

CAT Coalition (V2I Deployment Coalition Phase 2)
Technical Resources Working Group

White Paper: CAV Resources

Version 2.0

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1. Executive Summary

The Cooperative Automated Transportation (CAT) Coalition is a collaborative effort supported by United States Department of Transportation (USDOT), American Association of State Highway and Transportation Officials (AASHTO), Institution of Transportation Engineers (ITE), and Intelligent Transportation Society of America (ITS America) that includes broad participation in both public and private sectors to promote connected and automated vehicle initiatives and research. The Technical Resources Working Group (WG) is one of three WGs in the CAT Coalition and provides review, input, and analysis of developed connected and automated vehicle (CAV) documentation, tools, products, and resources, such as deployment guidance. The WG also focuses on the identification of CAV gaps regarding resource needs and institutional challenges, such as workforce development.

An action item identified for the Technical Resources WG was the development of a white paper to document CAV resources that have been developed or are currently being developed to help practitioners more easily identify all available documents to assist in deployments and also identify resource gaps. This white paper was initiated based on an identified need to consolidate information about available CAV resources developed by a variety of stakeholders into a single document for practitioners to more easily access. Given the expected publication of a Connected Vehicle Resources White Paper in coming months that accomplishes this, as part of the USDOT Connected Vehicle Outreach Plan and Website effort, the focus of this white paper summarizes projects and products reviewed or being tracked by this WG in order to minimize duplication of activities.

Contents of this Document

This document is a white paper developed by the Technical Resources WG to document CAV resources. Following this Executive Summary, the remainder of the document presents a background on the Technical Resources WG in [Chapter 2](#) and documents identified CAV resources in [Chapter 3](#), including those that have been reviewed, are of interest, or are being tracked by this WG. Finally, identified CAV Resource Gaps are identified in [Chapter 4](#).

2. Technical Resources Working Group Background

The Cooperative Automated Transportation (CAT) Coalition is a collaborative effort supported by United States Department of Transportation (USDOT), American Association of State Highway and Transportation Officials (AASHTO), Institution of Transportation Engineers (ITE), and Intelligent Transportation Society of America (ITS America) that includes broad participation in both public and private sectors to promote connected and automated vehicle initiatives and research. Previously known as the Vehicle-to-Infrastructure Deployment Coalition (V2I DC), the CAT Coalition focus has evolved in Phase 2 of the V2I DC to also cover broader issues related to both connected and automated vehicle (CAV) technologies. Three working groups (WGs) collaborate as a larger community to advance CAV technology in a variety of ways, as illustrated in Figure 1.

