Cooperative Vehicle-Infrastructure Systems

D.CVIS.1.3	**Final Activity Report Period: 01/02/2006 to 30/06/2010**

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Abstract	The Publishable final activity report is an expanded version of the Publishable Executive Summary which was provided with each Periodic activity report, cumulating and summarising the project activities and results over the full duration. It is of suitable quality to enable direct publication by the Commission. While not excluding technical language, it should be broadly comprehensible to an interested general reader.

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Control sheet

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Abbreviations and Definitions

Abbreviation	Definition
2G	Second generation cellular phone technology, e.g. GSM
3G	Third generation cellular phone technology, e.g. UMTS
ADAS	Advanced driver assistance systems
AIS	Automatic Identification System
a.k.a.	Also Known As
a.o.	among others
AO	Assessment Objectives
AP	Asia Pacific
API	Application Programming Interface
ASC	CVIS/FOAM Application Submission Contest
ASIC	Application-specific integrated circuit
ATC	Azienda Trasporti Comunali (public transport Bologna)
AVVC	Advanced Vehicles and Vehicle Control Knowledge Center
A&A	Authentification and Authorisation
BAES ATC	BAE Systems (Operations) Ltd Advanced Technology Centre
BO	Back office
BRRC	Belgian Road Research Centre
BSD	Berkeley Software Distribution (UNIX operating system)
CAG	Core Architecture Group Sub-project
CALM[1]	"Communication Access for Land Mobiles" standards
CALM Fast	One of CALM standards (ISO 29281) implemented in CVIS. "Fast" is a networking protocol for single hop unicast / n-hop broadcast communications
CAM	Cooperative awareness messages
CCH	Control channel
CCTV	Closed Circuit Television
CEN	Comité Européen de Normalisation
CENIT	Centre pour l'Innovation dans les Transports
CERES	Centre for Research on Embedded Systems

[1] http://www.tc204wg16.de/Public/CALMintro.html

CF&F	Cooperative Freight & Fleet Applications Sub-project
CINT	Cooperative Interurban Applications Sub-project
CIT	Cork Institute of Technology
CMT	Core Management Team
CNRS	Centre National de la Recherche Scientifique
COMeSafety	Communications for eSafety (EC-funded project)
COMM	Communications & Networking Sub-project
COMO	Cooperative Monitoring Sub-project
Concall	Conference call
COOPERS	"Co-Operative Systems for Intelligent Road Safety" EC project
CRF	Centro Ricerche FIAT
CS	Cooperatives systems
CSMA	Carrier sense multiple access
CTA	Cooperative Traveller Assistance application
CTAG	Regional Galician Government
CTG	Core Technology Group
CTMC	Cooperative Traffic Management Centre
CTS	Centre for Transport Studies, Imperial College of Science, Technology and Medicine
CURB	Cooperative Urban Applications Sub-project
CVIS	Cooperative Vehicle Infrastructure Systems
CV_UC	Cooperative Vehicles Use Case
C2C-CC	Car-to-car Communication Consortium
D	Deliverable
DASTS	Delivering A Sustainable Transport System
DATEX	Data Exchange: information exchange between traffic management centres, traffic information centres and service providers
DB	Database
DDM	Data Distribution Module
DDS	Dynamic Discovery Service
DEL	Deliverable
DEPN	Deployment Enablers Sub-project
DfT	Department for Transport

DG	Dangerous Goods
DG	Directorate General
DGT	Spanish road administration department
DLR	German Aerospace Center e.V.
DMOTION	German research project within the VM 2010 (Traffic Management 2010) research initiative funded by the German Ministry of Economy and Technology (BMWi), which aim is to develop and implement an integrated traffic management system for the conurbation of Düsseldorf.
DNS	Domain Name Server
DOM	Domain object model
DRG	Dynamic Route Guidance
DRIP	Dynamic Routing Information Panel
DRIVE	"DemonstRator for Intelligent Vehicular Environments" tesbed
DSL	Dynamic Speed Limit
DSRC	Dedicated short-range communications
EasyWay	EC project
EC	European Commission
eCoMove	"Cooperative Mobility Systems and Services for Energy Efficiency" EC project
EDA	Enhanced driver awareness
EDPS	European Data Protection Supervisor
EFCD	Enhanced Floating Car Data
EGEP	European GNSS Evolution Programme
EGNOS	European Geostationary Navigation Overlay Service
EICTA	European Information & Communications Technology Industry Association
EJB3	Enterprise Java Beans 3: component architecture for modular enterprise applications.
eMOV	Spanish eMobility technology platform
ERTICO	European Road Transport Telematics Implementation Coordination Organisation
ESA	European Space Agency
ETA	Estimated Time of Arrival
ETA	Environmental Transport Association
ETSI	European Telecommunications Standards Institute

