Course Syllabus

Topic Study 2: ITS and C-ITS user services

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This course syllabus is part of the CAPITAL e-learning platform, a project funded by the European Union to design and deliver a collaborative capacity-building programme, including training and further education, for public and private sector practitioners in the field of (cooperative) intelligent transport systems (C-ITS & ITS).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 724106.

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This document was last updated on June 5th, 2018.
### Abbreviations and Acronyms

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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>ABS</td>
<td>Anti-lock Braking System</td>
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<td>ACC</td>
<td>Adaptable Cruise Control</td>
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<td>ADAS</td>
<td>Advanced Driver Assistance System</td>
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<td>AEB</td>
<td>Automatic Emergency Braking</td>
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<td>ATIS</td>
<td>Advanced Traveller Information System</td>
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<td>BLIS</td>
<td>Blind Spot Information System</td>
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<tr>
<td>CACC</td>
<td>Cooperative Adaptable Cruise Control</td>
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<td>CCC</td>
<td>Conventional Cruise Control</td>
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<td>CEN</td>
<td>European Committee for Standardisation</td>
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<td>C-ITS</td>
<td>Cooperative Intelligent Transport System</td>
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<td>CPC</td>
<td>Certificate of Professional Competence</td>
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<td>DENM</td>
<td>Decentralised Environmental Notification Message</td>
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<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communication</td>
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<td>DTM</td>
<td>Dynamic Traffic Management</td>
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<td>EBA</td>
<td>Emergency Brake Assist</td>
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<td>EC</td>
<td>European Commission</td>
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<td>eCMR</td>
<td>Electronic Consignment Note</td>
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<td>ECU</td>
<td>Electronic Control Unit</td>
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<td>EP</td>
<td>European Parliament</td>
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<td>ESS</td>
<td>Emergency Stop Signal</td>
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<td>EVA</td>
<td>Emergency Vehicle Alert</td>
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<td>FCD</td>
<td>Float Car Data</td>
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<td>I2V</td>
<td>Infrastructure-to-Vehicle</td>
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<td>iTLC</td>
<td>Intelligent Traffic Light Controller</td>
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<td>ISA</td>
<td>Intelligent Sped Assistance</td>
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<td>IVI</td>
<td>In-Vehicle Information</td>
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<td>IVS</td>
<td>In-Vehicle Signage</td>
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<tr>
<td>GA</td>
<td>Grant Agreement</td>
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<td>GLOSA</td>
<td>Green Light Optimal Speed Advisory</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>HGV</td>
<td>Heavy Goods Vehicle</td>
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<td>LCV</td>
<td>Light Commercial Vehicle</td>
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<td>LDW</td>
<td>Lane Departure Warning</td>
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<td>LIDAR</td>
<td>Light Detection and Ranging</td>
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<td>LGS</td>
<td>Lane Guard System</td>
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<td>MSD</td>
<td>Minimum Set of Data</td>
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<td>NST</td>
<td>Non-stop Truck</td>
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<td>OBU</td>
<td>On-board Unit</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>PKI</td>
<td>Public Key Infrastructure</td>
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<td>PO</td>
<td>Project Officer</td>
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<td>PSAP</td>
<td>Public Answering Points</td>
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<td>PVD</td>
<td>Probe Vehicle Data</td>
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<td>RDS</td>
<td>Radio Data System</td>
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<td>RHS</td>
<td>Road Hazard Signalling</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>RLVW</td>
<td>Red Light Violation Warning</td>
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<td>RSU</td>
<td>Roadside Unit</td>
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<td>RTTI</td>
<td>Real-Time Travel and Traffic Information</td>
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<td>RWW</td>
<td>Road Work Warning</td>
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<td>SAS</td>
<td>Speed Alert System</td>
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<tr>
<td>SPAT</td>
<td>Signal Phase and Timing</td>
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<td>SPATEM</td>
<td>Signal Phase and Timing Extended Message</td>
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<td>TMC</td>
<td>Traffic Message Channel</td>
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<td>URI</td>
<td>Uniform Resource Identifier</td>
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<tr>
<td>V2V</td>
<td>Vehicle-to-vehicle</td>
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<tr>
<td>V2X</td>
<td>Vehicle-to-Everything</td>
</tr>
<tr>
<td>V-ITS-S</td>
<td>In-vehicle ITS Station</td>
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<tr>
<td>VMS</td>
<td>Variable Message Signs</td>
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<td>VRU</td>
<td>Vulnerable Road Users</td>
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<td>VSL</td>
<td>Variable Speed Limit</td>
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<td>WAVE</td>
<td>Wireless Access in Vehicular Environments</td>
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<td>WLAN</td>
<td>Wireless Local Area Network</td>
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<td>WP</td>
<td>Work Package</td>
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1. Introduction

This study looks at user services in Cooperative Intelligent Transport Systems (C-ITS) both for professional and non-professional drivers. C-ITS have quickly developed from a futuristic concept compared to mainstream ITS to widely adopted services supporting drivers in many different functions, from finding a parking spot to receiving in-vehicle warnings of adverse weather conditions ahead.

In many ways C-ITS are a next step on from by now conventional ITS, and from Advanced Driver Assistance Systems (ADAS), rather than brand new concepts. For instance, assisted braking systems have been standard in vehicles for a number of years, and C-ITS which use information about upcoming hazards to pre-charge or even apply brakes should be considered as a development of ABS rather than a new application.

Properly implemented C-ITS works together with existing on-road ITS and builds on existing in-vehicle support and advisory systems. An extensive review on communication technologies for ITS and C-ITS is found in Topic study 2: Communication technologies for ITS and C-ITS including relevant standards.

For this reason, in order to properly consider C-ITS, the student needs to have a good understanding of ITS as currently in use in all aspects of traffic management, safety, routeing and parking applications. He or she also needs to be familiar with the common ADAS now in use. Imparting this shallow but broad knowledge is not in the scope of this topic study, which assumes that the reader will have a high level familiarity at least with these areas.

2. Scope and objectives

The objectives of the study are to leave the reader with up-to-date information about all the C-ITS services currently available to drivers, whether professional drivers or those who use cars purely for personal transport. Many of the systems are applicable to both types of driver, and the study makes it clear where the demarcations lie. It also spells out the benefits of the C-ITS to the different categories of driver, to fleet operators and to road operators. This sketching of use cases gives some good clues to potential business cases, which are without the scope of this particular module but are covered elsewhere in the course. As with many ITS, the financial benefit does not necessarily accrue to the person or organisation which funded the service. Subscribing to services which enable HGV drivers to find safe and secure parking facilities will ultimately save money for the haulage operator, but services which reduce crashes due to poor road surface conditions save money for health services, the emergency services, insurers and individual drivers to a far greater extent than for the road operator who invested in the service. Understanding the different services enables a more informed approach to thinking about business cases, and is one of the contributions of this study.
At the same time as listing the C-ITS services for professional and non-professional drivers, the study in current or imminent use, the study also contains references to real life examples of implementations with references, so that the reader can seek detailed information about any particular service from those who have actually implemented or used it.

The study also looks at user acceptance of C-ITS services for non-professional drivers. Closely connected to the much more widely discussed topic of user acceptance of autonomous vehicles, this field of enquiry is both interesting and important. Professional drivers can to a large extent be compelled by their employers to use C-ITS (trade union activity and privacy legislation being the only possible barriers to this) but private car owners will only engage with C-ITS if they see a benefit to themselves, believe that there are no risks to themselves via privacy infringements or the detection of illegal activity such as speeding or red light running, and find the service affordable. The authors believe that the benefits in safety, comfort, reliable and predictable journeys outweigh the risks of surveillance inherent in C-ITS. A parallel might be the use of mobile phones, which constantly pin points the whereabouts of the user but appears to cause no fears about surveillance. The convenience and enjoyment the phones bring seem to stop users thinking about how their providers know their whereabouts in detail, all of the time.

However, other views on the non-professionals’ user acceptance of C-ITS can also be substantiated and it is hoped that this section of the module will engender thought and discussion in this area.

Finally, the study takes a look at how to communicate ITS to the public. This is of course connected to the issue of user acceptance, and it is fair to say that public understanding of ITS is generally low. While most people have some understanding of how clean water is made to come out of their taps, or how the engine of their car works, they have no idea of why traffic lights change colour when they do or how the correct fare is deducted from their smart card bus ticket. There is perhaps a general failure of all areas of IT to explain to lay people how their technology works – just as people do not understand traffic management technology, they generally do not understand how their emails or web browsing works, either. If we agree, as we hopefully do, that a better understanding of ITS would be a good thing, then the relevant section of this study looks at whose responsibility that might be and how it might be accomplished.

3. Methods

Information for this study was collected from a wide range of sources available to the FIA and ITS (UK), particularly published papers and project dissemination materials. With much C-ITS work having been undertaken in the form of publicly funded projects, research and implementations, the existing C-ITS are well documented in a fairly accessible way.

The information has been organised into a comprehensive list of C-ITS as currently available, plus some more analytical sections covering attitudes, different roles, and
thoughts on what the future might hold and what we might wish to do now in order to shape this in the way we would like it to develop.

4. ITS and C-ITS services for professional drivers

Before starting a discussion on various ITS and C-ITS services for professional and non-professional drivers, first of all, it is necessary to explain the terminology used in this chapter, namely, who are the ‘professional’ and ‘non-professional’ or ‘normal drivers.’ A brief summary of the ITS and C-ITS terminology is going to be presented in this chapter. In the next step, some ITC and C-ITS services designed for professional drivers will be presented more in detail.

4.1. Definition of professional and non-professional drivers

There is not a clear definition that can define both professional and non-professional drivers. A very simple explanation of a ‘professional driver’ is someone who is paid for driving a vehicle. It includes chauffeurs, taxi, bus, truck, and test drivers, etc.

