



CORDIS Results Pack on **connected and automated driving**

A thematic collection of innovative EU-funded research results

March 2019



The route
to a safer,
more efficient
and cleaner
transport system

An abstract graphic in the background features concentric blue and purple curved lines radiating from the bottom left. Overlaid on these lines is a stylized illustration of a self-driving vehicle. The vehicle has a large front window showing three small human figures. It is emitting blue and red light signals, including a prominent red beam from its side and several blue circular signals from its front. The overall theme is futuristic transportation technology.

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Editorial

Connected and Automated Driving (CAD) can contribute significantly to the European Commission's policy goals of bringing down the number of road fatalities, reducing harmful emissions from transport and reducing congestion. To fully unlock this potential, CAD has to be integrated in a transport system that favours social inclusion, low emissions and overall efficiency. This requires a multi-stakeholder cooperation across all disciplines to improve enabling technology and the supporting infrastructure and to ensure the right legal and policy framework for automated mobility.

Automation and connectivity can complement and reinforce one another, contributing enormously to the European Commission's goal of reducing road deaths. Even though fatalities have more than halved since 2001, 25 300 people still lost their lives on EU roads in 2017 and another 135 000 were seriously injured. The European Commission is convinced that CAD can help ensure safer roads and greater protection of citizens.

New technology solves old challenges

Connected and Automated Mobility could reduce transport congestion and harmful emissions, while strengthening the competitiveness of the European industry, creating new jobs and boosting economic growth. The European Commission also aims to make Europe a world leader in the deployment of connected and automated mobility, including a fully digital environment for information exchange in road transport to facilitate digital information flows among relevant stakeholders.

Technological solutions alone cannot overcome the challenges of congestion, transport emissions and road fatalities. We must also manage the long transition to self-driving vehicles properly and ensure that they promote low emissions and overall efficiency.

EU research - innovation and application

This CORDIS Results Pack focuses on eight projects that are spearheading CAD research funded under the EU's FP7 and Horizon 2020 research programmes. The potential of different automated driving functions in passenger cars to improve safety and traffic flow is explored by the now completed [ADAPTIVE](#) project and continues to be developed and tested by the current [L3Pilot](#) initiative. They explored the potential of these functions to improve road safety and traffic flow.

The [AutoMate](#) project devised a novel driver-automation interaction and cooperation concept to ensure that automated driving systems will reach their full potential and can be commercially exploited.

The [MAVEN](#) project, meanwhile, created algorithms for organising the flow of infrastructure-assisted automated vehicles and structuring the negotiation processes between vehicles and the infrastructure. [ROADART](#) developed intelligent transport systems (ITS) technology that enables trucks to wirelessly exchange information with infrastructure and other heavy-duty vehicles.

[TRAMAN21](#) investigated new traffic management methods and tools suitable for the era of connected transport. The aim is to enable traffic to flow as efficiently as possible, thereby preventing jams and delays.

[VI-DAS](#) employed the latest advances in sensor, data fusion, machine learning and user feedback to warn drivers about potentially dangerous situations and avoid accidents. The [SGCAR](#) project used 5G, the latest generation of cellular mobile technology, to inform drivers about manoeuvring connected vehicles and determining the position of vulnerable road users.

Finally, the work of the [CARTRE](#) project, which is continuing under [ARCADE](#), supports the development of clearer policies in EU Member States to ensure that automated road transport systems are interoperable and applied in a coherent way across Europe.

Automated driving in Europe

Intelligent vehicles will have a major impact on road transport and its infrastructure. Two EU-funded initiatives are developing and testing driving functions to explore the potential of automated mobility and transport to improve road safety and traffic flow.



European researchers have tested automated technologies to enhance driver comfort and safety, traffic flow and environmental performance. The [AdaptIVe](#) project tested innovations that take into account the driver's needs and the current legal environment. "The findings feed into the hugely ambitious EU-funded [L3Pilot](#) initiative, which increases understanding of how automated vehicles can be effectively integrated into Europe's transport infrastructure," says project coordinator Aria Etemad from Volkswagen Group Research.

AdaptIVe optimised the interaction between drivers and automated technologies by applying the 'shared control'

approach through a variety of systems, including vehicle-to-vehicle interaction, obstacle sensors, and technologies responding to driver status. Researchers also tested four of the five SAE (Society of Automotive Engineers) levels of automation – namely assisted, partial, conditional and high automation, using demonstrator vehicles ranging from city cars to larger passenger cars, and a heavy goods lorry.

Development involved three scenarios: close distance, urban, and highways. Close distance testing included manoeuvring for parking or in crowded environments, at speeds of under 30 km/h. Urban scenarios involved a range of everyday traffic



The findings feed into the hugely ambitious EU-funded L3Pilot initiative, which increases understanding of how automated vehicles can be effectively integrated into Europe's transport infrastructure.

focusing on large-scale piloting of SAE Level 3 functions, with additional assessment of some Level 4 functions.