EU	European Union
EUREKA	Europe-wide Network for Market-Oriented Industrial R&D
FCD	See “EFCD”
FEHRL	Forum of European National Highway Research Laboratories
FMS	Fleet Management Standard
FOAM	Framework for Open Application Management Sub-project
FOT	Field Operational Test
FP6	6th Framework Programme
FP7	7th Framework Programme
FPGA	Field-programmable gate array
FREILOT	EC-funded “Urban freight energy efficiency Pilot” project
FTP	File Transfer Protocol
GA	General Assembly
GCDC	Grand Cooperative Driving Challenge
GDF	Geographic Data Files
GeoNET	“Geographic addressing and routing for vehicular communications” EC project
GML	Geographic Markup Language
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GRL	GeoReferencing Language
GST	EC-funded “Global System for Telematics” project
GW	Gateway
HA	Highways Agency
HA	Home Agent
HaveIT	EC-funded “Highly Automated Vehicles for Intelligent Transport” project
HD	Hard Disk
HLA	High-level architecture
HLO	High-level objective
HMC	Host Management Centre
HMI	Human Machine Interface
HSUPA	High-Speed Uplink Packet Access

HTTP	HyperText Transfer Protocol
HTW	Hochschule für Technik und Wirtschaft des Saarlandes
HW	Hardware
ICT	Information and Communication Technology
IEEE	"Institute of Electrical and Electronics Engineers" (professional association dedicated to advancing technological innovation and one of the leading standards-making organizations in the world)
IETF	Internet Engineering Task Force
I/F	Interface
INCITE	Spanish program
INFSO	Information Society & Media
INRIA	Institut National de Recherche en Informatique et en Automatique
IntelliDrive^{SM}	U.S. Department of Transportation's program focused on advancing connectivity among vehicles and roadway infrastructure to improve safety and mobility of transport
IP	Integrated Project
IPM	IP Project Management
IPMAN	IP Management Sub-project
IPR	Intellectual property rights
IPv6	Internet Protocol Version 6
IR	Infrared
IRID	Image Recognition and Incident Detection
ISMB	Istituto Superiore Mario Boella
ISO	International Organization for Standardization
ISP	Internet Service Provider
iTETRIS	"Integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solutions" EC project
ITS	Intelligent Transport Systems
ITST	Intelligent Transport Systems Telecommunications
IVIS	In-Vehicle Information System
KoM	Kick-off Meeting
LCD	Liquid Crystal Display
LCPC	Laboratoire Central des Ponts et Chaussées
LDM	Local Dynamic Map

LDT	Local Device Tree
LOS	Line of Sight
LR	Location referencing
LSP	Lindholmen Science Park
LTC	Local Traffic Control
LTSM	Local traffic states for motorways
L2TP	Layer 2 Tunnelling Protocol
M	Month
M5	CALM microwave medium at 5 GHz, based on IEEE 802.11p and the set of IEEE standards P1609.x for WAVE.
MAC	Medium access control method
Makewave	New name of contractor 17, formerly “Gatespace Telematics”
MATLAB	MAtrix LABoratory, software produced by MathWorks
MCM	Microwave Communication Module
McoA	Multiple Care-of Addresses
MM	Man-month
MM	Millimetre
MT	MAT.TRAFFIC
ND	The Netherlands
NEMO	NEtwork MObility Standard
NMS	New Member State
NSP	Navigation Service Provider
NT	NAVTEQ
NTVE	Non-technical validation elements
OBE	On board entity
OBU	On board unit
OCR	Optical Character Recognition
OD	Origin-destination
ODB	On board diagnostic
OEM	Original Equipment Manufacturer
OPA	Open Platform Alliance
OS	Operating system
OSGi	Open Service Gateway Initiative

