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Sustainable Mobility
by providing Connected Mobility for all Modes of Transport

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Abstract

Climate, road safety, quality of life and traffic congestion are constantly increasing challenges for road authorities in urban areas around the world. The Dutch city of Almelo is challenged to keep its traffic flowing, to lower vehicle emissions and to increase social and road safety. Connecting road users and road side equipment will play a key role in cities that want to reduce and resolve these problems. Almelo is conducting an exciting and challenging project to introduce connected and predictive traffic light control algorithms on an entire ring road, considering all modes of transport and securing save passage for emergency services. In total the Almelo ring can be perceived as very innovative ring road. Using connected intelligent Traffic Light Controllers based on standardized Talking Traffic [1] protocols, Almelo is fulfilling the objectives mentioned above. This paper describes the project, the state of affair and future research and developments.

Keywords:

C-ITS, Talking Traffic, Network Optimalization, Traffic Flow, Target Group Prioritization

The challenge

The city of Almelo in The Netherlands is a small size city with some 75.000 inhabitants. Together with the cities Enschede and Hengelo, Almelo is part of a metropolitan area of approximately 320.000 citizens in the Twente region. Twente is located in the mid-eastern part of the Netherlands bordering Germany in the East. For most people outside The Netherlands Almelo is known for its local football club Heracles Almelo, a team playing in the Dutch secondary league. For Dutch people Almelo is known for traffic signals after the Dutch comedian Herman Finkers jokingly claimed Almelo being a sparkling city, because of its ever-changing traffic signals. At the end of the 19th century Almelo had a large textile industry and although most of this industry has moved elsewhere the city still has a lot of industrial areas. Today the impact is still visible due to the high volume of industrial plants around the city. Nowadays the city is well known for its high-tech industry and is developing into the central logistic hotspot in eastern Netherlands.

Despite being a relatively small town, there are many traffic light-controlled intersections. In total 27 controlled intersections are situated on the ring road and its access routes. Additionally, most of the 15 other controlled intersections are located in the area within the ring road, including the city centre. Almelo is eager to test new innovations and functions as a showcase for the National Talking Traffic Partnership. This showcase not only demonstrates technical approaches but also the inevitable collaboration between public and private organisations. By the end of 2024, Almelo will be one of the first municipalities in The Netherlands where all controllers will be 'intelligent', connected in one network and connected to road users.

In total six challenges to be solved with smart traffic controllers (iTLC) and smart control algorithms (ITS Applications) have been identified.

1. Reduction of emissions of greenhouse gas, particulate matter and noise. This way the quality of living for citizens and people that pass-through Almelo is improved. This should be achieved by reducing the number of vehicle stops, thus reducing the pollution caused by road traffic through optimized intersection control with smart algorithms that use network coordination;
2. Increase road safety as part of the Vision 0 goals. Reducing stops, thus smoothing traffic flows and reducing waiting time is increasing road safety;
3. Increase the use of zero emission vehicles in the modal split by reducing stops and waiting times for these vehicles particularly. In 2025 this will be applied to cyclists on main cycling routes (with special focus on platoons of school children) and inner city logistics (electrical trucks and vans, cargo bikes etc);
4. Get Almelo ready for Connected and Cooperative Automated Vehicles (CCAM) by digitally sharing the time to green and time to red times (SPaT);
5. Facilitate economic growth by allowing visitors (shoppers) to access the Almelo commercial areas smoothly. The entire city centre of Almelo has been upgraded during 2018 and 2019, creating a higher shopping experience for the visitors;
6. Facilitate a safe and joyful environment during Heracles Football matches for both the visitors as well as emergency services. Objective is a safe and timely entry and exit of large groups of supporter vehicles to and from the football stadium.

The combination of these six objectives and other project related specifics (e.g. timelines) make this a challenging and exciting project getting Almelo ready for the future.

Approach and partners

In 2018, the city of Almelo has initiated a project to address all six challenges at the 27 traffic signals on the Almelo ring road and its access routes. This project, TINA-3/4 (Traffic Information Network Almelo), should initially be finished in 2020, but unfortunately initial suppliers were not able to meet the technical challenges and the project had to be aborted that year. Subsequent talks between the city, national and provincial government resulted in the more ambitious project TINA-5 to widen the

installation to all 43 traffic signals in the city. Figure 1 shows their locations. In the first phase of this project the original 27 intersections will be installed until June 2023. In the second phase the other 15 intersection will be added until December 2024. The new defined project was tendered in 2022 and preparations started in August. By December 2024, the first 2 of 27 came into service.