The Directive 2003/59/EC of the European Parliament and the Council (15 July 2003)\(^1\) says that “certain drivers engaged in the carriage of goods or passengers by road must, depending on their age, on the category of vehicle used and on the distance to be travelled, hold a certificate of professional competence in conformity with Community rules on the minimum level of training for some road transport drivers. That minimum level is determined by Directive 76/914/EEC.” Then in §7 it is said “In order to establish that the driver complies with his or her obligations, Member States should issue the driver with a certificate of professional competence, hereinafter referred to as ‘CPC’ (Certificate of Professional Competence),\(^2\) certifying his or her initial qualification or periodic training.” Therefore, a professional driver needs to have a CPC and a valid driving license for the category of driven vehicle.

4.2. Definition of ITS and C-ITS services

Before starting the discussion about ITS and C-ITS services, it is important to mention Advanced driver-assistance systems (ADAS). They are the systems that help the driver during the driving process. ADAS are the system designed to automate, adapt and enhance vehicle systems for safety and better driving. The developed systems proved to reduce road

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2. Driver CPC is a Certificate of Professional Competence issued to drivers who are entitled to hold one. It was first introduced across the EU in 2008 for professional bus drivers and 2009 for professional truck drivers. Its objective was to set and maintain high standards of road safety, health and safety and driving among professional drivers of buses and trucks. Therefore, in order to drive a bus or truck, it is required that a driver holds a current valid driving license for the category of driven vehicle, and a current valid driver’s CPC card for the category of driven vehicle. Both documents need to be carried while driving a vehicle.
fatalities, by decreasing the human error. Safety features of ADAS designed to avoid accidents by providing technologies that alert driver about the potential problems, or avoid collisions by engaging safeguards and taking over control over vehicle. Adaptable features of ADAS may automate lighting, provide adaptable cruise control, connect to smartphones, alert the driver about the danger, lane departure or show what is in blind spot. ITS and the C-ITS make the part of ADAS.

There is no homogeneous definition that can explain ITS and C-ITS. The reason for it is that ITS have a very fast exponential development and highly cross-cutting and interdisciplinary nature.

The term ‘ITS’ stands for the ‘Intelligent Transport Systems’ or ‘Intelligent Transportation Systems.’ In a wider sense, ITS mean a system related to mobility that enhances the development through information technology (IT).

ITS apply advanced technologies of electronics, communications, computers, control and sensing and detecting in all kinds of transportation system in order to improve the management of the transport system, increase safety, efficiency and service, and traffic situation through transmitting real-time information. It can help to tackle congestion, pollution, poor accessibility and even social exclusion.

According to the EC “ITS are advanced applications which – without embodying intelligence as such – aim to provide innovative services relating to different modes of transport and transport management and enables various users to be better informed and make safer, more coordinated and ‘smarter’ use of transport networks” (European Commission, 2010b).

The ‘C-ITS’ term stands for the ‘Cooperative Intelligent Transport Systems.’ C-ITS focus on the communication or exchange of data between intelligent transport systems, whether it is a vehicle communicating with another vehicle, with the infrastructure, or with other C-ITS systems.

The NEWBITS project defines ITS and C-ITS, as following: “C-ITS are considered a subset of the overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone system.” It also considers the main function of ITS as increased efficiency in the transport system, with special focus on the service and information provision for the full spectrum of users (drivers, passengers vehicle owners, network operators…) which involves a diversity of stakeholders (network operators, public authorities, OEMs, service providers, technology developers…). With C-ITS communication is happening between vehicles (vehicle to vehicle, V2V), between vehicles and infrastructure (vehicle to infrastructure, V2I; infrastructure to vehicle I2V) and/or between vehicles and other transport participants (V2X), for instance pedestrians or cyclists.

3 https://cordis.europa.eu/project/rcn/205765_en.html
Figure 1. Intelligent Transport Systems

Figure 1 shows how various C-ITS (safety systems, warning systems, travel assistance, traffic signals, navigations, fleet management etc.) communicate and interact between themselves by using different communication networks, such as MAN, Mobile, WLAN, ITS-G5, and satellite to exchange the information and data. It is essential to understand that ITS as well as C-ITS are not limited to only one mode of transport, i.e. road, but they also include other modes of transport such as rail, aviation and waterways and communication between them. Because of numerous benefits and relatively moderate costs related to deployment of C-ITS, there is a big interest and need in society towards a fast introduction of these services.

All ITS and C-ITS services will be divided into two groups, i.e. the services that are designed only for the professional drivers and services that are intended for non-professional drivers. The last categories of the services can be used also by both categories. Therefore, in the next chapters we will try to present the existing ITS and C-ITS services aimed for professional drivers as well as their cooperation with the public authorities. Then the focus will be on the ITS and C-ITS services for normal or non-professional drivers and their cooperation with the public authorities.

5. ITS and C-ITS services for professional drivers

There are a number of ITS and C-ITS services that were created for professional drivers. However, in this chapter only some ITS and C-ITS services are going to be briefly presented. Many of these services are designed to be used by only professional drivers, or by both professional and non-professional drivers.

The chapter consists of two parts, i.e. the first part discusses some ITC services and the second one will focus on the C-ITS services. The main purpose of this chapter is to briefly present these services, explain how they function and what their benefits are for professional drivers. The covered services are supported by some examples.

5.1. ITS services for professional drivers

The selected ITS services are:

- Speed alert system
- Dynamic navigation system
- Eco-driving assistance
- Adaptable headlights
- Blind spot information system
- Lane departure warning
- Obstacle and collision warning
- Emergency braking

5.1.1. Speed alert system

Speed alert system (SAS) or intelligent speed assistance (ISA) helps drivers to keep their speeds within the recommended limits\(^5\) and warns a driver when the local valid speed limit is exceeded. The system uses audio, visual or haptic feedback.

The information regarding speed limit is received from transponders in speed limit signs or from a digital road map that reads positioning information, or is determined by software which analyses images from a camera and recognises traffic signs. Other systems also can use GPS information from satellites to monitor the actual speed of a vehicle and give alarms to a driver. The modern systems combine information from both sources, namely a camera and digital speed map/GPS.

This service can be used by both professional and non-professional drivers.

5.1.2. Dynamic navigation systems

Navigation systems guide a driver to the destination according to the objective function, which optimises travel time or travel distance, whereas a dynamic navigation system also takes into account dynamic traffic information, by using a real time traffic event and transport network status data to carry out a correct routing process in electronic navigation systems.

The system uses a positioning system to estimate a vehicle’s location and certain algorithms to calculate the best route to the destination. The estimation is based on information stored in a digital map. The dynamic navigation system helps drivers to avoid parts of roads with accidents, or roadworks, or congestions, etc. The Traffic Message Channel (TMC) is used to send the basis traffic information by means of Road Data System (RDS) radio communications. In dynamic navigation system more improved sourced content is utilised to improve the standard TMC services. The system informs a driver about the obstacle on a route and provides information regarding alternative routes. These services are provided via cellular networks.

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6 https://apkpure.com/sPEED-alarm/com.sq2soft.speedalarm
8 http://www.esafety-effects-database.org/applications_17.html
5.1.3. Eco-driving assistance

Eco-driving assistance provides information to a driver regarding the actual fuel and energy consumption in a vehicle. It also suggests gear selection, taking into account engine and transmission efficiency, vehicle speed, rate of acceleration etc. The information on instantaneous fuel consumption is displayed on the instrument panel. There also can be an Eco Drive Indicator, which informs the driver when a vehicle operates in a fuel-efficient manner. Eco-driving\(^9\) also indicates when a gearshift\(^{10}\) needs to be done.

One example of eco-driving assistance is Mitsubishi-Motors ECO indicator\(^{11}\), or, as it also called, instrument cluster to support eco-driving. ECO drive support has several indicators:


ECO indicator (ECO lamp), which is displayed when fuel efficiency is achieved:

Fuel consumption gauge, which shows fuel consumption and average fuel consumption:

AUTO STOP & GO (AS&G) monitor, which shows the accumulated time the engine has been stopped by AS&G system:
ECO drive assist, which displays how fuel-efficiently a vehicle is driven:

ECO score indicates the points a driver scored by driving fuel-efficiently:

5.1.4. Adaptable headlights

Adaptable headlights are an active safety feature designed to make driving at night safer by increasing visibility over hills and around curves. The system consists of electro-mechanically controlled headlights. The system aims to have optimal illumination of the lane in curves of a road.

The system is activated when a vehicle starts cornering. At that moment, headlight is directed into the bend according to steering input so that the vehicle’s actual path is lit up. Similarly, when a vehicle approaches a hill, the headlights beams are pointed down or up, according to the position of the vehicle. The system also ensures reduction of glare to the upcoming vehicle. The system uses yaw-rate and steering wheel angle as well as vehicle speed as input data to adapt headlights.
Adaptable headlight system consists of several sub-components that are monitored and controlled by an electronic control unit (ECU). There are four main sensors:

- Wheel speed sensor that monitors speed or rotation of each wheel;
- A yaw sensor that tracks a vehicle’s side-to-side movement;
- A steering input sensor that monitors the angle of the steering wheel;
- Small motors attached to each headlight.

The data is collected from all sensors and interpreted by ECU, which determines the vehicle’s speed and the angle and length of the curve. The ECU also controls each motor attached to headlights to move the beam to the degree specified by the ECU. In most cases, the headlight degree is up to 15 per side. The system also includes self-leveling. A leaving sensor sends information to the ECU about the vehicle’s position, whether it is tilted forward or backward. The headlights are then moved up or down to correct the vehicle’s position.

5.1.5. Blind spot information system

Blind spots are the areas outside a vehicle that a driver is unable to see. They can be caused by the window pillars, headrests, passengers and other objects. These areas are quite small close to the vehicle, but cover larger areas further away. Another type of blind spot is a driver’s peripheral vision and the area reflected by the rear-view mirrors.

Blind spot information system (BLIS)\(^\text{13}\) aims to either provide better vision into blind spot area or provide information to a driver about an obstacle that is located in this area by informing the driver using warning signals. Using cameras with image processing or radar sensors can provide additional information to a driver about the situation on both sides of the vehicle blind spots.

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\(^{12}\) [http://brainonboard.ca/safety_features/driver_assistance_technology_adaptive_headlights.php](http://brainonboard.ca/safety_features/driver_assistance_technology_adaptive_headlights.php)

The main benefit of the blind spot warning system is to prevent lateral accident between a vehicle leaving its own lane and an obstacle (other vehicle) moving on a road in the same direction.