OTAP	Open Travel data Access Protocol
P	Period
PCI	Peripheral Component Interconnect
PCN	Penalty charge notice
PNB	Provincie Noord-Brabant
POLIS	Promotion of Operational Links with Integrated Services
POMA	Positioning, Mapping & Location Referencing Sub-project
PPP	Point-to-Point Protocol
PRECIOSA	"Privacy Enabled Capability in Co-operative Systems and Safety Applications" EC project
PRT	Public road Tour
PTV	Planung Transport Verkehr AG
P2P	Peer to peer
QF	Q-Free ASA
Q&A	Questions and answers
QoS	Quality of Service
RACC	Reial Automóbil Club de Catalunya
RE	Road Editor
REALSAFE	"Real-time Safety-related Traffic Telematics Austrian" project
REP	Reference Execution Platform
RFQ	Request For Quotation
RI	Reference Implementation
RITA	Research and Innovative Technology Administration of the US Department of Transportation
RQ	User or System Requirement
RSU	Road Side Unit
RSE	Road Side Entity
RSSI	Received Signal Strength Indicator
RTD	Research & Technological Development
RTMaps	Real Time, Multisensor, Advanced, Prototyping Software
RWS	Rijkswaterstaat
SAFESPOT	"Cooperative vehicles and road infrastructure for road safety" EC project
SAP	Service Action Points

SC	Steering Committee
SDK	Software Developers' Kit
SEK	Swedish crowns
SERtec	The GST technology platform
SeVeCom	"Secure Vehicular Communication" EC project
SINTEF	Stiftelsen for industriell og teknisk forskning
SISCOGA	"SIstemas COoperativos Galicia" project
SLA	Software License Agreement
SMARTFREIGHT	"Smart Freight Transport in Urban Areas" EC project
SOAP	Service-Oriented Architecture and Programming
SOV	System overview
SP	Statens Provningsanstalt (Government Testing Institute)
SP	Sub-project
SPITS	"Strategic Platform for ITS" Dutch Project
Sqm	Square meters
SRA	Swedish Road Administration
SRA	Safety Demonstration Area
SSI	Standard Sensor Interface
STDMA	Self-organizing time multiple access
SVN	SubVersioN
SW	Software
TA	Tele Atlas
TASF	Thales Alenia Space France, new name of Alcatel Alenia Space
TC	Test Cases
TCC	Traffic Control Centre
TCP	Transmission Control Protocol
TeleFOT	"Field Operational Tests of Aftermarket and Nomadic Devices in Vehicles" EC project
TfL	Transport for London
TGW	Telematic Gate Way
TI	Telecom Italia SpA
TICBox®	Telefónica In-Car Box
TCC	Traffic control centre

TCP	Transmission Control Protocol
TMC	Traffic Management Centre
TMC	Traffic Message Channel
TNO	Netherlands Organisation for Applied Scientific Research
Topic 2	Openness and Interoperability
Topic 3	Safe, secure and fault-tolerant design
Topic 4	Utility, usability and user acceptance
Topic 5	Costs, benefits and business models
Topic 6	Risks and liability
Topic 7	CVIS and Policy
Topic 8	Deployment roadmaps
TP	Traffic Platform
TREN	Energy and Transport (EC Directorate-General for)
TS	Test Site
TSOV	Test site overview
TSRM	Test Site Reference Matrix
UC	Use Case
UK	United Kingdom
UML	Unified Modelling Language
UMTS	Universal Mobile Telecom System
UN	User Needs
UPS	Uninterruptible power supply
UTC	Université de Technologie de Compiègne
VENS	Vehicular Networks
VGSG	Vodafone Group Services GmbH
VLO	Vlaamse Overheid
VPN	Virtual private network
VZH	Hessen Traffic Management Centre
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
WAVE	Wireless Access in Vehicular Environments
WG	Working Group
VGW	Vehicle Gateway

WiKi	Collaborative web application. In CVIS COMM sub-project, a Wiki has been created by Ramsys to support and track COMM software developments.
WiseCar	Norwegian research project developing mobile information and communication technology for all road users.
WiVEC	"Wireless Vehicular Communications" IEEE symposium
WP	Workpackage
WP1	Project management
WP2	Use cases and requirements
WP3	Architecture and specifications
WP4	Reference execution platform implementation and prototype development
WP5	Field trials and test sites
WP6	Validation
WP7	Dissemination, exploitation and training
WS	Workshop
WSDL	Web Services Description Language
WSMP	WAVE Short Message Protocol
WSN	Wireless sensor networks
XFCD	Extended floating car data
XML	Extensible Markup Language

