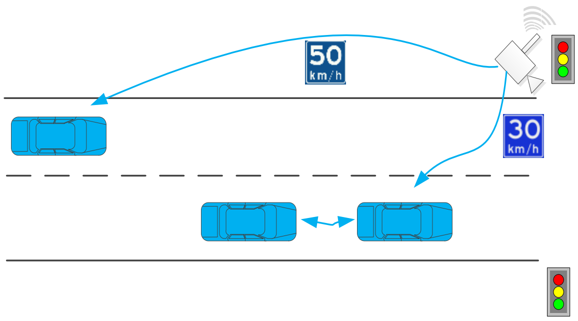
1 GLOSA - High Level Service Description

Service introduction	
Summary	This document described requirements for the GLOSA use case and it represents the collective input from France, Netherlands and the UK. Vehicles approaching traffic signal controlled intersections inform the driver in advance about the status of the traffic signals, and also advise them of an optimum approach speed that should minimise delay and ensure a smooth transition through the conflict area of an intersection.
Background	The GLOSA service provides drivers via in-car information system, or vehicle control systems, with advisory speed information. The advisory speed information is derived from a combination of traffic signal phasing and timing information (SPAT) that is relevant to the position and direction of travel of the vehicle, and topology information relating to the intersection (MAP).
Objective	To calculate advisory speeds for vehicles that will enable a vehicle or platoon of vehicles to pass through a signalised intersection in the most efficient manner, with minimal delay.
Expected benefits	The primary expected benefit is smoother vehicle flow through signalised intersection, reduced start/stop delay and reduced desire to chase green signals or the need to rapidly decelerate. With knowledge of the likely duration of the red signal, the driver or vehicle control system can also determine whether or not to stop the vehicle's engine. This should result in reduced energy consumption, reduced vehicle emissions (including CO_2), reduced vehicle wear and tear, increased safety, improved driver and passenger comfort, reduced stress and better average speeds, particularly in urban environments where there is generally a higher density of traffic signals. Where a vehicle is stationary at a red light and where the provision of 'count down to green' information is permitted, the start delay is expected to decrease as the start of the green phase is known in advance. Secondary benefits may result from interaction with other use cases like 'Traffic Signal Optimisation'. As the driving speeds and the signal phases and timing could be optimised synchronously, the delay times at the signalised intersection are expected to decrease.
Use Cases	There are two primary use cases: Situation 1: Time-to-red information and speed advice: a vehicle approaches a signalised intersection while the traffic light is green or will arrive at the stop line during the green phase. Situation 2: Time-to-green information and speed advice: a vehicle approaches a signalised intersection while the traffic light is red or will arrive at the stop line during the red phase.

