Co-financed by the Connecting Europe Facility of the European Union

The C-Roads Platform

An overview of harmonised C-ITS deployment in Europe

C-ROADS


Years of work: 5 since platform kick-off
Kilometres covered by ITS-G5: 20,000
Platform members: 18 Core Members + 7 Associated Members
Kilometres equipped with cellular/long-range: +100,000
Number of cities involved: 53
RSUs operational in Europe (fixed & mobile): 2,300
Recipients of C-Roads harmonised communication profile: 50 countries, +480 persons/ institutions
Time invested in cross-tests: +3,000 hours

Table of contents

VIP Statements

Intelligent transport systems have the potential to revolutionise road safety, reduce congestion and improve the environmental performance and economic efficiency of road transport. As outlined in the European Commission's recent Sustainable and Smart Mobility Strategy, we need to seize the opportunities presented by smart digital solutions to make transport safer, more efficient and sustainable.

The steady positive trend towards higher levels of road safety in the EU is slowing. Road transport is still responsible for the bulk of transport emissions and pollutants. And every day, congested roads represent a huge cost to the EU economy. Digital technologies can help to address all these challenges. The efficient exchange of data means transport supply and demand can be matched in real time, leading to a more efficient use of resources, be it for shared vehicles, container deliveries or railway networks. With this, we can build a truly multimodal transport system integrating all modes of transport into a single, seamless mobility service, allowing people and cargo to travel smoothly from door to door, spurring social innovation and facilitating mobility for all.

And of course, by enabling vehicles to interact with each other, as well as with the surrounding infrastructure and other transport users, cooperative intelligent transport systems can drastically reduce human error, one of the greatest source of accidents in transport, while also improving traffic efficiency and comfort.

I am proud that the EU and the Member States have been at the forefront of this technology, not least thanks to the shared vision and strategy developed through the C-ITS platform, and the coordination of interoperable deployment in C-Roads, which has resulted in the real-life deployment today. I am confident we can build on this successful cooperation towards the full realisation of cooperative, connected and automated mobility for all.

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Adina Vălean,
European Commissioner for Transport

Intelligent Transport Systems (ITS) are one of the cornerstones for boosting road safety, promoting transport efficiency and enhancing greener and smarter mobility. For this reason, the deployment of ITS services throughout Europe has been a priority for the European Commission for many years. On top of the numerous research and development projects, the European Union has also funded the deployment of ITS through different sources, such as the EU's TEN-T programme (2007-2013) and, since 2014, the Connecting Europe Facility (CEF).

CEF has already provided over €500 million of EU funding to ITS projects, matching investments of more than €1.3 billion. More than 30% of this CEF funding goes to the development of Cooperative ITS (C-ITS). The C-Roads Platform is the result of the combination of this support with the financial commitment from Member States, road operators and other stakeholders, all cooperating towards a unified approach for a harmonised and interoperable deployment of C-ITS services across our continent.

CINEA (European Climate, Infrastructure and Environment Executive Agency) has a key role in supporting the European Green Deal, the roadmap for making the EU's economy sustainable and achieve climate neutrality by 2050. To this end, the Connecting Europe Facility programme will co-finance, between now and 2027, the construction and upgrade of vital infrastructure, and encourage the rollout of smarter and safer solutions for transport. These solutions and upgrades will hail a new era for the road transport sector, helping to propel it into the fully digital era.

As Director of CINEA, I would like to thank Member States' authorities and all stakeholders involved in the C-Roads Platform for their commitment, and I look forward to future cooperation to make European Road Networks connected, greener and smarter.

© European Climate, Infrastructure and Environment Executive Agency (CINEA)

Dirk Beckers,
Director of CINEA - European Climate, Infrastructure and Environment Executive Agency

Transport infrastructure is the backbone of the European Union. From a philosophical and political point of view, it helps realise the dream of the EU's founding fathers, built on the four freedoms. From an economic point of view, the freedoms connect territories, decision-making centres, companies and citizens within the single market and contribute to its wealth.

However, the transport sector of the 21st century must face the challenge of digital transformation. Indeed, for more than a decade, the sector has been faced with fundamental changes in its organisation and functioning due to the emergence of new uses and new mobility. This ongoing revolution has profound consequences for the relationship between citizens and mobility, but also for the business model of traditional stakeholders in the transport sector.

The C-Roads Platform is the keystone of this revolution. Thanks to collaboration between road operators from 18 countries, it demonstrates that the ambitious objective of deploying a connected road network by 2050 is perfectly achievable. C-Roads also creates an attractive environment in Europe for developing cutting-edge and disruptive technological expertise on C-ITS, in a fierce globally competitive environment. Moreover, C-Roads demonstrates that, by combining their strengths, the Member States and operators have the capacity to build an interoperable, connected sovereign European infrastructure network.

The strength of the C-Roads Platform also lies in its concrete operational approach. In point of fact, intelligent transport systems will make it possible to improve the safety and quality of the network, optimise traffic and relieve congestion in cities.

Lastly, the European C-Roads project is a fine example of what European cooperation can bring to territories, companies and citizens.

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Christel Fiorina,
Chair of the C-Roads Platform

In recent years, Advanced Driver Assistance Systems (ADAS) in vehicles have become more and more sophisticated, have made driving easier and have improved road safety significantly. However, there are limits to what can be achieved with vehicle-only systems. C-ITS is a natural supplement to ADAS as it allows information to be shared that cannot easily be obtained using other ADAS systems. It also provides yet another source of information to enable verification of observations by merging data with the information from existing ADAS systems.

C-ITS deployment is a long-term investment in future transport infrastructure as we move closer to automated driving. In an early phase of C-ITS deployment, it might be used to provide warnings to drivers, road operators and other road users. Future active interventions – such as braking – will use the C-ITS information as part of the decision-making process. In subsequent phases, C-ITS will allow for negotiations between vehicles, and between vehicles and infrastructure, and will consequently be one of the enablers of fully automated accident-free driving.

For the automotive industry, Europe is a single market and so common specifications for C-ITS deployment across Europe are seen as an important initiative. For the CAR 2 CAR Communication Consortium, close cooperation with C-Roads is and has been a unique opportunity to leverage the potential benefits of C-ITS for all parties involved. Working together on common standards for C-ITS and the use cases has allowed both parties to reach a deep understanding of what information is needed and can be made available through C-ITS and how it can and will be used.

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Niels Peter Skov Andersen,
General Manager of the CAR 2 CAR Communication Consortium

Origin and concept

Cooperative Intelligent Transport Systems (C-ITS or cooperative systems) encompass a group of technologies and applications that allow effective data exchange through wireless communication technologies between components and actors in the transport system, very often between different vehicles or between vehicles and infrastructure (V2V or V2I). What may sound quite theoretical and complex has a very clear and direct advantage for road users:

C-ITS offers drivers the right information at the right time, based on where they are and the situations they encounter.

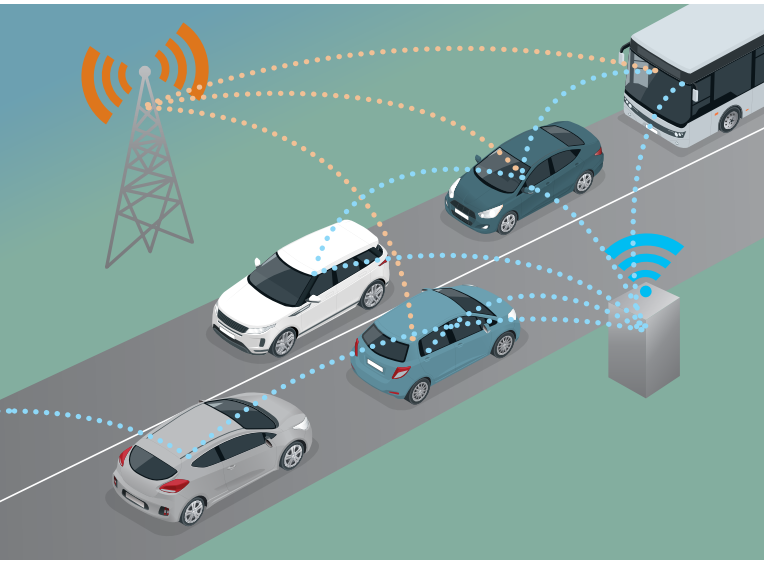

Fig. 1: The general principle of C-ITS, involving the communication between vehicles and roadside infrastructure

Consequently, C-ITS are highly capable of contributing to improvements in road safety in a targeted and individual way. With the necessary technologies deployed in traffic management centres, in vehicles and at roadsides, a range of situations and incidents on the road can be handled. These situations and incidents – and what to do when encountering them – are summarised in different sets of use cases. Although it is not an end in itself, C-ITS will also be a crucial enabler of automated driving and urban public transport management.

C-ITS has been at the centre of a number of projects[1] and European legislation[2], since 2008 and earlier. While the projects managed to lay down a sound, reliable basis for real-world operation of C-ITS, a legal and strategic framework was slowly but steadily being built up in parallel (e.g. ITS Action Plan). In 2008, the European Commission (EC) adopted a decision to reserve the 5.9 GHz band for safety-related ITS applications. This was followed by mandates to adopt specifications and standardisation, culminating initially in the publication of the EU C-ITS Strategy in 2016[3], the aim of which was to facilitate the convergence of investments and regulatory frameworks across the EU in order to see deployment of mature C-ITS services in 2019 and beyond.

The idea for the C-Roads Plaform

The need for a harmonised approach was identified on the basis of the insights gained in all previous initiatives and, at the same time, commitment and readiness for deployment was also visible. However, at the technical level, the projects and corridor initiatives did not take the final step to a coordinated pan-European approach, which was however necessary to ensure that all national efforts grew together in a concerted and harmonised way. To ensure this cross-border harmonisation of C-ITS, the C-Roads Platform was realised in 2016. Its distinct separation between platform and pilot activities gives flexibility to the national deployment activities while making sure that they all fit together in an pan-European perspective.

C-ITS services

What are C-ITS services?

The deployment of C-ITS is an evolutionary process that began with less complex ITS applications. These are referred to as "Day 1 services" and, in most cases, are applicable to motorway environments. The reason for starting with motorways is that – because they are designed for higher speeds – vehicles travel at more uniform speeds and traffic is less susceptible to unforeseeable factors. However, when something does not function in its usual way, impacts tend to be more severe. This first set of services can be developed further and applied as more specific use cases or in environments other than motorways, such as urban and peri-urban sections of road.

1 COOPERS, CVIS, Safespot, euroFOT, Drive C2X, C-ITS Corridor, etc.
2 ITS Action Plan, Decision 2008/671/EC, ITS Directive (mandate to adopt specifications), Standardisation mandate of EC
3 COM (2016) 766 - A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility

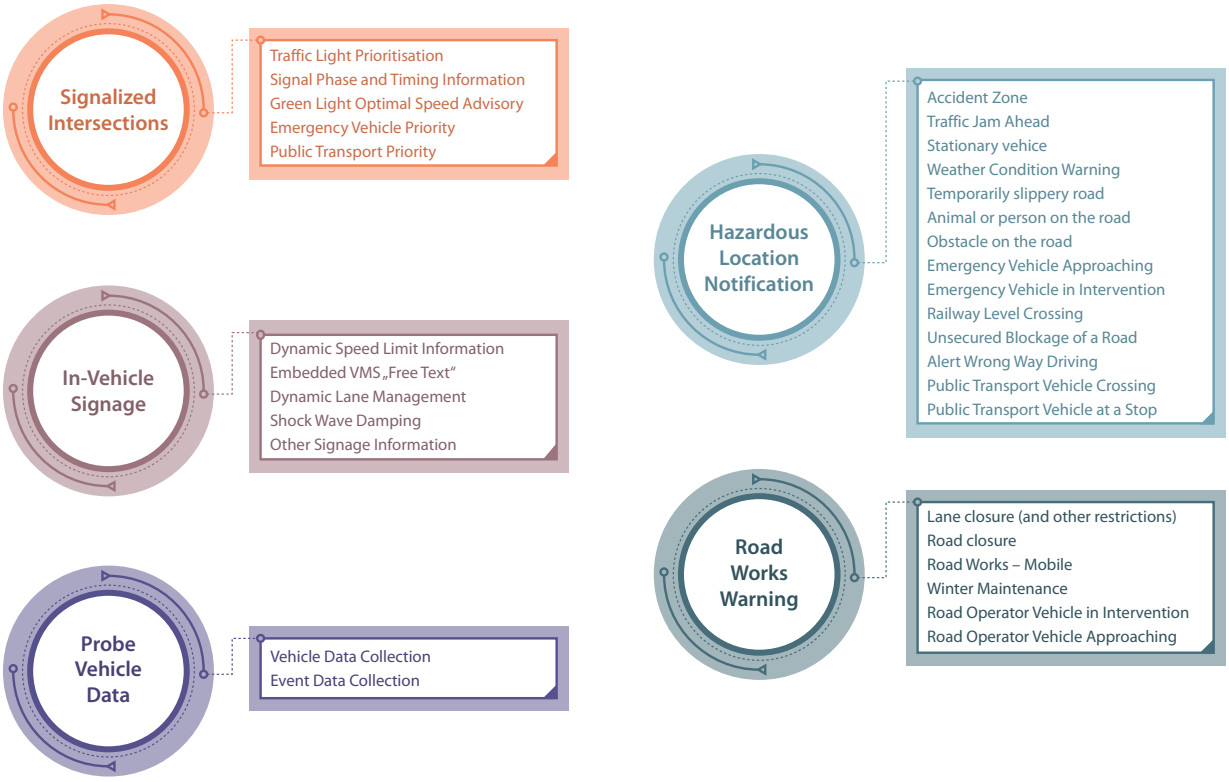

Fig. 2: All verified Day 1, Day1.5 and Day 2 C-ITS services and use cases

The purpose of these services is to improve traffic safety and traffic flow efficiency and to minimise external factors. As there is a certain dynamic nature to the factors that influence these aspects, service definitions have sometimes been modified and adapted to recent insights and operative needs. Nevertheless, there are three main operational tasks that the C-ITS services are intended to serve:

- To provide **information** to road users to improve road safety and comfort during a journey
- To display **regulatory boundaries** using signs that inform road users of specific obligations, restrictions or prohibitions
- To provide **warnings** to road users about incidents ahead an d their exact nature (if possible)

As of mid-2021, Day 1 services have become much more comprehensive in comparison to the way the services were initially conceived. The harmonised communication profile issued regularly by the C-Roads Platform covers all Day 1 services and also goes beyond the initial service definition by including a range of wireless communication technologies. The next generation of services (Day 1.5 and Day 2) will also be defined and harmonised using C-Roads Platform specifications.