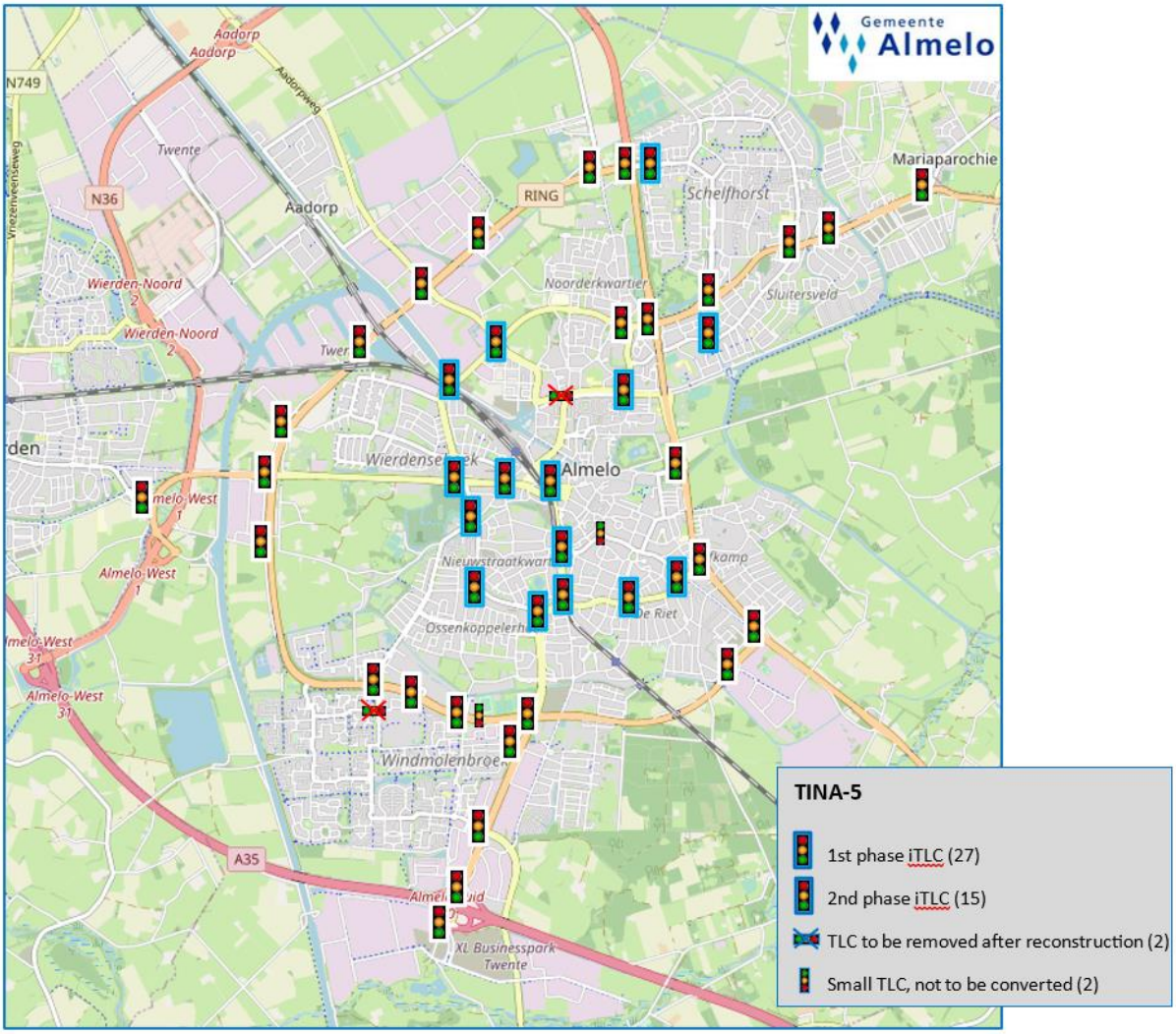

Figure 1 – Traffic signal intersections in Almelo (phase 1 / phase 2)

In this first phase, the locations have been divided into five adjacent trajectories, each being a subproject. In order to make the overall project successful all 27 traffic light controllers (TLC's) need to be upgraded to an iTLC. An iTLC complies with the standardized Talking Traffic communication protocols, separating the controller hardware and firmware from the ITS application with its control algorithms. Along the protocol the iTLC needs to be equipped by a low-latency data connection.

