U.S. Department of Transportation
BUILD Transportation Discretionary Grants
FY18 Grant Application

Project Name:	MaineDOT Traffic Safety and Mobility Improvements - Phase 1 Project
Project Type:	Road-Traffic Signal Replacement and/or Enhancements
Project Location:	Rural, Maine 1st and 2nd Congressional District
Funds Requested:	$8,241,100 - (50%)
Funds Matched:	$8,241,100 - (50%)
Total Project Cost:	$16,482,200
Contact:	Mr. Stephen Landry, PE - State Traffic Engineer Maine Department of Transportation 16 State House Station Augusta, ME 04333 Telephone: 207-624-3632 E-mail: stephen.landry@maine.gov

MaineDOT Traffic Safety and Mobility Improvements - Phase 1 Project

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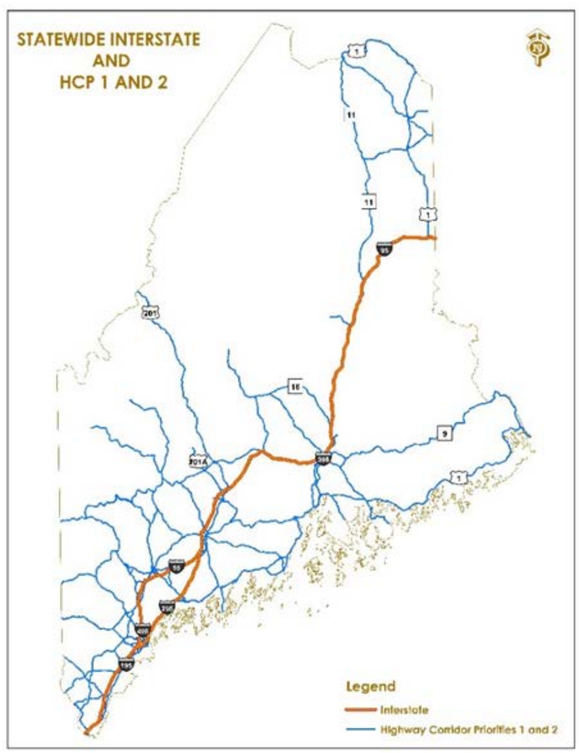
I. Project Summary

The Maine Department of Transportation (MaineDOT) is seeking $8,241,100 from the U.S. Department of Transportation (USDOT) "Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grant. The total cost of the Project is $16,482,200. MaineDOT will match 50 percent (50%) at $8,241,100.

Figure 1. Highway Corridor Priorities 1 and 2



The MaineDOT Traffic Mobility Improvements - Phase 1 Project ("Project") will:

a) Replace or enhance 101 traffic signals statewide. Selected signal systems shall have adaptive signal technology, Dedicated Short Range Communications (DSRC), infrared camera detection, fiber interconnect wiring, emergency pre-emption, back-plates with reflective striping, communication to the Traffic Management Center (TMC), Accessible Pedestrian Signals (APS), and Americans with Disability Act (ADA) improvements, where applicable.
b) Provide safety and mobility benefits, which support reduced fuel consumption and improved air quality.
c) Enhance the ability of First Responders to safely navigate through the signals in this area by use of the emergency pre-emption devices.
d) Improve traffic flow for commerce vehicles equipped to communicate with these traffic signal systems through Dedicated Short Range Communication (DSRC). The project will

serve as a test bed in which local trucking companies utilizing connected vehicle networking can communicate with our traffic signals.

e) Provide additional infrastructure to support Autonomous and Connected vehicles as they continue to come on line.

f) Decrease response time for traffic signal maintenance as each signal will be able to communicate with the TMC. The communication links will allow the signals to send alarms/alerts to TMC staff who will contact maintenance staff.

g) ADA improvements, including APS, where pedestrian facilities are present, to allow those with disabilities to cross the roadway at traffic signals more safely than with current design. Curb ramp upgrades will also be improved, providing better access for all users.

There are eight hundred and four (804) traffic signals currently operating within the state of Maine. Sixty percent (60%) are within the limits of Metropolitan Planning Organizations (MPOs). Forty percent (40%) are in rural areas. Eighty-five percent (85%) are on non-Interstate Highway Corridor Priority (HCP) 1 and 2 highways, indicated in blue on Figure 1. When operating properly, traffic signals move a significant amount of traffic, however, when malfunctioning they may create significant delays. Signal delays increase user fuel costs, air emissions, and add time or create user costs for travelers. Given Maine's predominantly rural nature, these rural corridors provide connectivity to interstate access points for many users. Subsequently, traffic signal delays drive up the cost for doing business in this state.

MaineDOT has spent significant money over the years to upgrade traffic signals statewide to achieve significant safety and mobility benefits. Historically, MaineDOT has delegated maintenance responsibilities for most signals to municipalities. Technology improvements have led to increased maintenance costs, particularly for replacement parts. MaineDOT has become increasingly concerned with municipalities abilities to adequately maintain the signals after the state committed significant resources to upgrade them. Therefore, MaineDOT is proposing to maintain all traffic signal detection and assume responsibility of any maintenance pertaining to devices inside the traffic controller cabinet.

