# Cooperative Automated Transportation
# Clarifications for Consistent Implementations (CCIs)

To Ensure National Interoperability

## Connected Signalized Intersections

DRAFT Version 1.9.5

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Note: This is a partial draft version of this document, circulated for discussion about approach, formatting, and content. Not a completed document.

Contents

# 1 Introduction

## 1.1 Background

Connected Signalized Intersections are Infrastructure Systems equipped to broadcast Signal Phase and Timing (SPaT), MAP, and Position Correction data, enabling equipped vehicles to receive the broadcasts and use the data to support on-board applications.

As more Connected Signalized Intersections are deployed, there is an increasing desire for these to communicate with the upcoming production vehicle deployments of on-board applications, specifically SPaT-based applications such as Red-Light Violation Warning (RLVW).

## 1.2 Need for this Document

It is understood by deployers that the established standards alone will not ensure open compatibility with production vehicles. Existing standards often include optional elements or flexibility given the variety of objectives or ways a system may be deployed. In some cases, the optional elements or flexibility may be interpreted differently for different deployments, despite the common objectives and applications of each deployment. These differences could lead to a lack of interoperability that prevents vehicles from using data at Connected Signalized Intersections across different jurisdictions.

Infrastructure Owner Operators (IOOs) and original equipment manufacturers (OEMs) need to reach common agreement on interpretations and clarifications regarding ***known ambiguities*** so that data from all Connected Signalized Intersections can support vehicle applications, regardless of the jurisdiction or vehicle type.

## 1.3 Use of this Document

The purpose of this document is to provide clarity for topics identified by IOOs and OEMs as possible areas of ambiguity.  Therefore, one intended use is for IOOs to examine the contents of this document when designing and implementing connected signal infrastructure systems to ensure that, as a minimum, these topics are addressed as stated in this document.  Similarly, the other intended use is for OEMs to examine the contents of this document as they design and implement the applications that interface with infrastructure systems.

### *1.3.1 Relationship of This Document to Existing and Future Standards*

This document is not a 'one-stop-shop' document for all information needed to deploy connected signalized intersections.  Rather, this document is organized around the topics of ambiguity that have surfaced in connected vehicle deployments to date.

Readers are reminded that several standards and resource documents exist and must be used to collectively understand standardized data exchanges.  Section 3.1 includes a list and hyperlinks to these standards and resources.  The SPaT Challenge Verification Document includes additional details about the data exchanges required to support RLVW and steps to verify deployments.

It is anticipated that future versions of standards may clarify some or all of the ambiguities described in this document. At such time, ambiguities clarified in the standards will be removed from this document.

### *1.3.2 Applicability to Various Communications Approaches*

Several clarifications presented in this document address ambiguities that relate to connected signalized intersections regardless of the communications medium or technologies used to communicate with vehicles. Some examples of these include clarifications about time synchronization to UTC time or clarifications about determining the appropriate enumeration value to represent the signal control. These, and other, clarifications are recommended for review by IOOs regardless of whether they are deploying systems to communicate using Dedicated Short-Range Communications (DSRC), Cellular V2X, Internet technologies, or other approaches.

Additionally, some of the ambiguities relate specifically to one communication technology. For example, there is a clarification regarding the DSRC Channel to use for message broadcast. As these technology specific ambiguities are identified (including other communications technologies not yet included in this document) by the industry and clarifications agreed, they will be included in this document. The intent is not to intentionally preclude any communication technology, but rather to reflect that at some point there is the need to offer communication specific clarifications when needed.

### *1.3.3 Known Ambiguities Covered by this Document*

The initial version of this document is being compiled to address known ambiguities and other topics requiring clarifications as understood from the Connected Vehicle Pilot Site deployments and other state and local government funded deployments (including agencies deploying infrastructure systems in response to the SPaT Challenge).

This document is envisioned to stabilize as an initial Working Draft Version 1.0 in 2019, however it will remain a working document as additional ambiguities are addressed. Section 3.2 includes a process for submitting additional ambiguities for inclusion in this document.

