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GLOSA-enabled corridor for traffic management and driver assistance

Insights from the GLOSA MobilitymoveZ.NL project

Table of Contents

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What does GLOSA do?

GLOSA stands for Green Light Optimal Speed Advisory. GLOSA supplies speed advice when passing through traffic lights. GLOSA's added value goes further than driver assistance alone. It is an important traffic management instrument which enhances quality of life and accessibility in urban environments.

Four different levels of GLOSA advice are available to drivers**, distinguished by increasing quality and complexity**. GLOSA provides information or advice on:

1. the current status of the traffic light phases (red, green, amber). This most rudimentary level helps, for example, as a warning to prevent drivers ignoring red lights.

2. The phase end time with a short time window of a few (5-10) seconds. This 'time-to-red' and 'time-to-green' information is, for example, relevant for stop/go decisions in the 'dilemma zone' in front of the stop line.

3. The phase end time with a time window of longer than 5-10 seconds. This information is relevant for GLOSA speed recommendations along a large portion of the 'arm' along which the driver approaches a junction. The speed recommendations restrict the speed variations on the road and help avoid unnecessary stops in the case of a simple junction[1].

4. continuous speed profiles, or phase time and queue information, along a 'corridor with successive junctions'. The time window is sufficiently large to provide GLOSA speed recommendations along the entire arm of a junction. The speed recommendations are supplied continuously along the entire corridor so that drivers can comfortably negotiate the successive junctions, like in a 'green wave'[2].

This pilot project included an investigation into how GLOSA can be made sufficiently usable to facilitate the above levels 3 and 4.

This is because a properly operating GLOSA helps reduce braking and accelerating. A study has demonstrated that there is a significant contribution to CO2 reduction. GLOSA can reduce NOx emissions by unnecessarily accelerating lorries by up to 75% and reduce CO2 emissions by up to 20%. The total annual Dutch CO2 production by lorries can therefore be reduced by 3.2%[3].

Although such results require large-scale application and optimal operation, they make it clear that **a high-quality GLOSA service could already make a contribution to the quality of life in urban environments. What is more, GLOSA is an essential part of the transition to cooperative traffic**

[1] This service is specified as GLOSA scenario 1a in the C-ROADS standardisation programme.
[2] This service is specified as GLOSA scenario 1b in the C-ROADS standardisation programme.
[3] Impact of Signalized Intersections on CO2 and NOx Emissions, of Heavy Duty Vehicles, Nicolás Deschle, Ernst Jan van Ark (TNO), René van Gijlswijk (TNO) and Robbert Janssen (TNO), 8 February 2022.

management and automated vehicles. These days, therefore, the promotion of a high-quality GLOSA service is really a 'no-regret measure'[4].

What is more, GLOSA increases comfort for drivers as they experience a kind of 'green wave'. The expectation is that this comfort will help to entice drivers to use preferential routes. **GLOSA is therefore contributing to a better distribution of traffic** and is making, for example, a success of combined routes. In the future GLOSA will be part of the advanced driver assistance system (ADAS). The effect on driving behaviour then increases and possible negative effects due to drivers being distracted are then removed.

What still has to be done to optimise GLOSA?

At the moment GLOSA's scope is frequently still limited. Although agreements are made about the supply of data during the traffic light phase times (when are the lights going to turn green or indeed red), none are being made about the usability of this data for driver assistance. This is precisely the problem. Although data is made available, even in accordance with the standards which guarantee technical interoperability, service providers have indicated that this data cannot be used for driver assistance.

Traffic control systems in the Netherlands are often adaptive and change the scheduling of the green and red phases as soon as new traffic is detected, usually in accordance with one of the following scenarios:

- Lots of conflicting traffic: you can, to some extent, predict the phase times, but the minimum end time cannot then be selected for very long.
- Little conflicting traffic: you then want an extending green phase, but it is difficult to predict the phase times.

The phase times indicated therefore say little about the moment at which the phase transition will ultimately take place. Reliable? According to some people it is, because the indicated minimum and maximum end times are respected (incidentally this is scarcely the case for the indicated 'likely time') and are a fair representation of the limited predictability of the moment. Others consider an indication which changes later to be unreliable. Because of this minor controversy, this project uses the term 'usable'. **Usability is then measured against the capacity of service providers to supply speed advice to assist drivers.** The current GLOSA cannot be used in the Netherlands for driver assistance and that is why GLOSA is currently not a usable traffic management instrument.

