

Enabling Connected Intersections

Connected Intersection Communications with Production Vehicles

February 2020

1. Background

For over a decade, infrastructure owner-operators (IOOs) have been discussing, exploring and piloting connected vehicle technology, with a specific intent of preparing the infrastructure for vehicle-to-infrastructure (V2I) applications when production vehicles are equipped with connected vehicle communications capabilities. Over the past four years, connected vehicle infrastructure has been deployed, often with operational V2I applications, in almost 50 locations in 27 states. This includes the three USDOT-funded CV Pilot Sites and many locations responding to the SPaT (Signal Phase and Timing) Challenge. Nearly all of these deployments have employed dedicated short range communication (DSRC) radios operating in the 5.9GHz band. Over the same four years, General Motors has deployed DSRC on one vehicle model for two years, Toyota announced their intent to deploy DSRC in production vehicles (although without a current timeline), and Ford has committed to deploying connected vehicle technology using cellular vehicle-to-everything (C-V2X) technology in the 5.9 GHz spectrum on their production vehicles in 2022. Other automakers have invested heavily in connected vehicle systems, but have not made specific announcements about intentions or timelines in the U.S.

Despite the fact that some automakers seem poised and ready to deploy connected vehicle technology and many IOOs have begun installing corollary roadside equipment, discussions between the automakers and the IOOs in the IOO/OEM Forum of the Cooperative Automated Transportation (CAT) Coalition have identified a series of issues that may prevent effective V2I communication. A plan is needed to support infrastructure owner-operators (IOOs) in their goal to broadcast SPaT and MAP messages that are interoperable with production vehicles to support V2I applications. The plan needs to address a number of issues that are agnostic to the communications approaches in order to accomplish true cooperative connectivity with production vehicles once a final communications medium or mediums are selected.

This intent of this paper is:

- To define the concept of “Enabling Connected Intersections” and identify what needs to be accomplished to overcome known issues;
- To map the Enabling Connected Intersections needs against existing initiatives as much as possible to identify the gaps that must be performed; and
- To define a work plan of activities to support discussions about who will perform the activities and provide the resources required.

It should be noted that the issues that need to be addressed are largely technology neutral. There are industry voices promoting both DSRC and C-V2X and, at the time this paper was prepared, there is considerable uncertainty surrounding the allocation of spectrum for these technologies by

[Enabling Connected Intersections Concept Paper – Working Draft to Support Discussions of the IOO/OEM Forum](#)
SPaT/RLVW Group

the Federal Communications Commission (FCC). Evaluation and resolution of the issues described in this paper can be pursued in parallel with discussions and decisions about radio technologies and spectrum, and can be applied to either path. In fact, in order to meet the 2022 goal, the industry must not wait to address these issues pending decisions about spectrum and technology.

2. Overview of Enabling Connected Intersections

The premise of *Enabling Connected Intersections* is the following:

- A. The industry needs a proven effective, reproducible, turnkey approach to testing and verifying the broadcasts of SPaT and MAP data that can be consistently and reliably implemented by IOOs throughout the United States and trusted by the OEMs.
 1. Testing procedures and reporting need to be collaboratively developed and ultimately trusted by both the IOOs that will execute the testing and the OEMs that are planning production vehicle deployments of on-board applications.
 2. Testing procedures should support the testing of both format and content of defined methods of communications within the safety spectrum, including network communications (over cellular networks) and direct communications (roadside to vehicle).
- B. For IOOs to deploy the infrastructure systems to meet the testing parameters, several resources and/or activities are needed to enable the deployments to meet the minimum requirements in the testing and verification process. Some of these are available today, some are in development, and some will need to be created prior to achieving connectivity with production vehicles.
- C. Since successful V2I communication involves both vehicles and infrastructure, it is essential that issues and solutions be addressed collaboratively by both the IOOs and the OEMs. Communication between these two sets of stakeholders is key to successful solutions, deployment, and operations.

