 50 traffic from Bay Bridge to Queenstown since Delaware opened the Middletown bypass in 2019 and provides an attractive and well-use alternate route to congestion and events along the I-95 corridor from Philadelphia to Washington, DC. US 301 is an important route for truckers, so the connections to US 50 are exacerbated by both freight and passenger vehicles using US 301 to avoid I-95. US 50 is one of the main freight corridors of the Delmarva Peninsula, a peninsula of three states, Maryland, Delaware, and Virginia, of which US 50 is the most direct, high-volume route to major markets and freight generators on Maryland's western shore and north on US 301 to northeast markets. The tri-state, joint Delmarva Freight Plan[14] identified truck as being the main freight mode through 2040. Out of 22 key project candidates identified for Maryland

[14] https://deldot.gov/Publications/reports/freight_plan/pdfs/2015/Delmarva_Freight_Plan_Exec_Summary.pdf?cache=1584957739420#:~:text=The%20Delmarva%20Freight%20Plan%20summarizes%20current%20and%20future,to%20enhance%20freight%20and%20goods%20movement%20and%20related

to support Delmarva, 7 are US 50 needs and 9 others are roadways that stem from US 50 or have an important freight movement relationship. The plan also identified need to reduce freight bottlenecks and improve mobility during peak tourist seasons using ITS/TSMO strategies. The ROUTE 50 project will implement several of these strategies to reduce freight delays, improve mobility, reduce emissions, and pass along the economic benefits through decreased transportation costs.

↗ Criterion #2: Climate change resiliency and the environment

ROUTE 50 will provide GHG reduction in a region where GHG are increasing due to high volumes of season traffic. Refer to Quantifiable Safety & Environmental Benefit Projections for a discussion of the emissions reduction benefits.

↗ Criterion #3: Equity, Multimodal options, and quality of life

Refer to the Partnering Plan for a discussion of the public engagement process. Refer to Issues & Challenges and Quantifiable Mobility Benefits Projections for a discussion of how each strategy will improve the quality of life in rural and disadvantaged communities.

Since the 1990s, Maryland has implemented a multi-billion dollar "Reach the Beach" program designed to make it faster and easier for vacationers from the Baltimore and Washington DC suburbs to get to Ocean City, Maryland; projects have roadway and intersection widening, grade separation, and bypasses around some towns on the Eastern Shore. While the benefit of Reach the Beach has been undeniable for vacationers and to some extent for Eastern Shore communities, the benefits have not been equitably distributed. Residents of lower income, minority communities like Cambridge, for example, often find it impossible to circulate locally from Friday through Sunday evenings because of long signal cycles and high traffic volumes intended to move traffic through Cambridge. Additionally, the regional air quality benefits of Reach the Beach have not been achieved in places like Cambridge and Salisbury as traffic backs up through their communities (even with the long signal cycles) creating potentially higher levels of air pollutants and contributing to lower health outcomes such as asthma (see *Figure 16*).

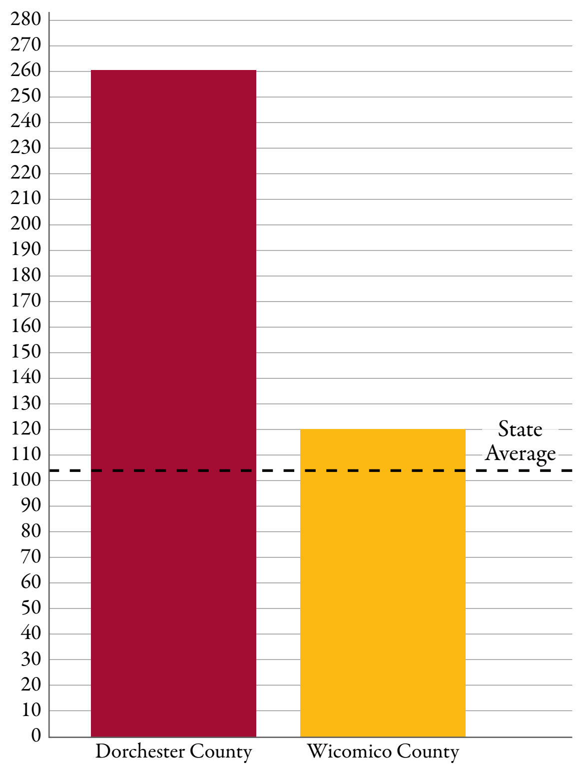


Figure 16: Dorchester County (Cambridge) has the second highest rate of hospitalizations for asthma in Maryland behind only Baltimore City. Wicomico County exceeds the state average as well.