1. CVIS Final Report: Publishable Summary

In mid-2010, after four and a half years the CVIS integrated project has successfully reached its completion, marking major progress towards the realisation of vehicle-infrastructure cooperation for Europe. The main achievement has been the creation and validation of hardware and software prototypes of the in-vehicle and roadside elements of an integrated platform for “connected vehicle” applications and services. These elements were integrated at test sites and validated in field trials, including large-scale real life demonstrations at public events.

This platform is provided to the ITS community as reference implementation for a European universal platform for cooperative systems, and has already during the CVIS project lifetime been taken up for evaluation by more than a dozen external projects and companies.

The consortium members are very satisfied with the CVIS results and have found them worth pursuing as a basis for larger-scale trials and then commercialisation, even if not market ready (as to be expected for an R&D project!). A number of CVIS partners have come together to launch an “Open Cooperative Mobility Alliance”, to be a neutral meeting place and workshop where all those active in the area of cooperative systems could discuss and work together to find solutions to the issues favouring or impeding deployment.

In this final report we summarise the CVIS achievements in technical development, cooperation, validation, dissemination and exploitation activities and how these are already helping to shape cooperative mobility for the future.

1.1. About CVIS

The EU-co-funded CVIS Integrated Project had the aim to bring major benefits for drivers as well as road authorities and managers, by allowing vehicles to communicate – and cooperate – directly with each other and with roadside infrastructure.

The objectives of CVIS were to:

- Create a wireless network between and amongst vehicles and infrastructure
- Create an open platform for V2V and V2I cooperative services
- Increase road efficiency and safety through vehicle-infrastructure cooperation.

CVIS has accordingly developed a technology platform providing wide-ranging functionality for data collection, journey support, traffic and transport operations and driver information. The project, launched in February 2006, included 62 partners with a budget of €41 million and €22 million co-funding from the Information Society priority of the 6^{th} Framework Programme of Research and Technology Development. The CVIS project was coordinated by ERTICO – ITS Europe.

The original 48-month project duration was prolonged by five months to allow extra time for integration of core technology components, and also for the organisation of a large-scale Cooperative Mobility Showcase demonstration in March 2010, neither foreseen in the original work plan of the project.

1.2. Reference platform for Cooperative Systems

The development path followed throughout the project was a classic "V-model". The first step was to identify user needs, develop use cases and define system requirements, the subject of workpackage 2 (WP2). During the first year, the following tasks were achieved:

- definition of common methodology for use cases, user needs and requirements description;
- harmonisation of use cases amongst sub-projects;
- harmonisation of use cases between CVIS and SAFESPOT projects;
- prioritisation of use cases;
- description of commonly agreed cooperative data elements;
- finalisation of deliverables at IP-level and SP-level;
- validation of results at an open workshop;
- handover of requirement results to system architecture workpackage (WP3).

The result was a consensus in each SP of just how the different applications would work, what functions they would perform, what use cases were needed to deliver the functions, and what user and system requirements needed to be satisfied by the systems to be specified. In particular IP-level use cases were developed for scenarios crossing project domains (e.g. urban-interurban).

Also completed in the first year was the Reference Architecture, describing the test platform developed in CVIS, as a guide to the system developers across the different sub-projects. The modular design was intended to allow easy adoption for in-vehicle use and also for installation in roadside and management centre equipment.

In year 2 the first stage of core technology development was completed, with fully defined high-level and component architectures as well as the specification of the reference implementation platform. The CVIS high level architecture addressed two important objectives:

- How to implement communication between mobile (vehicles and persons) and non-mobile system parts, such as the road side infrastructure or service centres (COMM sub-project);
- How to enable flexible deployment of application software, allowing an open market for services and ensuring interoperability throughout Europe (FOAM sub-project).

The CVIS technology is based on IPv6. Not only does the newest version of the Internet Protocol vastly increases address space (each vehicle may need several IP addresses), it also supports network mobility, essential for a vehicle-infrastructure architecture. To allow mobile system elements to use different media (e.g. 3G, WiFi, WiMAX, DSRC, Infrared), management of the physical media was implemented using the ISO "CALM" standard specifications.