The following seven needs have been identified, as a minimum, to enable connectivity:

1. Unambiguous accepted minimum requirements for the connected intersection broadcast of SPaT and MAP .
2. An industry understood and accepted approach, policy, and provider(s) for production security credential management systems (SCMS).
3. Test Procedures & Tools to verify 'proper' SPaT & MAP transmission over the air (pre and post SCMS). While testing of SPaT and MAP can proceed before an SCMS is implemented, a second round of testing with SCMS in-place is also needed.
4. A Reference Implementation with Functional Safety Assessment to demonstrate, validate, and document a set of instructions for IOOs and OEMs deploying V2I systems to ensure compatibility. **Note: Reference Implementation is defined for the context of Enabling Connected Intersections on the final page of this document.**

5. IOO training for successful connected signalized intersection deployments and expansion of deployment sites.
6. A national intersection numbering scheme and connected intersection tracking approach to support consistent population of the data element RoadRegulatorID and to enable national tracking of the intersections broadcasting valid data.
7. National approach to ongoing operations and maintenance of connected intersections and expansion of deployment sites, including a means to monitor connected intersection for continued proper operation and monitor conflicts between the signal controller and SPaT broadcast.

3. Mapping the Needs to Ongoing Initiatives and Identifying Gaps

The table below identifies existing initiatives that are partially or fully addressing the seven needs defined in section 2, and the remaining gaps that must be addressed by the CAT Coalition and IOO/OEM Forum.

#	Needs for Connectivity with Production Vehicles	Ongoing Initiatives	Gaps / Actions for the CAT Coalition - IOO/OEM Forum
1	Unambiguous accepted minimum requirements for the connected intersection broadcast of SPaT and MAP .	<ul style="list-style-type: none"> • Working draft SPaT Challenge ConOps & Requirements exist and could be edited to integrate the initiatives below to represent a structured approach to complete requirements; • USDOT/ITE CCI standardization effort is underway; • Recent activities of the IOO/OEM SPaT/RLVW group have documented SPaT & MAP data needs; • CAT Coalition IOO/OEM Forum CCI document draft exists & there is ongoing action to advance clarifications as input to the USDOT effort • CV PFS effort to develop guidelines for MAP creation to kickoff March 2020. • Ongoing SAE J2945/10 standards efforts. 	<p><u>Action #1: Create and reach consensus on minimum requirements for intersection broadcasts of SPaT & MAP.</u></p> <p>Leverage earlier work on the SPaT Challenge ConOps and Requirements, and coordinate with multiple ongoing activities contributing to SPaT/MAP guidelines.</p>

#	Needs for Connectivity with Production Vehicles	Ongoing Initiatives	Gaps / Actions for the CAT Coalition - IOO/OEM Forum
2	An industry understood and accepted approach, policy, and provider(s) for production security credential management systems (SCMS).	<ul style="list-style-type: none"> IOO/OEM Forum is planning to survey IOOs and OEMs about approaches to SCMS; An SCMS Manager has formed offering one approach to SCMS 	<u>Action #2: Summarize industry approach(es) to SCMS and develop guidelines for IOOs.</u>
3	Test Procedures & Tools to verify 'proper' SPaT & MAP transmission over the air (pre and post SCMS). While testing of SPaT and MAP can proceed before an SCMS is implemented, a second round of testing with SCMS in-place is also needed.	<ul style="list-style-type: none"> Early Signalized Intersection draft Test Plan developed by CAMP. Extensive CV Pilot and ATCMTD site testing conducted. FHWA led interoperability testing. CV PFS upcoming project to test and verify intersections. 	<u>Action #3: Test Plan.</u> Finalize a Connected Intersection Test Plan with detailed testing procedures and test reporting requirements to support pre-SCMS testing (SPaT and MAP only) and post-SCMS testing (full system).
4	A Reference Implementation with Functional Safety Assessment to demonstrate, validate, and document a set of instructions for IOOs and OEMs deploying V2I systems to ensure compatibility.	<ul style="list-style-type: none"> It is understood that the USDOT/ITE CCI project will most likely perform a reference implementation – timing and scope to be verified with Steve Sill. SPaT Challenge ConOps and Requirements (identified for updates in Activity #1 could form a basis for input to the Reference Implementation and the Functional Safety Assessment. 	<u>Action #4. Reference Implementation and Functional Safety Assessment</u> – Support USDOT plans for a Reference Implementation, and conduct a functional safety assessment.
5	IOO training for successful connected signalized intersection deployments and expansion of deployment sites.	<ul style="list-style-type: none"> CAT Coalition Peer Exchange & Outreach Working Group is available to inform the industry of this initiative, when appropriate. Network of national AASHTO, ITE, ITS America groups and initiatives with proven training and outreach strategies, as well as the NOCoE. 	<u>Action #5: Develop and execute the Enabling Connected Intersections Outreach and Expansion Strategy.</u> This strategy will communicate and inform IOOs on the Reference Implementation, minimum requirements, and test plan to help them prepare to deploy compatible SPaT and MAP broadcasts, with an emphasis on expanding deployments.