#### *1.3.3.1 Known Ambiguities Related to all Connected Signalized Intersection Deployments*

Section 2.1 contains clarifications of ambiguities that are applicable to multiple OBU applications that rely on Connected Signalized Intersection infrastructure systems. Therefore, IOOs deploying Connected Signalized Intersections should consider the clarifications included in Section 2.1. These include:

- Wireless communications channel utilization
- Situations where SCMS message certification is not available
- Minimum SPaT Message TIME MARK data elements
- Time accuracy and synchronization
- Inclusion of vehicle position correction data

- Approach to node point latitude/longitude coding (reference or true lat/lon?)
- Uniform assignment of enumeration values for all possible signal states
- SPaT Message content related to flashing yellow arrows
- Configuration of turn lanes
- Linking egress lanes to ingress lanes of downstream intersections
- Use of Intersection ID

#### *1.3.3.2 Known Ambiguities Specific to OBU Applications*

Some OBU applications rely upon specific requirements being met. These may include optional elements from published standards that are mandatory for an OBU application or may require lower latency of communications to ensure data exchanges are timely. Section 2.2 contains clarifications specific to the RLVW applications. These include:

- SPaT Message Frequency of Transmission
- The Frequency at which the signal controller outputs the current signal state
- MAP Message Frequency of Transmission
- RLVW vehicle position correction data exchange clarification.

Remaining subsections in section 2 are reserved for additional clarifications specific to other applications (to be added later).

# 2 Clarifications of Known Ambiguities

## 2.1 Cross-cutting Ambiguities – Applicable to Multiple OBU Applications

The following sub-sections contain those ambiguities that are expected to potentially prevent interoperability with any application using data from the Connected Signalized Intersection System. All IOOs deploying Connected Signalized Intersection Systems are encouraged to understand the ambiguities and to deploy the clarification/requirement provided.

### *2.1.1 Time accuracy and synchronization*

***Need:***

Since the minEndTime data element provides the time (in seconds) during the current hour or top of the next hour that the phase ends and not a "time to phase change", it is critical that there is synchronization between the time clock of the infrastructure system and the vehicle.

As stated in the J2735 standard, the TimeMark data element used for minEndTime to indicate time at which the signal phase change occurs is in units of 1/10$^{th}$ second from UTC time and NOT in GPS or in local time.

The TimeMark value for minEndTime is constructed by the RSU from the information provided by the signal controller. It is required that the signal controller internal clock provides the signal phase information at 1/10$^{th}$ second resolution.

***Clarification/Requirement:***

***OBU applications need signalized intersection infrastructure systems to ensure that SPaT message Time Marks are within 10 ms of UTC time.***

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### *2.1.2 Minimum SPaT Message TIME MARK data elements*

***Need:***

The TimeMark data element is the element that the OBU applications use to determine the time that the current phase is predicted to end and transition to the next phase. Therefore, it is critical that all SPaT messages broadcast the TimeMark consistently and according to the standards.

The TimeMark data element provides the time (in tenths of a seconds) within the current hour or top of next hour when the signal phase is predicted to change, in UTC-based time with a precision of 1/10$^{th}$ of a second. The following examples illustrate typical correct, standards compliant calculations of TimeMark. Note that TimeMark values are in tenths of a second.

**Example 1: minEndTime value for the current hour**

Let’s assume current UTC time is 13:45:25
The current green phase is to end (min time of the phase) at the end of 30s.
The TimeMark value for minEndTime is computed as follows:
(Current Minute (45)*60+Current Seconds(25)) * 10 + (Number of seconds for phase change(30)*10) = 27550 (< 36000)

**Example 2: minEndTime for top of next hour**

Let’s assume current UTC time is 13:59:50
The current green phase is to end (min time of the phase) at the end of 30s.
The TimeMark value for minEndTime is computed as follows:
(Current Minute (59)*60+Current Seconds(50)) * 10 + (Number of seconds for phase change (30))*10 = 36200 (> 36000)
The minEndTime is 36200 – 36000 = 200

**Error Scenario:**
In some cases, depending on the version of firmware in an RSU some vendors changed TimeMark to the 2016 format but kept the **value of time as a countdown instead of as a second in the hour**.

**Error Example:**

Let’s assume current UTC time 13:20:00 and current phase to change after 45 seconds at 13:20:45.

