MaineDOT

ATTAIN Grant, Volume 1
Technical Application
Maine Department of Transportation
Statewide Connected Vehicle Hazard Notification Project

I. Volume 1: Cover Page

Project Name	MaineDOT Statewide Connected Vehicle Hazard Notification Project
Eligible Entity Applying to Receive Federal Funding	MaineDOT
Total Project Cost (from all sources)	$6,500,000.00
Advanced Transportation Technology and Innovation Program Request	$5,200,000.00
Are matching funds restricted to a specific project component? If so, which one?	No
State(s) in which the project is located	Maine
Is the project currently programmed in the:	
• Transportation Improvement Program • Statewide Transportation Improvement Program • MPO Long Range Transportation Plan • State Long Range Transportation Plan	This project is not currently included in the STIP or TIP; however, it will be added upon award of this grant. This project is consistent with the goals of our statewide long range transportation plan. It is not included in an MPO long range plan.
Technologies Proposed to Be Deployed (briefly list)	C-V2X, CCTV, FMUs, MVDS, OBUs, RSUs, RWIS
Will the project use connected vehicle technologies? If so, which technologies will be used—for instance, will the project use: • DSRC/5.9 GHz spectrum? • Cellular/4G/5G communications? • Another connectivity technology? (please specify - e.g., "Wi-Fi," "Bluetooth," "RFID," etc.) If the connectivity technology has yet to be determined, please specify "TBD."	A focus of this project is the use of connected vehicle (CV) technologies, including V2I (5.9 GhZ) and C-V2X (4G/LTE/5G) using hybrid field monitoring units (FMUs)
Will the project use automated driving system technologies?	No
Rural Considerations: a) Is the project serving a rural area(s)? A rural area is an area with a population of less than 50,000 residents according to the 2020 Census population estimates. b) If yes, how much ATTAIN funding is being requested to be put toward serving the rural area(s)?	a) The project is largely focused on rural areas based on the 2020 census. The only exceptions are some bridges that are within the greater Portland and Bangor MPO Areas. b) 75% of the ATTAIN funding will be put toward rural areas.

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II. Project Narrative

1. Project Summary

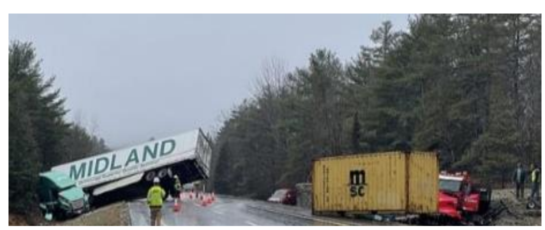
The *MaineDOT Statewide Connected Vehicle Hazard Notification Projec*t (Project) will leverage standardized C-V2X technology to send catered warning messages in areas with bridge height restrictions, congestion, and where hazardous weather may impact travel. This project will address challenges in safety, mobility, state of good repair, economic vitality, equity, and air quality. The Project's total cost is expected to be $6,500,000.00 with an ATTAIN grant request of $5,200,000.00.

Low Clearance Bridge Warning System: The Project's most significant component will consist of installing C-V2X roadside units (RSUs) and field monitoring units (FMUs) to broadcast bridge height restrictions to freight and trucking industry partners and to the traveling public. Audible notifications will be sent to the cabs of drivers' vehicles or to their mobile devices, alerting them of the potential obstacle. The messaging is intended to occur multiple times, providing repeated notices in advance of the posted overpasses to allow vehicles to divert prior to reaching the restricted bridge. The Maine Motor Transport Association (MMTA) is very interested in partnering with MaineDOT on this important project, which will help create a smarter, more efficient transportation network throughout the State.

Exit 109 Interchange Bridge Damage in Augusta

Brunswick US Route 1 Congestion and Weather Warning System: The same C-V2X technology will be used in the Town of Brunswick to alleviate congestion and improve traffic mobility in areas that regularly experience both recurrent and nonrecurrent congestion. Traffic monitoring equipment (cameras and radar) and road weather information systems (RWIS) will be integrated with the FMUs in this area so that audible messaging can inform drivers when roadways are congested. Messaging will be provided at strategic locations approaching Brunswick along US Route 1 so that drivers can make informed and intuitive travel decisions. MaineDOT has the strong support of several partners within the Greater Brunswick-Bath area including MMTA, Mid Coast-Parkview Health, the Midcoast Regional Redevelopment Authority (MRRA), and General Dynamics Bath Iron Works (BIW).

I-95 Palmyra-Carmel Weather Warning System: The C-V2X technology will be used to alert drivers of dangerous weather conditions that contribute to frequent and serious crashes on I-95 in the Palmyra-Carmel area, namely black ice, blowing snow, and solar glare. Like in Brunswick, traffic monitoring cameras will be installed, and RWIS will be integrated with the FMUs; however, the flexibility of the system will allow a separate targeted problem to be addressed. MaineDOT will monitor or estimate travel conditions, including both roadway state and sun glare status during high-risk periods and the system will send catered, audible warnings so that drivers can make informed travel decisions. This component also has strong partnership support from MMTA.



Icy Road Conditions on I-95 in Etna

US Route 1/Route 11 Aroostook County Weather Warning System: This C-V2X deployment, like in Brunswick and in the Palmyra-Carmel corridor, will include traffic monitoring cameras and integrated RWIS. It will leverage the flexibly designed system to address a unique set of hazardous weather conditions in these rural areas. Several segments along US Route 1 and Route 11 in Aroostook County are flat, with farmland on either side resulting in blowing snow, black ice, and white-out conditions.

Blowing Snow on US Route 1 in Van Buren

Information gathered by the integrated technology will be used to trigger alerts as drivers approach locations on US Route 1 and Route 11 that are experiencing adverse conditions. This will allow drivers to make well-informed travel decisions now and even more so as the consumer side of this technology becomes mainstream. Both the Aroostook County Emergency Management Agency and the MMTA strongly support the expansion of this technology to Aroostook County to improve safety and reduce crash risks in the area during hazardous weather conditions.

2. Geographic Area

Figure 1 on the following page provides an overview of the MaineDOT Statewide Connected Vehicle Hazard Notification Project and identifies all four components and locations across the State. Note that all project location figures are included in Appendix A as full-size graphics.

1. *Low Clearance Bridge Warning System*

Statewide, Maine

The overwhelming majority of people and goods in Maine are moved over the State's 23,513 miles of public roads. Trucking is still the dominant mode for freight shipments, accounting for 86 percent of all freight tonnage moved to, from, within, and through the State. The Low Clearance Bridge Warning System component of the project includes installation of communication equipment at 18 directional roadway approaches along major freight corridors for bridges with height restrictions throughout Maine. A map showing the location of the 18 low clearance bridges included in this project is shown in Figure 2. This project would include bridge warning systems in the following 5 rural areas and 3 urban areas:

Rural - Posted Bridges for Under Clearance	Urban - Posted Bridges for Under Clearance
Sidney	Bangor
Augusta	Cumberland
Waterville	Falmouth
Brunswick	Freeport
West Bath	South Portland

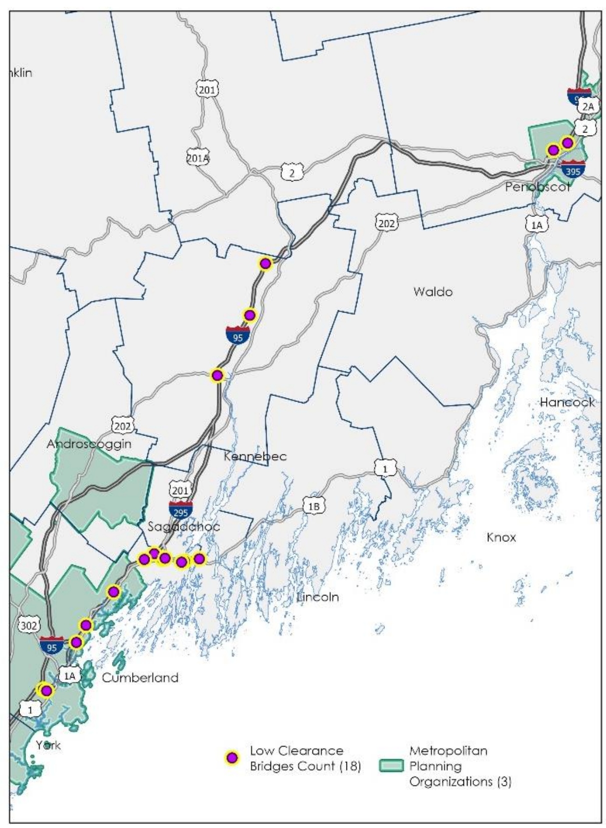
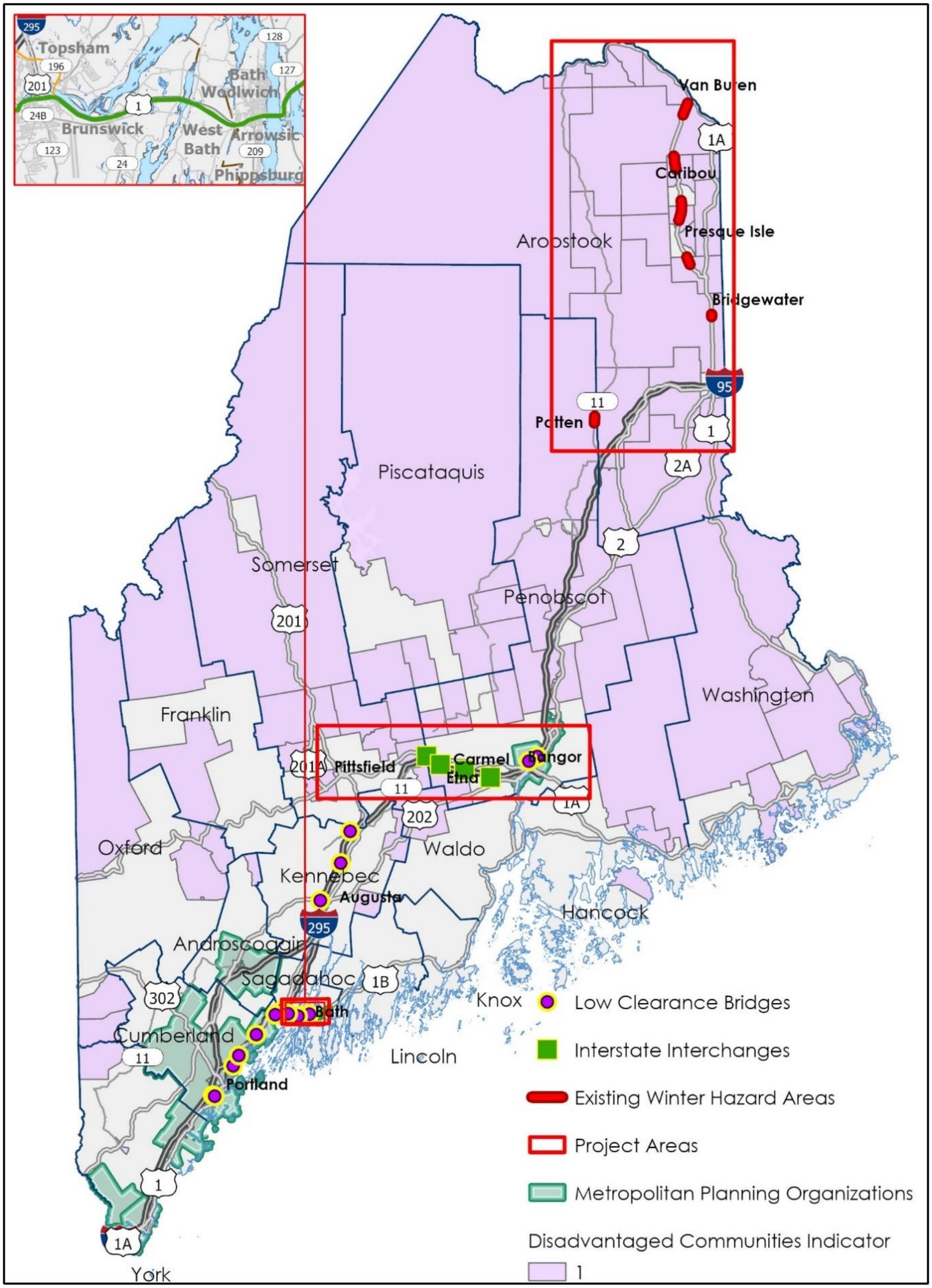


