GREEN LIGHT OPTIMAL SPEED ADVISORY WITH REDUCED DEFAULT SPEED: ANALYSES OF A NEW GLOSA SERVICE

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ABSTRACT

This work is an introduction to Green Light Optimal Speed Advisory (GLOSA) with reduced default speed (GLOSA-RDS), a special GLOSA service that allows for more flexibility while influencing traffic participants. In order to achieve that, GLOSA-RDS provides a default speed recommendation for the traffic participants that is lower than the maximum allowed speed of the road, unlike conventional GLOSA. This allows not only for deceleration advice to achieve a green wave, but also acceleration advice. Thus, vehicles can either slow down if they are ahead of the green wave or catch up when they are behind, allowing for more compact vehicle platoons, reducing necessary green times and improving the incorporation of vehicles from secondary directions into the green wave of the main direction. In particular, GLOSA-RDS could be an interesting mechanism for cities as regards introducing lower speeds for motorised traffic in city centres. GLOSA-RDS is implemented and tested in a microscopic traffic simulation on a green wave corridor with three signalised intersections. Results indicate notable improvement for waiting time and number of stops compared to conventional GLOSA services.

Keywords: C-ITS, GLOSA, green wave, traffic light control.

1 INTRODUCTION

The aim of a Green Light Optimal Speed Advisory (GLOSA) service is to provide a speed recommendation (SR) for traffic participants/vehicles for approaching a traffic light (TL) in a timely manner. Based on a vehicles' distance to the TL (precisely, the stop line of the TL) and future signal patterns of a TL, GLOSA calculates and provides a SR so vehicles can possibly pass the TL at a green light without stopping. By avoiding and reducing stops and stop time for vehicles at TLs, GLOSA could increase the traffic efficiency and thereby also the comfort of road users by creating a more homogeneous traffic flow. At the same time pollution and noise emissions can be reduced. Various studies of GLOSA services may be found in literature.

In a mapping study, Mellegård and Reichenberg [1] compiled 64 publications that were conducted on GLOSA and reviewed and classified them according to the papers topics. The analyses concern the research method and which sub-areas of GLOSA were investigated. Most investigations are simulations, mostly at single junction and often analysing energy consumption. Otto et al. [2] analysed how various influencing factors such as type of control or V2X (vehicle-to-everything) range affect a GLOSA service. It found that the more dynamic a controller is and the lower the V2X ranges are, the more potential GLOSA services lose. Eckhoff et al. [3] also investigated different GLOSA equipment rates and they found out that at low traffic densities GLOSA can increase the comfort for drivers by reducing waiting times and the number of stops and additionally, while reducing CO_2 emissions by up to 11.5%. Whereas, in dense traffic, several side-effects could be observed, including overall longer waiting times and even higher CO_2 emissions for unequipped vehicles. In a simulation

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WIT Transactions on Ecology and the Environment, Vol 262,
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SDP240311

study, Katsaros et al. [4] analysed the impacts various GLOSA equipment rates and traffic density on fuel and traffic efficiency. Their results indicate that GLOSA systems could improve fuel consumption up to 7% and improve traffic congestion and reduce stop time up to 89%. Pariota et al. [5] investigated the effects of GLOSA on a road network including several signalised intersections equipped with a GLOSA service. The analyses focused on vehicles fuel consumption and emissions. The results demonstrate that even using a simple control algorithm with the aim to avoid the stop and go, it can observe a reduction of fuel consumption and emissions in the region of 5% to 12%. Xu and Zuo [6] investigated how to support a GLOSA with reinforcement learning to reduce stop times, fuel consumption and CO_2 emissions. Seredynski et al. [7] analysed a GLOSA service which navigates through multiple signalised intersections; their simulations show that a multi-segment GLOSA improves fuel consumption by 12% and traveling time by almost 6% compared with the results of a single-GLOSA service for each intersection.

The remainder of the paper is structured as follows: Section 2 explains the objective/basic idea of GLOSA-RDS and how it is implemented compared to a conventional GLOSA service. Section 3 details the implementation of the GLOSA-RDS and presents the simulation results. Section 4 discussions the results and Section 5 provides a summary as well as a short outlook regarding future work.