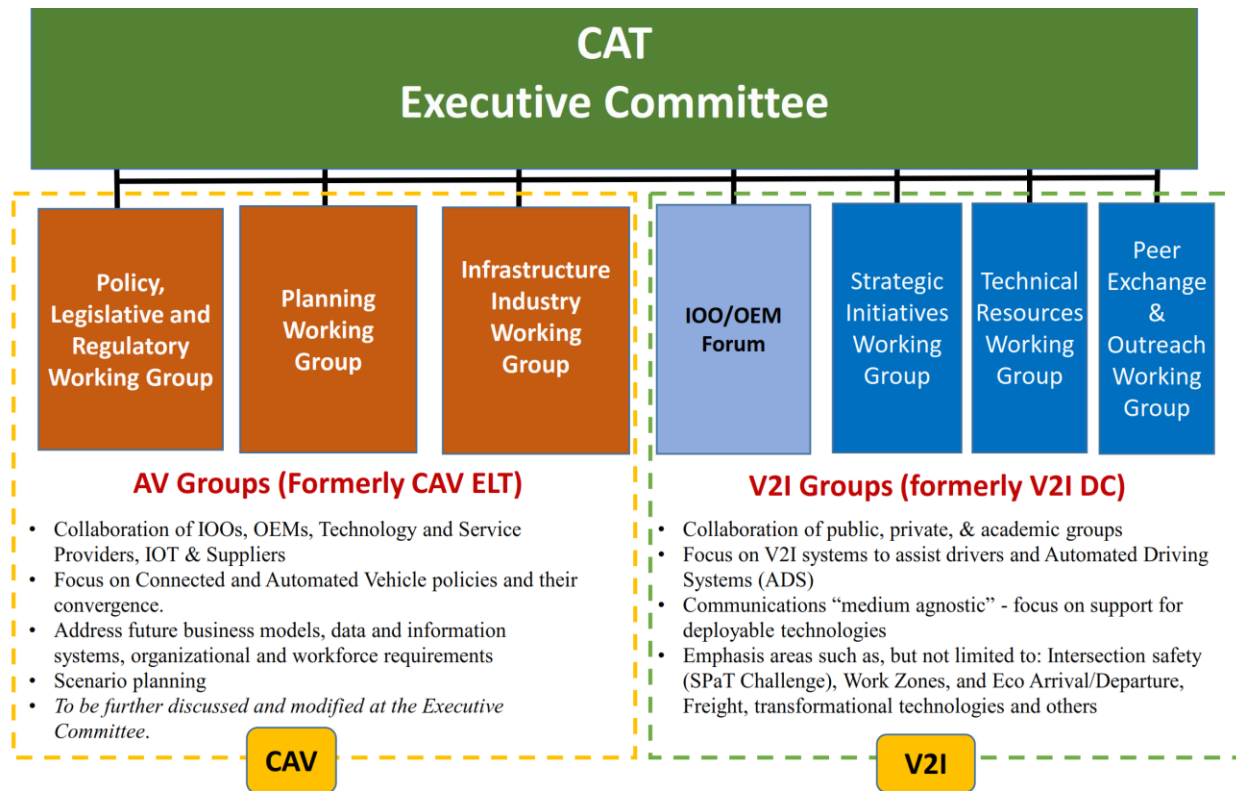


Figure 1. Cooperative Automated Transportation (CAT) Coalition Structure.

The Technical Resources Working Group (WG) is one of six WGs in the CAT Coalition. Note that this WG was previously identified as Technical Working Group 4: Deployment Guidance in the V2I DC. The Technical Resources WG provides review, input, and analysis of developed CAV documentation, tools, products, and resources, such as deployment guidance and Infrastructure Owner Operator - Original Equipment Manufacturer (IOO-OEM) Forum outcomes. The WG also focuses on the identification of CAV gaps regarding resource needs and institutional challenges, such as workforce development. This WG meets monthly on the second Wednesday of the month at 11:00AM Eastern Time. The Technical Resources WG includes over 100 individuals from USDOT, state and local departments of transportation (DOTs), Transport Canada, research and academia, industry, and consultants, as shown in Figure 2, and is chaired by Faisal Saleem of the Maricopa County DOT and co-chaired by Navin Katta of Savari, Inc.

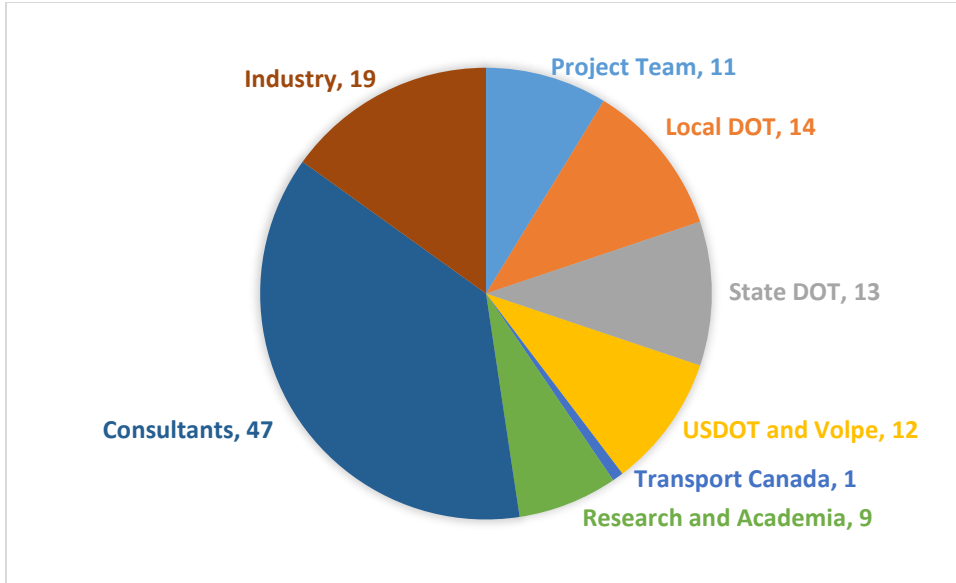


Figure 2. Technical Resources Working Group membership.