Figure 2: Low Clearance Bridges

Figure 1 Statewide Connected Vehicle Hazard Notification Project



2. *Brunswick US Route 1 Congestion and Weather Warning System*

Brunswick, Cumberland County, Maine

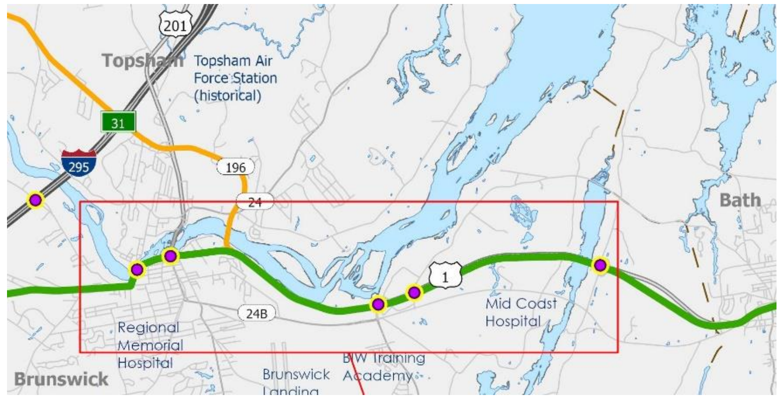


Figure 3: Brunswick Congestion and Weather Warning Area

Located on the southwest end of Midcoast Maine, Brunswick is a rural community with a 2020 census population of 21,756 residents located between Portland, Maine and the State Capital of Augusta. Brunswick, a 54 square mile area, is a regional hub and service center providing jobs, shopping, education, and medical care. Brunswick boasts a rich cultural scene and houses Bowdoin College. The town, continuously growing as an employment hub also houses Mid Coast Hospital. On its eastern border lies Bath, home to BIW, Maine's fourth-largest employer. The company, providing shipbuilding services for the U.S. Navy, is a subsidiary of General Dynamics, the world's fifth largest defense contractor.

Brunswick has two commercial and retail centers: Maine Street which serves as the community's downtown and Cook's Corner, located three miles east of downtown. Cook's Corner is a major commercial center, place of employment, and is surrounded by residential neighborhoods. These two centers are separated by the Brunswick Naval Air Station, which closed in 2011. Through the work of the Midcoast Regional Redevelopment Authority, the former Naval Air Station is now Brunswick Landing: Maine's Center for Innovation, a growing regional business center with more than 150 businesses and nonprofits. US Route 1 and Bath Road connect these two centers as well as downtown Bath, where BIW is located.

US Route 1 runs along the north side of the downtown area and the south side of the Androscoggin River. Maine Street runs through the downtown center in the north/south direction. As shown in Figure 3, US Route 1 is vital both locally and regionally as it provides access to I-295 for Midcoast Maine communities that experience heavy seasonal tourism. US Route 1 is also a major corridor and provides connectivity for commuters traveling to BIW and Brunswick Landing. The BIW complex also has a satellite facility just east of Cook's Corner where they plan to add additional satellite parking for workers that would then carpool to/from the larger facility in Bath, and would benefit from the implementation of this project.

3. *I-95 Palmyra-Carmel Weather Warning System*

As shown in Figure 4, I-95 runs generally east -west through this segment of the State. **Palmyra** is a rural town located in Somerset County, Maine and has a 2020 census population of 1,924 residents. It has a total land area of 41 square miles and is adjacent to Pittsfield and west of Bangor. **Carmel** is a small rural town in Penobscot County with a 2020 census population of 2,867 residents. The town is west of Bangor, comprising 37 square miles. This stretch of I-95 also provides access to the rural communities of Plymouth, Newport, and Etna. Palmyra and Plymouth are identified as disadvantaged communities.

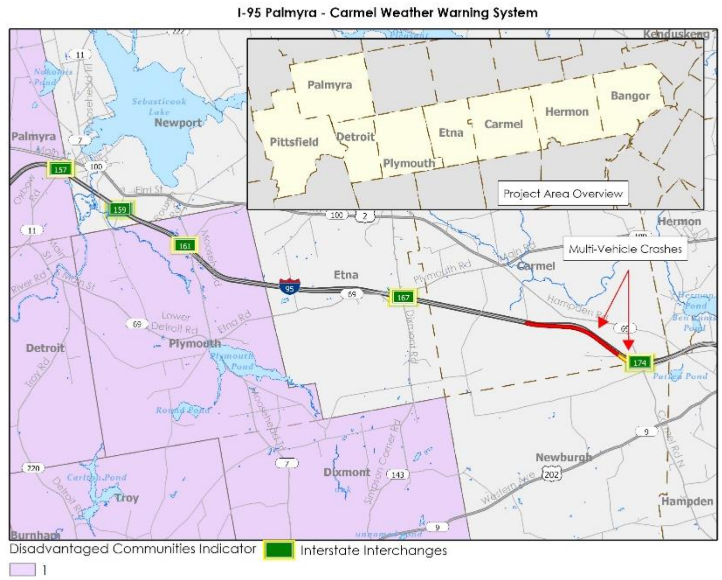


Figure 4: I-95 Palmyra to Carmel Weather Warning System

4. US Route 1/Route 11 Aroostook County Weather Warning System

Aroostook County, Maine

This element of the Project is on US Route 1 in Caribou, Presque Isle, Westfield, Bridgewater, Cyr, and Van Burren and on Route 11 in Patten and Mount Chase. All of these locations are in Aroostook County. Aroostook County borders Canada and is the northerly most county in Maine with a 2020 census population of 67,105 residents. Known as "The County," Aroostook is the largest county by land area in Maine with 6,800 square miles and is the largest county by area east of the Mississippi River. Despite its size, "The County" is lightly populated, with a population density of about 10 residents per square mile, making "The County" a largely rural area. Nearly a quarter of the county's population (24%) lives in its only two cities, Caribou and Presque Isle. These cities comprise of 7,396 residents and 8,797 residents respectively. Caribou is located just north of Presque Isle along US Route 1. Aroostook County is largely an agricultural producer, known for potato farming and forestry products resulting in high truck and farm vehicle traffic. The Aroostook River runs through Caribou on the east side of US Route 1. Note that the majority of these Project segments are located in disadvantaged communities.

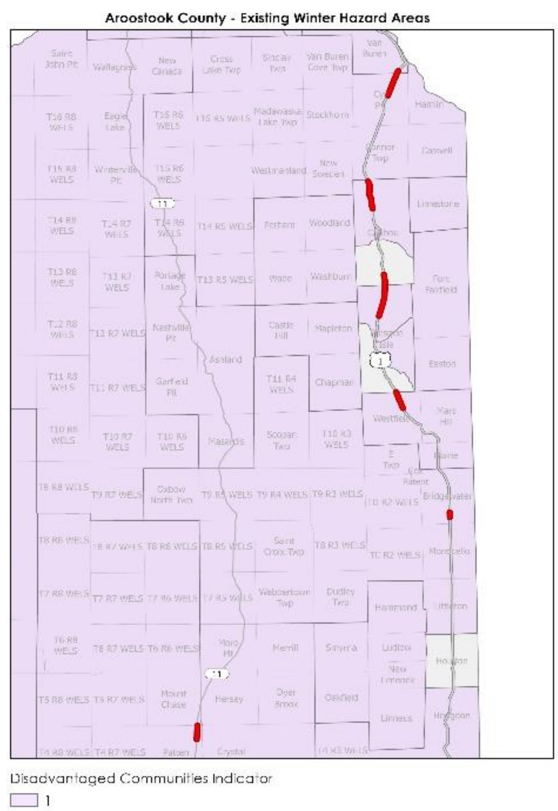


Figure 5: Winter Hazard Areas

3. Issues and Challenges

The project addresses the following transportation issues and challenges:

- **Bridge Infrastructure Damage due to Driver Inattention** — Existing signage for bridge height restrictions often gets ignored by drivers. Sometimes, this leads to vehicles hitting overhead bridges resulting in expensive damage to MaineDOT's infrastructure. MaineDOT spends approximately $150,000 on construction costs related to incidents of overheight vehicles hitting low clearance bridges each year. These annual construction costs do not include user costs related to detours and delays or larger incidents such as the one that occurred along I-95 at the Exit 109 Ramp F in Augusta and cost over $3.5M in unanticipated emergency bridge replacement costs.

I-95 Exit 109 Ramp F Bridge Damage

In the fall of 2017, an overheight vehicle hit the I-95 Exit 109 Ramp F Bridge, causing a crack in the southern beam and the north exterior beam, resulting in over 4 months of fast-track design and construction with related detours and cost the state over $3.5 million.