**5.1.6. Lane departure warning**

Lane departure warning (LDW) system was designed to warn a driver of a vehicle about the unintentional leaving of the lane and take corrective action if required. The most used technology is video image processing that detects lane marking on a road surface. The warning provided by the system can be either acoustic, or visual, or haptic, or combination of several types of warning.

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The forward viewing camera located on a vehicle sends the image of marking on the road to a central computer. By identifying reflective lane markings, an indication of vehicle lane position is established. The information from the steering wheel angle is combined with information received from a camera. The system determines whether the driver is unintentionally leaving the intended driving path. Then a warning is issued. The system can also attempt to correct the situation by nudging the steering wheel in a direction to maintain lane position.

5.1.7. Obstacle and collision warning

The obstacle and collision warning system provides an alert to a driver of a vehicle when collision is imminent. This service is a part of Adaptable Cruise Control (ACC) systems that use information received from radar sensors/radar or camera that are attached to the front of the vehicle monitor both distance and relative speed to the object in the forward travel path. The system sends visual and acoustic warnings to a driver. Some devices use a graduate warning system, employing a range of audible, visual or tactile responses, which can vary according to proximity and likelihood of a collision. It is possible that future systems will likely use long range / near range radar sensors or LIDAR and video image processing.

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17 Ibid.
18 LIDAR is a surveying method that measure distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor. Differences in laser light return and wavelength is used to produce a 3D representation of the target. The system is used to produce
Sometimes collision warning systems with pre-charged brakes are bundled with automatic braking or emergency braking assist systems (refer as well to chapter 5.1.8). It can provide a driver with a substantial amount of braking power\(^\text{19}\) the moment he depresses the pedal. It can effectively reduce the severity of an accident. In some systems when a collision is forthcoming, it can engage the brakes rather than merely pre-charge them.

### 5.1.8. Emergency braking

Emergency braking system is based on long range / near range radar sensors or LIDAR and / or camera. The system is designed to provide support in situations with a high risk of collision on a road by deploying the braking systems of a vehicle to reduce the collision speed and the total crash energy. There are various levels of support available, namely enhancement of driver's braking if necessary, automatic activation of partial braking, and automatic activation of full braking. In some systems reversible measures of occupant protection is triggered.

Many modern cars have automatic emergency braking (AEB) systems. Different car companies use various methods which bundle AEB with other systems, such as ACC, radar, high-resolution maps and to control and navigate for some autonomous cars.


camera, ABS, etc. These systems controlled by on-board computer can react faster to avoid situations with a high risk of collision.

MAN, for instance, has introduced a new generation of advanced emergency braking system with sensors fusion, the emergency brake assist (EBA) and the emergency stop signal (ESS). The EBA and the new lane guard system (LGS) will become standard accessories in majority of MAN trucks, both MAN and NEOPLAN coaches and intercity buses.²¹

![Figure 8. EBS by MAN](image)

### 5.2. C-ITS services for professional drivers

There is a number of C-ITS services that have been designed for professional drivers. However, in this chapter we will focus only on some of them.

The selected C-ITS services are:

- Urban parking availability
- Signal violation warning
- Warning system for pedestrian
- Green priority
- Green Light Optimal Speed Advisory (GLOSA)
- In-vehicle signage (IVS)
- Emergency Brake Light
- Cooperative Adaptive Cruise Control
- Motorcycle approach indication
- Blind spot detection / warning (VRUs)
- Non-stop truck

5.2.1. Urban parking availability

C-ITS service that focuses on urban parking availability provides information about parking availability and guidance for drivers to make informed choices about available parking places. This service aims at a reduction of congestion, time loss, pollution, and stress caused by cruising for parking. It can be used by truck and coach drivers as well as any vehicle driver. It provides information on the availability of parking places and it indicates dimension and weight restrictions, which is valuable information for truck and coach drivers. This service gives information about pick-up and drop-off places where coaches and trucks can stop for a limited time.

The service works as follows: when a truck or coach leaves a parking lot, it sends a message via the C-ITS app (V2V). This information is transmitted to and received by other search for a parking place vehicle (V2V). Then the searching vehicle confirms that it is approaching and when it arrives at the destination, the leaving vehicle leaves its parking space. The information is communicated through the C-ITS app that is installed on the driver’s smartphone or on-board unit.

There are multiple benefits of this service, namely a truck or coach driver does not need to spend a lot of time on searching for a parking place, congestion is reduced, pollution in urban areas is cut, and there is higher occupancy of parking lots.

However, this C-ITS service has some limitations. The service will not work in the covered parking lots due to positioning problems.

One of the intelligent parking systems was created in partnership by Deutsche Telekom and Kiunsys and a pilot project was deployed in Piazza Carrara in Pisa, Italy. The system combines sensors on the floor of spaces, information signs across the city and smart street lighting. It helps drivers to find parking spots. The information is send from the infrastructure to vehicles (I2V).

The sensors on the floor of each parking spot detect whether they are free or occupied. The data is collected by several units and sent to the city’s server infrastructure, using the mobile network. The information is then sent to the drivers and guides them to a free parking lot. They can also choose whether they want to pay for a parking lot by using Pisa’s existing Tap&Park app, which is integrated with the new system.

5.2.2. Signal violation warning

Signal violation warning service aims to reduce the number and severity of accidents at signalised intersections by warning drivers who are likely to violate a red light, or when another vehicle is likely to make a red light violation. Also known as the “Signal violation / Intersection Safety” or “Red Light Violation Warning” (RLVW). This service provides timely assistance information on a red light violation downstream of the current position.

The drivers are informed about the current and future state of relevant traffic light. They are also warned in case of probable own red light violation and other drivers are warned for a red light violation. In cases where an emergency vehicle is approaching, the drivers are warned to make way and that the emergency vehicle will run the red light. The service warns the drivers who make turn to give way to the vehicles from the opposite direction who have green light in the same time. The drivers are also notified when they make a turn to give way to vulnerable road users who have a green light at the same time and are crossing the side road.

A vehicle driver receives a red light violation information on a smart phone or the on-board unit. A road operator / RSU detects and signals the presence of a red light violation. This information is sent by the service provider to vehicle drivers. The information includes the remaining distance or time to reach the signalised intersection, traffic light state, which includes its presence, colour and time to change. This C-ITS service provides a driving recommendation.

There are three systems designs, depending on different level of complexity, namely informative, rule-based or predictive.

- Informative system provides the information about a traffic light state, i.e. its presence, colour and time to change.

- The rule-based system is based on monitoring spatial-temporal variables, for instance vehicle speed and time to stop line, subject to the traffic light state and informs a driver if pre-set thresholds are reached.

- The predictive system predicts the trajectory of the vehicle to estimate the likelihood of red light violation.

![Figure 10. Illustration of different RLVW scenarios (Source: Compass4D D2.1 User Requirements and Specifications)](image)

The turning warning in the signal violation warning can be static or dynamic. Static turning warnings are based on signal phase and timing information which indicates signal phases with a green light for two conflicting directions. Dynamic turning warnings also take into account the actual presence of traffic on these directions before a warning is given. Static turning warning messages are sent constantly, but dynamic turning warnings are provided when conflicting traffic is present.
5.2.3. Warning system for pedestrian

A warning system for pedestrian (not limited to crossing) is a C-ITS service that intends to detect risky situations (e.g. road crossing) involving pedestrians or cyclists, enabling the possibility of warning vehicle drivers or automatically controlling the vehicle (e.g. braking). This warning is based on pedestrian detection. The service is particularly valuable when the driver is distracted or visibility is poor. (Also known as "Vulnerable road user Warning" (ETSI TR 102 638, 2009)).

The service aims to inform a driver about a dangerous situation that is bound to occur, either due to driver behaviour, or VRU behaviour in the vicinity of the vehicle.

There are several ways to implement this service. The traffic lights can be connected to roadside units (RSU) which can collect and transmit the information about traffic, namely traffic lights, road hazards as well as position and behaviour of traffic users. The data may also be gathered from on-board unit (OBU) applications. Both sets of data are used to track whether a dangerous situation may arise and inform the user to improve decision making and safety.

Figure 11. A pedestrian warning example from an in-car safety application developed by BMW

The C-ITS application is installed on the driver’s smart phone or on-board unit and it detects a situation that may result in a traffic accident involving a VRU. The app receives the information from RSUs and other traffic users, VRUs and other on-board sensor and scans for dangerous situation. It provides warning to the driver. This message includes information about the presence of the VRU, accident avoidance advice and information about the detected situation. The driver takes the accident avoidance advice. The RSU can be

installed in the crossing and VRU can be equipped with signalling beacons. An alternative approach, which is supported by the Telcos is based on recognising pedestrians via their smartphones and/or with WiFi (V2X).

5.2.4. Green Light Optimal Speed Advisory (GLOSA)

The GLOSA service provides advice to drivers allowing them to optimise their approach to a traffic light (maintain actual speed, slow down or adapt a specific speed, time to green light). If a green traffic light cannot be reached in time, GLOSA may also provide time-to-green information when the vehicle is stopped in the stop bar. Application of GLOSA takes advantage of real-time traffic sensing and infrastructure information, which can then be communicated to a vehicle aiming to reduce fuel consumption and emissions.

There are several benefits from GLOSA service, namely expected smoother vehicle trajectory while passing a signalised intersection, reduction of stops, lower CO₂ emissions as well as fuel consumption. Other benefits are enhanced traffic flow and driver comfort.

The service can be available in two versions, namely for professional drivers (public transport, that make use of the maximum performance) and for commuters, who will use the light version (no sensor interfacing).²⁵

The GLOSA service can be implemented in various ways. For example, the traffic light that is connected to a roadside unit (RSU) can transmit information about the topology of the intersection and the traffic light phases to nearby vehicles. An approaching vehicle receives the information about the traffic light and calculates the optimal speed to the intersection. A driver of a vehicle will adjust the speed following the speed advice given by GLOSA.