II. Project Location

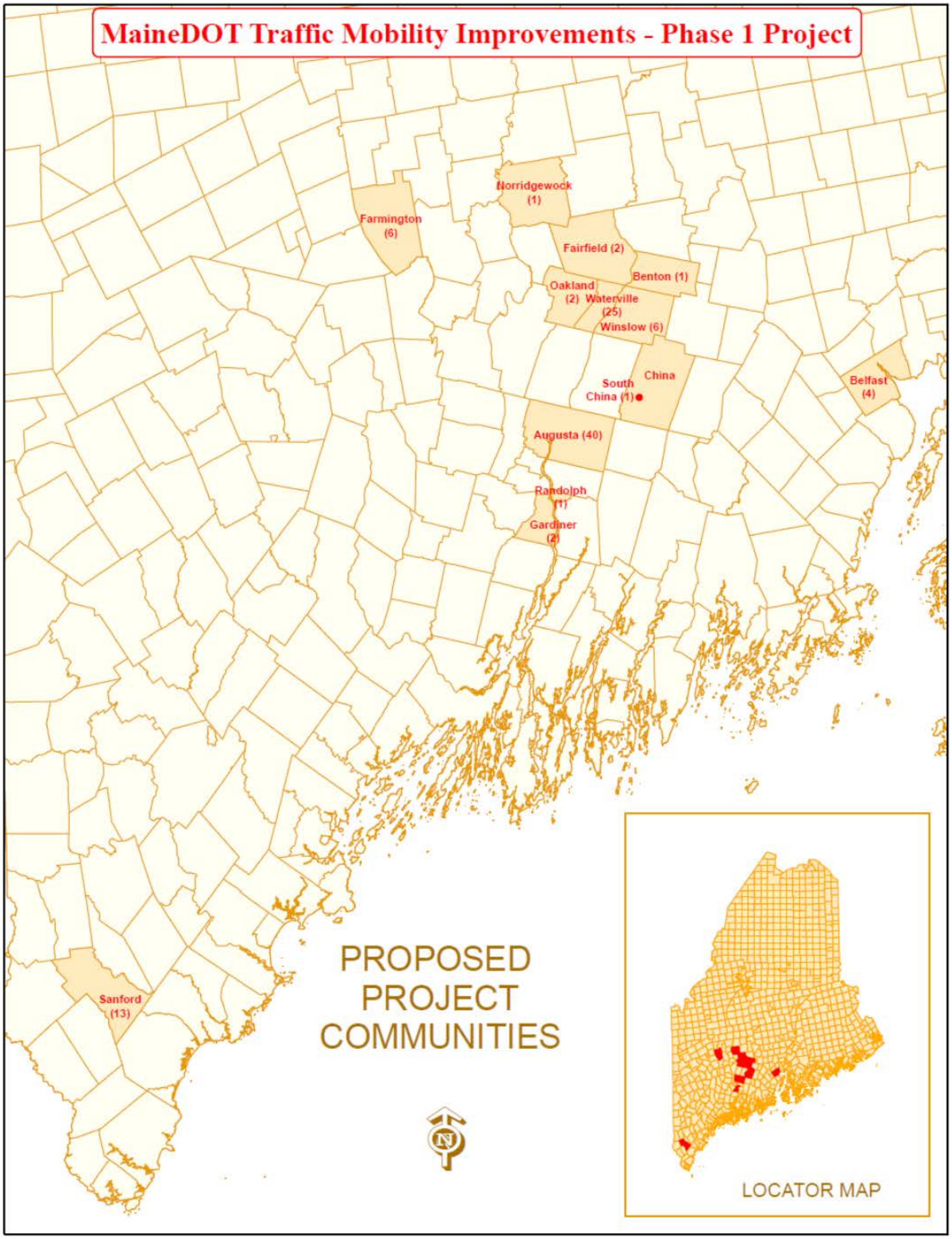


Figure 2. Location of Project Intersections by Municipality

Scope of Work by Location

Figure 2 shows the locations of 13 municipalities with more than 100 signalized intersections that are part of the MaineDOT Traffic Safety and Mobility Improvements – Phase 1 Project. The following are the nine scopes of work to be used in some, but not all, of the traffic signal locations:

Scope 1	Update detection with infrared cameras, and install Advanced Traffic Controllers (ATC), ATC controller cabinets and Dedicated Short Range (DSRC) Radio
Scope 2	Install adaptive signal technology
Scope 3	Update detection with infrared cameras
Scope 4	Add signal interconnect via fiber optics
Scope 5	Total traffic signal replacement including infrared detection, new ATC controller and cabinet, new signal head and wiring
Scope 6	Pre-emption for emergency vehicles
Scope 7	Add back-plates with 3-inch wide reflective striping
Scope 8	Add Accessible Pedestrian Signals (APS), including pedestrian countdown heads
Scope 9	ADA improvements at pedestrian crossings

Table 1 lists the intersections by municipality, their locations, and the work planned for each.

Table 1. Municipalities, Intersections and Scope of Work

Augusta				Scopes
1	Capitol St	at	Sewell St	3,5,7,8,9
2	Civic Center Dr	at	Commerce Dr	2,3,4,5,7
3	Civic Center Dr	at	Darin Dr	2,3,4,5,7,8,9
4	Civic Center Dr	at	I-95 NB	2,3,4,5,7,8,9
5	Civic Center Dr	at	I-95 SB	2,3,5,7,8,9
6	Civic Center Dr	at	Leighton Rd	2,3,5,7
7	Civic Center Dr	at	Market Place	2,3,5,7,8,9
8	Civic Center Dr	at	Townsend Rd	2,3,5,7,8,9
9	Eastern Ave	at	Cony Rd	5,6,7,8,9
10	Eastern Ave	at	Stone St	5,6,7,8,9
11	Eastern Ave	at	Togus Rd	5,6,7
12	Hospital St	at	Piggery Rd	5,6,7,8,9
13	Route 3	at	Church Hill Rd	3,5,6,7
14	Route 3	at	North Belfast Ave	3,5,6,7
15	Route 3	at	Riverside Dr	3,5,6,7
16	Route 3	at	Route 104	3,5,6,7
17	Senator Way	at	Target	3,5,6,7
18	South Belfast Ave	at	Cony Rd	5,6,7
19	State St	at	Capitol St	3,5,7,8,9

20	State St	at	Union St	3,5,7,8,9
21	Stone St	at	Hannaford	3,5,7,8,9
22	Western Ave	at	Airport Rd	1,2,3,5,7,8,9
23	Western Ave	at	Armory St	1,2,3,5,7,8,9
24	Western Ave	at	Augusta Xing	1,2,3,5,7,8,9
25	Western Ave	at	Edison Dr	1,2,3,5,7,8,9
26	Western Ave	at	Fuller Rd	1,2,3,5,7,8,9
27	Western Ave	at	Senator Way	1,2,3,5,7,8,9
28	Western Ave	at	Sewell St	3,5,7,8,9
29	Western Ave	at	Shuman Dr	2,3,5,7,8,9
30	Western Ave	at	U-Haul	3,5,7,8,9
31	Western Ave	at	Whitten Rd	2,3,5,7
32	Route 3	at	MaineGeneral	3,4,5,7
33	Route 3	at	Route 27	3,4,5,7
34	State St	at	Winthrop St	3,5,7,8,9
35	State St	at	Bridge St	3,5,7,8,9
36	Water St	at	Bridge St	3,5,7,8,9
37	Cony St	at	City Center	3,5,7,8,9
38	Bangor St	at	Quimby St	5,6,7,8,9
39	Bangor St	at	North Belfast Ave	5,6,7,8,9
40	Whitten Rd	at	Hannaford	5,7
Belfast				
1	Route 3	at	Haley Rd	5,6,7,8,9
2	Main St	at	Hannaford	5,6,7,8,9
3	Main St	at	High St	5,6,7,8,9
4	Route 1	at	Route 52	5,6,7,8,9
Benton				
1	Bridge St	at	Benton Ave	5,6,7
Fairfield				
1	Route 201	at	Bridge St	4,5,6,7,8,9
2	Route 201	at	Johnny's Seeds/KVCOG	4,5,6,7,8,9
Farmington				
1	Route 4	at	Broadway	5,6,7,8,9
2	Route 4	at	Route 2/27	5,6,7,8,9
3	Route 4	at	Bridge St	5,6,7,8,9
4	Route 4	at	Hannaford	5,6,7
5	Route 4	at	Walmart	5,6,7
6	Route 4	at	Hospital St	5,6,7
Gardiner				
1	Bridge St	at	Maine Ave	5,6,7,8,9
2	Bridge St	at	Water St	5,6,7,8,9

Norridgewock				
1	Main St	at	Madison Rd	5,6,7,8,9
Oakland				
1	Main St	at	Fairfield St	5,6,7,8,9
2	Pleasant St	at	Oak St	5,6,7,8,9
Randolph				
1	Water St	at	Bridge St	5,6,7,8,9
Sanford				
1	Main St	at	Walmart	5,6,7
2	Main St	at	Jagger Mill Rd	5,6,7
3	Main St	at	Shaw's	5,6,7
4	Main St	at	Westview	5,6,7,8,9
5	Main St	at	Sanford Plaza	1,6,7,8,9
6	Main St	at	Emery St	1,6,7,8,9
7	Main St	at	Washington St	5,6,7,8,9
8	Main St	at	Route 202	5,6,7,8,9
9	Main St	at	Route 224	5,6,7,8,9
10	Route 4 A/202	at	River St	1,6,7,8,9
11	Route 224	at	Route 202/4	5,6,7
12	Route 224	at	River St	5,6,7
13	Route 4 A/202	at	Grammar Rd	5,6,7
South China				
1	Route 3	at	Route 32	5,6,7
Waterville				
1	KMD	at	First Park Dr	1,2
2	KMD	at	I-95 SB	1,2
3	KMD	at	I-95 NB	1,2
4	KMD	at	Washington St	1,2
5	KMD	at	Camden Nat'l Bank	1,2
6	KMD	at	1st Rangeway	1,2
7	KMD	at	Hannaford	1,2
8	KMD	at	Cool St	1,2
9	KMD	at	West River Rd	1,2
10	KMD	at	Carter Mem Dr	1,2
11	Silver St	at	Elm St	5
12	Elm	at	Western Ave	5
13	Elm	at	Park St	5
14	Spring St	at	Main St	5
15	Spring St	at	Silver St	5
16	Spring St	at	Elm St	5
17	Main St	at	Temple St	5