↗ Proposed management Structure

→ Maryland Department of Transportation (MDOT) Organization

The Maryland Department of Transportation (MDOT) is a multimodal agency with responsibility for and expertise in roadway and bridge design, tolling infrastructure, motor vehicle safety, transit, vulnerable users (e.g. bicycle and pedestrian) issues, aviation and ports. The MDOT represents each of these categories through Transportation Business Units (TBUs) as demonstrated in *Figure 17*.

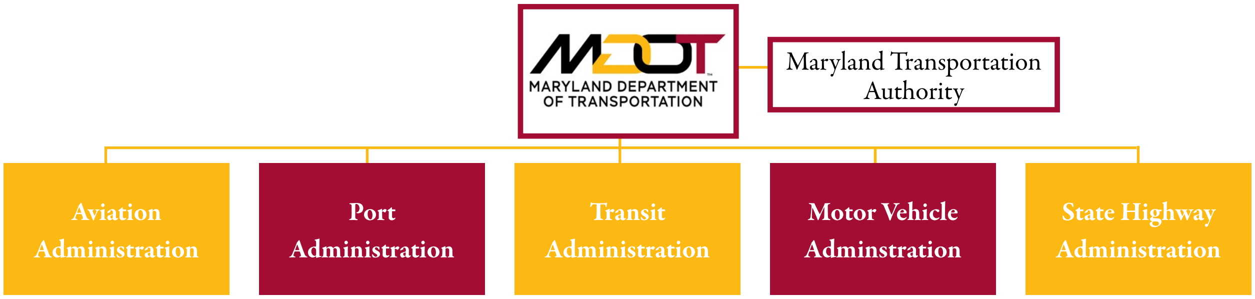


Figure 17: MDOT Organizational Structure

MDOT State Highway Administration (SHA), as one of MDOT's TBUs, is entrusted with the safe operations of all non-tolled state roadway facilities, including maintenance, construction, traffic incident monitoring and response, as well as business functions, to serve Maryland residents, commercial truck partners, businesses and travelers. The agency has a proven track record for grant oversight and implementation, and therefore will be designated as the recipient entering the agreement (i.e., receiving Federal funding) with FHWA and will oversee, implement, and administer the ROUTE 50 project in its entirety using the existing organizational structure, as well as their existing consultants, contractors, and vendors.

→ Route 50 Management Structure

A summary of the structure of the MDOT SHA offices and organization of divisions responsible for this project follows:

- Office of Transportation Mobility & Operations (OTMO) will have overall responsibility for the project including all project administration, day-to-day management, coordination among project partners, and management of funding. Within OTMO, the following departments will perform the following:
  - Mobility Planning and Engineering Division - preliminary engineering design, before vs. after project evaluation procurement
  - CHART Systems – integrate ROUTE 50 software and infrastructure into the CHART and MDOT SHA existing and proposed systems, and responsible for building, operating and maintaining the CHART ATMS systems and software
  - CHART Communications – ITS field infrastructure installation, operations, monitoring and maintenance
- Office of Traffic Safety – Traffic Development and Support Division (OOTS-TDSD) – Responsible for the design and implementation of all traffic signal-related upgrades, timing plans and optimization. TDSD will also investigate compliance with safety and overall engineering codes and principles and support the before vs. after project evaluation effort with crash analyses.
- Office of Traffic Safety – Traffic Operations Division (OOTS-TOD) - Construction administration and traffic signal device field operations, inspection (construction quality control) and maintenance activities.

- Office of Traffic Safety – Traffic Engineering Design Division (OOTS–TEDD) Responsible for the detailed engineering design, project plans, specification and estimates, including quality control of construction documents issued for construction. TEDD will issue tasks through their existing and available consultant contracts for construction of this project. The contracts under this division meet federal requirements for use as they were competitively bid and meet Maryland's procurement laws for use in this project.
- Office of Traffic Safety - Contracts & Finance Division (OOTS-CFD): Responsible for project advertisement, contract award and notice-to-proceed to the Contractors.
- Office of Finance (OOF)-Federal Aid Division: Obtaining Federal Authorization to activate the use of the funding received through this grant.
- Secretary's Office Resource Service Order: responsible for providing the information technology staff to develop the connected vehicle data exchange platform

In addition, the following partners will provide coordination and support: MDOT MDTA, Queen Anne's County, Talbot County, Caroline County, Dorchester County, Wicomico County, Worcester, Town of Ocean City, Town of Cambridge, City of Easton, City of Salisbury, and the Kent Island Chamber of Commerce.