2 GLOSA WITH REDUCED DEFAULT SPEED (GLOSA-RDS)

2.1 Objective GLOSA-RDS

GLOSA-RDS is used as a mechanism to support a green wave corridor. The main goal of GLOSA-RDS is to manipulate traffic participance flexibility and supporting the building of compact platoons, while at the same time keeping the speed of the vehicles as low as possible. Therefore, GLOSA-RDS can be an interesting mechanism for cities in introducing lower speeds for motorised traffic in city centres (e.g. 30 km/h instead of 50 km/h), while at the same time increasing the efficiency of traffic flow, reducing pollution and noise emissions and increasing the comfort of road users. The GLOSA-RDS approach is primarily intended for motorised vehicles at signalised intersections but could also be used for other vehicle classes such as cyclists. Connected and automated driving offers GLOSA-RDS the opportunity of realising its full potential, as these technologies enable more accurate compliance with speed recommendations. For this reason, technologies such as Cooperative Intelligent Transport System (C-ITS) make it possible to implement GLOSA services, especially GLOSA-RDS, as they enable the exchange of information between road users and infrastructure. In this paper we assume that vehicles as well as the infrastructure are equipped with C-ITS and can exchange data. The GLOSA service, including GLOSA-RDS, may be implemented on the vehicle side or as well on the infrastructure side. It is only important that GLOSA is provided for all of the information, regardless of where the GLOSA service is running.

2.2 Defined limits of GLOSA services

GLOSA services has defined constraints for speed recommendations (SR) to comply to the applicable road rules and safety interests. GLOSA has an upper limit (MaxSR) and a lower limit (MinSR) for speed recommendation. MaxSR must not be higher than the maximum speed limit (MaxSL) of a track, which is why MaxSR equals MaxSL to be compliant with the applicable road rules. Usually, MaxSL is in built-up areas from 30 km/h up to 50 km/h and outside built-up areas from 80 km/h up to 100 km/h. For safety and acceptance reasons MinSR should usually not be set too low, e.g. not lower than 20 km/h. Depending on the situation, a GLOSA can act as follows when issuing an SR: An SR can recommend, based on the available information regarding the distance to the stop line of a vehicle and regarding the future signalling pattern of TL, which allows a vehicle to pass the TL without stopping. Furthermore, GLOSA can recommend that the vehicle should roll out because there is no possible speed at which the vehicle can pass the TL without stopping. In this case GLOSA cannot recommend an SR for the vehicle.

2.3 Transformation of a conventional GLOSA to GLOSA-RDS

Fig. 1(a) shows the speed range of a conventional GLOSA Service. Motorised vehicles generally aim to drive with the maximum speed limit of a track in order to arrive at their destination as quickly as possible. As the MaxSR of a conventional GLOSA is usually equal to the MaxSL of track, motorised vehicles can only use SRs that lead to a lower speed. Fig. 1 shows a speed axis plotted in km/h. In this example, the MaxSL of track is 50 km/h. Motorised vehicles generally aim to drive with the maximum speed of track. If an SR is recommended by GLOSA, then the maximum possible recommended SR is MaxSR = 50 km/h (the following applies: MaxSR = MaxSL). For acceptance reasons, the minimum value MinSR for SR is defined, which is 20 km/h (Fig. 1(a)). The red arrow pointing downwards from MaxSR indicates that the values of the SR may only be lower than the normal vehicles speed MaxSL.