1.1 GLOSA - Time-to-green information and speed advice.

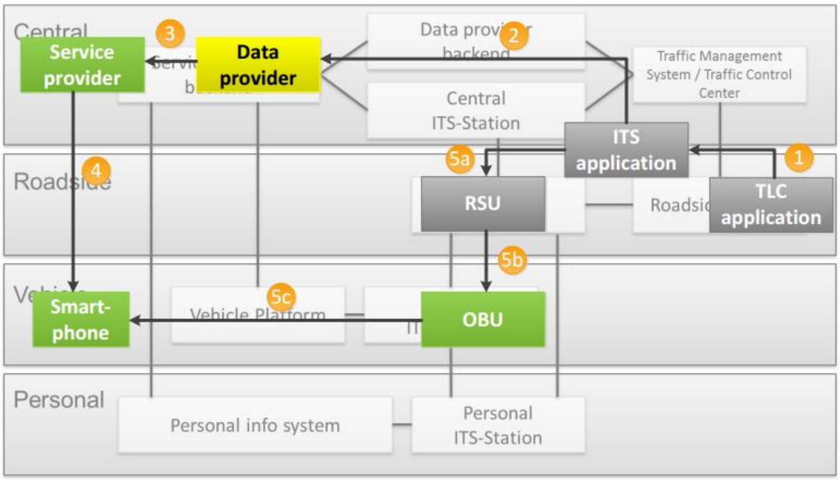
1.1.1 Functional description

Use case introduction	
Summary	While approaching a signalised intersection information is broadcast to approaching vehicles informing them of the traffic light phase schedule. This is either sent from the traffic signal controller via a roadside unit (R-ITS-S / G5), or via a central traffic control system via cellular 3G/4G. This information, combined with information on the position of the vehicle, the speed of the vehicle and the distance to the traffic light, will enable an algorithm in the vehicle to calculate an optimal speed of approach (under the mandatory speed limit). Vehicle drivers receive the speed advice information via the display (HMI) of the vehicle's OBU. Where legally permitted, when stationary at a red traffic signal, road users may also be advised of the time to green (currently this is forbidden in France and it is therefore not possible to give this information to drivers).
Background / added values	The information can be displayed in the driver's own language. Reduced driver anxiety and improve compliance with traffic signals.
Objective	The aim is to display an alert to the user that they are approaching a signalised intersection and to provide an advisory speed, or to notify the driver (where permitted) of the likely 'time to green'.
Desired behaviour	The vehicle driver or the vehicle controls will adjust the speed of the vehicle to comply with the speed change advice, and will maintain that speed while approaching or passing the signalised intersection. Or, they will be prepared to decelerate smoothly if they arrive at the intersection when it is displaying a red traffic signal.
Expected benefits	Comfort, safety and reduced fuel consumption and emissions.
Use case description	
Situation	Time-to-green information and speed advice: a vehicle approaches a signalised intersection while the traffic light is red or will arrive at the stop line during the red phase.
Logic of transmission	I2V via G5 beacon located at the traffic signal intersection, or cellular 3G/4G / broadcast
Actors and relations	• Vehicle driver: receives speed advisory information on the in-vehicle display (OBU HMI). • Road Operator or Highway Authority: provides signal phasing and timing (SPAT) and map information, either locally from the traffic signal controller, or centrally from their traffic signal control system. • Service provider: disseminates the speed advisory information to vehicle drivers. • Vulnerable road user: speed advisory information may be offered to cyclists too. Crossing vulnerable road users may affect the validity of the speed

	advisory information. • Other: n/a.
Scenario	There are three possible scenarios: 1. As indicated by the speed advice a vehicle maintains the current speed and arrives at the intersection during a green phase. 2. As indicated by the speed advice a vehicle decreases its current speed and arrives at the intersection at the start of a green signal phase. 3. As indicated by the speed advice a vehicle gradually decreases speed and stops to wait for the next green phase. In some member states, where legally permitted, the vehicle may then receive speed (acceleration) advice as soon as the signal turns to green, in order to minimise the start delay.
Display / alert principle	GLOSA speed advice information and ‘time to green’ information shall be displayed to the driver via the HMI.  **Figure 1: Green light optimal speed advisory** The SPAT / MAP information that is broadcast from the R-ITS-S/ G5 or via cellular communication reflects the real-time signal phase & timing status for each lane. Based on the SPAT / MAP information the vehicle (V-ITS-S) may advise an optimal speed to the driver for smoothly approaching the intersection (in case of red). The potential display/ alert scenarios are as follows: • When the light is red and the driver has to stop, the advice is to stop. The time to green (TTG) can be given only if permitted (currently forbidden in France). • When the light is red but about to turn green, the driver receives speed advice. The advice may either be to continue, or to reduce their speed in order to arrive at the intersection on a green signal phase.
Functional constraints / dependencies	• ‘Time to green’ (TTG) is forbidden in France except at the approach of temporary traffic lights for use at roadworks. (Note: Check if time to green prohibition in France can be avoided for C-ITS technologies and tested). • The speed advice has to be equal or lower than the legal speed limit. • The presentation of information on the HMI is <u>not</u> part of the service description. It is left to the provider of the in-vehicle information system how the information is presented. Information might e.g. be translated to the preferred language of the driver. • The information presented by means of I2V is advisory information only and may not take into consideration variables such as road conditions including weather or traffic density/ congestion.