When a driver approaches an intersection the intelligent traffic light controller (iTLC) sends the signal phase and timing information to the vehicle. The ITS G5 RSU transforms the data into a Signal Phase and Timing Extended Message (SPATEM) message which is received by the C-ITS app installed on the driver’s smart phone or on-board unit. The app provides a driver with GLOSA. The driver adjusts the speed of the vehicle and reaches the intersection at the beginning of the green phase.

Figure 12. Traffic light optimal speed advisory illustration (Source: Dutch Profile Part A - Use case catalogue)

Figure 13. Symbols from the EU’s green light optimal speed advisory (Source: ITS International\(^{26}\))

Figure 14. GLOSA Application\(^{27}\)

\(^{26}\) www.itsinternational.com/
\(^{27}\) http://c-the-difference.eu/
5.2.5. Emergency Brake Light

Emergency Brake Light service intends to avoid rear end collisions, which can occur if a vehicle ahead suddenly brakes, especially in dense driving situations or in situations with decreased visibility. The driver is warned before being able to perceive that the vehicle ahead is braking hard, especially if the driver does not see the vehicle directly (vehicles in between).

![Emergency Brake Light Diagram](image)

Figure 15. Emergency brake lights

The main benefits of this C-ITS service is enhancement of safety in dense driving environment by providing timely in-car driving assistance information. It is expected that this service will decrease the number of accidents.

The service is activated when a vehicle driver receives emergency brake light warning on the C-ITS app installed on a smartphone or in-vehicle display. A vehicle automatically detects the emergency braking, activates emergency brake lights and sends the detected emergency braking information to RSUs and other vehicles within the range. RSUs send this information to a road operator or traffic manager who flags up the sudden slowdown. Then the service provider sends the emergency brake light warning to vehicle drivers and it is shown on the C-ITS app.

5.2.6. Cooperative Adaptive Cruise Control

Cooperative Adaptive Cruise Control (CACC) is an evolutionary development of conventional cruise control (CCC) and adaptive cruise control (ACC). It uses V2V communications to automatically synchronize the motion of many vehicles within a platoon. While ACC uses Radar or LIDAR measurements to derive the range to the vehicle in front, CACC also takes the preceding vehicle's data included in CAM (e.g. position, speed, acceleration, etc.) and tries to maintain a fixed following time with the preceding vehicle, minimising the lack of stability and responding more quickly to speed change. (This is closely related to "Co-operative vehicle-highway automation system (Platoon)" (ETSI TR 102 638, 2009)).
This service intends to ensure smooth driving of vehicles with CACC function or platooning technologies for driving through C-ITS equipped intersections. Vehicles with this technology benefit from V2V information exchange to improve the efficiency of driving and traffic flow. When these technology are combined with V2I functionalities, the driving pattern and the traffic lights on intersections can be optimised for traffic flow around intersections.

Two pilot sites were selected, namely Bordeaux and North Brabant. The vehicles equipped with CACC service can improve their flow through a series of intersections by adjusting their speed and spacing in accordance with the advice received from the iTLC in order to reach the subsequent intersection during the green-light phase.

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In case of truck platooning, a set of three trucks will drive along the highway to a distribution centre in an urban area. The benefit is to maintain the platoon-mode when a set of trucks exits the highway and approaches traffic lights before reaching the distribution centre of a city. The iTLC will interact with the platoon leader, advising the speed for the platoon to approach the intersection at the proper time and guaranteeing a longer duration of the green light phase in order for the whole platoon to pass the intersection safely.

5.2.7. Motorcycle approach indication

Motorcycle approaching indication service that also include other VRUs intends to warn the driver of a vehicle that a motorcycle is approaching / passing. The motorcycle could be approaching from behind or crossing at an intersection. This service assists the driver with blind spots. This service aims to improve safety of two-wheelers and other VRUs.

There are two cases of deployment of this service, namely the warning message is transmitted from other vehicles (V2V) or from a vehicle to infrastructure (V2I) and to other vehicles (V2V).

In the first case the C-ITS app on the motorcycle continuously sends movement and position information to vehicles nearby. A vehicle driver receives an awareness warning about the motorcycle in proximity and can automatically compare his own movement data with the motorcycle data. A warning is issued to the driver when a possible conflict with the motorcycle is detected or the relative distance between both decreases below a given safety margin. The motorcycle also receives the information about other vehicles in proximity on the C-ITS app. The message is transmitted by the service provider.

In the second case the information is not only sent from the motorcycle to nearby vehicles but also to the traffic infrastructure (RSU).

5.2.8. Blind spot detection

The blind spot detection service intends to detect and warn the drivers about other vehicles of any type located out of sight. This can be considered as an extension to or an application of the motorcycle approaching indication service.

This C-ITS service provides information to a vehicle driver regarding a vehicle in a designated blind spot location. The information appears on the screen of the on-board unit or a smartphone. The information comes from the RSU located at the proximity of the designated blind spot location. When a vehicle enters the blind spot area the RSU and other vehicle drivers receive a timely awareness message on the C-ITS app. This message includes information about the presence of another vehicle in the blind spot location and, if necessary, a driving recommendation is displayed (e.g. to brake or adapt speed).

![Figure 19. Dynamic cooperative networks with Blind spot detection (Source: SAFESPOT Integrated Project)](http://www.safespot-eu.org/)

SAFESPOT Integrated Project\(^{32}\) has created a dynamic cooperation network where the vehicles communicate with infrastructure (Roads Side Unit) and other vehicles to share information that is gathered on-board and at the RSU. The network includes various systems to detect potentially dangerous situations in advance and increase the drivers' awareness of the surroundings in space and time. It also includes blind spot detection.


6. ITS and C-ITS cooperation among professional rivers and public authorities

This chapter aims to briefly present the existing ITS and C-ITS services that are designed for cooperation between professional drivers and public authorities. Due to a vast number of existing services only some of them will be discussed in this section of this topic study. This chapter consists of two parts, namely the ITS cooperation among professional drivers and public authorities and the second one presents selected C-ITS cooperation among professional drivers and public authorities.

6.1. ITS services

Selected ITS services that are going to be discussed in this chapter:
- eCall
- Advanced traveller information system (ATIS)
- Dynamic Traffic Management
- Local danger warnings

6.1.1. eCall

e-Call is an ITS service that provides a European in-vehicle emergency call system. The purpose of eCall is to send an automated emergency call by an In-Vehicle System (IVS) in case of a serious road accident. The service dials the European emergency number 112 and establishes a telephone link to the appropriate emergency call centre (Public Safety Answering Point – PSAP). The system is automatically triggered when a collision sensor installed in the vehicle detects an accident, or manually by pushing a button in the vehicle. It sends details of the accident (Minimum Set of Data - MSD) to the emergency centre. The message contains information on vehicle type, exact location (GPS), time of accident and direction of travel. In addition, the PSAP can make use of EUCARIS (EUropean CAR and driving license Information System) to retrieve more vehicle-related information. This service is included as one of the priority actions in the EC’ ITS Directive 2010/40/EU. On 28 April 2015 the European Parliament EP voted in favour of eCall regulation which requires all new cars need to be equipped with eCall technology from April 2018 (Directive 2007/46/EC in accordance to COM(2013) 316).

The EU funded project I_HeERO deals specifically with the needs and issues related to how eCall would operate in a commercial vehicle environment, including vehicles carrying dangerous goods, buses and coaches. It intends to provide a recommendation for CEN to develop a standard for eCall that includes HGV buses and coaches.

In a case of eCall for HGV, in order for the emergency service to respond in a proper manner and get to the scene equipped with appropriate tools and protection gear in case of dangerous goods, it is important that the emergency services possess information on the content of the cargo. This information can be provided by the IVS or can be retrieved from an external source of information, for instance e-CMR. It is the carrier who needs to decide which of two solutions to use but any PSAP needs to support both.

The project came up with two solutions that are based on CEN Technical Specification TS16405 and consider other eCall related standards.

The first solution is based on cargo information from a vehicle. In this approach the information regarding the transported cargo needs to be entered in the IVS before a vehicle starts the journey. Sensor data (e.g. cargo temperature, pressure) can be included in MSD which is sent to the PSAP. Since the capacity of MSD is quite limited, only some information on cargo can be transmitted to the PSAP. Furthermore, in such solution IVS requires an interface which increase the price of such units. This solution uses Schema A that is described in TS 16405.

36 http://www.righttoride.eu/eu-e-call/
Another solution is based on the principle that cargo information comes from an external source. In this case the information that is sent by MSD is not limited by size, since the IVS only provides the URI of the endpoint, the HGV information service, where the PSAP can retrieve full data on the cargo. This solution uses Schema B that is described in TS 16405.

In the Schema B, the communication between PSAP and HGV information service is secured using standard mechanisms (e.g. HTTPS). It was proposed by the project to use REST or SOAO web-services, using e-CMR data format based on UN/CAFACT Electronic Consignment Note (e-CMR) Business Standards data model. By using a single data format, it decreases the implementation burden for PSAPs, but it requires cargo management solutions of transport operators to implement e-CMR.

The project proposes a decentralised solution in which PSAP and HGV information services use Public Key Infrastructure (PKI) to ensure authenticity and data security. In a (semi) centralised option, where the cargo information service is provided by the widely-used EUCARIS service, this does not act as data storage, but instead only as a proxy/routing service.
Regarding eCall service for buses and coaches, it differs from eCall designed for passenger cars for a number of reasons, such as the type and size of the vehicle, its weight, number of passengers, etc. The project I-HeERO identifies that the number of passenger on board is key information that needs to be transferred to the PSAP in case of an incident. Similarly to passenger cars and HGV, buses and coaches need to be equipped with IVS, which requires information on the number of passengers.

The project provides two solutions. One is based on information regarding the number of passengers which is obtained from the vehicle and the second one is based on information on the number of passengers which is received from an external source. In the first solution the on-board systems that can estimate the number of passengers include as ticketing systems, CCTV on board cameras, seatbelt sensors and air-suspension sensors as possible sources of data. This information is passed to the IVS and is later sent to PSAP in case of an accident. The second solution uses the URI parameter from the MSD to connect to an external data source and retrieve information on the number of passengers.

eCall ITS is obligatory for private cars from 1 April 2018 but has not yet been mandated for HGVs, buses and coaches. However, the benefits of its deployment on other types of vehicles will be immense, and will impact road safety and the efficiency of emergency services in quicker responses to accidents.