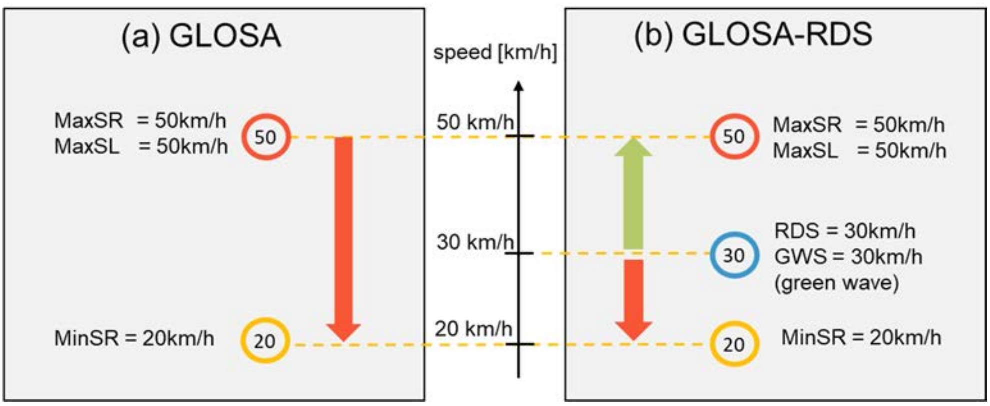

Figure 1: Range of (a) conventional GLOSA; and (b) GLOSA-RDS service.

The new GLOSA service, GLOSA-RDS provide a reduced default speed (RDS) for traffic participants that is lower than the MaxSL of the road. A vehicle always drives with RDS unless it has to adapt to the green time.

Fig. 1(b) shows GLOSA-RDS with an implementation of RDS of 30 km/h in the example. RDS is therefore lower than the MaxSL of 50 km/h. RDS is implemented and coordinated equally to the green wave speed (GWS). The green arrow pointing upwards from RDS and a red arrow pointing downwards from RDS indicates that the values of the SR depend on the situation and can therefore alternatively be lower or higher than the RDS. A conventional GLOSA thus is extended possibilities influencing vehicles, so that the probability of vehicles being able to pass the TL without stopping is increased. The extended conventional GLOSA is now called GLOSA-RDS. Therefore, GLOSA-RDS is considered to establish speeds between 50 km/h and 30 km/h, so that the benefits of higher speeds are realised but lower speeds are used for most of the time.

2.4 Expected mechanisms of GLOSA-RDS

Fig. 2 shows the comparison between GLOSA-RDS (Fig. 2(b)) and a conventional GLOSA (Fig. 2(a)). It visualises theoretical expected mechanisms of both GLOSA services (conventional GLOSA, GLOSA-RDS) and shows different points in time (t = 0, t = 1, t = 2). The direction of travel extends from left to right in the illustration. In addition, another arrow labelled Distance, shows the axis of the Distance on track up to the TL. Vehicles are represented by rectangles with capital letters inside. The green area represents the green wave. If a vehicle is on the green area, it is following the green wave. This means, if the vehicle continues its journey at the current speed, it can pass the stop line with green signal.

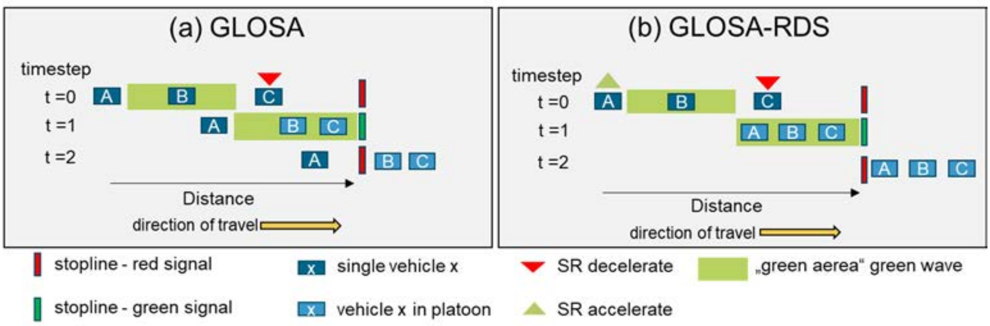

Figure 2: Mechanisms description of (a) conventional GLOSA; and (b) GLOSA-RDS.