18	Main St	at	Elm St	5
19	Main St	at	Eustis Parkway	5
20	Main St	at	Armory St	1,2
21	Main St	at	Waterville Commons Dr	1,2
22	Main St	at	I-95 NB	1,2
23	Main St	at	I-95 SB	1,2
24	College Ave	at	Hazelwood Ave	5
25	KMD	at	Airport Rd	1,2,5
Winslow				
1	Carter Mem Dr	at	Cushman Rd	5,6
2	China Rd	at	Cushman Rd	5
3	Route 201	at	Clinton Ave	5
4	Route 202	at	Halifax St	5
5	Route 203	at	China Rd	5
6	Route 204	at	Carter Mem Dr.	5,6

III. Grant Funds, Sources and Uses of Project Funds

All BUILD grant funding for the Project will be spent on actual construction costs. Federal funds will not be used for engineering-related costs.

The primary source of transportation funding in Maine is gas tax revenue, which by statute, can only be used for highways and bridges. Funding for MaineDOT's portion of the Project will come from State General Obligation Bond proceeds. MaineDOT is well equipped to manage and administer this Grant, having received and managed numerous USDOT grants for highway, railroad and transit programs including previous TIGER, FASTLANE and most recently INFRA awards. A match commitment letter from the MaineDOT Commissioner is attached in Appendix C.

Table showing sources and uses of project funds and percentage:

	MaineDOT	BUILD	TOTAL
Preliminary Engineering (PE)	$1,351,000	$0	$1,351,000
Right-of-Way	$0	$0	$0
Construction Engineering (CE)	$1,621,200	$0	$1,621,200
Construction	$5,268,900	$8,241,100	$13,510,000
TOTAL	$8,241,100	$8,241,100	$16,482,200
% of TOTAL Project	**50%**	**50%**	**100%**

Table showing further breakdown of project costs by city/town and use:

City/Town	Intersections	Const Cost	PE	CE	Total
Augusta	40	$4,995,000.00	$499,500.00	$599,400.00	$6,093,900.00
Belfast	4	$870,000.00	$87,000.00	$104,400.00	$1,061,400.00
Benton	1	$175,000.00	$17,500.00	$21,000.00	$213,500.00
Fairfield	2	$450,000.00	$45,000.00	$54,000.00	$549,000.00
Farmington	6	$1,170,000.00	$117,000.00	$140,400.00	$1,427,400.00
Gardiner	2	$470,000.00	$47,000.00	$56,400.00	$573,400.00
Norridgewock	1	$225,000.00	$22,500.00	$27,000.00	$274,500.00
Oakland	2	$430,000.00	$43,000.00	$51,600.00	$524,600.00
Randolph	1	$195,000.00	$19,500.00	$23,400.00	$237,900.00
Sanford	12	$2,420,000.00	$242,000.00	$290,400.00	$2,952,400.00
South China	1	$175,000.00	$17,500.00	$21,000.00	$213,500.00
Waterville	24	$1,815,000.00	$181,500.00	$217,800.00	$2,214,300.00
Winslow	6	$120,000.00	$12,000.00	$14,400.00	$146,400.00
TOTALS	102	$13,510,000.00	$1,351,000.00	$1,621,200.00	$16,482,200.00

IV. Merit Criteria

MaineDOT has identified several merit criteria met by the MaineDOT Traffic Safety and Mobility Improvements - Phase 1 Project. Included are safety, state of good repair, economic competitiveness, quality of life, innovation, and environmental protection. These criteria are all important to the project. Two of the criteria, safety and economic competitiveness, are the focus of the Benefit-Cost Analysis.

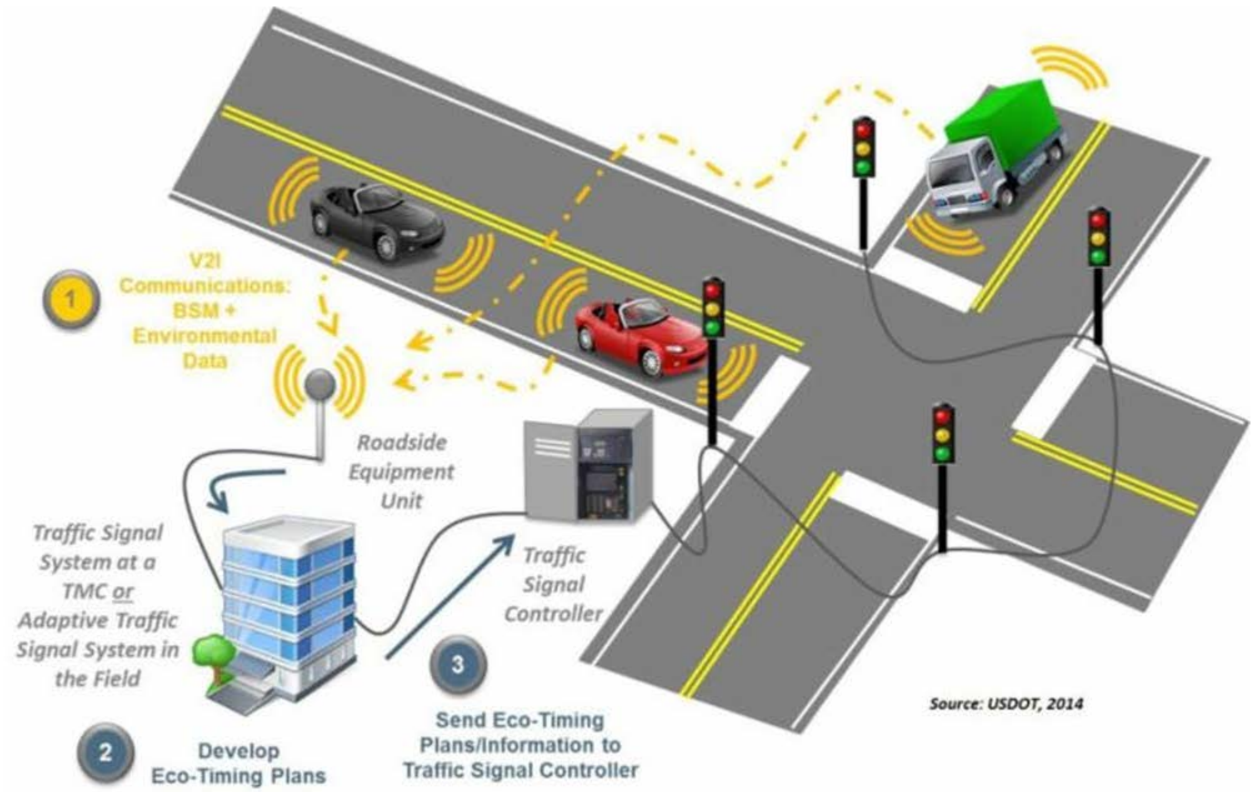
Safety

MaineDOT uses the American Association of State Highway Transportation Officials (AASHTO) Highway Safety Manual to help determine the safety benefit for all intersection projects. For the MaineDOT Traffic Safety and Mobility Improvements - Phase 1 Project, two proven countermeasures were evaluated to measure safety benefits:

1) Adaptive traffic signal control technology
2) Reflective back-plates

Adaptive Traffic Signal Control (ATSC) technology is an Intelligent Transportation System (ITS) technology developed to optimize cycle lengths, green times, and/or phasing sequences for traffic signals based on changing traffic volumes collected from advanced detectors.[1] Figure 3 illustrates the ATSC technology. Not all adaptive signal technologies work in the same way. Some types favor mainline flow while others smooth out total intersection level of service. Furthermore, some can change splits and offsets, while others can adjust cycle lengths. System engineering should be used when determining which adaptive product to use. We know that studies have shown that providing coordinated traffic signals in general and adaptive specifically have shown to reduce severe collisions on city streets by producing smoother traffic flow and fewer stops.[2] Some of those studies developed crash modification factors (CMF) for the Highway Safety Manual. A CMF of 0.83 (CMF ID 6856) for ATSC was used in the MaineDOT safety analysis for this project.

Figure 3. Adaptive Traffic Signal Overview



The adaptive signal process is simple. First, traffic sensors collect data. Next, the traffic data is evaluated and signal timing improvements are developed. Finally, ATSC implements signal timing updates. The process is repeated every few minutes on a continuous cycle to keep traffic flowing smoothly. On average ATSC improves travel time by more than 10 percent. In areas with particularly outdated signal timing, improvements can be over 50 percent.

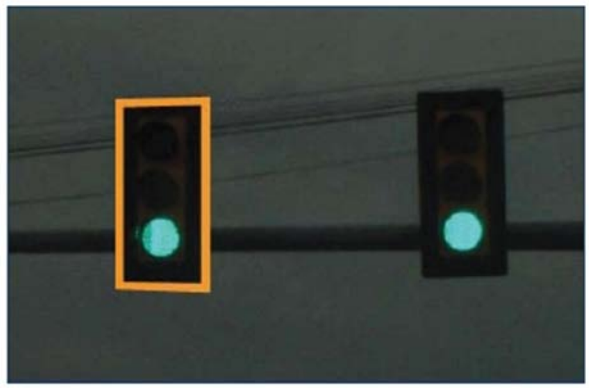
The main benefits of adaptive signal control technology over conventional signal systems are as follows:

- Continuously distribute green light time equitably for all traffic movements
- Improve travel time reliability by progressively moving vehicles through green lights
- Reduce congestion by creating smoother flow
- Prolong the effectiveness of traffic signal timing

This project will retrofit 30 signals along 4 corridors with adaptive signal technology. These corridors have traffic volumes that change significantly by time of day, day of week, and time of year. The adaptive signal technology changes signal timing on demand based on traffic flows entering the intersection from all approaches. These 30 signals are on corridors that provide interstate connectivity, support Maine's economy, and are priorities for maintaining mobility. The mobility benefits are shown in the economic competitiveness portion of the report.

Red-light running is one of the most serious traffic problems that Americans face today. It is estimated that vehicles running red lights cause more than 200,000 crashes, 170,000 injuries, and approximately 900 deaths per year.[3] Many of those were the result of people not knowing there was an intersection or not being able to see the traffic signal. Back-plates added to a traffic signal improves the visibility of the illuminated face of the signal by introducing a controlled-contrast background, which is made even more conspicuous by framing it with a retroreflective border. Signal heads that have back-plates equipped with retroreflective borders are more visible in and conspicuous in both daytime and nighttime conditions.[4]

Figure 4. Signal Head with Reflective Border



Many studies have been performed on the use of reflective back-plates and all have indicated significant reduction in crashes. In a South Carolina study, the three intersections monitored had a combined reduction in total crashes of 28.6 percent, 36.7 percent reduction in injury crashes, and 49.6 percent reduction in late-night/early-morning crashes after the installation.[5] Figure 4 shows the difference between a signal head with the reflective strip and signal head without the reflective strip. Reflective back-plates truly show their merit in low level lighting, adding more perspective to the signal head. Reflective back-plates are proposed to be installed at 73 intersections, as the remaining intersections already have them. The back-plates will certainly help traffic signal view sheds as several of these corridors are east/west corridors where sun can create issues with conspicuity. A CMF of 0.85 (CMF ID 1410) for reflective back-plates was used in the MaineDOT safety analysis for this project.

Table 2 is a summary the expected safety benefits of the project, by town, for the 2017 base year. The existing intersections experience over 450 crashes per year and more than $14 million in annual crash costs. MaineDOT uses observed crash experience and the Highway Safety Manual methodology to estimate expected annual crash costs at all signalized and most unsignalized intersections throughout the state. The estimated benefits of the project are based on the application of the appropriate CMFs for adaptive signal control and reflective back-plates to the base-year expected crash costs at each intersection in the project. Overall, the project can be expected to reduce crash costs by about 20%.

Table 2. Highway Safety Benefits for the MaineDOT Traffic Safety and Mobility Improvements – Phase 1 Project

City/Town	Intersections	Observed Crashes/Year	Expected Crash Costs/Year	Safety Benefits/Year
Augusta	40	160	$ 5,318,268	$ 1,047,391
Belfast	4	7	$ 318,480	$ 47,772
Benton	1	7	$ 249,383	$ 37,408
Fairfield	2	6	$ 138,361	$ 20,754
Farmington	6	27	$ 678,389	$ 101,758
Gardiner	2	17	$ 412,514	$ 61,877
Norridgewock	1	3	$ 142,858	$ 21,429
Oakland	2	5	$ 275,282	$ 41,292
Randolph	1	8	$ 30,024	$ 4,504
Sanford	12	54	$ 1,899,518	$ 284,928
South China	1	2	$ 143,948	$ 21,592
Waterville	24	123	$ 3,724,234	$ 947,110
Winslow	6	37	$ 1,023,856	$ 153,578
Total	102	456	$14,355,115	$ 2,791,393

State of Good Repair

Many of the proposed signal upgrade/replacement locations in this project are at the end of their service life and have substantial needs. Others are within their useful life but have been allowed to fall into a state of disrepair due to lack of maintenance. Many municipalities cannot afford to maintain their traffic signals as ever shrinking traffic signal budgets do not allow municipalities to perform proper diagnostics and repair. Figure 5 shows a typical outdated traffic signal controller. Figure 6 shows maintenance activity that few municipalities have the expertise or resources to undertake. As part of this project, MaineDOT will assume maintenance responsibility for detection and controller/cabinet maintenance. Traffic controllers and detection are the two most expensive features of the signal and experience the most failures. MaineDOT hopes that by taking over maintenance of these devices, we can protect our investments in our system.