6.1.2. Advanced traveller information systems

Advanced traveller information system (ATIS) provides drivers with information in real time on traffic jams, road closures, weather conditions and other situations that may impact travel time. ATIS can be categorize into two groups: pre-trip and en-route.37

Pre-trip ATIS may provide drivers with real-time traffic information (RTTI) to help them to plan their route, namely to decide on departure time, and route. RTTI aims to help drivers to make informed decision when on the road.

En-route ATIS, such as variable speed limit (VSL) may impact the entire road network and may be intended as a link control strategy. VSL system can be installed on certain segments of the road to provide dynamic speed limit, warning information, travel time, route guidance, etc.

The information on traffic situation is collected from the floating car data (FCD) and floating phone data (FPD) by service providers. The data is processed, integrated and transmitted to the vehicles, smart phones, etc. of the customers through traffic message channel (TMC) technology. This information is digitally coded into radio data system (RDS) and transmitted via FM radio broadcasting. Information on traffic can also be transmitted on digital audio broadcasting (DAB) or satellite radio. A new technology of transmitting traffic data is known as TPEG (Transport Protocol Expert Group). It sends information via digital broadcast formats such as DAB or internet. The real-time information can be read by a synthetic voice aloud or displayed as a text message, an icon or a colour-coded map.38

6.1.3. Dynamic Traffic Management

Dynamic traffic management (DTM) systems as well as local danger warning are services that aim to increase the safety and flow of traffic in case of disturbances or accidents on a road. DTM also include ramp metering, dynamic lane management, overtaking bans (HGV), dynamic speed limitation, warning messages about critical road conditions (e.g. snow/ice on road), etc. These systems are managed either automatically, or semi-automatically, or manually by traffic control centres who receive information on traffic flow from fixed monitoring systems or mobile sensors (FCD etc.) in certain locations on a road. The systems use variable message signs (VMS) to provide information to drivers. There are three categories of VMS, depending on the type of message, i.e. ‘regulatory messages,’ ‘danger warning messages’ and ‘informative messages.’

38 Ibid.
The dynamic traffic management is an ITS service that is used by all users of a road traffic, including professional and non-professional drivers.

6.2. C-ITS services

There is a number of C-ITS services that have been designed for professional drivers. However, in this chapter we will focus only on some of them.

The selected C-ITS services are:
- Rest-time management
- Motorway parking availability
- Road works warning
- Road hazard warning
- Emergency vehicle warning
- Cooperative traffic light for VRUs
- Mode & trip time advice for drivers
- Probe Vehicle Data (PVD)
- Slow or Stationary Vehicle Warning
- Non-stop truck

6.2.1. Rest-time management

Rest time management service will support managing the working hours of drivers engaged in the carriage of goods and passengers by road. The process is regulated by policies, laws or regulations (e.g., EU regulation (EC) No 561/2006)\(^{39}\) that lay down the rules on driving times, breaks and rest periods for the drivers. Driving time is measured by tachograph installed on coaches and trucks.

This C-ITS service provides truck drivers with real-time information on parking availability at a relevant frequency. There are two main benefits from this service, namely a better compliance with driving and resting time and also a reduction in time taken by drivers to find a parking space. It shows available parking spots along the route at a certain frequency, which can be adjustable, depending on type of vehicle, e.g. every two hours for LCV and for HGV drivers the frequency can be based on the driving time already completed to the rest time from the regulation.

There are two types of stakeholders involved in rest-time management service: the driver of the vehicle and parking operators. The driver receives advice when to rest according to available truck parking spaces and regulated driving times and resting times. A parking operator provides information about parking space availability and services provided at a parking lot.

All information is displayed on the C-ITS application that is installed either on the driver’s smartphone or on an on-board unit. The programme needs to run in the background. The system works by the parking or road operator collecting information, then sending this information to all vehicle within a perimeter. While the truck driver is driving, the information about the parking becomes available on the app or on-board unit at a certain frequency. The driver receives the information and adapts his route and can choose the parking area.

6.2.2. Motorway parking availability

Another C-ITS service that is designed for professional drivers is motorway parking availability. This service provides information on parking availability along the motorways. It proposes a number of options for truck drivers about available parking places and guides the drivers to a parking place. This existing service provides information about the location of HGV parks, capacity, and available equipment, facilities on site, security equipment and information about dangerous goods parking. Other options such as booking of a parking lot and payment of parking charges can be included in the service in future, as soon as the regulatory framework would allow that. Currently it is not possible to reserve parking lots in the public domain.

This service includes numerous benefits, namely it allows a driver to quickly identify the parking lots located along a motorway, it simplifies access to the parking lots, it reduces the time it takes a driver to find a parking lot; it optimises the flow of trucks in the parking lot which also reduces congestion and traffic jams in the lot; it improves safety in the parking lot; and it simplifies complying with driving times and rest periods and using driving time more efficiently.

The motorway parking availability service uses an Internet connection. The information on a specific parking lot (e.g. location of the lot, the number of available spaces, the vehicle types permitted to use the parking, services available and information on whether the parking area is secured) is collected by the parking lot operator and transmitted to trucks (I2V). A driver makes a reservation for a specific parking lot and the service guides the driver to the destination.

One of the examples of such service is the Truck Parking Europe platform. It is a free app that provides information on availability of parking spaces for truck drivers. It not only includes information on official parking lots along a route, but also parking places accessible to heavy traffic, for example in industrial areas.

40 https://truckparkingeurope.com/
Other parking management tools are: Talking Traffic Innovation Partnership, Parckr Smart Truck Parking, Praktijkproef Amsterdam, Transpark IRU, Truck-Parking, the European Truck Parking Area LABEL Project and Aegean Motorway MSS locations.

6.2.3. Road works warning

The road works warning (RWW) is a C-ITS service which is designed for all drivers that are on a road. It informs them in a timely manner about road works, restrictions, and constructions. It allows them to be better prepared for potential obstacles downstream on the road, therefore reducing the probability of collisions.

All road works areas are marked by road signs that are located prior to the working areas. However, often such changed conditions on roads / motorways frequently come as a surprise to drivers. It can lead to increased risk and sometimes even accidents, both for road users and workers. The road works warning service aims to make drivers not only aware far

41 https://appshop.transportlab.org/en/
42 https://www.beterbenutten.nl/talking-traffic
44 https://www.praktijkproefamsterdam.nl/
45 https://www.iru.org/apps/transpark-app
46 http://www.truck-parking.com/locations-map/?lang=en
47 http://truckparkinglabel.eu/assets/default.htm
in advance about the coming road works on a route, but also make driving more attentive while approaching and passing a work zone. It improves traffic safety, for it decreases the likelihood of accidents or collisions with safety equipment such as barriers located close to the road work area. It also helps safeguard the site workers.

The service provides drivers with information about approaching work zones. The guidance is displayed on the screen of a smartphone or on-board vehicle display. The instruction may include a recommendation to reduce the driving speed, change lanes, make certain manoeuvres, detouring, etc. It communicates the remaining distance to the hazardous location in real time.

The information is transmitted using ETSI ITS-G5 DENM messages over DSRC (Dedicated Short Range Communications 802.11p) or cellular network (2G, 3G, 4G).

There are three possible data downstreams:

Downstream 1: A traffic centre knows the location of the road works and sends the location to the vehicles through cellular networks.

![Downstream 1 Diagram]

Downstream 2: A traffic centre knows the location of the road works and sends the location to the vehicles using RSU with DSRC.

![Downstream 2 Diagram]

Downstream 3: The work site management sets up a mobile RSU at the start of the works to send the necessary DSRC (DENM) messages.

![Downstream 3 Diagram]

One example of RWW is C-The Difference. It is a traffic app that allows drivers to adapt driving depending on the infrastructure and various road events that may occur, including

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road works. The app was deployed and functional in the Bordeaux urban area.

![Figure 25. C-The Difference app](https://apkpure.com/c-the-difference-bordeaux/com.geolocsystems.cthedifference)

This app allows the drivers to receive information regarding the road events and traffic in real time. It has been designed to improve urban mobility while respecting traffic movement, the security of users as well as the environmental footprint.

### 6.2.4. Road hazard warning

The road hazard warning service intends to inform the drivers in a timely manner of upcoming, and possibly dangerous events and locations on a road. This allows drivers to be better prepared for the upcoming hazards and make necessary adjustments and maneuvers in advance. (This is also known as "Hazardous location notification" (ETSI, 2009) or 'Road hazard signalling'). The information on hazard situation is detected by a vehicle. This information is sent to traffic control centre (TCC). TCC provides services to other vehicle that are located in the vicinity to the hazardous area by warning them. The key benefit of this C-ITS service is to improve traffic safety.

Road hazard warning includes three services:
- hazard location notification,
- traffic condition warning,
- weather condition warning.


6.2.4.1. Hazard location notification

Hazard location notification service provides drivers with an advance warning of upcoming hazardous locations in the road that may lead to a driving situation with increased risk or in the worst case accident. Examples of these hazards include a sharp bend in the road, steep hill, pothole, obstacle, or slippery road surface. Using this information, drivers are better prepared for upcoming hazards and will be able to adjust their speed accordingly. This service aims at improving traffic safety and decrease the risk of accidents.

A driver of a vehicle receives the information about a hazardous location on a smart phone or on-board unit. This information is prepared by a road operator and transmitted by a service provider (I2V). Other organisations responsible for repair, maintenance or cleaning may act on the hazardous location information. When a vehicle approaches a hazardous area, a driver receives information via the C-ITS service. This information includes the remaining distance or time to reach the location and, when it is appropriate, the driver receives a driving recommendation regarding, for instance, speed or lane.

![Figure 26. Hazard location notification](image)

6.2.4.2. Traffic condition warning

The traffic condition warning service provides an alert to a driver who approaches the queue end of a traffic jam at a certain speed. An example is when a traffic jam is hidden behind a hilltop or curve. This allows the driver to react safely to traffic jams ahead. The main objective is to avoid collisions that are caused by traffic jams on highways. Therefore, the service provides a driver with information regarding traffic conditions on a road.