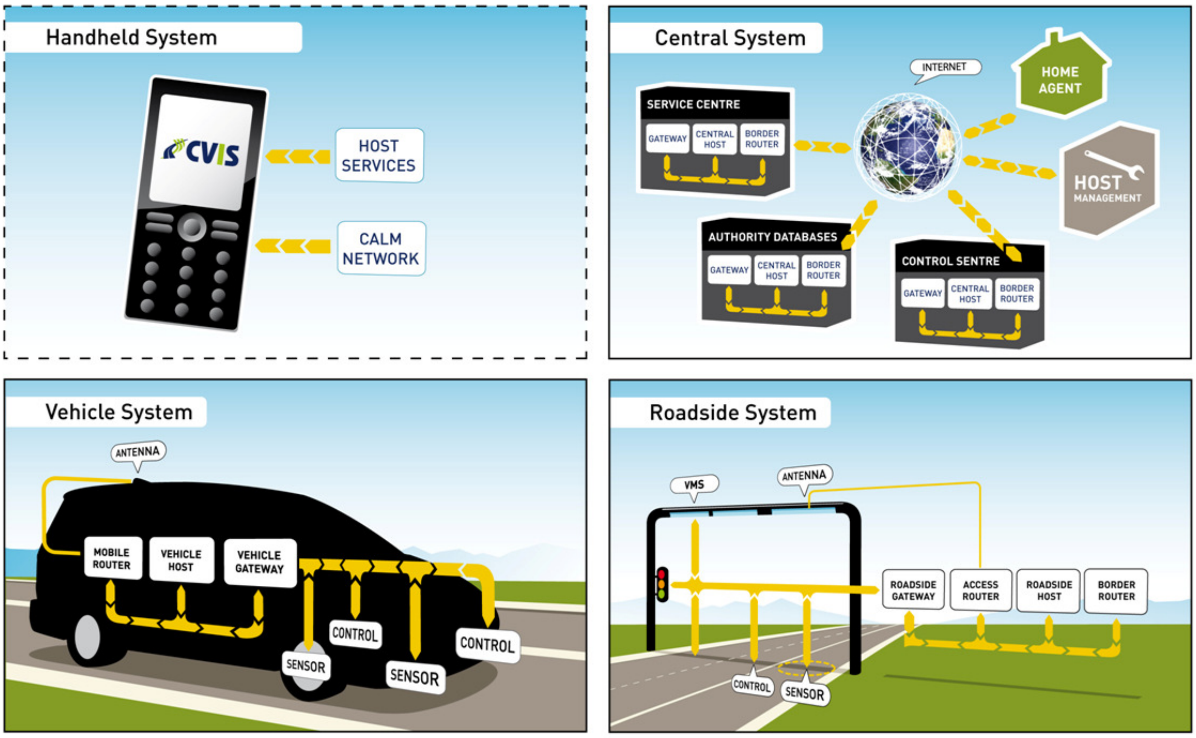
Flexible software download and management are provided by JAVA/OSGi, as extended to fit the needs of co-operative systems. The CVIS architecture foresees dynamic mechanisms for mobile and fixed units to obtain updates or new software on the fly, remotely if needed and permitted.

Based on the architecture and system specifications completed in year 2, the CVIS project completed development of the prototype reference platform in Year 3. This reference platform includes the communication components for M5 (5.9GHz mobile wireless local area network based on the IEEE 802.11p standard), infrared (IR), cellular (2G/3G) and an integrated "smart antenna". The final release of CVIS reference platform software included elements from the communication technologies (COMM), cooperative monitoring (COMO) and positioning, mapping and location referencing (POMA) sub-projects.

In the final step before validation at test sites, the core technologies were integrated and beta tested at Lindholmen Science Park in Gothenburg. Separate components from the sub-projects were brought together to verify that they all functioned properly together. The result of this stage was the initial integration and testing of in-vehicle and roadside equipment before the CVIS demonstrations organised at its six test sites (France, Germany, Italy, Netherlands-Belgium, Sweden and United Kingdom).