The ***incorrect*** TimeMark in minEndTime value may be transmitted as:

# of seconds to countdown*10 = 45*10 = 450 milliseconds instead of (20*60*10) + (45*10) = 12450.

The OBU would interpret this as 450 milliseconds at the top of next hour at 14:00:45

For OBU, the internal calculation based on current clock would be:

(40*60*10) + (45*10) = 24450 = 2445 seconds and not 45 seconds

***<u>Clarification/Requirement:</u>***

***OBU applications need signalized intersection infrastructure systems to calculate the minEndTime TimeMark value using the following formula:***

***(Current Minute*60+Current Seconds) *10 + (seconds value that the phase will change*10) = VALUE***

***Note: if VALUE is >36000 the MinEndTime is VALUE – 36000***

***Note: if VALUE is <=36000, the MinEndTime = VALUE***

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### *2.1.3 Approach to node point latitude/longitude Representation*

***Need:***

As specified in the J2735 standards document, the node points representing lane geometry in the MAP message can be specified using various options. One option is absolute lat/lon positions. Another option is reference node point(s) and offset values. OBU applications need consistency in representation of node points in order to interpret data from all intersections uniformly. One challenge that IOOs face in creating the MAP message is file size, and therefore offsets offer an advantage, while absolute lat/lon provide advantages in automating MAP message creation.

***Clarification/Requirement:***

***For consistent and unambiguous representation and interpretation, OBU Applications need signalized intersection infrastructure systems to represent lane geometry node points using the following approach:***

- ***The Center of the Intersection (reference point) is represented as an absolute lat/lon position with minimum of six decimal places for better than 0.11132m accuracy***
- ***The stop bar and subsequent node points for the lane geometry are represented by NodeOffsetPointXY using Node-XY-32b to represent X and Y offsets from the previous node point in 16bit value to provide maximum value of X and Y offset of 327.67m***

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### *2.1.4 Situations where SCMS message certification is not available*

***Need:***

Connected intersection infrastructure systems will sign and validate DSRC messages using the IEEE 1609.2 security standard and store the security certificates. It is expected that there will be times when no certification is available (e.g. due to a system or communication failure), and there is a need to clarify the approach to these times of missing certificates.

Depending upon the OBU application that is receiving/interpreting the SPaT/MAP/RTCM message, messages with missing certifications may (or may not) be used.

- *<Insert example with explanation of how an OBU might receive and choose to use this information, or not, in a manner that is different from a secured message.>*

***Clarification/Requirement:***

***OBU applications need signalized intersection infrastructure systems to continue to broadcast messages in times when a certificate is not available, but messages shall contain a security header containing a null or flag value (need to clarify), indicating the missing certificate.***

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### *2.1.5 Channel Utilization – DSRC Deployments*

***Need:***

As specified in the October 2017 draft version of the SAE J2945/0 channel plan (Table 4, pages 41-42), for RLVW application, the SPaT/MAP and optional RTCM message for position correction shall be transmitted on Channel 172.

An industry assumption is that during early deployment of DSRC based OBU applications in production vehicles, the OBUs may employ single channel units for both vehicle to vehicle (V2V) communications and V2I supported safety applications.

It is also assumed that in early deployment, during extremely low penetration, channel congestion will not be an issue for use of channel 172.

Examples of channel switching for real-time data communication from infrastructure to vehicle OBUs have not been identified (although CV Pilot Sites have indicated using service channels 174, 176, 180, & 182 for file and performance measurement data uploads but not for message transmission which remains on ch. 172).

***Clarification/Requirement:***

***OBU applications need signalized intersection infrastructure systems broadcasting DSRC messages to broadcast SPaT, MAP, and any appropriate RTCM messages on Channel 172.***