#	Needs for Connectivity with Production Vehicles	Ongoing Initiatives	Gaps / Actions for the CAT Coalition - IOO/OEM Forum
6	A national intersection numbering scheme and connected intersection tracking approach to support consistent population of the data element RoadRegulatorID and to enable national tracking of the intersections broadcasting valid data.	<ul style="list-style-type: none"> • SPaT Challenge tracking map and self-reports from multiple deployments. • CAT Coalition Strategic Initiatives and Technical Resources Working Groups are available to support industry collaboration and tracking of progress. • An ongoing activity is creating a national numbering scheme, no recent update on progress. 	<p><u>Activity #6: Deployment Tracking.</u> An activity to encourage the outside activity to develop a national intersection numbering scheme and to establish a scheme to coordinate, track and summarize progress towards implementing the Enabling Connected Intersections Plan.</p>
7	National approach to ongoing operations and maintenance of connected intersections, including a means to monitor connected intersection for continued proper operation and monitor conflicts between the signal controller and SPaT broadcast.	<ul style="list-style-type: none"> • Extensive CV Pilot and ATCMTD site testing conducted and O&M planning 	<p><u>Activity #7: O&M Approach.</u> An activity to define a common approach to operating, maintaining, testing, and verifying connected intersection operations to ensure consistency with the Reference Implementation.</p>

4. Work Plan to Address the Actions Needed

The following actions and responsibilities are identified to complete the actions identified above, with supporting details about outcomes/deliverables and schedule.

Gap	Actions / Outcomes / Schedule
<p><u>Action #1:</u> <u>Create and reach consensus on minimum requirements for intersection broadcasts of SPaT & MAP.</u> Leverage earlier work on the SPaT Challenge ConOps and Requirements, and coordinate with multiple ongoing activities contributing to SPaT/MAP guidelines.</p>	<p>Actions:</p> <ul style="list-style-type: none"> • Establish a process to exercise intersection deployments of SPaT and MAP broadcasts to enable OEMs to identify additional ambiguities or issues with current requirements and guidelines. • Assess and verify performance requirements as produced by the CV PFS MAP Guidelines project, the SPaT Challenge Model ConOps & Requirements, and the USDOT/ITE CCI project from an OEM perspective. • Update the SPaT Challenge ConOps and Requirements to incorporate what is learned from the intersection deployment and MAP guidelines review, and to incorporate the findings and outcomes of other ongoing initiatives. The Requirements can serve as the basis for the Reference Implementation and subsequently for the Test Plan. • Develop a prototype open-source software tool and supporting strategy of use to enable IOOs nationwide to convert high fidelity LiDAR survey mapping data to J2735 MAP messages (note: approach is similar to the Work Zone software toolchain creation) as a resource to facilitate accurate MAP creation. <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> • Minimum requirements for intersection broadcasts of SPaT and MAP; Prototype software tool and national strategy for automating conversion of LiDAR mapping data into J2735 MAP messages. <p>Schedule:</p> <ul style="list-style-type: none"> • Minimum requirements defined by August 2020. • Toolchain by July 2021.
<p><u>Action #2:</u> <u>Summarize industry approach(es) to SCMS and develop guidelines for IOOs</u></p>	<p>Actions:</p> <ul style="list-style-type: none"> • Survey IOOs and OEMs to understand existing/emerging approaches • Track progress as a national SCMS management approach (with associated manager) develops and engage this entity(ies) to understand and document the approach to national security credentialing. • Prepare a technical summary of the overall industry approach to SCMS management (i.e. as an SCMS manager develops) and the approved provider(s) to include guidance for IOOs when deploying SCMS. • Prepare a policy level summary of the processes and actions of IOOs to deploy SCMS, based on content received by the SCMS manager and provider(s). <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> • Technical summary of industry approach to SCMS • Policy summary of industry approach to SCMS <p>Schedule</p> <ul style="list-style-type: none"> • August 2020