↗ Partnering Plan

MDOT SHA's plan includes establishing traditional approaches with a unique twist, and non-traditional methods. The twist is that our approach is aimed at targeting the community, and not the drivers as we've traditionally targeted. Through our partnerships with cities, towns, and community groups we distribute postcards, post on social media, host virtual public meetings with breakout rooms, web-based surveys, project websites, print-ready webpages, press releases, and newsletters. Our Community Liaisons will "Walk-Shop" outreach (in the style of political canvassing or town-hall meetings) to the disadvantaged communities in Kent Island, Easton and Cambridge people who do not typically attend meetings, or use social media platforms to provide the same information that is available virtually.

Our plan also includes non-traditional partnerships such as with hotels chains, VRBO, Airbnb, and various resorts. Most resorts send out marketing emails to past and scheduled visitors several times a year and our intent is to convince as many as possible to include a simple survey link to a QR code in their messages. In that way, visitors during all seasons can be reached throughout the year and MDOT SHA can provide travelers with data-driven tools to make informed travel decisions.

We will leverage our existing partnerships with driving navigation applications such as Waze and Google Maps so that the applications don't route through traffic onto local roads within communities.

Our approach is consistent with the USDOT's Promising Practices for Meaningful Public Involvement in Transportation Decision-Making[15] process of addressing critical gaps, and meaningful public involvement. MDOT SHA has an existing high-capacity public involvement team to execute this plan successfully. *From the discussion in Issues & Challenges, you've noticed that we've clearly already engaged the public and have heard their pleas for a change in strategy – which the ROUTE 50 Project will do to improve the quality of life in rural, disadvantaged communities.*

Address Critical Gaps. | Identify key stakeholder groups and resource agencies and jurisdictions at the local, state, regional, and Federal levels. Identifying optimal and innovative outreach strategies including social media, virtual town halls, meetings in a box, and pop-up meetings to reach people where they live, work and play. Special emphasis will be placed on reaching minority, low-income and limited English-speaking populations and connecting with those who are averse to traditional public meetings

[15] https://www.transportation.gov/public-involvement

Meaningful Public Involvement | includes understanding the demographics and including people who are traditionally under served, and continuing the current, durable relationships our Community Liaisons have built over the years with the diverse community. Our approach is proactive and not reactive and will be a comprehensive documentation of the results.