The investigation covers a wide range of driving situations, like parking, overtaking on highways, and driving through urban intersections. The valuable data collected will help to evaluate technical aspects, user acceptance, driving and travel behaviour, and impacts on traffic and safety to create a standardised Europe-wide testing environment for automated driving. "We will then be ready to conduct large-scale field operational tests on public roads," notes Etemad.

Safer, more efficient driving

Researchers will also collect best practices on developing automated driving functions and compile them into a Code of Practice. "This describes a typical process for designing and developing automated driving functions, including hands-on checklists and safety aspects as well as methods for confirming the safe operation of automated driving functions," explains Etemad.

hazards at speeds of 10 to 70 km/h, with challenges coming from the complexity of the environment and density of traffic. Highway scenarios featured vehicles travelling up to 130 km/h, testing manoeuvres such as lane changing and merging into traffic.

In addition, project partners will investigate the impacts of automated driving functions under different traffic conditions and determine the system's technical robustness and cybersecurity. They will also focus on the user by considering a wide range of demographic aspects such as gender and age in the evaluation of automated driving systems.

Major European initiative

Researchers applied AdaptIVe results to the L3Pilot project, the largest EU-funded study of its kind with 1 000 drivers testing 100 automated vehicles under a range of conditions across ten European countries. The initiative aims to determine the viability of automated driving as a safe and efficient means of transportation on public roads,

Finally, L3Pilot will draw conclusions on technical aspects, user acceptance, driving and travel behaviour, and the impact of automated driving on traffic. "We will determine the safety, efficiency, mobility and economic impact of automated driving applications. Thereby, we will consider mixed automated traffic conditions based on real-world pilot data and provide a cost-benefit analysis with respect to Europe as a whole," Etemad points out.

PROJECT

**AdaptIVe - Automated Driving Applications and Technologies for Intelligent Vehicles;
L3Pilot - Piloting Automated Driving on European Roads**

COORDINATED BY

Volkswagen AG, Germany

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/610428

cordis.europa.eu/project/id/723051

PROJECT WEBSITE

adaptive-ip.eu/
l3pilot.eu/



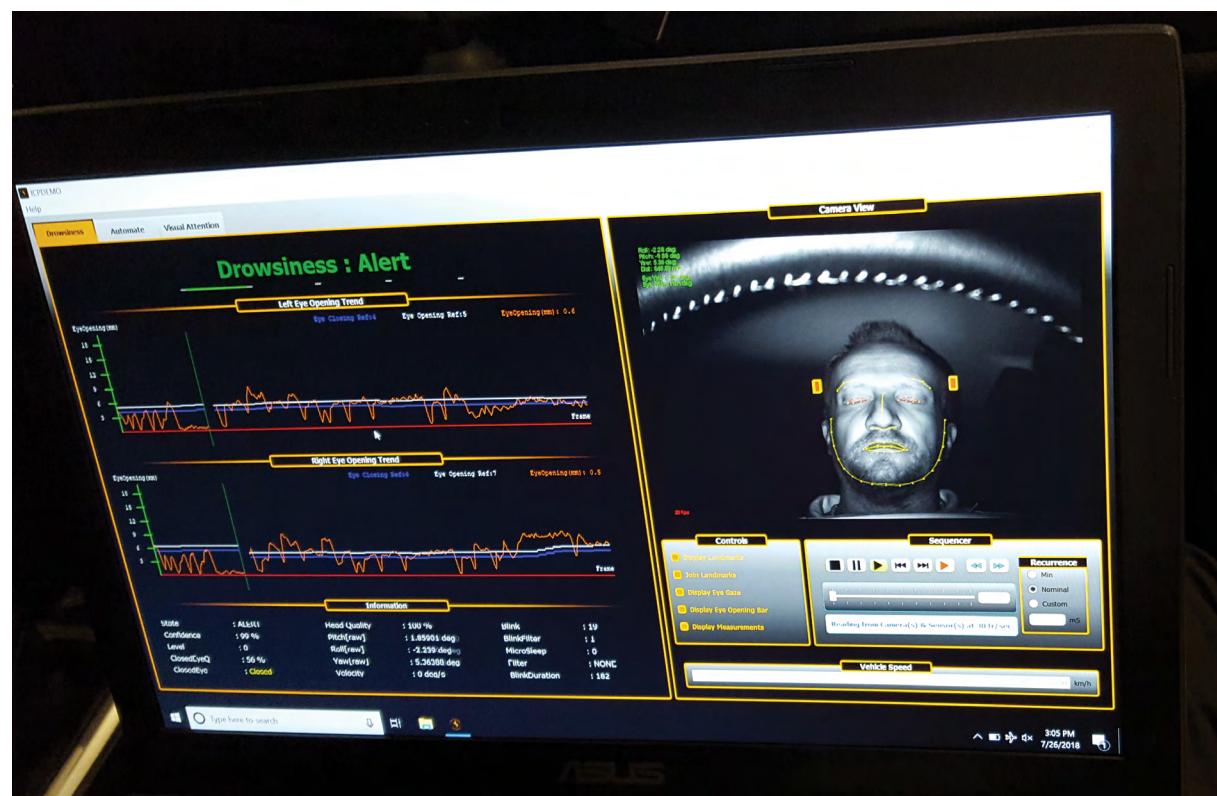
Human + machine capacity = safer and more efficient driving