Gap	Actions / Outcomes / Schedule
<p>Action #3: Test Plan. Finalize a Connected Intersection Test Plan with detailed testing procedures and test reporting requirements to support pre-SCMS (SPaT and MAP only) testing and post-SCMS testing (full system).</p>	<p>Actions:</p> <ul style="list-style-type: none"> • Determine an overall Test Plan Strategy for managing communications medium and SCMS uncertainties and phased deployments. This strategy will address how to manage the potential of multiple communications approaches (including multiple simultaneous communications, such as MAP message communicated by network cellular, SPaT message by direct roadside communications) and describe what can be tested pre-SCMS and what is tested post-SCMS. • Continue earlier efforts to develop and refine SPaT and MAP Test Plan, based on the minimum requirements defined in Action #1 and Reference Implementation. Note: Test Plan will include testing antenna position for achieving minimum performance requirements for range of broadcast. • Support the use of the draft versions of the Test Plan in Action #1 to assess test plan readiness. • Establish a process for broader input to the draft Test Plan. • Finalize the SPaT and MAP Test Plans (pre-SCMS and post-SCMS). • Establish a process for industry-wide circulation, encouraging use, and tracking test results using the Test Plans. <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> • Connected Signalized Intersection Test Plan to support pre-SCMS testing. • Connected Signalized Intersection Test Plan to support post-SCMS testing (full system). <p>Schedule</p> <ul style="list-style-type: none"> • Pre-SCMS Test Plan – February 2021 • Post-SCMS Test Plan – July 2021

Gap	Actions / Outcomes / Schedule
<p><u>Action #4.</u> <u>Reference Implementation and Functional Safety Assessment</u> - Support USDOT plans for a Reference Implementation, and conduct a functional safety assessment.</p>	<p>Actions</p> <ul style="list-style-type: none"> • Complete a Reference Implementation for SPaT and MAP broadcasts to support RLVW at signalized intersections. – Note this is understood to be part of the USDOT/ITE CCI project. • Assemble and communicate the outcomes of Actions #1-3 into the USDOT/ITE Reference Implementation activity. • Contribute to the USDOT/ITE Reference Implementation efforts to ensure the message requirements for the RLVW application are represented. • Engage a Functional Safety Expert to conduct the functional safety assessment. • Support the Functional Safety Expert by contributing OEM expertise in functional safety assessments. <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> • Input and participation in the Reference Implementation process. ¹ • Functional Safety Assessment completed, with walkthrough and deliverable. <p>Schedule</p> <ul style="list-style-type: none"> • Completion of Reference Implementation – TBD (seek input from FHWA) • Input to Reference Implementation – August 2020 • Functional Safety Assessment – February 2021

¹ Action #4 assumes from earlier discussions that the USDOT CCI project is developing a Reference Implementation. This will be verified and better understood as Enabling Connected Intersections planning progresses.