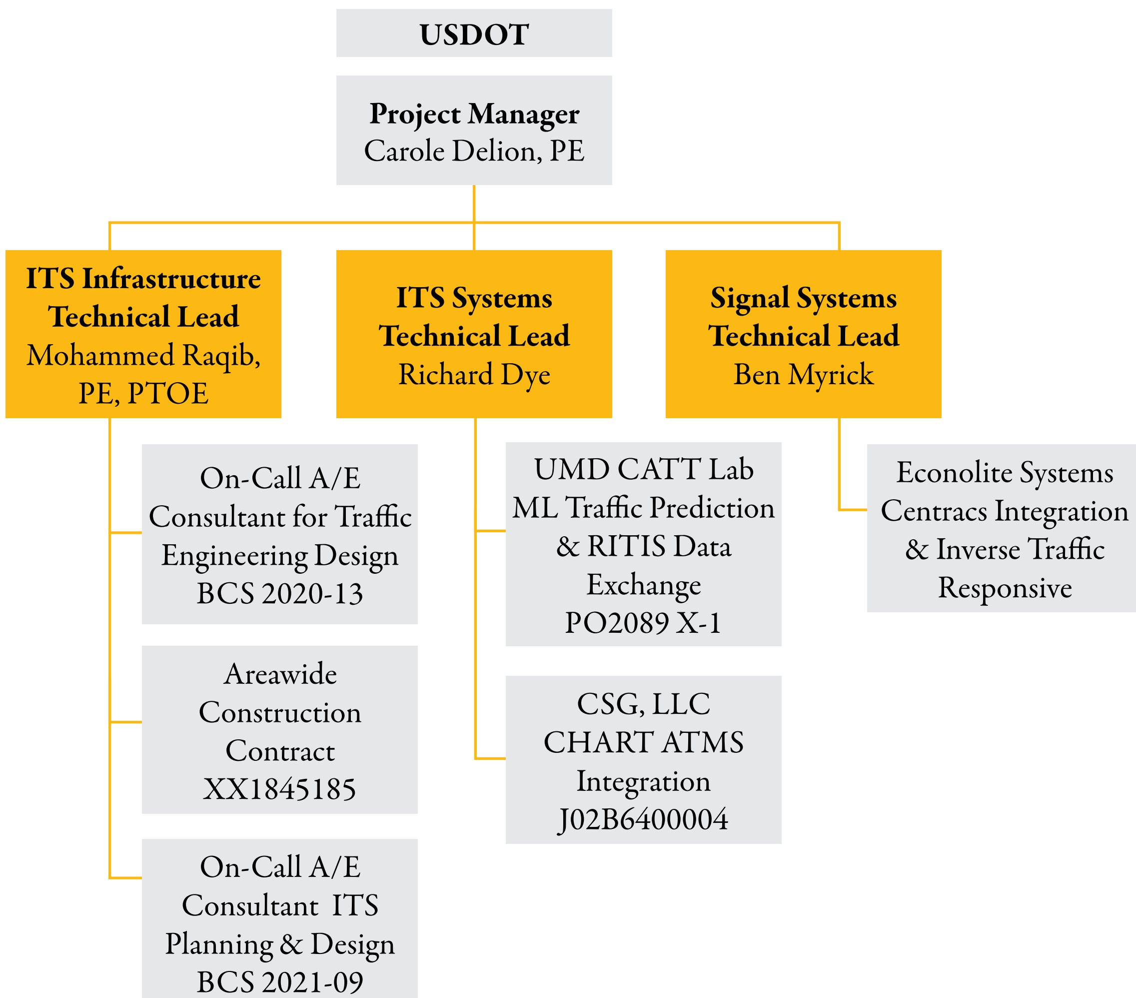
↗ Subrecipients

MDOT SHA is the sole recipient; there are no sub-recipients.

↗ Organizational Chart

Figure 18 shows an Organizational Chart of the key staff within the project team. The preceding section on Deployment Plan contains a discussion detailing how MDOT SHA will deliver the project through existing contractual relationships. Refer to our discussion on Proposed Management Structure for a description of the divisions within MDOT SHA and their roles and responsibilities. Lastly, the section entitled Key Staff Roles & Responsibilities highlights the individual key staff roles and responsibilities for this project. All Key Staff are State Employees.

Project OrganizationalChart



↗ Primary Point of Contact

The primary point of contact and Program Manager's contact information is:

- **Name & Position |** Carole Delion - Deputy Director, Office of Transportation Mobility and Operations
- **Address |** 7491 Connelley Drive Hanover, MD 21076
- **Phone |** 410-582-5521
- **Email |** cdelion@mdot.maryland.gov