How are C-ITS services deployed?

In order to put in place C-ITS services of any kind, communication technologies are obviously required. The starting point for pilot deployments is the short-range communication technology **ETSI ITS-G5** (basically WiFi boxes) and existing **cellular networks**. In accordance with the European C-ITS strategy, the C-Roads Platform also supports the combination of both technologies in a **hybrid communication mix**.

While the concept of "services" and "use cases" might seem somewhat confusing at first glance, their interplay represents a very effective mechanism for moving from developing an initial vision to providing tangible and relevant services that are installed in a harmonised European framework.

The first range of Day 1 services was published as part of the European Union's C-ITS Strategy[4] in 2016, at the same time that the C-Roads Platform was launched. Since then the services have evolved through refinements suggested by the technical working groups and industrial partners. Although the relevance of some services might be at the broader level and others may focus on very specific situations, they are all equally important in the big picture of harmonised European

4 COM (2016) 766 – A European strategy on Cooperative Intelligent Transport Systems, a milestone towards cooperative, connected and automated mobility

C-ITS deployment. Within the C-Roads Platform, all use cases are jointly elaborated and coordinated to build the basis for the development of C-ITS services (as part of the harmonised communication profile). The following diagram gives an overview of how operative C-ITS services come into existence.

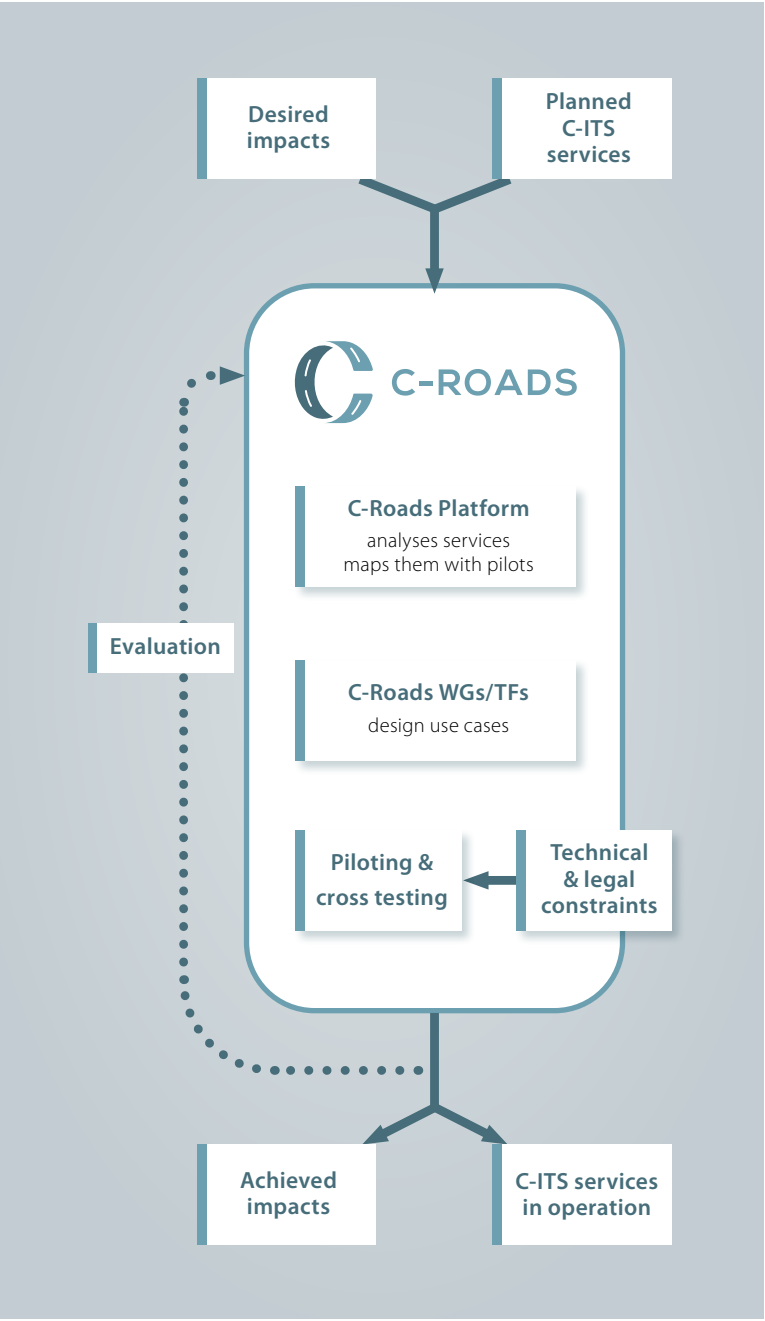

Fig. 3: The relation between C-ITS use cases and services

A service begins to emerge with the vision of the impact its developers want to achieve with the service and so is determined by the development of use cases that support the service. With development and implementation needs taken into account, the service might evolve or change to a certain degree as long as the original intended effect of the service is retained or even broadened. A service might consist of several use cases and a single use case may also be applicable to several services in a different context; for example, a closed lane may be relevant for Road Works Warning and Hazardous Location Notification.

Why use C-ITS services?

The main aim in deploying C-ITS services is to increase road safety and support drivers during journeys. In order to verify that this goal is achieved and end users' needs are fully addressed, the C-Roads Platform includes a thorough set of evaluation mechanisms. During the various test cycles, the pilots evaluate the impacts of Day 1 and Day 1.5 C-ITS services and use cases implemented in the following impact areas:

- User Acceptance
- Functional evaluation
- Socio-economic aspects
- Road safety
- Traffic efficiency
- Environmental effects

There is a particular focus on motorists' behaviour and how it is influenced by C-ITS services. During the field tests, different parameters are collected, measured or calculated to identify impact on behaviour as a result of the availability of C-ITS services. In order to ensure comparability of results, all pilots use the same guidelines to assess and evaluate the main impacts of C-ITS service introduction, covering aspects such as speed, acceleration and lane changes.

Preliminary results from some pilots have revealed that C-ITS is still an unkown matter for many people; however, the information provided through the services was considered relevant and useful. The most important information covered all types of road blockage, either caused by an accident, an obstacle, road closure or large animals on the road. C-ITS services are therefore often perceived as improving the flow of traffic and road safety. Motorists also appear to be willing to share data related to weather or road conditions collected by their vehicle, whereas information about their speed and location raised more concerns. In support of the harmonised approach of the C-Roads Platform, the possibility of receiving uniform C-ITS service coverage in other countries was considered important when driving abroad.

From the road operator perspective, the cost-benefit comparison indicates that, by 2030, the benefits of C-ITS deployment will exceed both the total of annual operating and maintenance costs as well as the investment costs up to that year in all countries, even in the low effectiveness scenario. However, sensitivity analysis showed that the outcome of the socioeconomic impact assessment depended significantly on the assumptions made in terms of coverage, use

and effectiveness of the services. This makes it all the more important to continue to pursue efforts to harmonise C-ITS across Europe, thereby contributing to broad and coordinated coverage to the maximum benefit of both the end users and the operators.

Organisational structure

The C-Roads Platform approach seeks cooperation at a holistic level in order to cover all of the dimensions linked to the deployment of C-ITS, such as sharing experiences and knowledge regarding deployment and implementation issues, as well as user acceptance. In order for this to work properly, a clear distinction is made between **overarching platform activities** and **national pilots.**

The C-Roads Platform is smanaged by the C-Roads **Steering Committee,** which is made up of representatives from the Member States. Decisions to achieve the goal of implementing interoperable end-user services are made with the help of the **Supporting Secretariat.** In this context, specifications that are proposed and recommended by specific Working Groups are approved. These specifications are the basis for implementing use cases and providing services in the single pilot activities.

In line with the bottom-up approach at the technical level, C-Roads clearly has to include national pilot sites. This will not be their sole function; instead they will form the basis of C-ITS implementation across Europe, along with coordination through the C-Roads-Platform. Based on results at national level, and widely discussed in the C-Roads Platform, together with common agreements and specifications on specific issues including security and privacy, the national pilot initiatives will move on to cross-site testing which will allow them to grow together and achieve transnational interoperability. A number of strategic milestones have formed the basis for establishing and supporting harmonisation as the fundamental connecting element in the platform as well as for for the wider scope and cross-border convergence of piloted services, and will continue to do so in the C-Roads 2 projects. This includes activities such as defined updates of the harmonised communication profile, plans for operational test infrastructure and evaluation. Reports on legal structures, security and interoperability of C-ITS services are another important factor. In this way, C-Roads will be able to ensure cohesion of C-ITS deployment in the European Union for long-term operational roll-out.

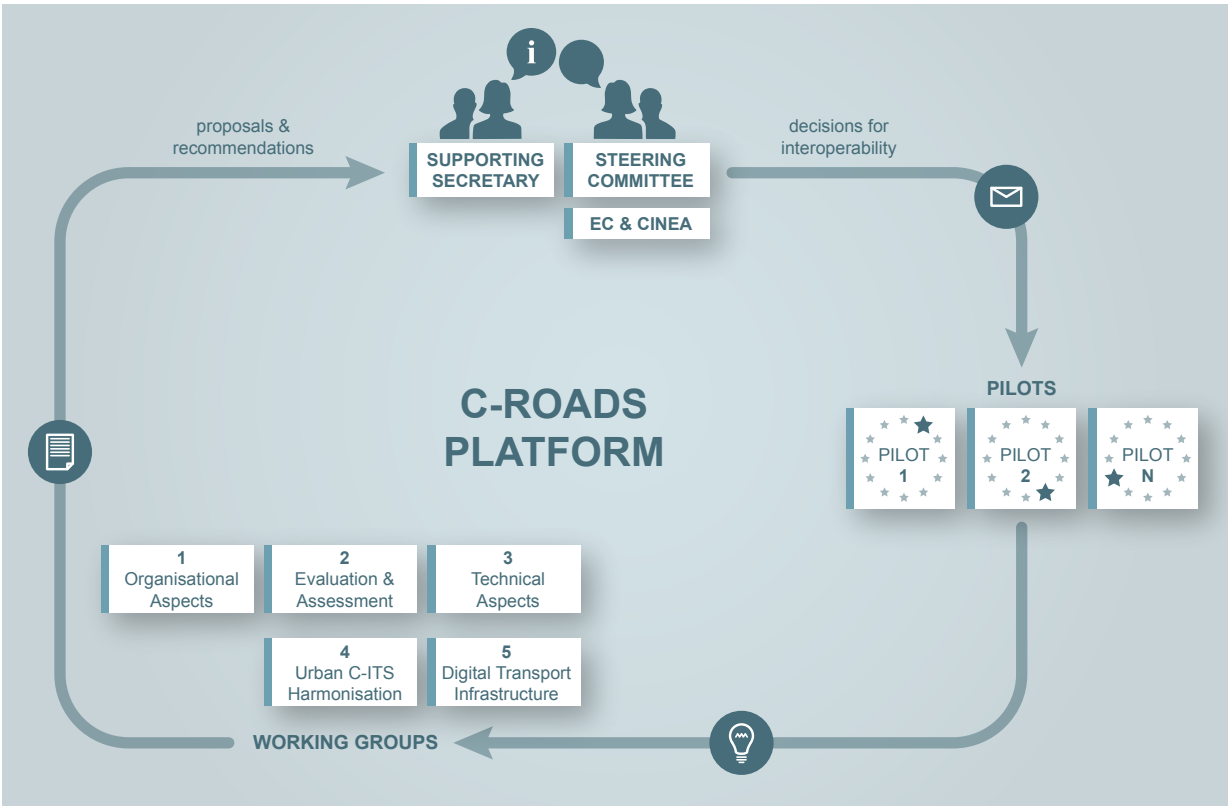

Fig. 4: The governance structure of the C-Roads Platform

The principle of Core Members and Associated Members

The **Core Members** of C-Roads are actively working together as part of a project submitted in response to a call by the Connecting Europe Facility (CEF). Their aim is to achieve deployments that enable interoperable and seamless cross-border C-ITS services for European travellers by linking the C-ITS pilot deployment projects in the EU Member States. Collaboration involves the joint development, sharing and publishing of common technical specifications and verifying their interoperability through cross-site testing. Based on the harmonised communication profiles, they are conducting system tests that encompass C-ITS's two main technologies (ETSI ITS-G5 and cellular networks), where each can be applied as a standalone or combined in a hybrid communication mix.

Associated Members, on the other hand, are representatives of states that are closely following the C-Roads Platform and the pilot deployments of C-ITS services, but do not have a voting right. They nevertheless have comprehensive access to the knowledge that has been collected and recognise the general principles of the C-Roads Platform. They are thereby committing themselves to following the C-Roads specifications in their own C-ITS pilot deployments.

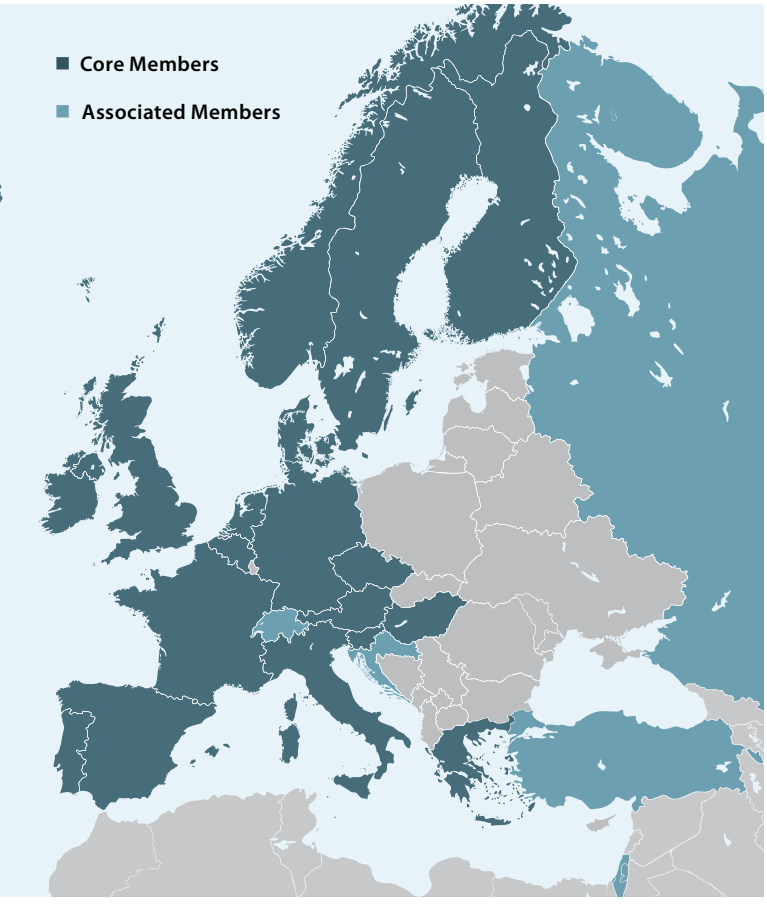

Fig. 5: The Core Members and Associated Members of the C-Roads Platform

The different iterations of the C-Roads Platform

Cooperation and harmonisation have always been considered fundamental enabling factors in the C-Roads environment. As part of an overall European perspective, this naturally includes establishing and extending cooperation between the various European states, but also involves connecting with external interest groups, associations and initiatives. This multi-faceted approach provides mutual access for stakeholders and the C-Roads Platform to technical developments and to a forum to work at the strategic level to make the transition into operational status for C-ITS together.