The high-level architecture is shown in Figure below. To enable maximum flexibility for deployment, the CVIS architecture concept describes a peer-to-peer network where no particular operational, business or legal hierarchy is built in: any entity can communicate with any other entity, and a vehicle can at one moment be a service provider for a data centre client, and the next moment be the client for a traffic information service. This structure is flexible and robust, making the overall system reliable, highly available and scalable to meet future demands.

Since all system entities are equals in the architecture, CVIS used the same platform for both in-vehicle and roadside installations. Only the antenna installation and configuration are different. This common platform design and specification can be physically realised in many ways, opening the door to a healthy competition in the marketplace.



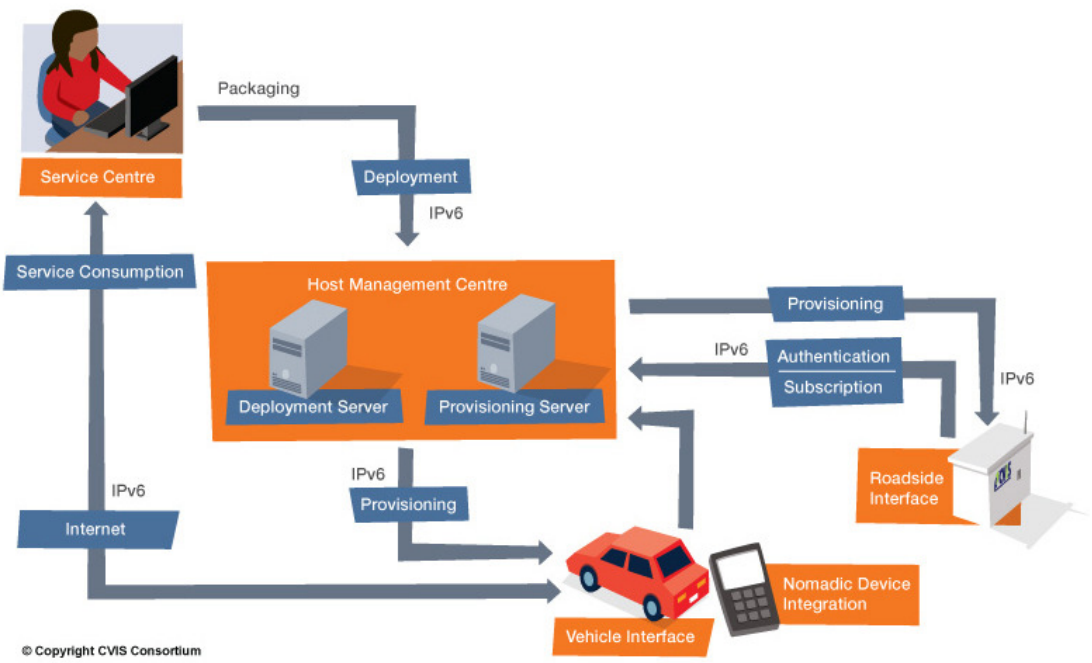
CVIS high-level architecture

The framework for open application management (FOAM) sub-project developed an open execution environment where a wide range of driver assistance and mobile service applications could be published, discovered, provisioned and maintained. A FOAM software developers' kit (SDK) was developed including the following components:

- Standards-based OSGi service platform
- Application manager
- Communication manager with application programming interface (API)
- Radio connections for M5, IR and 3G
- Local Device Tree (LDT) to access car sensor data
- Security modules including an authentication & authorisation framework
- Distributed Directory Service (DDS) that provides a sort of "yellow pages" for client (to search and find) and server (to publish and advertise)
- Location application programming interface (API)
- Native management agent to access legacy applications.

The CVIS service elements developed by FOAM are shown hereunder. FOAM also further enhanced the Host Management Centre (HMC) concept originally designed in the GST (Global System for Telematics) project with both Linux and Windows implementations. The HMC is the central point for the management of CVIS applications running on the CVIS Host. It provides two basic services:

- **Service Deployment** - makes a service available in a CVIS system via a host management centre;
- **Service Provisioning** - handles life cycle management of OSGi based applications using remote management mechanisms, i.e. install (download), start, stop, update etc. Limited support of native management is provided.



Service platform

The POMA sub-project developed extended positioning components with real time lane-level map-matching, which in practice showed the full “e-map” capabilities by displaying in real time the actual lane in which a vehicle is driving. This system performed even better than planned, i.e. an average accuracy of ~2 m instead of ~5 m.

