Quick Response: New England Connected Automated Vehicles

FINAL REPORT

Chris Chaffee, PE, PTOE, PI
Suzanne Murtha, Co-PI

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The following are the members of the Technical Committee that developed the scope of work for the project and provided technical oversight throughout the course of the research:

Dr. Emily Parkany, Vermont Agency of Transportation, Chairperson

Kara Aguilar, Maine Department of Transportation

Peter Calcaterra, Connecticut Department of Transportation

Julia Gold, Rhode Island Department of Transportation

Susan Klasen, New Hampshire Department of Transportation

Kody McCarthy, New Hampshire Department of Transportation

Joe Segale, Vermont Agency of Transportation

Daniel Sullivan, Massachusetts Department of Transportation

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16. Abstract

Regional coordination in anticipation of the widespread use of CVs/AVs will better educate New England's population, influence policy, reduce costs, and provide safer and more efficient roadways for the traveling public. This document provides considerations for identified cross-border issues and a roadmap for implementing regional initiatives. It is recommended that these elements be reevaluated periodically as technology, the political climate, and state agencies evolve.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

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List of Acronyms

4G	4th Generation (Wireless Systems)
5G	5th Generation (Wireless Systems)
6G	6th Generation (Wireless Systems)
AAA	American Automobile Association
AADT	Annual Average Daily Traffic
AAMVA	American Association of Motor Vehicle Administrators
AID	Accelerating Innovation Deployment (Grant)
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ATCMTD	Advanced Transportation & Congestion Management Technologies Deployment
AV	Automated Vehicle
BSM	Basic Safety Message
BUILD	Better Utilizing Investments to Leverage Development
CMAQ	Congestion Mitigation and Air Quality
ConOps	Concept of Operations
CTDOT	Connecticut Department of Transportation
CV	Connected Vehicle
CVPFS	Connected Vehicle Pooled Fund Study
DMV	Department of Motor Vehicles
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
EV	Electrical Vehicle
FAST	Fixing America's Surface Transportation (Act)
FirstNet	First Responder Network Authority
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FTA	Federal Transit Authority
GHSA	Governor's Highway Safety Association
HOC	Highway Operations Center
HSIP	Highway Safety Improvement Program
INFRA	Infrastructure for Rebuilding America (Grant)
ITD	Innovative Technology Deployment (Grant)
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
LoNo	Low or No Emission (Program)

List of Acronyms (Cont.)

MaineDOT	Maine Department of Transportation
MassDOT	Massachusetts Department of Transportation
MMUCC	Model Minimum Uniform Crash Criteria
MOU	Memorandum of Understanding
NCHRP	National Cooperative Highway Research Program
NETC	New England Transportation Consortium
NHDOT	New Hampshire Department of Transportation
NHPP	National Highway Performance Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PI	Principal Investigator
QPL	Qualified Products List
RFI	Request for Information
RIDOT	Rhode Island Department of Transportation
ROI	Return on Investment
RSU	Road Side Unit
SAE	Society of Automotive Engineers
SOP	Standard Operating Procedure
SP&R	State Planning and Research
STBG	Surface Transportation Block Grant
TAC	Technical Advisory Committee
TMC	Transportation Management Center
TRIP	Transportation Innovation Partnership
TSMO	Transportation Systems Management and Operations
USDOT	United States Department of Transpiration
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VTrans	Vermont Agency of Transportation

Executive Summary

In New England, policies, legislation, and technical issues regarding Connected Vehicles (CVs) and Automated Vehicles (AVs) will extend beyond state lines. This document provides considerations for identified cross-border issues and a roadmap for implementing regional initiatives. Much of this document represents a snapshot in time and it is recommended that these elements be reevaluated periodically as technology, the political climate, and state agencies evolve.

New England Status

Each New England state has already begun taking action to advance CV/AV deployments. These actions include forming external and internal committees and task forces, passing legislation, as well as planning and piloting emerging transportation technologies. Sharing of details from these individual state actions will benefit the whole region in avoiding double efforts and navigating known hurdles to implementation.

Cross-Border Issues, Challenges, and Opportunities

Existing studies and regional collaborative CV/AV efforts from around the country were reviewed to provide a baseline understanding of the research and work already accomplished to date, which helped to generate cross-border issues and determine best practices for New England.

A stakeholder workshop involving representatives from state, regional and national transportation agencies and organizations, as well as research institutions, was held to discuss challenges, opportunities, and the cross-border issues identified. Cross-border issues are summarized in the following categories:

1. *Legal and Regulatory* – includes continuity of insurance, registration, licensing policies across state lines. They also include regulations related to crash investigations, freight travel, and pilot testing of emerging technologies.
2. *Infrastructure* - includes existing and future communication networks in the region, deployment of roadside units, and the standardization of CV/AV infrastructure (basic safety messages, communication type, etc.) across state lines. Cross-border issues related to
3. *Operations* - includes the role of operations centers in the face of CV/AV testing and deployments, operations between state lines during adverse weather events and incidents, and facilitating international border crossings.
4. *Data and Technology* - includes data type and gathering mechanisms the region needed to consider, as well as ensuring network resilience and protection against cyberattacks.

The workshop concluded with a discussion regarding how the region can capitalize on the opportunities and minimize the challenges ahead. Challenges include coordination between the six states, executive buy-in, lack of mid-level understanding, and public anxiety towards emerging

technologies. Challenges were met with opportunities that are linked to the proposed regional initiatives workflow.

Roadmap of Actions

The culmination of this report is the regional roadmap of actions, presented in the initiatives workflow and timeline below. Initiatives are presented in the following five categories. The letter codes are referenced in the figure and throughout the document.

- M — Mission, Goals and Objectives
- L — Legal and Regulatory
- P — Technical Projects
- R — Emergency Response
- E — Public and Staff Education

The complete workflow and timeline is not final, but serves as a detailed framework for how and where New England states can collaborate on issues that are best addressed as a region. The first step in this process is developing a regional mission, goals, and objectives, which will fuel all future initiatives.

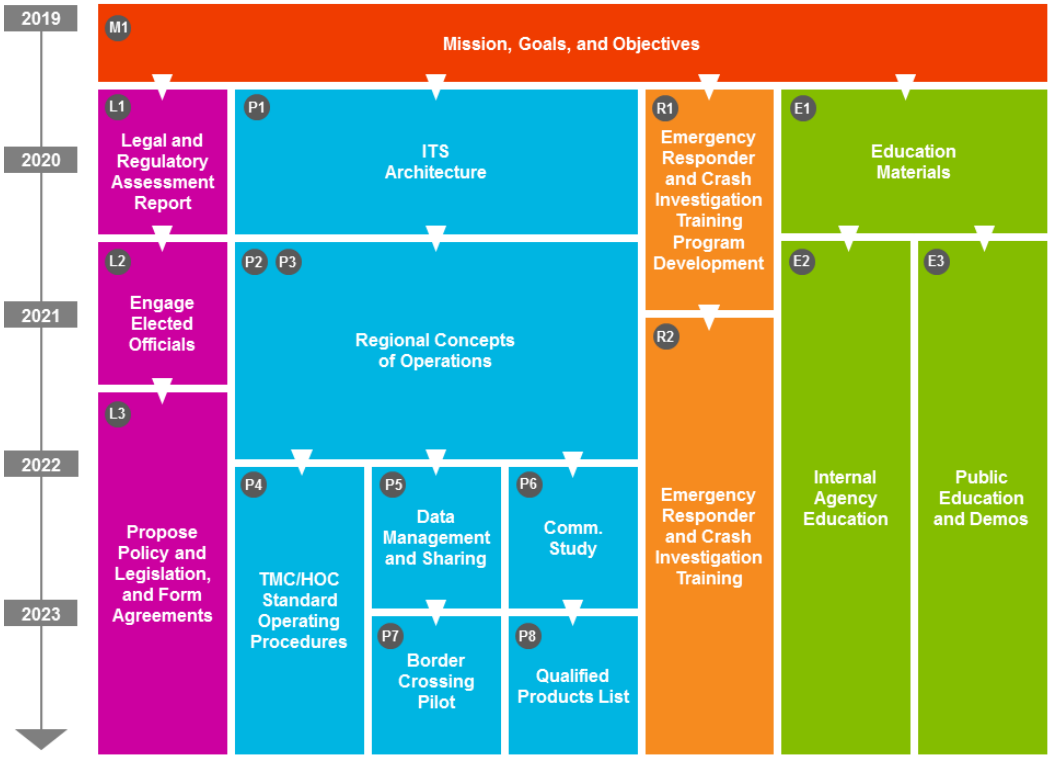


Figure: Regional Initiatives Workflow and Timeline

Regional coordination in anticipation of the widespread use of CVs/AVs will better educate New England's population, influence policy, reduce costs, and provide safer roadways for the traveling public.

1. Introduction

1.1 Research Purpose

Each of the six (6) New England states is working to advance policies, legislation, and technical issues regarding Connected Vehicles (CVs) and Automated Vehicles (AVs). There is minimal information on the types of CV/AV issues that extend beyond state lines and how states could collaborate to reduce risk, minimize challenges, and capitalize on opportunities. The purpose of this research, funded by the New England Transportation Consortium (NETC), is to determine considerations for cross-border and collaborative challenges, and to develop a roadmap of actions for the states to conduct to facilitate the operation of CVs and AVs in the region.

1.2 Research Team

The research was led by a team of Principal Investigators (PIs) from AECOM based on input from NETC's Technical Advisory Committee (TAC). AECOM is a national and international leader in planning, designing, and deploying CV and AV technologies. The following team of PI subject matter experts authored and contributed to this report:

Chris Chaffee, P.E., PTOE – Project Manager: AECOM's Lead for ITS in New England. Chris was responsible for project management tasks, coordinating the PI team, and is the primary author for this document.

Suzanne Murtha – Technical Lead: AECOM's Lead for Connected and Automated Technologies. Suzanne was responsible for directing strategic research efforts and providing national insights.

Yousef Alsharif – Investigator: Under the direction of Chris and Suzanne, Yousef conducted research of national and international best practices for this document.

Daniel Corey – Reviewer: AECOM's Deputy Practice Leader for Intelligent Transportation Systems (ITS). As a CV/AV expert, Dan was responsible for reviewing each project deliverable for quality and technical accuracy.

The following TAC members, representing all six New England states, provided direction, input, and recommendations for this report:

Kara Aguilar – Assistant Engineer: Maine Department of Transportation (MaineDOT)

Peter Calcaterra – Transportation Planner: Connecticut Department of Transportation (CTDOT)

Julia Gold – Chief of Sustainability, AVs, and Innovation: Rhode Island Department of Transportation (RIDOT)

Susan Klasen, P.E. – TSMO Bureau Administrator: New Hampshire Department of Transportation (NHDOT)

Kody McCarthy – Program Specialist: NHDOT

Dr. Emily Parkany, P.E. – Research Manager: Vermont Agency of Transportation (VTrans)

Joe Segale, P.E. – Policy, Planning and Research Bureau Director: VTrans

Daniel Sullivan – Policy Analyst: Massachusetts Department of Transportation (MassDOT)

1.3 Key Terminology and Levels of Automation

As part of the Connected Vehicle Pooled Fund Study (CVPFS), the University of Virginia published a 23-page glossary of CV/AV terms.[1] The New England region would benefit from using these terms for internal dialog as well as educational materials. Key terms include:

Connected Vehicle (CV) – a vehicle (car, truck, bus, etc.) that is equipped with a wireless communication device. A CV uses any of the available wireless communication technologies to communicate with other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and other travelers and the cloud

Vehicle to Vehicle (V2V) Communication – a communication that promotes the exchange of information between vehicles

Vehicle to Infrastructure (V2I) Communication – a communication that promotes the exchange of information between the vehicles and the infrastructure

Vehicle to Many (V2X) Communication – a communication that promotes the exchange of information between the vehicles and various counterparts including other means of transport, the infrastructure, traffic management centers and various Internet applications

Connected Vehicle Applications – applications that are built to take advantage of a connected vehicle environment prepared and provided at the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) website.

Dedicated Short Range Communication (DSRC) – a communications protocol developed to address the safety critical issues associated with sending and receiving data among vehicles and between moving vehicles and fixed roadside access points. These provide low-latency data-only V2V and V2I communications for use in connected vehicle applications such as Electronic Fee Collection, crash avoidance, In-Vehicle Signing and Cooperative Adaptive Cruise Control.

The Society of Automotive Engineers (SAE) published the Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems in 2016.[2] Soon after, SAE published a two-page synopsis of the previous report, including a summary table of the levels of automation (see Figure 1).

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
Human driver **monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system **("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 1: Society of Automotive Engineers Levels of Automation

1.4 Federal Legislation

Federal legislation regarding AVs is still pending, a year after the SELF DRIVE Act[3] passed unanimously in the U.S. House of Representatives in September 2017. The later Senate version, AV START Act[4] is has a lot in common with the SELF DRIVE Act, but is facing opposition following the fatal crashes involving AV testing in early 2018. Opponents seek stringent testing measures and an elimination of the ban on state regulation of AV systems in the absence of Federal rules.

The major differences between the House and Senate Bills include:[5]

- Senate bill prohibits states from issuing AV operating licenses that discriminate on the basis of disability.
- House bill encourages voluntary safety reporting whereas the senate bill requires manufacturers submit a safety evaluation report within 90 days of enactment to the U.S. Department of Transportation (USDOT). Manufacturers may opt out if they're only testing AVs.
- Senate bill has a more aggressive timeline in relation to updating federal motor vehicle standards. It tasks the Volpe Center in Massachusetts with reviewing federal vehicle

regulations that may be creating unintentional barriers for AVs within 180 days of enactment. Within 90 days of receiving the Volpe report, USDOT must commence a rulemaking to update any relevant safety standards. If USDOT does not complete the rulemaking within one year after receiving the Volpe report, its recommendations effectively turn into federal regulation. The house bill tasks USDOT directly with conducting a review of federal motor vehicle standards but with a slower and nuanced timeline.

- In relation to cybersecurity of AV systems, the house bill is more explicit and requires manufacturers to develop a written plan within 180 days of enactment or they won't be able to sell or introduce into commerce any AVs (does not include pilot vehicles). The senate bill is more lenient in its requirement of manufacturers to develop, maintain and execute a cyber security plan providing manufacturers 18 months to prepare one, but is broader and could include pilot vehicles.
- Both bills increase the number of exemptions to certain federal vehicle safety regulations that USDOT can issue to100, 000 over 4 years, but the senate bill raises the exemption caps faster than the House bill.
- Senate bill permits AV manufacturers to making inoperative any required safety devices in a vehicle while the automated driving system is performing the dynamic driving task. This is not mentioned in the house bill.
- Senate bill does not require privacy and data protection plans

The SELF DRIVE Act established the federal role, via the National Highway Traffic Safety Administration (NHTSA), of ensuring the safety of AVs as it relates to design, construction, and performance, while States kept their authority over vehicle registration and licensing. NHTSA and the USDOT issued the Federal Automated Vehicle Policy in 2016 that set a proactive approach to providing safety assurance and facilitating innovation. In 2017, following the passage of the SELF DRIVE Act, feedback received through public comments and Congressional hearings, NHTSA released A Vision for Safety 2.0.[6] The document provides voluntary guidance for the development of AVs and outlines best practices for state legislatures. It explains that the federal government does not want to impede progress with unnecessary or unintended barriers to innovation and encourages consistency of state laws and policies to promote innovation and the swift integration of AV technologies across the country. The differences in federal and state responsibilities are shown in Table 1. Given the fast paced evolution of AV technologies, NHTSA's guidance was intentionally flexible and meant to grow alongside technology.

Table 1: SELF DRIVE Act Outline of Federal and State Responsibilities

NHTSA's Federal Responsibilities	States' Responsibilities
Setting Federal Motor Vehicle Safety Standards (FMVSS) for new motor vehicles and motor vehicle equipment (manufacturers must certify compliance before selling vehicles)	Licensing drivers and registering motor vehicles in their jurisdictions

NHTSA's Federal Responsibilities	States' Responsibilities
Enforcing compliance with FMVSS	Enacting and enforcing traffic laws and regulations
Investigating and managing the recall and remedy of non-compliances and safety related motor vehicle defects nationwide	Conducting safety inspections, where States choose to do so
Communicating with and educating the public about motor vehicle safety issues	Regulating motor vehicle insurance and liability

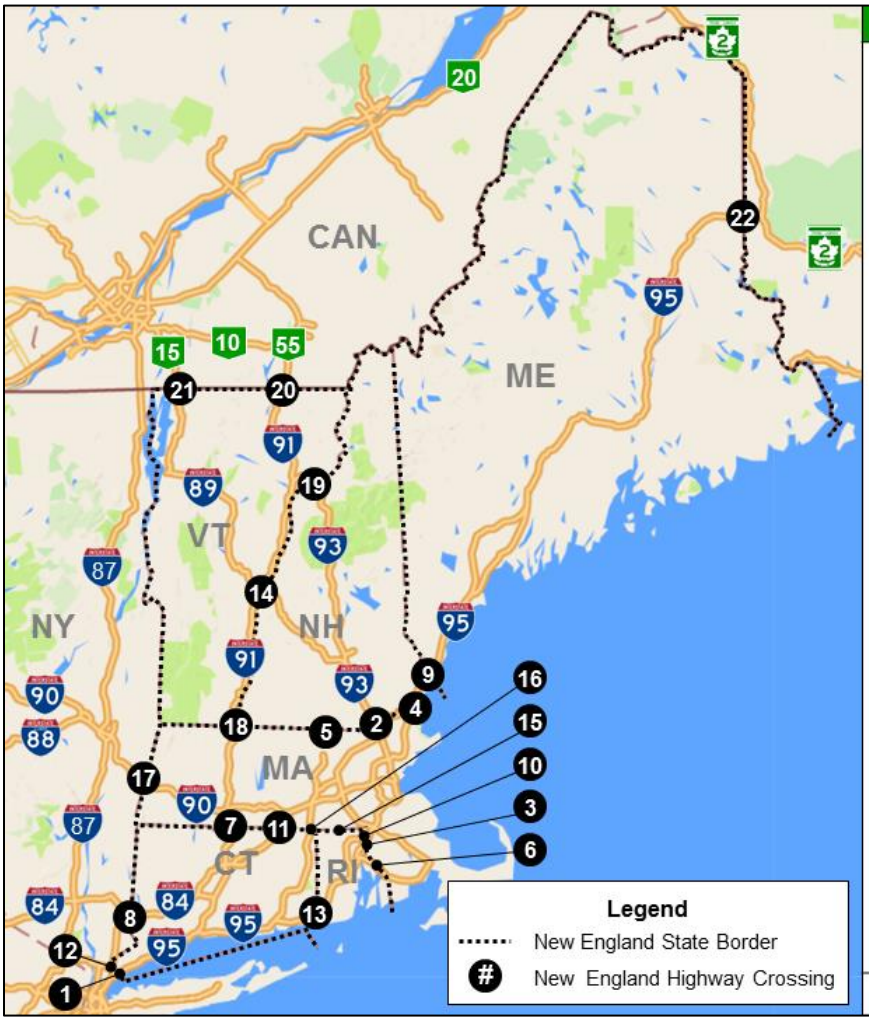
In October 2018, USDOT published a 3rd update to its voluntary guidance, titled Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.0),[7] which expands the scope of the previous version. The document provides new multi-modal safety guidance including commercial vehicles and on-road transit, and outlined a process of working with USDOT as automation technology evolves. USDOT invited public comments on AV 3.0 and other forthcoming announcements; including NHTSA setting exceptions to certain safety standards (relevant when a human driver is present) for AVs, streamlining and modernizing NHTSA's processing of exemptions, as well as changes in commercial vehicle safety regulations from the Federal Motor Carrier Safety Administration (FMCSA) that will no longer assume a commercial vehicle's driver is always a human or that a human is necessarily present onboard.