Fig. 2(a) describes the main mechanism of a conventional GLOSA. At t = 0 (Fig. 2(a)), all vehicles A, B, C are driving individually. Only vehicle B arrives at the stop line when the TL turns green and can reach the green wave. Vehicle B therefore receives no SR from GLOSA. Vehicle C is given the SR to decelerate (red arrow in Fig. 2(a) t = 0) in order to arrive at the stop line later and thus be able to pass the stop line on green and reach the green wave. From t = 0 to t = 1 (Fig. 2(a)), vehicle C has reduced its speed due to the SR. Both vehicles B and C can now pass the stop line on green at t = 1 (Fig. 2(a)) and have formed a platoon. A platoon refers to a group/association of vehicles driving together, with little distance between them and having similar speed on road. The formation of platoons in Fig. 2(a) is only possible with decelerating vehicles. Vehicle A can neither pass the stop line at green with its current speed nor with a SR (from GLOSA) while complying with the MaxSR and MinSR limits. As vehicle A has no other option than to arrive at the stop line on red under this condition, it does not receive an SR. Vehicle A cannot reach the green wave.

Fig. 2(b) describes the main mechanism of GLOSA-RDS. At t = 0 (Fig. 2(b)), all vehicles A, B, C are driving individually. Only vehicle B will arrive at the stop line when the TL turns green and can reach the green wave. Vehicle B therefore receives no SR. Vehicle C is given the SR to decelerate (red arrow in Fig. 2(b), t = 0) in order to arrive at the stop line later and thus be able to pass the stop line on green and reach the green wave. Vehicle A is given the SR to accelerate (green arrow in Fig. 2(b), t = 0) in order to arrive at the stop line earlier and thus be able to pass the TL on green and reach the green wave. From t = 0 to t = 1 (Fig. 2(b)), vehicle C has reduced its speed due to the SR and vehicle A has increased its speed due to the SR. The three vehicles A, B, C can now pass the TL on green at t = 1 (Fig. 2(b)) and all vehicles could reach the green wave. Vehicle A, B, C have formed a platoon. GLOSA-RDS makes it possible to form a platoon with decelerating and accelerating vehicles, so that all vehicles in the example could reach the green wave. The GLOSA-RDS therefore offers an advantage over a conventional GLOSA.

The example in Fig. 2(b) shows that GLOSA-RDS can form platoons not only by slowing down vehicles or letting them stop at a TL. Vehicles driving with RDS in particular can accelerate and catch up with vehicles driving in front of the TL and form a platoon with them without having to stop. It should be noted that if the RDS is equal to the MaxSL, it is not possible to recommend a higher speed to vehicles. Such a higher speed would allow these vehicles to catch up with vehicles in front and/or pass a traffic light without stopping and reach a green wave due to the higher speed. In particular, this possibility does not exist for vehicles as in the GLOSA example illustrated in Fig. 2(a).

GLOSA-RDS offers the following advantages over conventional GLOSA services: Due to the fact that GLOSA-RDS can accelerate and decelerate vehicles with SR to adapted them to the green wave, GLOSA-RDS should allow for more flexibility while manipulating traffic participants. Thus, vehicles should both slow down if they are ahead of the green wave or catch up when they are behind. The possibility that vehicles can accelerate should improve the incorporation of vehicles from secondary directions into the green wave of the main direction. Vehicles arriving from the main direction on the green wave corridor should better adapt to the green wave. Platoons could be built while vehicles are driving, which allows for more compact platoons. GLOSA-RDS should better compensate for fluctuations in traffic-dependent TL controls. The theoretically defined advantages of GLOSA-RDS are to be analysed in this study in a microscopic traffic simulation in Section 3.

3 SIMULATION

In order to subject the GLOSA-RDS to an initial practical test, a simulation study was carried out using the microscopic simulation software SUMO (Simulation of Urban Mobility) [8]. For this purpose, on a road section, a green wave and five defined scenarios were implemented to compare the GLOSA-RDS with a conventional GLOSA. The indicators average travel time, average waiting time and the number of absolute stops were recorded and are shown in the following.

