ITS USE CASE

Use Case Title:	**Green Light Optimal Speed Advisory (GLOSA)**
Project Name:	Standaardisatie Tafel (NL)
Source:	Amsterdam Group (AG), EcoAT, ISO-19091, ETSI-TS103301, SAE-J2735
Date:	2015-11-25
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Abstract:	Use case and related functional and technical requirements realizing improved traffic safety, lower CO^2 emissions, fuel reduction and predictable traveling time by efficient green light and speed adjustment by my means of ITS-G5.
Agenda Item:	None
Work item(s):	None
Document(s) Impacted	Dutch Profile
Intended purpose of document:	☐ Decision ☒ Discussion ☐ Information ☐ Other <specify>
Decision requested or recommendation:	

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1.1 Use Case Green Light Optimal Speed Advisory

1.1.1 Introduction Use-Case

1.1.1.1 Use case ID

GLOSA

1.1.1.2 Background

Vehicles approaching a traffic light will inform the driver in advance about the traffic signal status for crossing the conflict area of an intersection. The vehicle (V-ITS-S) may advise an optimal speed to the driver for smoothly approaching the intersection (in case of red) or for safely passing the conflict area of the intersection based on the signal phase and timing (SPAT) and intersection topology (MAP) information received from the infrastructure (R-ITS-S). The SPAT / MAP information broadcasted from the R-ITS-S reflects the real-time signal phase & timing status for each lane. Therefore, a vehicle may be able to predict the optimal speed advice on each lane [Eco-AT].

1.1.1.3 Objective

Smoother approaching and passing of intersection resulting in improved traffic safety, increased traffic flow for vehicles and increased energy efficiency by reducing vehicle stops.

1.1.1.4 Source

ECO-AT, ETSI TC ITS, ISO-19091, ETSI-TS103301, SAE-J2735, ETSI-CDD,

1.1.2 Description Use-Case

The R-ITS-S periodically broadcasts the intersection layout and signal phase and timing. This information is received by approaching vehicles equipped with a V-ITS-S. The V-ITS-S may advise an optimal speed to the driver for safely passing the conflict area of the intersection or for smoothly approaching the intersection (in case of red).

1.1.3 Target System (as applicable)

V-ITS-S and R-ITS-S

1.1.4 Implementation environment (as applicable)

Signalised intersections.

1.1.5 Actors (as applicable)

Traffic light controller (TLC) to provide the necessary signal status data.

Driver to act on the speed advice provided.

1.1.6 Pre-conditions (if any)

- TLC is connected to R-ITS-S and can provide information on the current and next phase.
- Special precautions should be taken to connect dynamically timed TLCs.
- R-ITS-S is able to send information on the static topology of the signalised intersection. Optionally this static information is provided to V-ITS-S by other methods.

- R-ITS-S supports I2V services and can send information on signal phase and timing.
- V-ITS-S supports I2V services and can receive information on signal phase and timing.

1.1.7 Triggers conditions (if any)

No trigger conditions, information is broadcasted periodically

1.1.8 Use-Case Diagram (if any)

No use case diagram at present.

1.1.9 Normal Flow (as applicable)

In normal flow there are two implementation options for GLOSA:

1. Speed advice is calculated by R-ITS-S (RIS), based on signal phase and timing information and send to V-ITS-S (VIS) or;
2. Speed advice is calculated by VIS itself, based on signal phase and timing information from RIS.

The signal phase and timing information can also be used by other types of applications like red light violation, whereas for green wave applications, speed advice can be used. The figure below shows the normal flow of GLOSA.