Figure 5. Typical Older Style Controller Being Replaced as Part of the Proposed Project

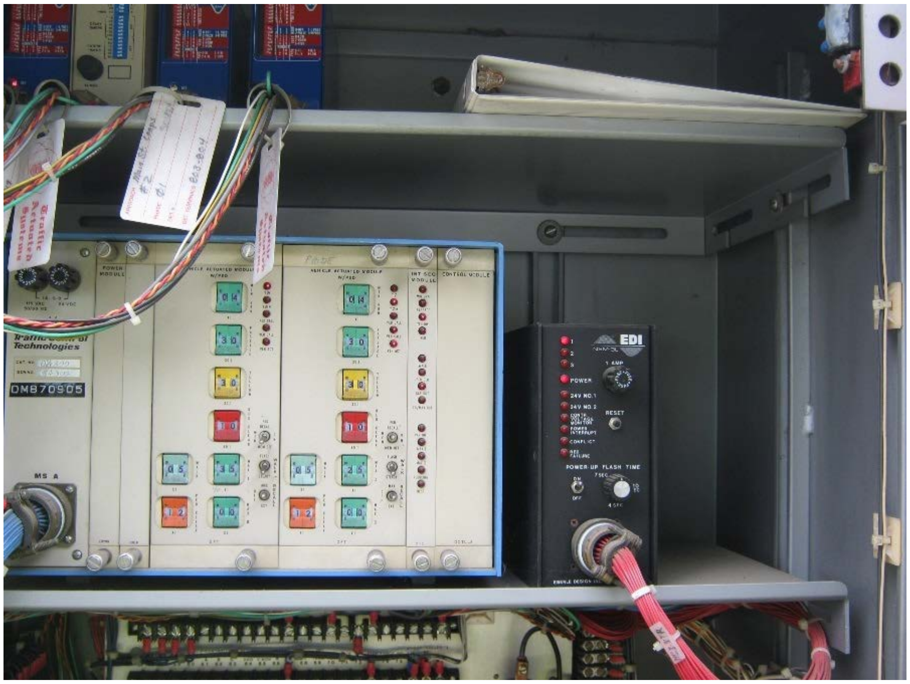


Figure 6. Maintenance of Traffic Signals is Paramount to Keeping Proper Signal Coordination

MaineDOT is also proposing that each signal/signal system has communications installed with a dedicated short-range communication (DSRC) device. This project will provide a direct connection from signals back to our Traffic Management Center (TMC) so that our TMC staff can be promptly alerted to malfunctions and we can make repairs to signals in a timely manner.

Also, part of our maintenance plan is a preventative maintenance check for each traffic signal every year. The plan includes reviewing connections, changing filters and cleaning cabinets to reduce life-cycle costs.

Economic Competitiveness

Traffic signals impact virtually every driver and pedestrian traveling on or along the roadway system. The average trip on any given roadway system is interrupted by one or many traffic signals. These interruptions could be designed or be the result of a poorly timed system. The average motorists place their trust in traffic signals, hoping they will help them to safely and efficiently navigate the roadway system

A traffic signal is a necessary "evil" that many times is demanded by users to ensure safety and mobility but cursed by others when it unduly impacts them. People often assume that signals are operating efficiently and effectively and only report the most obvious malfunctions or failures. Inefficient signal operation, even though such operation adds significant costs to the user in the form of increased fuel costs and longer trip time, is rarely reported or noticed. Most users seem to accept that a signal is working properly if it changes from red to green to yellow and back to red again. This project will not only significantly improve, if not optimize, all signals that are involved, but also provide a mechanism for any malfunctions to be communicated to MaineDOT staff in real time.

The overall objective of traffic signal installations is to provide for the safe and efficient traffic flow at intersections, along routes, and in street networks. A well-timed traffic signal system can reduce fuel consumption, eliminate unnecessary stops and delays, improve safety, and enhance the environment. [6]

Some of the advantages (goals) of signal installations include[7]:

- Provide for the orderly movement of traffic
- Reduce the frequency of certain types of crashes (i.e., right-angle and pedestrian)
- Increase the traffic handling capacity of the intersection
- Provide a means of interrupting heavy traffic to allow other traffic, both vehicular and pedestrian, to enter or cross
- Provide for nearly continuous movement of traffic at a desired speed along a given route by coordination
- Afford considerable economy over manual control at intersections where alternate assignment of right-of-way is required
- Promote driver confidence by assigning right-of-way

Some disadvantages to signal installations include[8]:

- Most installations increase total intersection delay and fuel consumption, especially during off peak periods
- Likely increase certain types of crashes (i.e., rear end collisions)

- When improperly located, cause unnecessary delay and promote disrespect for this type of control
- When improperly timed, cause excessive delay, increasing driver irritation

MaineDOT has experienced mobility improvements and emission reductions first hand through corridor signal coordination projects. Tables 3 and 4 show the reduced delay in the Western Avenue signal system in Augusta, Maine. The 25% to 45% reduction in travel time shown is indicative of similar corridor signal coordination projects. Unfortunately, if signals are not maintained properly, delays increase. For instance, a couple of recent travel time runs westbound on Western Avenue in Augusta showed travel times between 6 minutes and 16 seconds and 6 minutes and 50 seconds, which shows the degradation lack of maintenance can cause.

Table 3. Western Avenue Eastbound Travel

Measure of Effectiveness	Before Implementation		After Implementation
	September 2005	May 2007	March 2008
Travel Time	5 minutes 17 seconds	7 minutes 26 seconds	4 minutes 2 seconds
Stopped Delay	1 minute 9 seconds	2 minutes 41 seconds	0 minutes 12 seconds
Average Number Of Stops (of 9 signals)	4	4	1*
Average Speed On Road with Delay	23 mph	16 mph	30 mph
Average Speed On Road Segments (w/o Delay)	29 mph	25 mph	31 mph
* = 50% chance of stopping at Edison Drive for approximately 7 seconds, 50% chance of stopping at Sewall Street for approximately 5 seconds.			

Table 4. Western Avenue Westbound Travel

Measure of Effectiveness	Before Implementation		After Implementation
	September 2005	May 2007	March 2008
Travel Time	5 minutes 10 seconds	8 minutes 8 seconds	3 minutes 46 seconds
Stopped Delay	1 minute 24 seconds	3 minutes 58 seconds	0 minutes 5 seconds
Average Number Of Stops (of 9 signals)	4	4	~ 1**
Average Speed On Road with Delay	23 mph	15 mph	32 mph
Average Speed On Road Segments (w/o Delay)	32 mph	29 mph	32 mph
** = 50% chance of stopping at Orchard Street for approximately 5 seconds (average).			

Outdated traffic signal timing incurs substantial costs to businesses and consumers. They account for more than 10 percent of all traffic delay and congestion on major routes. For consumers, this causes excess delays and fuel consumption. For businesses, it decreases productivity and increases labor costs. According to the Texas Transportation Institute, the cost of traffic congestion is $87.2 billion in wasted fuel and lost productivity. That translates to $750 per traveler.[21]

The benefits observed in the Augusta project can be expanded beyond Western Avenue in Augusta and to other municipalities around the state. Table 5 summarizes the traffic signal delay experienced in the project municipalities and the potential mobility benefits that are possible with the traffic signal improvements. Existing annual delay costs for the project intersections is about $23.5 million. Overall, the project can be expected to reduce annual delay at these intersections by 18%.