See [Appendix A](#) for a full roster of the Technical Resources Working Group distribution list, as of December 5, 2018.

3. Identified Connected and Automated Vehicle (CAV) Resources

This chapter identifies CAV resources that have been reviewed by the Technical Resources Working Group (WG). This white paper was initiated based on an identified need to consolidate information about available CAV resources developed by a variety of stakeholders into a single document for practitioners to more easily access. In addition, it is expected that this white paper will assist in the identification of Resource Gaps, which are identified in [Chapter 4](#). Given the expected publication of the USDOT Connected Vehicle Resources White Paper that accomplishes this, as part of the Connected Vehicle Outreach Plan and Website effort, the focus of this white paper summarizes projects and products reviewed or being tracked by this WG in order to minimize duplication of activities.

3.1 Project and Products Reviewed by the Technical Resources Working Group

Table 1 shows specific projects and products recently presented for review and input to the Technical Resources WG. Table 2 identifies the projects and products reviewed by this WG, then known as TWG 4: Guidance, during Phase 1 of the Vehicle-to-Infrastructure Deployment Coalition (V2I DC).

Table 1. Efforts Reviewed by the Technical Resources Working Group under the Cooperative Automated Transportation (CAT) Coalition (Phase 2 of the Vehicle-to-Infrastructure Deployment Coalition [V2I DC]).

Lead Stakeholder	Projects, Products, Topics Reviewed	Date of Review
United States Department of Transportation (USDOT)	MAP Creation Tool	6/2018
	Security Credential Management System (SCMS) Update	8/2018
	AV Policy 3.0	11/2018
	CARMA Platform	11/2018
Cooperative Automated Transportation (CAT) Coalition	DSRC Deployment Summary Document	5/2018
	Connected Fleet Challenge: Background	5/2018
	SPaT (Signal Phase and Timing) Challenge: Procurement Resource	5/2018
	SPaT (Signal Phase and Timing) Challenge: Cost Estimate Resource	5/2018
	Resources WG White Papers on Lessons Learned and CAV Resources	7/2018, 10/2018
Crash Avoidance Metrics Partnership (CAMP)	MAP Creation Tool for Work Zones	6/2018
NOCoe	Proposed CV deployment site self-reporting on website	7/2018
Colorado DOT	Colorado DOT and Panasonic partnership and DSRC + C-V2X deployment	8/2018
Equipment Manufacturer	Considerations and lessons learned for deploying and integrating roadside units	9/2018
Other	Tool for Agency Self-Evaluation of Capabilities to Develop a CAT Program	10/2018

Table 2. Efforts Reviewed by the Technical Resources Working Group, then known as TWG 4: Guidance, in Phase 1 of the Vehicle-to-Infrastructure Deployment Coalition (V2I DC).

Stakeholder	Projects or Products Reviewed	Date of Review
United States Department of Transportation (USDOT)	V2I Benefits Tool Framework	2/2017
	V2I Deployment Guidance	1/2017; 6/2015
	Data Policy Playbook	12/2016
	Deployment Installation Checklist and V2I Hub	11/2016
	V2I Deployment Guidance Product: Connected Vehicles and the Planning Process	8/2016; 4/2016
	V2I Deployment Guidance Product: V2I Message Lexicon	7/2016
	V2I Deployment Guidance Product: Pre-Deployment Guidance	6/2016; 5/2016
	V2I Outreach Plan and Website	4/2016; 2/2016; 10/2015
	V2I Deployment Guidance Product: Near-Term Transition and Phasing	4/2016
Vehicle-to-Infrastructure Deployment Coalition (V2I DC)	Federal V2I Policy Statement	1/2016
Connected Vehicle Pooled Fund Study (CV PFS)	Ongoing activities and CVRIA Outreach	11/2015

3.2 Efforts of Interest Tracked by the Technical Resources Working Group

Error! Not a valid bookmark self-reference. identifies the projects and products of interest that are being tracked by this WG for possible presentation during a Technical Resources WG monthly meeting at a future date.