Gap	Actions / Outcomes / Schedule
<p><u>Action #5:</u> <u>Develop and execute the Enabling Connected Intersections Outreach and Expansion Strategy.</u> This strategy will communicate and inform IOOs on the Reference Implementation, minimum requirements, and test plan to help them prepare to deploy compatible SPaT and MAP broadcasts.</p>	<p>Actions:</p> <ul style="list-style-type: none"> Establish and support a process to outreach and coordinate the implementation of the Reference Implementation, SPaT and MAP requirements, and test plan to encourage nationwide deployment of compatible testing and future ambiguity identification by SPaT Challenge sites. Integrate the overall approach to outreach and coordination with existing CAT Coalition Working Groups and association’s working groups and resources (e.g. NOCoE) to conduct sharing and training on the Enabling Connected Intersections Plan with as many IOOs as possible. CAT Coalition Project Team members to include outreach and training in regularly scheduled activities ITE, ITS America, AASHTO to include outreach and training in regularly scheduled activities <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> Monthly activities to outreach and educate about the Enabling Connected Intersections Plan through regularly scheduled activities and added webinars/meetings as needed. Outreach, education, and training on the Reference Implementation, requirements, and test plan through established organizations. <p>Schedule</p> <ul style="list-style-type: none"> Planning activities to occur between August – December 2020 Intensive outreach activities following the completion of the Reference Implementation (estimated April 2021 to provide IOOs with the information needed to allow them to begin final preparations for 2022. Outreach activities encouraging implementation of the plan through July 2022.
<p><u>Activity #6:</u> <u>Deployment Tracking.</u> An activity to encourage the outside activity to develop a national intersection numbering scheme and to establish a scheme to coordinate, track and summarize progress towards implementing the Enabling Connected Intersections Plan.</p>	<p>Actions:</p> <ul style="list-style-type: none"> Organize one or more liaisons to interact with external efforts developing the intersection numbering scheme development project to establish communications and support the effort. Define a sustainable plan for an existing or new entity (potentially connected to the issuing of SCMS certificates) to perform the roll of coordinating and tracking IOO deployment status (i.e. connected intersections where the test plan was successfully completed). Establish and implement the plan for coordinating and tracking deployments and testing results (note: tracking may be performed by a new entity, such as the SCMS Manager). <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> Gold Stars identified on tracking map of IOOs that have completed the testing verification process <p>Schedule</p> <ul style="list-style-type: none"> Planning activities to occur between August – December 2020 Tracking and coordination between December 2021 and July 2022.

Gap	Actions / Outcomes / Schedule
<p>Activity #7: O&M Approach. An activity to define a common approach to operating, maintaining, testing, and verifying connected intersection operations to ensure consistency with the Reference Implementation.</p>	<p>Actions:</p> <ul style="list-style-type: none"> • Define the operational concepts and scenarios for ongoing operations of connected intersections, including agreement on approaches to situations such as the following exemplary examples: power outages, roadwork, short-term (1-8 hour) closures, medium term (1-3 day) closures, and long-term closures; • Develop an industry accepted approach (involving OEMs, IOOs and signal manufacturers) to address the need for conflict (malfunction) monitoring between signal status and SPaT broadcasts • Define O&M Guidance document (and potentially a reference implementation agreed by IOOs, OEMs, and signal manufacturers) defining minimum criteria and requirements for handling situations identified by the operational concepts, as well as candidate approaches to accomplish this for all IOOs <p>Outcomes/Deliverables:</p> <ul style="list-style-type: none"> • O&M Guidance Document (potentially reference implementation) for connected signals. <p>Schedule</p> <ul style="list-style-type: none"> • Concepts and scenarios defined by December, 2020; • Industry accepted approach by August 2021; • Finalization of guidance document by December 2021.

5. Definition of Reference Implementation

Wikipedia defines Reference Implementation as an implementation of a specification to be used as a definitive interpretation for that specification. Wikipedia further defines characteristics of a reference implementation as:

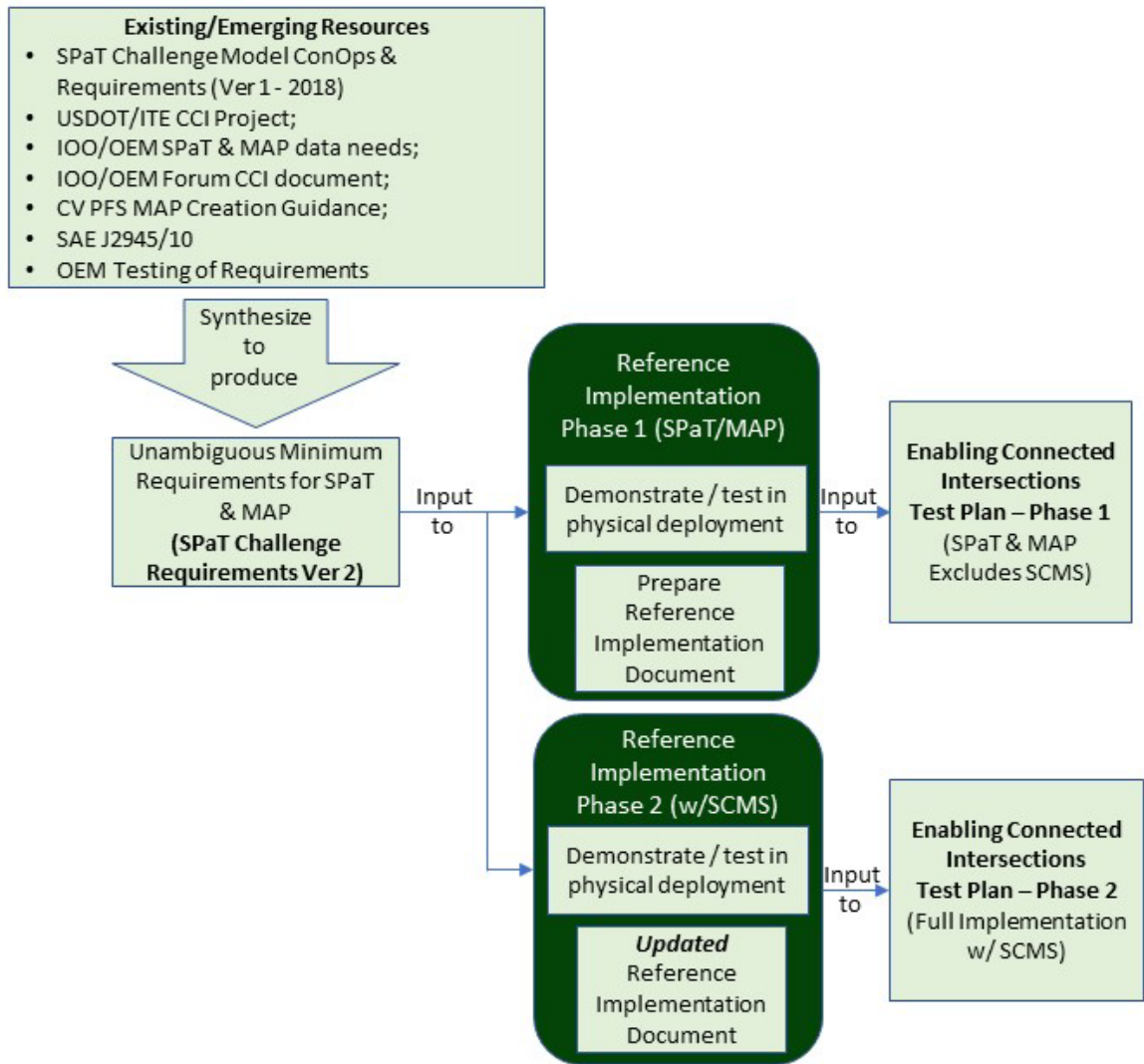
1. Developed concurrently with the specification and test suite;
2. Verifies that specification is implementable;
3. Enables the test suite to be tested;
4. Serves as a Gold Standard against which other implementations can be measured;
5. Helps to clarify the intent of the specification in situations where [conformance tests](#) are inadequate

For purposes of Enabling Connected Intersections, the Reference Implementation will initially include a physical deployment of an intersection with infrastructure broadcasting SPaT and MAP data and applications receiving and using the data to support RLVW applications. This deployment will test the requirements and other guidance documents developed. In addition to the physical deployment, the Reference Implementation will be a written document that comprises a ‘set of instructions’ to guide both IOOs and OEMs to successfully deploy their portion of the connected intersection ecosystem. This ‘set of instructions’ could be considered a link between the SPaT and MAP Requirements and the Test Plans (including the initial SPaT & MAP Test Plan (excluding SCMS) and the final full system Test Plan) that will be circulated widely to guide IOOs as they test their connected intersections for compatibility with anticipated applications in production vehicles. While the Reference Implementation will be heavily focused on the use of standards, it will also describe instructions regarding:

- The “correctness of the data” (e.g. a time mark may be formatted to the standard, but is the time mark value accurate enough for RLVW applications?), and
- The “Correlation of data” (e.g. does the SPaT message data correlate to what is actually displayed on the sign?).

As it is logistically impossible for each OEM that ultimately releases applications in production vehicles to test at every intersection, the Reference Implementation will give Enabling Connected Intersections a resource that, if followed and tested, will give both the IOOs and OEMs confidence for successful integration. Figure 1 illustrates the role of the Reference Implementation in the overall development of the Enabling Connected Intersections Test Plan.