Another important functionality is the Local Dynamic Map (LDM) database, to allow the dynamic display of the vehicle in its immediate environment on a layered map. The main LDM developments were done in the SAFESPOT integrated project[2] and adapted for use in CVIS. This component is a concrete result of the excellent cooperation between these two projects over the past four years.

CVIS algorithms were implemented in the LDM to calculate the traffic state by fusion of sensor information from stationary loop detectors with vehicle-based sensor and incident information. These fused data were available not only to other vehicles and the infrastructure but also to the cooperative monitoring (COMO) service centre to calculate the global traffic state.

The goal of the technology development in CVIS was to showcase the benefits of the “cooperative approach” as implemented in a number of reference applications and services. The CVIS project selected 20 applications in urban, interurban and freight & fleet domains, to prove that the concept of cooperative systems was feasible and to demonstrate their potential to help improve safety, efficiency and driver comfort. These applications were based on existing use cases for driver safety, traveller information and traffic management, and were selected for their potential to show the improvement gained by adding vehicle-infrastructure communications and placing them in a cooperative framework.

These applications included the following:

> **Cooperative Urban Applications** (CURB sub-project) include rerouting and individual on-trip information for drivers based on accurate area-wide travel time information derived from “floating vehicle data collection”, while by communicating directly with road users, road operators can improve their traffic management strategies in order to reduce congestion and vehicle emissions.
>
> Other examples include priority to emergency vehicles at intersections; speed advice to drivers for passing through a series of traffic lights without stopping; bus-lane sharing by other vehicles when not needed for public transport, in order to increase road capacity.
>
> **Cooperative Inter-urban Applications** (CINT sub-project) can improve drivers’ awareness of the road environment around their vehicle through alerts and warnings on road incidents, weather and traffic conditions, speed regulations or wrong-way drivers.
>
> Cooperative Inter-urban Applications can improve drivers’ awareness of the road environment around their vehicle through alerts and warnings on road incidents, weather and traffic conditions, speed regulations or wrong-way drivers.
>
> **Cooperative Freight and Fleet Applications** (CF&F sub-project) offer substantial benefits for professional drivers and fleet managers. Rest area parking or loading space booking can give shorter delivery times, less fuel consumption and emissions while

[2] http://www.safespot-eu.org/

searching for parking, and enhanced traffic flow by avoiding double-parking.

Other applications developed in CVIS include dangerous goods transport monitoring and access control to restricted areas, e.g. bridge, tunnel, environmental zone, etc.

In addition to these applications developed within the project, a number of new applications were developed by CVIS partners and third parties, and demonstrated at ITS World Congress in Stockholm (September 2009) and at the Cooperative Mobility Showcase in Amsterdam (March 2010): these included pedestrian warning, local advertising, social networking and multimodal traveller support, to mention just a few. They were developed by non-CVIS partners in the framework of an application innovation contest[3].

1.3. Test site implementation & validation

The field trial activities were carried out during the final period of the project, once the technology platform was integrated and verified. Field trials and data collection were carried out from Autumn 2009 until Spring 2010.

The validation partners used the test site results to evaluate whether CVIS core technologies and applications were functioning according to expectations and objectives set for the project.

In year 4, the following activities related to validation were carried out:

- Finalisation of beta and gamma technology validation (sub-project level).
- Implementation of tests for test site validation (sub-project level).
- Managing validation of main high level objectives (integrated-project level)
- Processing all validation results.
- Managing non-technical validation.
- Organisation of validation workshop

The validation performed at the CVIS test sites showed that the consortium did succeed in achieving the substantial majority of initial objectives, for the integrated project as a whole (IP) as well as for each sub-project (SP). In more detail:

<u>Finalisation of component-level (beta) and integrated platform-level (gamma) validation (SP level):</u> The core technology sub-projects still had some open issues at the stage of beta/gamma validation. These issues were overcome and these validation stages were successfully finalised in the final project year.

CVIS defined a set of high level project objectives forming the basis of the validation activities. The high level objectives were of two sorts:

- General objectives specifying requirements at IP level, such as interoperability, open source and user acceptance;
- Specific objectives specifying requirements at SP level, e.g. defining the communication speed of IR communication.

[3] http://www.cvisproject.org/en/about_cvis/application_submission_contest/

The progress towards achieving IP level objectives is summarised below:

CVIS objective 1: Interoperability.