Talking Traffic

The Almelo project has been initiated via the Talking Traffic Partnership initiative. This national initiative was started in 2016 by the Dutch Ministry of Transportation. In total six end-user use cases have been specified, being real-time parking information, two safety related traffic information (SRTI)

cases and three traffic light controller use-cases (information, priority and network coordination). The Talking Traffic program is an Innovation Partnership, involving both governmental and commercial organisations to jointly develop and deploy new technology. Within the program a full chain of services provide, among others, traffic controller use-cases for in-vehicle usage. After a process defining exchange points, protocols and 'Dutch profiles' the eco-system was fully developed and tested before on-street deployment. Starting 2019 the on-street deployment has started and is still ongoing while writing this article, for example on the intersection displayed in figure 2. The Talking Traffic ecosystem (technology, protocol's, governance etc) is the basis for the Almelo deployment. However, the unique approach of Almelo is aiming at large scale deployment while most other governmental organisations stick to pilots or short routes. Relevant for this paper is that iTLC's have been split into the controller part (hardware and firmware), ITS Applications with their control algorithms and RIS (Real time Information exchange System).

Figure 2 – One of the traffic signal intersections on an Almelo access road

iTLC

Due to the city's hardware investment scheme, most Traffic Light Controllers (TLC's) involved in the project are relatively new, meaning that full replacement of the hardware is not required in most cases. The upgrade is done by installing additional modules in the TLC, making the controller suitable for the TLC-FI exchange format as defined by Talking Traffic. The make of the controller does not need to be the same as the make of the additional modules as long as they meet the standard Dutch Talking Traffic requirements. In Almelo two makes of TLC's are installed, Vialis and Swarco (Dynniq). Along with the iTLC module also an DSL modem is installed to provide communication to the city's

highspeed internet access point which is dedicated to traffic related functions. Connection using 4G+ sim-cards placed in the TLC cabinet is an option if the existing and rather old cable connections fail to transmit the real-time data at the required speed. After setting up all relevant VPN tunnels and endpoints it is possible for authorized applications to reach the TLC via the internet. Due to this upgrade the iTLC is able to be controlled by an authorized remote ITS application for network coordination purposes.

Next to the hardware and connectivity-aspects, a backup application is present in the iTLC. This back-up application can take over the control once the connectivity has dropped or other issues arise. Between December 2022 and June 2023 all 27 TLC's will be upgraded to iTLC, allowing external connection and coordinated traffic management. While writing this paper the upgrade is still ongoing.

The software used is standard CCOL software, widely used in The Netherlands to control traffic lights. To the CCOL software specific modules have been added to provide the connections and coordination needed. The coordination between intersection is based on a step-up scheme. With low volumes of traffic, e.g. in the evening, intersections do not coordinate. When volumes rise, intersections coordinate locally with adjacent intersections. With higher volumes of traffic, in peak hours, coordination gets more centralized. Thus, for every time of the day and every traffic situation an optimized coordination level is guaranteed. Information and priority functions are maintained in all situations.

In all situations it is possible to prioritize specific user groups (e.g. cyclists or trucks), as part of road authority policies and objectives to reduce pollution or encourage the use of certain modes of transportation. In Almelo the traffic is detected using existing detection systems like inductive loopdetectors, camera's, radar, infra-red, push-buttons, short range radio and so on. In the future, further optimization can be reached by adding Floating Car Data. Floating Traffic Data would be a more accurate term, because it will also come from cyclists and pedestrians carrying smartphones with applicable apps.

Configuring the challenges

As stated earlier, introducing the Talking Traffic connected traffic light control system comes with six challenges addressed by the Almelo municipality in the TINA-5 project.