USDOT published AV 3.0 in hopes of starting a national discussion, involving various operating administrations and stakeholders, about the future of automated mobility in the country amidst weak public confidence in emerging technologies.

2. New England Status

Within the New England region, there are 22 limited-access highways that cross state borders. Due to the relatively small geographic size of its states and numerous population centers, the region experiences a cross-border Annual Average Daily Traffic (AADT) of over one million vehicles at these locations (see Figure 2).[8 9 10] In addition to interstate highways, there are dozens of state and municipally owned roadways that cross state borders including 25 non-interstate National Highway System (NHS) highways (full NHS list and volumes located in Appendix A). Regional coordination will help facilitate the smooth and safe movement of CVs/AVs across these roadways.

Regional freight flow maps for the six states are shown in Appendix B. Electric Vehicle (EV) charging station location maps within each New England state are shown in Appendix C. Each of these may prove to be useful for identifying areas for regional collaboration.



Number	Roadway	Crossing	AADT
1	I-95	CT - NY	125,900
2	I-93	MA - NH	107,320
3	I-95	MA - RI	98,341
4	I-95	MA - NH	97,907
5	Rt. 3	MA - NH	91,555
6	I-195	MA - RI	83,646
7	I-91	CT - MA	78,357
8	I-84	CT - NY	72,300
9	I-95	ME - NH	71,788
10	I-295	MA - RI	59,555
11	I-84	CT - MA	57,908
12	Rt. 15	CT - NY	46,882
13	I-95	CT - RI	44,400
14	I-89	NH - VT	40,700
15	Rt. 146	MA - RI	33,480
16	I-395	CT - MA	24,157
17	I-90	MA - NY	24,012
18	I-91	MA - VT	14,946
19	I-93	NH - VT	6,663
20	I-91	VT - CAN	2,700
21	I-89	VT - CAN	2,500
22	I-95	ME - CAN	1,749
	Total		1,186,766

Figure 2: Limited-Access Highway AADT at State Border Crossings

Each New England state has already begun taking action to advance CV/AV deployments. These actions include forming committees, passing legislations, as well as planning and piloting emerging

transportation technologies. Each New England state is following a different approach in planning for CV/AV technologies. These intentional differences all lead to the common goal of ensuring the safe and meaningful adoption of these technologies in the region.

2.1 Connecticut

In June 2017, Connecticut passed a law that established a pilot program allowing manufacturers and fleet service providers to test AVs in up to four (4) municipalities. The law outlines the requirements for testing and requires participating municipalities to enter into agreements with AV testers. The law establishes a 15-member task force to study AVs and develop legislative recommendations for regulating AVs. The task force will also evaluate the pilot program established under the law. The task force consists of six (6) legislative appointees, three (3) legislative transportation committee appointees, two (2) governor appointees (one with insurance expertise), and four (4) ex-officio members representing the Department of Motor Vehicles (DMV), CTDOT, state police, and the Office of Policy and Management.[11] The task force convened for the first time in June 2018. In addition to the inter-agency taskforce, CTDOT formed an internal working group to build their knowledge base and expertise in CV/AV related issues.

CTDOT is developing a Traffic Signal Management Plan to be complete in 2019 and a Strategic Plan for Implementing CVs/AVs in Connecticut, which will be used to highlight the current status of CV/AV technologies and their high-level impacts, and justify next step strategies, investments and partnerships. The plan outlines CV/AV interests and needs by bureau/office, identifies Connecticut's mission, vision, goals and objectives, presents an internal organizational structure for the implementation of CV/AV in the state, and provides an action plan with roles and responsibilities separated into four time frames (immediate, near term, mid-term and long term). The plan is scheduled to be published in fall 2018. CTDOT is also looking to update their existing Statewide ITS Architecture to include CV/AV applications. They've programmed approximately $2.5 million for CV/AV projects in the Capital Program for 2019 (pending approval).

CTDOT has submitted an FHWA Advanced Transportation & Congestion Management Technologies (ATCMTD) grant application to test and deploy AV micro-shuttles at the University of Connecticut and the city of Stamford. They're also exploring additional opportunities for AV micro-shuttle testing and CV pilot projects, including participation in AASHTO's Signal Phasing and Timing (SPaT) Challenge for the deployment of DSRC V2I devices, harnessing the safety benefits of CV technologies.[12] On the research side, the Department is a participant in the CVPFS and is exploring a potential partnership with the University of Connecticut to address a variety of CV/AV interests and needs. They have also hosted two Northeastern Summits on CVs/AVs, encouraging regional knowledge transfer and sharing of best practices.

2.2 Maine

In January 2018, Maine signed an Executive Order that established an Advisory Committee for the purposes of overseeing the beneficial introduction of AV technologies, as well as assessing, developing, and implementing recommendations regarding potential pilot projects initiated to advance these technologies. The 11-to-15-member committee consists of state-level public agency staff, and other interested public and private sector entities and individuals, including members of the legislature and the public, each appointed by the Commissioner of Transportation.[13]

In April 2018, a law was passed that establishes the former Advisory Committee as the Commission on Autonomous Vehicles to coordinate efforts among state agencies and knowledgeable stakeholders to inform the development of an AV pilot program that allows for the testing of AVs on public ways. In addition to the members previously listed, the law recommends three (3) additional commission members; one with expertise in AV technologies, one representing a nonprofit transit provider, and one representing the motor carrier industry, to be appointed by the Commissioner of Transportation. The law tasks MaineDOT, in consultation with the Commission, with establishing the AV pilot testing program and grants it the power to prohibit any AV testing that fails to comply with its requirements.[14] The Commission is currently working with the City of Portland and INRIX, a tech company that's piloting its AV Road Rules platform in the city, in mapping critical corridors.

2.3 Massachusetts

In October 2016, Massachusetts signed an Executive Order that established the Autonomous Vehicle Working Group which works with experts on vehicle safety and automation, members of the legislature on proposed legislation, and supports Memorandum of Understanding (MOU) agreements that AV companies enter with MassDOT, municipalities, and state agencies.[15] The 11-member group consists of seven (7) public agency staff at the state level and four (4) legislative designees (two legislators and two civilians). All meetings of the AV Working Group are open to the public. The Executive Order also tasked MassDOT with obtaining input from the AV Working Group and other technical experts on the development of guidance for AV pilot testing on public ways. The Order enabled pilot testing of AVs to commence on public ways, starting in the streets of Boston.

In June 2018, the Governor entered into a MOU with the mayors of 13 cities and towns in addition to the Department of Conservation and Recreation, expanding and refining the initial testing framework created by the 2016 Executive Order. The agreement offers a uniform and streamlined process for interested companies seeking to test their self-driving technologies on public ways and Commonwealth-owned parkways and encourages collaboration with municipalities and local communities in the development of such technologies.[16]

In September 2018, the AV Working Group published a draft report for public discussion, providing a summary of key background information, and several recommendations for advancing the state of the AV industry in the Commonwealth.

Massachusetts has a list of pending legislation relating to the testing and deployment of CV/AV technologies. The bills range from cybersecurity regulations to protect AVs and their users,[17] to AV pilot testing requirements that outline the process of testing,[18] [19] to establishing a transportation technology advisory commission that studies the impacts and consequences of changing technologies.[20] Some pending bills look to restrict AVs, with one bill limiting automated driving capabilities to zero emission EVs.[21] Another pending bill prohibits AVs from transporting interstate commerce or transporting eight or more people unless a human operator is present.[22] The majority of pending bills were delivered to the transportation committee for further study.

In addition to the pilot testing of AVs in the city of Boston,[23] MassDOT is planning to participate in AASHTO's SPaT Challenge by equipping traffic signals along Route 9 from Worcester to Wellesley with DSRC V2I devices as well as collecting and using signal performance measures to help improve service at signalized intersections.

2.4 New Hampshire

In March 2018, New Hampshire rejected a bill that prohibited operating AVs on public ways.[24] In May 2018, the Senate voted and passed a bill that established a CV/AV Testing and Deployment Commission and an AV pilot testing program.[25] In July, the bill was vetoed by the Governor citing public safety concerns.[26] When defining AVs, the bill only addressed vehicles with SAE level 5 automation technologies and would have granted vehicles with SAE levels 3 or 4 technologies permission to test on public ways without participating in the AV pilot testing program, obtaining a license or even notifying the state. The Governor encouraged lawmakers to address this issue and work on passing a similar bill next session (January 2019).

The 11-member commission that would have been established by the Senate bill consisted of seven (7) public agency staff at the state level and four (4) legislative designees (three from the House and one from the Senate). The commission would have worked on preparing the state for the use of AV technologies on public roadways by following legislative developments at the state and federal levels, engaging stakeholders, attracting CV/AV manufacturing to the state, engaging residents, and reviewing existing state statutes and rules that impede the testing and deployment of CV/AV technologies.

NHDOT is participating in AASHTO's SPaT Challenge at three intersections on Silver Street in Dover. The project includes 360˚ cameras and a fiber-based network interconnect.

2.5 Rhode Island

RIDOT published a request for information (RFI)[27] in June 2017 seeking advice and suggestions on how to develop a framework for implementation and integration of connected and automated vehicles and other innovative transport system technologies. The RFI requested information related to possible public-private partnerships, the impact on the state's long-range capital planning process, regional safety programs, environmental impacts, identification of law or regulation gaps, workforce impacts, and professional training needs.

In April 2018, Rhode Island's Transportation Innovation Partnership (TRIP) introduced the Mobility Challenge, a pilot program that aims to leverage highly automated vehicles, easy-access mobility platforms, and other emerging technologies to position the state at the forefront of mobility testing. The pilot test, in conjunction with Rhode Island Public Transportation Authority, will fill a transportation gap in the City of Providence.[28] This is led by RIDOT's Policy and Innovation Team, a six-member internal task force representing different RIDOT departments. The request for proposals closed July 2018.[29]

2.6 Vermont

Vermont passed a law requiring VTrans to convene a meeting of stakeholders with expertise on a range of topics related to AVs.[30] The Secretary of Transportation reported to the House and Senate committees on transportation regarding the meeting and provided recommendations related to AVs, including proposed legislation. The recommendations included a permit process that encourages the testing of AVs on Vermont's public roads, a review of state statutes that create barriers to the safe and responsible deployment of AVs that have passed road tests and satisfy the FMVSS and other federal regulations, and the creation of an internal multi-disciplinary working group to develop AV testing and deployment legislation. The final recommendation was for VTrans to continue monitoring and assessing the longer-term implications of AVs by coordinating with other state agencies, stakeholders, neighboring states, and national organizations.[31]

An internal working group representing VTrans, the DMV, and the Department of Public Safety are drafting legislation for the testing of AVs in the state, using guidance from the American Association of Motor Vehicle Administrators (AAMVA).

2.7 Summary

Table 2 summarizes New England's current efforts and accomplishments in regards to CVs/AVs. The more our states within the region look and sound the same in various areas, including state legislation for testing and deploying AVs, the better we will be positioned as a region to attract and conduct safe and effective testing and deployment of CVs/AVs.

Table 2: Summary of New England States' CV/AV Status

CV/AV Item	Status	CT	ME	MA	NH	RI	VT
Have AV Committee or Task Force	Pending				●		
	Established	●	●	●		●	●
Have CV/AV Legislation or Executive Action	Pending Legislation			●	●		
	Passed Legislation	●	●				●
	Executive Action		●	●		●	
CV Pilot Testing or Deployment	Planning	●		●			●
	Underway				●		
AV Pilot Testing	Planning	●				●	
	Underway			●			

3. Relevant Studies and Reports

Existing studies provide a baseline understanding of the research and work already accomplished to-date. The goal of this research is not to duplicate any studies already completed, but to extract relevant information for New England. Additional relevant studies and reports are listed in Appendix D.

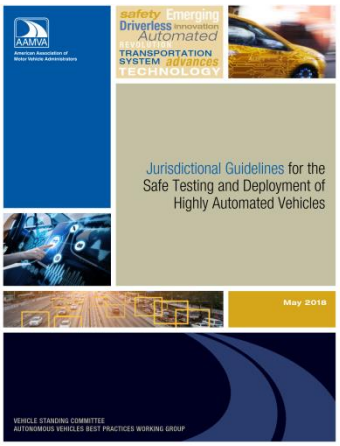
3.1 I-95 Corridor Coalition: Connected and Automated Vehicles Workshop Summary Report

The summary report was developed after a two-day workshop that gathered representatives from 15 state transportation agencies and other transportation agencies spanning the I-95 corridor. The report provided an update on CV/AV related activities in the states of Virginia, Florida, Maryland and Connecticut; it compiled a list of challenges and potential solutions affecting CV/AV testing and deployment; and it defined a set of implementation steps that agencies could take to facilitate CV/AV development in their states.[32]

The main lessons learned from states' experiences were that CVs/AVs must be factored into long-range planning and included in planning documents, even with large amounts of uncertainty and lack of political support or funding. Acknowledging the fast-paced development of technology and the need for continuous engagement and robust collaboration with stakeholders will be crucial for successful initiatives.

Barriers to CV/AV implementation included public mistrust, institutional factors, funding, law enforcement, as well as operator and vehicle licensing. The report includes a list of regional priorities the I-95 Corridor Coalition needs to work on collaboratively, including creating a regional working group to keep members informed and up to date, developing a CV/AV academy to train agency staff, determining CV/AV data formats and standards to promote consistency and interoperability across states, and pursuing regional funding opportunities.

3.2 AAMVA: Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles



The American Association of Motor Vehicle Administrators (AAMVA) report is the culmination of a three-year effort by their AV working group that aims to facilitate a uniform regulatory framework that balances current public safety with the advancement of vehicle innovations, avoiding unnecessary hurdles in the path of vehicle and technology manufacturers. It addresses the impacts of AVs on vehicle registration and titling programs; driver training, testing and licensing programs; enforcement of traffic laws; and emergency response to

traffic related incidents. Its recommendations target motor vehicle administrators, law enforcement, manufacturers and other entities for the safe testing and deployment of AVs.[33]

The guideline covers a wide range of considerations and recommendations. At the administrative level, it recommends establishing an AV taskforce and identifying a lead agency to manage testing and review existing laws and regulations that may hinder the development of AVs.

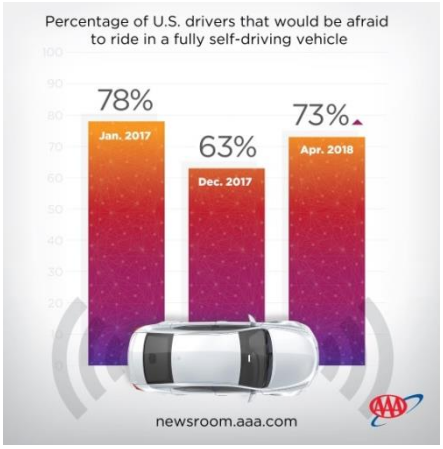
For vehicle credentialing, the study recommends uniform language on registrations to identify AVs and vehicle-specific testing permits. It discusses issues related to titling and branding of new and aftermarket AVs, AV specific license plates, and minimum financial responsibility requirements for insurance and liability.

For driver licensing, it recommends defining driver and passenger roles, preferably following SAE's international definitions (see Section 1.3). It then discusses licensing requirements for test drivers and consumers during deployment. It recommends standardized updates to driver education and testing to include AV technologies and limits the use of AV technologies during driver skills testing, allowing safety critical technologies only (e.g. emergency braking assist) and disengaging convenience technologies (e.g. parking assist).

At the law enforcement level, the guideline delves into the misuse of AVs in criminal and terrorist activities and presents ways to mitigate related risks. It provides recommendations for crash and incident reporting, prioritizing first responder safety when addressing incidents and encouraging manufacturers to develop standardized first responder training on safely interacting with vehicles and users in both the testing and deployment phases of AVs.

3.3 American Automobile Association: Vehicle Technology Survey

In 2016, the American Automobile Association (AAA) started surveying American drivers to better understand consumer attitudes toward self-driving vehicles. Surveys happen on an annual basis and ask this main question: Are U.S. drivers comfortable with the idea of riding in a fully self-driving car?