[4] In other projects work is processing on conditioned priority for lorries. This GLOSA project does not use priority requested by lorries and neither is a service provider or special On Board Unit (OBU) required. However, the principle of making a reservation to connected through traffic along a corridor is crucial for both GLOSA and for the priority service.

How then do you ensure that GLOSA is actually usable? At least the following two things have to happen:

1. A set of requirements has to be drawn up to enforce the usability of GLOSA, in other words requirements for GLOSA to be a minimum viable product.

2. A recognisable application framework has to be made operational in which suppliers and road authorities apply the above-mentioned usability requirements and in which service providers deliver successful GLOSA driver assistance, the so-called 'GLOSA-enabled corridor'.

The sections below contain a clarification of how this project has developed and validated both elements.

What has this project achieved?

On the basis of assumptions and expectations this project has specified the improvements which are intended to make GLOSA usable for driver assistance. It also started developing the application framework:

1. The requirements for GLOSA to be a minimum viable product (MVP).

2. A feasible application framework which is recognisable for motorists and service providers: the GLOSA-enabled corridor.

The requirements for the GLOSA MVP were implemented by 2 independent suppliers as part of (or as an extension to) the current ITS application.

These ITS applications are loaded onto the intelligent traffic control systems (iTCS) of three different routes where the GLOSA-enabled corridor has been tested.

Two service providers implemented GLOSA as driver assistance[5] and also processed the requirements from the GLOSA MVP.

After that the project consortium carried out an extensive test and evaluation. The underlying reasons why GLOSA is still unsuitable for driver assistance are basically the traffic engineering requirements and the road authority's preconditions. These traffic engineering requirements and the usability requirements are interdependent. In other words if you impose less stringent traffic requirements, you can improve usability. A traffic engineering evaluation of the driver assistance provided must therefore be part of the validation of the GLOSA MVP. The validation conclusions and recommendations are presented in the final section of this report.

The GLOSA-enabled corridor concept

From the perspective of the service providers and end user, a driver assistance service in the vehicle does not need to work at all times and in all places. The frequency with which GLOSA has to be usable in order to be integrated into a driver assistance service is ultimately a decision for the service providers and car manufacturers and they have not yet expressed a concrete opinion. However, this project has produced the following findings:

1. Various car manufacturers have already started offering GLOSA as part of a driver assistance service. In doing so they have opted for countries where traffic controls are less adaptive.

2. In general the user requirement in the context of non-mission-critical applications is not so much that the applications have to work all the time but that it is clearly recognisable when they work and when they do not.

[5] – for the time being an information service which is presented to drivers via a smartphone but, as already mentioned, may in time be embedded into ADAS, like adaptive cruise control -

If we in the Netherlands manage to improve the possibilities for usage and follow-up in recognisable situations, we will have succeeded in our mission as far as the service providers are concerned.

From the perspective of the road authority as well it is not always necessary to impose the same traffic engineering requirements on the traffic control system at all times and in all places. Consequently there are routes where the road authority considers it important that traffic on the main route receives usable GLOSA data. The controls have to be able to make a reservation for connected traffic that is travelling straight ahead. In practice the connected traffic that is travelling straight ahead will be more important and conflicting movements will no longer be given an immediate green light as traffic approaches.

This choice by the road authority for the GLOSA-enabled corridor, and consequently for an ITS application which can make a reservation, is therefore a necessary condition for such a corridor. On other roads the road authority will then be able to serve conflicting movements directly. Although levels 1 and 2 *(see first section)* will still be working there, a GLOSA-enabled corridor will have been created.

The GLOSA-enabled corridor is therefore a route chosen carefully by the road authority on which GLOSA data is usable for driver assistance and traffic management. GLOSA is rendered usable by:

- the road authority ensuring that ITS applications are running which are suitable for a GLOSA-enabled corridor (see section below for the relevant specifications);
- service providers having access to GLOSA data which is primarily used for level 4 driver assistance;
- service providers and/or car manufacturers being able to process GLOSA data, which has been made available on the basis of European standards, for driver assistance purposes.