↗ Key Staff Roles & Responsibilities

- **Program Manager, Key Personnel #1:** Carole Delion, PE will serve as the primary point of contact and Project Manager. She will be the primary technical decision-maker and will have overall responsibility for the project delivery including budget and schedule adherence, progress reporting, and liaison with USDOT and offices with MDOT supporting the work on this project including the Secretary's office and the Office of Finance. She is also responsible for providing connected vehicle subject matter expertise. Carole expects to dedicate 35% of her work time to the project during the period of performance.
- **ITS Technical Lead, Key Personnel #2:** Mohammed Raqib, PE, PTOE will serve as the Deputy Program Manager and Technical Lead for ITS Infrastructure including systems engineering, preliminary engineering and final design. As the Assistant Division Chief for CHART-PPD, Mr. Mohammed is responsible for developing near-term and long-range ITS deployment plans, identifying budgetary needs and programming funding, developing capital projects, preparing preliminary engineering packages, and supporting project and contract management. Mohammed expects to dedicate 30% of his work time to the project during the period of performance.
  - **Keith Riniker**, **PE, PTOE** will report to Mr. Raqib as the consultant manager for BCS 2021-09. As part of his role on this project, Keith will also be responsible for public outreach. Keith has served as consultant program manager for traffic prediction project for the 60-mile system centered on the Bay Bridge and was responsible for the full systems engineering lifecycle from ConOps to verification and validation. He has led numerous traffic engineering design task for signing and signals including construction documents, timing and operations. Keith expects to dedicate 40% of his work time to the project during the period of performance.
- **Systems Integration Technical Lead, Key Personnel #3:** Richard Dye is the CHART ATMS Systems Administrator and will serve as the Technical Lead for Integration and ATMS development. He is responsible for the unit that designs, builds, operates, and maintains all automated control systems that drive the CHART ATMS Platform and will manage the work of CSC, LLC and the CATT Lab. Rick expects to dedicate 15% of his work time to the project during the period of performance.
- **Signal Systems Technical Lead, Key Personnel #4:** Ben Myrick is the Team Leader of the Signal Systems Operations Team in the Office of Traffic and Safety Traffic Support & Development Division. In this position, he oversees the development and implementation of timing for MDOT SHA's 1,500+ coordinated traffic signals. He has also worked closely with the Traffic Operations Division to improve MDOT SHA's signal technologies and implement adaptive operations and piloted the Inverse Traffic Responsive Signal System on US 50 last season. Ben will serve as the Technical Lead for Signal Systems and manage the work of MDOT SHA TDSD staff and Econolite, MDOT SHA's signal system vendor for ASCT, ATSPMs and TRPS. Ben expects to dedicate 25% of his work time to the project during the period of performance.

↗ Support Staff Roles & Responsibilities

- **ITS Construction:** Willy Gayle is the Assistant Division Chief for Engineering and Technical Support for the MDOT SHA Office of Transportation Mobility & Operations' (OTMO's) - Intelligent Transportation Systems Division (ITSD). He has been managing the deployment, acceptance, and maintenance of OTMO's ITS devices and communications networks for over 15 years and will be overseeing the ITS construction and final acceptance stages of the project. Over the years, Mr. Gayle has provided senior expertise and managerial direction for a highly complex technical field of communications engineering and design for statewide Microwave and Land Mobile Radio communication networks, Voice Over IP phone (VOIP) systems and ITS for the OTMO CHART Program. He manages and supervises career State employees and full-time consultant support staff assigned to the Engineering and Technical Support Team, which is responsible for managing Radio Tower construction, Microwave Communications networks, Public Safety Radio systems, Interoperable Communications engineering, and CHART ITS devices such as CCTV Traffic Cameras, Roadway Weather Information Systems (RWIS), Radar Speed Detection Systems, Dynamic Message Signs (DMS), Highway Advisory Radios (HARs), and Connected Vehicle Roadside Units (RSUs).
- **Traffic Signal Construction:** Rebecca Lichtenstein is the Division Chief for the MDOT SHA's Office of Traffic & Safety (OOTS) Traffic Operations Division (TOD) and manages the Traffic Signals Operations Section. She has over 10 years of traffic signal and ITS device construction experience and will be in charge of the engineering and maintenance staff responsible for all traffic signal system and infrastructure deployment and operations.
- **Traffic Engineering Design:** Lili Liang is the Division Chief for MDOT SHA's OOTS Traffic Engineering Design Division (TEDD). She manages all traffic signal and ITS design engineers and consultants for MDOT SHA and will be overseeing the design of all signal and ITS design requests to ensure compliance with National and Maryland State standards. Ms. Liang is a registered professional engineer with over 13 years of experience in traffic studies, transportation engineering design, standard and guideline development, and project management. Her duties will include the supervision and management of transportation engineering design from initiation to construction.
- **Data Exchange:** Michael Pack is the founder and director of the CATT Laboratory and manages a team of 75+ data scientists, software developers, systems integrators, and transportation professionals. He sets the Lab's strategic vision to make federal, state, and local transportation data easily accessible and usable by diverse user communities. Through the development of RITIS' innovative applications and data visualization tools, Michael's team enables data sharing, public transparency, informed decision-making, better response to emergencies, insight discovery, and increased productivity. Michael will report to Rick Dye for the duration of this project.
- **ML Traffic Prediction:** Dr. Kaveh Farokhi is a Senior Faculty Specialist at the Center for Advanced Transportation Technology (CATT) at UMD. He brings 20 years of professional experience in various areas of transportation planning and operations, engineering, and intelligent transportation systems. Kaveh was the lead for the MDOT traffic prediction project for the 60-mile system centered on the Bay Bridge. Kaveh will report to Rick Dye for the duration of this project.