The first survey, conducted in January 2016, showed that 75% of U.S. drivers were afraid to ride in a fully self-driving vehicle.[34] The second survey was conducted in January 2017 and showed that 78% of U.S. drivers were afraid.[35] The third survey was conducted in December 2017 and showed that 63% of drivers would be afraid,[36] and the last survey, conducted in April 2018, showed that 73% of drivers would be afraid to ride in a fully self-driving vehicle.[37]

The April 2018 survey was conducted to see how high-profile incidents involving AV technologies affect consumers. Two weeks before the survey, an Uber self-driving vehicle was involved in a fatal pedestrian crash[38] and a Tesla was involved in a fatal crash while in Autopilot mode.[39] The 10%

decrease in perceived comfort within 3 months is significant but expected given the circumstances. The results immediately after the incidents are still lower than the first survey conducted in 2016, suggesting consumer attitudes may have begun to start accepting these technologies as they're being developed. However, the majority of American drivers still do not feel comfortable riding in fully self-driving vehicles, emphasizing the role of states and the region on public outreach and education.

3.4 USDOT CV Pilot Development Program

Since 2013, the USDOT ITS Joint Program Office's (JPO) application prototyping and assessment has been a focus of federal CV research and development activity. As a result, more than three dozen CV application concepts have been developed. Building upon USDOT's research, the applications developed were tested at three different locations through the CV Pilot Deployment Program. The JPO website CV Pilots Portal contains resources for the pilot sites, CV pilot videos, deployment resources, and fact sheets.[40]

The New York City pilot, aimed at improving safety for travelers and pedestrians in the city, deployed 15 CV applications; these included Red Light Violation Warning, Curve Speed Compliance, Reduced Speed/Work Zone Warning, and Pedestrian in Signalized Crosswalk Warning.[41] The Tampa CV pilot, aimed at transforming the experience of automobile drivers, transit riders, and pedestrians by increasing safety and efficiency of the transportation network, deployed 13 CV applications. These included End of Ramp Deceleration Warning, Wrong-Way Entry Warning, and Probe Data Enabled Traffic Monitoring, among others.[42] The Wyoming DOT pilot, aimed at improving freight and passenger car driver safety along I-80, deployed 5 CV applications.[43] These included Forward Collision Warning, Infrastructure to Vehicle Situational Awareness, Work Zone Warning, and Spot Weather Impact Warning.

New England should consider using the results of these pilot tests when evaluating CV applications for its own use. Based on discussions with NETC's TAC, applications for the region may focus on weather, work zones, difficult roadway geometries, queue protection, and traffic signals.

4. Comparable Collaborative and Regional Efforts

Existing regional CV/AV efforts were reviewed to determine best practices for New England.

4.1 Connected Vehicle Pooled Fund

The CV Pooled Fund is a multi-state financial effort that supports the research, development, and deployment of CV applications. The program provides a means to conduct the work necessary for state and local transportation agencies and infrastructure providers to play a leading role in advancing the CV environment. Studies aim to facilitate the field demonstration and deployment of connected vehicle infrastructure applications, as well as document and share deployment best practices and guidelines.[44] Connecticut is the only pooled fund member from New England, joining the program in 2018. Additional New England transportation agencies have expressed interest and are looking into options for joining as well.

4.2 Smart Belt Coalition

The Smart Belt Coalition is a three (3) state joint effort between state agencies and academic institutions from Pennsylvania, Michigan, and Ohio that have taken the lead in developing and testing of CV/AV technologies, hoping to create the first multi-state autonomous-connected vehicle corridor in the country. The goals of the coalition is to support research, testing, policy, funding pursuits and deployment, as well as share data and provide unique opportunities for private-sector testers. The coalition believes that in order to create a uniform code that will allow driverless cars and connected vehicles to seamlessly cross state borders, a collaborative effort beyond one state and one jurisdiction is needed.[45] The coalition developed a strategic plan that focuses on connected and automated applications in work zones, traffic incident management and commercial freight, enabling truck platooning.[46]

4.3 I-10 Corridor Coalition

The I-10 Coalition is a four (4) state joint effort between the Arizona, California, New Mexico and Texas Departments of Transportation. With a vision to achieve a connected corridor throughout the four (4) states, the coalition will tap the transportation expertise of the states collectively, enabling resource sharing, joint testing, and economies of scale, applying regional best practices to ensure safe and efficient corridor operations. The coalition members are developing technology, standards of practice, and protocols to enable better freight and passenger movement along the corridor, utilizing CV/AV applications such as truck platooning and V2V/V2I communications. The coalition is currently working on producing a Concept of Operations (ConOps) that identifies and implements operations and technology improvements that will lead to their vision for a connected corridor.[47]

4.4 North/West Passage

The North/West Passage is a seven (7) state effort between the Idaho, Minnesota, Montana, North Dakota, South Dakota, Washington, and Wyoming Departments of Transportation.[48] Established as a Transportation Pooled Fund, the group is focused on developing effective methods for sharing, coordinating, and integrating traveler information and operational activities across state and provincial borders. The seven predominantly rural states experience extreme weather conditions, affecting operations on Interstates 90 and 94, disrupting commercial vehicle travel. The Freight Task Force was established to work on alleviating these issues and has explored best-practices and funding opportunities related to truck parking information systems and management, traveler information dissemination to truck drivers, regional truck permitting and AV truck platooning. [49]

5. NETC Stakeholder Workshop

A stakeholder workshop was conducted on June 11, 2018 with the PIs, TAC, stakeholders from state transportation agencies and research institutions, as well as representatives from regional and national organizations. The purpose of this workshop was to discuss cross-border issues, identify challenges and opportunities for the region, and begin planning the roadmap of actions. The results of this workshop provided information to develop considerations for cross-border issues (see Section 6) and define the roadmap ahead for the region (see Section 7). A list of workshop attendees is in Appendix E.

Figure 3: Stakeholder Workshop

Many potential initiatives were discussed that the stakeholders agreed would be beneficial for individual states to address as opposed to the region as a whole. These state initiatives are listed in Appendix F. Undertaking individual state initiatives now will better prepare the region for larger collaborative initiatives in the near future.

A primary outcome of the Stakeholder Workshop was identifying regional challenges and opportunities, which are summarized in Table 3. Opportunities are linked to proposed regional initiatives that are further described in Section 7.1. Initiatives fall into five categories:

- Mission, Goals, and Objectives (M1)
- Legal and Regulatory (L1-L3)
- Technical Projects (P1-P8)
- Emergency Response (R1- R2)
- Public and Staff Education (E1-E3)

Table 3: Challenges and Opportunities

Challenges	Opportunities	Initiatives (See Section 7.1)
Coordination Between Six States - Each state has its own governing structure, constituents, and priorities. It has been a challenge to start CV/AV initiatives in individual states, let alone as a region.	Define a Regional Mission, Goals and Objectives - CVs/AVs promise benefits for safety, the economy, and the environment, among others. Referencing the goals/objectives met with each implementation step would keep these targets in mind, focusing and driving regional efforts.	M1
	Collective Bargaining - CV/AV providers will be asking a lot from the states, so it is important that states know what to ask for in return. Bargaining as a region may help states obtain important data to enhance safety on their roadways.	E3, P5, P7
	Economies of Scale - Many preparatory initiatives will contain significant overlap among the states. Regional initiatives can reduce the duplication of efforts and save money (see Section 7.2 for potential funding sources).	All
	Peer Exchanges - Participating in peer exchanges with other states to see how they are collaborating and partnering with others, including states, universities, stakeholders, etc., would benefit the region. The NETC may help fund these peer exchanges for further learning.	E1, E2
	Seamless CV/AV Operations Across State Lines – Ensuring interoperability between New England states will enable interstate travel which is essential for both commuters and commercial operators.	P1-P8
	Consistent Emergency Response and Crash Investigation – a regional approach to first responder training would ensure their safety on New England's roads and better prepare the region for AV deployments.	R1, R2
Executive Buy-In - Agency leaderships have been bombarded with information on CVs/AVs. They do not want any more introductory material.	Focus on Initiatives - Developing one-page initiative summaries that simply display key information such as Return on Investment (ROI), potential funding sources, stakeholders, and schedule gives executives a tangible action linked to a benefit.	All
	Participate in Regional Meetings – Attending events, such as the Northeast Autonomous and Connected Vehicle Summit, serves as a regional training and information sharing platform. Seeing what other states are doing would pique the interest of executive staff and encourage buy-in. Such meetings would also help executives identify potential funding sources and partners.	E1, E2

Challenges	Opportunities	Initiatives (See Section 7.1)
Lack of Mid-Level Understanding - While many technology providers are marketing heavily to executives, there is an education gap among mid-level transportation agency personnel. Getting their buy-in and understanding is a key component to any successful regional effort.	Internal Education Programs - Although internal education may happen on a state-by-state basis, using regional educational materials can help promote a unified vision and create support for regional projects and initiatives. Partnerships with universities in New England would be an opportunity to grow the research and workforce at the same time.	E1, E2
Public Anxiety - Studies and polls show that the public is skeptical of AVs and have reservations about using emerging transportation technologies.[50]	Demonstrations - Research suggests that demonstrations of physical technologies are the best way to quell the anxieties that surround them.[51] [52] [53] Technology providers from outside the region may be more willing to demonstrate in New England if they are able to plan multiple stops on their trip, coordinated through a regional effort.	E1, E3
	Engaging Local and State Elected Officials – Lack of knowledge regarding emerging technologies may lead elected officials to pass unnecessary laws and regulations to put their bases at ease. Engaging and informing elected officials of the benefits and challenges ahead makes them more knowledgeable and able to answer voter concerns.	L1, L2
	Coordinating with Stakeholder Groups – Coordinating with public stakeholder groups like AAA and universities would help engage the public directly through demonstrations and presentations, constructively and in a "safe space" to address all issues.	E1, E2, E3
	Marketing and Public Outreach – Marketing on current pilots and demonstrations in the region and throughout the country would educate the public and concentrate on the successes seldom mentioned in news headlines.	E1, E2, E3

6. Cross-Border Issues

Cross-border issues were identified by PIs, the TAC, and the Stakeholder Workshop considering a time horizon of approximately five years. A summary of cross-border issues, presented in the following categories, is shown in Table 4:

1. Legal and Regulatory
2. Infrastructure
3. Operations
4. Data and Technology

Each issue is provided with a description of why it deserves regional cooperation and potential regional considerations for how the issue might be addressed. Table 4 references the specific initiatives described in Section 7.1 that relate to the consideration. This summary should be viewed as a "living list" to be updated over time.

Table 4: Summary of Cross-Border Issues

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Legal and Regulatory	AV Pilot Testing	Currently, MA, CT, and RI have frameworks in place for AV pilot testing, each focusing on a limited geographic area.	Share and discuss these testing agreements and approaches with other New England states to create a unified framework. Include municipalities in the discussion for non-state highways and local roads. Pilot testing framework will likely change for full deployments.	L1, L2, L3
Legal and Regulatory	Crash Investigation	Currently, crash investigation requirements differ state by state. Some states are Model Minimum Uniform Crash Criteria (MMUCC) 4 compliant, some states have updated to MMUCC 5 compliance that includes new sections on AVs.[54]	Standardizing crash investigation procedures in New England, at least in part, would better position the region to attract cross-border AV deployments. Regional coordination with the National Transportation Safety Board (NTSB), Governor's Highway Safety Association (GHSA), NHTSA and others could help define best practices for local investigator responsibilities and procedures. AAMVA recommends adopting MMUCC 5 as soon as practical (see Section 3.2).	R1, R2

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Legal and Regulatory	Freight Policy and Regulation	Freight trucks, essential to interstate commerce, are adopting AV technologies to lower fuel consumption and CO2 emissions, improve safety and increase efficiency. AV freight deployments are currently underway in other regions of the country.	Cross-state truck platooning pilots are accruing along the North/West passage and on I-10 in the southwest. Freight corridors are being established in Michigan, Ohio and Pennsylvania as part of the Smart Belt Coalition as well. The Smart Belt Coalition has interests to extend east to New England, establishing a CAV freight corridor from Chicago to Boston. New England should consider a legal and regulatory framework that outlines when and where freight platooning can occur to/from New England and within New England, in coordination with the FMCSA. Aligning freight corridor polices, work zones, and incident management enables cross-border CAV travel for freight trucks.	L1, L2, L3
Legal and Regulatory	Insurance	A consistent and uniform approach to regulating insurance across all six states would make it easier to attract AV deployment in the region and provide the opportunity for cross-border pilot testing in the future.	Consider establishing insurance frameworks for both the testing and deployment phases which ensures continuous coverage for AVs over state lines. Insurance criteria and minimums should be established and agreed upon by each state in the region, especially for testing. Look to NHTSA & AAMVA guidelines to set common criteria and minimums for the region. Each of the New England State Insurance Departments should coordinate amongst themselves and with other regional partners to help set regional insurance criteria for AV.	L1, L2, L3

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Legal and Regulatory	Licensing	At this point, it is unclear who would need AV operator licenses and how AV operator licenses will be obtained by the public, as well as the geographic operating domain for licensure.	As the issue of AV licensing develops, the region should consider supporting operator licensing that spans state borders to promote uninhibited travel in the region. A major consideration for the region is whether operator licensing is needed during the deployment phase, and if so, the prerequisite training required. Making training requirements uniform among the states could be a cost effective and efficient way in the development of training materials. Since it has not been determined who will "responsible" for the operation of an AV of each level of automation, the discussions of licensing should also include vehicle registration.	L1, L2, L3
Legal and Regulatory	Registration	Most states have vehicle registration reciprocity agreements for the majority of vehicle types. The basis for most of these reciprocity agreements are the FMVSS which define vehicles as meeting the federal requirements for operation on public roadways. Since there are no FMVSS for AVs yet, each state may need to form a basis to regulate each AV type for operating on their public roadways and for working with other states to develop interstate reciprocity agreements.	Currently, unless FMVSS are formed for AVs, it is possible that one state could have dramatically different rules for registration of AVs on public roadways than a neighboring state. New England states should be prepared for its own agreements to promote the use of AVs in the region in the absence of federal standards. Each of the State DMVs in the region should work together to outline a framework for reciprocity agreements in New England in coordination with all stakeholders. States should work together and participate in discussions with other states, federal partners and other stakeholders who are looking into developing new FMVSS for AVs.	L1, L2, L3

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Infrastructure	Communication Network	Each New England state has a communications network for ITS devices. These networks are developed with a certain bandwidth in mind for transmitting data between devices and operations centers. Existing communications maps are shown in Appendix G.	Understand communication resources from the First Responder Network Authority (FirstNet). Consider a regional effort to estimate the bandwidth requirements for Road Side Units (RSUs) to determine if an increase in communications capacity is warranted. Additionally, an analysis of communication gaps, especially near state borders, could benefit smooth cross-border operations.	P1, P2, P3, P6
Infrastructure	Infrastructure Standards	Roadway infrastructure standardization will likely benefit CV/AV deployments such as signage, signals, pavement condition, work zones, power, and communications.	Define the user needs of each state and then determine where there is common ground to develop a regional strategy. Consistent infrastructure will likely help AV sensors recognize roadway regulations as well as changes in driving conditions. The region might consider a baseline capability requirement for traffic signal controllers.	P2, P3, P6
Infrastructure	Road Side Units	Connected vehicles communicate using 4G and DSRC, as well as 5G and 6G in the future. It is important for the New England states to understand the benefits and drawbacks of each in relation to data type, data ownership and infrastructure needed to capture the data.	Standardizing for certain V2I applications would help promote cross-border pilots and consistent operations across state lines. New England should consider a regional qualified products list (QPL) for prequalifying RSU vendors.	P1, P2, P3, P5, P6, P7, P8
Operations	TMC/HOC Role	State Transportation Management Centers (TMCs) and Highway Operations Centers (HOCs) collect highway vehicle data, disseminate traveler information, and perform critical tasks for emergency response and incident management. The introduction of CVs/AVs will affect each of these responsibilities. NH, VT, and ME share a centralized TMC software and many TMC functions.	A regional effort could benefit New England when determining and implementing new roles and responsibilities for TMCs/HOCs and unify operations to enable data sharing.	P2, P4

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Operations	International Vehicles	ME, NH, and VT each share a border with Canada including roadways with U.S. Customs and Border Protection facilities.	Developing policy and practices for international AVs to cross these borders as well as travel through the rest of New England will help facilitate the use of AVs from other countries.	P2, P5, P7
Operations	Operations Between State Lines	There are 22 limited access highways and dozens of state routes that cross state borders within, into and out of New England. Some operational issues for the region include winter weather operations, work zones, consistent RSU messages, uses of CV/AV data, and changes in infrastructure across state lines.	Consider forming regional Standard Operating Procedures (SOPs) to coordinate operations near state borders.	P2, P4
Operations	Outreach, Education, and Driver Behavior	As regional operations procedures are developed, reaching out to affected stakeholders and the public would be best coordinated on a regional level to ensure consistent messaging.	Consider coordinating with or joining an existing regional entity to coordinate outreach materials, methods, and possibly AV demonstrations.	E1, E2, E3
Data and Technology	Data Gathering	The powerful data gathering abilities of CVs/AVs have great potential for New England states in terms of asset management and roadway operations. AVs will ultimately know where every sign, pavement marking, and traffic signal is, along with their conditions.	Value can be provided to public agencies in knowing when and how often CV applications are triggered and when certain AV functions occur, such as windshield wiper activation or loss of traction control. Collective bargaining as a region would aid New England in obtaining this valuable information.	P2, P3, P5

Issue Type	Issue	Description	Considerations	Initiatives (See Section 7.1)
Data and Technology	Network Resilience / Cybersecurity	In computer networking, resilience is the ability to provide and maintain an acceptable level of service for data transfer when faced with different threats. Threats and challenges for services can range from simple misconfiguration to targeted attacks.	Providing regional standards for network resiliency may help ensure proper cybersecurity for CVs/AVs in the region. New England may consider creating 3rd party certificate policies for vehicle original equipment manufacturers to provide operational security. New England should consider the recommendations of National Cooperative Highway Research Program (NCHRP) Project 03-127[55] which is developing guidance for state and local transportation agencies on mitigating the risks from cyberattacks on the field side of traffic management systems.	P2, P3, P5

7. Roadmap of Actions

The roadmap of actions was determined from examining the current status or each New England state, reviewing CV/AV best practices and research, the stakeholder workshop, and discussions with transportation agency leaders and industry experts. The roadmap is meant to be flexible and provide regional guidance as technologies continue to emerge and gain traction.