1. Reducing emissions of CO2, NOx and PM10 caused by road traffic. The connected traffic control enables continuous optimization based on a more accurate image of actual traffic demand. Especially camera and radar detection and the future addition of Floating Car Data will increase and improve the data used by the traffic controllers. For instance, using the connection to other traffic controllers and combining those date with Floating Car Data will widen the area of which the traffic light controllers have data. Moreover priority vehicles like those from emergency services, public transport, trucks and platoons of cyclists will be "seen"

by the traffic light controllers in much larger distances than with the 'old' means of detection. By continuous following these priority vehicles and continuous calculating their Estimated Time of Arrival (ETA) the iTLC can advise the driver in-car on the optimal speed in approach the next intersection and grant them the priority needed within a very small time frame. In this way the extra waiting time for the other traffic that is normally caused by prioritization is minimized;

2. Increased road safety is realized by optimizing the flow of traffic on the most busy lanes of an intersection, minimizing stops and waiting queues. Moreover, prioritization of trucks will minimize even more stops of these heavy vehicles. Stopping and going of this kind of vehicles causes additional unsafety. When priority is granted, the truck will receive a save and smooth passage over the intersection;

3. Increase the zero emission vehicles in the modal split by reducing stops and waiting times for these vehicles particulary. In 2025 this will be applied to cyclists on main cycling routes (with special focus on platoons of school children). Cyclists can load an app on their smart phone which connects to the intersection controller using the standardized Talking Traffic features. In The Netherlands, several apps for cyclists are already available. Also in 2025, as a result of a national agreement between central government and cities, zero emission logistic vehicles will get more rights to access the inner city shopping area, where access is limited between 07.00-11.00 AM. In 2023 Almelo is installing a camera surveillance system to enforce this rule and connected zero emission vehicles will get access in a much wider time frame. Moreover these vehicles will get additional priority at the traffic light controlled intersections. These two measures combined make logistics with zero emission vehicles much more efficient than with other vehicles.
4. In order to make Almelo ready for CCAM vehicles all iTLC intersections continuously stream real-time SPaT data. The predicted traffic signal states before actual realisation are published in the SPaT stream. These data are shared on Talking Traffic platforms and can directly be used by various smartphone app backends as well as future OEM service suppliers. The SPaT data quality is location specific, as it is fed with proper local detector data. As the detection data quality is location specific the resulting quality of the SPaT data will differ per location. It is expected that the quality will improve as additional Floating Car Data and Floating Bicycle Data become available.
5. Another objective is to facilitate visitors of the Almelo City Centre. As indicated before, the city centre received a facelift during 2018 and 2019 in order to improve the shopping experience. Proper accessibility is key item for visitors and their impression of Almelo. To meet these objectives, the connected controllers will respond to actual vehicle demand. The system will adapt the intersection controls automatically when either direction gets much busier the other day. The recently (2022) installed new Parking Guidance System (PGS) will

add information on the availability of free parking spaces and send this information through the existing Network Management System (NMS). The NMS can directly and automatically adjust the iTLC control by using the IVERA-APP exchange protocol;

6. The last objective is to facilitate a safe and swift inflow and outflow of traffic before and after Heracles Football matches. In order to make this use case successful a large number of visitor's buses and vehicles need to be guided using the intelligent traffic controllers on the routes to and from the stadium. This case uses priority requests SRM messages (as indicated at the emergency use-case). The only difference here is that this does not involve a single vehicle but a platoon instead. A continuous flow of the platoon improves the safety of both supporters as well as emergency vehicles. This scenario is triggered by a leading and trailing vehicle sending SRM requests and SRM cancellations respectively. The applicable intelligent traffic controllers know which directions to force to green.

Results

The overall TINA-5 project will be delivered in first half of year 2023. As a result, it is not possible to share on-street results while writing this paper. However the city of Almelo has become partner in the European CONDUCTOR [2] innovation project. Once in operation, the TINA-5 systems will be used in use case 1 (Integrated traffic management) of CONDUCTOR. In Almelo it will focus on flow-as-a service for trucks, containing the following features:

- Green-light optimized speed advice;
- Truck prioritization using signal timings adaptations;
- En-route (ad-hoc) truck platoon forming.