Automation in passenger cars is constantly increasing, but successful commercial uptake will depend on several factors. These mainly include how well they interact, communicate and cooperate with humans both inside and outside the car.

Highly automated vehicles require optimised interaction between humans and machines before introduction onto the market to ensure traffic safety and efficiency. "Human driver and automation have to be regarded as a team that shares the driving task, as they're both responsible for driving safely, efficiently and comfortably from A to B," says Dr Andreas Luedtke, coordinator of the EU-funded [AutoMate](#) project.

Automation and human driver dynamics - boosting safety

The objective of design isn't the automated driving system itself, but how machine and human driver cooperate to deal



with complex situations. "AutoMate will create an extremely reliable automated driving system that users can understand, accept, trust and eventually regularly use," notes Dr Luedtke. The overall vision is a novel driver-automation interaction and cooperation concept to ensure that automated driving systems will reach their full potential and can be commercially exploited. "This concept is based on viewing and designing automation as the driver's transparent and cooperative companion or teammate," he explains.

Project partners are devising a TeamMate car concept to enhance safety by capitalising on the strengths of both automation and human drivers. To do so, they're performing research and developing innovations for seven technical enablers that range from a sensor and communication platform to online risk assessment. They are also building three demonstrators to test the safety, efficiency and effectiveness of the TeamMate car technologies under different driving scenarios. The corresponding innovations will be integrated into and implemented on several car simulators and real vehicles to evaluate and demonstrate progress and results in real-life traffic conditions.

Researchers developed a framework to provide a general understanding of how driver and automation will interact in the TeamMate car and the traffic and interaction situations to be tackled overall. They defined scenarios and use cases relevant to the car concept. These focus particularly on situations where drivers need the support of an automated teammate to achieve safe, efficient and comfortable driving, and where the automated teammate reaches its system limits and needs the driver's support. The scenarios and use cases also place emphasis on circumstances where control of the driving task or subtasks has to be shifted between driver and automation, and where the automated teammate learns from the driver.

Team members refined and defined new requirements and fully specified the TeamMate system architecture. These updated requirements will improve the software components and extend the scope of each component's functionality. They



AutoMate aspires to the creation of a complex automation system based on the advanced interaction between humans and cars.

implemented a first version of the TeamMate car demonstrators on driving simulators and proceeded with evaluation in relevant scenarios.

A demo for vehicle automation

With the baseline cars now ready, the team is preparing the demo vehicles that will assess the benefits of using AutoMate with respect to factors such as safety, acceptability and usability. "Our goal is to reuse these prototypes after the end of the project to equip highly automated driving systems with sophisticated human-machine cooperation capabilities," says Dr Luedtke.

"AutoMate aspires to the creation of a complex automation driving system based on the advanced interaction between humans and cars," he concludes. "We're not eliminating drivers, but rather changing their roles so that they can improve safety compared to traditional driverless approaches to vehicle automation." The team will also address potential barriers, legal, privacy and standardisation issues.

PROJECT

AutoMate - Automation as accepted and trustful teamMate to enhance traffic safety and efficiency

COORDINATED BY

OFFIS EV, Germany

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/690705

PROJECT WEBSITE

automate-project.eu/



Platoon driving inches a step closer

Grouping vehicles together in road trains or platoons can save fuel, reduce congestion and improve safety. Thanks to an EU-funded project, the technology is beginning to emerge from the drawing board to become reality.

Automated and connected vehicle technologies are gradually becoming more prominent in newer vehicles. There is no doubt that the digital connectivity between vehicles, and between vehicles and transport infrastructure will considerably influence mobility and urban living.

A promising possibility to enhance traffic efficiency is the formation of dynamic platoons as a group of cooperative automated vehicles at city level and more precisely on signalised junctions where the greatest effect is expected. Effective platoon management together with speed advice calculation based on signal phase and timing information will enable a platoon to pass a signalised intersection in the most efficient manner.

The EU-funded project MAVEN worked on several possible paths to make the technology a reality. It provided novel solutions for managing automated vehicles in urban environments with signalised intersections and mixed traffic. "Project work revolved around developing algorithms for organising the flow of infrastructure-assisted vehicles and structuring the negotiation processes between vehicles and the roadside infrastructure," explains lead researcher Robbin Blokpoel.