7.1 Regional Initiatives

Regional initiatives are presented in the following five categories. It is recommended that the region engage in initiatives from each category to facilitate a cohesive deployment of CVs/AVs in the region. The letter codes are referenced in the figure and list of initiatives on the following pages.

- **M** **Mission, Goals and Objectives**
- **L** **Legal and Regulatory**
- **P** **Technical Projects**
- **R** **Emergency Response**
- **E** **Public and Staff Education**

The proposed regional initiatives workflow and timeline, shown in Figure 4, provides a framework for delivering successful regional initiatives. Each step in the workflow is derived directly from the challenges and opportunities derived from the stakeholder workshop (see Table 3), and cross border issues developed by the TAC (see Table 4). Each of the initiatives is then described, including potential leadership.

Initiatives that involve the implementation of technology were developed in accordance to the Systems Engineering process to ensure all stakeholder needs are satisfied and to meet requirements for many federal funding sources.

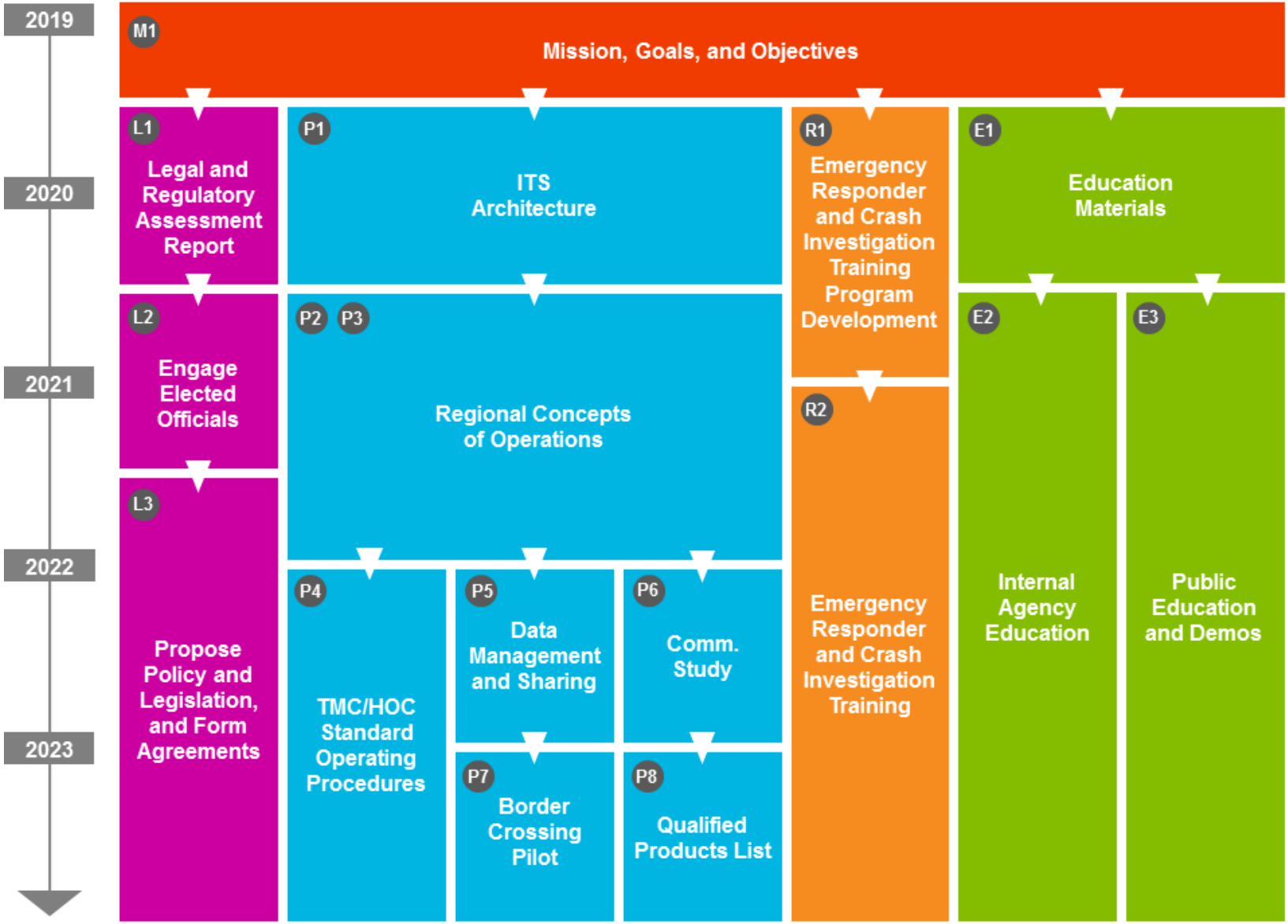


Figure 4: Regional Initiatives Workflow and Timeline

Mission, Goals, and Objectives (M)

Initiative Leadership: transportation agency executives or their representatives.

Resources Required: in-house staff and existing/ programmed funding.

M1 Mission, Goals, and Objectives – Defining these three attributes is critical to the success of any regional CV/AV project or program. Based on discussions with stakeholders, potential goals include improving traveler safety, increasing mobility, reducing transportation emissions, reducing congestion, improving infrastructure, and supporting economic vitality. Once the region has a clear mission, the overall workflow and initiatives should be augmented as needed to ensure there is buy-in from all six states. A regional or national entity may be designated to coordinate this initiative.

Legal and Regulatory (L)

Initiative Leadership: transportation agency policy makers, insurance representatives, DMV leadership, legislative members and universities.

Resources Required: in-house staff and existing/programmed funding; possibly consultant support.

L1 Develop Legal and Regulatory Assessment Report – Delve deeper into the legal aspects identified in this report (see Table 4) to determine specific laws and regulations that would benefit the region and have success in multiple New England States, given their varying political climates. The report will focus on tangible legal aspects that are most easily achieved. The report should include stakeholder feedback and outline sample legislation to elicit feedback from elected officials.

L2 Engage Local and State Elected Officials – Present findings from the Legal and Regulatory Assessment Report to local and state elected officials and affected stakeholders for feedback and listen to their needs for enacting CV/AV policy. Identify any obstacles for enacting legislation and potential ways to overcome them.

L3 Propose Policy and Legislation – Refine the proposed policy and legislation, now with buy-in from elected officials and stakeholders, in a coordinated effort across multiple states to help facilitate a consistent framework for the operation of CVs/AVs in the region.

Technical Projects (P)

Initiative Leadership: transportation agency ITS, Information Technology, HOC/TMC, and traffic engineering staff.

Resources Required: consultant, existing/programmed funding, and/or additional federal funding depending on the initiative.

P1 Regional ITS Architecture – Having an up-to-date architecture is required to receive certain categories of federal funding for technology projects. The new federal standards for ITS

architectures have been updated to include CV technologies and outline how these fit into the overall architecture framework.[56] Pursuing a regional ITS architecture would likely save states money due to economies of scale and reducing the duplication of efforts. Additionally, a regional architecture would better identify areas for regional CV projects. If a regional architecture is not pursued, it is recommended that each state ensure their individual ITS architecture is up to date.

P2 Regional Concept of Operations for Highway Connected Vehicle Deployments – This ConOps takes into account all users' needs to develop requirements for the proposed systems. Requirements may include communications, electrical, software, data standards, device placement, operations, maintenance, and other aspects. The ConOps will help identify appropriate safety applications, such as Spot Weather Impact Warning and Reduced Speed/Work Zone Warning. This regional document can be a starting point for each state to create specific standards and SOPs.

P3 Regional Concept of Operations for Arterial Connected Vehicle Deployments – Throughout New England there is significant overlap of traffic signal operational characteristics, software, hardware, and maintenance needs. Similar overlap is found at non-signalized locations such as stop-controlled intersections, sharp bends, and rural roads. A regional ConOps will help to better define what states need when planning RSU connectivity, generating procurement documents, and developing maintenance contracts. The ConOps would also provide consideration for effective CV applications that will provide the greatest safety benefit to New England such as the Red Light Violation Warning, Curve Speed Warning, and Stop Sign Gap Assist.

P4 Regional Winter Weather Standard Operating Procedures – Each TAC member voiced concern for CV/AV operations during winter weather. Creating regional SOPs for winter weather provides important coordination for CV message lexicon, message types (weather information, travel restrictions, travel times, etc.), plowing/salting operations, and specific CV applications that apply to New England driving conditions. These SOPs can be expanded upon and incorporated into individual state's SOPs.

P5 Data Management and Sharing – First, develop an understanding of what types of data are available from CVs/AVs, which are or could be beneficial to state agencies, and what methods exist to safely collect and use the data. Second, determine existing data storage and sharing capabilities in the region. Last, begin to implement resilient data management and sharing strategies that capitalize on valuable data sources.

P6 Cross-Border AV Pilot – Standardizing testing processes and ensuring reciprocity of licensing and registration for AVs and backup drivers will allow AV pilot testing across state highways and routes through the region. Connectivity allows a potential increase in security capabilities and applications at the Canadian border and may also reduce crossing times for regular or prescreened users. A regional approach to addressing this use case may allow better use of existing international border systems as well as allow for a scalable and replicable connected

system that may be deployed in other regions. USDOT may support the development of a detailed plan for implementing the International Border Crossing-Electronic Screening System for trucks, motor coaches, and buses.

P7 Communications Study – The purpose of this study is to identify communication gaps on the NHS and identify opportunities for shared resources. These shared resources may be state-to-state, such as sharing tower resources near state lines, or sharing communications infrastructure with private companies. Additionally, the study should consider the roles of DSRC, 5G for CVs.

P8 Regional Qualified Products List (QPL) – Once requirements are developed for CV technologies (from a regional CV ConOps), technologies can be tested to determine if they meet the needs of the region, and then added to the QPL so they can be deployed more readily and reliably. Individual states may desire additional testing specific to their systems, but could still use the regional QPL as a prequalification requirement.

Emergency Response (R)

Initiative Leadership: state police, first responders, crash investigators, and HOC/TMC.

Resources Required: in-house staff and resources and existing/programmed funding; possibly consult support.

R1 Emergency Responder and Crash Investigation Training Program Development – If an absence of national standardized law enforcement training for CVs/AVs continues, the region should consider developing its own training courses, materials, and standards for emergency responders in cooperation with State Highway Safety Offices and State Police. This would include the role of NTSB and local responsibilities for a CV/AV crash. This project is underway in Massachusetts and New England states are invited to participate in its development.

R2 Emergency Responder and Crash Investigation Training – Training law enforcement and crash investigators in the region, in an absence of national standardized law enforcement training, will ensure the safety of first responders and drivers on New England's roads. Regional training courses, materials, and standards for emergency responders should be implemented in cooperation with State Highway Safety Offices, State Police, and police departments in major cities.

Public and Staff Education (E)

Initiative Leadership: state transportation agencies and universities.

Resources Required: in-house staff and existing/programmed funding; possibly consultant support.

E1 Educational Materials – Currently, there is a lack of understanding about CV/AV capabilities and benefits. This education program would start with providing education materials for mid-level transportation agency staff that deliver introductory information on CVs such as

communication capabilities, Basic Safety Messages (BSMs), RSUs, common safety applications, and highlights of national research. The program may also focus on the differences between CVs and AVs from a transportation agency perspective. Additional materials could target other state agencies, other transportation stakeholders, and the general public. The program should start by examining resources already developed from federal, regional, and other state agencies.

E2 Internal Agency Education – Using the education materials created above; enact an internal agency education program focused on mid-level staff. The purpose of such program is to fill the education gap among mid-level staff and create a more educated transportation agency across all levels that anticipate CV/AV uses in their planning and projects. The program should consider before and after surveys to gauge effectiveness, and should cover technology, policy, and public perception aspects of CVs/AVs.

E3 Public Education and Demonstrations – Although demonstrations would happen in individual states, CV/AV technology providers are often more willing to travel to give demonstrations when there is a particularly large event and/or are multiple stops on their trip. The region could benefit from scheduling demonstrations in multiple states on consecutive days. Additionally, demonstrations could be scheduled around regional conferences such as the CV/AV Northeast Summit or the New England ITS Annual Interchange.

7.2 Funding Opportunities

At the workshop, all stakeholders agreed that funding is a challenge for implementing CV/AV initiatives. States can collaborate for little to no money and use only existing/programmed funds and staff resources to implement some of the initiatives listed in section 7.1; but many of the regional initiatives listed would require external funding to implement, whether it is internal state funding, federal grant funding, federal formula funding or other grant funding opportunities. Table 5 provides an introductory list of grant opportunities that may be leveraged to fund the regional initiatives.

Table 5: Grant Funding Opportunities

Name	Agency	State Match	Max. Amount	Description
ATCMTD Grants [57]	FHWA	50%	$12M/yr	Development of deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure ROI.

Name	Agency	State Match	Max. Amount	Description
Better Utilizing Investments to Leverage Development (BUILD) Grants [58]	USDOT	20% (urban) 0% (rural)	$25M	Invest in multi-modal and multi-jurisdictional surface transportation infrastructure projects (roads, bridges, transit, rail, ports or intermodal transportation) while also increasing support for rural areas to ensure equitable funding across the country.
Bus & Bus Facilities Infrastructure Investment Program[59]	FTA	20%	$36.6M	Assist in the financing of buses and bus facilities capital projects, including replacing, rehabilitating, purchasing or leasing buses or related equipment and facilities; including technological changes or innovations to modify low or no emission vehicles or facilities.
Low or No Emission (LoNo) Program[60]	FTA	10-15%	N/A	Support the transition of the nation's transit fleet to the lowest polluting and most energy efficient transit vehicles.
Accelerating Innovation Deployment (AID) Grants[61]	FHWA	None	$1M	Accelerate the implementation and adoption of innovation in highway transportation.
Infrastructure for Rebuilding America (INFRA) Grant[62]	USDOT	20-40%	≥$25M	Creating opportunities for all levels of government and the private sector to fund infrastructure, using innovative approaches to improve the necessary processes for building significant projects, and increasing accountability for the projects that are built.
High Priority Innovative Technology Deployment (ITD) Grant Program[63]	FMCSA	≤15%	N/A	Financial assistance to advance the technological capability and promote the deployment of intelligent transportation system applications for commercial motor vehicle operations, including commercial motor vehicles, commercial driver, and carrier-specific information systems and networks; and to support and maintain commercial motor vehicle information systems and networks.

Name	Agency	State Match	Max. Amount	Description
Highway Safety Grant Programs[64]	NHTSA	N/A	N/A	Grants for effective highway safety programs including occupant protection, state traffic safety information systems, impaired driving countermeasures, distracted driving, motorcyclist safety and state graduated driver licensing laws.
Automated Transit Buses[65]	FTA	TBD	TBD	Demonstration and evaluation of use cases where commercially ready AV technology and products could be applied to transit to provide early demonstrable results. Use cases include Transit Bus Advanced Driver Assistance Systems; Automated Shuttles; Maintenance, Yard and Parking Operations; Mobility on Demand Service; and Automated Bus Rapid Transit.
Highly Automated Vehicle Research and Development Program (To Be Announced)	FHWA	None	$10M	Fund demonstration projects that test the feasibility and safety of Highly Automated Vehicles and Advanced Driver-Assistance Systems deployments, as well as necessary administrative expenses.
NCHRP Grants[66]	TRB	None	$600K	Conduct research in acute problem areas that affect highway planning, design, construction, operation, and maintenance nationwide. Solutions must be practical, readily usable, address issues of critical concern and be of interest to many states.
Smart and Autonomous Systems Program[67]	National Science Foundation	None	$1M	Promote fundamental academic research into Intelligent Physical Systems that can act autonomously and reliably in a variety of situations and environments.
Data Science Research Grant Program[68]	Bloomberg	None	$70K	Support academic research in data science, typically focusing on natural language processing, information retrieval, machine learning, and data mining and creation of, or contributions to, open source software used for data science.

In addition to grants, federal-aid highway funds as part of the Fixing America's Surface Transportation (FAST) Act for individual programs are apportioned by formula, using factors relevant to the particular program. This formula funding can be used for CV/AV initiatives.

Table 6: Federal Formula Funds

FAST Act Formula Program	Eligible Uses
Congestion Mitigation and Air Quality Improvement Program (CMAQ)[69]	A wide range of projects to reduce congestion and improve air quality in nonattainment and maintenance areas for ozone, carbon monoxide, and particulate matter.
Surface Transportation Block Grant program (STBG)[70]	A broad range of surface transportation capital needs, including roads; transit, sea, and airport access; and vanpool, bicycle, and pedestrian facilities.
Highway Safety Improvement Program (HSIP)[71]	Implementation of infrastructure-related highway safety improvements that are consistent with the state's strategic highway safety plan.
State Planning and Research (SP&R)[72]	Establishment of a cooperative, continuous, and comprehensive framework for making transportation investment decisions and to carryout transportation research activities throughout the state.
National Highway Performance Program (NHPP)[73]	Improvements to interstate routes, major urban and rural arterials, connectors to major intermodal facilities, and the national defense network. Including replacing or rehabilitating any public bridge and resurfacing, restoring and rehabilitating Interstate routes.

7.3 Next Steps

Implementing regional initiatives will require regional coordination, cooperation, and collaboration between the six states.

Members of the TAC have agreed to meet after the publication of this final report to discuss the next steps forward and start developing an implementation plan to advance the initiatives in the roadmap. This discussion will identify a facilitator to convene the six states regularly and track the implementation of the initiatives.

8. Summary

Regional coordination in anticipation of the widespread use of CVs/AVs will better educate New England's population, influence policy, reduce costs, and provide safer and more efficient roadways for the traveling public. This document provides considerations for identified cross-border issues and a roadmap for implementing regional initiatives. It is recommended that these elements be reevaluated periodically as technology, the political climate, and state agencies evolve.