GLOSA improvements and GLOSA MVP specifications

One crucial condition for a usable GLOSA, in other words driver assistance at level 4 (see section 1), is that the ITS application can make a reservation. In practice this reservation is translated into a combination of a speed profile and phase end times. This project has specified and evaluated a total of five improvements to GLOSA and has gained the following insights[6]:

1. The SPAT[7] (Signal Phase And Timing) speed profile based on a reservation is an essential data element for a usable GLOSA. The project has draft specifications which can be used to make the

[6] The 5 improvements in this section have been written out in more detail and are available as GLOSA MVP requirements for the GLOSA project as an annex to the evaluation report that was drawn up under the guidance of TNO [2].
[7] SPAT, MAP are digital messages which have been fully laid down in European standards profiles containing fields which include information about phase times and other variables which are important for GLOSA as a driver assistance service. Something that has not yet been standardised are the requirements imposed on the data in these fields to ensure usability/quality.

obligatory completion of this speed profile by the traffic control system part of a standard. This includes the following:

- an availability requirement and quality requirement.
- that the control system is determined on the basis of processing both available authenticated CAM notifications and loop detections and an accurate estimate of the queue and the expected increase and decrease of this queue over time (see queue).
- that if the control system is insufficiently sure that the speed profile will be correct it leaves the speed profile empty or otherwise indicates this lack of certainty in the SPAT message.

2. SPAT (Signal Phase And Timing) phase times which converge towards the actual end time form an essential data element for a usable GLOSA:
   - During the red phase the difference between the phase end times (MaxEndTime and MinEndTime) must not exceed 2 seconds for at least ten[8] seconds before the phase transition[9].
   - Parties abroad do not use SPAT phase end times, but the SPAT-LikelyTime instead. This project therefore observes that, for international connection and interoperability, it is essential also to apply the GLOSA MVP phase end time during the red phase to the LikelyTime (follow-up research is then necessary into how, for example, it must not increase for 10 seconds during the red phase and it can differ from the eventual phase transition by a maximum of 2 seconds).
   - During this project the suppliers managed to make a usable SPAT phase end time available during the green phase. An analysis revealed a solution which makes a green time reservation possible during this phase. A minimum green time must be provided which is dependent on the traffic situation. Further development is necessary in order for this to be worked out in more detail.
   - Because the phase end times cannot always be made usable, it is essential to provide insights to the service providers as to when the issued phase time is and is not usable. The collaboration with foreign parties, including Ford, revealed that the SPAT confidence can be filled in with information on the basis of which a service provider can estimate the usability of the phase times. It is possible that the de facto standard of various European car manufacturers will be adopted, or that it will be possible to use the presence of a speed profile as an indication of whether follow-up is possible.
   - When the ITS application determines phase times it is essential that both available authenticated CAM messages and loop detections are processed.

[8] This project has empirically demonstrated that a difference between the phase end times, during a red phase, of no more than 2 seconds throughout a 10 second period is feasible immediately before the phase transition and make GLOSA data usable. The project has not been able to demonstrate that the 2 or 10 second periods lead to the best results and the expectation is that, in due course, the difference between the end times needs to be further reduced over a longer interval.
[9] See footnote above.

3. The SPAT queue length is an essential data element for usable GLOSA. The project has formulated draft specifications for the obligatory provision of queue length. Supplementary to this, quality requirements must be formulated containing:
    - the obligatory processing of both CAM messages and loop detections when determining a queue;
    - minimal differentiating capacity between stationary vehicles alongside the road and in the queue (for example a calculated queue must never be at a location at which authenticated CAM messages from moving vehicles are also received).

    Comment: Because the SPAT queue length in the ETSI standard does not offer the possibility of taking account with the decrease or increase in the queue, it is important to re-emphasise the need for an available speed profile which actually includes the dynamics of the queue (see 'speed profile' section).

4. The MAP message must contain the geographical information of the entire arm up to the adjacent junction, even if it is longer than 300m. Because this information can also be realised in the event of a long arm (>500m), with a small quantity of extra data (<3%), the project has been able to demonstrate that the related implications (costs, complexity of procedures, quantity of exchanged data, data load for recipients, etc.) are negligible.