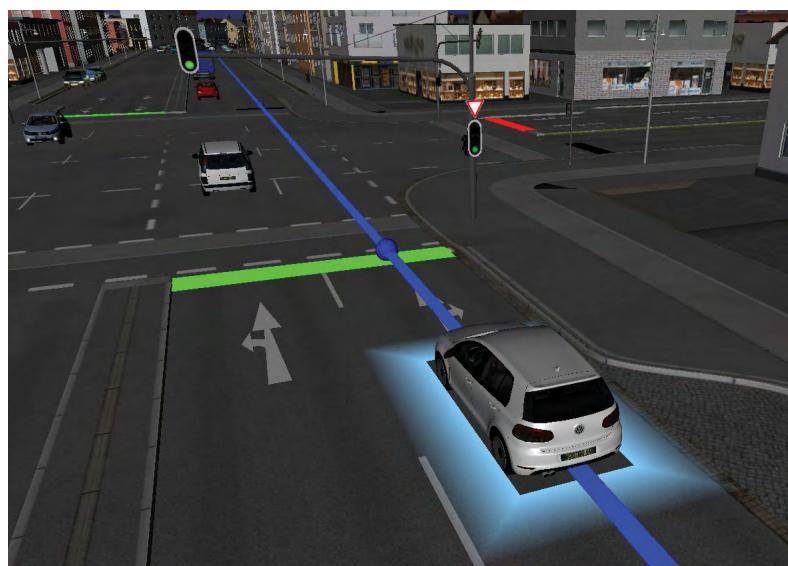


Finding the balance between being flexible for maximum traffic efficiency and predictable for services towards connected and automated vehicles such as Green Light Optimal Speed Advisory (GLOSA) service is vital – MAVEN found new algorithms to get the best of both worlds.

Innovative applications

The gradual introduction of automated vehicles into a mixed traffic stream needs careful management to achieve the necessary safety and efficiency levels. MAVEN researchers worked to extend existing communication standards to support the newly developed concepts for safety and efficiency.

An outstanding example of a cooperative intelligent transportation system is the green



© MAVEN

light optimal speed advisory (GLOSA) service. This is now combined with a bi-directional negotiation process to achieve mutually beneficial updates to the signal plan. Vehicles 'talk' to the traffic lights to indicate various trip details, which enhance the estimation of the queue length at intersections. Fusing of this data is an important yet rarely modelled or quantified phenomenon in mixed traffic streams and is critical to the GLOSA functionality to achieve high traffic control efficiency. As a result, more accurate GLOSA instructions including lane advice could be sent back to the vehicles.

Another major focus of MAVEN was on developing algorithms for smart and efficient traffic light control. "Finding the balance between being flexible for maximum traffic efficiency and predictable for services towards connected and automated vehicles such as GLOSA is vital – MAVEN found new algorithms to get the best of both worlds," explains Mr Blokpoel. In addition, the project team developed novel local level routing techniques

that help find optimal routes using short-term predictions based on local information exchanged between vehicles and infrastructure.

Protecting vulnerable road users and drivers of automated vehicles is a key objective of MAVEN. The project developed new functions for advanced driver-assistance systems that reduce the risk of collision with cyclists or obstacles and safely handle human-controlled vehicles trying to interfere with a platoon.

With the impact assessment of MAVEN currently on its way, researchers can already conclude that the combined innovative applications could eliminate stopping at intersections completely, resulting in a CO₂ reduction of 80 tonnes per year per intersection.

Enabling technologies

High-definition map data is a key feature for enabling highly automated driving. Researchers identified the need to represent road intersections as a ‘corridor’ – a pair of virtual boundary lines that connect lane markings of inbound lanes to markings of outbound lanes. This should prevent vehicles from invading conflicting zones when making turns at intersections.

Finally, MAVEN’s new roadmap for introducing vehicle-road automation should help road authorities further understand changes in their role and the tasks of traffic management systems.

PROJECT

MAVEN – Managing Automated Vehicles Enhances Network

COORDINATED BY

Deutsches Zentrum für Luft- und Raumfahrt Ev (DLR), Germany

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/690727

PROJECT WEBSITE

maven-its.eu/



Connected communications make their mark on heavy trucks

EU-funded researchers have developed intelligent transport systems technology (ITS) that allows trucks to wirelessly exchange information with infrastructure and other heavy-duty vehicles in their vicinity.

Safe, comfortable and greener driving is at the heart of the development of highly automated vehicles. Thanks to a multitude of systems and sensors, automated and connected technology warns drivers of imminent dangers, helps them avoid highly congested roads and provide traffic-sign information. What's more, it communicates safety-critical information to other vehicles such as their speed and heading and whether they are braking or accelerating.