- **Traffic Congestion in Brunswick-** Since US Route 1 and Bath Road are bottlenecked by the Androscoggin River and the former Navy base between the east and west sides of Brunswick, they carry most local and through traffic moving between the two sides of the town or onward to points east (Bath, BIW, and Midcoast Region) or west (I-295 with access to population centers like Augusta and Portland). The bottleneck is exacerbated by a lane drop at the US Route 201 and Route 24 Business interchange, reducing US Route 1 westbound through traffic from two lanes to one lane. There are recurring and dramatic traffic volume peaks in westbound through traffic coming from Bath as BIW shift workers commute home to population centers along I-295, passing through Brunswick. This congestion is only exacerbated by seasonal travel to coastline attractions. A BIW structural fabrication facility located on Bridle Road at Bath Road in Brunswick generates a high volume of traffic due to the transport of both workers (non-commercial drivers) as well as parts manufactured at the facility (commercial drivers) to the shipyard in Bath. BIW is very interested in partnering with MaineDOT on this important project and to help in testing and pilot programs that can help improve the safety and wellbeing of their work force.

- **Travel Time Reliability and Traveler Information Systems** – Travel time in the rural areas varies based on several contributing factors including weather, congestion, and crashes. A reliable transportation system provides the end user a dependable mode of transportation with an expected travel time. Rural communities often lack the real-time dissemination of travel conditions as compared to urban communities. This is a particular challenge in Brunswick, as east-west travel is limited to either US Route 1 or Bath Road, and an accident or poor roadway conditions can easily lead to congestion along the corridor. Providing active management of US Route 1 with advanced technologies (RSUs, camera detection systems, radar detection systems, RWIS), will enable the dynamic routing of vehicles onto less congested roads, providing for the optimization of the travel corridors. In addition to travel time challenges related to congestion, travel time reliability is impacted when bridges are

RSU (cabinet hardware with antenna)

struck and detours are required. Often times bridge strikes can result in long detours through rural areas. When large multicar pileups occur due to adverse winter weather, these incidents also result in extensive delays on I-95 and Routes 1 and 11.

- **Safety in Brunswick –** MaineDOT crash records indicate there were over 1,745 crashes in Brunswick alone during the years of 2021-2023. In the project corridor along US Route 1 southbound, there were 228 total crashes in the ten years between 2013 and 2022 with the majority of the crashes rated as property damage only. This section exceeds the statewide crash rate for similar corridors. Travelers in rural Maine and smaller towns such as Brunswick are at greater risk particularly during winter due to snow and ice. In August of 2021, a six-car pileup[1] resulted in life-threatening injuries in Brunswick. This crash occurred during a congested period when vehicles were stopped on Route 1.

Brunswick Route 1 crash
SOURCE: Brunswick Police Dept.

- **Winter Weather** – Solar glare, black ice, wind-driven snow, and other adverse winter weather conditions have resulted in a number of multi-car pileups on I-95 in the Palmyra-Carmel area. One major example of a winter storm related pileup occurred on February 25, 2015 and involved 39 vehicles. Another multi car pileup event occurred on January 7, 2020. It involved 29 vehicles and was attributed to solar glare along I-95 in Carmel.

  US Route 1 and Route 11 in Aroostook County have sections that are susceptible to blowing snow due to the lack of tree coverage adjacent to the roadway throughout the area. The proposed CV technology will be able to warn the drivers of snowy conditions before they travel into an area with low visibility.

Multi-vehicle crash on I-95 northbound in Carmel (01/07/20)

The proposed CV technology deployments address many of the ATTAIN program goals as described through the application. Table 2 in Section 16 identifies all program goals this project meets. The project also meets the following USDOT focus areas:

1 https://www.wmtw.com/article/six-vehicle-crash-closes-route-1-in-brunswick/37396244#

- **State of Good Repair** – As previously discussed, height restriction signage often gets ignored leading to significant damage and expense when bridges are struck by trucks. This project would add additional warning messages to help maintain and protect the structural integrity of the program's bridges. The RWIS stations will identify roadway icing, aiding in dispatching salt trucks and snowplows during weather events to maintain safe travel corridors.
- **Efficiency of Freight Movement**: The use of traffic monitoring cameras and RWIS technology is expected to improve efficiency of freight movement throughout the project component corridors in Brunswick, Palmyra-Carmel and the communities identified in Aroostook County. The use of these CV technologies will warn drivers prior to entering congested routes in Brunswick and/or adverse weather on I-95 in Palmyra-Carmel or US Route 1/Route 11 in Aroostook County resulting in improved traffic operations. The daily congestion along US Route 1 in Brunswick would be addressed with the advance warnings regarding delays and allow drivers to take other routes which improves mobility of people and goods and in turn future potential economic growth. In addition, deploying the Low Clearance Bridge Warning System is expected to reduce the number of vehicles that hit overhead bridges and will therefore result in more efficient freight corridors since bridge hits cause detours and additional congestion.


Closed Circuit Television (CCTV) for Traffic Monitoring.

- **Rural Opportunities to Use Transportation for Economic Success (ROUTES) Initiative:** The Brunswick element of the project is located along a major corridor within the region that connects people to jobs (such as BIW) and communities in Bath and beyond to Midcoast, Maine. The technologies proposed will enhance mobility by providing remote monitoring of traffic conditions and providing the ability to clear incidents faster. The project will include weather advisories in rural areas to improve roadway weather management in Brunswick, Palmyra to Carmel, and the communities identified in Aroostook County. Enhanced mobility for freight movement in Aroostook County contributes to greater economic equity by getting products to markets effectively.
- **Data Availability:** MaineDOT will provide baseline data prior to project deployment and collect data after project deployment related to travel time, traffic volume, crashes, and incident clearance times. All these metrics will be used to determine the benefit-cost ratio for the proposed implementation. MaineDOT commits to sharing any traffic data that is generated by the equipment proposed in this project with FHWA and other interested government agencies.

4. Program Vision, Program Goals, the Administration's Priorities, and DOT Focus Areas

MaineDOT envisions a safer and more efficient transportation roadway network that has the ability to warn drivers ahead of time about restricted bridge clearances, congestion, and adverse weather conditions. Through the innovative use of CV technologies, MaineDOT intends to provide active, audio messaging within the transportation corridor in real-time. The project vision aligns with the ATTAIN program goals and the USDOT program goals, priorities and focus areas described as follows:

Goals: The project is expected to reduce the number and severity of traffic crashes and bridge hits by alerting drivers to hazardous weather conditions and low clearance bridges. Reducing crashes (quantity and severity) is expected to increase safety for all road users. The reduction of bridge impacts strongly correlates to maintaining a state of good repair of the roadway infrastructure. All four components of the project will foster and support economic development by improving mobility, reducing delays and allowing the traveling public more efficient and equitable access to jobs, healthcare, schools, commercial uses and recreation. The project will also increase the capacity of the transportation network to accommodate anticipated residential developments in the Brunswick area.

The project will reduce transportation costs through reduced fuel consumption, costs associated with crashes, and maintenance and construction costs for repairing bridges following bridge strikes. The use of CV technology will support commerce by improving mobility for freight and offering competitive advantages in the region, and particularly in several disadvantaged communities through transportation access for both businesses and residents. The project will optimize the existing transportation capacity by allowing drivers to choose alternative routes when US Route 1 is congested in Brunswick.

The project aims to enhance the durability and prolong the lifespan of low clearance bridge infrastructure by reducing the incidents of drivers ignoring the warning signs and causing significant damage to the bridges. Protecting the infrastructure and avoiding bridge strikes also reduces the costs of maintaining the infrastructure in a state of good repair by eliminating the need for emergency repairs and costly replacements of bridge elements.

MaineDOT will evaluate the success of these CV technology enhancements to its roadway network as described in Section 8 System Performance Measures. MaineDOT expects that the technology used for the four components of this project will be able to be replicated and applied to other communities in other states in addition to other areas throughout Maine.

The project aligns with the Administration's Priorities:

- **Safety:** The project is expected to improve safety for all road users by warning drivers prior to entering an area with a low bridge clearance, an area with congestion, or an areas with weather advisories including black ice, snow, white out conditions or solar glare. These warnings are anticipated to reduce the quantity and severity of crashes related to bridge impacts, congestion, and adverse weather.
- **Climate Change and Sustainability**: On December 1, 2020, Maine released a four-year plan for climate action titled *Maine Won't Wait*[2], which sets greenhouse gas reduction goals. This advanced technology project will directly support the state climate plan and reduce emissions by reducing congestion.
- **Equity**: Components of this project, including portions of the I-95 Palmyra-Carmel corridor and Aroostook County corridors, fall within federally designated disadvantaged communities, reflecting Maine's desire to better serve all the residents of Maine. The project team will engage the public and work to ensure the positive benefits from the project will flow to residents of color, low-income, and disadvantaged populations as designated by the Climate and Economic Justice Screening Tool (CEJST). MaineDOT

2 https://www.maine.gov/climateplan/sites/maine.gov.climateplan/files/inline-files/MaineWontWait_December2020_printable_12.1.20.pdf

recently updated its Public Involvement Plans, outlining the Department's efforts to ensure disadvantaged populations and underserved communities are afforded meaningful opportunities for public involvement[3]. Public outreach for this project will be conducted in accordance with these processes. MaineDOT is also in the process of developing an Equity Outreach Dashboard as part of its virtual public involvement tool PIMA. This dashboard will help identify how MaineDOT is reaching different underserved populations, including Title VI and Environmental Justice requirements along with other data. This can help MaineDOT further understand how it is doing and what else can be done to reach underserved populations. Additionally, MaineDOT includes a Demographics Survey with all of our virtual meetings to measure our effectiveness in reaching underserved communities. For this project, MaineDOT will use a combination of in-person and virtual public meetings to ensure we reach the underserved and vulnerable communities within the project limits.

MaineDOT has launched a new DEI initiative and has an external equity statement that states our commitment to ensuring that all Maine people have access to safe and reliable transportation options. Furthermore, "in accordance with Title VI of the Civil Rights Act of 1964 and other authorities, MaineDOT is committed to ensuring that the fundamental principles of equal opportunity are upheld in all decisions involving our employees and contractors/consultants, and to ensuring that the public-at large is afforded access to our programs and services."[4]

- **Workforce Development, Job Quality and Wealth Creation:** US Route 1 is a vital corridor throughout the Midcoast Region connecting the workforce with jobs at BIW, Midcoast Hospital and Bowdoin College. BIW is the fourth largest employer in Maine and a large majority of BIW employees commute along US Route 1 through Brunswick. Efficient access to jobs and businesses is imperative to maintaining and growing the economic vitality of the region. Improving congestion and maintaining the structural integrity of Maine's low clearance bridges will continue to allow the movement of freight and people throughout the State's roadway network. Additionally, the US Route 1 corridor through Brunswick is the gateway to the Midcoast region, a significant seasonal tourism area for all of Maine. By improving the travel time reliability through congestion relief and crash avoidance, transportation improvements can lead to wealth creation throughout the State.