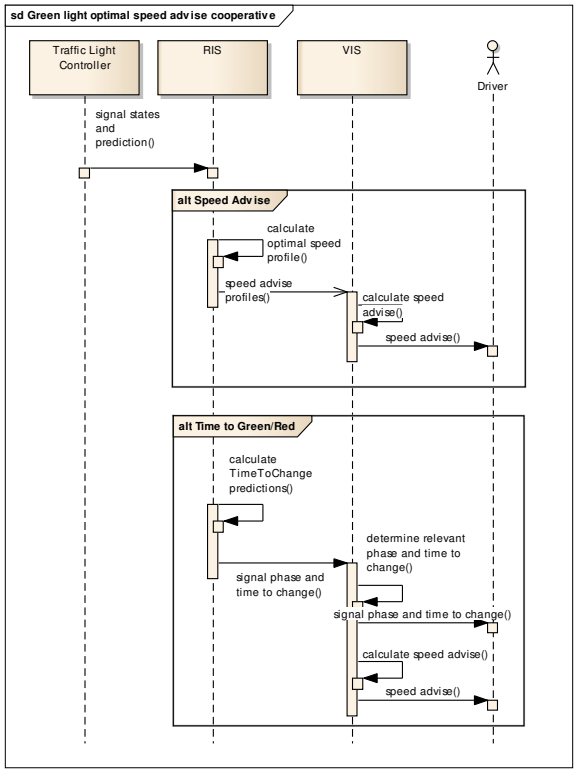

Figure 1: Sequence diagram for GLOSA via cooperative communication

1.1.9.1 Alternative flow (if any)

As an alternative to cooperative communication (ITS-G5) signal phase and timing information can be transmitted via connected communication. The figure below shows this alternative flow of GLOSA.

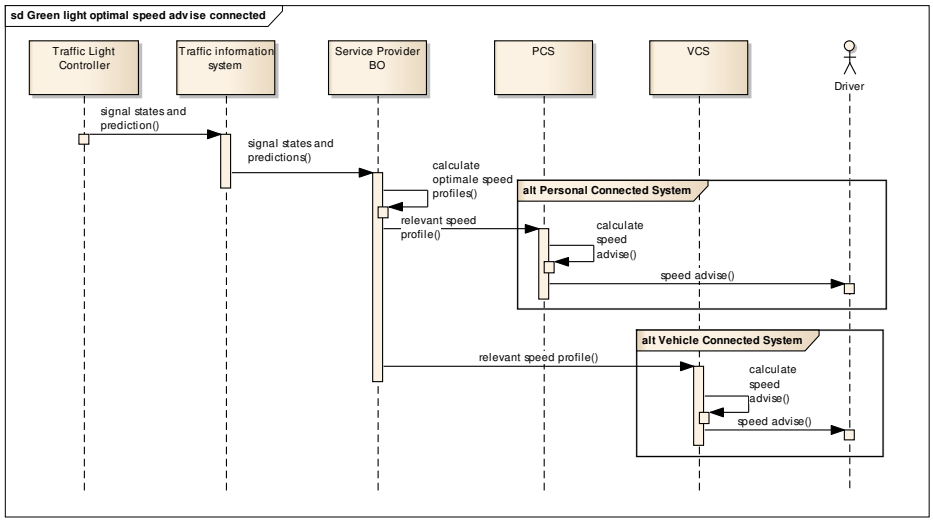

Figure 2: Sequence diagram for GLOSA via connected communication

1.1.10 Post-conditions (if any)

The driver can anticipate to the signal phase and timing information provided.

1.1.11 Termination conditions (if any)

Given the nature of the DSRC communications, the GLOSA use case described herein relies on the replication of messages and the probability that the target ITS-S will receive the message in time to take appropriate action. Additionally, subsequent signal phase and timing information replaces previously transmitted information. For example, a priority treatment can be immediately terminated to accommodate an emergency vehicle of higher priority and considerably affect previously broadcasted signal phase and timing information. Thus the entity must continuously monitor the messages received and act accordingly, for example, whether it is to modify signal timing or provide driver warnings. Finally, signal phase and timing information is cancelled if the vehicle has passed the intersection.

1.1.12 Use-Case Illustration (as applicable)

The following use case illustration is derived from ISO TS 19091.

1. V-ITS-S equipped vehicle enters R-ITS-S range.
2. R-ITS-S transmits MAP and SPAT information.
3. V-ITS-S verifies that R-ITS-S (RSE) messages are acceptable (authentic, valid, etc.).
4. V-ITS-S matches vehicle location to intersection geometry/lane and associated signal phase, intersection speed limit, vehicle routing, turn signal status, vehicle type, and queue length (by lane) information.
5. V-ITS-S determines if vehicle is expected to arrive at intersection during red interval or if the queue length is excessive.
6. If arrival at/near red interval is expected, V-ITS-S determines optimal deceleration profile to stop at intersection, or acceptable acceleration profile, and provides information to driver. If the queue length is excessive, the V-

ITS-S alerts driver of the situation and recommends a change in speed or a change in lanes.