Cooperative, connected and automated technology is highly valued both in cars and heavy trucks, yet the architecture differs due to the large size of the truck-trailer combination. In light of this, the EU-funded project [ROADART](#) successfully unveiled a new wireless communication platform for trucks that considerably increases drivers' safety and efficiency, while helping to reduce harmful emissions. ROADART worked on several possible paths to make truck-to-truck (T2T) and truck-to-infrastructure (T2I) systems a reality within a few years.

Multiple antennae, multiple gains

Researchers investigated various antenna array designs that can be easily integrated in the side mirrors of trucks or installed in infrastructure towers. "The antennae implemented in ROADART



ESPAR antenna design demonstrates low cost, reduced complexity and compact size, making them excellent candidates for T2T and T2I links.

platform are electronically switched parasitic arrays (ESPARs). Their design demonstrates low cost, reduced complexity and compact size, making them excellent candidates for T2T and T2I links," notes project coordinator Dr Christos Oikonomopoulos.

ESPAR antennae allow dynamic adaptation of their radiation pattern to increase the link quality. To further improve the reliability of a message, researchers used the antenna diversity technique coupled with a novel beam pattern selection scheme known as open-loop beamforming. "Another major advantage of ESPAR antennae is their ability to support

various digital communication techniques such as pattern diversity," adds Dr Oikonomopoulos.

Successful proof of concept

Improving the robustness of wireless communications with respect to data packet loss and latency increases the availability of communication applications. Reliable T2T communications are especially relevant for safety and time-critical cooperative driving applications. ROADART successfully demonstrated a use case involving cooperative adaptive cruise control (CACC) – a cooperative ITS function that allowed two trucks to drive close



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one behind the other. "Platooning allows for shorter inter-vehicle distances, which reduces fuel consumption and helps avoid 10 % of all accidents on motorways", notes Dr Oikonomopoulos.

Effective communications can also help truck platoons find the best possible route in situations where other communication modes may not be available such as in long-distance tunnels. ROADART's localisation engine is based on an extended Kalman filter that fuses data from various heterogeneous sources including the GPS, truck sensors, positioning information from cooperative vehicles and openly available map data. During demonstration of the two trucks driving for two kilometres in a tunnel, the accumulated localisation error did not exceed two metres.

Platform design

The newly developed ROADART platform handles the entire signal processing. It consists of a set of software-defined radio modules and two ESPARs mounted on the outer side of each side mirror, as well as a corresponding communication unit installed inside the truck cabin. The implemented software for the selected diversity techniques and the localisation algorithm are also executed in the communication unit.

Overall, use of diversity/multi-antenna techniques extended coverage and increased throughput by 50 %. High throughput combined with low data packet errors reduced latency by 900 % compared to conventional antennae systems. The architecture concepts developed so far by ROADART should cope with changing traffic levels and provide a solid foundation for continued research.

PROJECT

ROADART - Research On Alternative Diversity Aspects foR Trucks

COORDINATED BY

IMST GmbH, Germany

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/636565

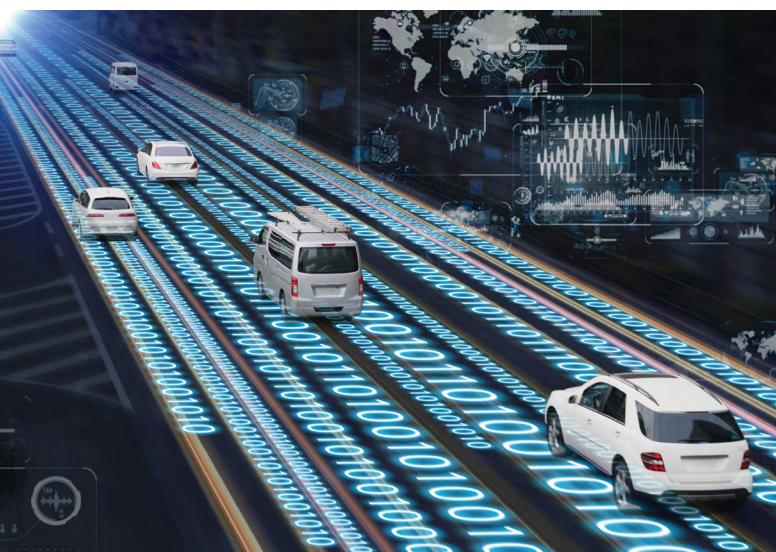
PROJECT WEBSITE

roadart.eu/



Connected and automated vehicles could end road congestion

Can highly automated vehicles fare better than traditional cars in traffic gridlock conditions? Cooperation between vehicle intelligent transport systems via connected vehicles may provide a solution.



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Drivers' and passengers' safety and convenience is at the heart of the development of highly automated vehicles. Yet, despite conjuring up the image of free-flowing city streets, automated vehicles will not mean the end of congestion unless proper traffic management concepts are applied.