1.1.2 High level technical description

Use Case Implementation	
Model Implementation	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. This information will either be received from the local infrastructure (R-ITS-S / G5), or it will be provided centrally via cellular (3G/4G) communication. TfL proposes piloting a cellular only implementation of this service and Kent County Council proposes piloting hybrid communication. The Signal Phase and Timing message (SPAT) and the corresponding intersection layout message MAP as specified in SAE-J2735 are messages designed for infrastructure-to-vehicle communication. Their purpose is to transmit either the current and/or the future status of signalling on the entire intersection in an electronic, machine readable way to vehicles. The SPAT / MAP information that is broadcast, together with other information, reflects the real-time signal phase & timing status for each lane. Therefore, a vehicle may be able to calculate or derive the optimal speed advice for each lane. Fast (low latency) communication and suitable HMI to communicate to the driver are needed. The GLOSA application communicates information to the driver about which speed he should adopt to keep in continuous flow with no need to stop. The millisecond timing is less important than the fact that a correct forecast-message is available before reaching the intersection. A digitised map of the area is also pre-requisite for SPAT, which might include road topography and road attributes, such as number of lanes on each approach to the intersection and the manoeuvres possible between them. SPAT messages relate to these relations in the MAP. Once the SPAT with forecast and a MAP is implemented, this enables Green Light Optimal Speed Advisory (GLOSA) to be given to the drivers via the same interface. Drivers travelling at or close to the advised speed are likely to clear the intersections, creating what is commonly referred to as the “Green Wave” - minimising erratic stop/start behaviour.
Reference architecture	**NL:** In the Netherlands, the GLOSA service is implemented following the architecture of the ‘intelligent Traffic Light Controller (iTLC) . The architecture allows for integration of the C-ITS domain with the TLC domain by allowing ITS Applications to use facilities from both the Traffic Light Controllers (TLC) and Roadside ITS stations (RIS) and therefore enable the implementation of various ITS use-cases related to TLC’s. The ‘TLC-Facilities’ and ‘RIS-Facilities’ describe the functionality of respectively TLC and RIS. The goal of the architecture is to provide the TLC Facilities and RIS Facilities functionality to ITS Application by defining open interfaces. The figure below shows the functional architecture of the GLOSA service.



Every colour could indicate another stakeholder

The process for this application contains several steps:

- The ITS application receives TLC-information from TLC applications (1).
- The ITS application sends messages containing SPAT / MAP information towards data providers (2) and towards RSUs (5a) to broadcast the message during the requested duration time with a specific repetition rate to OBUs (5b). In the vehicle the message of the OBU is forwarded to an application on a smartphone (5c).
- Data providers collect the data of ITS applications and provide that to service providers (3).
- Service providers determines whether SPAT / MAP information is required for individual users and send the appropriate information to smartphones (4).

UK: The UK will pilot hybrid (KCC) and cellular only (TfL) systems of communication for the pilot GLOSA services. The primary reason for this is that TfL is not currently planning to implement G5 infrastructure .Should this project develop from a trial, then the future deployment of these services could pose a future financial encumbrance that TfL may not be able to commit to (there are circa 6000 sets of traffic signals in London).

The above reference architecture is fully applicable to the KCC pilot and items 1 – 4 are applicable to TfL.

Transport for London (TfL) will pilot the provision of a GLOSA service over a cellular (3G/4G) communications solution for this use case. This will require the development of back-office systems to provide the required outputs from TfL's Urban Traffic Control (UTC) system, to provide near real time traffic signal timing information. A third party or parties will then provide the service to end-users.

Kent Country Council will trial GLOSA on one of Kent's major arterial routes into Maidstone (the County town), and will assess the compatibility of GLOSA with Kent's adaptive control system. Dyniq, the system supplier has been asked about the provision of system adapters to expose the SPAT data that can be used to provide this service. It is expected that Kent's current on-street communications with be used for communications between the control system and R-ITS-S.