The project aligns with the following DOT Focus Areas which were described in detail in the previous Section 3:

- State of Good Repair
- Efficiency of Freight Movement
- Rural Opportunities to Use Transportation for Economic Success (ROUTES) Initiative
- Data Availability

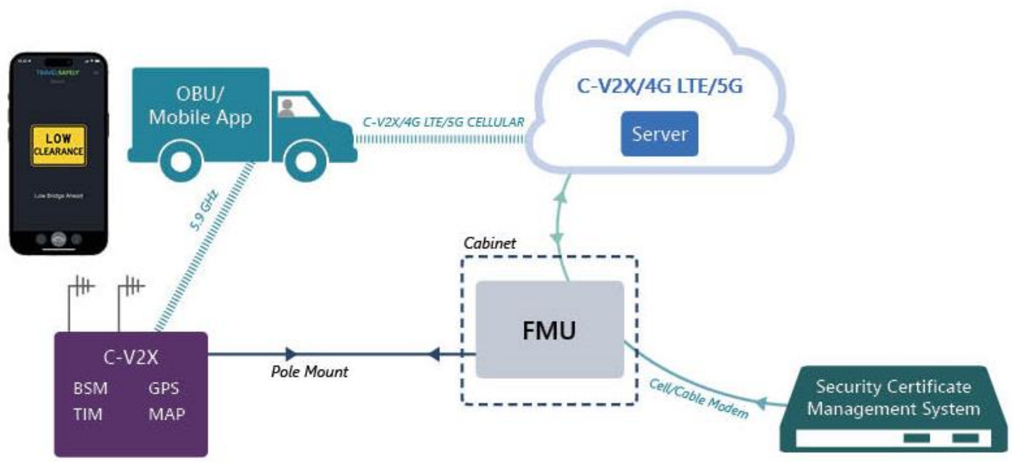
5. Systems and Services

The overall goal of this proposed project is to protect bridges and improve congestion and weather-related roadway safety in rural areas of Maine. Safety improvements will be

3 https://www.maine.gov/mdot/env/NEPA/public/
4 https://www.maine.gov/mdot/civilrights/title-vi/

accomplished through hardware and software upgrades and the use of innovative CV technologies. The following subsections describe in detail the technologies and services proposed. Mobility improvements will be accomplished through traveler information dissemination, both for pre-trip planning and in real-time along the roadway.

OVERHEIGHT VEHICLE WARNING SYSTEM



5.1 C-V2X Technology

The Mobile Application was deployed through a BUILD grant along several signalized corridors in Maine. This is an example screen that is active today.

Through a prior BUILD grant and project, MaineDOT has made a commitment to dual mode V2I (5.9 GHz) and C-V2X communication technologies. Early in the design phase of the statewide BUILD project (2019-2021), MaineDOT recognized that the Federal Communications Commission (FCC) was proposing changes to the spectrum allocation for CV. Several, but not all, vehicle manufacturers are moving forward with C-V2X communications as part of their OBUs. MaineDOT decided to deploy hybrid RSUs that would allow for multiple communications system architectures. Currently, MaineDOT's RSUs use 5.9 Ghz, C-V2X and cellular 4G-LTE/5G to broadcast Signal Phase and Timing (SPaT), Basic Safety Message (BSM), and Traveler Information Messages (TIMs) to a mobile application without the need for an OBU to be installed in a vehicle.

This hybrid RSU CV system design calls for the use of a free mobile application (Travel Safely) available to everyone via Google Play store and the Apple App Store to allow free universal access to these CV messages. During the BUILD deployment of the CV systems at traffic signals, MaineDOT used geofencing to provide accurate geo-spatial location information to facilitate the broadcast of SPaT, BSM and TIMs messages to both pedestrians and motorists. Nearly half of the currently deployed geofence zones are in rural areas. As part of the proposed ATTAIN project, MaineDOT intends to expand the application of these technologies to solve other problems.

5.2 *Low Clearance Bridge Warning System*

The State of Maine restricts the maximum structural height of vehicles on public ways to 13'-6", with an allowance of not more than six additional inches above the structural height for a total maximum vehicle height of 14'-0". (Maine Revised Statutes, Title 29-A, Chapter 21, Section 2380). The Manual on Uniform Traffic Control Devices (MUTCD) requires posting bridges with a Low Clearance sign (W12-2) where the actual clearance is less than 12 inches above the statutory maximum vehicle height. In Maine, these clearances can vary by time of year when the pavement heaves due to frost.

Throughout the State of Maine, there are 18 directional roadway approaches on major freight corridors with posted bridge clearances less than the desirable clearance of 15 feet (15'-0"). All of these bridges are on National Highway System (NHS) roadways, including interstate highways and US Route 1. These corridors represent some of the highest volume roadways in the state and are heavily used by the trucking industry as freight corridors. As such, an incident involving a vehicle exceeding the low clearance bridge tolerance can cause congestion, secondary collisions, and significant infrastructure damage that could close the overpass structure until repairs can be made.

Tuttle Road Bridge Strike in Cumberland, ME I-295 NB (10/16/21)

In October 2017 an overheight vehicle struck an interchange ramp overpass at Exit 109 in Augusta. The resulting infrastructure damage was so severe that the bridge could not be rehabilitated and had to be shut down and replaced. As the Exit 109 interchange is one of the highest volume interchanges in the Augusta Capital region, the sudden closure and replacement of this bridge required extensive re-routing and detours in and around the capital city resulting in traffic backups up to four miles long. The bridge replacement project was fast-tracked using accelerated construction techniques and included raising the bridge clearance by over a foot to reduce the potential of future impacts. The bridge was reopened in February 2018 and cost well over $3.5 million. (See Appendix B for additional information related to this incident.)

Staff graphic by Sharon Wood

MaineDOT has a long-range program to raise any low clearance bridges to provide adequate under clearance when the structures require rehabilitation and replacement. Meanwhile, the restricted under clearance remains a hazard to trucks and other high profile vehicles and similarly, these high clearance vehicles remain a hazard to the structures themselves. Several of these bridges include passive warning signs indicating the clearance in advance of the bridge. Some bridges with a history of vehicle strikes have been upgraded with active warning systems which include overheight vehicle detection systems (OHVDS).

Despite these passive and active messages, some overheight vehicles still strike low clearance bridges with multiple impacts each year. These impacts result in an average annual cost of $150,000 per year to determine if the bridge is still serviceable and includes costs for traffic control and other construction issues related to each incident. This annual cost does not include major strikes such as the one described at Exit 109 above. Nor does it include road user costs related to long detours in rural areas for example.

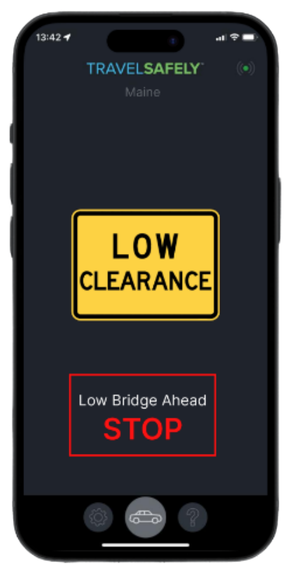
Overheight Vehicle Detection System on I-295 in Brunswick, ME

MaineDOT is proposing to expand the current CV deployments to enhance the reach and range of passive warning messages. By implementing lessons learned during the BUILD project installations, MaineDOT intends to use the hybrid RSU model to provide warning messages to overheight vehicles in advance of low clearance bridges. Using FMUs, MaineDOT intends to geofence multiple locations on the approaches to a low clearance structure to activate targeted warning messages. This CV system deployment will use multiple overlayed geofence zones on the roadway approaches to the low clearance bridge to provide a tiered level of warning messages (TIMs and BSM) depending on physical proximity to the bridge. Since the design of the hybrid RSU system uses dual communications (C-V2X via 5.9 Ghz and via 4G/LTE/5G), the range of the message alerts can be extended beyond the typical line-of-sight communications needed for legacy DSRC systems.

The proposed system design calls for one level of TIMs and two BSMs, and two or more overlapping geofence zones set at varying ranges. The initial TIM broadcast using a cellular communications link to the OBU (or to the mobile application) would also include a warning message to inform the driver that a bridge with a clearance restriction is on the roadway ahead. This initial message (Tier 3 message) would be a general information message and the geofence zone would be set at an appropriate distance in advance of the potential detour route to avoid the low clearance bridge.

The secondary message (Tier 2 message) to be broadcast would also use a Cellular communications link to the OBU (or to the app) and would be a BSM. This BSM would be correlated with a geofence zone immediately in advance of the decision point to allow the target overheight vehicle driver to exit the roadway prior to the bridge to seek an alternate route. The third level message (Tier 1 message) to be broadcast would use the dual communications links (5.9 Ghz and 4G/LTE/5G) to the OBU (or to the app) and would be a BSM for any over height vehicle to stop and not proceed. This BSM would be correlated with a geofence zone at a distance to allow for the vehicle to safely stop along the roadway.

Sample TIM message shown on the existing Mobile Application



Sample BSM screen shown on the existing Mobile Application

A sample scenario is the Route 24 bridge over US Route 1 Southbound in the Town of Brunswick, ME. This bridge has a minimum clearance ranging from 14'-5" to 14'-10" over the southbound travel lanes and is posted for 14'-3" on the bridge. This location has been upgraded to include an OHVDS but still records several strikes each year. Until the bridge can be programmed for rehabilitation and/or replacement, the proposed solution is to provide advanced warning well in advance of the bridge location.

MaineDOT proposes to install an FMU along US Route 1 southbound north of the bridge location. MaineDOT would program three geofenced areas along the US Route 1 southbound corridor warning approaching drivers of the low clearance structure ahead. The first location would be approximately four miles north of the bridge with a verbal warning message similar to "LOW CLEARANCE BRIDGE FOUR MILES AHEAD. VEHICLES OVER 14 FEET PREPARE TO EXIT." At approximately two miles north of the bridge, a second geofenced zone would include a verbal warning message similar to "LOW CLEARANCE BRIDGE 2 MILES AHEAD. VEHICLES OVER 14 FEET USE NEXT EXIT." At approximately 1,500 feet north of the exit ramp for Route 24, a third geofenced zone would include a verbal warning message similar to "VEHICLES OVER 14 FEET, EXIT NOW".

