27th ITS World Congress, Hamburg, Germany, 11-15 October 2021

5G enabled logistics using GLOSA for Truck Platoons

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Abstract

5G-Loginnov will focus on designing an innovative framework in the industry 4.0 and ports domain piloting 11 families of use cases based on new 5G core technologies. The project is supported by 5G technological building blocks, including new generation of 5G terminals notably for future Connected and Automated Mobility, new types of Internet of Things 5G devices, data analytics, next generation traffic management and emerging 5G networks, for ports to handle upcoming and future capacity, traffic, efficiency and environmental challenges. For the city-port of Hamburg, the efficient corridor management of nearby hinterland logistics, including warehouses and hubs as well as their connection to the port's terminals, in especially with regards to an efficient inter-modal hand-over of the container flow, will be implemented in four use cases including Floating Truck Emission Data (FTED) analysis, 5G enabled GLOSA (Green Light Optimal Speed Advisory) for Truck Platoons and Dynamic Control Loop for Environment Sensitive Traffic Management Actions (DCET).

Keywords: Connectivity, Truck Platooning, Port Logistics and Automation, Emission Reduction

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Introduction

In the pre-Covid-19-year 2018, seven out of the world's top 20 container terminals were located in China, whereas Europe was ranked among the list with the three ports: Rotterdam, Antwerp and Hamburg. Driven by Asia's strong economic growth and the increasing importance of efficient port operation, Chinese Mega-Ports heavily invested into the Automation of Container Terminals, already employing Hydrogen energy systems and 5G Technology to improve port operation [1]. Germany's two mayor ports (Port of Hamburg and Bremerhaven) go similar directions (see [2] and [3]) as sustainable energy management and efficient digitization are the backbone for the country's export-oriented economy. Nevertheless, it must be mentioned that progressing Automation inside the ports often goes with challenges in the multimodal hinterland connections from hubs and warehousing to the port's terminals. Therefore, a leading European port such as Hamburg, has the interest of improving hinterland connection by efficient logistics corridor management. In 5G-Loginnov, Hamburg use cases were designed exactly along the objective of increasing the long-term efficiency of the logistics flow from city to port by 5G enabled GLOSA services for Truck Platoons and Automated Driving.

5G enabled logistics use cases within 5G-Loginnov in Hamburg

Within the 5G-Loginnov project, one family of Use Cases is targeting the detection of fuel consumption and CO2 emissions using IoT devices including 5G smartphones as vehicle on-board units. The applied algorithm for fuel and CO_2 is based on the ISO-23795 standard which is implemented in the T-Systems solution LCMM (Low Carbon Mobility Management). In the context of the planned field trial of 5G-Loginnov in Hamburg, Figure 1 shows the architecture of using LCMM as data source for Floating Truck Emission Data by using three different hardware platforms collecting trip data. The IoT-Device of Continental is connected directly to the vehicle's CAN Bus, whereas EnTruck of the company tec4u evaluates additional external sensor data, e.g., tire pressure. Both telematics units are complemented by 5G smartphones with T-Systems LCMM APP on board. The equipped vehicles will exchange data with the Deutsche Telekom 5G mobile edge computing infrastructure linked via API to the traffic management centre of SWARCO. The 5G architecture is the key enabler for implementing the 5G-Loginnov use cases planned in Hamburg as 5G ensures that data transfer is accessible and scalable and that 5G enabled precise positioning information can be used for building sustainable traffic management services. The 5G mobile edge computing server is also needed for ensuring that GLOSA speed advice and collision warning messages are transmitted using the uRLLC properties of the 5G mobile network, in especially for enabling stable operation of truck platooning with reliable V2X latency < 25ms, see [4].

