

## PURPOSE AND DESCRIPTION

Unlike human drivers that can view the signal indications as they approach an intersection, connected vehicles must receive data to determine the current signal status (i.e., red, yellow, green) along their path of travel.

The intent of broadcasting SPaT messages is to provide secure transmissions of real-time signal phase and timing data from the traffic signal controller to connected vehicles operating in-vehicle applications.

Connected vehicles will use the SPaT messages to support applications such as Red Light Violation Warning (RLVW) and signal priority or preemption applications.

# Signal Phase and Timing (SPaT) Message

## Connected Intersections Program Brief



(Source: USDOT)

### Introduction

The SAE J2735 Signal Phase and Timing (SPaT) message provides status information about a signalized intersection, including dynamic signal indication and timing information for the individual signal groups at the intersection.

The data included in the SPaT message enables in-vehicle applications to understand the current and near future status of the signal controller (i.e., red, yellow, green, green arrow, etc.) as they approach a connected intersection. Once the status of the signal controller is known, applications such as Red Light Violation Warning (RLVW) can determine appropriate notifications to be delivered to drivers, such as alerting drivers who are not decelerating that the signal indication is currently red.

The SPaT message alone is not enough information for in-vehicle applications. An accompanying MapData (MAP) message provides geographic information to enable in-vehicle applications to understand their lane of travel and planned maneuvers in order to recognize which signal group controls their lane of travel.

***The SPaT message, in addition to mapping information and position correction data, must be broadcast by an infrastructure system to vehicles for all connected intersections.***

### SPaT Message Operation

The operation of a SPaT message broadcast can be described by three high level actions that must occur, as follows:

- 1. SPaT Messages Output from Traffic Signal Controller.** The traffic signal controller located roadside at the intersection will generate the current signal phase and timing parameters used to control the signal heads and pedestrian crossing signs. NTCIP 1202 compliant traffic signal controllers are typically capable of generating an output of the SPaT parameters as NTCIP 1202 SPaT messages.
- 2. Conversion of NTCIP 1202 SPaT Messages to SAE J2735 SPaT Messages.** In order for the broadcasts of SPaT messages to be compliant with the SAE J2735 standards, the SPaT data from the controller must be converted into SAE J2735 formats prior to broadcast. This conversion may happen either:
  - in the controller,
  - by using software in the RSU, or
  - on another computing device in the cabinet.Currently, the SAE J2735 Version 2020 is the latest version.

- 3. SPaT Messages Broadcast by RSU.** The SPaT message is then broadcast by the roadside unit (RSU) to be received by on-board units (OBUs) in the vehicles. The most common approach is the use of 5.9 GHz direct communication at a frequency of 10 Hz. Network cellular and Internet sharing of SPaT data (without the use of RSUs) may also be used. Please see the CV PFS Guidance Brief "[Comparing Direct Communication to Network Cellular](#)" for more details.

## SPaT MESSAGE RESOURCES

SAE J2735 Standard (that includes the SPaT Message):  
[https://www.sae.org/standards/content/j2735\\_202007](https://www.sae.org/standards/content/j2735_202007)

Cooperative Automated Transportation (CAT) Coalition, SPaT Challenge Resources (includes SPaT V2I Infrastructure System Concept of Operations and System Requirements; SPaT Verification Document):  
<https://transportationops.org/spatchallenge/resources>

ITE, Connected Intersections (including Functional Requirements, Concept of Operations, System Design Details, and Implementation Guide):  
<https://www.ite.org/technical-resources/standards/connected-intersections>

## SPaT Message Content

The following table provides an overview of the message content of the SPaT message:

<i>Intersection State</i>	This includes information such as whether the intersection is currently in preemption or priority, whether the intersection is in failure flash, whether it is fixed time or traffic actuated, and indicators that the MAP message has been updated, among other things. It also includes a list of which revocable lanes are currently enabled, if the MAP message had indicated any revocable lanes.
<i>Signal Group State</i>	For each active signal group in use at the intersection, the SPaT message describes the current state (i.e., the current interval for that phase), provides the best estimate for when that interval may end, and potentially describes future interval states and times. In order to be applicable across regions and countries, the state of the signal group is described in the message by its meaning, rather than how it is displayed at the intersection (e.g., ‘ <i>stop and remain</i> ’ to represent a red light, ‘ <i>protected movement allowed</i> ’ to represent a green left turn arrow).
<i>Signal Group Timing</i>	The SPaT message uses a point in time, called a time mark, to indicate when an interval will change rather than a countdown to when the interval will change. For a traffic actuated traffic signal system, the SPaT message for a green interval may start with an earliest end time being a time in the future when the minimum green will expire. Using time marks rather than countdowns minimizes the SPaT message updates needed and can help mitigate the impact of latency in transmitting the message.
<i>Future Intervals</i>	The SPaT message can provide information about the future states and times of signal group intervals in addition to the current interval with its end times.
<i>Connection Maneuver Assistance</i>	The SPaT message can include connection maneuver assistance. The traffic signal system knows if a pedestrian has activated the pedestrian pushbutton to request a walk indication. In addition to the presence of a pedestrian pushbutton actuation, the intersection may include detection equipment specifically designed to detect pedestrians in the crosswalk.

### Additional Guidance on Related Topics

- The SPaT message must be accompanied by a MAP message describing the same intersection to enable the in-vehicle application to determine their lane of travel and which signal group controls their planned maneuver. Additional details of the MAP message are available in the CV PFS Guidance Brief “[The MAPdata \(MAP\) Message](#)”.
- SPaT messages are typically accompanied by position correction data to enable on-board GPS systems to correct for atmospheric conditions (formatted according to the Radio Technical Communications for Maritime Services (RTCM) standards. Additional details of the use of RTCM messages to communicate position correction are available in the CV PFS Guidance Brief “[RTCM for Position Correction](#)”.

### Relevance to CV PFS Members

- The SPaT message is an integral component for IOOs planning to deploy connected intersections.
- When considering a connected intersection deployment, agency staff should familiarize themselves with SPaT resources to understand minimum requirements, and ensure that all required data is available from traffic signal controllers at the signalized intersection.
- Agency staff should work with their signal controller manufacturer to understand the compatibility of signal controller data outputs to the data needed to create the SPaT message.
- Overall Connected Intersection Guidance being developed by the Connected Vehicle Pooled Fund Study will include additional details.