Table 5. Highway Mobility Benefits for the MaineDOT Traffic Safety and Mobility Improvements – Phase 1 Project

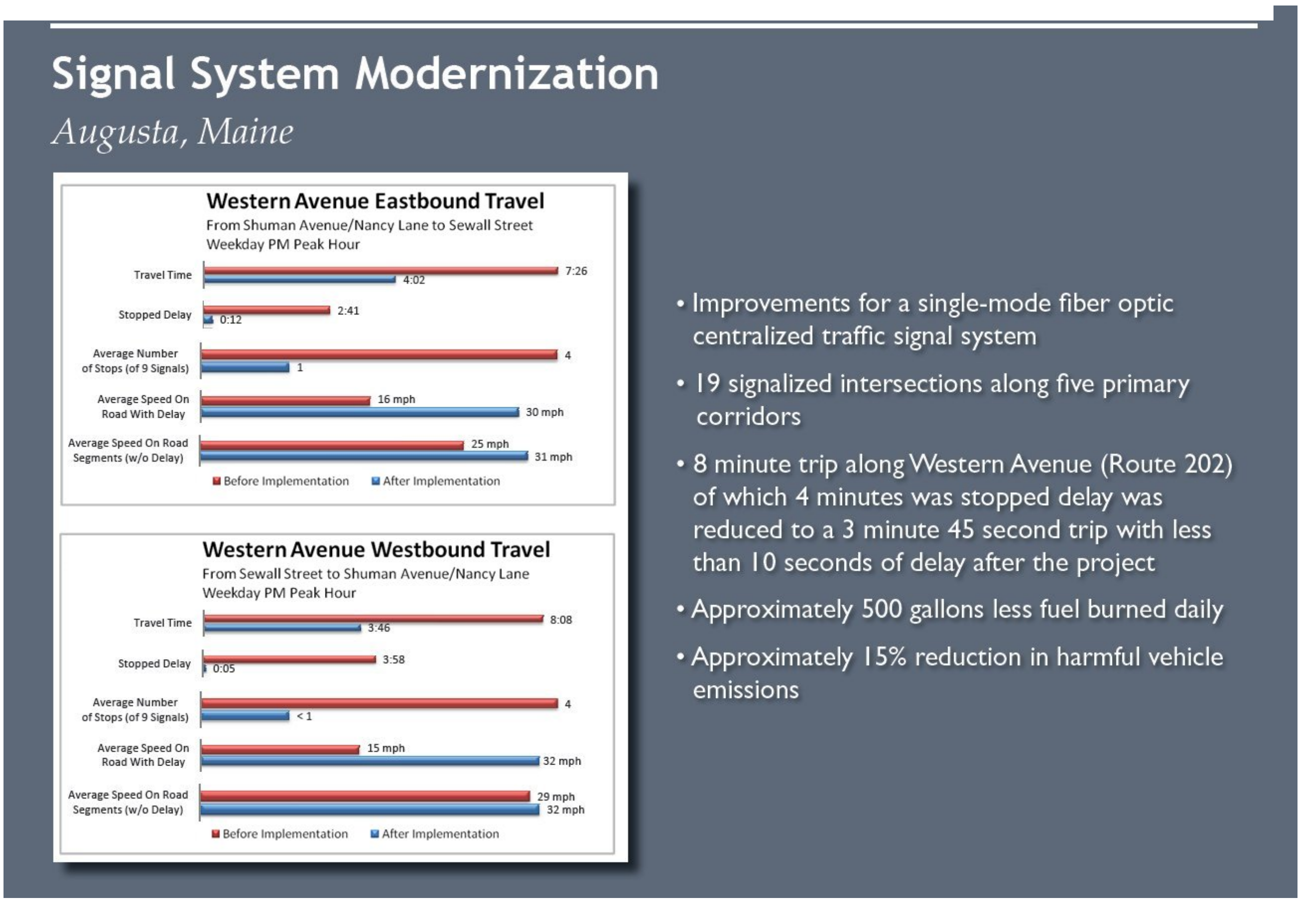
City/Town	Intersections	Annual Delay (veh-hrs)	Annual Delay Cost	Reduced Annual Delay (veh-hrs)	Reduced Annual Delay Cost	Mobility Benefits/Year
Augusta	40	472,503	$ 9,834,134	367,915	$ 7,657,358	$ 2,176,776
Belfast	4	29,024	$ 604,066	25,831	$ 537,619	$ 66,447
Benton	1	7,910	$ 164,637	7,040	$ 146,527	$ 18,110
Fairfield	2	12,182	$ 253,543	8,782	$ 182,779	$ 70,764
Farmington	6	66,331	$ 1,380,538	59,035	$ 1,228,679	$ 151,859
Gardiner	2	23,403	$ 487,078	20,828	$ 433,499	$ 53,579
Norridgewock	1	6,076	$ 126,449	5,407	$ 112,540	$ 13,909
Oakland	2	13,559	$ 282,199	12,067	$ 251,157	$ 31,042
Randolph	1	14,054	$ 292,495	12,508	$ 260,321	$ 32,174
Sanford	12	137,838	$ 2,868,799	122,676	$ 2,553,231	$ 315,568
South China	1	8,138	$ 169,370	7,243	$ 150,739	$ 18,631
Waterville	24	282,467	$ 5,878,950	221,440	$ 4,608,794	$ 1,270,156
Winslow	6	55,812	$ 1,161,600	55,812	$ 1,161,600	$ -
Total	102	1,129,296	$23,503,859	926,584	$19,284,843	$ 4,219,016

Environmental Protection

Sitting in traffic during rush hour is not just frustrating, it adds unnecessary greenhouse gas emissions to the atmosphere. MaineDOT has observed that properly timed and maintained traffic signals not only prevent delay, but also have an impact on the quantity of vehicle emissions. In a before and after study on two corridors, MaineDOT saw decreases in both harmful emissions and fuel consumption. The 2008 Augusta project showed a 15% reduction in emissions and a fuel savings of around 500 gallons per day, as shown in Figure 7. MaineDOT's plan to install Adaptive Traffic Control Systems will help with the lack of retiming due to changing volumes and as MaineDOT takes over future maintenance, it is anticipated that there will be better response times for fixing controller and detection issues.

In a study performed by Portland State University, modeling results indicated that green time allocation and traffic volumes have a significant impact on fine particulate matter (PM2.5) concentration levels.[19] This not only puts the driver at risk as the particulate matter enters into the vehicles driving cab through vents, but is also an issue for pedestrians crossing at traffic signals as the particles are small and light and increases the chances of humans and animals inhaling them.[20]

Figure 2 Augusta Signal Project - Impacts on Emissions



Quality of Life

Maine is a rural state and for many years, our highway system was designed to move traffic and enhance economic capacity for industry and commerce. In more recent years, MaineDOT has focused on inclusivity for all modes of transportation including pedestrian and bicycle use. In 2014, MaineDOT implemented a Complete Streets Policy in which “MaineDOT strongly supports a multimodal transportation system, and recognizes that pedestrian and bicycle infrastructure such as sidewalks, bicycle lanes, separated facilities, transit stops, ADA-accessible routes, and travel lanes are important elements of the transportation system. Such a multimodal system is crucial to the safety and economic vibrancy of businesses, villages, downtowns, neighborhoods, and rural areas."

MaineDOT also complies with ADA law and federal guidance as it improves its infrastructure. With the upgrades of these traffic mobility improvements, where pedestrian infrastructure exists, all ADA upgrades will be included, to the maximum extent feasible.