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Appendix A: Cross-Border Traffic Volumes

Border	Type	Route	AADT	Year	Source
CT/NY	Interstate System	I-95 I-84	125,900 72,300	2017 2016	CTDOT[1]
	Other NHS Route	RTE-15 US-44	46,882 4,608	2015	NYS Traffic Data Viewer[2]
CT/MA	Interstate System	I-91 I-84 I-395	78,700 50,700 22,700	2015 2016 2017	CTDOT[1]
	Other NHS Route	US-7 US-202	5,595 7,206	2017	MassDOT[3]
CT/RI	Interstate System	I-95	37,600	2017	CTDOT[1]
	Other NHS Route	US-6 RTE-78	19,200 6,900	2013 2011	CTDOT[1]
MA/NY	Interstate System	I-90	24,012	2017	MassDOT[3]
	Other NHS Route	RTE-20	5,214	2017	
MA/VT	Interstate System	I-91	14,946	2017	MassDOT[3]
	Other NHS Route	US-7	7,000	2016	VTrans[4]
MA/NH	Interstate System	I-93 I-95	107,320 97,907	2017	MassDOT[3]
	Other NHS Route	RTE-12 US-3 RTE-125	4,669 82,986 23,643	2017	
ME/NH	Interstate System	I-95	71,788	2017	NHDOT[5]
	Other NHS Route	US-1 US-202 US-2 US-302	11,444 10,927 2,569 9,978	2017	NHDOT[5]
ME/CAN	Interstate System	I-95	1,749	2016	MaineDOT[6]
	Other NHS Route	US-1 US-201	6,670 1,180	2016	
NH/VT	Interstate System	I-89 I-93	40,700 6,663	2017	NHDOT[5]
	Other NHS Route	US-2 RTE-9 RTE-12	3,592 12,326 13,353	2017	
NH/CAN	Other NHS Route	US-3	84	2017	NHDOT[5]
VT/NY	Other NHS Route	RTE-9 US-4 RTE-279 US-2	3,800 7,800 7,300 5,100	2016	VTrans[4]
VT/CAN	Interstate System	I-91 I-89	2,700 2,500	2016	VTrans[4]

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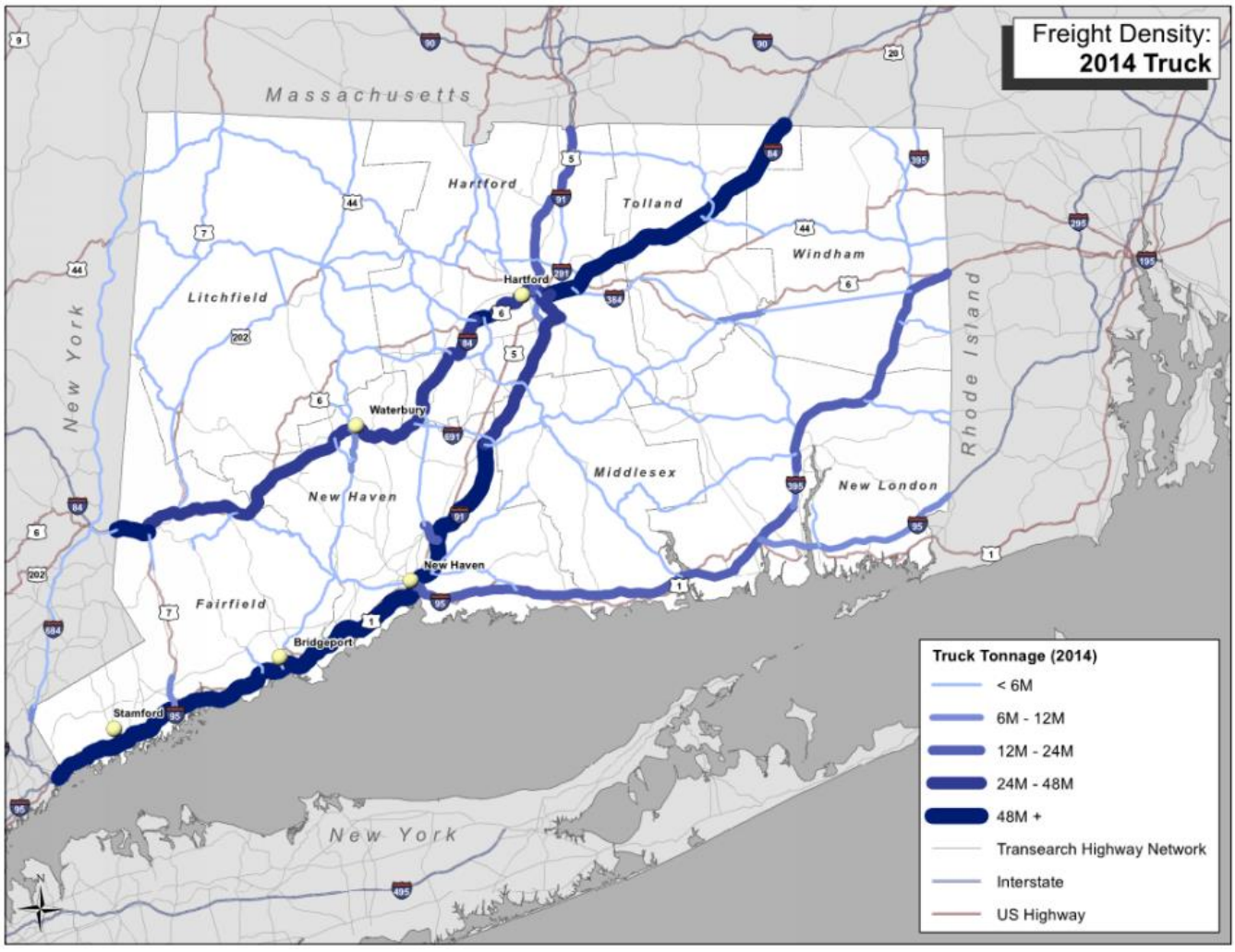
Appendix B: Freight Flow Maps

Connecticut

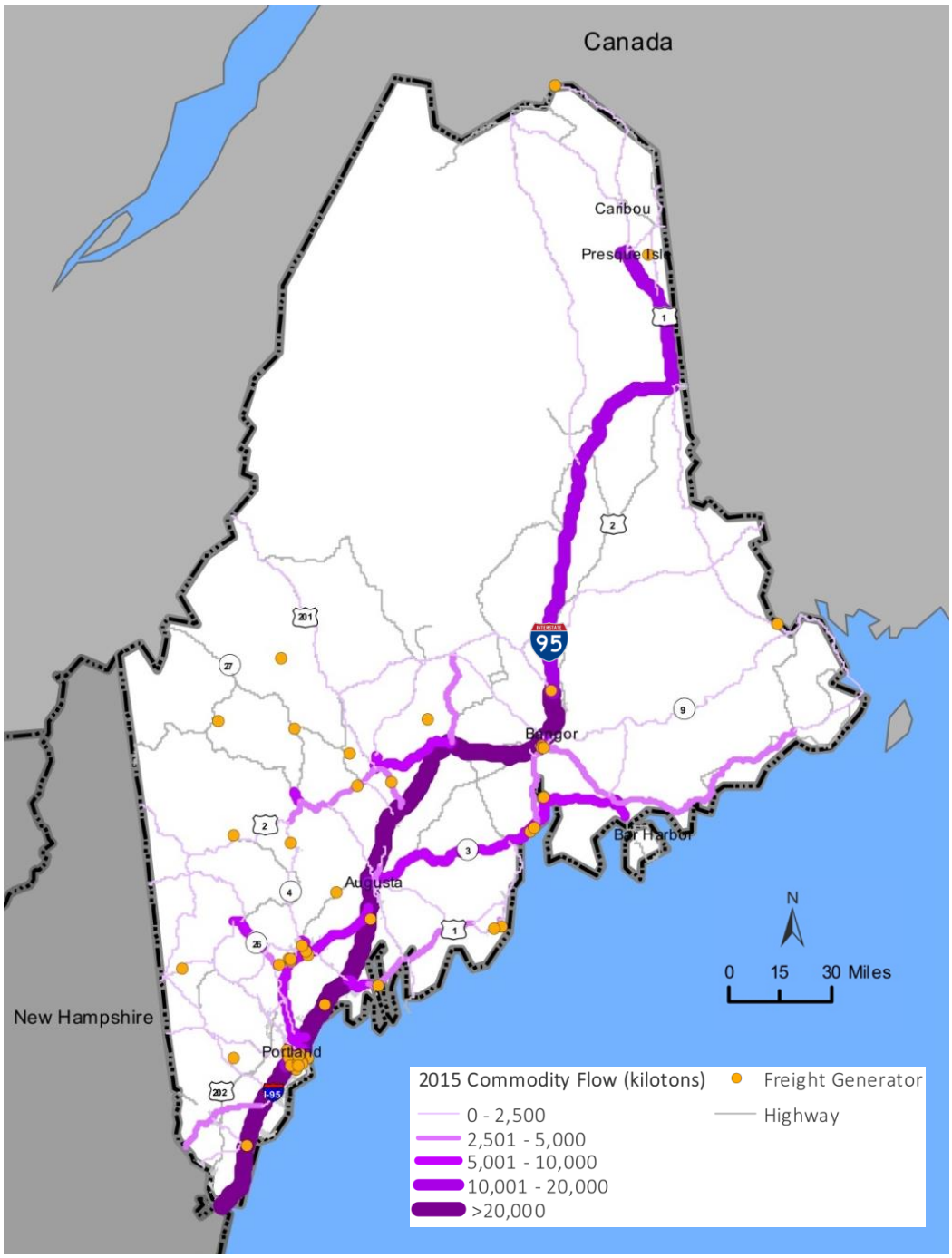
Major truck freight corridors include major interstates (I-95, I-91, I-84 and I-395). The densest truck freight routes are from New York City to New Haven along I-95, from New Haven to Hartford along I-91, and most of I-84.



Source: Connecticut Statewide Freight Plan Appendix A (2016)[1]

Maine

Major truck freight corridors include interstate highways I-95 and I-295. The densest truck freight route is from the New Hampshire border to Bangor along I-95 and I-295. Freight routes between I-95 and US-2 north of Portland, along US-2 between New Hampshire and Bangor, on the coast between Searsport and Eastport, and from Bangor to the northern part of the State were also significant.



Source: Maine Integrated Freight Strategy (2017) [2]

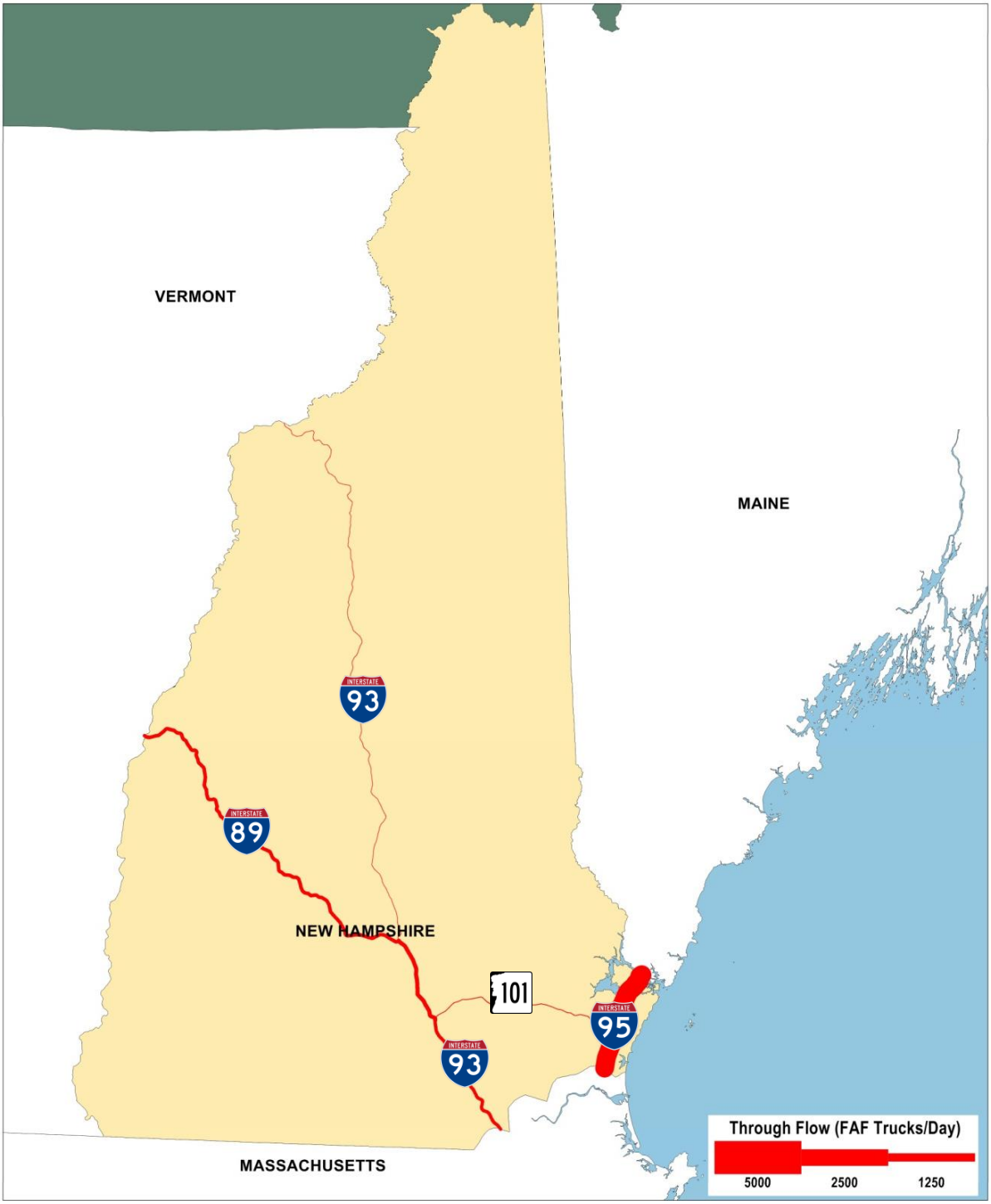
Massachusetts

The primary through route in Massachusetts enters the Commonwealth on I-84 from Connecticut and New York City, proceeds past Worcester on I-90, continues north on I-495, and exits using I-93 to New Hampshire and I-95 to Maine. An additional through route from Chicago and the Midwest enters Massachusetts via I-90 from New York.

Source: Massachusetts State Freight Plan (2010)[3]

New Hampshire

Major truck freight corridors include major interstates (I-89, I-93 and I-95). The densest truck freight routes are from Montpelier, VT to Concord along I-89, from Concord to Boston along I-93, and from Maine to Massachusetts along I-95 (shown below).



Source: FHWA Freight Management and Operations State Info (2012) [4]

Rhode Island

Major truck freight corridors include interstate highways I-95, I-295 and I-195. The densest truck freight route is along I-95, serving Rhode Island's through, inbound and outbound truck traffic. A number of principal arterials, (Routes 1, 4, 6, 10, 24, 33, 114, 117, 138, and 146) provide additional access. They also provide important connectivity to neighboring states and local centers of economic activity.

	2013		2030		
	Thousand Tons	Percent	Thousand Tons	Percent	CAGR 2013-2030
Through	13,696	31.0%	19,633	32%	2.1%
Outbound	12,873	29.1%	15,801	25.7%	1.2%
Inbound	12,578	28.5%	19,884	32.4%	2.7%
Local	5,061	11.4%	6,125	10%	1.1%
Total	44,208		58,922		2.0%

Truck through traffic is dominated by goods moving to and from southeastern Massachusetts, and nearby Northeastern states. The New Jersey to Massachusetts freight route is the most significant through route, followed by Massachusetts to New York and Connecticut to Massachusetts in both directions. These routes form the majority of through traffic by tonnage.

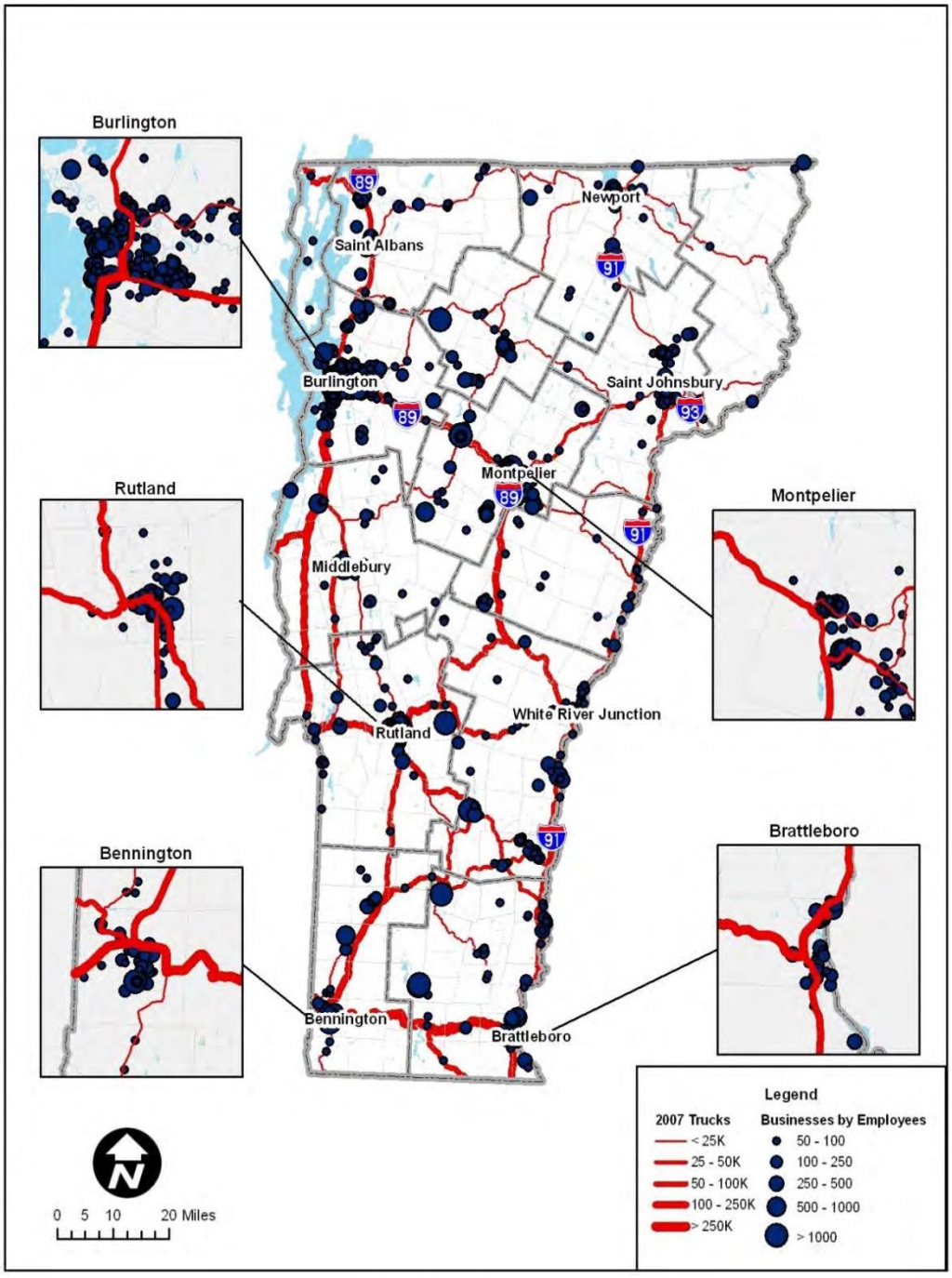
Origin State	Destination State	Thousand Tons	Percent
New Jersey	Massachusetts	1,611	11.8%
Massachusetts	New York	1,493	10.9%
Connecticut	Massachusetts	1,468	10.7%
Massachusetts	Connecticut	1,379	10.1%
Pennsylvania	Massachusetts	1,288	9.4%
New York	Massachusetts	983	7.2%
Massachusetts	New Jersey	698	5.1%
Massachusetts	Pennsylvania	574	4.2%
Florida	Massachusetts	356	2.6%
Maryland	Massachusetts	320	2.3%
All	**All**	**13,696**	
	Top 10 Share of Total	74%	

Source: State of Rhode Island Freight and Goods Movement Plan-Appendix 3 (2015)[5]

Source: FHWA Freight Management and Operations State Info (2012)[6]

Vermont

Major truck freight corridors include major interstates I-91 and I-89 and US-4, US-7 and US-2. State Route 9 also sees a significant volume of truck traffic from Bennington to Brattleboro, primarily from through shipments moving to and from eastern New England (New Hampshire, Massachusetts and Maine).