The use of the dual mode (5.9 GHz/V2I and 4G/LTE/5G) communications and geofencing offers additional flexibility to address temporary needs. During bridge cleaning and painting operations, it is not unusual to temporarily decrease the minimum clearance of a bridge for the staging and enclosure. The proposed system design can be easily adapted and redeployed for temporary restricted clearance bridges.

The installation of the dual mode 5.9 GHz/V2I and Cellular devices provides MaineDOT with the ability to target and partner with freight companies to implement CV technology within trucking fleets to help with route planning and real-time route adjustments. MaineDOT intends to partner with MMTA and offer after-market OBUs to fleet drivers through this Project. For drivers without a factory installed OBU in their vehicles, the Travel Safely app is free for all iOS and Android users. This mobile application is available to all drivers on their own mobile devices.

After-market On-Board Unit (OBU) in vehicle

5.3 Brunswick US Route 1 Congestion and Weather Warning System

MaineDOT intends to deploy the same CV technologies to the US Route 1 corridor between Brunswick and Bath. This corridor is subject to daily recurring congestion that lasts 30-60 minutes most weekday evenings. Part of the recurring traffic comes from BIW shift workers commuting home to population centers accessible from I-295, located just west of Brunswick and serviced by US Route 1. MaineDOT proposes to install traffic monitoring cameras and radar-based motor vehicle detection systems (MVDS) along US Route 1 at three interchanges along the corridor between Brunswick and Bath. These camera images will be available to the public via the New England 511 website.[5] Drivers can quickly access video images of the corridor prior to getting on the road to determine if congestion is ahead and, based on which cameras show the congestion, make informed dec

5 https://newengland511.org/

isions about when to get on the road and whether to follow an alternate route. These cameras provide the public with a pre-trip planning tool that provides near real-time information.

One of these camera sites will include roadway weather information system (RWIS) sensors to monitor and report the road conditions, particularly during winter weather. Specifically, MaineDOT intends to install a mini-RWIS site co-located with one of the new closed-circuit television (CCTV) camera sites that will measure the temperature and surface condition of the pavement, reporting a grip factor. When the grip factor is below a pre-determined threshold, MaineDOT can use the FMUs to provide verbal messaging directly to drivers via OBUs and/or the mobile application to inform drivers of the adverse road conditions.

Newer vehicles with this CV technology built into the operating system (via integral OBUs) would automatically receive the messages warning of congestion and/or weather advisories. All other traveling public would be able to download a free application on their mobile device that would transmit the verbal and graphic warning messages. MaineDOT intends to partner with major employers in the area such as BIW, Midcoast Hospital and Bowdoin College to encourage their employees to download the mobile application and use it while traveling through Brunswick. The goal is to increase the driver's awareness of the system and to potentially provide a level of congestion messaging and alerts to their employees before those employees leave the campus.

5.4 I-95 Palmyra-Carmel Weather Warning System

The I-95 corridor in the towns between Palmyra and Carmel are subject to several adverse conditions for drivers. Due to this section of I-95 running generally east-west, the corridor is subject to sun glare in the spring and fall, when the sun appears low in the sky during peak traffic hours. This sun glare condition has been so severe at times to cause multiple vehicle crashes in this corridor. Additionally, this corridor is subject to wind-driven snow which can cause a clear roadway to suddenly transform into a black ice surface. The wind-driven snow can also cause momentary "white-out" conditions where the fine snow particles reduce visibility to less than 15 feet in seconds.

From 2013 through 2022, there were 104 crashes along I-95 northbound and 95 crashes along I-95 southbound on a sample 2.75 mile section in eastern Carmel. While the vast majority of these crashes were property damage only, there was one fatality and nine incapacitating injuries reported. Over the past three years, the proposed Palmyra to Carmel section is over-represented in the I-95 crash statistics, with 16 of the 17 miles of the corridor identified as a high crash location.

MaineDOT intends to install both traffic monitoring cameras and mini-RWIS equipment along the corridor to report conditions that could lead to the formation of black ice and verify wind-driven snow conditions with the CCTVs. Similar to the Brunswick corridor, MaineDOT will use CV technology to alert drivers of dangerous weather conditions well in advance of entering the monitored corridor. The traffic monitoring cameras can also be used to estimate the time of day when solar glare could be a factor, allowing MaineDOT to post glare warning messages at geofenced zones that meet the east-west criteria. The camera and RWIS data can also be shared on the New England 511 website for pre-trip planning purposes. The use of FMUs provides near real-time alerts to drivers already on the road to use extraordinary caution when traveling through this I-95 corridor when conditions are not ideal. When this system proves its value, it will be easy for MaineDOT to expand the system to more segments along I-95 and throughout the state.

5.5 US Route 1/Route 11 Aroostook County Weather Warning System

Aroostook County is subject to severe winter weather from October to April. There are several segments of US Route 1 and Route 11 in "The County" that experience frequent bouts of wind-driven snow, creating sudden patches of black ice and occasional white-out conditions[6]. The wind-driven snow is particularly an issue in this area as much of the roadside is open and flat due to adjacent agricultural fields. As winds increase and swirl across the roadway, the winds pick-up the fine snow crystals and drop them back onto the previously cleared roadway. These fine particles rapidly melt on the pavement and refreeze from the cold winds, causing black ice to form. While this condition can happen anywhere, MaineDOT maintenance personnel have identified a couple of strategic locations where black ice forms frequently. MaineDOT has targeted these sections for a weather warning system.

Route 1 in Cyr Plantation. Photo by Fort Fairfield Police

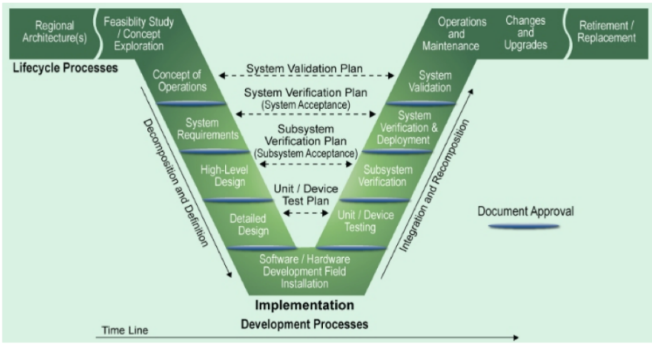
Similar to the I-95 Palmyra-Carmel corridor, the proposed project will install traffic monitoring cameras and mini-RWIS at several segments along US Route 1 in Bridgewater, Presque Isle, Caribou, Cyr Plantation and Van Buren and along Route 11 in Patten. The mini-RWIS will provide grip factor information and trigger alarms at the TMC to request operators to review the monitoring cameras. Upon verification by the operators that conditions are likely to develop black ice and white-out conditions, MaineDOT can use the deployed FMUs for the segments and publish messages throughout the US Route 1 and Route 11 corridors. The FMUs permit multiple geofenced zones to customize messages along the corridor based on individual and cumulative results of the grip sensors. MaineDOT will partner with major employers, trucking companies, and road user groups in Aroostook County to encourage use of the mobile application for winter weather advisories. The mobile application can also be used for customized messaging in the event there are crashes or other incidents causing delay on the corridor. This application of CV technology to one of the most rural and remote places in Maine is a positive investment in this disadvantaged area that does not ordinarily see investments in ITS.

6. Deployment Plan

The key to successful implementation of this project requires a thoughtful and flexible deployment plan. The proposed project includes several components that must be coordinated and integrated. The deployment plan components include the development of requirements, detailed design, construction, testing, operations, and continuing maintenance, all following the FHWA systems engineering approach in accordance with Title 23 CFR 940.11 (Rule 940).

Once construction is completed, the deployment plan will be adjusted based on the individual components of the project. Regardless of the individual components, however, all components of the deployed systems will be integrated into the MaineDOT Traffic Management Center (TMC) for 24/7 operations and monitoring.

6 https://www.newscentermaine.com/article/traffic/drifting-snow-causes-crashes-in-and-impassable-roads-in-aroostook-county/97-efc986ff-7f05-4deb-bc3b-223dbd6421a4
https://www.newscentermaine.com/article/traffic/two-hospitalized-in-snowy-aroostook-county-crash-ice-road-ambulance-collision/97-5735078e-2f00-416c-bb8a-1c91f94454ae



The developed system will be used by MaineDOT daily. MaineDOT will provide funds to support the long-term system operation and maintenance, and the anticipated safety, mobility, and maintenance benefits of this system will allow MaineDOT to justify the expenditures. This also ensures that the deployed system will be maintained and utilized beyond the funding period. MaineDOT will prepare any necessary agreements to assume continuing responsibility for operations and maintenance of the several technologies within the component project limits.

6.1 Procurement Plan

In previous technology deployments, MaineDOT has hired engineering consultants to assist in the preparation of system functional requirements and contract documents that will then be advertised for construction by a qualified contractor. It is anticipated that MaineDOT will follow a Design-Bid-Build (DBB) procurement strategy for all four components of this project but we have not determined if the four components will be advertised as a single contract or a series of separate contracts.

6.2 System Operations

The operations of the system devices and system corridors will be performed by MaineDOT's TMC operators with technical and field support by a consultant team for the first two years after deployment. These teams will monitor the passive systems (such as the low clearance warning system component) to verify that the messages are appropriate and geofenced to provide optimal benefit. These teams will also monitor the active systems (such as the Brunswick congestion warnings and wind-driven snow warnings) to provide the daily/seasonal monitoring of the ITS devices and react to any threshold alarms for system activation.

The MaineDOT TMC Standard Operating Guidelines (SOG's) will be modified to account for the operations of the four components of the project. The operations of these systems will adhere to the standard protocols for operators to follow during times of an actuated event. It is expected that over time, MaineDOT operators will find opportunities to automate some operations with pre-packaged FMU messaging.

6.3 Systems Maintenance

Following successful installation, testing, and initial operations, MaineDOT is committed to the on-going maintenance of these systems. A key factor in the value of these systems is that the public can trust the information that is provided to them, both during pre-trip planning and in real-time on the corridors. Therefore, on-going routine preventative maintenance as well as expeditious emergency maintenance is critical.

Active systems require regular status checks and preventative maintenance of the equipment to ensure that the systems are monitoring conditions continuously and will trigger alarms when design thresholds are met. With real-time communications between the TMC and the field equipment, identification of system malfunctions becomes easy and efficient.

Passive systems require routine monitoring to ensure that the appropriate messages are being broadcast to the correct geofenced zones. It is anticipated that a schedule of regular office and field checks of broadcast messages will be incorporated into MaineDOT's existing SOPs for ITS system maintenance. MaineDOT is committed to ITS system resilience and will be designing in redundancy so that these systems, especially the ones sending weather alerts, will have high operational uptime.