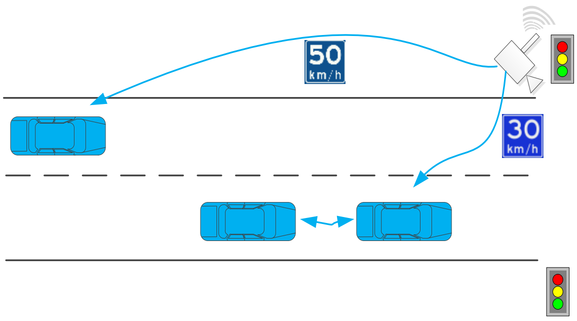
Functional and non-functional requirements	
Sources of information	The following information will either be provided locally at each junction via the infrastructure, i.e. Traffic Light Controllers (TLC) and Roadside ITS stations (RIS), or it will be provided centrally via cellular communication: • Signal Phase and Timing message (SPaT) • Intersection topology message (MAP)
Standards	The following standards apply to GLOSA: • ETSI TS 103 301 Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services • SAE J2735 Dedicated Short Range Communications (DSRC), Message Set Dictionary. • CEN ISO/TS 19091 Intelligent transport systems - Cooperative ITS - Using V2I and I2V communications for applications related to signalized intersections. • ETSI TS 102 894-2 • Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary.
Technical Constraints / dependencies	• The highly dynamic nature of some traffic control systems, which are able to can make late signal phasing decisions, combined with other adaptive systems (e.g. selective vehicle detection bus priority), could limit the viability of GLOSA in some applications. This will need to be assessed during the Evaluation phase of the project. • For GLOSA via G5: The TLC is connected to R-ITS-S and can provide information on the current and next signal phase. • For GLOSA via 3G/4G cellular: back-office systems and interfaces exist or are established to enable the outputting of current and next signal phase information to the cloud. • GPS accuracy could potentially be a constraint at signal controlled intersections that employ multiple traffic phases on an approach (e.g. left turn and/or right turn traffic phases that are on a different phase to the ahead movement). OBUs will need to be able to identify a vehicle’s position and intended direction with sufficient accuracy in order to identify the correct traffic phase. • 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. • If there is a traffic queue/ congestion in front of a traffic light, GLOSA becomes useless, but could be adapted if it is possible to integrate this information into the algorithm. • GLOSA depends on the data provided by the Traffic light controller or centrally. The information that is provided may not be adapted to GLOSA, especially if the phases are adaptive. • Information received by HMI via 3G/4G cellular should be consistent

	with information received via G5.

1.2 GLOSA - Time-to-red information and speed advice.

1.2.1 Functional description

Use case introduction	
Summary	While approaching a signalised intersection information is broadcast to approaching vehicles informing them of the traffic light phase schedule. This is either sent from the traffic signal controller via a roadside unit (R-ITS-S / G5), or via a central traffic control system via cellular 3G/4G. This information, combined with information on the position of the vehicle, the speed of the vehicle and the distance to the traffic light, will enable an algorithm in the vehicle to calculate an optimal speed of approach (under the mandatory speed limit). Vehicle drivers receive the speed advice information via the display (HMI) of the vehicle's OBU.
Background / added values	The information can be displayed in the driver's own language. Reduced driver anxiety and improve compliance with traffic signals.
Objective	The aim is to display an alert to the user that they are approaching a signalised intersection and to provide an advisory speed, or to notify the driver to be prepared to stop.
Desired behaviour	The vehicle driver or the vehicle controls will adjust the speed of the vehicle to comply with the speed change advice, and will maintain that speed while approaching or passing the signalised intersection. Or, they will be prepared to decelerate smoothly if they are likely to arrive at the intersection when it is displaying a red traffic signal.
Expected benefits	• Smoother vehicle flow through signalised intersection, reduced start/stop delay and reduced desire to chase green signals or the need to rapidly decelerate. • Improved driver and passenger comfort. • Increased safety. • This should result in reduced energy consumption, reduced vehicle emissions (including CO_2), reduced vehicle wear and tear • Reduced stress and better average speeds, particularly in urban environments where there is generally a higher density of traffic signals.
Use case description	
Situation	Time-to-red information and speed advice: a vehicle approaches a signalised

	intersection while the traffic light is green or will arrive at the stop line during the green phase.
Logic of transmission	I2V via G5 beacon located at the traffic signal intersection, or 3G/4G / broadcast
Actors and relations	• Vehicle driver: receives speed advisory information on the in-vehicle display (OBU HMI). • Road Operator or Highway Authority: provides signal phasing and timing (SPAT) and map information, either locally from the traffic signal controller, or centrally from their traffic signal control system. • Service provider: disseminates the speed advisory information to vehicle drivers. • Vulnerable road user: speed advisory information may be offered to cyclists too. Crossing vulnerable road users may affect the validity of the speed advisory information. • Other: n/a.
Scenario	There are two possible scenarios: 1. As indicated by the speed advice a vehicle maintains the current speed and arrives at the intersection during a green phase. 2. As indicated by the speed advice a vehicle increases the current speed (never beyond the legal speed limit) and arrives at the intersection before the end of a green phase. This facility may not be implemented in all member states.
Display principle / Alert logic	GLOSA speed advice information and ‘time to red’ information shall be displayed to the driver via the HMI. GLOSA speed advice information and ‘time to green’ information shall be displayed to the driver via the HMI.  **Figure 2: Green light optimal speed advisory** The SPAT / MAP information broadcasted from the R-ITS-S/ G5 or via cellular communication, reflects the real-time signal phase & timing status for each lane. Based on the SPAT / MAP information the vehicle (V-ITS-S) may advise an optimal speed to the driver for approaching the intersection. The potential display/ alert scenarios are as follows: • When the light is green (and the driver can pass it without exceeding the speed limit), the driver receives a speed advice to continue and pass the green light. • When the light is green but the driver cannot pass it without exceeding the speed limit, no speed advice is given. The driver receives the advice to prepare to stop.
Functional constraints /	• The speed advice has to be lower than the speed limit. • The presentation of information on the HMI is not part of the service