The C-Roads Platform was initially launched on 4 October 2016, and comprised authorities and road operators from **eight European Member States** (Austria, Belgium, the Czech Republic, France, Germany, Netherlands, Slovenia and the UK). As an open platform, the clear mission was to harmonise the deployment activities of C-ITS across Europe and beyond. This overarching perspective, which took into account national interests and priorities while harmonising them across borders, was the main appeal of the C-Roads concept and was the factor that attracted other states and organisations to join the platform and commit to a common strategic approach.

The **CAR 2 CAR Communication Consortium** (C2C CC) has been an important partner since the beginning. It brings together leading European and international vehicle manufacturers, equipment suppliers, engineering companies, road operators and research institutions in the deployment of C-ITS to prevent road accidents. C2C CC's cooperation with C-Roads was made official in 2017 when a Memorandum of Understanding (MoU) was signed.

Enlargement of the C-Roads Platform was the logical next step and was ratified in November 2017. Now with **sixteen European States** (with Denmark, Finland, Hungary, Italy, Norway, Portugal, Spain and Sweden added) participating as Core Members, the C-Roads Platform approach had a greater capacity to pursue cooperation at a whole European level. Enlargement allowed for improved coverage of all aspects linked to the deployment of C-ITS, such as the sharing of experiences and knowledge about deployment and implementation issues and about user acceptance.

In March 2018, C-Roads' strategic efforts took another step forward with a new MoU signed with **ASECAP** (the European Association of Operators of Toll Road Infrastructures). European harmonisation is a high priority for both organisations and they have since then combined their strategic efforts towards creating and supporting seamless services for road users.

The MoU between **DATEX II** and the C-Roads Platform, signed in 2019, was another major European initiative for harmonisation committed to a joint approach on C-ITS deployment. The considerable potential for synergies led to

an agreement to adapt the DATEX II model to develop C-ITS services. Requirements in both C-ITS and DATEX II messages were harmonised and aligned to guarantee the efficient exchange of information.
2019 was also the year that another two EU Member States joined the C-Roads Platform. Ireland and Greece increased membership to **eighteen Core Member countries.** This increase in quantity was accompanied by a qualitative increase with the inclusion of **urban use cases by seven platform members.**

Technical structure

The harmonised communication profile

One of the most powerful means C-Roads has for ensuring and supporting harmonisation of C-ITS across Europe is the set of specifications that has been developed jointly both within the platform and in cooperation with external stakeholders such as the CAR 2 CAR Communication Consortium. The specifications are updated and published at regular intervals and are known as the **harmonised communication profile.**

The primary target audience for the C-Roads specifications are road authorities (e.g. policy makers, road operators, traffic managers, traffic engineers) who are responsible for maintaining and operating roads in order to maintain traffic safety, traffic flow efficiency and minimise external factors. They are also targeted at industry and service providers who deliver the capabilities for the required functionality.
C-Roads established a process to ensure a new release is delivered every six months. The release documents contain specific requirements, standards or use-case descriptions. This includes, for example, C-ITS security and governance issues, service and use-case definitions, C-ITS message profiles and parameters, profiles for ITS-G5 and IP-based communication, and information about cross-border testing.
As indicated in the diagram below, each of the documents is intended to support implementation of C-ITS at different stages:

- Stage 1: Begin C-ITS Implementation
- Stage 2: High Level Service Specific Definitions
- Stage 3: System Specification
- Stage 4: Architecture & Technology Definition (including ITS-G5 and IP-based technology)
- Stage 5: Test & Pilot

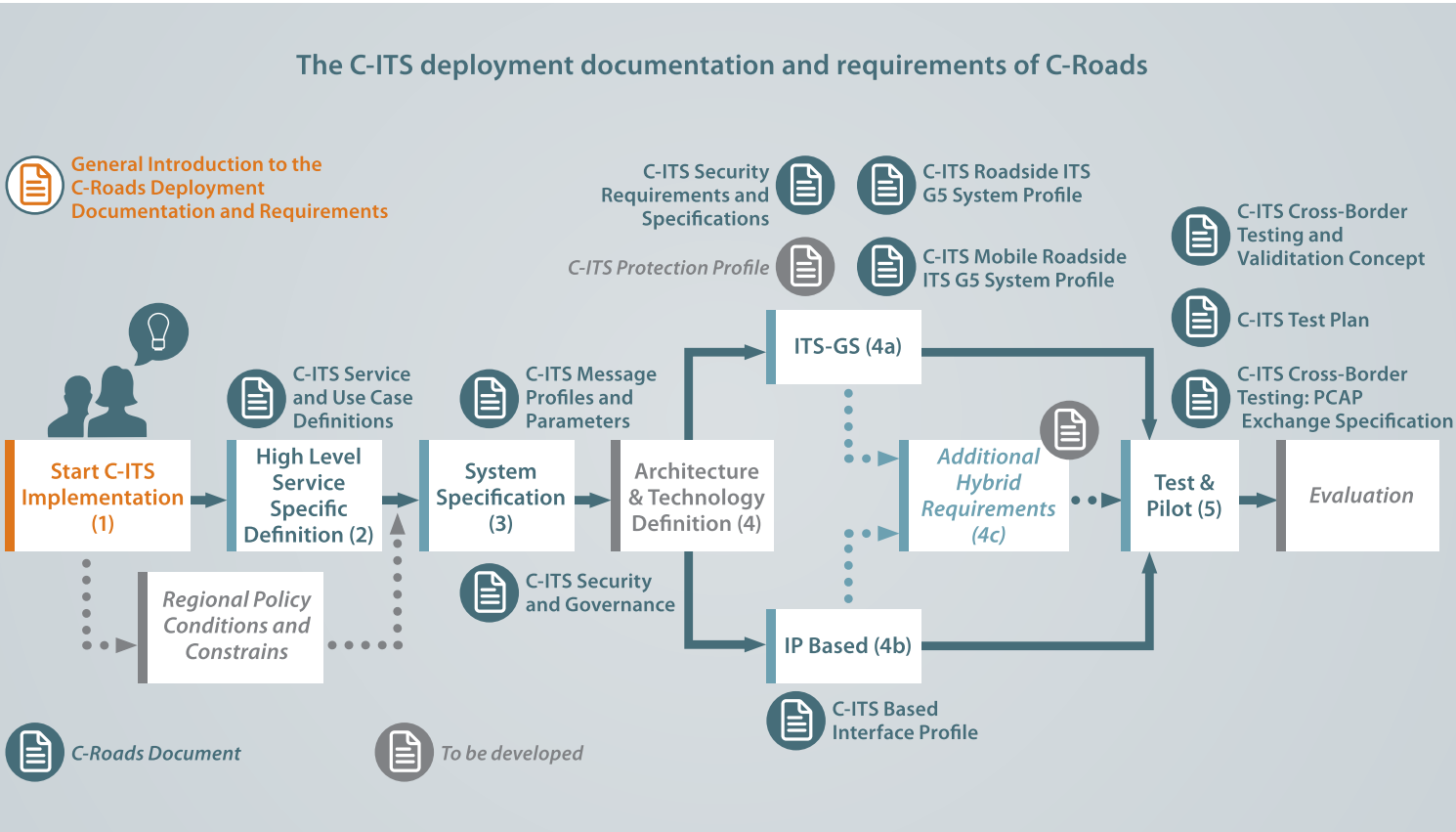

Fig. 6: The process of elaborating new specifications for the harmonised communication profile

The harmonised communication profile is the high point of harmonisation, surpassing the C-Roads Platform's organisational borders, and forming the basis for the roll-out of infrastructure-driven C-ITS services across the whole of the EU. Since its initial release, it has been requested more than 480 times and has been distributed to 50 countries all over the world. It can be requested free of charge from the C-Roads website (www.c-roads.eu) and recipients will automatically be notified as soon as an updated version is published.

Service interoperability based on cross-testing

Within the C-Roads Platform, harmonisation is not just a buzzword but a vital, integral part of the C-Roads Platform as it holds the whole model together at all levels, including both the organisational and technical perspectives. In road transport, C-ITS typically involves vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. In order to enable an efficient and uninterrupted exchange of information, especially uniform cross-border implementation of this service, harmonised C-ITS specifications are essential.
There is obviously not much point connecting vehicles and road infrastructure if the services provided do not work when crossing borders or if they suddenly work in a completely different way. Therefore, in order to optimise cross-border harmonisation, C-Roads has included the principle of cross-testing from the very beginning as an important aspect of harmonisation work, so that vehicles equipped with C-ITS are tested on foreign pilot sections in Europe.
To enable this to function properly, the C-Roads Platform differentiated the test environments into single-country tests and cross-border tests, which involve two or more countries, operators or manufacturers. The requirements in the profiles were also divided into three different categories.

- **Category 1 (C1):** Requirements labelled C1 are relevant for local implementation and have to be tested in the country of implementation.
- **Category 2 (C2):** Requirements labelled C2 are relevant for cross-border interoperability but can be tested within the environment of the local country, operator or manufacturer. They are, however, a prerequisite for further cross-border testing.
- **Category 3 (C3):** Requirements labelled C3 need to be validated by means of actual cross-border tests.

To ensure that results are harmonised and comparable, each hosting Member State is required to use a common template and common process for reporting all C-Roads cross-border testing results.

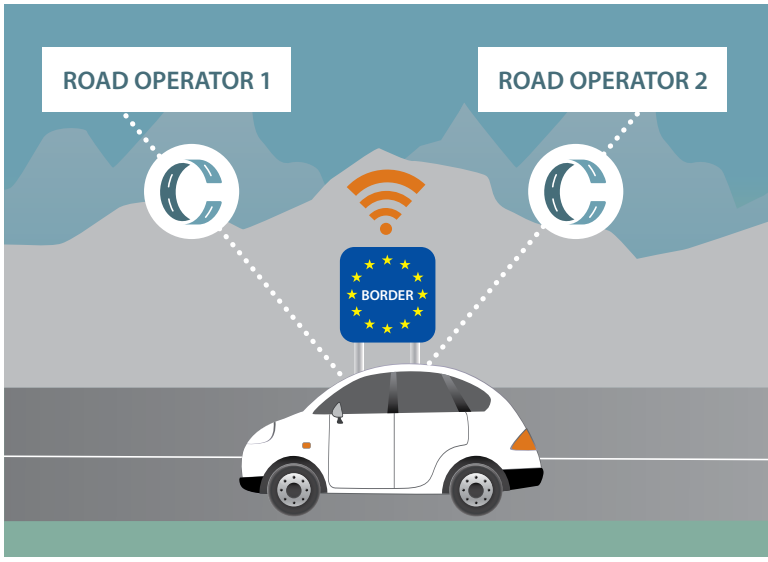

Fig. 7: Ensuring transnational harmonisation of C-ITS services through cross-testing

As explained in the previous section, the Stage 5 deliverables (Test & Pilot) provide the basis for validating the interoperability of C-ITS implementation and provide a guide through all aspects of interoperability testing for C-ITS services. These documents contain a common procedure for generating and naming data packets (PCAP files) for cross-border exchange between C-Roads project partners. This procedure enables interoperability testing by using a range of equipment before the actual road tests take place. As a result of travel restrictions caused by the COVID-19 pandemic, virtual testing sessions have also been explicitly defined and successfully conducted. All C-Roads partners have currently set up and tested their pilot implementations, and numerous cross-border tests have so far been conducted. Tests of this kind ensure that all vehicles in Europe speak the same "C-ITS language" and can connect with each other and the road infrastructure. Tests of this kind are of great importance for the harmonisation of C-ITS across the European Union and also represent the basis for subsequent services supporting connected and automated driving.

Security context

The European ITS-Station architecture[5] defines a set of sub-systems which allow diversification and future options to extend the applicable standards used. In order to achieve interoperability between sub-systems, many of these options need to be made specific, they need to be described by profiles with selected options and should include additional specifications to ensure interoperability. The profile provides

5 outlined in EN 302 665

descriptions, definitions and rules for all levels of the reference architecture. Management issues are included, but security is out of scope, which again raises the need to focus on this topic separately. Industry stakeholders viewed the security of Infrastructure-to-Vehicle (I2V) and Vehicle-to-Infrastructure (V2I) communication as a potential impediment to C-ITS roll-out.

The reports on C-ITS security aspects were therefore processed in what is known as a public key infrastructure (PKI). This is a set of roles, policies, hardware, software and procedures required to create, manage, distribute, use, store and revoke digital certificates and manage public-key encryption. Working with the industry, C-Roads aligned the definitions of the required technical elements and agreed within a specific PKI architecture.

The defined elements in the EU PKI for secure data exchange and communication between C-ITS stations were put out for tender by the European Commission in 2019 and 2020 in accordance with the agreed security and certificate policy specifications. The EC confirmed that it would handle the operation for a minimum of five years. The following diagram gives an overview of the PKI.

The core elements of the PKI have been implemented – including a commonly defined trust list (ECTL) – and have been publicly accessible at the European Union's Central Point of Contact – (CPOC) since May 2020[6]. The list of participating entities has continued to grow since then and is regularly published in order to support the safe deployment of C-ITS in Europe.