3.1 Road section

A 1,600 m long road section (Fig. 3) is used for the simulation. There are three signalised intersections on the road section. All intersections are equidistant, with a distance of 400 m

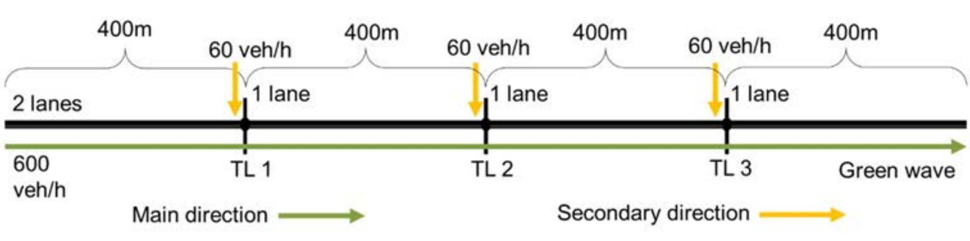

Figure 3: Road section.

between them. There is one main direction and three secondary directions that meet the main direction. Vehicles coming from the secondary direction continue their journey at the main direction. All vehicles in the simulation follow the main direction from west to east.

Fig. 3 shows the traffic demand and the number of lanes on each route. The main direction is a track with two lanes and a traffic demand of 600 vehicles per hour. From each secondary direction (a track with one lane), 60 vehicles per hour meet the main direction. A green wave is implemented for the main direction, which is implemented above the three TLs.

3.2 Green wave configuration and scenario definition

For the scenarios defined in Table 1, two different green waves must be implemented for the road section (Fig. 3): One green wave with the green wave speed (GWS) of 30 km/h and one with GWS of 50 km/h. To make it easier to compare the different scenarios with each other, each TL has a fixed-time control in all scenarios, which always has the same release time (green) for the main and secondary directions.

- Release time (green) main direction: 32 s
- Release time (green) secondary direction: 15 s
- Cycle time: 53 s (including 6 s yellow)

In order to implement green waves with different speeds on the road section, different offset times are selected for GWS = 30 km/h and GWS = 50 km/h for the start of release times of the TL. The offset time is calculated on the basis of the GWS and the distances between the TLs.

- Offset time with green wave of 30 km/h: (400 m/(30 km/h/3.6 m/s)) = 48 s
- Offset time with green wave of 50 km/h: (400 m/(50 km/h/3.6 m/s)) = 29 s

The various scenarios are listed in Table 1. Each scenario defines a specific combination of a green wave with no GLOSA, GLOSA and GLOSA-RDS. Abbreviations appearing in the scenarios refers to the following:

- 'G30': a green wave with GWS = 30 km/h
- 'G50': a green wave with GWS = 50 km/h
- 'GLOSA': GLOSA is active according to the scenario parameters
- 'GLOSA-RDS ': GLOSA-RDS is active according to scenario parameters

Table 1: Defined scenarios.

Scenarios	GLOSA	MaxSL	RDS	GWS	MinSR	MaxSR
G30	No	30 km/h	–	30 km/h, GWS = MaxSL	–	–
G30_GLOSA	Yes	30 km/h	–	30 km/h GWS = MaxSL	20 km/h	30 km/h
G30_GLOSA-RDS	Yes	50 km/h	30 km/h	30 km/h, GWS = RDS	20 km/h	50 km/h
G50	No	50 km/h	–	50 km/h GWS = MaxSL	–	–
G50_GLOSA	Yes	50 km/h	–	50 km/h GWS = MaxSL	20 km/h	50 km/h

For the simulation, the software SUMO is used. The available GLOSA service from SUMO [9] is parameterised with the stated parameters of the scenarios (Table 1) so that GLOSA-RDS and GLOSA may be implemented. All scenarios are simulated with 10 h (four randomised simulations, each with 2.5 h simulated time, 10 h in sum total).

In order to be able to evaluate the results of GLOSA-RDS, the results of a green wave only (30 km/h and 50 km/h) are always compared with a ‘green wave + GLOSA’. This is followed by a comparison of ‘GLOSA-RDS + green wave’ with ‘GLOSA + green wave’ and all scenarios. The results are analysed separately for each indicator for the main and secondary directions.

3.3 Simulation results

3.3.1 Average travel time

Fig. 4 shows the results for average travel time (in seconds) occurring in the simulation as bar plots. Each result is displayed separately for the main and secondary direction for all five scenarios (blue vs. orange bars).