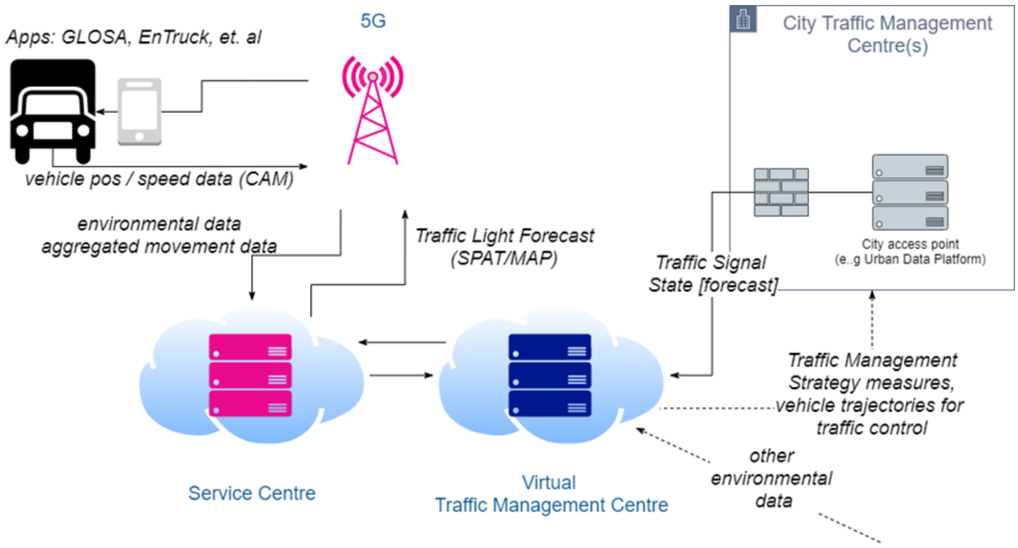

Figure 1 Service Architecture for 5G-Loginnov uses cases in Hamburg

Complementary to GLOSA, Figure 2 shows the solution architecture for carbon foot-print monitoring based on LCMM. The mobile terminal in Figure 2 is collecting GPS data including position, time and most importantly, speed per second. The information is transferred by the mobile telecom network to the cloud and from there to an IoT data base platform. The information can be accessed and visualized on different dashboards and client / mobile applications. In 5G-Loginnov, it is planned to calculate the energy consumption based on Newtonian Physics of driving a vehicle in motion, see [5].

Newtonian Physics uses the inertia forces to calculate energy demand as indicated by equation [1] and [2] shown in Figure 3. For the sake of clarification, it should be mentioned that LCMM does not directly measure fuel consumption but deviation in percent relative to the fuel consumption of the standard speed reference cycle, WLTP. Thus, the complex determination of fuel and carbon consumption shifts from the rather complicated direct measurement of fuel to the much easier statistical trip evaluation of fixed vehicle parameters and speed profile per second as described in the ISO-23795 standard [6]. The accuracy is as good as the speed profile and the stability of the vehicle parameters. From numerous field trials it could be proven that in more than 95% of trips recorded, the statistical approach published in the ISO-23795 standard leads to reasonable results for fuel consumption and CO_2 emissions when compared to CAN-Bus data or fuel cards. The information is available in Mega-Joule and percent deviation per Mega-Joule to avoid dependencies on specific fuel types and engine efficiencies.