[53](https://www.beterbenutten.nl/talking-traffic)
A driver of a vehicle receives information about the traffic conditions on a smart phone or on-board unit. This information is prepared by a road operator and transmitted by a service provider (I2V). The information on traffic jams can be also used by an end user in route planning. When a vehicle approaches an area on a road with a traffic condition, the driver receives an awareness message on the C-ITS app. This message contains information about the remaining distance or time to the traffic condition. The recommendation can be issued to a driver to adapt speed or change a lane. It may include an adjustment of the scheduled route to the final destination on the basis of the designated diversion route.

6.2.4.3. Weather condition warning

The weather condition warning service provides an alert to a driver of a vehicle on weather conditions on a route derived from the current position and the driving direction of the vehicle. The vehicle detects a slippery road stretch and sends this information to the road operator (V2I). Then this information is sent to other drivers’ smartphone or on-board unit (I2V) as a warning message. This information on traffic conditions intends to improve traffic safety by reducing the risk of accident. The driver receives the information on traffic condition which is prepared by a road operator and transmitted by a service provider.

When a vehicle approaches a weather condition such as fog, rain, snow, or ice, the driver receives a timely awareness message on the C-ITS app. The message contains information on the remaining distance or time to reach the weather condition and, if necessary, a driving recommendation, which includes for instance speed adaptation, mandatory equipment or deviation.

54 https://www.beterbenutten.nl/talking-traffic
6.2.5. Emergency vehicle warning

Emergency vehicle warning uses information that is provided by the emergency vehicle itself. The purpose of it is to identify and inform other vehicles about the position, direction and speed of the emergency vehicle even when its siren and light bar may not yet be audible or visible. This is also known as “Emergency Vehicle Alert (EVA),” and alerts the driver about the location and the movement of public safety vehicles responding to an incident so the driver does not interfere with the emergency response. The service is enabled by receiving information about the location and status of nearby emergency vehicles responding to an incident (CVRIA, 2017).

The main objective of this service is to provide an early warning indication of an approaching emergency vehicle and to facilitate the driver to give way to it. It also aims to create more attentive driving, better awareness of emergency vehicles and better response by giving way in a less hasty manner thus preventing risky behaviour and causing accidents. It also intends to create an uninterrupted route for the emergency vehicle to its destination.

![Emergency vehicle warning](image)

**Figure 28. Emergency vehicle warning**

In a real world scenario, when an emergency vehicle approaches a vehicle from behind, the driver of this vehicle is informed about the emergency vehicle. The driver is expected to give priority to the emergency vehicle by pulling over or speeding up in order not to block it. In such a scenario, the driver of the vehicle receives the information on the display when an emergency vehicle is approaching. The emergency vehicle transmits the information on its location. The road operator may signal about the existence of an emergency vehicle. All information about the emergency vehicle location is transmitted by a service provider.

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55 [https://www.linkedin.com/pulse/your-connected-vehicle-largest-wearable-setrag-khoshafian/](https://www.linkedin.com/pulse/your-connected-vehicle-largest-wearable-setrag-khoshafian/)
The information is transmitted using ETSI ITS-G5 DENM messages over DSRC (Dedicated Short Range Communications 802.11p) or cellular network (2G, 3G, 4G).

There are three possible data downstreams:

Downstream 1: a traffic centre sends information about an emergency vehicle location to the vehicle via cellular networks.

![Traffic Centre](image1)

Downstream 2: the emergency vehicle transmits the DENM message using DSRC to be received by the equipped vehicles (V2V).

![Traffic Centre](image2)

Downstream 3: the RSUs disseminate information about the emergency vehicle to the equipped vehicles (I2V), using DSRC.

![RSU with 802.11p](image3)

Project MOBiNET discussed a similar service called “Ad-Hoc Priority.”\(^\text{56}\) The service aimed to grant priority to VIP vehicles, HGV and emergency service vehicles at intersections. The driver needs to specify his route and in the back-office the RSUs will be informed of the direction the driver plans to take. Authentication is a crucial part of the service. The navigation system is incorporated in the C-ITS app, and enables the system to extract the route and request the correct priority along the route.

6.2.6. Green priority

Green priority C-ITS service intends to change the traffic signals status in the path of an emergency or high priority vehicle (e.g., public transportation vehicles), halting conflicting traffic and allowing the vehicle right-of-way, to help reduce response times and enhance traffic safety, as well as emissions. This service is also known as “Traffic signal priority request by designated vehicles” (EC: C-ITS Deployment Platform, 2016) or “Priority Request” (Sambeek et al., 2015). This service aims to enhance traffic safety and increase punctuality and response times for the services provided by emergency vehicles.

Green priority service aims to change the traffic signal status along the route of an emergency vehicle, suspending conflicting traffic and allowing the vehicle to pass. It will help to reduce response times and increase traffic safety.

In the implementation of the service, the green priority requests including the identification information of the high priority vehicle can be sent via an on-board software app in the vehicle. The signal is picked up by traffic light controllers (see Figure 4)\(^7\) which determine in what way they can and will respond to the request. This information can also be received by RSUs and communicated to other traffic light controllers on the route of the vehicle. Here, different levels of priority can be applied, e.g. extension or termination of the current phase to switch to the required phase. The appropriate level of green priority depends on vehicle characteristics, such as type (e.g. HGV or emergency vehicle) or status (e.g., public transport vehicle on-time or behind schedule). The vehicles request priority for an

\(^{7}\) https://ops.fhwa.dot.gov/publications/fhwaop08024/chapter9.htm
intersection, and the traffic light controller determines in what way it can and will respond the request.

![Image of intersection with emergency vehicle]

**Figure 30. Emergency Vehicle Signal Preemption Example, US Department of Transportation - Federal Highway Administration**

The C-ITS app calculates the distance to the intersection and sends the priority request to the intelligent traffic light controller (iTLC) in the vicinity and fixes its intersection ID. The iTCL sends this information to the traffic manager. The traffic manager authenticates and authorises the C-ITS app and processes the priority request and sends the reply to the iTLC. The iTLC decides whether to give green priority or not. The decision is made on a basis of vehicle data and conditions set by the road traffic manager. The iTLC sends the signal phase and timing (SPAT message) to the C-ITS app. The message is received by the app and the driver is informed about the priority status. Meanwhile iTLC realises green priority. After passing the intersection, the C-ITS app stops the priority request and iTLC stops the green priority.

**6.2.7. Cooperative traffic light for VRUs**

The cooperative traffic light for vulnerable road users (VRU) service aims to increase the safety of VRUs through warranting priority or additional crossing time (i.e., extending the green light phase or lessening the red phase) based on pedestrian characteristics (or on special conditions, such as weather). The service can also be extended to cover other VRUs, such as cyclists. The service is also known as “Pedestrian Mobility” (CVRIA, 2017) or “Traffic light prioritisation for designated VRUs.”

This C-ITS service has several benefits, namely it intends to increase VRUs safety, enhance
traffic flow and comfort of VRUs, as well as reduction of emissions rates as a result of decreased car usage.

The service provider offers a priority crossing for VRUs at intersections. The provider equips VRUs with a code to activate the app, which runs in the background and interacts with traffic lights at intersections. When a VRU approaches the iTLC, the app sends the priority request to the iTLC. Then the iTLC sends the priority request with its current state information to the traffic manager. The traffic manager authenticates and authorises the C-ITS app. He also creates a reply and sends it to the iTLC and iTLC acts on the request.

![Figure 31. Cooperative traffic light for VRU Illustration (Source: VRUITS)](http://www.vruits.eu/)

### 6.2.8. Dynamic lane management

The dynamic lane management service aims to exchange information about lanes with traffic users. It provides dynamic lane management in certain circumstances, such as traffic congestion. The dynamic lane management includes solutions such as auxiliary lanes, reserved lanes, and reversible lanes. It intends to provide better awareness and safer traffic and traffic optimisation (the road operator can improve the management of the dynamic lane in real time).

The dynamic lane management service informs drivers of the presence of a reserved lane and notifies them whether they can use it (I2V). The road manager informs the drivers about a dynamic lane in a specific area. The C-ITS services installed on the driver’s smartphone or on-board unit of the vehicle, receives this information in this specific area. The information

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on its characteristics (PVD) relevant to the dynamic lane is sent via an app (V2I). Then the road manager receives the PVD and decides to open or close the dynamic lane, to adapt the features of the lane, etc. The service provider transmits in-vehicle signage (IVS) information, warning or guidance from the road operator to vehicle drivers.

6.2.9. In-vehicle signage

The in-vehicle signage (IVS) service intends to inform drivers through in-vehicle information systems about static and dynamic road signs along the road. The service includes both mandatory and advisory signs. The information is transmitted by means of infrastructure to vehicle communication (I2V). The driver receives actual and continuous IVS related information on the in-vehicle display. The transmitted information may include reducing the driving speed, changing lanes, and preparing for a manoeuvre.

The expected benefit is more attentive driving by providing actual and continuous information about road signage and speed limits, which improves traffic safety.

6.2.9.1. In-vehicle signage (static traffic lights)

In-vehicle signage aims to provide static IVS information (speed limits) to the driver about the road signs. Having received this information, the driver adapts the driving velocity of the vehicle to the applicable driving regulation according to the static road signs. The benefit of this service is more attentive driving by providing actual information and warnings which improve the awareness of driving.

The driver receives information and warnings from the vehicle display. The information about road signage is provided by a road operator and a service provider transmits IVS related information. IVS messages are transmitted into different data streams:

Data stream 1: the RSU transmits the road signs information to relevant equipped vehicles using DSRC (802.11p).
Data stream 2: a traffic centre sends the speed limit information to the relevant vehicles using cellular communication.

6.2.9.2. In-vehicle signage (dynamic traffic lights)

In-vehicle speed limits service aims to provide information to drivers about speed limits on the roads. This is typically performed through broadcasting roadside units (RSU) at key points along the roads.