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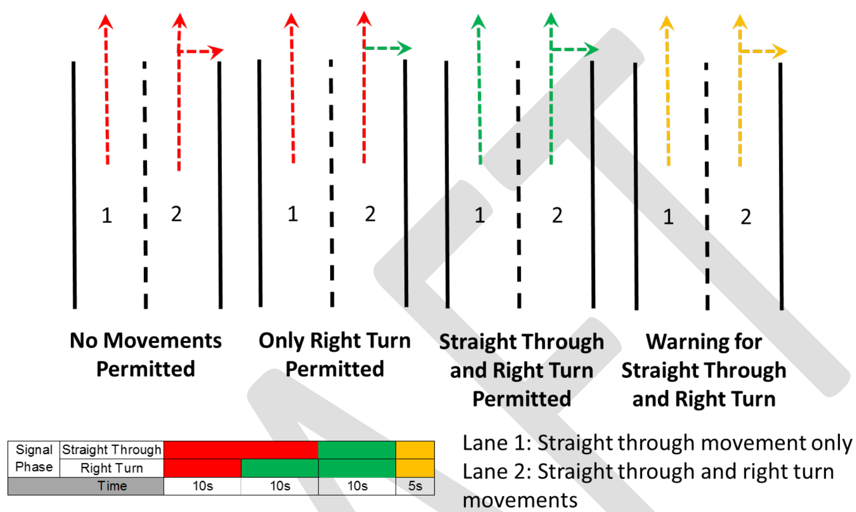
### *2.1.6 Configuration of turn lanes*

***Need:***

At the stop line of an approach having turn lanes, vehicles in the through lane can only go straight. However, upstream of the start of the turn lane, the through lane is for the turning traffic also.

The data element AllowedManeuvers is used to indicate which maneuvers are allowed for the lane. If a vehicle is located in the through lane at a point upstream of where the turning lane begins, OBU applications may interpret this as the wrong lane (i.e. they are intending to turn, but are in a through only lane). However, if the through lane is identified as both a through and turning lane, then an OBU application may interpret this to mean that the vehicle can turn from the lane.

OBU applications that rely on lane specific activities (as illustrated in the figure below) need for infrastructure systems supporting intersections where the through lane splits into through and turn movements to describe this in the MAP message.




***<u>Clarification/Requirement:</u>***

***For approaches where one or more turning lanes split from the through lane, the configuration of the through lane shall be split into two lanes by inserting a node adjacent to the start of the turn lane(s). The upstream portion of the through lane will be connected to both the remainder of the through lane and to the turn lane(s).***

***The through lane segment upstream of the node point (which also includes the turning movement) shall be described as both through and turning. The portion of the through lane after the start of the turn lane shall be described as through only.***

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### *2.1.7 SPaT Message content related to flashing yellow arrows*

***<u>Need:</u>***

Flashing yellow arrows are used to indicate a ‘permissive movement allowed’ (e.g. allowing vehicles to turn left in a permissive movement). According to the Manual on Uniform Traffic Control Devices (MUTCD), flashing yellow arrows are followed by a steady “yellow” arrow phase or a “green” arrow phase before turning to red.

OEMs need to understand the enumeration values and action at the end of a flashing "yellow" phase.

***Clarification/Requirement:***

***For intersections operating flashing "yellow" arrow phases, OBU Applications need signalized intersection infrastructure systems to identify flashing "yellow" phases as enumeration (5) (permissive-Movement-Allowed).***

***OBU Applications also need infrastructure systems to transition to an intermediate phase of solid "yellow" arrow before transitioning to a display of "red" arrow (i.e. not transition directly to "red" arrows from flashing "yellow" arrows), identified as enumeration (7) (permissive-clearance). Note: for reference, when a solid "yellow" arrow follows a "green" arrow, the movement is protected-clearance; however a solid "yellow" arrow following a flashing "yellow" arrow is permissive-clearance because it is not a protected movement.***

<Note: This clarification is still being discussed and is expected to be updated as data is verified>

### *2.1.8 Linking egress lanes to ingress lanes of downstream intersections*

***Need:***
When coding the ingress and egress lanes, there are benefits is the OBU application can receive information about the downstream ingress lane (e.g. to understand which MAP message to process in situations when multiple MAP messages may be received). There is some ambiguity regarding the relationship between egress lanes of one intersection and ingress lanes of another downstream intersection.

***Clarification/Requirement:***

***When defining the ingress/egress lanes in the MAP message:***

***The ingress lane will always connect to an egress lane of the same intersection.***

***In mid-block downstream, each egress lane connects to an ingress lane of the next intersection.***

<Note: There are open ended questions regarding this clarification. Ongoing discussions with IOO are being conducted to clarify this.>

### 2.1.9 Use of Intersection ID

***Need:***
In situations where vehicles may receive SPaT and MAP messages from multiple intersections, Intersection IDs are critical for associating a MAP message and the related SPaT message to the physical intersection.