Source: Vermont Freight Plan (2017)[7]

[1] Connecticut Department of Transportation. Connecticut Statewide Freight Plan Appendix A. https://www.ct.gov/dot/lib/dot/fastlane/freight_plan/appendix_a_-_transearch_freight_movements_(08.04.17).pdf. October, 5, 2016.
[2] Maine Department of Transportation. Maine Integrated Freight Strategy. https://www1.maine.gov/mdot/ofbs/docs/FreightStrat.pdf. November 2, 2017.
[3] Massachusetts Department of Transportation. Massachusetts Freight Plan. https://www.mass.gov/files/documents/2017/10/19/MAFreightPlan2010.pdf. September 2010.
[4] Federal Highway Administration Office of Freight Management and Operations. Map of Major Freight Flow by Trucks that Pass-Through the State of New Hampshire-2012. https://ops.fhwa.dot.gov/freight/freight_analysis/state_info/new_hampshire/images/hi_res_pdf/nh_state_trkflow_2012.pdf. June 22, 2017.
[5] Rhode Island Department of Transportation. Truck Commodity Flows and Forecasts. http://www.planning.ri.gov/documents/trans/freight/08-Appendix_CommodityFlow.pdf. September 10, 2015.
[6] Federal Highway Administration Office of Freight Management and Operations. Map of Major Freight Flow by Trucks that Pass-Through the State of Rhode Island-2012. https://ops.fhwa.dot.gov/freight/freight_analysis/state_info/rhode_island/images/hi_res_pdf/ri_state_trkflow_2012.pdf. June 22, 2017.
[7] Vermont Agency of Transportation. Vermont Freight Plan. http://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/Vermont_Freight_Plan_Update_June2017_Final%20%281%29.pdf. June 2017.

Appendix C: Electric Vehicle Charging Station Maps

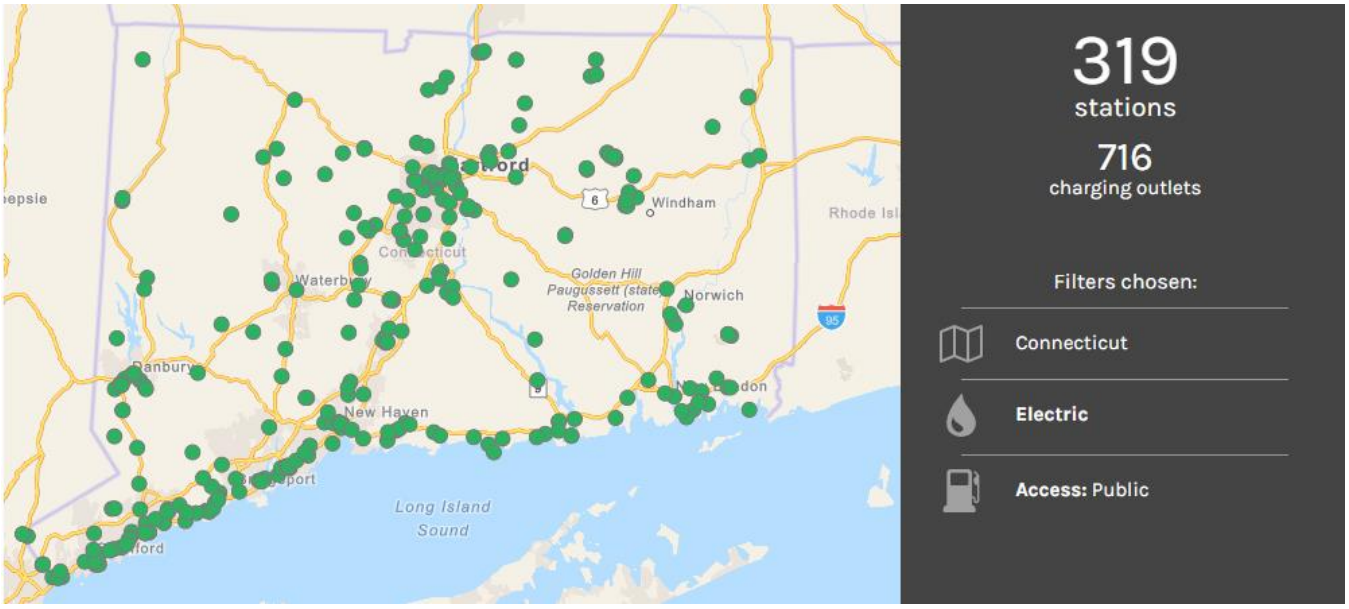
Electric Vehicle (EV) charging station maps were obtained from the U.S. Department of Energy's Alternative Fuels Data Center. The maps include Level-1, Level-2 and DC-Fast charging stations.

- Level-1 charging is a 120V standard wall plug using a J1772 connector. It provides 2 to 5 miles of range per 1 hour of charging.
- Level-2 charging uses 240V/208V for residential or commercial charging using a J1772 connector. It provides 10 to 20 miles of range per 1 hour of charging.
- There are three types of DC-Fast charging systems depending on the type of charge port on the vehicle (SAE CCS, CHAdeMO and Tesla). They provide 60 to 80 miles of range per 20 minutes of charging.

The majority of charging stations in New England are Level-2. DC-Fast charging stations are essential for interstate travel.

Connecticut

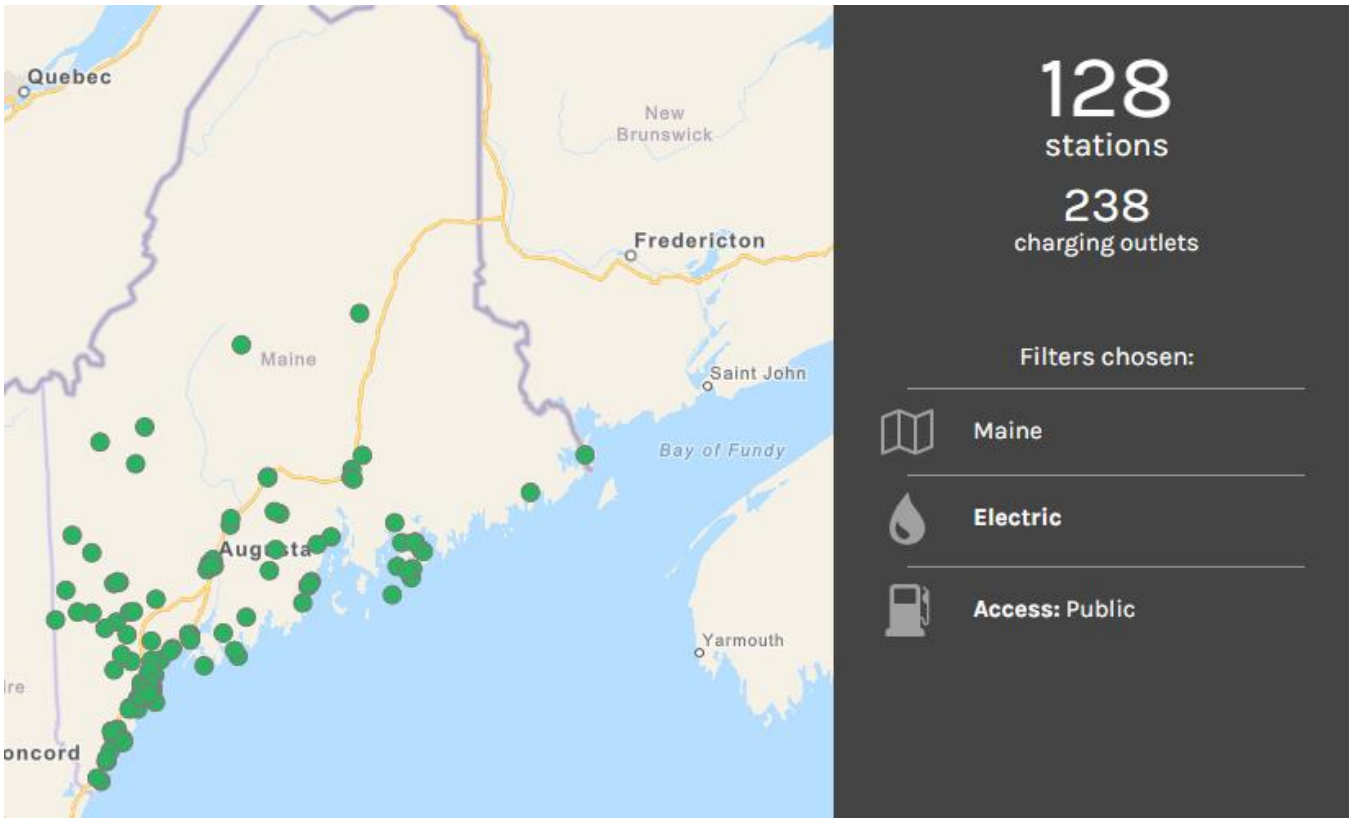
Extensive EV charging station coverage along I-95 from New York City to New Haven, stations also located along I-91 and I-84 near Hartford. Connecticut has 11 Level-1 stations, 290 Level-2 stations, and 39 DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[i]

Maine

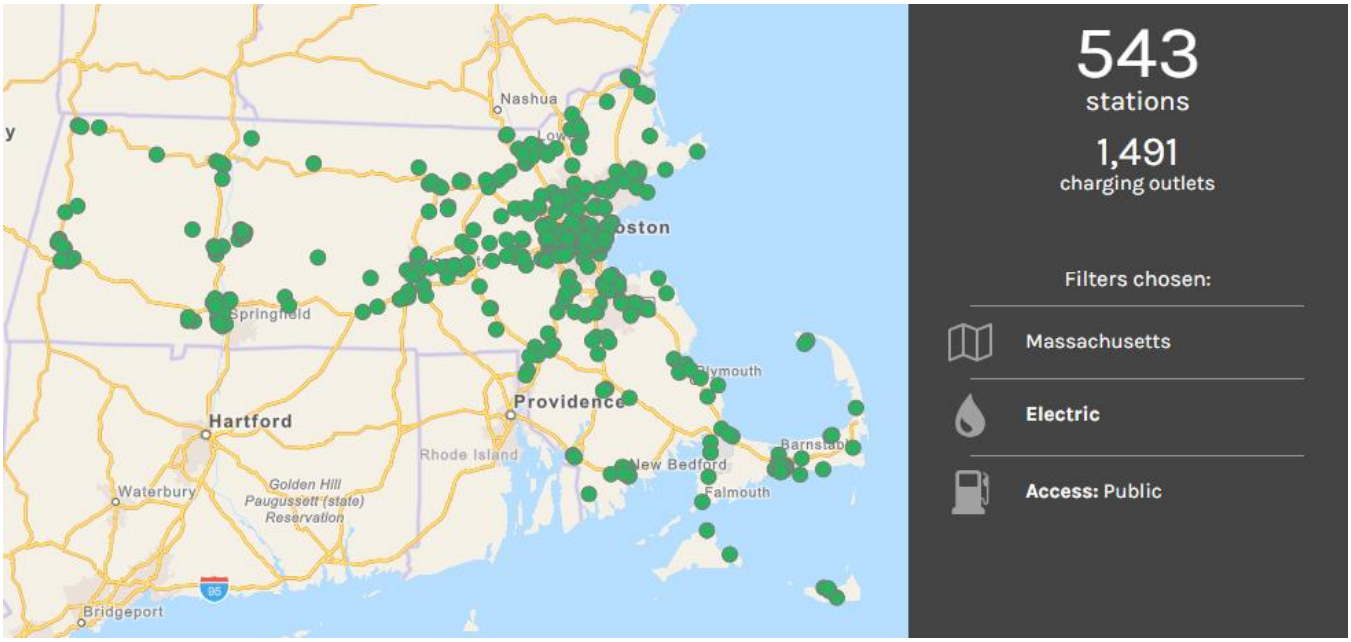
Extensive EV charging station coverage along I-95 from the Maine border to Portland, stations also located along I-95 near Augusta and Bangor. Significant gap is apparent along I-95 towards the Canadian border. Maine has five (5) Level-1 stations, 119 Level-2 stations, and 15 DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[1]

Massachusetts

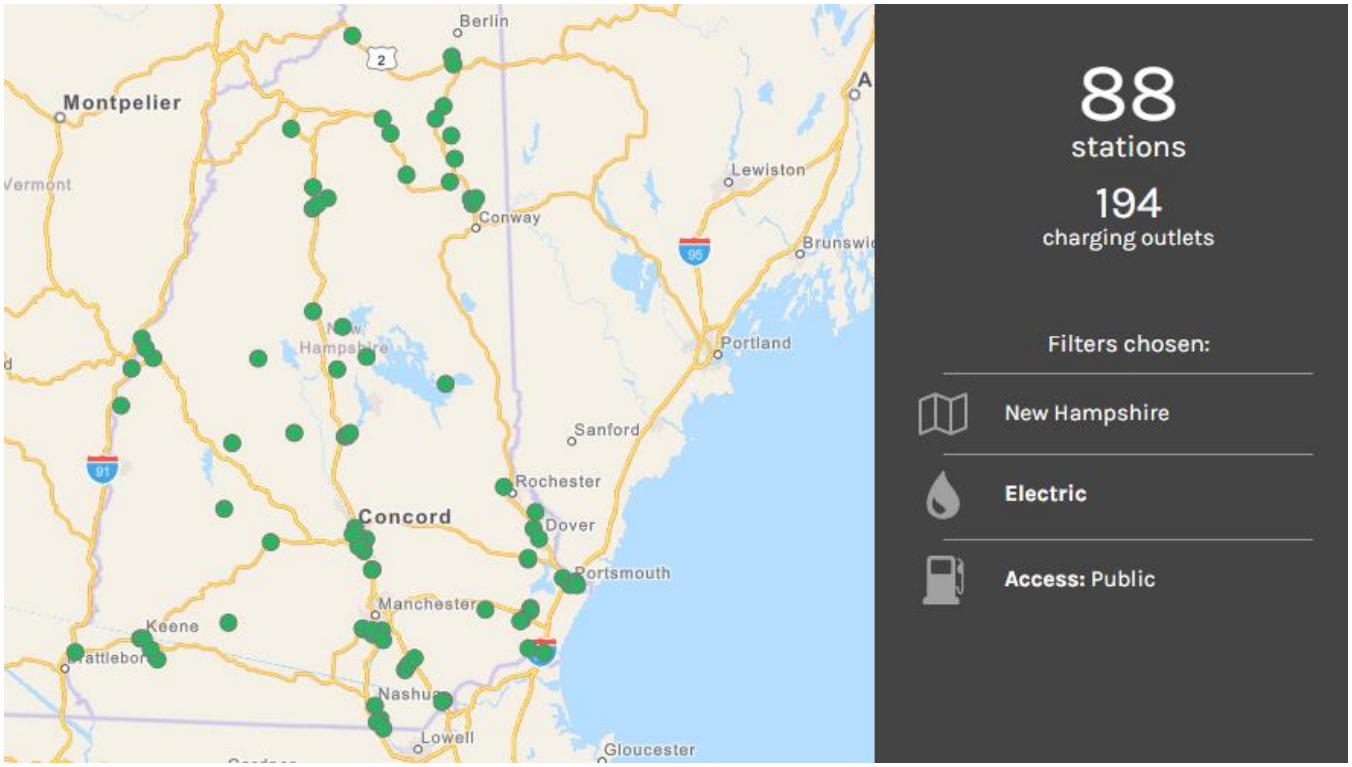
Extensive EV charging station coverage in the Greater Boston region, stations also located along I-90 near Springfield, I-91, I-93, I-95 near the Massachusetts border, and I-495 near Lowell.
Massachusetts has 23 Level-1 stations, 511 Level-2 stations, and 55 DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[1]