MaineDOT is committed to meeting our obligations to perform the necessary routine maintenance throughout the life of the equipment, as well as to address faults and failures expeditiously. MaineDOT uses a combination of in-house personnel and contracted services to maintain our existing ITS equipment and systems. These new systems will easily integrate into our ordinary maintenance efforts.

7. Regulatory, Legislative, or Institutional Challenges

MaineDOT does not foresee any major potential challenges or obstacles to deployment. All of the ITS devices and transportation technologies proposed in the several components of this project have been in use in Maine for over two years already. Any regulatory or legislative challenges that existed have been discovered and mitigated through previous technology projects like the BUILD and ATCMTD grant projects. The technologies for this project are mature while the specific applications proposed in this project are new and innovative for the state of Maine. The deployment risk is very low and MaineDOT is firmly committed to this project.

8. System Performance Measures

The overall goal of this proposed project is to enhance mobility, safety and protections for vulnerable infrastructure in Maine. Implementation of the MaineDOT Statewide Connected Vehicle Hazard Notification Project is expected to provide numerous benefits related to reducing crash frequency and severity; increasing compliance with restricted bridge clearance; and providing targeted traveler information to motorists, in real-time on the road and for pre-trip planning purposes. These benefits will accrue overwhelmingly to rural areas of Maine.

Much of the proposed project uses established CV and ITS technologies for innovative purposes. As such, there are not well-defined system performance measures that can be described prior to conducting the systems engineering for the project. MaineDOT is committed to using the FHWA systems engineering process to ensure that the technology investments operate to meet the purpose and need as described in this application. As part of the systems engineering, MaineDOT will develop the system requirements through the planning phase of the project. These requirements will help define the system performance measures by which the system will be evaluated through the verification and validation steps of the deployment.

MaineDOT staff will be responsible for developing the baseline performance measures for the project corridors, for which all reporting will be compared, to measure benefits. Performance measures for the Brunswick corridor as well as the Palmyra-Carmel and Aroostook County corridors will be analyzed to demonstrate benefits. The performance measures require the collection of relevant data, which will include the following:

Crashes	Crashes: quantity, rate, severity
Travel time	Travel per vehicle (in seconds)
Corridor traffic volumes	Traffic counts
Bridge impacts	Bridge impacts: quantity, frequency, severity, location, cost for repairs
Emissions	Estimated pounds of carbon emissions
Fuel Consumption	Estimated gallons of fuel
Message Dispersion	Mobile App use; downloads, response rate

The return on investment will be provided through comparative analysis of baseline statistics and comparisons to similar times of the year beyond the first year of operation.

8.1 Reducing Traffic-related Crashes, Congestion, and Costs

Based on the rural geography of the area, the number of crashes experienced in Brunswick and in the Palmyra-Carmel section of I-95 are higher than the statewide average for similar roadway segments. As a major goal and benefit of the project is the reduction of crashes, both in quantity and severity, two of the system performance measures will be reduction in total crashes and reduction in crash severity.

Expected Performance Measure (Component 1): Impact frequency and severity after deployment of the Low Clearance Bridge Warning System compared to the crash frequency and severity prior to deployment.

Parameters: Five-year impact quantity, impact frequency (per 100 Million Vehicle Miles); identify any bridges that received multiple strikes within the five-year review period.

Expected Performance Measure (Component 2): Crash frequency and severity after deployment of the Brunswick US Route 1 Congestion and Weather Warning System compared to the crash frequency and severity prior to deployment.

Parameters: Three-year and five-year before and after crash quantity, crash rate (per 100 Million Vehicle Miles), and crash severity index; compare seasonal crashes (summer vs. winter); compare crashes that occur during the congested peak hours vs. crashes that occur during periods of free-flow traffic.

Expected Performance Measure (Component 3): Crash frequency and severity after deployment of the I-95 Palmyra-Carmel Weather Warning System compared to the crash frequency and severity prior to deployment.

Parameters: Three-year and five-year before and after crash quantity, crash rate (per 100 Million Vehicle Miles), and crash severity index; compare seasonal crashes (summer vs. winter); compare crashes during high solar glare conditions vs. crashes at other times of year; comparison to a control corridor of similar characteristics.

Expected Performance Measure (Component 4): Crash frequency and severity after deployment of the US Route 1/ Route 11 Aroostook County Weather Warning System compared to the crash frequency and severity prior to deployment on each of the segments.

Parameters: Three-year and five-year before and after crash quantity, crash rate (per 100 Million Vehicle Miles), and crash severity index; compare seasonal crashes (summer vs. winter); comparison to control corridors of similar characteristics.

MaineDOT commits to a continuing program of data-driven safety analysis and evaluation for the project corridors for the life of this project. MaineDOT expects that the project will achieve a reduction in total crashes and in crash severity and will demonstrate the actual safety benefits to date as part of the final report. As crash statistics often require a longer time line for reliable results, MaineDOT commits to preparing the safety evaluations when sufficient data has been collected.

8.2 Optimizing System Efficiency

Infrastructure and capacity improvements can be resource intensive, time consuming, and usually quite expensive. One benefit of transportation technology is that for a relatively low investment cost (compared to the alternatives), MaineDOT can make the existing transportation system more efficient, providing mobility benefits to all road users immediately.

Expected Performance Measure (Component 2): Average travel time through the target corridor after deployment of the Brunswick US Route 1 Congestion and Weather Warning System compared to the average travel time prior to deployment.

Parameters: Free flow travel time through the corridor vs. travel time during recurring (weekday evening peak hours) and non-recurring (winter weather conditions) congestion.

Expected Performance Measure (Component 2): Travel time balance between the US Route 1 southbound corridor to I-295 and using Route 196 (Topsham-Brunswick Bypass) to I-295 after deployment of the Brunswick US Route 1 Congestion and Weather Warning System

Parameters: In an ideal system, the travel time for drivers using US Route 1 to I-295 southbound at Exit 28 will be equal to the travel time for drivers using Route 196 to I-295 southbound at Exit 28. As the origin-destination data necessary to make this comparison may be difficult to obtain, MaineDOT will use average travel time on the two corridors as a proxy.

8.3 Environmental

As mobility improvements are realized along the project corridors, there will be associated environmental benefits. Carbon emission and fuel consumption reductions will be a direct result of a reduction in congestion delays and travel time improvements.

Expected Performance Measure (Component 2): Daily estimated carbon emissions and fuel consumption in the project corridor after deployment of the Brunswick US Route 1 Congestion and Weather Warning System compared to the daily estimates prior to deployment.

Parameters: Free flow emissions and fuel consumption; congestion emissions and fuel consumption.

9. Quantifiable Safety, Mobility, and Environmental Benefit Projections

The proposed project includes several components that have not been tried in rural areas. Therefore, estimating benefits using real world data is challenging. However, lessons can be learned from projects with similar goals (reduce infrastructure damage, provide traveler information to relieve congestion, and provide traveler information for enhanced safety).

There are numerous studies that have shown positive benefits in the use of enhanced traveler information to allow drivers to make more informed, real-time decisions. This project expands that premise by using CV technology to reach each driver in their vehicle at several locations along the approach to congestion, prior to an alternate route option available to the drivers.

Wyoming DOT's CV Pilot Deployment showed that 46.5 gallons of diesel fuel per truck could be saved by reducing idling time for trucks on a road closure[7]. It is expected that commensurate fuel savings can be achieved by reducing congestion in Brunswick and reducing the probability of winter weather crashes on the Palmyra-Carmel segment and the Aroostook County segments.

A study in Michigan[8] found that use of a weather responsive traveler information system resulted in a decrease in user delay costs of 25 to 67 percent during National Weather Service Advisories and Warnings. The Michigan study provided automated weather alerts on dynamic message signs while the proposed project intends to leverage CV technology to publish and push notifications directly to OBUs and the mobile application. It is expected that similar user delay savings may be possible for the three project components that include a weather advisory system (Brunswick, Palmyra-Carmel, and Aroostook County) using CV-based weather information alerts.

At a broader range, there are several lessons learned and benefits documented in all three of the Connected Vehicle Pilot Deployments (Wyoming DOT, New York City DOT and the Tampa Hillsborough Expressway Authority). MaineDOT intends to use the lessons learned from these pilot projects in the development and refinement of requirements as well as during the verification and validation testing.

9.1 Quantifiable Projections

The 2023 AADT along the US Route 1 corridor in Brunswick is 28,200 vehicles per day (vpd). Based on data in the TTI Urban Mobility Report in 2019, TRIP estimates the total value of lost time and wasted fuel in Maine is approximately $250 million per year. This equates to approximately $568 per driver in the Brunswick area. While the actual benefits to be expected by this project cannot be quantified at this time, the benefits will be related to the following areas and will be defined as part of the systems engineering studies:

- Reduction in travel time
- Reduction in crashes
- Reduction in secondary incidents
- Reduction in fuel consumption
- Reduction in emissions
- Reduction in maintenance costs

The Development of Network Level Evaluation Tool for Managing ITS Infrastructure study, published by the USDOT to document benefits recognized for network level devices reports that use of CCTV can generate a five percent (5%) reduction in crashes.

7 https://www.itskrs.its.dot.gov/2023-b01761#:~:text=Wyoming%20DOT's%20Connected%20Vehicle%20Pilot,for%20Trucks%20Per%20Road%20Closure.

8 https://www.itskrs.its.dot.gov/2017-b01145

9.2 Safety

The Federal Highway Administration estimates the economic loss related to each crash event recorded in Maine from 2016-2020 is as follows:

Fatality (Per Crash)	$10,098,000
Suspected serious injury (Per Crash)	$585,600
Suspected minor injury (Per Crash)	$177,500
Possible injury (Per Crash)	$112,300
Property damage only (Per Crash)	$10,600

Average Comprehensive Costs are based on 2018 Federal Highway Administration estimates. As noted in Section 9.1 above, the use of traffic monitoring CCTV cameras has been shown to generate a five percent reduction in crashes. Using the US Route 1 southbound data for Brunswick between 2013 and 2022 with 228 crashes, a five percent reduction is equivalent to 12 fewer crashes. If we assume that all 12 saved crashes were property damage only, the benefits for the Brunswick corridor would be $127,200 over the next ten years. If even just one of the crashes saved might have been a suspected minor injury crash, that value increases to $294,100 over ten years.

As part of MaineDOT's project development process, we will estimate additional safety benefit values based on how enhanced traveler information may generate new crash modification factors (CMFs). As part of MaineDOT's final report, we intend to investigate whether the project can certify additional or new CMFs for peer review.