There is also a need for consistency in how the Intersection IDs are assigned, and it is critical that Intersection IDs be unique, at least in the geographic vicinity and eventually unique world-wide.

***Clarification/Requirement:***
***IOOs should use the same unique Intersection ID to identify both the MAP message and SPaT message for each physical intersection.***

### 2.1.10 Uniform assignment of enumeration values for all possible signal states

Need:
Several new signal states have been introduced and are being used more frequently in recent years, such as the flashing arrow signal state. There is a need for a uniform assignment of enumeration values for all possible signal states such that there is no ambiguity when an on-board application receives a signal state in a SPaT message.

< Note: There are open ended questions regarding this clarification. Ongoing discussions with IOOs and OEMs are being conducted to clarify this. An estimated resolution date is not known>

### 2.1.11 Inclusion of vehicle position correction data

***Need:***
Various OBU applications need to determine the correct lane that the vehicle is traveling, and therefore it is critical that the location of the vehicle (determined by the on-board GPS) is accurate. Early testing of deployments has shown that atmospheric conditions at some intersections create situations where on-board GPS receivers are able to accurately locate the vehicle lane. However, some testing has demonstrated (at least in some locations) that supplemental data to correct for atmospheric conditions is required to enable on-board GPSs to more accurately determine the vehicle position. This can be accomplished by a broadcast of GPS correction information as standardized by the Radio Technical Commission for Maritime Services (RTCM) as a method for minimizing the effects of GPS error caused by atmospheric conditions or reduced satellite access.

There has yet to be an industry-wide decision regarding location-based correction data broadcast. The options include at least the following:

- Clarify that all connected signalized intersections need to broadcast position correction data, allowing OBU applications consistent data at each equipped intersection;
- Clarify that the inclusion of broadcasts of position correction data are a local decision to be reached by each IOO, creating a situation where OBU applications need to react to this data field as an “optional” field, not to be received at all intersections.

***Clarification/Requirement:***

< Note: There are open ended questions regarding this clarification. Ongoing discussions with IOOs and OEMs are being conducted to clarify this. An estimated resolution date is not known>

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### *2.1.12 Consistent broadcast of Minimum and Maximum End Times for traffic dependent operation (actuated or adaptive signal timing)*

***Need:***

As described in the SAE J2735 specification, the DF_TimeChangeDetails data frame conveys details about the timing of a phase within a movement. The core data concept expressed is the time stamp (TimeMark) at which the related phase will change to the next state. This is often found through a combination of the MinEndTime, MaxEndTime, and LikelyEndTime elements. The challenge is that there is not uniform implementation of the timing elements, especially related to actuated or adaptive signal timing plans. For example:

- SPaT messages broadcasting data output from actuated signals that are currently operating in a “rest mode” could be indicating a minEndTime data value that indicates the green phase has ended (i.e. minEndTime is the same as the current time) or will end in the next tenth of a second, causing Red Light Violation Warning applications to interpret that the current phase has ended or that a phase change is more imminent than the reality; and

- SPaT messages broadcasting data output from actuated signals where MinEndTime could be a large value intended to hold the green phase until a pedestrian or cross-traffic actuation occurs. When a pedestrian or cross-traffic actuation occurs, the MinEndTime is reduced and the phase change occurs. This reporting of a large value for MinEndTime could adversely affect on-board applications that determine the ‘green window’ of the intersection.

At least two situations have been observed regarding traffic dependent operations of signal timing:

- ***Situation 1:*** The major street has a pre-defined green phase time. When this time is reached, the intersection transits to green "Rest Mode" where the major street continues in green operation until either a pedestrian actuation, a cross-street vehicle actuation, or an eventual timing out occurs. In this situation, the MinEndTime is typically the current time or .1 seconds into the future. The reality is that the intersection would perform a clearance phase if a pedestrian or cross-traffic actuation occurred (e.g. approximately 12 seconds) and therefore the MinEndTime is not the current time or .1 seconds into the future. This could cause Red Light Violation Warning applications that approach an intersection when the MinEndTime is incorrectly reporting the end time to be the current time or .1 seconds into the future to interpret that the phase has ended or that a phase change is more imminent than the reality.
- ***Situation #2:*** The major street has a very lengthy pre-defined green time (e.g. MinEndTime ending 5,000 seconds into future), with the concept that after a minimum period of time a pedestrian or cross-street actuation would shorten the green time down to a clearance phase (e.g. approximately 12 seconds) before transitioning to yellow. This could pose a challenge to on-board applications using the MinEndTime and MaxEndTime to determine the "green window" of the intersection to support eco-approach/departure related applications.