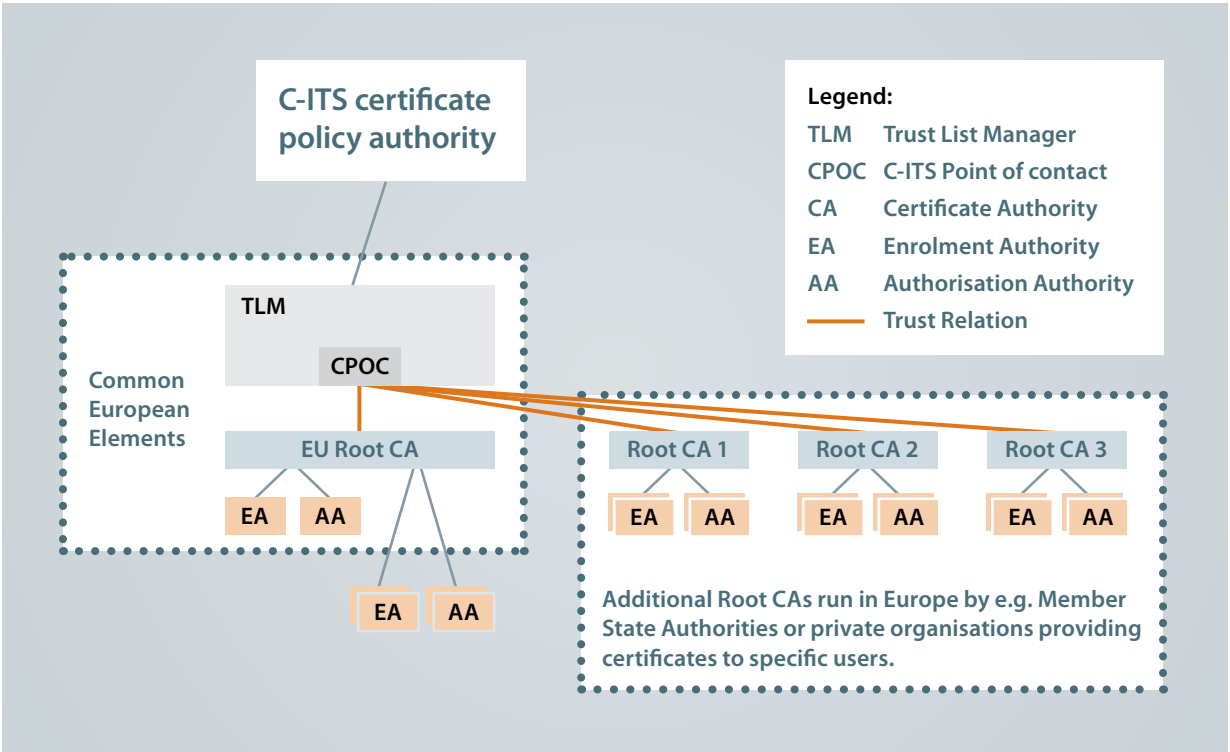

Fig. 8: The Public Key infrastructure for C-ITS

6 Refer also to:
www.ec.europa.eu/transport/sites/transport/files/c-its_certificate_policy_release_1.pdf
www.ec.europa.eu/transport/sites/transport/files/c-its_security_policy_release_1.pdf
www.c-its-deployment-group.eu
www.cpoc.jrc.ec.europa.eu/ECTL.html

C-Roads Austria

Scan or click the QR code for more information

Summary facts

Dedicated C-ITS pilot

- 25 ITS-G5 roadside stations around Vienna, Graz and Linz

Operational C-ITS deployment

- Fully "hybrid" C-ITS system with short-range ITS-G5 and long-range cellular communication
- Includes roadside, vehicle and trailer deployments
- Roadside deployments
  - › 175 ITS-G5 roadside stations operational until the end of 2021
  - › Surrounding Vienna and Graz, the "west corridor" from Vienna to Linz to Salzburg, and several border regions
  - › Extendable to a maximum number of 525 ITS-G5 roadside stations until the end of 2023
- Vehicle deployments
  - › 100 road operator (amber/blue light) vehicles equipped with ITS-G5 vehicle stations until 2023
- Trailer deployments
  - › 15 multifunctional roadworks trailers including ITS-G5 stations deployed in 2020

Fig. 9: Location of the Austrian C-ITS pilot sites

Pilot description

C-Roads Austria was built on the European C-ITS Corridor project in Austria (ECo-AT[7]), as defined in the Austrian C-ITS Strategy. The aim was to replace the ECo-AT Living Lab with an operational C-ITS system on the Austrian motorway network. For this, a large tender for the national rollout of a fully "hybrid" C-ITS roadside system was issued in 2018, including several hundred roadside stations and various Day 1 and future Day 2 use cases from the C-Roads catalogue.

After the formation of the **C-ITS Deployment Group**[8] and its successful statement on continued deployment in late 2019, a first contract for dedicated pilot installations was awarded in late 2019, with 25 ITS-G5 roadside stations around Vienna, Graz and Linz. In the same year, a framework contract for roadworks trailers equipped with ITS-G5 was established. The tender for national roadside C-ITS deployment was concluded in October 2020 and a framework contract was awarded to Siemens Mobility Austria. Out of that framework, the initial contract included the delivery of the central C-ITS station and 175 ITS-G5 roadside stations, including service and operation for up to twelve years. Until the end of 2021, these roadside stations will be placed on the motorways around Vienna, the west corridor Vienna-Linz-Salzburg (as part of the C-ITS corridor Rotterdam-Frankfurt-Vienna), around Graz and on several border regions.

In addition to the roadside deployment of C-ITS, Austria also decided to equip ASFINAG's road operator vehicles with C-ITS on-board units until the end of 2021. A contract to equip 100 vehicles was awarded in 2020 to Kapsch TrafficCom AG out of an existing framework tender.

From 2022 onwards, the operational deployment of C-ITS in Austria will continue in C-Roads Austria 2. The roadside framework contract allows for the deployment of up to 525 roadside stations on Austria's motorway network, shortening the average distance between to stations to less than 4 kilometers. The coming years of C-Roads Austria 2 will also see significant deployment in the urban areas of Graz, Salzburg and Vienna. Until 2023, the gaps between motorways and urban areas will be bridged and incorporate city-specific issues such as frequently congested commuting sections. Heavy focus will be on including public transport as part of the overall multimodal traffic management strategies.

7 http://eco-at.info/home-en.html
8 https://c-its-deployment-group.eu/

C-Roads Belgium (Flanders)

Scan or click the QR code for more information

Summary facts

Project duration: 02/2016 - 06/2021

Milestones:

- Q1-2019: 11 use cases were developed and ready for testing
- Q3-2019: start of pilot with limited users, delay problems detected.
- Q1-2020: System ready for full range pilot.
- Q4-2020: End of pilot with 650 users having tested the app.
- Q2-2021: Evaluation report expected.

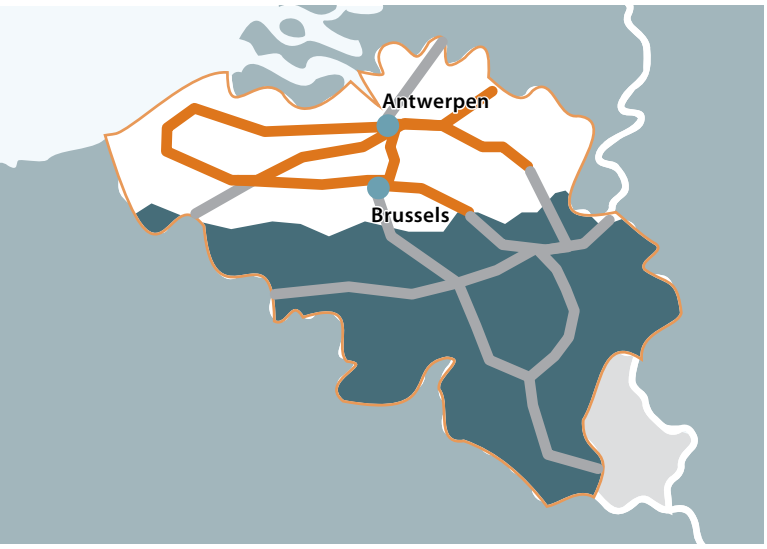

Fig. 10: Location of the Belgium (Flanders) pilot site

Pilot description

At the test site existing cellular based 3G-4G/LTE mobile communication networks was used in combination with the HERE Location Cloud and the local Traffic Management Centre which allowed a group of approximately 650 test drivers to receive and potentially update selected Safety Related Traffic Information (SRTI) using low latency data exchange, in line with the European Commission Delegated Regulation 886/2013. As a cooperation between road authorities and services providers, the pilot features partners from various areas:

- Flemish Department of Mobility
- HERE
- ITS.be
- Tractebel Engineering

The pilot covers all motorways part of the core network in Flanders, including R001, E313, E17/ E19, E34 and E40 that are part of TEN-T corridors. For evaluation purposes emphasis was given to the E313/ E34 segments. The following Use cases were developed:

1. Stationary Vehicle
2. Accident Area
3. Obstacle on the road
4. Road Works
5. Slow Moving Vehicle
6. Slippery Road
7. Traffic Jam Ahead
8. Shockwave Damping
9. Reduced Visibility
10. Extreme Weather Condition
11. In-Vehicle Signage

The main objective of the C-Roads Flemish pilot was to operate and assess the deployment of a cloud based 'virtual infrastructure' for the effective deployment of C- ITS services connecting road users with the Traffic Management Centre (TMC) while allowing the TMC to directly interact with the end users. A smartphone application called Hermes was developed as interface with the test drivers. A dashboard for the interface between the TMC and the system was also developed.

By the end of 2020, the pilot was finalised with around 650 users participated. In late 2020, there was a limited cross-border test with the Netherlands and with the Belgian Walloon region. The results were promising in terms of interoperability and end user perception. The final results of the evaluation report will be available in summer 2021.

C-Roads Belgium (Wallonia)

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Summary facts

- 427 km of Walloon motorways covered with cellular communication
- One crucial junction equipped with 5 ITS-G5 Road Side Units

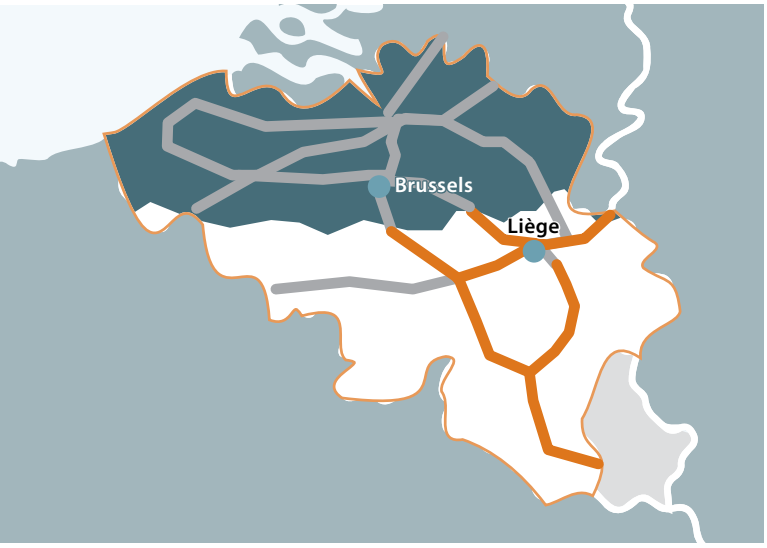

Fig. 11: Location of the Belgium (Wallonia) pilot site

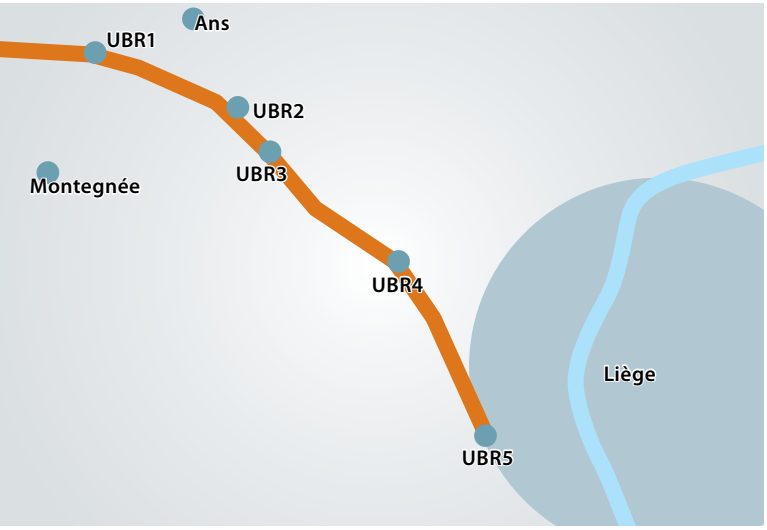

Fig. 12: Localisation of the RSU's near Liège

Pilot description

The main objectives of the C-Roads Wallonia pilot include the operation and assessment of the deployment of a cloud based solution for C-ITS services. In further consequence, this means connecting road users with Traffic management centres (TMC) and allowing the operators in the TMC to directly interact with the end users. The pilot has contributed to expanding and upgrading Traffic Information Services and Traffic Management Services offered today, building on a digital infrastructure. The results feed and support a discussion on the future role of the public road operator.

As a cooperation between road authorities and services providers, the pilot features partners from various areas with experience from previous implementation work related to many traffic information and traffic management services on the motorway network:

- SOFICO (technically assisted by Public Service of Wallonia / Directorate of Road Traffic Management)
- Tractebel Engineering SA
- ITS Belgium

SOFICO is financing an extensive ITS strategy from 2017 onward to renovate and increase C-ITS systems along its highway and road network. A new traffic management centre has been recently equipped with a new traffic management system. Wallonia has worked on the modernisation of its traffic management based on the newest technologies through different interfaces for data collection, data management and for road user information.

As member state of the C-Roads platform, Wallonia is participating in the testing and implementing of harmonised and interoperable C-ITS services. Through a Partnership in between SOFICO, Tractebel and ITS Belgium, **two pilot projects** for C-ITS use cases deployment have been implemented on the Wallonia highway network.

For the first one, the focus has been placed on the ITS - G5 technology: **5 RSU's** have been installed on the A602 junction as well as a C-ITS messages server. The A602 junction hosts important traffic volumes and features major security issues since it consists in an urban environment highway featuring a succession of tunnels and bridges through the city of Liège.

For the part based on cellular communication (4G) technology, after having considered the development of a specific own application, it has been decided to work with Coyote, a service provider already active on the Belgian market.The pilot will be deployed along approximately **427 km of Walloon motorways** via the Coyote community.