Figure 1: Summary of Enabling Connected Intersections Document Creation Process



6. Responsibility Chart

Enabling Connected Intersections Responsibility Chart – With Target Completion Dates

Version 3 (1/20/2020)

	Actions Identified in Enabling Connected Intersections Concept Paper	Target Completion	R-Responsible; S-Support; I-Informed						
			Coalition Activities		Individual Members				
			CAT Coalition ²	CAMP	IOOs	OEMs	CV PFS	Assoc. AASHTO, ITE, ITS A	US DOT
1	Action #1: Create and reach consensus on minimum requirements for intersection broadcasts of SPaT & MAP.		I	R	I	I	I	S	S
1a	Establish a process to exercise intersection deployments of SPaT and MAP broadcasts to enable OEMs to identify additional ambiguities or issues with current requirements and guidelines.	6/20	I	R	S	S	I	I	S
1b	Assess and verify performance requirements as produced by the CV PFS MAP Guidelines project, the SPaT Challenge Model ConOps & Requirements, and the USDOT/ITE CCI project from and OEM perspective.	9/20	I	R	I	I	I	S	S
1c	Update the SPaT Challenge ConOps and Requirements to incorporate what is learned from the intersection deployment and MAP guidelines review, and to incorporate the findings and outcomes of other ongoing initiatives. The Requirements can serve as the basis for the Reference Implementation and subsequently for the Test Plan.	12/20	R	S	S	S	I	I	I
1d	Develop a prototype open-source software tool and supporting strategy of use to enable IOOs nationwide to convert high fidelity LiDAR survey mapping data to J2735 MAP messages (note: approach is similar to the Work Zone software toolchain creation) as a resource to facilitate accurate MAP creation.	7/21	S	R	I	I	S	I	I
2	Action #2: Summarize Industry Approach(es) to SCMS and develop IOO Guidelines		R	S	I	I	I	S	I

² CAT Coalition refers to a combination of the CAT Coalition Project Team, Working Group Chairs, and Working Group members. A further breakdown of expected roles will be defined at a later date.

	Actions Identified in Enabling Connected Intersections Concept Paper	Target Completion	R-Responsible; S-Support; I-Informed							
			Coalition Activities		Individual Members					
			CAT Coalition ²	CAMP	IOOs	OEMs	CV PFS	Assoc. AASHTO, ITE, ITS A	US DOT	
2a	Survey IOOs and OEMs to understand existing/emerging approaches	3/20	R	S	S	S	I	I	I	
2b	Track progress as a national SCMS management approach (with associated manager) develops and engage this entity(ies) to understand and document the approach to national security credentialing.	12/20	R	S	I	I	I	S	I	
2c	Prepare a technical summary of the overall industry approach to SCMS management (i.e. as an SCMS manager develops) and the approved provider(s) to include guidance for IOOs when deploying SCMS.	2/21	R	S	I	I	I	S	I	
2d	Prepare a policy level summary of the processes and actions of IOOs to deploy SCMS, based on content received by the SCMS manager and provider(s).	2/21	R	I	I	I	I	S	I	
3	Action #3: Test Plan		S	R	I	I	I	I	S	
3a	Determine an overall Test Plan Strategy for managing communications medium and SCMS uncertainties and phased deployments. This strategy will address how to manage the potential of multiple communications approaches (including multiple simultaneous communications, such as MAP message communicated by network cellular, SPaT message by direct roadside communications) and describe what can be tested pre-SCMS and what is tested post-SCMS.		S	R	I	I	I	I	I	
3b	Continue earlier efforts to develop and refine SPaT and MAP Test Plan, based on the minimum requirements defined in Action #1 and Reference Implementation. Note: Test Plan will include testing antenna position for achieving minimum performance requirements for range of broadcast.		S	R	S	S	I	I	S	
3c	Support the use of the draft versions of the Test Plan in Action #1 to assess test plan readiness.		I	R	I	I	I	I	S	
3d	Establish a process for broader input to the draft Test Plan.		R	S	S	I	S	I	S	
3e	Finalize SPaT and MAP Test Plans (pre-SCMS and post-SCMS).		S	R	S	I	I	I	S	
3f	Establish a process for industry-wide circulation, encouraging use, and tracking test results using the Test Plan.		R	I	I	I	I	I	S	
4	Action #4. Reference Implementation and Functional Safety Assessment		S	S	I	I	I	I	R	
4a	Complete a Reference Implementation for SPaT and MAP broadcasts to support RLVW at signalized intersections.		S	S	I	I	I	I	R	
4b	Assemble and communicate the outcomes of Actions #1-3 into the USDOT/ITE Reference Implementation activity.	8/20	I	S	I	I	I	I	R	