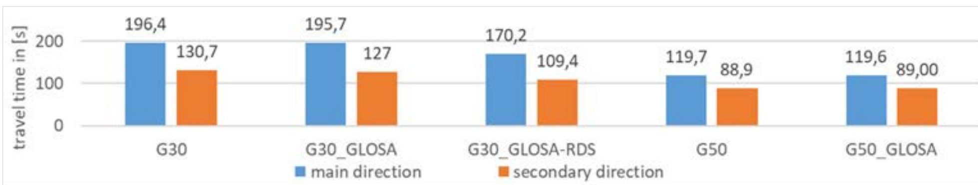

Figure 4: Average travel time of a vehicle to pass the road section – all scenarios.

Firstly, the average travel time with a green wave of 50 km/h (G50 and G50_GLOSA) is notably lower than with a green wave of 30 km/h (G30 and G30_GLOSA and G30_GLOSA-RDS). Comparing the travel times of G30 with G30_GLOSA, it shows that the additional GLOSA can reduce the average travel time only very slightly (0.7 s up to 3.7 s). This applies to both the main direction and the secondary direction. Concerning the G50 compared to G50_GLOSA, the bar plots show that the additional GLOSA reduce the average travel time only in a very small scale (0.1 s) for either direction. The GLOSA-RDS can reduce travel times for the main direction by 13.0% (25.5 s) and by 13.8% (17.6 s) for the secondary direction, when comparing G30_GLOSA with G30_GLOSA-RDS. These travel time reductions improve up to 13.3% (26.2 s) for the main direction and up to 16.3% (21.3 s) for the secondary direction, when comparing G30 with G30_GLOSA-RDS.

3.3.2 Average waiting time

Fig. 5 shows the results of average waiting time occurring in the simulation. The results are divided into the main and secondary directions for all five scenarios. The average waiting time describes the length a vehicle has to wait/stop on average when it passes the road section.

Comparing average waiting time (in seconds) of G30 with G30_GLOSA, it shows that the additional GLOSA can reduce the average waiting time for the main direction by 10.7% (0.3 s) and for the secondary direction by 15.5% (3.0 s). Concerning the G50 compared to G50_GLOSA, the bar plots show that the additional GLOSA reduce the average waiting time in a very small scale for either direction (0.1 s up to 0.3 s). The GLOSA-RDS can reduce the average waiting time for the main direction by 60.0% (1.5 s) and the secondary direction by

Figure 5: Average waiting time of the vehicles passing the road section – all scenarios.

20.2% (3.3 s), when comparing G30_GLOSA with G30_GLOSA-RDS. The GLOSA-RDS can reduce waiting time for the main direction by 64.3% (1.8 s) and for the secondary direction by 32.6% (6.3 s), when comparing G30 with G30_GLOSA-RDS. GLOSA-RDS (G30_GLOSA-RDS) achieves the lowest average waiting time of all five analysed scenarios.

3.3.3 Absolute number of stops

Fig. 6 shows the number of absolute stops that occur during 10 hours in the simulation. The results are divided into main and secondary directions for all five scenarios.

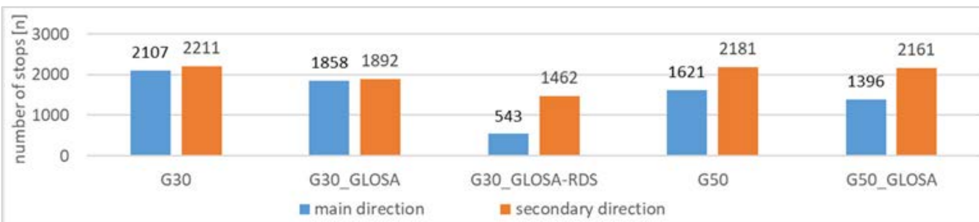

Figure 6: Number of absolute stops in 10 h – all scenarios.