A vehicle driver receives information from the in-vehicle display or smartphone. The actual information on dynamic road signage is provided by the road operator. The IVS information is disseminated by the service provider. The information includes warnings and guidance to drivers. The IVS message can be transmitted by two different data streams:

Data stream 1: a traffic centre is aware of the dynamic information and sends it to the RSU which disseminates the road signs information to equipped vehicles using DSRC (802.11p).
Data stream 2: a traffic centre is aware of the dynamic information and sends it to the relevant vehicle using cellular communications.

6.2.10. Mode & trip time advice for drivers

Mode & trip time advice aims to provide drivers with information on the most efficient route while driving as well as the expected travel time based on floating vehicle data. The floating vehicle data is collected either through roadside units (RSUs) or through an on-board software app in the vehicle to assess the density, throughput and congestion of traffic within a specific area. The service offers drivers reliable arrival times at delivery locations. They can plan their trip according to the advice received by the mode & trip advice service.

When a truck driver wants to obtain the best time advice for his journey, C-ITS app asks for the departure time and the arrival locations. Having indicated both locations, the app connects to the service provider and requests traffic information (FTD, dynamic traffic data, urban and highway parking availability data, static road network data, etc.). Then the service provider collects the traffic information from the Data / Content provider and sends this information to the C-ITS app. The app generates mode & trip time advice, which is based on the traffic information and shows it on the screen to the driver.

6.2.11. Probe vehicle data

Probe Vehicle Data (PVD) is data generated by vehicles. The collected traffic data (traffic conditions, road surface conditions and the surroundings) can be used as input for operational traffic management (e.g., to determine the traffic speed, manage traffic flows by informing drivers, where the danger of accidents accumulates), long-term tactical/strategic purposes (e.g. road maintenance planning) and for traveller information services.

The impact of this service includes safer road conditions (e.g. traffic jams/collisions alert and
adverse weather conditions warnings), less CO$_2$ emissions (from a more stable traffic flow) as well as faster travel times.

Driver assistance technologies that are installed on modern vehicles know their own position, speed and direction and sometimes other vehicle properties (e.g. collision sensors, ABS, windscreen wiper status, etc.) This data can be communicated when a vehicle is in range of a RSU. This data will provide the road authority with information about traffic, road surface and environment conditions which can be used further in traffic management.

When driving along RSUs, the C-ITS app sends information or a message that contains information about the vehicle and surroundings. The road operator collects this data via a central system and it is then sent to the third parties (OEMs, service provider) for the app. The users of the service receive warnings to avoid dangerous situations and advice to change the driving behaviour (accelerate, brake, change route, etc.) OEMs may act as a service provider and also as an intermediate between the service provider and end users.

![Figure 32. Probe vehicle data](image)

The probe vehicle data service was implemented in the Netherlands in the Dutch C-ITS Corridor$^{59}$ and Praktijkproef Amsterdam.$^{60}$

### 6.2.12. Slow or Stationary vehicle warning

The slow or stationary vehicle warning service intends to inform or alert approaching vehicles about (dangerously) immobilised, stationary or slow vehicles that impose significant risk. This service aims to improve traffic safety due to the reduction in number of accidents.

The service will notify drivers about accidents or incidents on the road, stationary vehicles with problems, or roadside inspection, roadside assistance and emergency vehicles located on a road. The slow and stationary vehicles that are on the road may cause hazardous situations especially when they are not noticed in a timely way by other vehicle drivers passing by.

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59 https://itscorridor.mett.nl/default.aspx  
60 https://www.praktijkproefamsterdam.nl/
The purpose of slow or stationary vehicle warning is to alert the drivers so that they can adapt their driving behaviour compliant to any advice or guidance received.

When a vehicle approaches a stationary vehicle on a road, the driver will receive stationary vehicle information on the C-ITS app in-vehicle display or smartphone. The information is sent by road operator who detect and signal the presence about a stationary vehicle. A service provider sends the information to all vehicle drivers in the vicinity. The message includes information on the remaining distance or time to reach the stationary vehicle and, if appropriate, driving recommendation. The information about traffic jams on a road can be also used by the end user for route planning.

![Figure 33. Stationary vehicle illustration (Dutch Profile Part A Use Case Catalogue)](https://www.beterbenutten.nl/talking-traffic)

### 6.2.13. Non-stop truck

The non-stop truck (NST) service intends to transfer the weight information from a truck to the road administrator, when a truck is on move. Since vehicle weight control requires vehicles to stop in order check their weights at a physical scale, it has a negative effects on traffic throughput, fuel consumption as well as emissions. The non-stop truck service aims to reduce these negative effects by sharing the truck weight information with public authorities to obtain a free pass for law-abiding vehicles in vehicle control.²

The non-stop truck is a service by means of which trucks share information with public authorities to receive a free pass for law-abiding vehicles in vehicle controls. When a vehicle

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¹ https://www.beterbenutten.nl/talking-traffic
passes a road-side ITS Station (R-ITS-S), the in-vehicle ITS Station (V-ITS-S) sends the information on vehicle weight together with its identifier to the R-ITS-S. The road administrator will use the history of the vehicle. It will be decided whether to grant a clearance to the vehicle or a manual control of the vehicle is required.

The owners of trucks can register their trucks for voluntary sharing of identity and truck status to public authorities and road operators to allow the interaction. The MOBiNET service matches vehicle data from on-board devices to data required by public authorities. The service allows trucks to decide to share data with public authorities and it allows public authorities to offer self-declaration to any truck that has an appropriate on-board device.

7. ITS and C-ITS services for non-professional drivers and user acceptance

7.1. ITS and C-ITS services for non-professional drivers

The European Commission’s work on C-ITS has among other things produced a list prioritising C-ITS services to be delivered, known as Day 1, Day 2 etc services. The list is the result of extensive consultations with stakeholders and can be taken to represent a broad consensus of experts in the field.

**Day 1 C-ITS services list**

**Hazardous location notifications:**
- Slow or stationary vehicle(s) & traffic ahead warning;
- Road works warning;
- Weather conditions;
- Emergency brake light;
- Emergency vehicle approaching;
- Other hazards.

**Signage applications:**
- In-vehicle signage;
- In-vehicle speed limits;
- Signal violation / intersection safety;
- Traffic signal priority request by designated vehicles;
- Green light optimal speed advisory;
- Probe vehicle data;
- Shockwave damping (falls under European Telecommunication Standards Institute (ETSI) category ‘local hazard warning’).
Day 1.5 C-ITS services list

- Information on fuelling & charging stations for alternative fuel vehicles;
- Vulnerable road user protection;
- On street parking management & information;
- Off street parking information;
- Park & ride information;
- Connected & cooperative navigation into and out of the city (first and last mile, parking, route advice, coordinated traffic lights);
- Traffic information & smart routing.

Adapted from *A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility, 2016*

The services to be deployed first for the benefit of drivers cover hazard warnings and other in-vehicle advisory services relating to speed limits and traffic signals. These have been judged to be those of most benefit to drivers, including non-professional drivers, and also relatively easy to deliver at the beginning of C-ITS implementations.

### 7.1.1. Talking Traffic project

The Talking Traffic project in the Netherlands is a good example of early C-ITS adoption for the benefit of everyday drivers. The Dutch Ministry of Infrastructure and Environment set out to maximise traffic flow on existing roads, rails and waterways while avoiding costly investments in new infrastructure. They decided to utilise the cloud and IoT (Internet of Things) to build a national Intelligent Vehicles and Road Infrastructure (IVRI) system.
Project highlights:

- First government-led project to create a national ITS solution
- A cloud-based solution delivered within 6 months
- 25% of all traffic lights nationwide connected so far
- 10% less road congestion during peak hours

Table 1 – Adapted from The Talking Traffic Case Study, Ericsson 2017

In the Talking Traffic project, the following six services in 12 Dutch regions are in the first tranche made available to drivers:

1. In vehicle signage and speed advice
2. Individual real-time data on potentially dangerous situations and road work warnings
3. Prioritising (conditioned and general) of groups of road users at traffic lights
4. Provide road users with real-time data from traffic lights (first 20% of all Dutch TLIS)
5. Optimising traffic flow through traffic lights
6. In-car parking data.

So, Dutch drivers will be able to make use of information, including speed limits, which was previously only available via road signs, now being delivered straight into their vehicles and displayed via a dedicated interface. They will also get real time warnings about unplanned...
hazards, such as crashes or weather events, faster than by relying on variable message signs or radio broadcasts. Parking information will also be made available.

In addition, the Talking Traffic service will use C-ITS data to dynamically manage traffic lights to optimise traffic flow and prioritise vehicles or groups of vehicles. Drivers will not have the option of “opting out” of using these C-ITS services, like they do for instance with the speed limit or hazard warning information which they can choose to ignore. But these “involuntary” C-ITS services will deliver benefits in terms of journey times and smoother journeys. Most likely drivers will often simply not realise that their journeys are supported by a C-ITS services. If they do, they will also notice the benefits and find the C-ITS “interference” with their driving to be beneficial.

7.1.2. Next steps for C-ITS for non-professional drivers

As C-ITS mature, a wider range of services (“Day 1½, Day 2”) are envisaged for drivers. More intelligent, dynamic routeing; more advanced parking information; and information about vulnerable road users (VRUs) such as pedestrian and cyclist proximity warnings are some of these services. Private cars will gradually become part of a nation- or even Europe-wide ecosystem of vehicles and infrastructure. Commercial fleet operators will of course keep their business-related data confidential, but in many areas of C-ITS, both private and commercial vehicles will play their part in providing data and using the services partly created with their data input.

7.2. User acceptance of ITS and C-ITS for non-professional drivers

The general public is at a very early stage of finding out about, let alone using, cooperative ITS services. At the same time, these will never become widely adopted if non-professional drivers do not embrace them.