New Hampshire

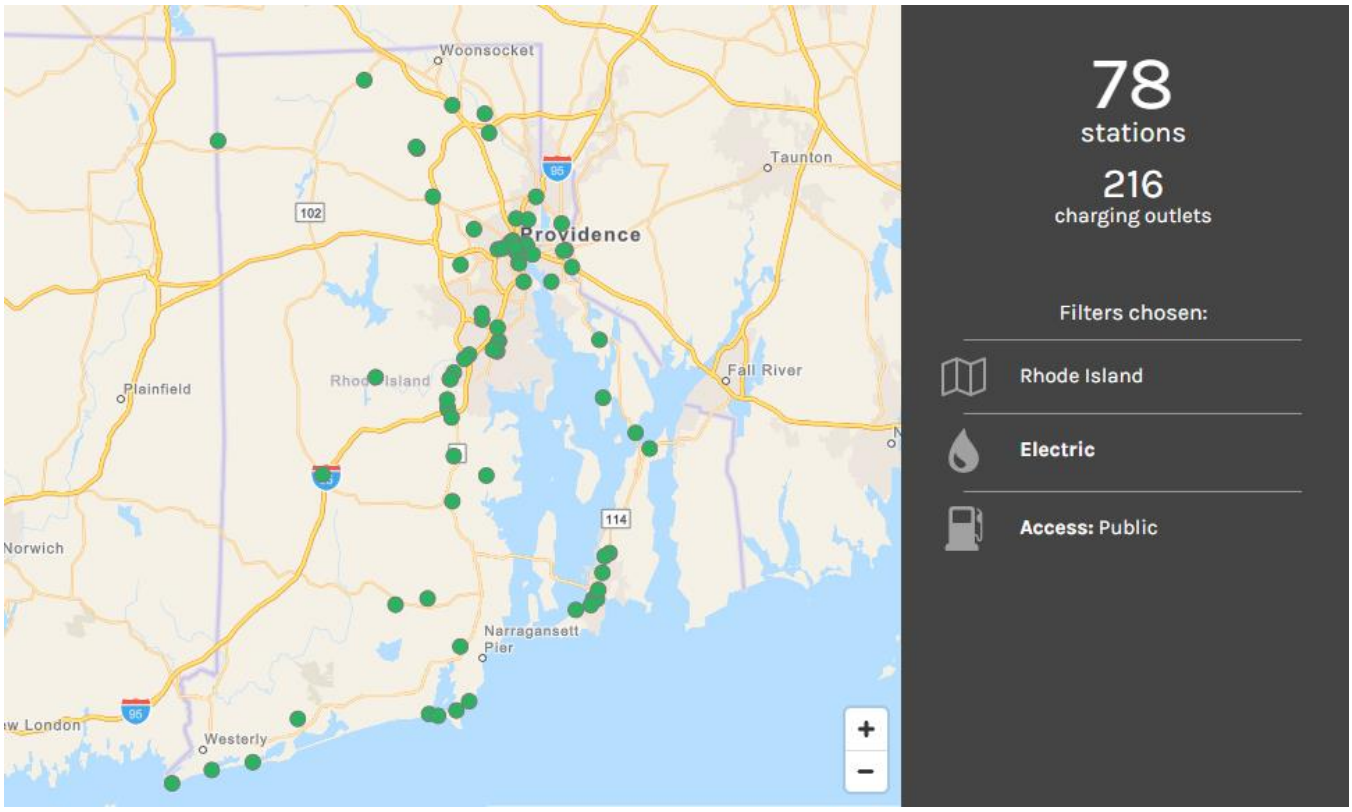
EV charging stations located along I-93 near Concord and Lincoln, I-95 near Portsmouth and I-293 near Manchester. New Hampshire has three (3) Level-1 stations, 81 Level-2 stations, and 10 DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[1]

Rhode Island

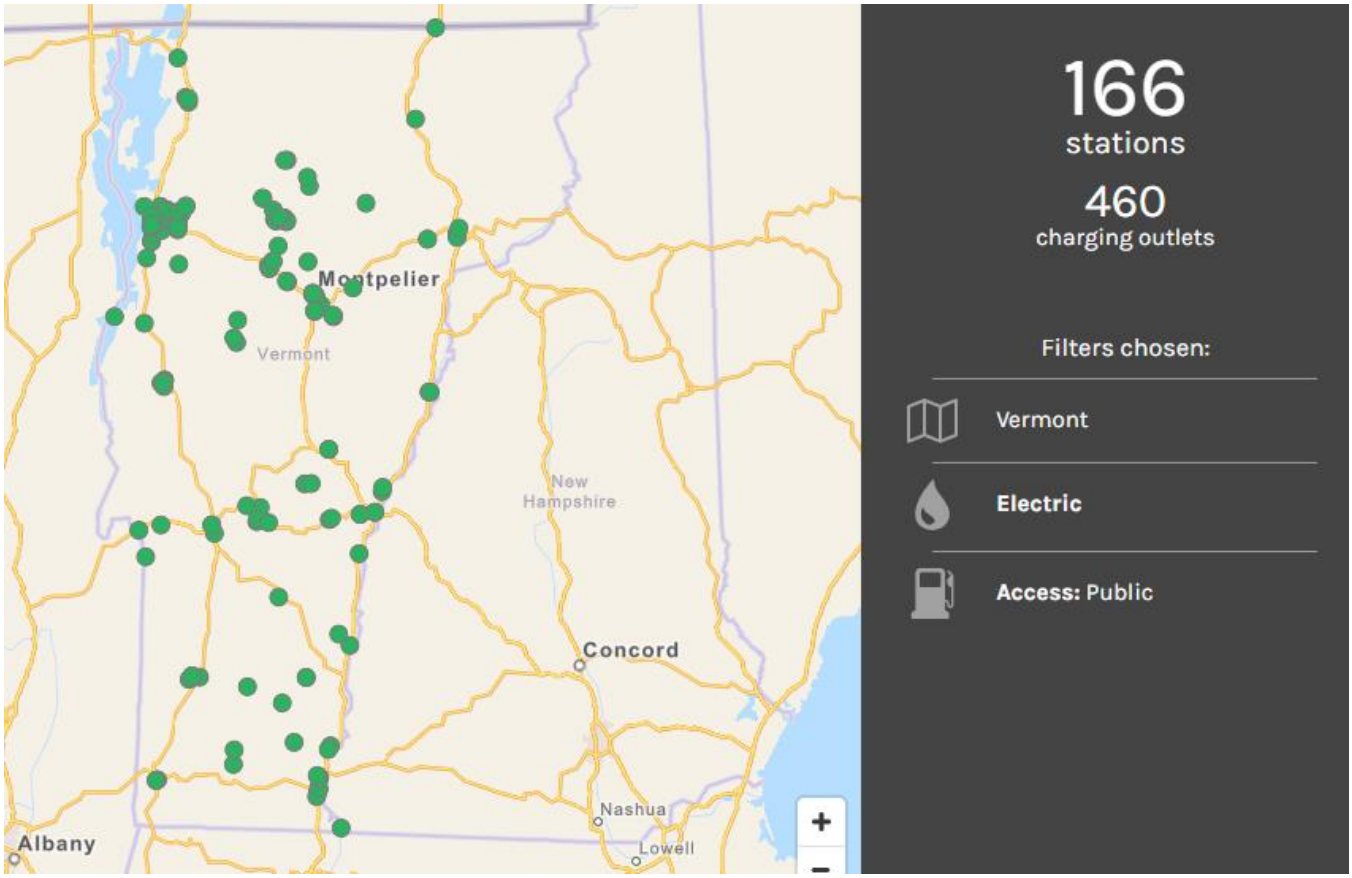
EV charging stations located near Providence. Significant gap is apparent along I-95 towards the Connecticut border. Rhode Island has three (3) Level-1 stations, 71 Level-2 stations, and eight (8) DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[1]

Vermont

Extensive EV charging station coverage along I-89 near Montpelier and Burlington, stations also located along I-91 from the Massachusetts border to the Canadian border. Vermont has 10 Level-1 stations, 139 Level-2 stations, and 23 DC-Fast charging stations.



Source: U.S. Department of Energy Alternative Fuels Data Center (August 2018)[1]

[i] U.S. Department of Energy. Alternative Fuels Data Center – Alternative Fueling Station Locator. https://www.afdc.energy.gov/stations/#/find/nearest. August 2018.

Appendix D: Additional Relevant Studies and Reports

Name	Author(s)	Year	Link
Report of the Massachusetts Autonomous Vehicles Working Group	Massachusetts Autonomous Vehicles Working Group	2018	https://www.mass.gov/files/documents/2018/09/12/DraftReport_AV_WorkingGroup.pdf
Preparing for Automated Vehicles: Traffic Safety Issues for States	Governors Highway Safety Association	2018	https://www.ghsa.org/sites/default/files/2018-08/Final_AVs2018.pdf
Smart Transport for Cities and Nations: The Rise of Self-Driving and Connected Vehicles	University of Texas at Austin	2018	https://www.caee.utexas.edu/prof/kockelman/public_html/CAV_Book2018.pdf
Issues in Autonomous Vehicle Deployment	Congressional Research Service	2018	https://fas.org/sgp/crs/misc/R44940.pdf
Driver Assistive Truck Platooning: Considerations for Florida State Agencies	University of Florida	2018	http://www.fdot.gov/legislative/documents/datp.pdf
Cybersecurity Literature Review and Efforts Report	Southwest Research Institute	2018	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP03-127_Cybersecurity_Literature_Review.pdf
Connected and Autonomous Vehicles in Ontario: Implications for Data Access, Ownership, Privacy and Security	Deloitte	2018	https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/consulting/ca-EN-CVAV-Research-Final-Data-Privacy-Security-Report-20180425-AODA.PDF
Implementation Recommendations for Management Procedures for Data Collected via CAV	Center for Automotive Research	2018	https://www.cargroup.org/wp-content/uploads/2018/07/A3_Implementation_Recommendations_for_Management_Procedures_25May2018.pdf
Autonomous Shuttle Testing in Winter Weather Conditions	AECOM & WSB	2018	http://www.dot.state.mn.us/automated/bus/finalreport.pdf
Opportunities to Encourage On-Road Connected and Automated Vehicle Testing	Center for Automotive Research	2018	https://www.cargroup.org/wp-content/uploads/2018/05/Opportunities-to-Encourage-OnRoad-CAV-Testing_Saginaw.pdf

Name	Author(s)	Year	Link
Strategies to Advance Automated and Connected Vehicles: A Primer for State and Local Decision Makers	Texas A&M Transportation Institute	2017	https://orfe.princeton.edu/~alaink/SmartDrivingCars/Videos/AV-CV%20policy_021017KornhauserComments.pdf
Social and Behavioral Questions Associated with Automated Vehicles: A Literature Review	UCL Transport Institute	2017	https://www.ucl.ac.uk/transport-institute/pdfs/social-and-behavioural-literature-review.pdf
An Assessment of Autonomous Vehicles: Traffic Impacts and Infrastructure Needs	University of Texas at Austin	2017	https://library.ctr.utexas.edu/ctr-publications/0-6847-1.pdf
Automated Driving Systems 2.0: A Vision for Safety	NHTSA	2017	https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf
Taming the Autonomous Vehicle: A Primer for Cities	Bloomberg Philanthropies	2017	https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDF.pdf
Driverless Future: A Policy Roadmap for City Leaders	ARCADIS	2017	https://driverlessfuture.webflow.io/
Autonomous and Connected Vehicles: Navigating the Legal Issues	Allen & Overy	2017	http://www.allenovery.com/SiteCollectionDocuments/Autonomous-and-connected-vehicles.pdf
Driving to Safety: How Many Miles of Driving Would it Take to Demonstrate AV Reliability?	RAND Corporation	2016	https://www.rand.org/content/dam/rand/pubs/research_reports/RR1400/RR1478/RAND_RR1478.pdf
Autonomous Vehicle Technology: A Guide for Policymakers	RAND Corporation	2016	https://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR443-2/RAND_RR443-2.pdf
Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations	University of Utah	2018	https://doi.org/10.1016/j.tra.2015.04.003

Appendix E: Workshop Attendees

Last Name	First Name	Organization	Email	TAC	PI
Aguilar	Kara	MaineDOT	Kara.a.aguilar@maine.gov	●	
Calcaterra	Peter	CTDOT	Peter.Calcaterra@ct.gov	●	
Chaffee	Chris	AECOM	Chris.Chaffee@aecom.com		●
Cotter	Pam	RIDOT	Pamela.Cotter@dot.ri.gov		
Danh	Kevin	CTDOT	kevin.danh@ct.gov		
Decker	Hal	CTDOT	harold.decker@ct.gov		
Dowds	Jon	UVM	jdowds@uvm.edu		
Elovirta	William "Jake"	VT DMV	william.elovirta@vermont.gov		
Geanuracos	Sharon	CT DMV	sharon.geanuracos@ct.gov		
Gold	Julia	RIDOT	Julia.Gold@dot.ri.gov	●	
Gunn	Sally	NHDOT	Sally.Gunn@dot.nh.gov		
Jackson	Eric	UConn	eric.d.jackson@uconn.edu		
Klasen	Susan	NHDOT	Susan.Klasen@dot.nh.gov	●	
Koopmann	Jonathan	USDOT Volpe Center	jonathan.koopmann@dot.gov		
Lieu	Chan	Venable LLP	cdlieu@venable.com		
Lorrimer	Luke	MaineDOT	luke.a.lorrimer@maine.gov		
Makuch	Mark	CTDOT	mark.makuch@ct.gov		
Murtha	Suzanne	AECOM	Suzanne.Murtha@aecom.com		●
O'Brien	Parker	MaineDOT	parker.obrien@maine.gov		
Parkany	Emily	VTrans	Emily.Parkany@vermont.gov	●	
Parker	Marygrace	I-95 Corridor Coalition	mgparker@i95coalition.org		
Pittman	Laz	CTDOT	lazarus.pittman@ct.gov		
Rolfe	Mark	CTDOT	mark.rolfe@ct.gov		
Segale	Joe	VTrans	joe.segale@vermont.gov	●	
Sullivan	Daniel	MassDOT	Daniel.a.sullivan@dot.state.ma.us	●	
Thomson	Herb	MaineDOT	herb.thomson@maine.gov		
White	Robert	VTrans	robert.t.white@vermont.gov		
Zicconi	John	VTrans	john.zicconi@vermont.gov		

Appendix F: State Initiatives

This report is focused on how states can act as a region to capitalize on CV/AV opportunities. Over the course of the research, interviews, and discussions, many initiatives were identified that states should consider undertaking individually to better prepare themselves for CV/AVs and will better prepare the region for larger collaborative initiatives in the future. This list is not exhaustive and can be used as a tool for states to enhance their action plans.

CV/AV Committee

1. Ensure the state's CV/AV committee is meeting regularly, communicating with relevant stakeholders, hosting experts, and forwarding the state's CV/AV program
2. Ensure all pertinent stakeholders are represented on the committee
3. Develop the state's mission, goals, and objectives
4. Create committee support materials that present pertinent information in a simple format, such as a 1-page flyer, for stakeholder engagement and executive buy-in
5. Develop a CV/AV strategic plan including policy, projects, and other initiatives
6. Identify organization changes needed to accommodate transportation agency CV/AV initiatives
7. Consider joining the CV Pooled Fund Study

Legal/Regulatory

1. Create incentives/requirements for electric vehicles and charging stations
2. Develop policy on vehicle occupancy, especially zero-occupancy AVs
3. Determine law enforcement policy and procedures
4. Create policy and regulations for ride-hailing AVs

Infrastructure

1. Conduct an infrastructure assessment to determine CV/AV readiness
2. Determine communication gaps and develop a plan for connecting priority links
3. Deploy RSUs at traffic signals transmitting signal phase and timing data
4. Deploy RSUs along limited-access highways transmitting BSMs
5. Consider participating in the Signal, Phasing and Timing (SPaT) Challenge

Operations

1. Re-define the roles and responsibilities of the HOC/TMC in regards to CV/AV
2. Incorporate CV technologies in work zones
3. Investigate tolling applications (where appropriate)
4. Investigate transit signal priority applications (where appropriate)

Data/Technology

1. Conduct an assessment of existing data storage, management, and sharing to determine where and how CV/AV data will be incorporated
2. Create a system to keep necessary records of CV/AV data for legal compliance and to limit liability exposure

3. Create requirements for CV/AV cyber security

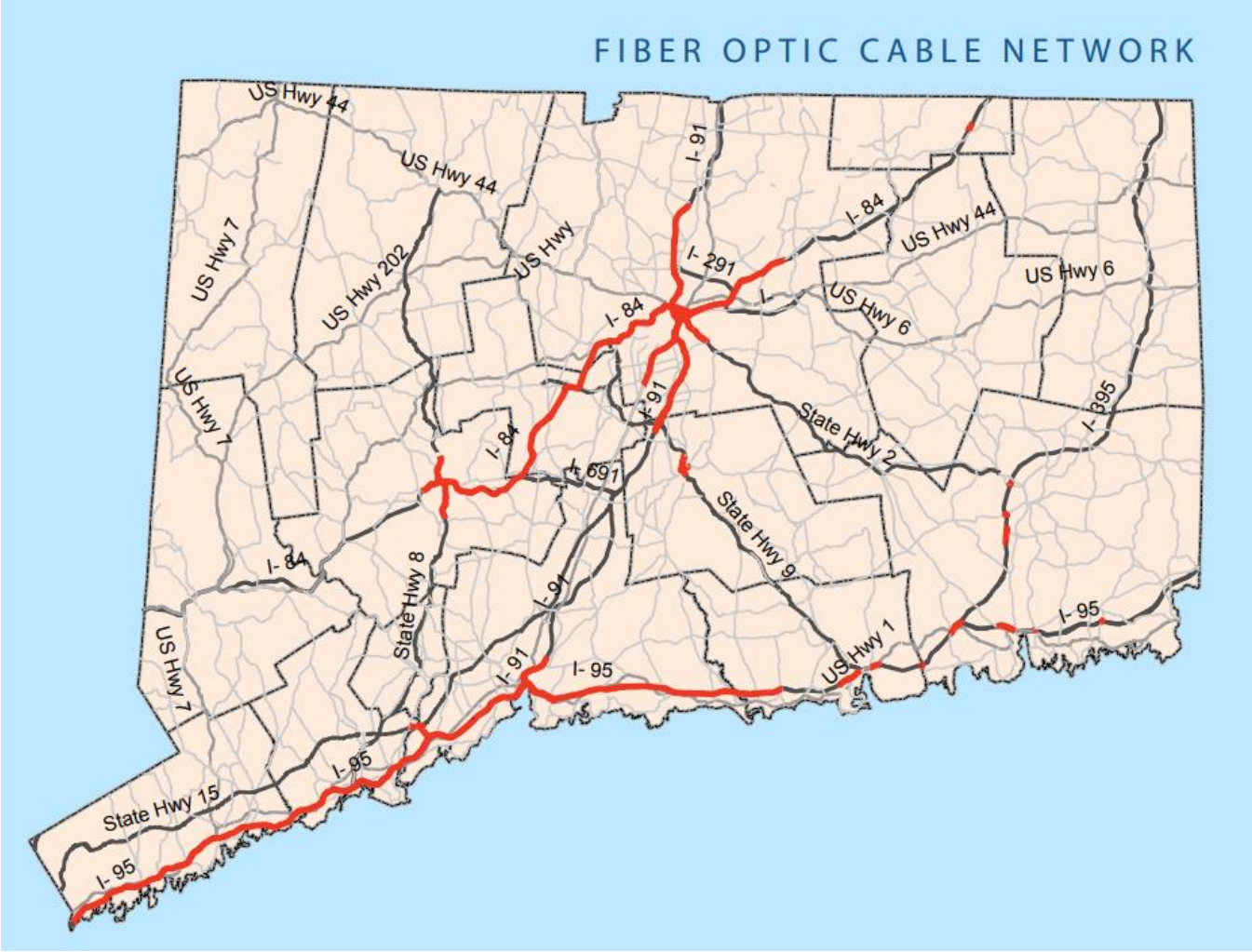
AV Pilot Testing

1. Make agreements with OEMs to test vehicles on roadways, as appropriate
2. Determine testing approach, conditions, phases, and approved domain/roadways
3. Engage in transit vehicle testing to encourage shared-use mobility
4. Engage in truck platooning testing to encourage safer and more efficient freight travel
5. Engage in paratransit vehicle testing to increase mobility for elderly and disabled passengers

Appendix G: Communications Maps

Connecticut

There is extensive fiber coverage on I-95 from the New York Border to New Haven and on I-84 and I-91 near Hartford.