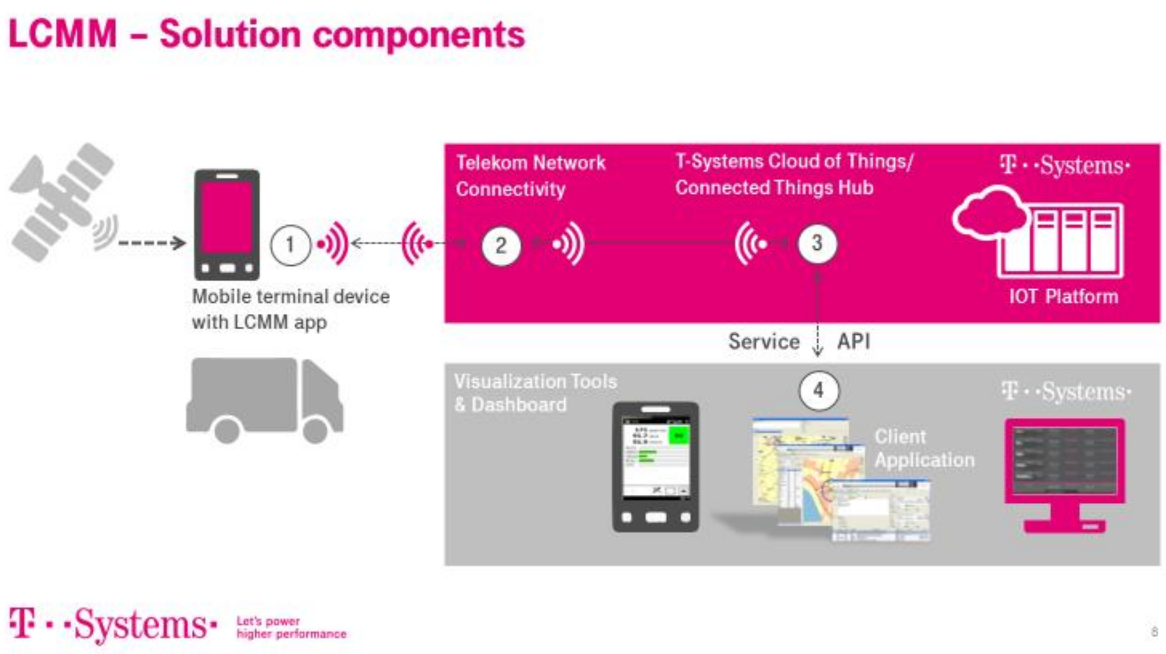

Figure 2 – Solution architecture for Low Carbon Mobility Management (LCMM)

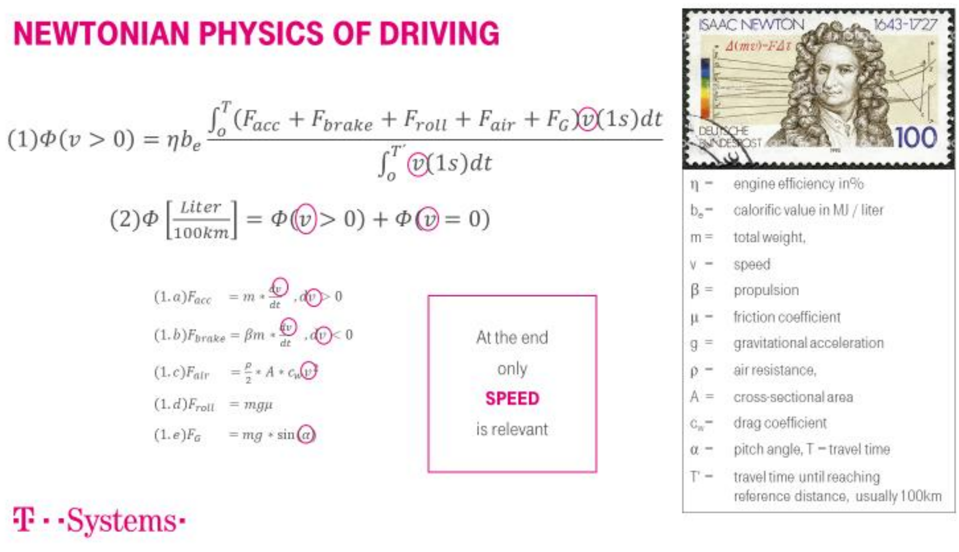

Figure 3 Newtonian Physics

An example how to use ISO-23795 by LCMM is presented in Figure 4. A trip of 11 km length is evaluated in Yellow-Green-Red traffic light color codes and shown on OpenStreetMap. Here, Green indicates %-deviation relative to a WLTP low speed profile <100%, Yellow profiles between 100% and 150%, whereas Red shows results above 150%. To the right, standstill is shown and increased emissions while driving in a congested shopping area. The speed profile is presented in Figure 5.