9.3 Environmental Benefits

Based on the EPA, the average vehicle creates 4.640 metric tons of CO2 emissions per year based on an average of 11,520 vehicle miles traveled (VMT). Based on the AADT of the Brunswick US Route 1 project corridor previously specified (2023 AADT = 28,200 vpd), it is estimated that each one minute reduction in delay time per vehicle can save an estimated 41.9 kilograms of CO2 emissions across all vehicles along US Route 1 southbound during the peak hour. Averaged over a full year of weekdays (260 days per year), that is a potential reduction of 10.9 metric tons per year of CO2 emissions.

Similarly, the prevention of crashes can reduce idling time and travel time delays, resulting in reductions of CO2 emissions. It is difficult to estimate the quantity of CO2 emissions reductions along the I-95 Palmyra-Carmel and Aroostook County corridors as it is dependent on the volume of traffic present at the time of the prevented crash.

10. Vision, Goals, and Objectives

The vision for this project is a series of rural, CV technology deployments that enhance safety, economic opportunity, and quality of life for residents and visitors throughout the state of Maine.

The project goals are to (1) improve the safety of the roadway system, (2) improve mobility and travel time reliability on project corridors, (3) reduce air emissions, (4) improve communication to travelers before and during a trip, (5) reduce the number and frequency of impacts to bridge infrastructure, and (6) support the community's growth and redevelopment goals. The vision and goals for the project align well with MaineDOT's mission to:

> *"Support economic opportunity and quality of life by responsibly providing our customers the safest and most reliable transportation system possible, given available resources."*

MaineDOT has scoped this project to align with the CAV goals identified in the most recent ITS strategic plan:

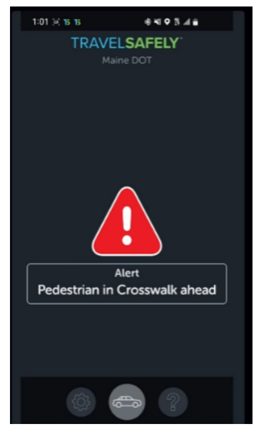
- **Goal 1) Develop MaineDOT as a CAV leader in the Northeast Region:** Deploying this project will allow MaineDOT to continue to practically advance its existing CAV program and document standards and lessons-learned so that it can provide technical support for other regional states.
- **Goal 2) Partner with non-traditional resources to grow CAV in the state of Maine:** Focusing much of this Project on warnings for trucks will necessitate close collaboration with commercial fleet operators in the state of Maine. Additionally, by working with local employers, MaineDOT can both address their specific problems and begin to grow public use and trust prior to OBUs being commercially mainstreamed.
- **Goal 3) Develop a secure communication protocol to allow connections now:** As identified in the discussion under Goal 2, it is important to MaineDOT that all connected vehicle deployments have immediate utility. In this project, MaineDOT intends to leverage an established technical standard that is consistent with existing buildouts. This standard offers accessible and secure (SCMS) communications that have been validated through prior project testing. This project will provide MaineDOT an opportunity to expand this standard beyond intersection applications.
- **Goal 4) Develop a plan for data storage and use:** MaineDOT's 140+ completed or funded C-V2X deployments are all at intersection locations. The existing project contracts all have specific data storage and use requirements, built on one standard back-end system. This deployment in non-intersection locations will allow MaineDOT to expand its system to support a more diverse set of applications.

MaineDOT is in the process of rewriting its ITS Strategic Plan and rolling it into a more comprehensive Transportation Systems Management and Operations (TSMO) Plan. This new plan will build on the goals above and identify further opportunities to use CV technologies to solve real-world operational problems. If awarded, this project will help guide that plan.

11. Leveraging Existing Technology Investments

MaineDOT has been deploying CV devices along arterial corridors to improve traffic signal systems and arterial corridor flow for the past two years. Through these projects, MaineDOT has proven the technology works in Maine and provides localized improvements. This ATTAIN grant will enable MaineDOT to leverage these early deployments to make positive regional impacts. As vehicle manufacturers begin to make OBUs standard equipment on vehicles, the infrastructure to share with these OBUs will already be commonplace and distributed throughout the state of Maine.

Once an FMU is deployed, that single device can be used for other applications in the local area. With additional geofencing, additional TIMs and BSM traveler information and incident management information can be broadcast along nearby freeway and arterial corridors. Similarly, the FMUs already deployed for traffic signal use can be leveraged to create additional TIMs and BSM messages for winter weather advisories, community alerts (Amber, Silver), School Zone warnings, Curve Ahead, queue warning systems and incident management. These efficiencies allow the proposed equipment and devices to serve multiple purposes, creating efficiency in operations particularly in the rural environments.



The hybrid RSU equipment and FMUs that MaineDOT has deployed also allow for enhanced protection of Vulnerable Road Users (VRUs) such as pedestrians and bicyclists for safety applications to be deployed via the mobile application. These safety applications can be audible and visual alarms for approaching vehicles that could have an impact on the VRU. This feature can be actively deployed at traffic signal locations as well as other areas.

With the oncoming deployment of vehicles equipped with integral OBUs, additional CV applications can start being used such as Eco Drive. The primary aim of eco-driving control for vehicles is to optimize velocity profiles based on real world information disseminated by the FMU/RSU for fuel savings. The equipment and hardware proposed for this project has sufficient flexibility that if it is no longer applicable for its original intended purpose at its original location, that equipment and hardware can easily be removed and redeployed where it is more urgently needed. For example, as MaineDOT rehabilitates/replaces existing low clearance bridges, the FMUs will no longer be needed for that specific bridge location. However, the FMU can be repurposed and redeployed to any winter weather corridor, congestion corridor, or coordinated traffic signal system with minimal effort.

12. Project Schedule

Table 1 provides a preliminary project schedule for the proposed project. MaineDOT does not anticipate any specific needs for permitting, related to wetlands impacts or historic requirements. It is expected that this work will meet the requirements for a Categorical Exclusion. (See Appendix C)

Table 1 Preliminary Project Schedule

RFP for Consultant Services	Winter 2025
Consultant under Contract	Spring 2025
Preliminary Project Kickoff	Spring 2025
Draft Cooperative Agreement	Spring 2025
Fully executed Cooperative Agreement	Summer 2025
Project Kickoff	Summer 2025
Project Evaluation Plan	Summer 2025
Data Management Plan	Summer 2025
Systems Engineering Documentation	Fall 2025
Annual Budget Review (and subsequent years)	Late Fall 2025; Late Fall 2026; Late Fall 2027
Preliminary Plans	Winter 2026
Final Plans	Fall 2026
NEPA	Fall 2026
PS&E	Fall 2026
ADV	Fall 2026
Construction Begin	Spring 2027
Construction Complete	Spring 2028
Final Report	Fall 2028

This preliminary project schedule is based on receiving a positive response on the ATTAIN grant award. If this project does not receive a 2024 ATTAIN grant, the components of this project will need to be separated into several independent projects and phased in accordance with available funding over many years, delaying the potential safety and mobility benefits.

13. Exemptions (FMVSS, FMCSR)

The MaineDOT Statewide Connected Vehicle Hazard Notification Project will comply with all current Federal Motor Vehicle Safety Standards (FMVSS). Nothing in the proposed Project changes the vehicles' integral crash avoidance, crashworthiness, or post-crash survivability requirements. Similarly, the proposed Project will comply with all current Federal Motor Carrier Safety Regulations (FMCSR). Nothing in the proposed Project changes the standards that vehicles, vehicle owners, and operators are subject to follow. No exemptions will be required for this proposed Project.

14. Comply with Buy America Act

Through prior deployments of the hardware and equipment included in this proposed Project (FMUs, CCTVs, RWIS and mini-RWIS stations, for example), MaineDOT has demonstrated that procurement can and will comply with the Buy America Act regulations and will not require an exemption. Similarly, the hardware associated with the Project is expected to comply with the Build America, Buy America (BABA) Act.

15. Any support or leveraging of the ITS Program or innovative technology initiatives (The DOT ITS initiatives are described online at http://www.its.dot.gov.)

This project will benefit significantly from the DOT ITS Program and Innovative Technology Initiatives on-line at https://www.its.dot.gov during the project planning, design, deployment, evaluation, and results sharing stages of this Project. Specifically, this Project will benefit from the lessons learned through previous studies on the effectiveness of dynamic message signs (DMS) by posting verbal messages that drivers can receive right in their vehicle, through a mobile application until the vehicle fleet includes more vehicles equipped with OBUs (integral and after-market devices). Also, MaineDOT will leverage the many resources available on the Smart Community Resource Center and the ITS4US Program webpages.

Travelers in the proposed project areas tend to receive less communication from MaineDOT because of the limited ITS infrastructure coverage in the large, rural areas throughout the state. This project allows MaineDOT to reach those drivers through cellular-based CV technology. As CV resources become more prevalent and valuable, this project provides rural drivers, and particularly the targeted commercial drivers, the ITS benefits they otherwise would not receive, by using existing infrastructure, existing cellular networks, and a mobile application to maximize the return on MaineDOT's investment. This project may potentially set up a cost-effective example for growing the V2I infrastructure into rural communities, that may be followed by other states.

16. Technologies, Program Goals, and DOT Focus Areas Addressed

Table 2 summarizes the technologies that will be deployed, as well as the DOT goals and focus areas that will be addressed, as part of the proposed project.