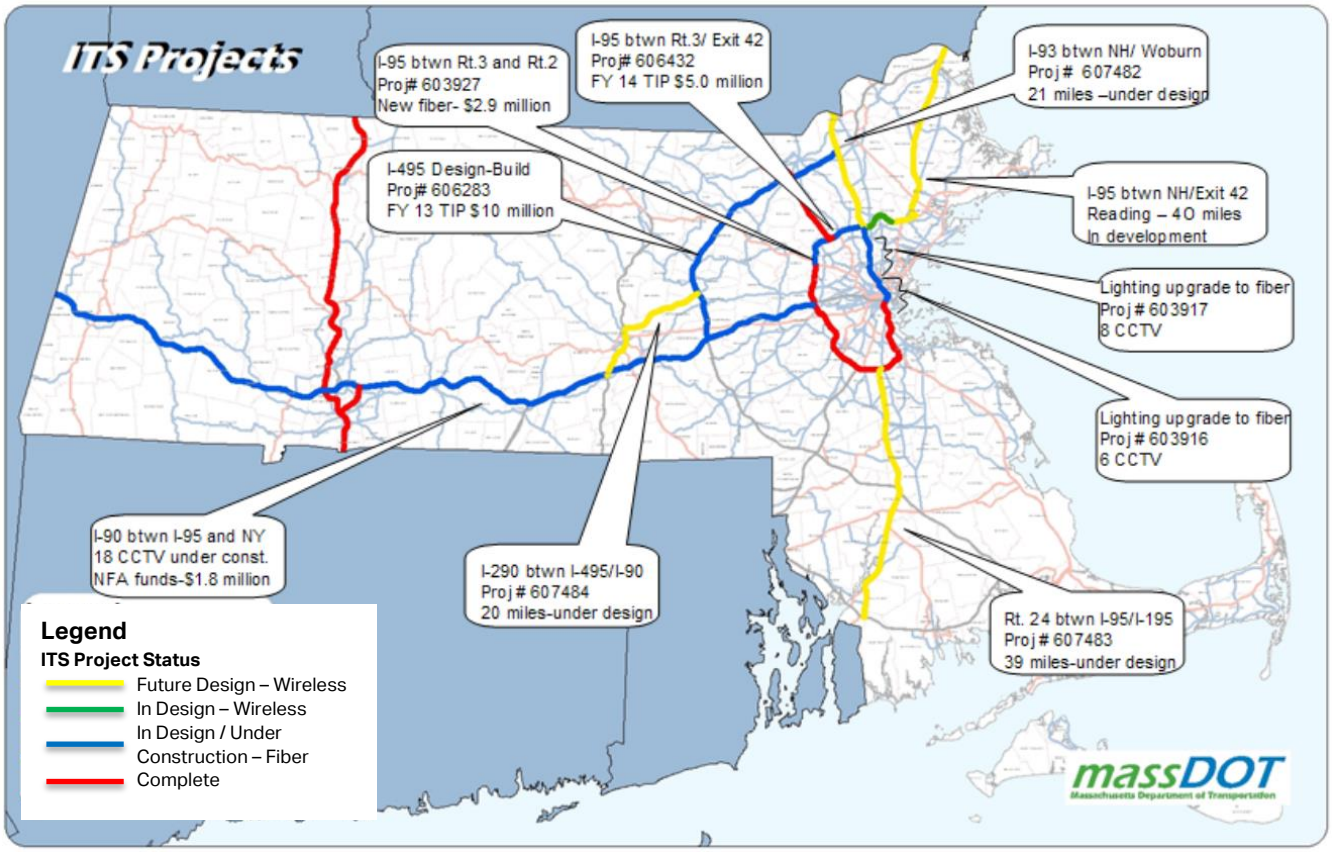
Source: ATMS Needs Assessment (2013)

Maine

Maine DOT does not have a communications map.

Massachusetts

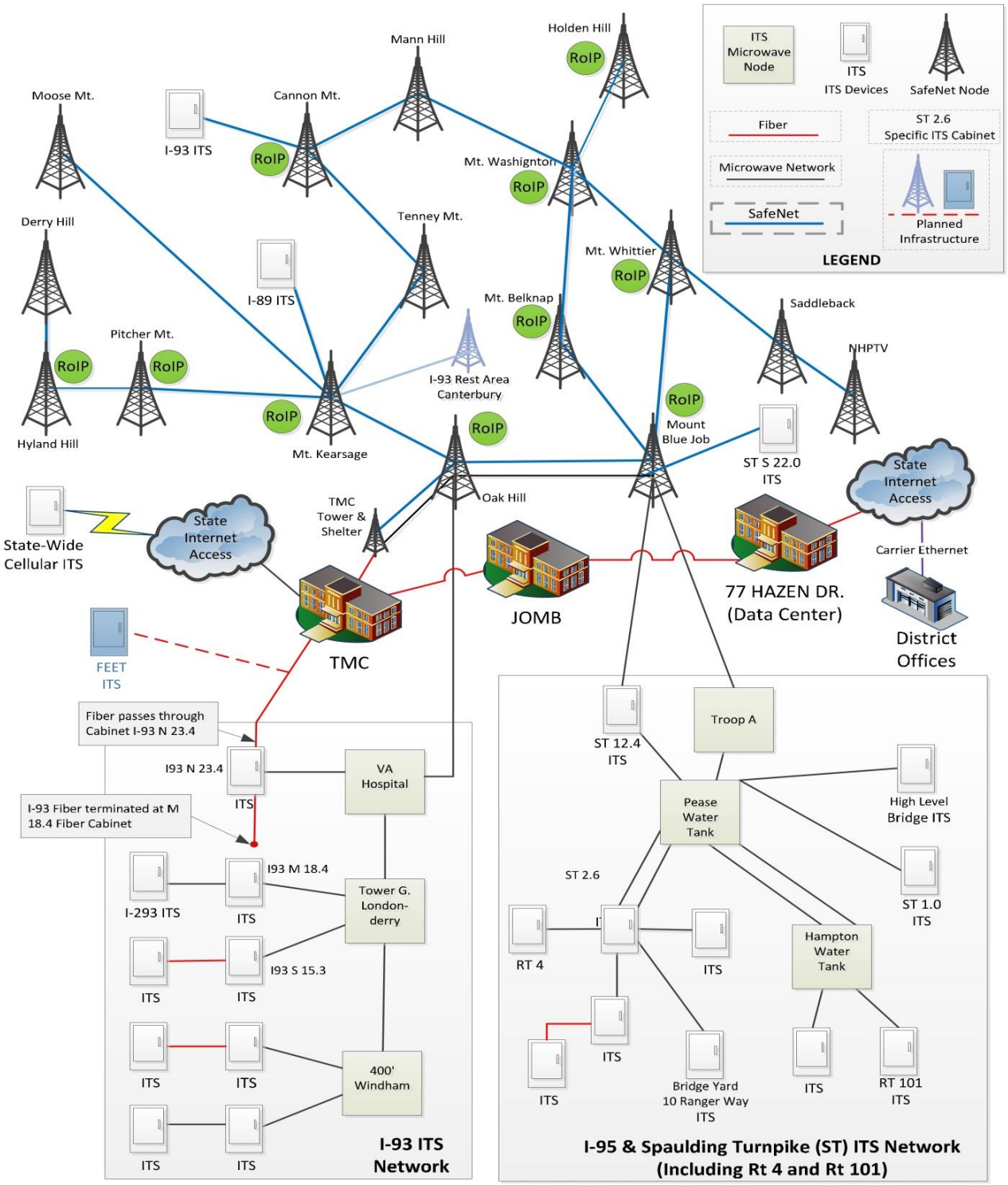
There is extensive fiber coverage (in design/under construction) on I-90 from the New York Border to Boston and on I-91 to the New Hampshire and Connecticut borders.



Source: ITS Status Report (2014)

New Hampshire

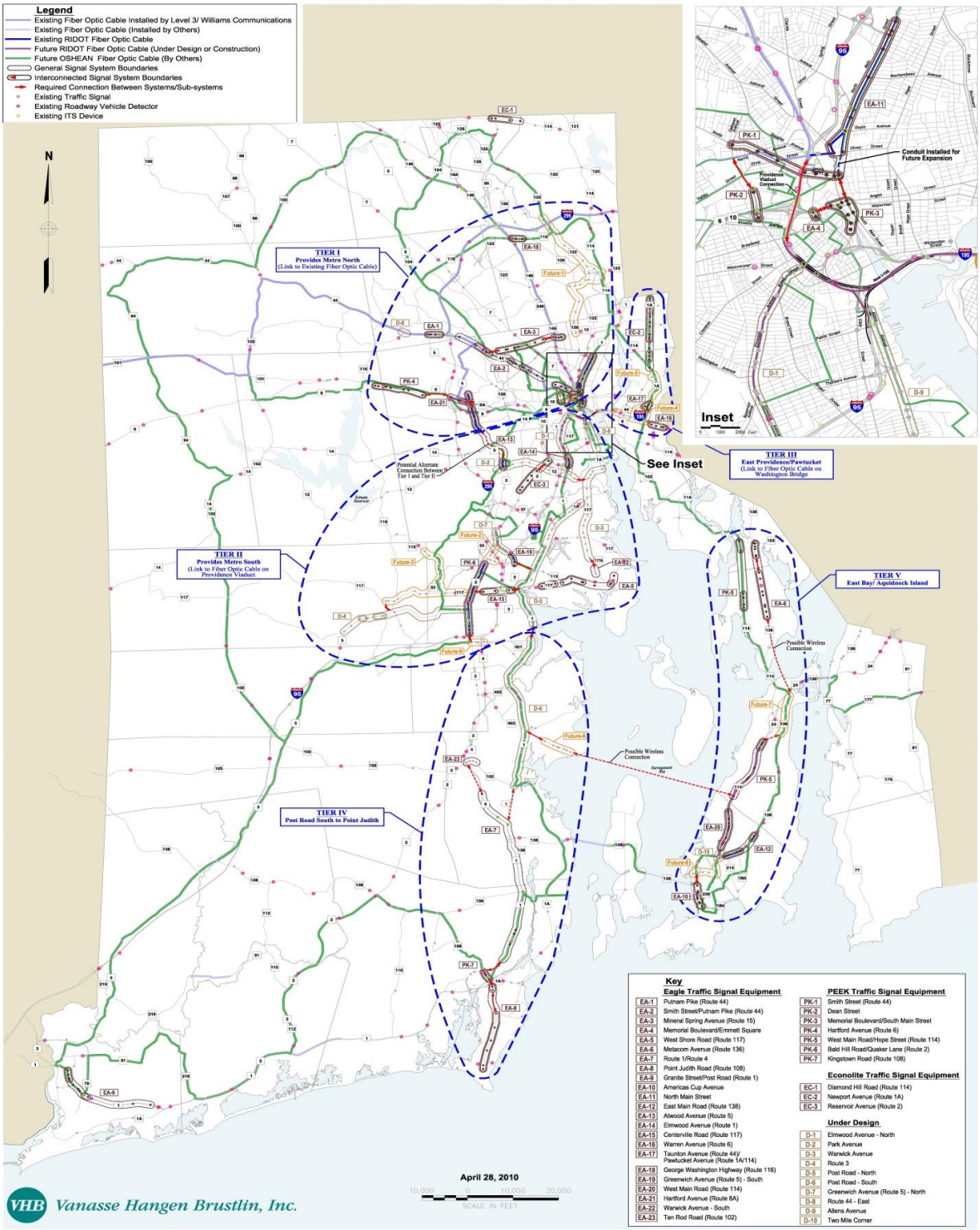
There is existing fiber coverage along I-93 from Concord to Manchester and an extension is under construction to the Massachusetts Border.



Source: DRAFT Communications Master Plan (2018)

Rhode Island

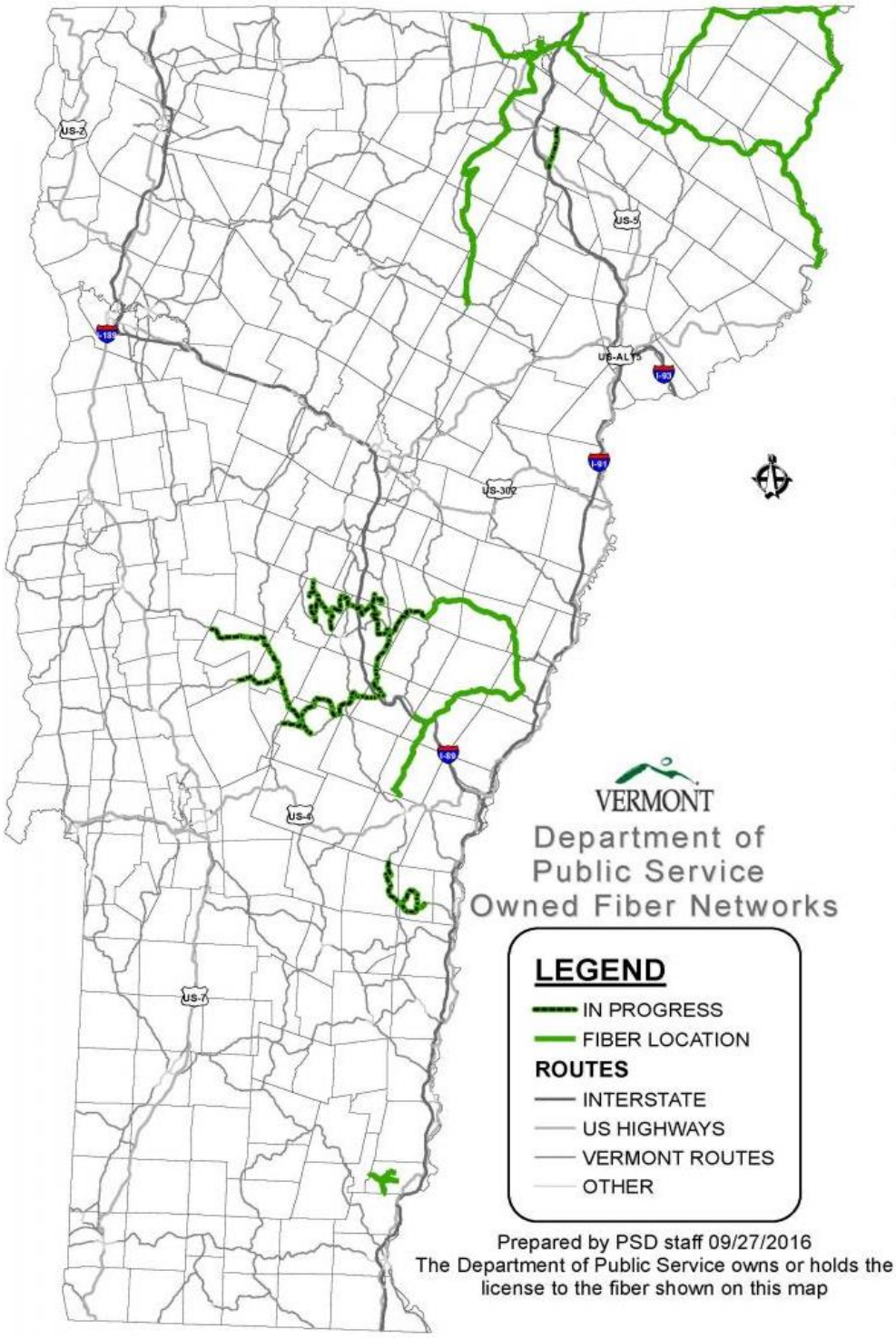
There is existing fiber coverage on I-295 from the Massachusetts Border to Providence, future coverage is planned for I-95 and other State and U.S. highways.



Source: RIDOT Arterial Traffic Signal Systems Fiber Optic Network Vision (2010)

Vermont

There is no existing or planned fiber coverage on I-89, I-91 or I-93. A patchwork of fiber interconnect exists on some State and U.S. routes near Montpelier and the North East New Hampshire Border.



Source: Vermont Department of Public Service (2016)

New England Cellular Coverage

Various online resources are available for providing cellular coverage maps. Two detailed sources include:

- OpenSignal - https://opensignal.com/networks
- Federal Communications Commission - https://www.fcc.gov/reports-research/maps/