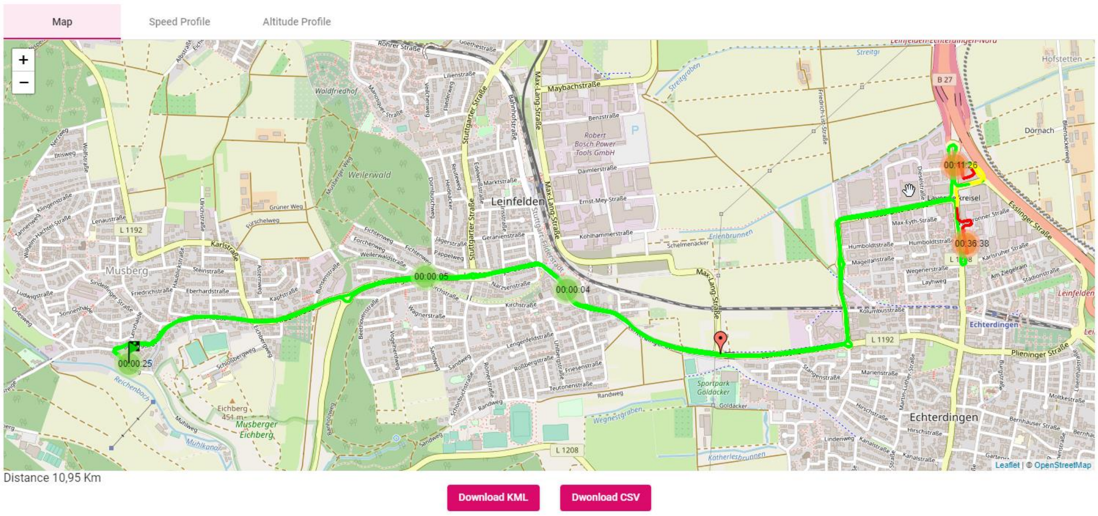

Figure 4 Example of truck trip using LCMM

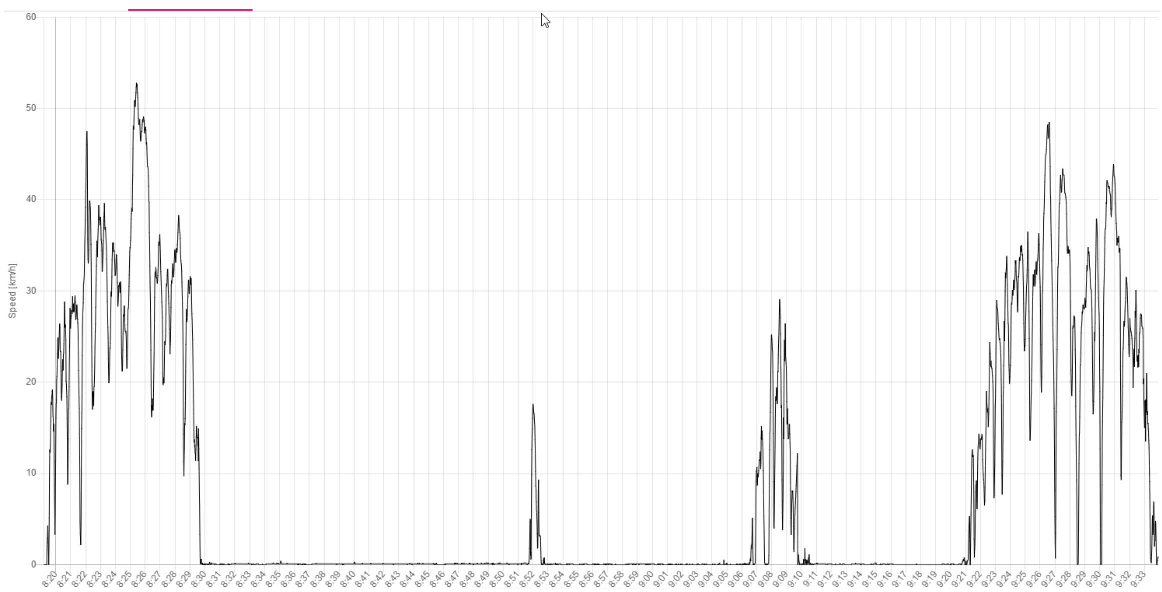

Figure 5 speed profile

5G and Floating Truck Emission Data Analysis

In 5G-Loginnov it is planned to use a 5G enabled service called “precise positioning” which increases the accuracy of positioning data compared to purely GPS. Figure 6 shows the altitude profile of the trip presented in Figure 4. As can be seen, there is a jump between minute 8 and 9, where the height of the position changes of almost 50 meters, even though the vehicle shown does not move at all. For sustainable traffic management, such virtual changes of height positions cause problems for the calculation of energy demand, fuel consumption and carbon emissions. To avoid such errors, 5G-Loginnov will use the precise positioning service of Deutsche Telekom to guarantee the accuracy required. Additionally, it has to be ensured that the mobile network is not occupied by data consuming mobile web-services in the mobile cellular network, therefore accessibility and network slicing of the 5G network are important success factors for Floating Truck Emission Data services.