dependencies	description. It is left to the provider of the in-vehicle information system how the information is presented. Information might e.g. be translated to the preferred language of the driver. • The information presented by means of I2V is advisory information only and may not take into consideration variables such as road conditions including weather or traffic density/ congestion.

1.2.2 High level technical description

Use Case Implementation	
Model implementation	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. This information will either be received from the local infrastructure (R-ITS-S / G5), or it will be provided centrally via cellular (3G/4G) communication. TfL proposes piloting a cellular only implementation of this service and Kent County Council proposes piloting hybrid communication. The Signal Phase and Timing message (SPAT) and the corresponding intersection layout message MAP as specified in SAE-J2735 are messages designed for infrastructure-to-vehicle communication. Their purpose is to transmit either the current and/or the future status of signalling on the entire intersection in an electronic, machine readable way to vehicles. The SPAT / MAP information that is broadcast, together with other information, reflects the real-time signal phase & timing status for each lane. Therefore, a vehicle may be able to calculate or derive the optimal speed advice for each lane. Fast (low latency) communication and suitable HMI to communicate to the driver are needed. The GLOSA application communicates information to the driver about which speed he/she should adopt to keep in continuous flow with no need to stop. The millisecond timing is less important than the fact that a correct forecast-message is available before reaching the intersection. A digitised map of the area is also pre-requisite for SPAT, which might include road topography and road attributes, such as number of lanes on each approach to the intersection and the manoeuvres possible between them. SPAT messages relate to these relations in the MAP. Once the SPAT with forecast and a MAP is implemented, this enables Green Light Optimal Speed Advisory (GLOSA) to be given to the drivers via the same interface. Drivers travelling at or close to the advised speed are likely to clear the intersections, creating what is commonly referred to as the “Green Wave” - minimising erratic stop/start behaviour.
Reference architecture	**NL:**. In the Netherlands, the GLOSA service is implemented following the architecture of the ‘intelligent Traffic Light Controller (iTLC) . The architecture

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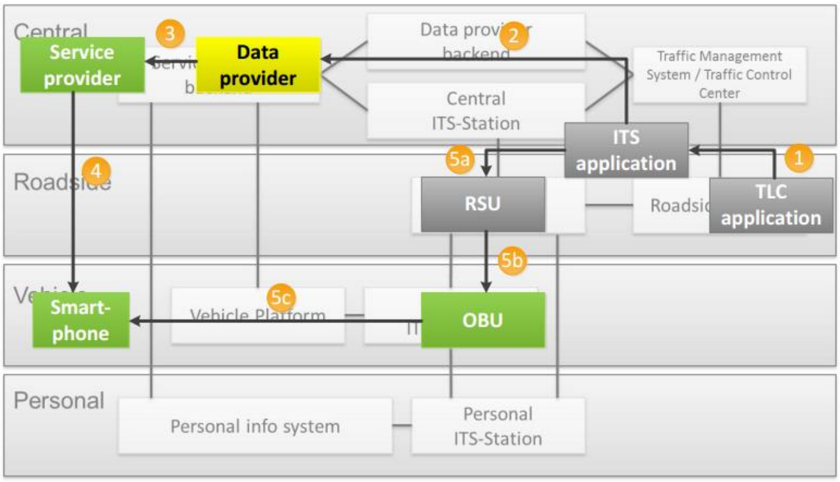

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The process for this application contains several steps:

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- Data providers collect the data of ITS applications and provide that to service providers (3).
- Service providers determines whether SPAT / MAP information is required for individual users and send the appropriate information to smartphones (4).