Spurred by the potential of emerging intelligent vehicle automation and communication systems (VACS), the [TRAMAN21](#) project, which was funded by EU's European Research Council, worked on new traffic management methods and tools suitable for the era of connected transport. The idea is to ensure that traffic flows as smoothly and efficiently as possible, potentially avoiding the jams and delays caused by human behaviour.

New models spanning both micro and macro scales

Traffic flow modelling based on VACS is key to the design and testing of efficient traffic management approaches. Vehicle trajectories, time and distance headways are the most important microscopic traffic flow characteristics. Researchers argue that managing individual vehicle behaviour can influence the macroscopic traffic flow characteristics – intensity, density and speed. "Adjusting properly microscopic vehicle movements provides a means to improve the overall traffic flow of city roads," notes Professor Markos Papageorgiou, head of the Dynamic Systems & Simulation Laboratory at the Technical University of Crete, Greece.

Building on Aimsun Next traffic modelling software, researchers tested the impact of selected onboard cooperative technologies on the vehicle microscopic behaviour. The simulator conducted traffic operation assessments on a large network scale. In addition, they developed advanced first and second-order macroscopic traffic flow models and novel numerical approaches for approximating them. The methodologies were extended to handle multi-lane highways and mixed traffic.

Not only automated, but also cooperative

Traditional stationary sensors collect traffic data of vehicles passing the location in which they are installed on the highway. "Connected and automated vehicles represent a new traffic data



Mobile data collected by the distributed mobile sensors from vehicles equipped with intelligent technology will not only measure traffic information but also communicate it in real time.

source that will be more common in the near future. Mobile data collected by the distributed mobile sensors from vehicles equipped with intelligent technology will not only measure traffic information but also communicate it in real time," says Prof. Papageorgiou. TRAMAN21 developed reliable and robust traffic flow estimation methods that outperform the state of the art in terms of accuracy and simplicity.

An innovative traffic control concept that was developed and tested in TRAMAN21 was cooperative merging. The system assists drivers in lane-changing manoeuvres in areas where lanes end or merge by creating and maintaining an appropriate time or space gap in traffic for the merging car.

Researchers also looked at how adaptive cruise control can improve traffic flows. The technology adjusts time gaps between cars to cut congestion and reduce phantom traffic jams.

Combining conventional highway control systems

Today's motorway traffic control practice applies control measures independently of each other, and, for some of them, there is no evidence that they have any positive contribution

to congestion mitigation. "Field implementation of novel control strategies that employ ramp metering and variable speed limits in an integrated way can lead to significantly improved travel times, fuel consumption, environmental pollution and traffic safety," notes Prof. Papageorgiou.

TRAMAN21 has been running tests on a highway near Melbourne, Australia, and is currently using variable speed limits and ramp metering to actively intervene in traffic to improve flows. Researchers expect that tests will prove successful in offering a smoother and more efficient journey for motorists.

PROJECT

TRAMAN21 - Traffic Management for the 21st Century

COORDINATED BY

Technical University of Crete, Greece

FUNDED UNDER

FP7

CORDIS FACTSHEET

cordis.europa.eu/project/id/321132

PROJECT WEBSITE

traman21.tuc.gr/



Automotive technology and personalised models to reduce road accidents

Human error is estimated to play a role in 94 per cent of accidents, making failures or mistakes by drivers a major public safety concern. Intelligent systems that can monitor the driver's state and behaviour show promise in contributing to citizens' collective safety.

By incorporating the latest advances in sensors, data fusion, machine learning and user feedback, the capability to better understand the driver's state and the driving context has improved. This represents a major step towards truly semi-automated and automated vehicles. However, there's still a long way to go as vehicle automation needs to support and eventually replace the need for a driver.

Technology and models to boost situational awareness

To tackle this issue, the EU-funded [VI-DAS](#) initiative will develop enhanced driving scene models that include driver behaviour, a



significant milestone that the automotive industry hasn't achieved yet. It will also develop the technology required to analyse the driver's state to considerably improve safety and efficiency.

VI-DAS is designing next-generation 720° connected advanced driver assistance systems (ADAS) on scene analysis and driver status. "The project is addressing the goals of improved road safety by developing and deploying ADAS and navigation aids in a societally acceptable and personalised manner," says project coordinator Dr Oihana Otaegui. "This will be based on both the global understanding of a traffic scene and consideration of the driver's physical, mental, demographic and behavioural state."

So far, the focus has mainly been on completing the development and integration of the alpha and beta VI-DAS prototypes. Work began by defining specifications in line with driver needs, requirements and system architecture. Then, the research and technological development activities began for the main interrelated modules of the VI-DAS system that provide a comprehensive analysis of the driver's situational context: Sense (outside, inside); Understand, Decide and Check; Connect and Cooperate; Assist and Act; and Risk.