There are approximately 30,000 blind or visually impaired people in the state of Maine, half of which are in the age bracket of 18 to 64.[9] This age bracket represents the most active set of those with visual impairments. Many people in this group maintain regular careers. However, since they cannot drive, they need facilities to get to and from work and/or bus or train stations. The risk of having an unintentional injury is higher for people who are visually impaired compared with the fully sighted population.[10] Intuitively, people with visual impairment are more susceptible to injury: they have fewer visual clues to alert them to potential hazards such as oncoming traffic.[11]

Figure 8. Accessible Pedestrian Signal Push Button

Individuals with ambulatory disabilities rely on our transportation system for the same reasons as those with visual impairments. The pedestrian system in Maine is old and many intersections have been identified as non-ADA compliant. As we improve identified intersections in this application, we will also include curb ramp improvements and ADA access. Individuals who use mobility devises such as wheel chairs, scooter, walkers, and crutches will have better access to pedestrian facilities.

ADA improvement do not just assist those with disabilities but make it easier for *all* to use the pedestrian facilities. These improvements provide opportunities for pedestrians to confidently use signals and ramps and way find easier to get to work, make appointments, and visit with family and friends, providing an improved quality of life for all users.

As part of the BUILD grant request for MaineDOT's Traffic Mobility Improvements, Phase 1 of the project includes APS and other ADA improvements. These improvements are being proposed to enhance the movements for individuals with visual impairment, allowing them to gather more information, whether from detectable warning fields, braille signs, audible messages, or tactile push buttons, and improved curb access. The implementation of these improvements at over 100 intersections will provide consistency and reliability to better accommodate individuals with visual impairment. Figure 8 shows an example of an accessible traffic signal push button. Figure 9 shows an accessible ramp at a crosswalk.

APS can provide information to pedestrians about:[12]

Figure 9. ADA Accessible Curb Ramp

- Existence of and location of the pushbutton
- Beginning of the WALK interval
- Direction of the crosswalk and location of the destination curb
- Intersection street names in braille, raised print, or through speech messages
- Intersection signalization with a speech message
- Intersection geometry through tactile maps and diagrams, or through speech messages

Research has found that APS improved crossing performance by blind pedestrians:[13]

- More accurate judgments of the onset of the WALK interval
- Reduction in crossings begun during DONT WALK
- Reduced delay
- Significantly more crossings completed before the signal changed

These improvements provide connectivity for the sight impaired. It allows them to get to jobs, healthcare, shopping, bus stops, train stations and to their homes more safely. MaineDOT has been working with partners from the Department of Labor's Division of the Blind and Alpha One, a designated Center for Independent Living, to make our roadways safer for those with disabilities.

Innovation

Dedicated Short Range Communications (DSRC) is a two-way short- to- medium-range wireless communications capability that permits very high data transmission critical in communications-based active safety applications. In Report and Order FCC-03-324, the Federal Communications Commission (FCC) allocated 75 MHz of spectrum in the 5.9 GHz band for use by Intelligent Transportations Systems (ITS) vehicle safety and mobility applications.[14] The USDOT has identified more than 40 use cases for V2I technologies, such as the ability to pay for parking and tolls wirelessly, identify when a car is approaching a curve too quickly and alert the driver, adjusting traffic signals to accommodate first responders in an emergency, and alert drivers of conditions such as road construction, among others. MaineDOT is proposing to install DSRC in this project to begin testing V2V and V2I applications and to take the SPAT challenge to the next level. MaineDOT is seeking trucking industry partners with large fleets to help test the system and is actively working with several entities to partner with us. MaineDOT will also be testing V2V and V2I with our own fleet. Figures 10, 11, and 12 show examples of innovative traffic signal technology.

DSRC was developed with a primary goal of enabling technologies that support safety applications and communication between vehicle-based devices and infrastructure to reduce collisions. DSRC is the only short-range wireless alternative today that provides:[15]

- **Designated Licensed Bandwidth:** For secure, reliable communications to take place. It is primarily allocated for vehicle safety applications by FCC Report and Order FCC 03-324.
- **Fast Network Acquisition:** Active safety applications require the immediate establishment of communication and frequent updates.
- **Low Latency:** Active safety applications must recognize each other and transmit messages to each other in milliseconds without delay.
- **High Reliability when Required:** Active safety applications require a high level of link reliability. DSRC works in high vehicle speed mobility conditions and delivers performance immune to extreme weather conditions (e.g. rain, fog, snow, etc.).
- **Priority for Safety Applications:** Safety applications on DSRC are given priority over non-safety applications.
- **Interoperability:** DSRC ensures interoperability, which is the key to successful deployment of active safety applications, using widely accepted standards. It supports both V2V and V2I communications.
- **Security and Privacy:** DSRC provides safety message authentication and privacy.

Figure 10. Connected Vehicle Technology Will Help in Decreasing Crashes between Light and Heavy Vehicles

Potential DSRC Transportation Applications for Public Safety and Traffic Management include:

- Blind spot warnings
- Forward collision warnings

- Sudden braking ahead warnings
- Do not pass warnings
- Intersection collision avoidance and movement assistance
- Approaching emergency vehicle warning
- Vehicle safety inspection
- Transit or emergency vehicle signal priority
- Electronic parking and toll payments
- Commercial vehicle clearance and safety inspections
- In-vehicle signing
- Rollover warning
- Traffic and travel condition data to improve traveler information and maintenance services

Figure 11. ATC Traffic Controller Cabinet

Besides DSRC, MaineDOT is looking to install Advanced Transportation Controllers (ATC) at all 102 intersections. The Advanced Transportation Controller (ATC) Standards are intended to provide an open architecture hardware and software platform that can support a wide variety of Intelligent Transportation Systems (ITS) applications including traffic management, safety, security and other applications.[16]

Figure 12. Connected Vehicles of All Types Communicating at a Traffic Signal

ATC operates on an open architecture platform and uses a Linux Operating system. In this context, the words "open architecture" mean that the system can support both public and private sector developers, and have modular software cooperatively running on standardized and shared modular hardware platforms.[17]

It is anticipated that ATC will be able (or configurable) to serve at least the following applications:

- Traffic Signal
- Traffic Surveillance
- Transit
- Communications
- Field Masters
- Ramp Meter
- Variable/Dynamic Message Signs
- General ITS beacons
- CCTV Cameras
- RWIS
- Weigh in Motion
- Irrigation Control
- Lane Use Signals
- Highway Rail Intersections
- Speed Monitoring
- Incident Management
- Highway Advisory Radio
- Freeway Lane Control
- Electronic Toll Collection
- Automatic Vehicle Identification
- High Occupancy Vehicle Systems
- Violations
- Access Control
- Traveler Information
- Commercial Vehicle Operations

In the ATC System, there are two major assemblies: the cabinet and the controller. Within each major assembly there are subassemblies, or in the case of the controller application, software packages that add to the system functionality. The system is much like the menu at an a la carte restaurant where the user can pick things from multiple menu areas to suit the user's preferences (sort of a mix and match approach.)[18] Figure 13 shows an example of a modern ATC controller.

Figure 13. ATC -2070 Controller

Partnerships

Several partnerships have been developed for this project. As mentioned previously, MaineDOT works closely with the Maine Department of Labor's Division for the Blind and Visually Impaired, whose mobility specialists assist individuals with visual impairments on how to best use our system. We also rely on individuals from Alpha One, a designated Center for Independent Living, to assess and provide input on ADA improvements. Several of the communities chosen for this project came out of needs based discussions with them.

MaineDOT is also partnering with municipalities involved in the project. Although previously MaineDOT required municipalities to maintain and operate traffic signals, MaineDOT will now partner with municipalities and co-maintain them. MaineDOT will be responsible for controller and detection based issues. There are also partnerships between neighboring municipalities as some signals are on corridors that cross municipal lines, so keeping corridor signalization well maintained helps in mutual response for fire and safety.