C-Roads Czech Republic

Scan or click the QR code for more information

Summary facts

- Start/end date (important milestones): February 2016 / December 2021
- Motorways covered: Hybrid ITS-G5/LTE system deployed, 230 km covered by ITS-G5
- Cities involved: 3
- Urban intersections equipped: 25
- Railway level crossings equipped: 4
- Roadside units in total: 115
- Motorway maintenance vehicles equipped: 109
- Advance warning trailers equipped: 124
- Trams, buses and trolley buses equipped: 7
- Emergency vehicles equipped: 1 fire rescue response vehicle

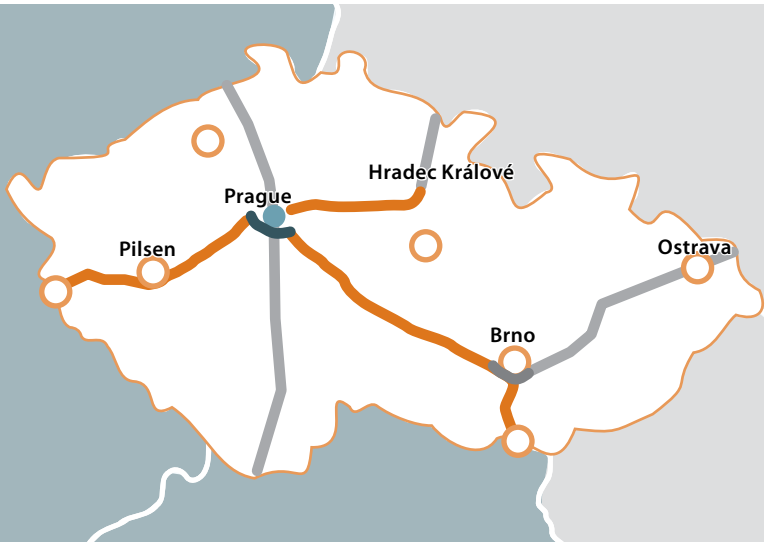

Fig. 13: Location of the Czech C-ITS pilots

The government strategy for ITS deployment in the Czech Republic 2021-2027 emphasises the significant impact of C-ITS on transport safety through the reduction in traffic accidents in both numbers and severity, resulting in reduced social costs. C-ITS can support all modes of transport, not just passenger cars, as commonly perceived today. Initiatives like C-Roads Czech Republic provide valuable feedback to the Ministry of Transport and knowledge base for future C-ITS deployment.

Pilot description

The Czech Republic is one of the founding members of the C-Roads Platform because of its previous experience implementing C-ITS technology. The pilot has targeted cities, public transport and railway level crossings as well as motorways. The cities of Brno, Ostrava and Pilsen are among the first European cities where C-ITS has been fully implemented. Similarly, the first trams and the first railway level crossing signalling systems in Europe were equipped with C-ITS technology as part of the Czech C-Roads pilot.

C-ITS services put in place on the sections of Czech motorways, provide secure warning messages to drivers about road works, slow and stationary vehicles, hazardous locations and approaching emergency vehicles, allowing motorists to adjust the way they are driving. In addition to information for motorists, the Road Works Warning service also protects road workers through messages that inform motorists about road works ahead. National field tests were carried out in March 2020 to check the functionality of the system.

In an urban context, the road operator in Brno has brought together a number of public and private stakeholders to form a complex C-ITS system, which is already being used in cooperation with public transport and the fire brigade. In line with C-Roads' harmonisation approach, it was demonstrated that it is even possible to create a functional and fully interoperable cooperative C-ITS network with so many different actors. In the cities of Ostrava and Pilsen, the specific challenge of equipping public transport vehicles involved the need to deal with special railway regulations. This has highlighted future demand for coordinating these requirements more closely with C-ITS equipment manufacturers.

Further pilots interfacing with other modes of transport were conducted in the Pardubice region. Customised C-ITS systems for broadcasting the status of level crossings were deployed on two intersections in 2019 to increase safety on crucial sections. Two additional railway level crossings in the Ústí n. L. region were equipped with the systems in 2020, followed by testing and evaluation activities.

C-Roads Czech Republic has addressed the issue of personal data protection, which is a necessity for the system's credibility with its users. A subsequently formed European working group confirmed the problem that current legislation on personal data protection makes it virtually impossible to build an open C-ITS system. The project outcome is a recommendation to set up an international group of experts to suggest future changes in legislation to allow new transport solutions.

C-Roads Finland (NordicWay project)

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Summary facts

- The NordicWay 2 project started on 7 February 2017 and ended on 31 December 2020.
- The NordicWay 3 project started on 1 February 2019 and ends on 31 December 2023.

Fig. 14: Locations of the NordicWay C-ITS pilot projects in Denmark, Finland, Norway and Sweden - nationwide mobile network coverages and individual test locations

The NordicWay projects are mainly based on cellular cloud communication. Finland has 1 Roadside Unit pilot deployed in a city environment for private industry testing.

Pilot description

The Finnish pilot was part of the NordicWay 2 project (2017-2020) and is currently part of the NordicWay 3 project (2019-2023) pilots running in the Nordic countries of Denmark, Finland, Norway and Sweden. The main objectives of the NordicWay actions are to deploy pilot studies in order to further develop interoperable Day 1 and Day 1.5 C-ITS services and support infrastructure readiness for connected and automated driving. The NordicWay 3 project (2019-2023) will continue to harmonise and build European C-ITS interoperability in the C-Roads Platform (www.nordicway.net).

The **Arctic challenge for automated driving in snowy and icy arctic conditions** addressed automated driving in snowy and icy arctic conditions. The pilot included posts and poles for guidance and positioning, C-ITS hybrid communication, communication infrastructure, including pre-5G, remote driving and vehicle positioning. The pilot studies were completed with prototype automated vehicles around Finland and evaluated on Muonio Intelligent Road in North Lapland to guarantee winter conditions. The project results are available online in the Finnish Transport Infrastructure Agency publication [9].

The activity **Relevant Day 1 services on core corridor** piloted Day 1 and Day 1.5 services in Finland based on cellular communication, covering the whole main road network in Finland (80,000 km). Most of the data was provided around ring roads and major incoming roads in the Helsinki region, and from the E18 between Helsinki and Turku and between Helsinki and Tampere. The full evaluation results of the Finnish and other NordicWay 2 pilots are available at www.nordicway.net.

The Finnish pilot deployed the following Day 1 and Day 1.5 services and use cases:

- Slow and stationary vehicle(s) & Traffic ahead warning
  - › Use case: Traffic jam ahead
- Road works warning
  - › Use case: Road and lane closure
- Weather and road condition
  - › Use case: Weather conditions, Reduced visibility, Temporary slippery road
- Other hazardous location notifications (OHLN)
  - › Use cases: Accident zone description, Emergency vehicle approaching, Animal or person on the road, Obstacle on the road
- In-vehicle signage
  - › Use case: In-vehicle speed limits
- Probe vehicle data
  - › Use case: Single-vehicle data
- Traffic information and smart routing

Activities using cellular and C-Roads hybrid communication technologies will be implemented between 2021-2023.

9 https://julkaisut.vayla.fi/pdf12/vt_2019-19_arctic_challenge_web.pdf

C-Roads France & InterCor

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Summary facts

- Start date: 16/02/2016 for C-Roads France and 1/09/2016 for InterCor
- End date: 31/12/2021 for C-Roads France and 29/02/2020 for InterCor
- Location :
  - › 4 local pilot sites for C-Roads France and InterCor
- 146 roadside units and 66 on-board units deployed in C-Roads Fr + 46 roadside units and 50 on-board units deployed in InterCor.

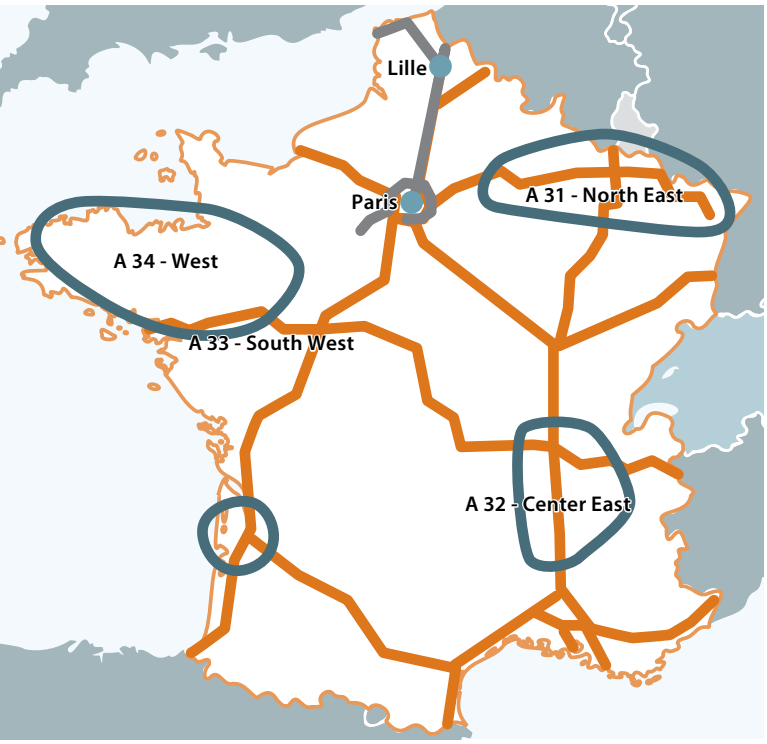

Fig. 15: Location of the French C-ITS pilot locations

France plans to commission systems and services developed within Scoop@F, C-Roads France and InterCor on local sites by the end of 2021. For harmonised use cases, systems are planned to be in line with level L1 as defined by the European Commission, allowing services to be delivered to compatible vehicles. In order to increase penetration rates, France has deployed a fully functional app in its hybrid C-ITS architecture.

Pilot description

France is participating in C-Roads phase 1 via two pilots: C-Roads France and InterCor. These two projects build mainly on SCOOP@F, which was the first pilot at national level to test C-ITS with all the different players in the operating chain: road operators, road authorities, car manufacturers, cyber-security providers, etc. Both pilots aim to go further in experimentation with and assessement of C-ITS services, tackling new issues such as urban use cases and a mobile application in the case of C-Roads France, and freight-related use cases for InterCor.

The aim of the pilots is to push for the early adoption of flexible, interoperable and scalable C-ITS solutions. Their involvement in the C-Roads Platform is intended to foster harmonisation of C-ITS at European level, i.e. on strategic topics such as security. They provide extended test beds that include strategic sections of the TEN-T Core Network, key bottlenecks and black spots and interfaces with urban hubs.

C-Roads France is a deployment project. New services were developed in addition to those developed in SCOOP@F: services in the urban environment and at the urban/interurban interface (such as GLOSA), and in-vehicle traffic information (such as dynamic speed limits and dynamic lane management). This project has contributed to the deployment of 146 R-ITSS and 66 V-ITSS on road operator vehicles on four sites in France, covering different road configurations and use cases. The project has also developed a C-ITS smartphone application that supports early I2V services for roll-out and further scaling-up.

InterCor is also a deployment project. The use cases developed contain road work warnings, traffic management services, multimodal cargo transport optimisation and lorry parking information in particular. They were implemented in a cross-border section in the north of France, which was equipped with 46 R-ITSS and 50 V-ITSS.

Services on C-Roads France and InterCor are supported by hybrid technology that enables seamless switching between ITS-G5 and cellular. They provide a consistent solution for the deployment of almost all Day 1 services and of some of the Day 1,5 services as defined by the C-ITS Platform.

French partners will pursue this work through InDiD (C-Roads phase 2), which will focus on testing new urban use cases and technologies related to enhanced perception (for automated vehicles). This pilot will also allow the smartphone app to be pursued further and for preparations to be made for the industrialisation of C-ITS solutions.

C-Roads Germany

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Summary facts

- Location(s) of actions:
  - Federal states of Hessen and and Niedersachsen (Phase 1)
  - City of Hamburg, Kassel and Dresden (Phase 2)
- Implementation Schedule:
  - Phase 1 started 01/02/2016 and ends 31/12/2021
  - Phase 2 started 01/01/2019 and ends 31/12/2023
- Phase 1 Deployment of Day 1 C-ITS services:
  - C-ITS Pilot Hessen: 60 Roadside-ITS-Stations and Vehicle-ITS-Stations, 7 C-ITS services on 280 km motorway
  - C-ITS Pilot Niedersachsen: 3 Roadside-ITS-Stations, 2 Vehicle-ITS-Stations, 3 C-ITS services on 22 km motorway
- Phase 2 Deployment Day 1 and Day 1.5 C-ITS services:
  - C-ITS Pilot Hamburg: 140 Roadside-ITS-Stations, 3 C-ITS services on 38 km urban roads
  - C-ITS Pilot Hessen/Kassel: 85 Roadside-ITS-Stations, 46 Vehicle-ITS-Stations, 6 C-ITS services on 21 km urban roads
  - C-ITS Pilot Dresden: 30 Roadside-ITS-Stations, 2 Vehicle-ITS-Stations, 5 C-ITS services on urban roads

Fig. 16: Location of the German C-ITS pilots in Hessen and Niedersachsen

Pilot description

Since 2016, C-Roads Germany has been one of 19 national pilots that have been testing trial C-ITS services in a real traffic environment. As a Member State, Germany is contributing to the C-Roads cooperation via the results of the implementation and operation of a total of eight different Day 1 C-ITS services that use ETSI ITS-G5 (short range) communication on motorways. These services have been implemented at two different pilot sites. The national demonstration events involving the C-ITS Pilots in Hessen and Niedersachsen took place at the end of 2020.

The services in Hessen were deployed on the Test Field Germany and were implemented by Autobahn GmbH, Swarco Traffic Systems, AVT Stoye, Continental Teves, GEVAS Software, Heusch/Boesefeldt, Bayrische Medien Technik, Hessen Digital Radio and Garmin Würzburg. The Hessian C-ITS infrastructure was improved by expanding the existing services, road works warning and probe vehicle data, and by implementing five new C-ITS services. Extensive tests ensured a regular exchange of information to harmonise specifications and functionalities.

The services in Niedersachsen were deployed on the North Sea-Baltic and Orient/East-Mediterranean corridor (motorway A2/A39) near Braunschweig and Wolfsburg and were implemented by NORDSYS, OECON, IAV, the Ministry for Economy, Labour, Transport and Digitalisation in Niedersachsen, e-Shuttle, ESCRYPT and the German Aerospace Center (DLR) as associate partner. The activities focused on three new C-ITS services on the A2 motoway, the connection between these 3 roadside stations and the Traffic Management Centre and the future connection of a further 12 roadside stations along the A39 motorway.