***Clarification/Requirement:***

***In the above example,***

- ***The current RSU time has reached the MinEndTime (no time remaining before the phase change), however the current green phase has transitioned to "Rest Mode" and is still displaying green, but an OBU receiving the SPaT message would interpret the change to yellow as imminent***
- ***It is required for the in-vehicle application to either:***
    - ***Receive data elements in the SPaT message that enables the application to determine when the current green phase will change for certain; or***
    - ***Receive data elements in the SPaT message that enables the application to determine if there is a minimum amount of time before the green phase will change, if the time of change cannot be determined.***

< Note: There are open ended questions regarding this clarification. Ongoing discussions with IOOs and OEMs are being conducted to clarify this. This will likely involve both technical clarifications and policy-level clarifications. An estimated resolution date is not known>

### *2.1.13 Consistent transition following Yellow Flashing Arrow and Yellow Flashing Ball Movement Phase States*

**<u>Need:</u>**

On-board applications need to understand the next movement phase state in order to operate properly. Currently, there is ambiguity in what movement phase state follows the Yellow Flashing Arrow and Yellow Flashing Ball phase states.

- The most expected implementation is flashing yellow states (ball or arrow) transition to solid yellow for the full duration of solid yellow determined for that approach and then transition to RED phase.
- Another alternative implementation observed is that flashing yellow states (ball or arrow) transition to Green state (either directly or following a solid yellow). Implementations like this could impact on-board applications that are based on the progression of flashing yellow to solid yellow to RED before the return to green.

**<u>Clarification/Requirement:</u>**

< Note: There are open ended questions regarding this clarification. Ongoing discussions with IOOs and OEMs are being conducted to clarify this. An estimated resolution date is not known>

## 2.2 RLVW Specific Clarifications

This section contains ambiguities that are specific to the use cases and requirements of RLVW applications. IOOs that are deploying Signalized Intersection Systems to support production vehicle OBU applications of RLVW are encouraged to deploy the clarifications/requirements provided.

### *2.2.1 SPaT message frequency of transmission*

***Need:***

RLVW safety applications need to receive SPaT messages frequent enough to support the actions of the application. For RLVW safety application to perform as intended, the SPaT message broadcast frequency requirement is established based on following conditions/assumptions to receive the message, process for threat assessment and allow driver to take an appropriate action.

1. Vehicle approach speed – 55mph (~25m/s or 2.5m between consecutive transmitted message)
2. Human reaction time – 1.5s to 2s
3. Abrupt or last-minute lane change maneuver
4. Time to assess threat and generate alert
5. Time to stop vehicle at 3m/s/s deceleration rate.
6. Message receive probability considering potential non-line of sight receiver position or obstruction.

Based on above assumptions, if the SPaT message is transmitted at 1Hz, the vehicle will travel ~25m in one second. For an RSU range of 300m, the approaching vehicle would have ~12 seconds to receive 12 messages. This may not be sufficient time for the vehicle algorithm to receive, decode, perform lane level map matching for vehicle position, perform threat assessment, and generate warnings for the driver to take appropriate actions.

***Clarification/Requirement:***

***Based on the above conditions/assumptions, OBU applications need signalized intersection infrastructure systems to broadcast SPaT messages at a frequency of 10 Hz with signal phase time update rate at 1/10$^{th}$ second***

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### *2.2.2 Signal State Frequency of Output from the signal controller*

***Need:***

RLVW safety applications need the most current signal status in order to immediately process any changes to signal status and take appropriate action. In cases where the infrastructure system updates signal phase information at 1 Hz and at 1s resolution, repeating the same value in minEndTime data element at 10Hz in a SPaT message can have a delay of up to 9/10 second and therefore delay actions by applications for up to 9/10 second. As a result, the RLVW application may generate incorrect alerts.