Table 3. Efforts of Interest Being Tracked by the Technical Resources Working Group for Possible Review.

Stakeholder	Projects Underway or Products Developed
United States Department of Transportation (USDOT)	<ul style="list-style-type: none"> • Connected Vehicle Resources Website and White Paper • Connected Vehicle Pilots - progress updates • Security Credential Management System (SCMS) • V2I Products to support deployment • Turner-Fairbank Research Projects • CVRIA Implementation • Agency Capabilities for V2I - workforce and collaboration • Roadside Unit (RSU) Certification activities • Guidelines for Applying Capability Maturity Model Analysis to CAV Deployment • National Dialogue on Highway Automation • CAV data exchange and governance
Cooperative Automated Transportation (CAT) Coalition	<ul style="list-style-type: none"> • SPaT Challenge and Connected Fleet Challenge Resources • Other documents developed by other WGs
Transportation Research Board (TRB) / National Cooperative Highway Research Program (NCHRP)	<ul style="list-style-type: none"> • Impacts of Connected Vehicles and Automated Vehicles on State and Local Agencies • Business Models to Facilitate Deployment of CV Infrastructure to Support AV Operations NCHRP Project 20-102(12) • Other Efforts
Infrastructure Owner Operator-Original Equipment Manufacturer (IOO-OEM) Forum, Crash Avoidance Metrics Partnership (CAMP)	<ul style="list-style-type: none"> • RSZW-LC Model Concept of Operations • TOSCo
Connected Vehicle Pooled Fund Study (CV PFS)	<ul style="list-style-type: none"> • Basic Infrastructure Message (BIM) • MMITSS 3, which includes connected traffic signals + ramp meters • V2I queue warning • IOO framework for information to third-party V2I services
National Transportation Communications Information Protocol (NTCIP)	<ul style="list-style-type: none"> • NTCIP 1218 (RSU monitoring and information exchange with control management stations) • NTCIP 1219
Other topics of interest	<ul style="list-style-type: none"> • How vendors and industry see the ecosystem changing, the impact of automation on connectivity, and how agencies can prepare

3.3 Status of Technical Resources to Support Priority Applications

To help accelerate V2I deployments that support passenger vehicles, freight, emergency vehicles and transit in both urban and rural areas, the Coalition previously have agreed the initial focus should be on:

1. Intersections (signalized & unsignalized)
2. End of queue warnings
3. Work zone management
4. Curve warning systems

As such, Table 4 presents resources identified by the Technical Resources WG that can be used by agencies to develop and deploy CV applications related to these areas.

These tables do not present a comprehensive list of all relevant CAV projects and products. This white paper is expected to be a working document such that additional project and products will be added to these tables as they are identified.

Table 4. Resources identified by the Technical Resources Working Group to support CAV deployments in the identified high-priority areas.

Topic Area	Document	Published By	Year
<i>Intersections (Signalized and Unsignalized)</i>			
Signal Phase and Timing (SPaT)	Implementation Guide	CAT Coalition	2017
	Guidelines for Selecting Corridors	CAT Coalition	2016
	Infrastructure System Model Concept of Operations	CAT Coalition	2018
	Infrastructure System Model Requirements	CAT Coalition	2018
	Procurement Resource with Sample Bid Specifications	CAT Coalition	2018
Multi-Modal Intelligent Traffic Signal System (MMITSS) - Intelligent Traffic Signal System (I-SIG) - Transit Signal Priority (TSP) - Freight Signal Priority (FSP) - Mobile Accessible Pedestrian Signal System (PED-SIG) - Emergency Vehicle Preemption (PREEMPT)	Concept of Operations	USDOT/CV PFS	2012
	System Requirements	USDOT/CV PFS	2012
	System Design	USDOT/CV PFS	2013
	Deployment and Field Test Plan	USDOT/CV PFS	2013
	Impacts Assessment	USDOT	2015
	Policy and Institutional Issues	USDOT	2015
	System Development, Deployment, and Field Test Report (Arizona and California)	USDOT/CV PFS	2016
	California System Design	CV PFS	2016
	Arizona Application Source Code and Documentation	USDOT/CV PFS	2015
	California Application Source Code and Documentation	USDOT/CV PFS	2017
	Deployment Readiness Enhancements (in progress)	CV PFS	
Red Light Violation Warning (RLVW)	Concept of Operations	USDOT	2012
	System Requirements	USDOT	2012
	Performance Requirements	USDOT	2015
Stop Sign Gap Assist (SSGA)	Concept of Operations	USDOT	2012