The C-Roads Germany consortium consists of 18 partners. From the very beginning, ITS mobility has led C-Roads Germany as the project coordinator alongside the Federal Highway Research Institute (BASt) as technical coordinator.

In 2019, the deployment of C-ITS in urban areas began with the new C-Roads Germany - Urban Nodes project, which will end in December 2023. Within the framework of the C-Roads Platform, the project contributes to the implementation and operation of services in three different urban nodes in Hamburg, Hessen/Kassel and Dresden. As a geographical extension and technical complement to the first C-Roads Germany project, this guarantees the support and harmonisation of Day 1 and Day 1.5 C-ITS-services in urban environments.

The deployment of C-ITS services is an important milestone for Germany in increasing road safety, making traffic more efficient and reducing emissions. C-Roads Germany has implemented at large scale a broad range of C-ITS services on motorways: connecting traffic management centres, field infrastructure and vehicles. The mobility of the future can be experienced in Germany today.

C-Roads Hungary

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Summary facts

- 07/11/2017 Hungary joins C-Roads Platform as a core member
- 08/07/2020 Works contract signed
- 18/02/2021 Pilot installation operational
- 70 fixed road side units
- 20 mobile units
- 20 test OBUs
- 405 km, and 10 urban junctions covered with C-ITS services

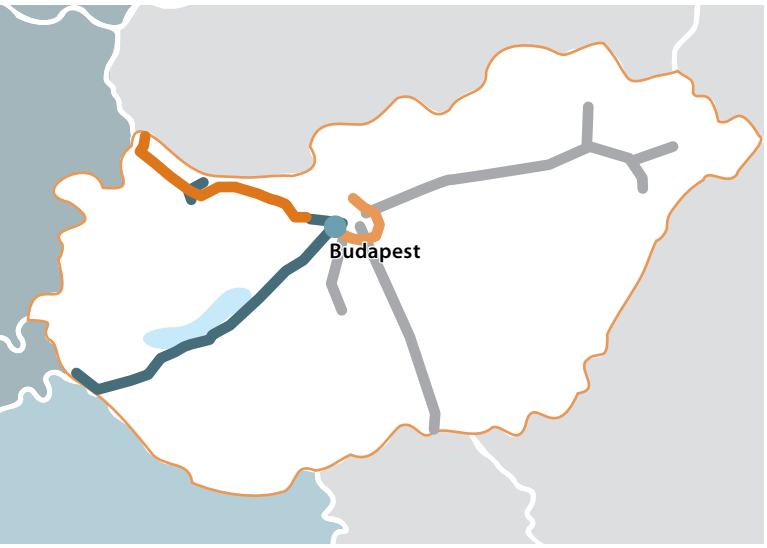

Fig. 17: Location of the Hungarian C-ITS pilots

Although technological innovation causes plenty of challenges for road operators and leaves many uncertainties for CCAD, Hungarian Public Roads is focusing on supporting connected mobility. The ongoing deployments involving a national C-ITS infrastructure and a planned European C-ITS ecosystem also help this goal by providing more valuable information, best practice and harmonisation guidelines.

Pilot description

In Hungary, C-ITS deployment started back in 2015. A 136-km-long stretch of the M1 motorway between Austria and Budapest was selected for C-ITS services pilot deployment. The focus of the trial was the improvement of road safety – especially in work zones – therefore maintenance vehicles and mobile RSUs were also installed, which can also operate in stand-alone mode. As part of C-Roads, the Hungarian Public Roads company carried out an upgrade and extension of the 2015 pilot in terms of coverage and functionality. Additional Day 1 use cases were introduced with the capability of hybrid communication along the M1 motorway (towards Austria), and the M7 motorway (towards Croatia and Slovenia). Besides core network corridors, special attention was also paid to urban applications. Traffic light controllers were improved in the town of Győr in order to provide TTG/GLOSA information at 10 neghbouring junctions along the main traffic route, where intersection safety services are also available. The pilot sites have been operational since February 2021.

Hungary has also already signed the grant agreement for C-Roads 2 Hungary, as a continuation of the current phase. The planned Hungarian work programme devotes particular attention to creating an urban test environment for autonomous and connected vehicles in the town of Zalaegerszeg, linked to the Automotive Proving Ground Zala (APZ), and building on the experiences of the pilot project in Győr. The deployment will focus on Day 1 and Day 1.5 C-ITS services with the option of scaling up to Day 2 C-ITS services. The "ZalaZone" is the greater area that includes the town and the test track that will be ready for autonomous vehicle testing, but there are even more ambitious plans. As part of trilateral multi-level cooperation, Austria, Slovenia and Hungary plan to implement cross-border test routes. C-Roads 2 Hungary will enhance this effort by implementing C-ITS services in the greater city area and TEN-T corridors (with domestic and cross-border sections).

C-Roads Italy

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Summary facts

- Start 08/02/2017/end date 31/12/2021 (important milestones)
- Locations of the Italian pilot site
- 82 RSUs installed along the 367 km of road sections involved in the first pilot.

Fig. 18: Location of the Italian C-ITS pilots

Technological innovation and new business models have generated demand for new mobility services. Digital technologies are one of the most important, if not the most important, drivers of this process. In the coming years, digital infrastructure will acquire significant importance and will support connected and automated vehicles to make road transport safer, more efficient and more sustainable.

Pilot description

C-Roads Italy has implemented and tested a set of "Day 1" and "Day 1.5" C-ITS services in real traffic conditions. Moreover, cooperative systems based on V2X technologies have been deployed and tested for the following automated driving applications: truck Platooning and Highway Chauffeur.

Four trucks were equipped with innovative technology to enable platooning and interaction with the C-ITS Day 1 services implemented. The vehicles are currently able to send and receive ITS-G5 standard messages, interacting with the infrastructure and other cooperative vehicles.

Extensive driving activity is currently ongoing, and will see more than 300,000 km travelled with active platooning technology. The vehicle communication will be tested to Infrastructure (V2I) and related C-ITS services, such as Electronic Emergency Brake Light (EEBL), the Slow or Stationary Vehicle Warning, Traffic Jam or Road Works Warnings, In-vehicle signage or In-vehicle speed limits.

Highway Chauffeur is a supervised automated and cooperative driving functionality for passenger cars along motorways with a maximum speed of up to 130 km/h.

3 vehicles were equipped with C-ITS technology and are currently operational along the Brenner corridor motorway. The on-board equipment installed includes modules both for connectivity and for the processing of the V2X information. In particular, vehicle connectivity regards V2X communication via ETSI ITS G5 and 4G cloud connectivity in order to exchange messages with other vehicles and to receive messages from the RSUs installed along the infrastructure test site.

Considering that integrating Cooperative Intelligent Transportation Systems into existing urban transport environments will require a new drive toward standardisation in Europe, in 2018 a second phase of C-Roads Italy started to study and pilot C-ITS services in real urban traffic conditions in the cities of Turin, Verona and Trento, including:

- Green Light Optimal Speed Advisory (GLOSA)
- Traffic signal priority request by designated vehicles
- Signal violation/Intersection safety
- On street parking management & information
- Traffic Information and Smart Routing

C-Roads Netherlands

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Summary facts

- Total pilot network: 268 km
- 60 km (22%) on comprehensive network

Fig. 19: Location of the Dutch C-ITS pilots

Pilot description

The Dutch Corridor Area that forms part of the InterCor project is situated in the south of the Netherlands. In its role carrying out the practical execution of the work of the Dutch Ministry of Infrastructure and the Environment, the Rijkswaterstaat (the Dutch Directorate-General for Public Works and Water Management) is supporting the development and dissemination of innovative road solutions. Based on the work on services it has carried out for InterCor, the Netherlands is providing enhanced and extended test fields, including strategic sections of the TEN-T Core Network, thereby strengthening the efforts of the C-Roads community.
The Day 1 services Road Works Warning (RWW), Probe Vehicle Data (PVD) and In Vehicle Signage (IVS) have been tested and implemented in the whole Dutch Corridor Area.
A parking information service for lorries was also tested and implemented. This service indicates locations of, and free spaces at, lorry parks along the whole Dutch Corridor Area.
Tunnel management information uses information from traffic management systems to communicate with logistics companies to optimise road usage through information before and during journeys. The solutions are therefore able to cover travelling at other times or using different routes. This can save logistics companies a lot of time and help reduce congestion for the road authority.
The tunnel management service is based on Day 1 services such as in-vehicle signage and road works warning, using the hybrid communication concept. A service focused on optimising delivery of cargo goods was piloted near the port of Rotterdam, the industrial area of Moerdijk and the trade port of Venlo. This service, which is based on the speed-docking concept, is focused on the optimisation of multimodal cargo container loading and unloading and the planning of cargo goods delivery. In order to reduce the built-in slack in delivery planning, transport will follow the principle of just-in-time planning via various measures along the corridor, including dynamic speed advice, temporary parking and forecast waiting times.
The reduction of slack has resulted in less buffering at nodes and roads and therefore a reduction in congestion, emissions and costs. This pilot site uses previous achievements to build on deployment initiatives with ITS equipment that are already operational or being installed, such as the ITS corridor, eCoMove, Compass4D, the Beter Benutten programme, DRIVEC2X and FREILOT.

C-Roads Slovenia

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Summary facts

- In 2017 the upgrade of the ITS infrastructure began, and in 2019 the pilot site for ITS-G5 roadside infrastructure was prepared and 10 ITS-G5 roadside units were installed.
- First set of C-ITS Day 1 services implemented and tested in 2019.
- Location-aware mobile application using cellular technology launched and evaluated in 2019.
- ITS-G5 roadside infrastructure upgraded with PKI and second set of C-ITS Day 1 services implemented in 2020.

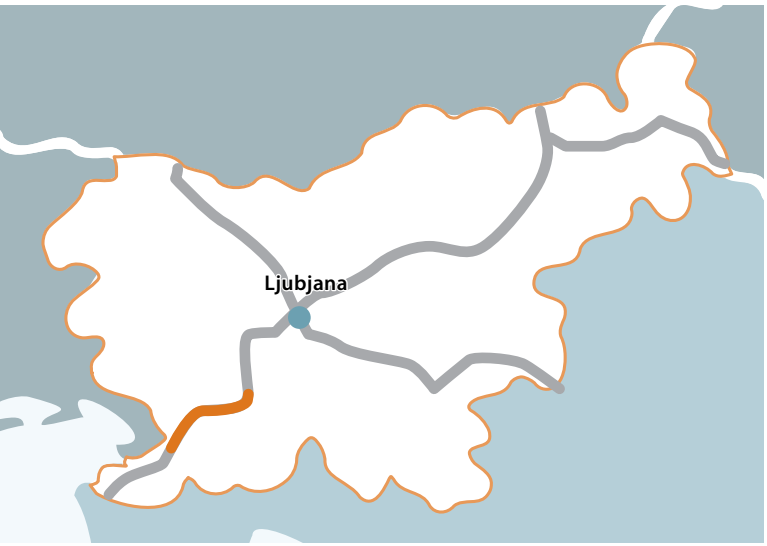

Fig. 20: Location of the Slovenian C-ITS pilot

Pilot description

Since 2016, DARS, the Slovenian implementing body, has deployed Day 1 C-ITS services using both short-range ITS-G5 and long-range cellular technologies. The services have been implemented on the A1 motorway section between Postojna and Divača as part of the TEN-T core network. The pilot site was deliberately chosen because of the extreme weather conditions that occur, especially in winter (strong winds, fog, snowstorms), frequently causing traffic accidents involving up to 70 vehicles (in 2016). The overall length of the test site is 24 km, where nine roadside units are installed at fixed positions. The roadside units are connected to the traffic management centre in Kozina. Additionally, one mobile roadside station was set up to broadcast C-ITS messages in stand-alone mode (e.g. with trailers). The central application, running in the back office, allows various C-ITS messages to be triggered to implement use cases involving the services Hazardous Location Notification, Road Works Warning and In-Vehicle Signage, in line with the C-Roads harmonised specifications. In 2020, the roadside ITS-G5 infrastructure was upgraded and equipped with PKI to guarantee secure C-ITS communications.

Alongside activities related to ITS-G5 roadside infrastructure, the ITS infrastructure was upgraded and integrated into real-time services, with real-time traffic information becoming operational in 2019. Provision of real-time traffic information supports cloud information services. In 2017, cellular connected car activities began, resulting in a location-aware mobile application for end users. It was launched, successfully tested and evaluated in 2019.

The next steps for C-ITS services deployment in Slovenia in C-Roads 2 are already in progress. In 2020, the pilot implementation of automatic transfer of traffic events from tunnel monitor and control systems into the information cloud was successfully implemented. The positive results mean that the project will be extended to other regional traffic management centres, including automatic transfer of traffic events from other traffic management and control systems. At the same time, the roadside infrastructure will be upgraded via the installation of additional ITS-G5 roadside units. The mobile application for end users will be updated with new features to improve users' experience. In order to enable hybrid C-ITS solutions, development of the C-ITS IP basic interface is also in progress, with implementation scheduled to finish in 2021.

C-Roads Sweden (NordicWay project)

Scan or click the QR code for more information

Summary facts

- The NordicWay 2 project started on 7 February 2017 and ended on 31 December 2020.
- The NordicWay 3 project started on 1 February 2019 and ends on 31 December 2023.

Fig. 21: Locations of the NordicWay C-ITS pilot projects in Denmark, Finland, Norway and Sweden - nationwide mobile network coverages and individual test locations

The NordicWay projects are mainly based on cellular cloud communication. Sweden has 2 mobile roadside unit pilots deployed.

Pilot description

The Swedish pilot was part of the NordicWay 2 project (2017-2020) and is currently part of the NordicWay 3 project (2019-2023) pilots running in the Nordic countries of Denmark, Finland, Norway and Sweden. The main objectives of the NordicWay actions are to deploy pilot studies in order to further develop interoperable Day 1 and Day 1.5 C-ITS services and support infrastructure readiness for connected and automated driving. The NordicWay 3 project (2019-2023) will continue to harmonise and build European C-ITS interoperability in the C-Roads Platform (www.nordicway.net).

The Swedish NordicWay 2 pilot covered C-ITS Day 1 and Day 1.5 services in urban and interurban areas.

The pilot covered the design, implementation, testing and evaluation of relevant Day 1 and Day 1.5 services in urban and interurban areas. By including a range of operating environments, from city streets to inter-urban motorways, the pilot was able to assess the viability of different applications on different types of road network.

The pilot was based on the use of a set of state-of-the-art passenger cars, public transport buses and heavy goods vehicles which were equipped with appropriate driver interfaces and connected through clouds by cellular and, for certain applications, ETSI ITS-G5 communication technologies.