Comparing the results of the number of absolute stops (occurring in 10 hours) of G30 with G30_GLOSA, it shows that the additional GLOSA can only slightly reduce the number of absolute stops. This applies to both the main direction and the secondary direction. Comparing the results of the number of absolute stops of G50 with G50_GLOSA, it shows that the additional GLOSA can only slightly reduce the number of absolute stops. This applies to both the main direction and the secondary direction. The GLOSA-RDS can reduce the number of absolute stops for the main direction by 70.8% (1,315 stops) and for the secondary direction by 22.7% (430 stops), when comparing G30_GLOSA with G30_GLOSA-RDS. Comparing the results of the number of absolute stops of G30 with G30_GLOSA-RDS, it shows that GLOSA-RDS can reduce the number of absolute stops for the main direction by 74.2% (1,564 stops) and for the secondary direction by 33.9% (749 stops). G30_GLOSA-RDS achieves the lowest number of absolute stops of all the scenarios analysed. The main direction in particular benefits here the most.

3.3.4 Observations in the simulation

Fig. 7 shows the road section for which a green wave and GLOSA-RDS (G30_GLOSA-RDS) was implemented. Each time step (t = 0 to t = 4) shows a snapshot of vehicles on the road section. It can be seen that two vehicles (framed in orange, Fig. 7) can catch up a green wave by accelerating SR > RDS (t = 0 to t = 1) and become part of a platoon (framed in blue, Fig. 7). After they catch up the green wave and become a part of the platoon, they continue their journey with RDS (t = 2 to t = 3) and can pass the stop line at green light. Shortly after all vehicles have passed the stop line at t = 3, the TL signal changes to yellow at t = 3 and later to red. It is an example which shows that vehicles can catch a green wave and build and join a platoon with an SR to accelerate.

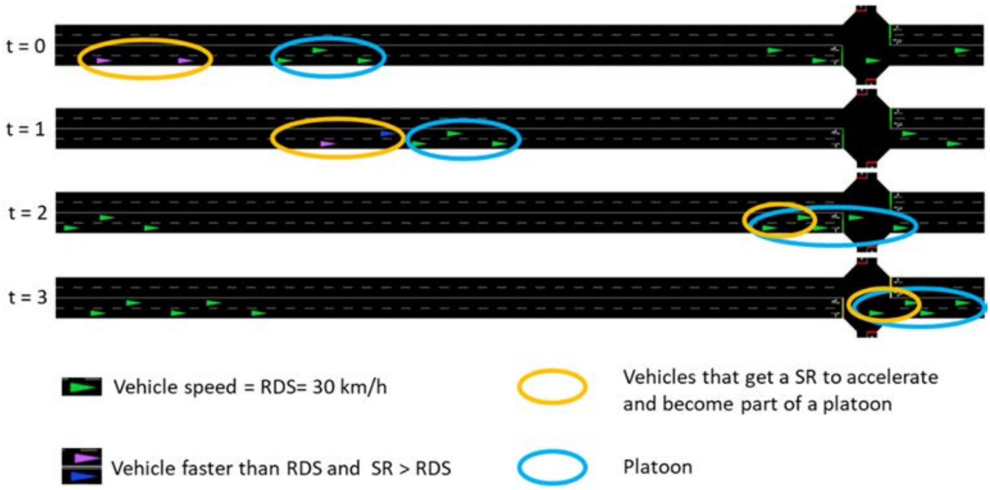

Figure 7: Observation example out of the SUMO Simulation.

4 DISCUSSION

GLOSA-RDS reduces the average travel time compared to G30_GLOSA and G30 between 13% to 16%. This is due to the fact that vehicles can drive faster than 30 km/h for a short period of time. This allows vehicles to catch up the green wave with an acceleration and could avoid a stop. For GLOSA-RDS compared with G50_GLOSA and G50, the travel time is longer because all vehicles generally driving 30 km/h, their speed only deviates (faster, slower) when they adjust their speed to the green wave. The simulation results also show that GLOSA-RDS can significantly reduce the average waiting time (20% to 60%) and number of absolute stops (20% to 70%) compared to a conventional GLOSA implemented at a green wave corridor. Significantly fewer vehicles have to accelerate again from a standstill. This could lead to reductions in CO_2 and noise emissions and increased comfort of road users.