UK: The UK will pilot hybrid (KCC) and cellular only (TfL) systems of communication for the pilot GLOSA services, with a similar functional architecture to that displayed above. The primary reason why TfL is piloting a cellular only system is that to implement ITS G5 would require the provision of additional infrastructure on TfL's road network. Should this project develop from a trial, then the future deployment of these services could pose a future financial encumbrance that TfL may not be able to commit to (there are circa 6000 sets of traffic signals in London).

Transport for London (TfL) will pilot the provision of a GLOSA service over a cellular (3G/4G) communications solution for this use case. This will require the development of back-office systems to provide the required outputs from TfL's Urban Traffic Control (UTC) system, to provide near real time traffic signal timing information. A third party or parties will then provide the service to end-

	users. Kent Country Council will trial GLOSA on one of Kent's major arterial routes into Maidstone (the County town), and will assess the compatibility of GLOSA with Kent's adaptive control system. Dyniq, the system supplier has been asked about the provision of system adapters to expose the SPAT data that can be used to provide this service. It is expected that Kent's current on-street communications with be used for communications between the control system and R-ITS-S. [TfL and KCC are currently determining the architecture that will be required to deliver their GLOSA pilots. Once this has been determined, a schematic of the architecture will be provided here].
Functional and non-functional requirements	
Sources of information	The following information will either be provided locally at each junction via the infrastructure, i.e. Traffic Light Controllers (TLC) and Roadside ITS stations (RIS), or it will be provided centrally via cellular communication: • Signal Phase and Timing message (SPaT) • Intersection topology message (MAP)
Standards	• ETSI TS 103 301 Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services • SAE J2735 Dedicated Short Range Communications (DSRC), Message Set Dictionary. • CEN ISO/TS 19091 Intelligent transport systems - Cooperative ITS - Using V2I and I2V communications for applications related to signalized intersections. • ETSI TS 102 894-2 • Intelligent Transport Systems (ITS); Users and applications requirements; Part 2: Applications and facilities layer common data dictionary.
Technical Constraints / Dependencies	A significant proportion of TfL's traffic signals operate under networked Urban Traffic Control (UTC) i.e. they are remotely controlled and coordinated centrally via one of five UTC computer cells. The majority of the UTC system operates under dynamic UTC SCOOT control. SCOOT continually monitors traffic flow and congestion from thousands of on-street sensors and adjusts the traffic signal timings in real-time (green splits, off-sets between signals and signal cycle times), to minimise vehicle stops and delay. In addition to this, bus selective vehicle detection (SVD) is deployed at many junctions in London and this can also extend or rapidly recall traffic signal phases at discrete signal controlled junctions when an approaching bus is detected. The provision of GLOSA in this environment poses a significant challenge for TfL, because we would like to provide drivers with accurate and useful GLOSA information, without compromising the operational efficiency benefits of dynamic signal control. Transport for London (TfL) will pilot the provision of a GLOSA service over a cellular (3G/4G) communications solution for this use case. This will require the development of back-office systems to provide the required outputs from TfL's Urban Traffic Control (UTC) system, to provide near real time traffic signal timing information. A third party or parties will then provide the service to end-

	users. A potential technical challenge for TfL will be that the GLOSA pilot should be scalable (in case wider deployment is required following successful trials). This is potentially easier to achieve using localised infrastructure and G5 communication, rather than a centralised service that is provided via cellular communication. A limited scale, cellular-based cooperative traffic signals trial was previously jointly undertaken in 2011 by TfL, BMW and ITIS Holdings on the Embankment in London. The aim of the trial was to investigate the ability to send traffic light information in real time from TfL's UTC SCOOT system to vehicles. Key learning from this and other trials will be used to inform TfL's GLOSA pilot.

2 National implementation plans GLOSA

Here we describe national technology choices, scenarios implemented.

The table below explains the implementation plans for IVS in the member states of InterCor:

Use Case	**France**	**NL**	**Belgium**	**UK**
GLOSA – time to green	Yes, via ITS - G5, but without 'count down to green' unless legislation permits its use.	Yes, ITS-G5	No	Yes- via G5 and cellular
GLOSA - time to red	Yes, via ITS-G5	Yes, ITS-G5	No	Yes- via G5 and cellular

3 Common areas for Interoperability testing

See individual test cases for testfest.