The aim of the Swedish pilot was to demonstrate the possibility of communicating between vehicles, infrastructure and clouds and to show the interoperability, scalability and flexibility of the NordicWay interchange network with connected clouds. This was shown by testing Day 1 and Day 1.5 services.

C-ITS Day 1 services:

- Emergency vehicle approaching (EVA)
- Connected Traffic Signals including:
  - › Traffic signal priority request by designated vehicles (TSP)
  - › Green Light Optimal Speed Advisory (GLOSA)
- Hazardous Location notification (HLW): Roads works warning, emergency brake light, Emergency vehicle approaching and other hazards.

C-ITS Day 1.5 services:

- Traffic information and smart routing (TISR)
- Dynamic environmental zones

The NordicWay 3 pilot will build on NordicWay 2 and scale up the services being implemented or close to implementation. The Swedish pilots will be carried out in close coordination with the other countries within NordicWay 3.

C-Roads United Kingdom

Scan or click the QR code for more information

Summary facts

- The UK's pilot services were deployed in phases from October 2018 when a hybrid communications 'TESTFEST' was held. Full pilot operations commenced in March 2019 and completed at the end of February 2020.
- The pilot comprised long-range cellular only services on TfL's network, long-range cellular and short range (ITS-G5) on HE's network (hybrid) and a short-range ITS-G5 GLOSA service on KCC's network.
- New roadside ITS-G5 infrastructure was deployed for HE's and KCC's pilot services, including 32 new roadside units that were installed on the M2 and a single beacon that was installed at KCC's GLOSA site.
- Utilising partner vehicle fleets a total of 271 usable evaluation test runs were carried out over the entire pilot operation period.

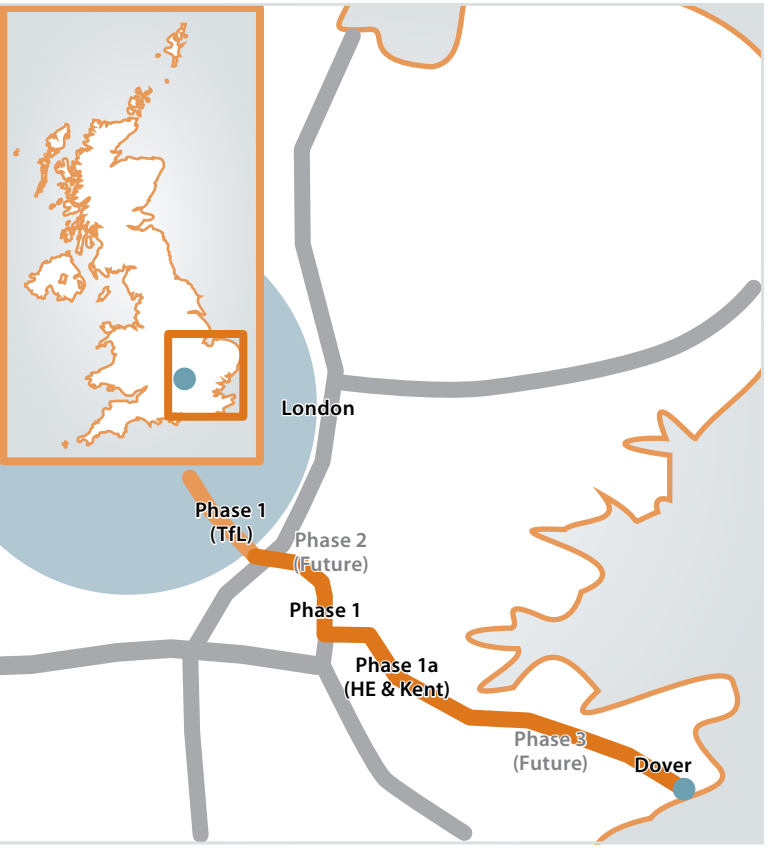

Fig. 22: Location of the United Kingdom C-ITS pilots

Pilot description

The United Kingdom pilot "A2M2 Connected Corridor" conceived in 2015, is located in the south-east of England on a 110 km corridor from Greenwich in London to Dover. Implemented by four partner organisations – the Department for Transport (UK project lead), Transport for London (TfL), Highways England (HE) and Kent County Council (KCC), with technical support from consultants WSP and Capita – the route incorporated urban, inter-urban and rural roads that provided a variety of operational environments in which to develop, test and evaluate the UK's pilot C-ITS services. The UK focused on the development, operation and evaluation of an interoperable C-ITS platform and the Road Work Warning (RWW), In Vehicle Signage (IVS), Probe Vehicle Data (PVD) and Green Light Optimised Speed Advice (GLOSA) services.

The UK has no national data centre for real-time traffic systems data, so C-ITS service data from the UK highway authorities' partners (TfL, HE and KCC) was integrated at a Unified Interchange Node (UIN) developed specifically for the InterCor project services. Each highway authority developed its own back-office traffic control systems and systems interfaces (APIs) to enable their systems data to be output and then received by the UIN. The UK's high-level systems architecture was developed by the UK project team in discussion with other European project partners in InterCor, to ensure compatibility between the UK's and the other Member States' systems. Security was implemented with manual certificates valid only for the duration of the chosen testing event, with the long-term UK preference is still to be decided.

The majority of the vehicle fleet used for evaluation were Kent County Council works vehicles that used the routes regularly and were called upon for randomised controlled testing as per the evaluation detailed methodology (focused test events). The UK partners and associates as well as European partners taking part in the InterCor TESTFESTs all contributed towards the testing and evaluation.

The pilot completed operations at the end of February 2020 with the results being published on the InterCor website (https://intercor-project.eu/library). The future of the pilot is uncertain, in part due to the impact of COVID-19, but the UK is successfully utilising the learning from the A2-M2/InterCor in developing its policy approach to the roll-out and evaluation of connected vehicle services in the future.

C-Roads Denmak (NordicWay project)

Scan or click the QR code for more information

Summary facts

- The NordicWay 2 project started on 7 February 2017 and ended on 31 December 2020.
- The NordicWay 3 project started on 1 February 2019 and ends on 31 December 2023.

Fig. 23: Locations of the NordicWay C-ITS pilot projects in Denmark, Finland, Norway and Sweden - nationwide mobile network coverages and individual test locations

The NordicWay projects are mainly based on cellular cloud communication. Denmark has not deployed roadside units in the pilot.

Pilot description

The Danish pilot was part of the NordicWay 2 project (2017-2020) and is currently part of the NordicWay 3 projects (2019-2023) with pilots in Denmark, Finland, Norway and Sweden. The main objectives of the NordicWay actions are to deploy pilot studies in order to further develop interoperable Day 1 and Day 1.5 C-ITS services and support infrastructure readiness for connected and automated driving in Denmark, Finland, Norway and Sweden.

The NordicWay 2 project (2017-2020):

- Contributed to the harmonisation and interoperability of the C-ITS services in Europe with requirements agreed by the C-Roads Platform.
- Supported the deployment of new "Day 1" and "Day 1.5" C-ITS services in the Nordic countries and extend its use in vital road freight transport routes, subject to extreme weather conditions, and in urban and interurban environments.
- Supported the infrastructure readiness for connected and automated driving in the Nordic countries in snowy and icy arctic conditions.
- Evaluation results (2020) include technical feasibility, ecosystem and business models, socio-economic impacts of the piloted Day 1 and Day 1.5 C-ITS services as well as the impact on users' mobility and traffic behaviour and on public acceptance. Final evaluation results are available in www.nordicway.net.

The NordicWay 3 project (2019-2023) will continue to harmonise and build European C-ITS interoperability in the C-Roads Platform.

The Danish contribution to NordicWay focuses on the integration of traffic management centres into the NordicWay interchange network. The central systems of the Danish national traffic management centre are connected directly to the interchange network. All messages generated and broadcast from the Danish traffic management centre are available to all NordicWay partners in real-time through the interchange. This was demonstrated in 2019 during the NordicWay tour, where a car drove through the Nordic countries using the main roads across Denmark and received real-time information on incidents, roadworks and variable speed limits along the entire route.

Furthermore, the national traffic management centre is able to receive real-time information from all the other NordicWay partners in order to create a better overview of the current situation on Danish roads. Denmark is contributing to NordicWay horizontal activities, such as interoperability issues, data sharing, communication and tests, including testing on the Danish road network.

C-Roads Norway (NordicWay project)

Scan or click the QR code for more information

Summary facts

- The NordicWay 2 project started on 7 February 2017 and ended on 31 December 2020.
- The NordicWay 3 project started on 1 February 2019 and ends on 31 December 2023.

Fig. 24: Locations of the NordicWay C-ITS pilot projects in Denmark, Finland, Norway and Sweden - nationwide mobile network coverages and individual test locations

The NordicWay projects are mainly based on cellular cloud communication. Norway has 3 mobile roadside unit pilots deployed in an intersection at Patterø on the E6.

Pilot description

The Norwegian pilot was part of the NordicWay 2 project (2017-2020) and is currently part of the NordicWay 3 project (2019-2023) pilots running in the Nordic countries of Denmark, Finland, Norway and Sweden. The main objectives of the NordicWay actions are to deploy pilot studies in order to further develop interoperable Day 1 and Day 1.5 C-ITS services and support infrastructure readiness for connected and automated driving. NordicWay 3 project (2019-2023) will continue to harmonise and build European C-ITS interoperability in the C-Roads Platform (www.nordicway.net).

The two Norwegian pilots include use cases of Day 1 and Day 1.5 C-ITS services on peripheral networks and the mapping of infrastructure readiness for connected and automated driving on major freight routes on Norway's comprehensive network. To ensure smooth transitions between the networks, testing on the comprehensive and peripheral networks allows for a broader test of functionalities than would be the case with testing on the core network alone. After successful testing on the non-core network, the Day 1 and Day 1.5 C-ITS services tested will be applied under extreme weather conditions on the core network. The pilot was particularly designed to explore the feasibility of the following Day 1 and Day 1.5 services on rural routes with poor cellular connectivity.

The communication technology tested in this pilot will be cellular communication. Selected roadside infrastructure and vehicles may also be equipped with ETSI ITS-G5 when needed in order to ensure interoperability.

The purpose of the second pilot was to map and assess infrastructure readiness for connected and automated driving on major freight routes on Norway's comprehensive network. Consequently, the pilot aimed to identify what parts of the network the vehicle sensors find hard to read and to explore the potential for communicating information from the road authorities' back-end, instead of rebuilding the infrastructure using C-ITS.

The pilot was extended and covered main roads in all four Nordic countries. The inclusion of the other NordicWay countries gave the Norwegian Public Roads Administration a unique chance to create a dataset for direct comparison between the Nordic countries, differentiating the data into three groups:

- Mobile network coverage and quality
- GNSS availability and quality
- The vehicles' understanding of the infrastructure

C-Roads Spain

Scan or click the QR code for more information

Summary facts:

- 5 pilot sites including interurban and urban areas.
- 12,270 km of road network covered using Hybrid Communication Technologies including ITS-G5 and Cellular Technologies
- 25 partners: Public Authorities, road operators, technology and service providers, research centres, universities and associations

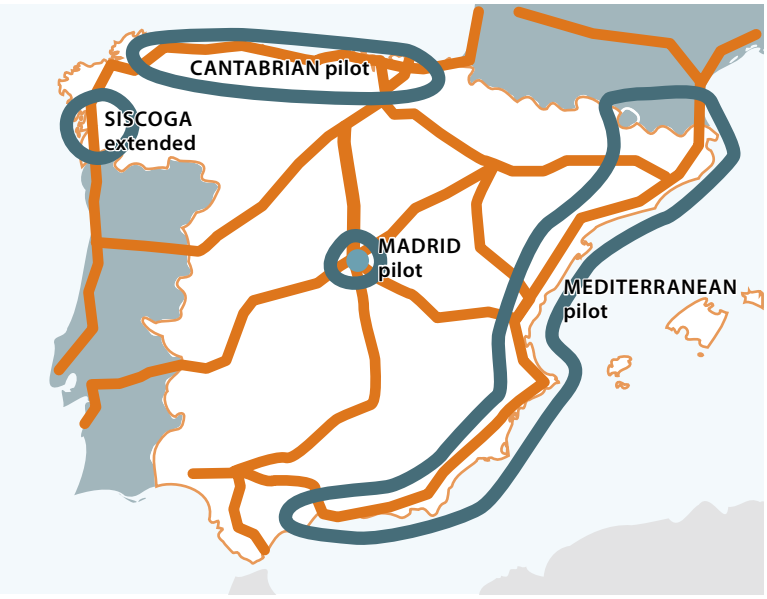

Fig. 25: Location of the Spanish C-ITS pilot locations

Pilot description

The Spanish pilot is made up of five different pilot sites, each with a unique set of technologies and C-ITS services. This heterogeneity covers a wide spectrum of use cases to assess the impact of connected mobility in several representative scenarios. This set of pilots was carefully chosen to verify interoperability at national and European level, as well as the added value of C-ITS services in different scenarios.

The **DGT 3.0** pilot is located along the overall road network in Spain at a length of approximately 12,270 km. Spanish public road operator DGT has implemented a Connected Vehicle Platform offering real-time traffic information. It will be deployed using cellular-based communication technologies.

SISCOGA Extended includes 200 km of urban road sections (cities of Vigo and Porriño) and interurban sections on which Day 1 and Day 1.5 have been implemented using ITS-G5 and cellular technologies. The existing test-site infrastructure located in the city of Vigo and its metropolitan area includes 104 ITS-G5 RSUs in Urban environment and 47 ITS-G5 RSUs in Interurban Corridor. SISCOGA Extended is connected with the Portuguese C-ITS Corridor and is also the Spanish PKI Centre.

The **Madrid** Pilot is located along the ring road "Calle 30" in Madrid and is approximately 32 km long. C-ITS services are deployed using hybrid communication technologies. The C-ITS Hub integrates third party traffic information, weather information and simulation tools. The pilot is also connected to a parking facility in the city centre to provide Day 1.5 services related to parking information and Smart Routing.

The **Cantabrian** pilot covers approximately 75 km in the north of Spain and it is made up of three sub-pilots focused on different objectives: Galicia, managing black spots of traffic accidents due to fog hazards; Asturias, deploying multimodal public transport and advanced C-ITS services; Bizkaia, improving the capture of traffic and weather data and informing users based on their habits in real time.