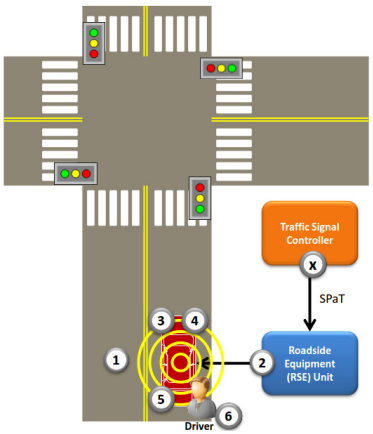

Figure 3: illustration GLOSA (source ISO TS 19091)

1.1.12.1 SPAT Data Frames

The main data frames and data elements used for the description of the traffic light signal phase and timing are shown in the figure below. For a detailed description see the documents ISO-19091, ETSI-TS103301, SAE-J2735 and ETSI-CDD. Due to publication restrictions of SAE J2735 only a general description is provided below.

SPAT may contain the *IntersectionState* of up to 32 intersections. Each *IntersectionState* contains the *MovementState* for each manoeuvre. For each manoeuvre the *MovementState* contains a *SignalGroupID* and a *MovementEvent*. *SignalGroupID* is used to match the SPAT message data to the MAP message data. *MovementEvent* forms the core of the SPAT message by means of *eventState*, *timing* (TimeChangeDetails - optional) and *speeds* (AdvisorySpeed - optional). *evenState* includes the phase state (i.e. green, red or amber) as a directional, protected or permissive state. *Timing* consists of *TimeMarks*, at least the expected shortest end time of the phase (minEndTime) and optionally completed with the expected longest end time, the best predicted end time (including confidence value) and a rough estimate of time when this phase may next occur again. *Speeds* includes among others *SpeedAdvice* (optional) and the distance (described by *ZoneLength* - optional) for which the advised speed is recommended.

Additionally, the regional extension *activePrioritizations* as part of *IntersectionState* reflects the state of the priority request on each of the relevant signal groups which is how priority states can be acknowledged. *ManeuverAssistList* as part of either *IntersectionState* or *MovementState* contains information about the dynamic flow or traffic, e.g. the length of queues per lane (described as *ZoneLength*), for manoeuvres in question.