Topic Area	Document	Published By	Year
	System Requirements	USDOT	2012
	Performance Requirements	USDOT	2015
Stop Sign Violation Warning (SSVW)	Concept of Operations	USDOT	2013
Pedestrian in Crosswalk Warning - Transit Retrofit Package (TRP)	Concept of Operations	USDOT	2014
	Application Requirements	USDOT	2014
	Architecture and Design Specifications	USDOT	2014
<i>End of Queue Warnings</i>			
Intelligent Network Flow Optimization (INFLO)	Concept Development and Needs Assessment of Prior and Ongoing Research	USDOT	2012
	Concept of Operations	USDOT	2012
	Source Code	USDOT	2015
	Functional and Performance Requirements, and High-Level Data and Communication Needs	USDOT	2012
	Test Readiness Assessment	USDOT	2012
	Queue Warning Algorithm Design Report	USDOT	2014
	Prototype System Design	USDOT	2014
	Prototype Architecture Description	USDOT	2014
	Policy and Institutional Issues	USDOT	2014
	Detailed Requirements for Prototype	USDOT	2013
	Prototype Acceptance Test Summary	USDOT	2015
	Prototype Small-Scale Demonstration Plan	USDOT	2015
	End-of-Project Technical Report	USDOT	2015
	Impacts Assessment Report	USDOT	2015
	Prototype Small-Scale Demonstration Report	USDOT	2015
	V2I Queue Advisory / Warning Project	USDOT/CV PFS	
<i>Work Zones</i>			
Reduced Speed Zone Warning with Lane Closure (RSZW-LC)	Infrastructure System Concept of Operations (in progress)	CAT Coalition	
	Concept of Operations	USDOT	2013
	System Requirements	USDOT	2013
	Performance Requirements	USDOT	2015
<i>Curve Warning Systems</i>			
Curve Speed Warning (CSW)	Concept of Operations	USDOT	2012
	System Requirements	USDOT	2012
	Performance Requirements	USDOT	2015
<i>General</i>			
MAP Message Creation	Best Practices for Surveying and Mapping Roadways and Intersections for CV Applications	CV PFS	2016
	MAP Creator Tool for Intersections	USDOT	2018
	MAP Creator Tool for Work Zones (in progress)	CAMP	

Topic Area	Document	Published By	Year
DSRC Licensing	Recommended Practices - Summary	CAT Coalition	2018
	Recommended-Practices - Full Report	USDOT	2015
DSRC and C-V2X Comparison Testing	V2X Functional and Performance Test Report; Test Procedures and Results	5GAA	2018
C-V2X Resources	V2X Cellular Solutions	5GAmericas	2016
	White Paper on Vehicle-To-Everything (V2X)	NGMN	2018
	Cellular V2X Communications Towards 5G	5GAmericas	2018
	C-V2X Workshop for North American Transportation Planning and North American Road Operators in Washington, DC	5GAA	2018
	Ford, Panasonic, Qualcomm Technologies, and the Colorado DOT C-V2X Testing	Qualcomm Technologies	2018
	5GAA Petition for Waiver to the FCC	5GAA	2018

4. Identified CAV Resource Gaps

Table 5 presents resource gaps that have been identified by the Resources WG members during monthly webinars.

Table 5. Resource Gaps identified by the Technical Resources Working Group.