The observation stated in Section 3.4.4 shows that vehicles can receive a GLOSA-RDS SR in order to accelerate. This basically confirms GLOSA-RDS design to accelerate and decelerate vehicles to adapt their speed to green waves and signal patterns. The simulation results and observations also highlight that GLOSA-RDS can manipulate traffic participants more flexibly than a conventional GLOSA. Most notably, the observations highlight the potential of SR to accelerate, when GLOSA-RDS navigates vehicles from secondary directions into the green wave of the main direction. Additionally, vehicles from the main direction arriving the start point of green wave corridor can better adapt their speed to the green wave. The observation evidence that platoons can be built with acceleration SR and while driving, which allowing for more compact platoons. Platoons do not have to be actively formed/calculated from a service, the formation of a platoon is an automatic effect of GLOSA-RDS. In this investigation GLOSA-RDS was only analysed with a fix time control, however, the possibility to influence/control traffic participants more flexibility enables

GLOSA-RDS also to better compensate for example fluctuations in traffic-dependent TL controls.

The use of the default speed recommendation transforms a conventional GLOSA service in GLOSA-RDS and achieve advantages that vehicles can better adapt to a green wave. GLOSA-RDS could be an interesting mechanism for cities in order to introduce lower speeds for motorised traffic in the city centre while at the same time reducing stops and waiting times of traffic participants. If GLOSA-RDS were to be implemented in today's traffic, all vehicles would have to possess C-ITS in order to receive the current signal status or speed recommendations from GLOSA-RDS. The GLOSA-RDS service could either operate in a vehicle or on the infrastructure side. The specific implementation of RDS is important. The RDS may be communicated to the driver/vehicle via the GLOSA-RDS service as well as via variable speed indicator or signs on the road. It is only important for the operation of GLOSA-RDS that all vehicles comply to the RDS and their speed only deviates (faster, slower) when they adjust their speed with the assistance of GLOSA-RDS to the green wave. Only then GLOSA-RDS can be realised to its full potential. If vehicles do not comply to RDS and drive with the speed limit of the road, GLOSA-RDS will lose the flexibility to manipulate the vehicle; then only decelerating SR are possible for this vehicle.

5 SUMMARY AND OUTLOOK

In this paper, a novel GLOSA-RDS service was developed that allows for more flexibility while influencing/manipulating traffic participants giving out a default speed recommendation for the traffic participants that is lower than the maximum allowed speed of the road. A vehicle always drives with reduced default speed (RDS) unless it has to adapt to the green wave with the assistance of GLOSA-RDS. This allows not only for deceleration advice in reaching a green wave, but also acceleration advice. Thus, vehicles may either slow down if they are ahead of the green wave or catch up when they are behind, which allows for the formation of more compact vehicle platoons. The implementation and analysis of GLOSA-RDS was realised in a microscopic traffic simulation at a green wave corridor with three signalised intersections.

The simulation results show that both average waiting time (up to 60%) and total number of stops (up to 70%) can be significant reduced compared to a conventional GLOSA services. The average travel time can be reduced up to 16% with temporary higher speeds for vehicles influenced by GOLSA-RDS.

In further studies, it would be interesting to investigate the GLOSA-RDS with different traffic demand for the main and secondary direction. The range of upper and lower limits of speed recommendations of GLOSA-RDS was chosen for the investigation in such a way that speed recommendations more accelerating is possible than decelerating. A balanced or different distribution would be worthwhile, as regards investigating, so that decelerating and accelerating SR are equally distributed. In the present simulation set-up, all vehicles followed the green wave, so that there were no traffic flows that made a turn off to leave the main direction (e.g. right, left turn). For that reason, vehicles do not have to stop at main directions to incorporate other road users. It would be interesting to analyse their influence on the GLOSA-RDS in a further study. The analyses of noise and CO_2 emissions were not part of the investigation, so it would be beneficial to investigate emissions in further simulation studies. GLOSA-RDS could also be used for public transport prioritisation to enable buses to reach the green wave more quickly after a stop.

The simulation study seems to confirm the principal idea of GLOSA-RDS. Therefore, there are still many questions which need to be answered regarding the idea of GLOSA-RDS.

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