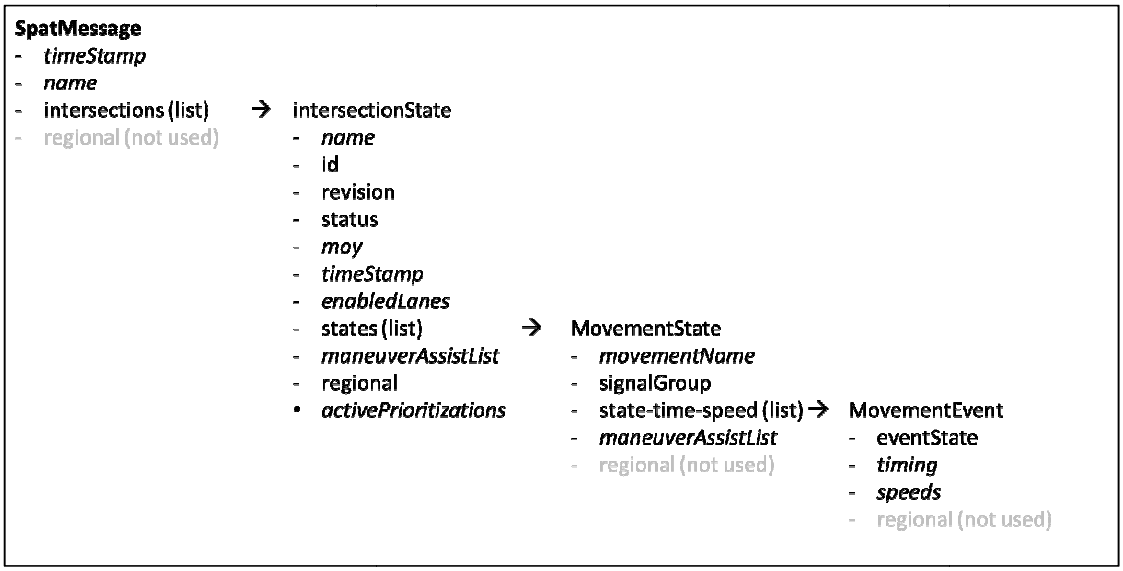

Figure 4: main DF and DE SPAT message

It is important to consider that the SPAT message is not designed to transmit time windows (e.g. the green window), but is designed to transmit the current state of each movement and the expected duration of this state until the next state. As such it provides a cross-cut of a signal phase diagram at the time it is transmitted. However, for each *SignalGroup* up to 16 *MovementEvents* can be included, which allows conveying multiple predictive phase and timing of the current signal group. For example, in the example below and assuming pre-timed control, if *MovementEvent* of signal group 5 would be transmitted at t = 15 seconds, the *eventState* would indicate 'Movement-Allowed' (either permissive or protected) and the *timing* would indicate a *minEndTime*, *maxEndTime* and *likelyTime* of 9 seconds (in *TimeMark* coding). A second *MovementEvent* would indicate: 'protected-clearance' for the amber phase and *minEndTime*, *maxEndTime* and *likelyTime* would indicate 12 seconds. Similarly, a third *MovementEvent* would indicate: 'stop-and-remain' and 38 seconds.

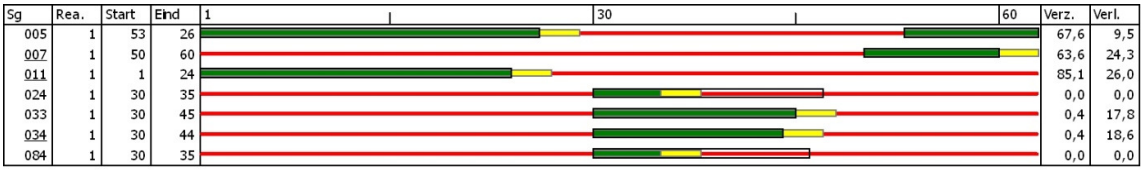

Figure 5: example phase diagram

1.1.12.2 Infrastructure services

In scope of the GLOSA use case, ETSI TS 103 301 [REF] specifies the application support facilities provided by the facility layer that construct, manage and process messages distributed from infrastructure to end-users or vice-versa based on payload received from the application. Within the scope ETSI TS 103 301, the term message refers to the facilities layer; the term payload refers to the applications layer. The payload is generated by the application and provided to the corresponding service of the Facilities layer. The Facilities service merges the "ItsPduHeader" (ETSI TS 102 894-2 **Fout! Verwijzingsbron niet gevonden.**) with the SPAT or MAP payload (as specified in ISO TS 19091 [REF], in order to construct a message. These message are then referred to as "SpatMessage" or Intersection Status Service (ISS) and "MapMessage" or Road Topology Service (RTP) respectively (ETSI TS 103 301 [REF]).

1.1.13 Potential requirements (as applicable)

- R-ITS-S shall support I2V services and can send information on signal phases and timing and intersection topology.
- V-ITS-S shall support I2V services and can receive information on signal phases and timing and intersection topology.
- The static topology of the signalised intersection, including road segments, lanes and traffic light layout shall be available for the V-ITS-S.
- Reliable information on current and expected signal phase and timing shall be available from the TLC.
- V-ITS-S shall receive the signal phase and timing information timely.
- For ITS-G5:
  - R-ITS-S at the traffic light controller shall broadcast the Signal Phase and Timing (SPAT) message at 1 Hz. to indicate the current (and future) signal state information.
  - R-ITS-S at the traffic light controller shall broadcast at 0.5 Hz. information that describes the geometrics of the intersection in MAP format. Changes to the base geometry are flagged, to allow a vehicle receiving the MAP information message to only process the changes if the version for the base geometric is different from what is currently stored in the vehicle.

1.1.14 Linked use cases (as applicable)

- Priority Request (for emergency, public transport and freight vehicles)
- Red Light Violation Warning
- Dilemma Zone Protection
- Turning Assistant
- Green Wave
- Continuous Speed Advice (Corridor Speed Guidance)
- GLOSA / Green Wave for Cyclists
- Idling Stop Support
- Start Delay Prevention