Topic Area	Resource Gap	Current efforts?
General	SCMS (i.e. security)	-USDOT exploring ways to scale SCMS to a national level.
	Benefits / Business Case	-CV Pilots extensively documenting for USDOT; -Resources WG plans to contact sites and will document benefits; -Volpe is developing a framework for benefits analysis.
	CAV data on sites with high crash / near miss / emergency maneuver frequency	-None identified
	Troubleshooting	-None identified.
	Lessons Learned	-CV Pilots documenting this; -SPaT Challenge Webinars capture this; -Resources WG White Paper.
	As-built CAD files for MAP messages	-Possible collaboration with Turner-Fairbank and AASHTO Design Committee.
	Deployment Sites and Status	-NOCoE may have self-reporting on website for deployment sites; -Strategic Initiatives WG leading survey of SPaT deployment sites; -SPaT Challenge webinars contact deployments to present; -Resources WG plans to contact sites for lessons learned.
	Technology neutrality	-None identified; help agencies make procurement now that anticipates and more easily transfers to new, future technologies or communications.
	Technology adaptability	-None identified; help agencies procure technologies that can be updated, and understand firmware and software updates
	Scalability	-USDOT CV Pilot outcomes will inform the feasibility of scalability with current technologies and approaches
Interoperability	-USDOT CV Pilot Interoperability Report coming soon.	
General – All Focus Areas	Some ConOps and other documents are dated, and may need an update. As such it is a resource gap.	
<i>Intersections (Signalized and Unsignalized)</i>		
SPaT	Controller to RSU	-NTCIP 1202 v03 update in progress.
	Channelization standardization	-None identified; deploying agency makes determination for SRM and SSM based on their Concept of Operations and objectives.
	Next steps after SPaT Challenge	-Strategic Initiatives WG developing Connected Fleet Challenge as a follow-on activity for SPaT Challenge deployments.

Appendix A: Technical Resources Working Group Roster

Name	Organization	Business Email
Local Representatives		
1. Faisal Saleem (Chair)	Maricopa Co., AZ	faisalsaleem@mail.maricopa.gov ;
2. Blair Schlecter	Beverly Hills Chamber of Commerce	schlecter@beverlyhillschamber.com ;
3. Daniel Lai	City of Bellevue	dlai@bellevuewa.gov ;
4. Chris Henry	City of Eugene	chris.c.henry@ci.eugene.or.us ;
5. Joanna Wadsworth	City of Las Vegas	jwadsworth@lasvegasnevada.gov ;
6. Francois Thibodeau	City of Montreal	francois@thibodeau.com ;
7. David Lucas	City of Tempe	David_Lucas@tempe.gov ;
8. Hossam Abdel All	Macomb Co., MI	habeldall@rcmcweb.org ;
9. Ed Alegre	Metro	alegree@metro.net ;
10. Emil Wolanin	Montgomery Co., MD	emil.wolanin@montgomerycountymd.gov ;
11. Rob Rich	MTC	r-rich@mtc.ca.gov ;
12. Gary Piotrowicz	RCOC	gpiotrowicz@rcoc.org ;
13. Peter Thompson	SANDAG	Peter.thompson@sandag.org ;
14. Shaun Quayle	Washington Co., OR	shaun_quayle@co.washington.or.us ;
State DOT Representatives		
15. Nitin Deshpande	Colorado DOT	nitin.deshpande@state.co.us ;
16. Alvin Stamp	Colorado DOT	alvin.stamp@state.co.us ;
17. Bob Koeberlein	Idaho TD	robert.koeberlein@itd.idaho.gov ;
18. Jeffrey Marker	Idaho TD	jeffrey.marker@itd.idaho.gov ;
19. Donna Matulac	Iowa DOT	Donna.Matulac@iowadot.us ;
20. Adam Shell	Iowa DOT	Adam.Shell@iowadot.us ;
21. Roxane Mukai	Maryland Transportation Authority	rmukai@mdta.state.md.us ;
22. Subrat Mahapatra	Maryland State Highway Administration	smahapatra@sha.state.md.us ;
23. Ray Starr	Minnesota DOT	ray.starr@state.mn.us ;
24. Andrew Dick	Oregon DOT	andrew.e.dick@odot.state.or.us ;
25. Alexandra Lohman	Oregon DOT	Alexandra.LOHMAN@odot.state.or.us ;
26. Jianming Ma	Texas DOT	Jianming.Ma@txdot.gov ;
27. Peter Jager	Utah DOT	pjager@utah.gov ;
Research and Academia Representatives		
28. Osayamen Omigie	East Tennessee State University	omigio@etsu.edu ;
29. Mohammed Hadi	Florida Int'l University	hadim@fiu.edu ;