Additionally, MaineDOT is also partnering with municipalities in ongoing traffic signal training. MaineDOT is offering training at least twice per year regarding signal operations, including a 1-day session of hands on traffic controller/cabinet training. In addition to MaineDOT helping establish a certification program with Maine Community Colleges, MaineDOT is also developing a curriculum to develop Traffic Control Electricians (in Maine, that is a Limited Use Electrical License).

As mentioned in the innovation section, MaineDOT has begun discussions with several trucking firms in the area regarding V2V and V2I technology using DSRC. We have invited these stakeholders to attend some informational sessions to learn more about DSRC and Autonomous and Connected Vehicles.

V. Project Readiness

The MaineDOT Traffic Safety and Mobility Improvements – Phase 1 Project is ready to be developed. The project schedule below shows that construction is planned to begin in 2020.

Technical Feasibility

MaineDOT will be developing an RFP to procure consultant services in early October. The consultant will be ready to start design as soon as the agreement is signed with FHWA. The consultant will be responsible for complete design of the 102 signalized intersections. The consultant will be responsible for performing needed systems engineering, specification development for any project items, review of all the sites, develop plans for all ADA improvements needed for all current crosswalks, add Accessible Pedestrian Signals where necessary, ensure all work takes place within the current right-of-way, as well as work with project communities and any trucking firms to partner on the DSRC.

Project Schedule

RFP for Consultant Services	10/15/18
Consultant under Contract	12/1/18
Project Kick-off	1/15/19
Preliminary Plans	9/15/19
Final Plans	3/1/20
NEPA	3/1/20
PS&E	5/1/20
ADV	6/1/20
Construction Begin	7/15/20
Construction Complete	10/15/21

Required Approvals

NEPA will be required on this project and will be done as a Categorical Exclusion. We do not anticipate any other permit issues, wetlands impacts or historic issues.

MaineDOT has already met with half of the communities to discuss the project. They are all in support of the project and what MaineDOT is proposing to do. MaineDOT has also had preliminary discussions with several trucking firms for DSRC connections for V2I.

MaineDOT plans to include this project the department's annual Work Plan as well as the State Transportation Improvement Program (STIP).

Project Risks and Mitigation

The Project will be located within the current right-of-way, and as noted previously, it is not anticipated that this Project will encounter any permitting issues or issues in obtaining the required approvals.

Benefit-Cost Analysis (BCA)

The MaineDOT Traffic Safety and Mobility Improvements – Phase 1 Project offers a range of benefits as described in the Merit Criteria sections. The BCA for this project focuses on a comparison of the quantified safety and mobility benefits to the associated costs of implementation. The annual (2017 base year) safety and mobility benefits presented in Tables 2 and 5, respectively, under Merit Criteria were projected into the future through the 20-year life of the project. Also projected into the future were the added operations and maintenance (O & M) costs to maintain vehicle detection and update traffic signal timing. In the BCA these O & M costs were treated as annual costs subtracted from the annual safety and mobility benefits. The combined benefits in each year were converted to a present worth for comparison with the cost to design and construct the project. This comparison produced a net present worth and a benefit/cost ratio for the project.

Several assumptions were made in the BCA:

- The project would have a 20-year life, with benefits accruing in the years 2021 through 2040.
- Overall traffic volumes at the intersections would increase at an annual straight-line rate of 0.5% per year between 2017 and 2040. This would mean that 2040 volumes would be 11.5% higher than 2017 volumes. This growth rate originated from the MaineDOT Statewide Travel Demand Model forecast of vehicle-miles traveled (2010 to 2040).
- Growth in safety and mobility benefits would parallel the growth in traffic volumes at 0.5% per year. The added O & M costs ($2000 per intersection per year) would remain constant.

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- All benefits and costs would be expressed in 2017 dollars.
- Future benefits would be discounted at 7% per year between 2017 and 2040. No salvage value would be anticipated in 2040.

Table 6 summarizes the results of the BCA. The annual combined benefits in 2017 (less the added O & M costs) would be close to $7 million. The present worth of these combined benefits over the period from 2021 through 2040 would be over $62 million, compared to a project cost of approximately $16.5 million. The benefit/cost ratio of the project is estimated to be 3.78.

Table 6. Summary of MaineDOT Benefit-Cost Analysis

Annual Safety Benefits (from Table 2)	$ 2,791,393
Annual Mobility Benefits (from Table 5)	$ 4,219,016
O & M Costs (detection & timing)	$ (204,000)
Annual Combined Benefits	$ 6,806,409
Present Worth of Combined Benefits	$ 62,291,208
Project Cost	$ 16,482,200
Net Present Worth	$ 45,809,008
Benefit/Cost Ratio	3.78

Appendix

Benefit-Cost Analysis Worksheet	A
Letters of Support	B
Match Commitment Letter	C
Federal Wage Rate Certification	D

For additional information, please visit: http://www.maine.gov/mdot/grants

Definitions

Accessible Pedestrian Signals (APS) are devices that communicate information about the WALK and DONT WALK intervals at signalized intersections in non-visual formats (usually audible) to pedestrians who are blind or who have low vision.

Adaptive Traffic Signal Control (ATSC) is a traffic management strategy in which traffic signal timing changes, or adapts, based on actual traffic demand. This is accomplished using an adaptive traffic control system consisting of both hardware and software.

Automated Vehicle is a vehicle that is capable of sensing the surrounding environment and navigating without human input. There are six levels of automation ranging from humans having total command to a fully automated vehicle.

Automated Traffic Signal Performance Measures (ATSPM) is the use of high resolution, current data to proactively manage traffic signals. It allows targeted maintenance, improved operations and increased safety.

Connected Vehicle is a vehicle that is capable of communicating with infrastructure, other vehicles, the cloud, pedestrians or all of the above. The ability to communicate and make corrections will help toward establishing more efficient flow and improved safety.

Dedicated Short Range Communications (DSRC) are one-way or two-way short-range to medium-range wireless communication channels specifically designed for use by the automotive industry for use with autonomous and connected vehicles. DSRC needs to be administered by a set of protocols and standards.

Highway Safety Manual (HSM) is a resource for information on quantifying and evaluating highway safety performance. It uses a predictive method for estimating expected average crash frequency and Crash Modification Factors to quantify the change in average crash frequency.

Infrared Traffic Signal Cameras are cameras that use the infrared wavelengths (heat signatures) emitted by vehicles, pedestrians and motorcycles to detect those entities as they approach traffic signals. Newer versions of these cameras can communicate directly to autonomous/connected vehicles.

Recall is a call that is placed for a specified phase each time the controller is servicing a conflicting phase. This will ensure that the specified phase will be serviced again. Types of recall include soft, minimum, maximum, and pedestrian.

Retroreflective Back-plate is a louvered panel that fits around the outside of a traffic signal used to properly shield a traffic signal from background obstructions such as ambient lights, signs, sunlight and other environmental conditions that tend to reduce the brilliance of the traffic signal light indications. A three (3) inch reflective strip is place around the border to enhance conspicuity.

Vehicle-to-infrastructure (**V2I**) is a communication model that allows vehicles to share information with the components that support a country's highway system. Such components include overhead RFID readers and cameras, traffic lights, lane markers, streetlights, signage and parking meters.

Vehicle-to-vehicle communication (V2V communication) is the wireless transmission of data between motor vehicles. The goal of V2V communication is to prevent accidents by allowing vehicles in transit to send position and speed data to one another via a local area network.

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