The **Mediterranean** pilot is deployed along the Mediterranean Corridor at selected road sections located in Catalonia and Andalusia, using also hybrid technologies. Tests in Catalonia take place in a section of about 40 km on the AP-7 highway near Girona. The Andalusia tests take place in the part of the Mediterranean Corridor that runs through Southern Spain, especially near the city of Marbella.

C-Roads Portugal/ Cooperative Streets

Summary facts

- C-Roads Portugal started in 2017 and will last until the end of 2023.
- Currently, C-Roads has been almost fully implemented, and evaluation and impact assessment activities are underway.
- Cooperative Streets started in 2019 and will end in December 2023.
- Cooperative Streets is planning and setting up procurement, and launching several activities.

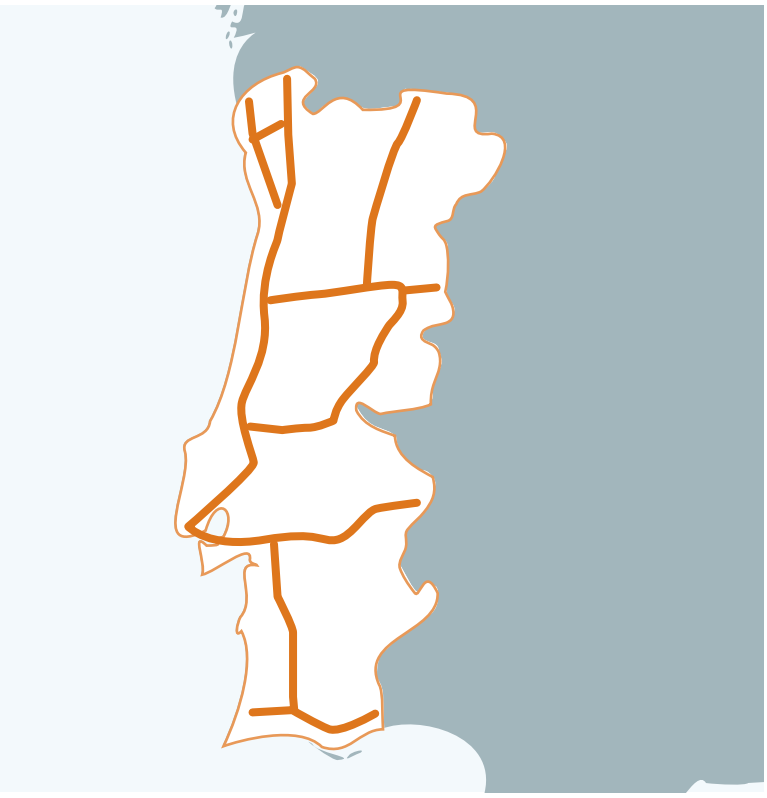

Fig. 26: Location of the Portuguese C-ITS pilots

Pilot description

Deployment of 5 C-ITS testbed Macro Pilot cases in the Atlantic Corridor in Portugal, covering relevant sections of the core network, the comprehensive network and two urban nodes. Combined with the pilot cases, the project will also develop a study aiming for national large-scale deployment of C-ITS services, notably Day 1 and selected Day 1.5 services.

Scan or click the QR code for more information

Pilot 1 – Single Access Point

Design of the national single point of access (SPA) prototype in compliance with EU law and covering information for around 3390 km (20%) of the network.

Pilot 2 – Portuguese network for C-ITS

Deployment of a pilot to test Day 1 and Day 1.5 services over 460 km of the core and comprehensive networks, including cross-border sections, and roads leading to the urban nodes in Lisbon and Porto, using hybrid communication system (ITS-G5 and cellular).

Pilot 3 – Network preparation for Connected and Autonomous Vehicles

Preparation of the TEN-T network for connected and autonomous vehicles with levels of automation 2 and 3, also using hybrid communication system (ITS-G5 and cellular).

Pilot 4 – C-ITS Pilot in the Lisbon Urban Node

Deployment of a C-ITS Pilot in the Lisbon urban node, i.e. traffic service-level monitoring and travel-time prediction; parking availability system; signal corridor and bus corridor prioritisation; estimation of potential benefits of integrating private car usage with other modes of transport in the last mile of inter-urban motorway corridors.

Pilot 5 – C-ITS Pilot in the Porto Urban Node

Deployment of a C-ITS pilot in the Porto urban node, i.e. testing traffic predictions in real time and travel time two hours ahead using cellular, wifi and DATEX II communication; integration of an "intelligent bus" with the infrastructure for information and services sharing, using the DATEX II communications protocol and cellular communication technologies.

Cooperative Streets Location

Study with pilots, aimed at testing C-ITS services in several urban areas along the TEN-T network that will complement the results from C-Roads Portugal. Cooperative Streets aims to develop projects and pilots whose purpose is to include a larger number of vehicles and a wider range of vehicle types, including public transport (bus, tram), emergency vehicles, freight and vulnerable road users (pedestrians, cyclists, motorcyclists, etc.).

C-Roads Greece

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Summary facts

- **Start date:** June 2019
- **Units deployed/km equipped/no. of road sections covered**
  - a) The northern Greece test site includes 30 km of motorway with 25 RSUs + 1 mobile RSU to be deployed;
  - b) The Attica region test site includes 20 km of motorway with 10 RSUs + 1 mobile RSU to be deployed.
- **Test sites:** The locations of the test sites for the Greek pilot are shown below

Fig. 27: Location of the Greek C-ITS pilots in Northern Greece and Attica Region

Pilot description

As part of the C-Roads Platform initiative, Greece has been participating as a Member State with its national pilot since June 2019. The Greek pilot takes place at two test sites, one in northern Greece (the Egnatia Odos Tollway Pilot) and one in the Attica Region (the Attica Tollway Pilot), and its main objective is to conduct a specific set of Day 1 and Day 1.5 C-ITS services via a balanced mix of ETSI ITS-G5 and cellular communication technologies.

A breakdown of the selected Day 1 C-ITS services of the Greek pilot contains a) road works warning with special focus on lane closure and other restrictions; b) hazardous locations notification, which includes the cases involving a stationary vehicle, a weather condition warning and an obstacle in the road; c) the in-vehicle signage (which applies to vehicles equipped with this technology) where variable message signs of "free text" and speed advice messages to avoid the shockwave damping effect are sent to vehicles by the road operators; and d) probe vehicle data for CAM aggregation. Lastly, the Greek pilot has also selected smart routing from the Day 1.5 C-ITS services.

These services will be achieved in each case at the two abovementioned test sites. At the northern Greece test site, 30 km of the "Egnatia Odos" motorway, which has specific attributes such as geometry, traffic volumes, rural environment, a mountainous area, successive tunnels and bridges, will be examined and 25 roadside access points (Roadside units – RSUs) and one mobile RSU will be installed. RSUs will enable communication and the transfer of ITS messages between vehicles and road infrastructure. In the Attica region, 20 km of the road section of the Attica Tollway (central sector) within the same prefecture will be studied and 10 roadside access points and one mobile RSU will be installed.

Design of the Greek test sites has now been completed. The C-ITS services that will be deployed have also been specified and the necessary procurement process has been initiated. The Attica Tollway test site has already identified its supplier, while the other test site, Egnatia Odos, is in the process of doing so. Finally, the first set of services for the Greek pilot have been launched and validated.

Greece is fully committed to contributing to the C-Roads Platform and to align with its results. The ultimate goal is to pave the way and contribute to large-scale deployment of interoperable C-ITS services in Greece.

C-Roads Ireland

Scan or click the QR code for more information

Summary facts

Start/end dates with projected milestones:

- **2019/20** Planning, procurement and development of systems/solutions
- **2020/22** Pilot deployment, operations and trials
- **2022/23** Pilot evaluation and assessments, including planning for wider deployment

Units deployed/km equipped/no. of road sections covered

ITS-G5 road side units will be deployed on section 2, which comprises sections of the M50 and M1 motorways. A total length of approximately 60km will be equipped with road side units.

Fig. 28: Location of the Irish C-ITS pilots

Pilot description

Since 2019, Ireland has taken an active role in the implementation of the European Union Cooperative-Intelligent Transport Systems (C-ITS) strategy, upgrading its membership within C-Roads Platform to "core" member along with other Member States.

This €10 Million project is funded by the European Union at a 50% funding rate and was awarded and signed by Ireland in 2019, allowing Ireland to implement a national C-ITS pilot. The overall aim of the C-Roads Ireland C-ITS pilot is to deploy, trial and evaluate Day 1 and future C-ITS services. The pilot will include development of services to align with Irish priorities, whilst recognising relevant standards and regulation. The pilot will test and evaluate C-ITS services on the Irish road network, predominantly on the Irish TEN-T network and also along urban corridors within Dublin city.

One of the earliest challenges encountered by the pilot design team was in relation to identification of suitable sites for deploying roadside units to achieve optimal ITS-G5 coverage. A number of factors were considered, such as the identification of suitable existing ITS assets e.g. gantry sites, fibre access points, proposed ITS infrastructure being installed in parallel to support other projects, the characteristics of the roadside unit and factors affecting signal propagation, e.g. topography, overbridges etc. To inform the design, detailed radio modelling was undertaken which provided greater certainty on the location and number of sites required. The modelling analysis will need to be verified by site surveys, but early conclusions have indicated that fewer installations will be required to achieve optimal coverage than initially envisaged, which will save on civil infrastructure costs.

The next steps for the C-ITS pilot are to work with the recently appointed contractors to develop both in-station and out-station designs and the interfaces between their different systems and solutions. Other activities include development of use cases for implementation within Dublin city and the exploration of scalable options for cross-border testing with Northern Ireland.

The future of C-ITS

Operational status of C-ITS in Europe

As C-Roads has pushed hard towards ongoing and harmonised C-ITS deployment, the operational status as of 2021 is quite dynamic and is evolving quickly. One important focus for the currently operational status of C-ITS in Europe is a map[10] issued by the European Commission that depicts the locations of operative roadside C-ITS stations all over Europe. This marks an important milestone for improving the public perception and visibility of C-ITS services in the course of the ongoing transition from roll-out to live operation of cooperative services. The large number of operative roadside stations and their wide distribution is further proof of the success of the harmonised approach pursued by the C-Roads Platform and all of its pilot sites.

The comprehensive availability of C-ITS stations underlines the importance and practical relevance of the short-range ITS-G5 approach as a counterpart to long-range cellular communication as part of a hybrid communication approach seen in the harmonised communication profile of C-Roads. It is clear that C-ITS has been successful in its initial visibility in daily motoring and is on the verge of producing concrete results with respect to a harmonised European approach to greater road safety and efficiency.

This has been complemented by the introduction of C-ITS to the market in production vehicles from 2019, beginning with the VW Golf VIII[11] and followed by others across the whole Volkswagen group. Other manufacturers are currently following Volkswagen's lead. Road operators are also getting their infrastructure ready for the widescale roll-out of C-ITS and have issued their initial tenders and started deployment.

C-ITS in urban environments

The future of C-Roads is in urban areas, as 37 European cities have joined the C-Roads Platform, at least 29 of which will implement C-ITS services. However, as most of C-Roads' use cases are focused on motorway environments, cities are attempting to implement services that are applicable to urban roads. Therefore, within the scope of C-Roads, the list of C-ITS Day 1 services has been extended to include services that are designed specifically for urban areas, i.e. the current Day 1.5 services.

Of all of the C-ITS Services, cities have shown most interest in signalised intersections (SI). More than half of all participating cities will implement services designed to optimise green light phases of traffic lights. This is no surprise, as the benefit of SI services is a reduction in traffic jams and emissions through the provision of speed advice and prioritisation of public transport or heavy good vehicles. In addition, a third of all participating cities will implement probe vehicle data collection. Collecting data such as position or speed from vehicles is vital for potential traffic management measures. As the services are being implemented and tested, C-Roads is working on collaboration with various urban platforms in order to promote the benefits of using C-ITS services in urban areas.

The global dimension of C-ITS

While C-ITS services are at the deployment stage across Europe, similarities can be identified across the globe. This is especially the case in Asia, where C-ITS services are being deployed, or are in a pre-deployment phase. In addition to technological developments, the user-driven approach is of particular interest in Asia where, especially in Japan and South Korea, several C-ITS services are focusing on enhanced safety for vulnerable road users (mainly pedestrians).

Alongside Europe and Asia, the USA is one of the driving forces for making connected vehicles a reality. The deployment of C-ITS services was established with the vehicle infrastructure integration programme . The most important step towards C-ITS deployment was initiated in September 2016, when the US Department of Transport (DoT) awarded cooperative agreements to three connected vehicle pilot sites in New York City, Wyoming and Tampa, Florida. The goal of this pilot deployment programme is to support motorists with infrastructure-based information services to reduce their stress levels while improving the safety of vulnerable road users.

Current deployment activities in Australia and New Zealand are primarily being undertaken by Austroads, which is an Associated Member of the C-Roads Platform. As the umbrella organisation of road transport and traffic agencies in Australia and New Zealand, Austroads closely follows the European C-ITS deployment approach. In this capacity, they make use of the interface specifications, the Day 1 use-case descriptions and the European certificate policy.

Outlook: C-ITS for automation

There is an expectation that automated vehicles will be equipped with high-level sensory and HD maps to perceive the environment and perform automated driving tasks. However, in some cases, automated vehicles need assistance from the infrastructure, which is where C-ITS comes into the equation. Automated vehicles operate under certain circumstances that are also known as Operational Design Domains

10 https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html

11 https://www.euroncap.com/en/press-media/press-releases/volkswagen-safety-technology-rewarded-by-euro-ncap/

(ODD). Examples of ODDs are weather conditions, detection of traffic signage or roadway types. Automated driving is by definition not safe if weather conditions are adverse, the vehicle does not detect traffic signs, or in general if an ODD is not fulfilled. C-ITS therefore acts as an extra sensor for automated vehicles to determine whether or not an ODD has been fulfilled.

If there are temporary changes to the physical infrastructure, caused for instance by road works blocking a lane, the vehicle needs to be informed via a C-ITS message, as it relies solely on static information provided on its map. Because the ODD has not been fulfilled, automated driving is no longer feasible and the driver has to take over. C-ITS is also applied to warn motorists about unfavourable traffic conditions such as accidents or traffic jams. In this case, advice is provided about reducing speed and taking other potential routes to avoid blockages. Unexpected events are also covered by C-ITS messages, creating awareness of people, animals or objects in the road, for example, and of unfavourable weather conditions on certain sections of road.

Although C-ITS supports automated vehicles in a variety of situations, fully automated vehicles are not yet within reach. However, various projects are working on traffic management measures and digital infrastructure adaptations to support automated mobility, where C-ITS has a key role.

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