Name	Organization	Business Email
30. Nicola Tavares	ITE	ntavares@ite.org ;
31. Barry Pekilis	Natl Res Council Canada	barry.pekilis@nrc-cnrc.gc.ca ;
32. Purser Sturgeon	Southwest Research Institute	psturgeon@swri.org ;
33. Ray Derr	TRB	rderr@nas.edu ;
34. Hyungjun Park	University of Virginia	hjp4w@virginia.edu ;
35. Debby Bezzina	UMTRI	dbezzina@umich.edu ;
36. Madhav Chitturi	University of Wisconsin	madhav.chitturi@wisc.edu ;
Industry Representatives		
37. Navin Katta (Co-Chair)	Savari, Inc.	navin@savarinetworks.com ;
38. Justin Johnson	3M	jmjohnson2@mmm.com ; justin@mmm.com ;
39. Alan Clelland	Applied Information	aclelland@appinfoinc.com ;
40. Joe Brady	ASCE	jbrady@asce.org ;
41. Amir Bushehristam	Cal Amp	abushehri@calamp.com ;
42. Timor Brik	DataRemote	tbrik@dataremote.com ;
43. Eric Raamot	Econolite	eraamot@econolite.com ;
44. Karen Nguyen	Econolite	knguyen@econolite.com ;
45. Persephone Oliver	Econolite	poliver@econolite.com ;
46. Jim Frazer	Gridadaptive Technologies	jfrazer@gridaptive.com ;
47. Jennifer Carter	HERE	jennifer.carter@here.com ;
48. John Roman	Intel	john.m.roman@intel.com ;
49. Jean Johnson	NEMA	jean.johnson@nema.org ;
50. Doug Hohulin	Nokia	doug.hohulin@nokia.com ;
51. Pawel Majka	Nokia	pawel.majka@nokia.com ;
52. Michael Stelts	Panasonic	michael.stelts@us.panasonic.com ;
53. Jim Misener	Qualcomm	jmisener@qti.qualcomm.com ;
54. Vladimeros Vladimerou	Toyota	vladimeros.vladimerou@toyota.com ;
55. Jeffery Spinazze	Trafficware Group	jeffspinazze@trafficware.com ;
Consultant Representatives		
56. Karnvir Mashiana	Advantage Engineering Associates	karnvir.mashiana@aeapc.com ;
57. Md Shah Imran	Atkins	MdShah.Imran@atkinsglobal.com ;
58. Josh Kolleda	BAH	kolleda_joshua@bah.com ;
59. Dominie Garcia	Battelle	garciad1@battelle.org ;
60. Matthew Windholtz	Battelle	Windholtz@battelle.org ;
61. Kristin Virshbo	Castle Rock	kristin.virshbo@crc-corp.com ;
62. Patrick Chan	Consyspec	patrick.chan@consystec.com ;