After defining the modules, the project team defined the testing and validation methodology and integrated the first prototype. The outputs of this prototype served as inputs for the second prototype, which consisted of an integrated feature-ready system deployed on a simulation environment and a vehicle for conducting test activities.

Smoothing the path towards fully automated vehicles

Project partners are currently developing the third and final prototype. Dr Otaegui further explains: "We're addressing a set of real challenges for the automotive industry, including

reliably assessing the driver's condition, evaluating danger after gathering information about surroundings at any given time and adapting behaviour accordingly, adapting legislation to fully automated transport, as well as standardising an approach to risk assessment in the insurance sector."

The prototype will be showcased during the [European ITS Congress](#) in June 2019 in the Netherlands. This Congress is one of the largest events dedicated to intelligent transportation systems and smart mobility in general. "VI-DAS is positioned to accelerate the development and inclusion of ADAS and navigation aids in vehicles, while considering the driver's mental state and behaviour when responding to everyday traffic conditions," concludes Dr Otaegui.



VI-DAS is positioned to accelerate the development and inclusion of ADAS and navigation aids in vehicles, while considering the driver's mental state and behaviour when responding to everyday traffic conditions.

PROJECT

VI-DAS - Vision Inspired Driver Assistance Systems

COORDINATED BY

Vicomtech, Spain

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/690772

PROJECT WEBSITE

vi-das.eu/



5G to unlock the potential of automated driving

Robust and ubiquitous wireless networks with extensive coverage, high data transfer speeds and low latency are key to safe automated driving. EU-funded researchers developed forward-looking concepts of optimised end-to-end vehicle-to-everything (V2X) networks based on next-generation 5G technology.

V2X-supported automated driving will dramatically improve safety and driving comfort. By sharing data with surrounding vehicles and infrastructure, V2X systems can raise driver awareness about upcoming potential dangers and dramatically improve collision avoidance. V2X refers in particular to the car's communication system, where information from sensors and other sources travels through high-bandwidth, low-latency and high-reliability links.

Led by Ericsson, the EU-funded project [5GCAR](#) demonstrated and validated concepts of building a V2X network that uses 5G in novel ways. Work has mainly revolved around developing novel components for radio interface and network architecture designs to meet the unprecedented stringent V2X requirements for the automotive industry.

Innovations on the radio interface level

"Offering latency-sensitive services requiring extremely high reliability, availability and security across a wide coverage area comes at the expense of providing high data rates," notes project coordinator Dr Mikael Fallgren. To address this challenge, the project proposed several advanced infrastructure, sidelink and positioning technology components.

Researchers proposed use of both centimetre and millimetre-wave (mmWave) frequency bands as candidate spectrums for achieving the high mobile data rate targets. Amongst the key related technologies studied were realistic multi-antenna schemes, mmWave broadcast and beamforming schemes, high-mobility channel tracking, diversity techniques, resource allocation and management, and interference control techniques. Dynamic multiplexing of different traffic types and radio frame design were also investigated.

The proposed concepts related to 5GCAR's sidelink-based V2X technology included a network-assisted discovery mechanism, reference signal and synchronisation signal design, adjacent channel interference mitigation, radio-resource management, and power control and scheduling mechanisms. Undoubtedly, 5GCAR's sidelink proposed components can complement cellular communications to enhance V2X service reliability.



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A combination of sophisticated tracking algorithms like the particle filter and radio-based positioning are key to improving positioning accuracy. 5GCAR investigated a positioning algorithm for the case involving a single base station and antenna arrays both at the base station and the terminal. Possible extensions of the positioning protocol for future standardisation were also studied.

Innovations on network architecture level

5GCAR proposed advanced network architecture concepts and support V2X services and applications.



Our technical solutions target very low latencies below 5 milliseconds, very high reliability (99.999 %) and vehicle positioning accuracy of below a metre.

Enhancements covered a broad range of fields including network orchestration and management, network security, multi-connectivity cooperation and edge computing. The definition of flexible and reconfigurable road-side units and the related concept of smart zones is a representative example.

New procedures were proposed to increase network awareness. Related technologies enable V2X services to inform the network about the service's area of reference, vehicle trajectory, amount of data to be transmitted, expected service duration and more. Such information should be either used to optimise service delivery on the network side or inform the service about the network's capability to fulfil the service.

The project has also highlighted the use of multiple links (both direct vehicle-to-vehicle and vehicle-to-network) and multiple radio-access technologies – sub-6 GHz and mmWaves – of paramount importance to improve reliability and data rates. Other architectural solutions to support the deployment of use cases in multi-operator scenarios were also provided.

Overall, 5GCAR proposed radio interface and network architecture solutions leveraging 5G tailored to the needs of the automotive industry. "Our technical solutions target very low latencies below 5 milliseconds, very high reliability (99.999 %) and vehicle positioning accuracy of below a metre," added Fallgren.