Figure 6 LCMM 3D height profile

5G enabled GLOSA for Truck Platooning

The basis for proving and demonstrating the effectiveness of GLOSA in interaction with truck platooning is, in addition to a safe and target-oriented communication strategy and environment, the automatic recognition and evaluation of the emission impact of driving manoeuvres, and the related influence of the infrastructure, traffic management systems (TMS) and TMS linked GLOSA measures. The driving manoeuvres are classified into characteristic cases (braking, accelerating, constant speed) and linked to the static infrastructure characteristics (curve, uphill, downhill); in parallel, the dynamic traffic control systems (traffic lights, lane and speed displays) are recorded/localised (and located as specific GLOSA POIs) and the specific information need/available content is queried and structured.

Based on the changes in driving manoeuvres (when TMS/GLOSA measures, the status of the traffic situation and the knowledge of other boundary conditions are known), the changes in emission behaviour will be determined, assigned and evaluated, based on the driving profile change. To determine the emissions, the LCMM methodology is calibrated by means of CAN bus data, using real driving and consumption profiles; thanks to this approach, the effect can be recorded for individual vehicles and platoons in the context of complex urban driving situations.

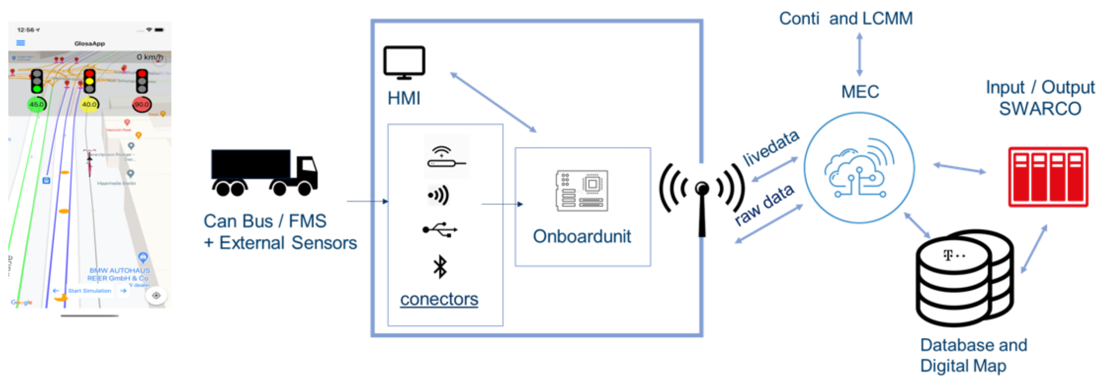

Figure 7 - 5G-Loginnov use case for setting up C-V2x GLOSA based vehicle platooning

Figure 7 shows the solution architecture for using GLOSA in real traffic situation in the city of Hamburg. On the left side, lanes of the road network as implemented in the GLOSA-App are presented, the platoons in the field trials planned will have this view inside the vehicle. Live data will be exchanged via 5G-MEC-Server, i.e. to ensure low E2E latency required for the V2V communication inside the platoon. In complex urban driving maneuvers, platoons easily are degenerated and interrupted, therefore the inter-distance between lead and follow vehicles cannot exceed typical vehicle lengths of 3 to 5 meters. On the other hand, such relatively short distances easily risk dangerous braking events caused by external traffic incidents. Therefore, E2E latencies of <25ms are published for vehicles platooning (see [4]) which is fully covered by the uRLLC capability of the 5G network as recently studied and monitored in Truck Platooning Proof-of-Concept Activities for 5G and Beyond (see [7]).

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