Name	Organization	Business Email
63. Jeff Holabaugh	Dye Management Group	jholabaugh@dyemanagement.com ;
64. Greg Nixon	Global-5 Communications	GregNixon@global-5.com ;
65. Naveen Lamba	Grant Thornton	naveen.lamba@us.gt.com ;
66. Philip Riggio	HDR	priggio@hdrinc.com ;
67. Matt Volz	HDR	matthew.volz@hdrinc.com ;
68. Cliff Heise	Iteris	cdh@iteris.com ;
69. Darryl Dawson	ITS Engineering Ltd.	ddawson@itsengineering-ltd.com ;
70. Brian Burkhard	Jacobs	brian.burkhard@jacobs.com ;
71. Jeff Adler	Kapsch	Jeff.adler@kapsch.net ;
72. Imran Inamdar	Kapsch	imran.inamdar@kapsch.net ;
73. Nu Rosenbohm	Kapsch	nu.rosenbohm@kapsch.net ;
74. Martha Morecock Eddy	KCI Technologies	martha.eddy@kci.com ;
75. Sonya Badgley	Leidos	Sonya.S.Badgley@leidos.com ;
76. Animesh Balse	Leidos	Animesh.Balse@leidos.com ;
77. Aaron Greenwood	Leidos	Aaron.Greenwood@leidos.com ;
78. Chris Stanley	Leidos	chris.stanley@leidos.com ;
79. Robert Dingess	Mercer Strategic Alliance	rdingess@mercerstrategic.com ;
80. Jim Katsafanas	Michael Baker	jkatsafanas@mbakerintl.com ;
81. Joe Guevara	Miovision	jguevara@miovision.com ;
82. Barbara Staples	Noblis	bstaples@noblis.org ;
83. James Chang	Noblis	james.chang@noblis.org ;
84. Peiwei Wang	Noblis	Peiwei.Wang@noblis.org ;
85. Scott Shogan	PB	shogan@pbworld.com ;
86. Shel Leader	Private Consultant-Telecom	shel@sleader.com ;
87. Richard Cane	Smart Aerial Solutions	richardcane@smartaerialsolutions.com ;
88. Koorosh Olyai	Stantec	koorosh.olyai@stantec.com ;
89. Rod Schebesch	Stantec	rod.schebesch@stantec.com ;
90. Stephen Mensah	Stantec	stephen.mensah@stantec.com ;
91. Steve Lockwood	Steve Lockwood LLC	lockwood@slockwood.com ;
92. Michael Baril	STV Incorporated	michael.baril@stvinc.com ;
93. Robert Rausch	Transcore	robert.rausch@transcore.com ;
94. Justin Chan	Transpo Group	justin.chan@transpogroup.com ;
95. Dean Erickson	Triunity Eng. & Mgmt.	dean.erickson@triunityeng.com ;
96. Israel Lopez	Triunity Eng. & Mgmt.	israel.lopez@triunityeng.com ;
97. Cheryl Lowrance	VHB	clowrance@vhb.com ;
98. Peter Pavao	VHB	ppavao@vhb.com ;

Name	Organization	Business Email
99. Steve Kuciemba	WSP	steve.kuciemba@wsp.com ;
100. Tom Timcho	WSP	tom.timcho@wsp.com ;
101. William Whyte	OnBoard Security	wwhyte@onboardsecurity.com ;
USDOT and Volpe Representatives		
102. Karen Timpone	USDOT	karen.timpone@dot.gov ;
103. Mike Pina	USDOT	mike.pina@dot.gov ;
104. Deb Curtis	USDOT	deborah.curtis@dot.gov ;
105. Bob Arnold	USDOT	robert.arnold@dot.gov ;
106. Jonathan Walker	USDOT	jonathan.b.walker@dot.gov ;
107. Bob Sheehan	USDOT	robert.sheehan@dot.gov ;
108. Govindarajan Vadakpat	USDOT	g.vadakpat@dot.gov ;
109. Ed Fok	USDOT	edward.fok@dot.gov ;
110. Stephanie Fischer	Volpe Center	stephanie.fischer@dot.gov ;
111. Suzanne Sloan	Volpe Center	suzanne.sloan@dot.gov ;
112. Sean Peirce	Volpe Center	sean.peirce@dot.gov ;
113. Hannah Rakoff	Volpe Center	hannah.rakoff@dot.gov ;
Transport Canada Representatives		
114. Pierre Rasoldier	Transport Canada	pierre.rasoldier@tc.gc.ca ;
Project Team Representatives		
115. Jeremy Schroeder	Athey Creek	schroeder@acconsultants.org ;
116. Venkat Nallamothe	AASHTO	vnallamothe@aashto.org ;
117. Dean Deeter	Athey Creek	deeter@acconsultants.org ;