The University of Twente, also partner in CONDUCTOR, will take the lead in the CONDUCTOR pilot and perform a specific research on the prioritization of trucks. Results can be expected in 2024/2025. The city, being a logistic hotspot in the region, will use the results of the pilot to fine tune its systems in order to maintain and widen the operation of flow-as-a-service for trucks and other logistical vehicles (for instance cargo bikes). Further experience in upgrading TLC's and configuration and deployment of the ITS Application will be achieved along the way.

At the time this final version of the paper is written, mid-April 2023, the installation of the iTLC's of the first phase of 27 intersections is going as planned. Where installed, flow of traffic already seems to benefit from the intelligent connection between intersections, resulting in less stops and less waiting times for platoons on main directions. Traffic crossing those main directions however does not seem to experience disadvantages. Unforunately it is too early to prove these statements by figures. If possible, at the ITS Europe congress in May 2023 we will share the actual results.

Future-Proof eco-system

With increasing traffic volumes and at the same time growing demand to reduce the impact of car traffic

to the climate, the local environment and liveability, controlling traffic light intersections with Talking Traffic connected functions responds to today's needs. It provides a road authority with much more instruments to meet the policy goals and needs of people and enterprises in the city. Moreover, it offers a platform for introducing additional use cases. The software of the ITS application is independent of the hardware of the controller. This means that as long as the interface does not change, additional functionality can be added without changing the entire eco-system. An example of this phenomenon is that information about the length of the queue can be added to the SPaT message without making any changes to the TLC. Another example is the work around the iSPaT initiative. This new concept facilitates automated vehicles with a time slot for crossing the intersection. This while having regular vehicles in the traffic mix. This concept can be launched as an extension of the current roll-out, without the need to modify other components in the chain. All this makes Almelo a future-proof eco system for future and new concepts.

References

1. TALKING TRAFFIC is a Dutch partnership and program facilitating the exchange of data between road users and intelligent infrastructure within a public-private data chain in order to reduce the adverse effects of mobility on the basis of real-time data. An increasing amount of parties wants to join the data chain, more outdoor objects are digitally linked and more cities acknowledge the added value of being able to guide and manage groups of road users in a smart way. As a result, Talking Traffic is becoming increasingly important for governments as a combination of tools for simplifying management and maintenance, as well as policy decision-making. Interest in this type of data-driven mobility is growing, especially in cities that are in the process of rolling out the Smart City concept. They are increasingly aware of the possibilities offered by Talking Traffic applications: determining which vehicles are allowed to enter an environmental zone and which are not, granting a degree of privilege to shared cars or electric cars, or determining in a simple way that residents of an apartment complex, i.e. access traffic, have access to a certain road that remains closed to others. The availability of real-time data offers a view of what is happening on the streets in the city at any moment in time. That view enables authorities to steer and facilitate desired mobility behaviour, but also to manage other challenges in areas such as housing, climate change and energy transition in an integrated and targeted way. An increasing amount of cities in the Netherlands consider this form of data-driven mobility to be a major cornerstone for making cities smarter, more sustainable, cleaner and safer.

   https://www.talking-traffic.com/en/

   https://dutchmobilityinnovations.com/landing-EN

2. CONDUCTOR project’s main goal is to design, integrate and demonstrate advanced, high-level traffic and fleet management that will allow efficient and globally optimal transport of passengers and goods, while ensuring seamless multi-modality and interoperability. Using

innovative dynamic balancing and priority-based management of vehicles (automated and conventional) CONDUCTOR will build upon state-of-the-art fleet and traffic management solutions in the CCAM ecosystem and develop next generation simulation models and tools enabled by machine learning and data fusion, enhancing the capabilities of transport authorities and operators, allowing them to become “conductors” of future mobility networks. We will upgrade existing technologies to place autonomous vehicles at the centre of future cities, allowing heightened safety and flexible, responsive, centralized control able to conduct traffic and fleets at a high level. These innovations will lead to less urban traffic and congestion, lowered pollution, and a higher quality of life. Project innovations will

be integrated into a common, open platform, and validated in three use cases, testing the interoperability of traffic management systems and integration of different transportation means for both people and goods. Use case UC1 integrates traffic management with inter-modality, UC2 tests demand-response transport, and UC3 urban logistics. In each use case and its demonstrations, simulations will be validated through real life data.

https://conductor-project.eu/