***Clarification/Requirement:***

The infrastructure system shall ensure that the 10Hz SPaT message reflects the current state of the signal indications within 100ms of a change in the signal indications.

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### *2.2.3 MAP message frequency of transmission*

***Need:***

RLVW safety applications need to receive MAP messages frequent enough to support on-board calculations to determine which lane/approach to the intersection the vehicle is traveling. Since the MAP message does not change regularly, low latency for receiving updates is not as critical as with the SPaT message, however the MAP message must be received far enough upstream of the intersection to support calculations.

***Clarification/Requirement:***

***OBU applications need signalized intersection infrastructure systems to broadcast MAP messages at a frequency of 1 Hz.***

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### *2.2.4 RLVW vehicle position correction data exchange clarification*

***Need:***

RLVW safety applications need to determine the correct lane that the vehicle is traveling to alert drivers in lanes approaching red lights. For the vehicle to accurately identify the approach/phase using the MAP message, it is critical that the location of the vehicle (determined by the on-board GPS) is accurate. Early testing of deployments has shown that atmospheric conditions at some intersections create conditions where on-board GPS receivers are able to accurately locate the vehicle lane. However, some testing has demonstrated (at least in some locations) that supplemental data to correct for atmospheric conditions is required to enable on-board GPSs to more accurately determine the vehicle position. This can be accomplished by a broadcast of GPS correction information as standardized by the Radio Technical Commission for Maritime Services (RTCM) as a method for minimizing the effects of GPS error caused by atmospheric conditions or reduced satellite access.

RLVW applications need to have a uniform approach for the broadcast of position correction data using RTCM in order to support one standardized approach for receiving and interpreting position correction data. Note: It is recognized that the broadcast of position correction data may not occur at every connected signalized intersection, however it is important to have uniformity within those systems that do broadcast the corrections.

***Clarification/Requirement:***

< Note: There are open ended questions regarding this clarification. Ongoing discussions with IOOs are being conducted to clarify this. An estimated resolution date is not known>

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## 2.3 Signal Priority Application Specific Clarifications

<Placeholder for future section>

## 2.4 Pedestrian in Signalized Crosswalk Conflict Warning Application Specific Clarifications

<Placeholder for future section>

## 2.5 Other Application Specific Clarifications

# 3 Supporting Content and Information

## 3.1 Links to Related Standards and Resources

The following standards, references, and resources to support connected signalized intersection infrastructure system deployment.

1. CAMP SPaT Challenge Verification Document version 1.2 (revised October 30, 2017). The latest version of this document can be requested by submitting contact information on the following website: https://transportationops.org/content/spat-challenge-verification-document.
2. SAE J2735 standard. At time of preparation of this document: "Dedicated Short Range Communications (DSRC) Message Set Dictionary." SAE J2735_201603 (March 30, 2016). Available at: https://www.sae.org/standards/content/j2735_201603/.
3. SPaT Challenge Infrastructure System Model Concept of Operations version 1.6 (revised March 2016). Available at: http://transops.s3.amazonaws.com/uploaded_files/SPaT%20Challenge%20Model%20Concept%20of%20Operations%20Draft%20Ver%201.6.pdf
4. SPaT Challenge Infrastructure System Model Functional Requirements version 1.1 (revised March 2016). Available at: https://transops.s3.amazonaws.com/uploaded_files/SPaT%20Challenge%20Infrastructure%20System%20Model%20Requirements%20Draft%20Ver%201.1.pdf
5. SAE J2945/0 standard. At the time of preparation of this document: "Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts." SAE J2945_201712 (December 7, 2017) Available at: https://www.sae.org/standards/content/j2945_201712/.

## 3.2 Process for Identifying Additional Ambiguities

IOOs or OEMs wishing to contribute additional ambiguities are requested to describe the need and the recommended clarification when submitting their request.

IOOs or OEMs wishing to encourage dialog about a clarification already included in this document are requested to identify the ambiguity and describe the alternate suggested approach.

These and other inquiries can be submitted to <TBD>.