PROJECT

5GCAR - Fifth Generation Communication Automotive Research and innovation

COORDINATED BY

Ericsson AB, Sweden

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/761510

PROJECT WEBSITE

5gcar.eu/



Foundation for a European roadmap on Automated Road Transport

Automated road transport (ART) could help Europe resolve several societal challenges with green transport and mobility, including road safety, decarbonisation and smart cities. Effective coordination and harmonisation could accelerate the implementation of connected and automated driving (CAD) in Europe.

The ART community faces important challenges and gaps, requiring a uniform approach to R&D, testing and deployment. Furthermore, effective integration and coordination with policy-making is required to prevent fragmented rules and procedures.

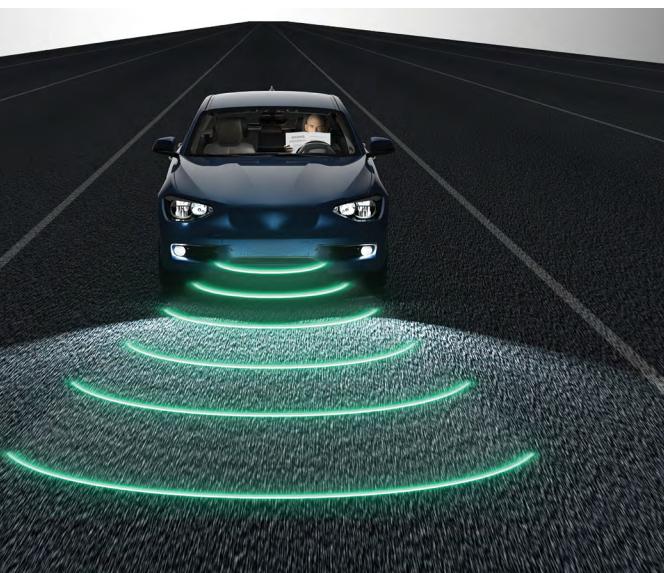
The EU-funded [CARTRE](#) project sought to accelerate ART development and deployment by increasing market and policy certainties. “It supported the development of clearer, more consistent policies in EU Member States to ensure that ART systems and services are interoperable and implemented in a coherent way across Europe,” says coordinator Dr Stéphane Dreher.

Stakeholder Forum for the advancement of ART

CARTRE gathered key public and private stakeholders from the automotive, infrastructure, ICT and service provision sectors involved in CAD. “They exchanged experiences and knowledge about past and ongoing project results at national, European and international levels to avoid replication and built consensus for harmonised CAD deployment in Europe,” he adds.

Project partners defined deployment paths and identified challenges, drivers, influencing factors, and future research needs for CAD across Europe in [10 thematic areas](#). These include policy and regulation needs, safety validation and road worthiness testing, digital and physical infrastructure, and in-vehicle technology. Additional thematic areas concerned socioeconomic assessment and sustainability, plus user and societal awareness and acceptance. The consortium produced position papers in all 10 areas, which reflect the collective position of contributing stakeholders. The papers were used to update the [ERTRAC Roadmap](#) on Automated Driving and the Strategic Transport Research and Innovation Agenda on Connected and Automated Transport in 2017 and 2018, respectively.

CARTRE team members delivered a global overview and analysis that includes roadmaps, action plans, pilots and test sites from EU Member States. The result is a synopsis of topics that need



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to be further examined in a more harmonised and precise way to support authorities and cities in developing future roadmaps and action plans.

Coordinating and harmonising European and global ART approaches

Several meetings between the European Commission, the United States and Japan supported information exchange, and identified needs for collaboration on common issues. Two high-profile events promoted European research in ART. CARTRE was responsible for co-organising the first [European conference on CAD](#) and an [interactive symposium](#).



It supported the development of clearer, more consistent policies in EU Member States to ensure that ART systems and services are interoperable and implemented in a coherent way across Europe.

The ARCADE project is building on the successful outcomes of CARTRE. It will leverage the CAD stakeholder community and provide a forum to exchange lessons learnt and best practices. ARCADE aims to extend international cooperation with other countries identified as taking on a leading role in ART development, while contributing to the ongoing trilateral EU-US-Japan cooperation efforts. It will further develop the existing knowledge base on the state of the art in European R&D vehicle automation activities and build up synergies and shared views on deployment scenarios and research needs for CAD.

ARCADE is co-organiser of the [2nd European Conference on CAD](#) to be held in Brussels in April. Participants will include political leaders from the Commission and Member States with high-level representatives from industry and road authorities to discuss all the major challenges related to automated mobility.

PROJECT

**ARCADE – Aligning Research & Innovation for Connected and Automated Driving in Europe;
CARTRE – Coordination of Automated Road Transport Deployment for Europe**

COORDINATED BY

European Road Transport Telematics Implementation Coordination Organisation - Intelligent Transport Systems & Services Europe (ERTICO), Belgium

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