	Actions Identified in Enabling Connected Intersections Concept Paper	Target Completion	R-Responsible; S-Support; I-Informed						
			Coalition Activities		Individual Members				
			CAT Coalition ²	CAMP	IOOs	OEMs	CV PFS	Assoc. AASHTO, ITE, ITS A	US DOT
4c	Contribute to the USDOT/ITE Reference Implementation efforts to ensure the message requirements for the RLVW application are represented.	8/20	I	R	S	S	I	I	I
4d	Engage a Functional Safety Expert to conduct the functional safety assessment.	2/21	I	S	I	I	I	I	R
4e	Support the Functional Safety Expert by contributing OEM expertise in functional safety assessments.	2/21	I	R	S	S	I	I	I
5	Action #5: Develop and Execute the Enabling Connected Intersections Outreach and Expansion Strategy		R	I	I	I	I	S	S
5a	Establish and support a process to outreach and coordinate the implementation of the Reference Implementation, SPaT and MAP requirements, and test plan to encourage nationwide deployment of compatible testing and future ambiguity identification by SPaT Challenge sites.	12/20	R	I	I	I	I	S	S
5b	Integrate the overall approach to outreach and coordination with existing CAT Coalition Working Groups and Association's working groups and resources (e.g. AASHTO, ITE, ITS America, NOCoE) to conduct sharing and training on the Enabling Connected Intersections Plan with as many IOOs as possible.	4/21	R	I	I	I	I	I	I
5c	CAT Coalition Project Team members to include outreach and training in regularly scheduled activities, with an emphasis on expanding the intersection deployments.	7/22	R	I	I	I	I	I	I
5d	ITE, ITS America, AASHTO to include outreach and training in regularly scheduled activities	7/22	I	I	I	I	I	R	I
6	Activity #6: Deployment Tracking		R	S	I	I	I	S	S
6a	Organize one or more liaisons to interact with external efforts developing the intersection numbering scheme development project to establish communications and support the effort.	3/20	R	I	I	I	I	S	S
6b	Define a sustainable plan for an existing or new entity (potentially connected to the issuing of SCMS certificates) to perform the roll of coordinating and tracking IOO deployment status (i.e. connected intersections where the test plan was successfully completed).	6/21	R	S	I	I	I	S	S
6c	Establish and implement the plan for coordinating and tracking deployments and testing results (note: tracking may be performed by a new entity, such as the SCMS Manager).	12/21	R	S	I	I	I	S	S

	Actions Identified in Enabling Connected Intersections Concept Paper	Target Completion	R-Responsible; S-Support; I-Informed						
			Coalition Activities		Individual Members				
			CAT Coalition ²	CAMP	IOOs	OEMs	CV PFS	Assoc. AASHTO, ITE, ITS A	US DOT
7	Activity #7: O&M Approach		R	S	I	I	I	S	S
7a	Define the operational concepts and scenarios for ongoing operations of connected intersections, including agreement on approaches to situations such as the following exemplary examples: power outages, roadwork, short-term (1-8 hour) closures, medium term (1-3 day) closures, and long-term closures;	12/20	R	S	I	I	I	S	S
7b	Develop an industry accepted approach (involving OEMs, IOOs and signal manufacturers) to address the need for conflict (malfunction) monitoring between signal status and SPaT broadcasts	8/21	R	S	I	I	I	S	S
7c	Define O&M Guidance document (and potentially a reference implementation agreed by IOOs, OEMs, and signal manufacturers) defining minimum criteria and requirements for handling situations identified by the operational concepts, as well as candidate approaches to accomplish this for all IOOs	12/21	R	S	I	I	I	S	S