5. The project has demonstrated that, for GLOSA to work in an acceptable fashion, it is not essential for vehicles to supply information about the intended direction of travel (and therefore the lane). However, the project does recommend that it should be made obligatory for ITS applications to process any available information on this because the control system does not necessarily take account of turning vehicles when providing a usable speed profile aimed at traffic that is going straight ahead.

GLOSA: conclusions and recommendations

The current standards do not provide sufficient guarantees for a usable GLOSA. Consequently, countries with adaptive traffic control systems, such as the Netherlands, cannot yet use GLOSA for traffic management purposes.

The condition for making GLOSA suitable for driver assistance and traffic management is that the road authority opts for the active ITS application to be able to make a reservation for specific traffic (in this project connected traffic which is travelling straight ahead). In this project this is referred to as a GLOSA-enabled corridor. The road authority can choose where it wants to use such a corridor and where it does not. The Dutch road authorities can therefore start making GLOSA usable in phases (from small to large).

This project has validated the following requirements for making GLOSA usable for driver assistance and traffic management:

1. a speed profile on the basis of a reservation
2. a queue
3. the use of large MAP messages
4. phase times (only during red phase) based on a reservation

The project also examined the operating aspects and the feasibility of the above improvements. This did not generate any requirements which significantly drive up the costs, risks, or complexity.

The project focused on the usability of GLOSA for traffic travelling straight ahead along the GLOSA-enabled corridor. Another benefit of this project is the insight that it gives you usable information which you can forward to traffic on conflicting side routes: 'It is not yet your turn'. If this concept is properly developed, advice can also be given to this traffic to drive slower, or even choose a different route.

The project did not focus on any requirements relating to the way in which service providers process SPAT data in their services. However, the project did generate the insight that the extent to which this data can be followed up changes and is more familiar to suppliers of adaptive traffic control systems than to service providers. For GLOSA to be a success, including as a traffic management instrument, it is therefore important that the meaning of SPAT data becomes clear to service providers. This requires a follow-up development and collaboration with OEMs and the project has made a start with this by developing a number of guidelines in the evaluation report [*2*].

The above 4 improvements have been written out in more detail and are available as GLOSA MVP requirements for the GLOSA project as an annex to the evaluation report that was drawn up under the guidance of TNO [*2*]. All the insights and specified improvements have been transferred as recommendations to the CAB (Change Advisory Board), as the nationally authorised body, for further development specification of iTCS-related standards and any internationalisation thereof via C-Roads.

The project has consequently demonstrated that the GLOSA-enabled corridor can be selected carefully so that the use of the GLOSA MVP does not cause any detrimental traffic engineering effects. The results on the Deurneseweg in Helmond show that approximately 90% of the test vehicles receive speed advice and that 70% of these can pass through the junction without having to change their speed. This result surpasses expectations in terms of fulfilling the set targets.
In Helmond a plausible empirical case has therefore been made that the proposed GLOSA MVP can be used without any conflict with existing traffic engineering requirements or road authority preconditions. This empirical validation is confirmed by extensive simulations by the supplier. On

routes with very little conflicting traffic the use of the GLOSA-enabled corridor is presumably also possible and improvements in the usability of GLOSA are feasible. However, those improvements have not yet been demonstrated by the project. The road authority will therefore have to choose to make a reservation for traffic travelling straight ahead which will be at the expense of the speed at which any traffic coming from a conflicting direction is served.

The use of the 'GLOSA-enabled corridor' concept makes it possible to use GLOSA locally in a way which allows service providers and car manufacturers that already support this functionality (for example via a business case outside the Netherlands) to process it into driver assistance. This corridor therefore has the short-term potential of making GLOSA usable for driver assistance and traffic management. However, that will have to happen locally on selected corridors and will not be possible at all times and in all places.

References

1. Impact of Signalized Intersections on CO2 and NOx Emissions, of Heavy Duty Vehicles, Nicolás Deschle, Ernst Jan van Ark (TNO), René van Gijlswijk (TNO) and Robbert Janssen (TNO), 8 February 2022.
2. MMZ GLOSA Final report version 1.1, evaluation, conclusions and recommendations relating to GLOSA, Bart Netten (TNO) in collaboration with the project consortium, 30 June 2022.

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