Table 2 – Adapted from A Survey of Public Opinion about Connected Vehicles in the US, the UK and Australia; University of Michigan Transportation Research Institute 2014

<table>
<thead>
<tr>
<th>Response</th>
<th>US</th>
<th>UK</th>
<th>Australia</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very positive</td>
<td>22.0</td>
<td>23.3</td>
<td>25.2</td>
<td>23.4</td>
</tr>
<tr>
<td>Somewhat positive</td>
<td>34.9</td>
<td>43.3</td>
<td>39.2</td>
<td>39.0</td>
</tr>
<tr>
<td>Neutral</td>
<td>36.5</td>
<td>29.4</td>
<td>31.6</td>
<td>23.6</td>
</tr>
<tr>
<td>Somewhat negative</td>
<td>5.0</td>
<td>3.8</td>
<td>2.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Very negative</td>
<td>1.6</td>
<td>0.2</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>
There are two sources of knowledge for us when exploring the topic of user acceptance of C-ITS: user views on the wide range of advanced driver assistance systems (ADAS) already in well-established use, and a small amount of research into non-professional drivers’ attitudes to C-ITS services.

Until around 20 years ago most drivers manually controlled and executed all tasks associated with travelling by car. There were a small number of ADAS already in existence, but only in vehicles with the highest specifications. Most drivers would not experience these.

Gradually ADAS spread through the fleet as vehicle manufacturers found that there was demand from car buyers, and in a virtuous circle the technology became both better and cheaper as it went into mass production. No doubt there was a small number of drivers who either believed that their own driving skills were better than anything technology could achieve, or were suspicious of technical assistance believing that it might be prone to malfunction or failure and therefore not to be relied on. However, enough of a majority welcomed ADAS for them to develop into a normalised part of the driving experience. Speed warnings, lane following assistance, assisted parking and so on are now ubiquitous and accepted.

To a non-professional driver with no special knowledge of transport technology C-ITS will not appear so very different from ADAS. Therefore the ADAS implementation and acceptance processes are a valuable source of information about how C-ITS may work in the everyday driving context.

Experts know that C-ITS are something quite different from ADAS. In C-ITS, the data powering the services comes from other vehicles or from the infrastructure and the services may well be provided from a traffic control centre or from a private sector service provider. C-ITS integrate the vehicles into a much larger eco-system of infrastructure, vehicles, information, advice and control. This may even entail an individual driver having a worse experience, with a longer trip, slower speeds or more congested conditions, in order for a much larger number of drivers having a better trip. It may also mean a large number of drivers having a slower or longer journey in order to deliver air quality benefits to people not even on the road, but living or working adjacent to it.

But at the point where the driver is affected by the C-ITS service, it will not appear very different to him or her than a more traditional ADAS. The driver will perceive that they are assisted in the driving task via for instance speed or parking advice, or weather warnings, and will not question how this advice has been created or transmitted as long as it is accurate and useful. In the case of C-ITS such as dynamic traffic light settings to optimise traffic flow or reduce air pollution, the driver is unlikely to be aware that he has even received (or been subjected to) a C-ITS service.

It is therefore likely that C-ITS will be acceptable to drivers and even popular and desirable. The only alternative scenario is one where the network operator implements policies which radically alter individual driver experiences for what the drivers perceive as worse. An
example would be obvious and lengthy re-routing for air quality benefits. Most drivers are familiar with the networks they are using and would realise that they are taking what appears to them as lengthy detours, and would find this unacceptable. Conversely, if they were informed that the longer journey was to improve safety at a primary school or kindergarten, they may well find this more acceptable. So, a blend of not overreaching in the application of C-ITS to the detriment of individual drivers, and of taking care to explain the reasons for how C-ITS is use especially when these reasons are likely to be attractive to drivers, will ensure the highest levels of acceptability.

Just like traditional ITS, C-ITS services must also be of the highest accuracy and timeliness. Information delivered by VMS on the UK motorway network still suffers from drivers not taking it seriously and therefore ignoring it. They base their decision on previous experiences of the information being out of date or the problem overstated. Often, these experiences are by now years in the past, but the pattern of behaviour is hard to shift. This creates a vicious circle of drivers ignoring requests to slow down, drive in certain lanes, or take detours, and then adding to the problem which caused the warning to be given in the first place. C-ITS based information and actions must be close to real time and always accurate, or the same problems with driver behaviour will be created. The technical processes must be thoroughly and inventively tested, and it is also essential not to build in too many layers of checks and controls, including by human interventions.

8. Communicating ITS to the public

ITS are as a rule poorly understood by its users, which include more or less everybody who travels. Whether you travel by car, bus, rail or air, for some or all of your journey the operator of your services and you yourself will have used and/or been supported by ITS. But still, the general public has a very weak grasp of how traffic signals change or an out of date public transport ticket does not open the gate. It may be tempting to argue that this does not matter; that as long as the operators and their contractors and suppliers have the knowledge, it does not matter how deep is the ignorance of the users.

However, in a democratic society, the transport user is also a voter and the ITS are almost completely public sector funded, so in the longer term it would be better for ITS implementation if users both understood the basics of the services and appreciated the outcomes enough to support expenditure on transport technology. Instead, while it is not unusual to hear members of the public support the building of railway lines and roads, there will be a long wait if you are expecting to hear anybody outside the sector talking enthusiastically about dynamic traffic management or automatic vehicle location in the bus industry.

Perhaps part of the problem is that nobody takes responsibility for the task of communicating ITS to the public. Private sector provided services are explained as part of the task of selling them: advertising and more subtle information campaigns highlight all the benefits of the service and try to paint a picture of value for money.
In ITS, this task would need to be undertaken by a highways authority or a city public transport authority, both as a rule public sector organisations in Europe. This sits badly with the prevailing ethos of public service which can be summarised aspiring to deliver an adequate service as discreetly as possible.

When a transport authority decides to undertake this activity, the results are often just as good as anything the private sector can achieve. One example is the introduction of integrated public transport ticketing via smartcards in the 2000s, where cities such as Hong Kong and London were able to not only convince the public that getting these cards would be beneficial, but even create brand loyalty and recognition by naming the cards (“Octopus”, “Oyster”) and building relationships between passengers and their cards.

Another example is the “smart motorways” concept in the UK where the hard shoulder, initially mandatory as an emergencies-only lane on motorways, has been converted to a full- or part-time running lane. Communicating this to the public was a challenge: it could be predicted that there would be strong safety concerns when such a well established and recognised safety feature was simply removed. The information campaigns recognised these fears and explained all the reasons, including the use of mature and reliable technology, why they were unfounded. They also of course made much use of the fact that congestion would ease, and journey times improve.

So it can be seen that there are effective ways of communicating ITS to the general public. Transport operators could definitely do better at communicating ITS, and should take the lead in doing so. The benefit to them would be a better understanding of why ITS needs to be funded, implemented, maintained and developed. This better understanding would lead to better political support and fewer interventions along the line of “Why is this money not spent on care for the elderly?” It is also odd that a general education includes the basics of most of our utilities such as electricity and water supply, but not the basics of our transport systems, which these days would include ITS.

But private sector actors also have an important role to play in communicating ITS. Some do it already and do it well: Siemens Intelligent Traffic Systems in the UK has both a community and a schools outreach programme, and welcomes organised visits to its factory in Poole, Dorset.
The benefits to a private sector company doing this type of communication is not just that increasing understanding increases support and demand and therefore is good for business. A higher profile for the ITS sector and a better general understanding of what it does, will also translate into a better supply of potential workers. It is not possible to choose to do a job you do not know exists.

9. Discussion and conclusions

This topic study focuses on cooperative intelligent transport systems (C-ITS) user services. It provides a concise and clear overview of the existing and new C-ITS services designed for professional and normal drivers and their functionality and limitations. In addition, the topic study offers some insight on the required cooperation and exchange of data between professional drivers and public authorities for C-ITS systems. Finally, the topic study introduces some best practices for increasing user acceptance of ITS and C-ITS and disseminating information on the systems in question to the public.

The topic study has listed a comprehensive set of C-ITS services, some of use to both professional and non-professional drivers, and some only applicable to the former. C-ITS for haulage operators has huge potential in terms of optimising routeing, ensuring safe and
secure parking with good facilities for the driver, reducing environmental impacts, and assisting drivers and managers in keeping to drivers' hours legislation. It would be interesting to investigate how all these potential C-ITS for HGVs measure up in terms of costs and benefits against the AV approach of platooning HGVs.

C-ITS for non-professional drivers also offer many benefits: in the fields of safety, convenience, comfort, reduced and / or more predictable journey times, and less environmental impact. If we assume user acceptance will continue to be forthcoming, the next topic to consider will be how quickly C-ITS services will spread through the fleet. While older and cheaper vehicles do not use them, their impact will be less, and the imperative for the road operator to support and deliver them will be less. On the other hand, when they have fully penetrated the fleet, costs associated with traditional forms of informing, advising and enforcing road users will fall away. Here is another interesting research topic: when and how will C-ITS become the normal way of operating our road network?

User acceptance is key, and user understanding is key to user acceptance. Whose job is it to make drivers, professional or not, understand the technology on our roads, and how do we create and satisfy an interest in understanding?

Information on C-ITS for both professional and non-professional drivers is widely available in the form of published papers, project reports, trade magazine articles, conference presentations and conference reports, etc. It was a dominant topic in ITS activity for a number of years until autonomous vehicles became the number one priority around the world, and as a result is very well documented. If there was an issue with material for this study, it was rather that there was too much available than too little. The authors have taken the view that the best use of space in the study is to mention all C-ITS briefly, rather than a few C-ITS in depth. Readers wanting to research any particular C-ITS in detail should follow up the references provided.

The one area of C-ITS where information is harder to come by is business cases and this topic is examined further in Topic study 6 (Financial incentives, business models and procurement models for C-ITS deployment). The ITS sector has seemed unable to develop the rigour necessary to conduct solid cost – benefit analysis, which would involve detailed before-and-after studies and a wide ranging look at costs and benefits which often accrue well outside the transport sector, for instance in public health or in employee productivity. The reasons for this weakness in the ITS sector are complex and well outside the scope of this study, but it should be noted that credible C-ITS cost-benefit analysis is not widely documented. The available information on these topics have been summarised in Topic study 5 (Impact assessment of ITS and impacts of selected ITS and C-ITS systems) and Topic study 7 (Cost-benefit analyses of ITS services).
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