Table 2 Technologies, Program Goals and DOT Focus Areas

	Implemented/Addressed by Application (Check all that apply)
TECHNOLOGIES	
1. Advanced traveler information systems	✓
2. Advanced transportation management technologies	✓
3. Advanced transportation technologies to improve emergency evacuation and response by Federal, State, and local authorities	✓
4. Infrastructure maintenance, monitoring, and condition assessment	✓
5. Advanced public transportation systems	
6. Transportation system performance data collection, analysis, and dissemination systems	✓
7. Advanced safety systems, including V2V and V2I communications, technologies associated with automated vehicles, and other collision avoidance technologies, including systems using cellular technology	✓
8. Integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems	
9. Integrated corridor management systems	

Table 2 Technologies, Program Goals and DOT Focus Areas

	Implemented/Addressed by Application (Check all that apply)
10. Advanced parking reservation or variable pricing system or system to assist trucks in locating available truck parking	
11. Electronic pricing, toll collection, and payment systems	
12. Technology that enhances high occupancy vehicle toll lanes, cordon pricing, or congestion pricing	
13. Integration of transportation service payment systems	
14. Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly and disabled individuals	
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	
16. Advanced transportation technologies, in accordance with the research areas described in section 6503 of Title 49	✓
PROGRAM GOALS	
1. Reduction in the number and severity of traffic crashes and an increase in driver, passenger, and pedestrian safety;	✓
2. 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;	✓
3. 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;	✓
4. Improvement in the mobility of people and goods;	✓
5. Improvement in the durability and extension of the life of transportation infrastructure;	✓
6. Reduced costs and improved return on investments, including through the enhanced use of existing transportation capacity;	✓
7. Protection of the environment and delivery of environmental benefits that alleviate congestion and streamline traffic flow;	✓
8. Measurement and improvement of the operational performance of the applicable transportation networks;	✓
9. 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,	✓

Table 2 Technologies, Program Goals and DOT Focus Areas

	Implemented/Addressed by Application (Check all that apply)
including access to safe, reliable, and affordable connections to employment, education, healthcare, freight facilities, and other services;	
10. Facilitating account-based payments for transportation access and services and integrating payment systems across modes;	
11. Monitoring transportation assets to improve infrastructure management, reduce maintenance costs, prioritize investment decisions, and ensure a state of good repair;	✓
12. Accelerated deployment of V2V, V2I, vehicle-to-pedestrian, and technologies associated with automated vehicle applications and other advanced technologies;	✓
13. Integration of advanced technologies into transportation system management and operations;	✓
14. Reproducibility of successful systems and services for technology and knowledge transfer to other locations facing similar challenges;	✓
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.	✓
ADMINISTRATION'S PRIORITIES	
1. Safety	✓
2. Climate Change and Sustainability	✓
3. Equity	✓
4. Workforce Development, Job Quality, and Wealth Creation	✓
DOT FOCUS AREAS	
1. State of Good Repair	✓
2. Integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems	
3. Advanced public transportation systems	
4. Freight (or Port) Community Systems	✓
5. ROUTES Initiative	✓
6. Complete Trip Program	
7. Data Availability	✓

III. Management Structure

The MaineDOT will be the designated recipient of this project. The MaineDOT is a cabinet-level state organization with primary responsibility for all modes of statewide transportation. The MaineDOT employs roughly 1,600 individuals and annually expends or distributes more than $675 million in federal, state, and local funds.

The MaineDOT Traffic Engineering Division of the Bureau of Maintenance and Operations will lead the development, implementation and operation of this project. The Traffic Engineering Team will collaborate with the Department's finance, administration, and program development personnel to manage the project's budget. Traffic Engineering staff previously led the Maine Advanced Signal Control and Connected Vehicle System for Safe, Efficient and Equitable Rural Transportation (MAST) project through the federal grant process under the ATCMTD. Best practices and lessons learned from that project will be employed to ensure the successful planning, management, and execution of the MaineDOT *Statewide Connected Vehicle Hazard Notification Project*. Table 3 summarizes the project team roles for the MaineDOT Connected Vehicle project. Figure 6 illustrates the proposed organizational structure. The MaineDOT will carry out the design, construction, operation, and maintenance of the roadway as part of this project. The MaineDOT will conduct a competitive selection process to determine a qualified Consultant/Contractor to implement the proposed project on behalf of the Department. The Traffic Engineering Team will coordinate closely with all of the communities the project components are located in to ensure the proposed project is serving their needs.

Table 3 Project Team

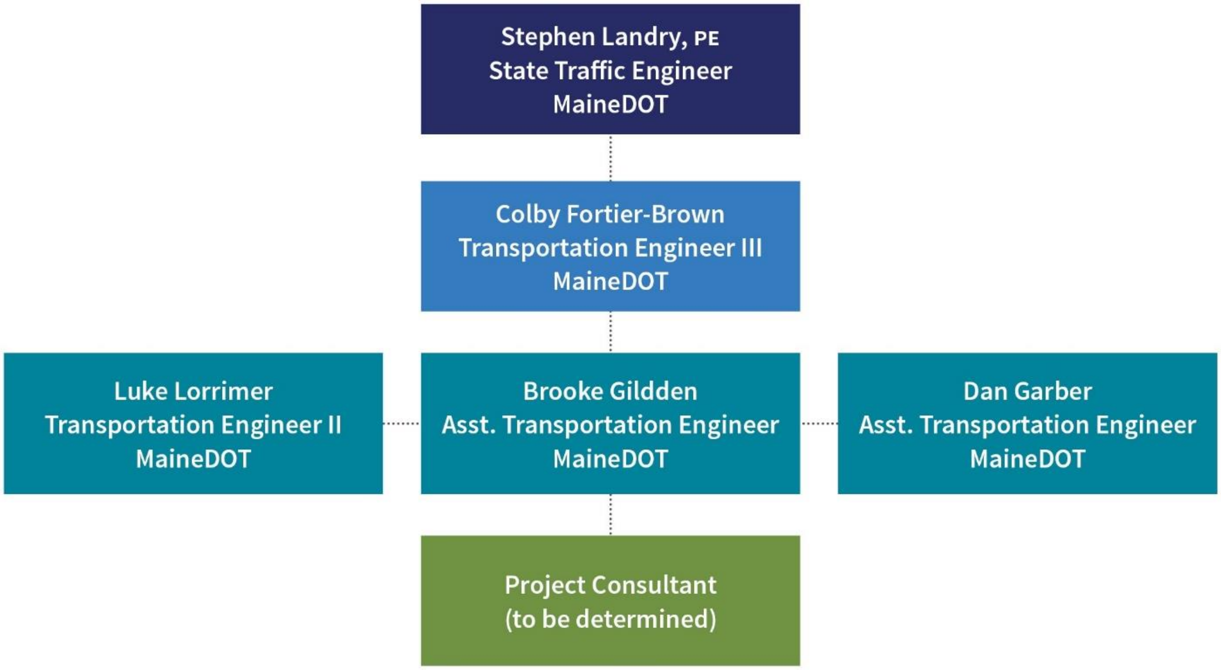
Organization	Project Role	Grant Designation
Maine Department of Transportation	• Project Management • Design & Construction • Operations & Maintenance • Data Management • Performance Measurement	Award Recipient
Consultant (To be determined)	• Project Implementation • Project Reporting • Design • Construction	Contractor

There are no subrecipients on this project.

MaineDOT will work with several key public and private sector partners to deliver this project including the Maine Motor Transport Association, Aroostook County Emergency Management, Mid Coast-Parkview Health, and Bath Iron Works. Partnering letters of support can be found in Volume 2, Appendix 2. Part of this project includes purchasing OBUs to be installed in vehicles from these key stakeholders to provide them with the latest updated weather and congestion related data, along with messaging related to low clearance bridges.

Figure 6 illustrates the organizational structure proposed for the MaineDOT Statewide Connected Vehicle Hazard Notification Project.

Figure 6 Organizational Structure



IV. Staffing Description

The primary MaineDOT Traffic Engineering staff responsible for managing and executing the *Statewide Connected Vehicle Hazard Notification Project* has over 60 years of combined experience and includes Stephen Landry, Colby Fortier-Brown, Luke Lorrimer, Brooke Glidden, and Dan Garber. Stephen Landry will serve as the point of contact for the project. Staff responsibilities for this project are listed below; resumes are provided in Appendix C.

<u>Stephen Landry, P.E., State Traffic Engineer, MaineDOT</u>

Stephen Landry will act as the team leader. He has 37 years of experience at MaineDOT, including 11 as State Traffic Engineer and leader of ITS technologies. He has overseen two major grant projects obtained by MaineDOT including a BUILD Grant for 104 traffic signals and an ATCMTD grant for 43 traffic signals that have used the same technologies as being proposed in this ATTAIN grant application. Stephen will be responsible for managing the MaineDOT Statewide Connected Vehicle Hazard Notification Project. Stephen will have availability for 10% of his time to work on this project. Stephen will also be the primary point of contact for the project. His contact information is provided below:

Stephen Landry, P.E.
207-624-3632
Stephen.Landry@maine.gov

Colby Fortier-Brown, Assistant State Traffic Engineer, MaineDOT

Colby Fortier-Brown has 5 years of experience at MaineDOT and currently manages the ITS group and the Transportation Management Center (TMC). Colby has been instrumental in setting up our TMC, ensuring that there are secure and operational systems in place for practical use of ITS devices and data. As MaineDOT's technical lead for RWIS, Colby has led the program's recent modernization and planning initiative since 2020. Colby is also MaineDOT's Broadband Liaison with the Maine Connectivity Authority (MCA), having worked in a shared capacity in 2022. While with MCA, Colby learned about wireless spectrum uses and technology applications by managing a wireless communications pilot program, Jumpstart Connectivity, from scoping through project selection. Colby is involved with many research and industry groups, including USDOT's Accelerating V2X Cohort and AASHTO CTSO's leadership team. Colby will assist Stephen with project coordination, technical design, and cyber security aspects of the project. Colby will have availability for 15% of his time to work on this project.

Luke Lorrimer, Transportation Engineer II, MaineDOT

Luke Lorrimer has 13 years of experience at MaineDOT, the last 11 working on ITS projects, Luke has done a significant amount of work on ITS communications and will be working with the consultants to ensure that proper communication protocols are followed. He has overseen the implementation of our permanent CMS boards, setting up network connections for our ITS devices, New England Compass Integration to the ITS devices (MaineDOT's ATMS software) and has worked in cellular, radio and DSRC communications to our field devices. Luke will be responsible for working with consultants to ensure cybersecurity and MaineDOT protocols for information sharing are followed. Luke will have availability for 20% of his time to work on this project.

Brooke Glidden, Assistant Transportation Engineer, MaineDOT

Brooke Glidden has 4 years of experience at MaineDOT, the last 2 years in ITS. Brooke has been our lead on day-to-day activities on the BUILD grant and ATCMTD grant. She has been instrumental in the set-up of Cellular/C-V2X technology and communications to our RSUs and communication to our FMUs using AI Glance software. Both of those technologies are essential to this ATTAIN grant application. Brooke will be overseeing the quality control of these technologies being applied for in the grant. Brooke will be responsible for day-to-day communications with the project team and ensuring the project manager and consultant work towards completing the project as defined in the grant application. Brooke will have availability for 20% of her time to work on this project.

Dan Garber, Assistant Transportation Engineer, MaineDOT

Dan Garber has 2 years of experience at MaineDOT, all in ITS. Dan has played a strategic role in quality assurance/quality control ensuring that the devices in the BUILD and ATCMTD meet the specifications in the contract. Dan has performed significant field testing of the devices and will be performing the same activities on this project. Dan will have availability for 20% of his time to work on this project.

Resumes for key personnel are provided in Appendix D.