A total of 56 vehicles in 14 test sites in 7 countries were used to demonstrate the CVIS cooperative ITS concepts. Several makes of vehicle were used during these demonstrations. The CVIS and SAFESPOT systems were demonstrated to be interoperable: routers could be shared, and both systems understood the same cooperative awareness messages. Interoperability with COOPERS was limited to three demonstration scenarios at the 2009 ITS World Congress in Stockholm, so real interoperability was not validated. Within the CVIS project interoperability has been achieved in that various SPs used each others' software modules.

CVIS objective 2: Open source.

From the individual SPs, the requirement that 80% of software modules and interfaces should be under open source license was fully realised by COMM. Moreover:

- All interface descriptions were fully open source.
- CVIS was implemented on an open source operating system (Ubuntu Linux)
- The Knopflerfish OSGi service platform (the heart of FOAM) was also open source.

CVIS objective 3: Reference platform.

A software repository was created providing source code, installation guides, FAQ and documentation (wiki). The reference platform containing the core technologies could be obtained from this software repository. The application innovation contest proved that external developers could also rapidly develop applications using the reference implementation.

CVIS objective 4: User acceptance.

CVIS questionnaire surveys carried out at several events and online assessed user acceptance of CVIS applications. Although the majority of the end-users considered the presented applications to be useful and easy to use, they also showed somewhat less enthusiasm to pay for these systems.

CVIS objective 5: Data sharing.

According to CVIS surveys, most European drivers (60%) are willing to share data from their vehicles for supporting cooperative systems as long as no personal data are involved. The eSecurity Working Group of the *e*Safety Forum has been drafting a code of practice to deal with privacy issues related to cooperative systems. CVIS contributed via the eSecurity Working group to the work plan of the Article 29 WP (European Union Working Party on the Protection of Individuals with regard to the processing of Personal Data).

CVIS objective 6: Impact on driving behaviour.

During the development of the Validation Plan it was concluded that this objective could not be achieved during the CVIS project lifetime since it requires a large number of vehicles driven in a realistic context over a long period of time using applications that are product ready. This objective is one of the main points for forthcoming Field

Operational Tests (FOT)s.

Implementation of tests for validation at test sites (SP level): All SPs conducted the tests at various test sites as specified in their validation plans. A table summarising the degree to which each of the validation objectives was met is presented below. The rating scale ranges from 1 (unsuccessful) to 5 (fully successful).

ID	Description	Rating
COMM-OB1	Communication mechanisms	5
COMM-OB2	Roaming (horizontal van vertical handover)	4
COMM-OB3	Continuous IP connection	4
FOAM-OB1	Service platform for development, provisioning and deployment	4
FOAM-OB2	Openness in deployment	4
FOAM-OB3	Remote management	5
FOAM-OB4	Data security	4
POMA-OB1	Positioning tools	4
POMA-OB2	Mapping tools	4
COMO-OB1	Data collection and processing	4
COMO-OB2	Data fusion and information distribution	3
COMO-OB3	Information utilization	3
CURB-OB1	Traffic management scenario's	5
CURB-OB2	Incident detection	5
CURB-OB3	Traffic state information and intersection control	4
CURB-OB4	Dynamic road space allocation	5
CURB-OB5	Legacy system interoperability	5
CINT-OB1	CINT Toolkit realisation	3
CINT-OB2	Enhanced driver awareness	4
CINT-OB3	Cooperative travellers assistance	3
CF&F-OB1	Dangerous goods	4
CF&F-OB2	Parking zones	5
CF&F-OB3	Access control	3
CF&F-OB4	Technology interoperability	3

The final validation results were presented at an open workshop in May 2010. The validation outcomes of all sub-projects, as well as a high-level summary were presented to more than 50 persons at the meeting. Presentations are available via the CVIS website.

1.4. Liaison & standardisation

Since the project start, CVIS actively promoted liaison with other European-funded projects including its sister projects SAFESPOT and COOPERS[4]. This cooperation culminated in the joint organisation by the three integrated projects of an unprecedented showcase of cooperative technologies and applications (see below).

Under the umbrella of COMeSafety[5], the results of these three projects together with input from the Car-to-Car Communication Consortium contributed to the further refinement of a commonly agreed communications architecture for cooperative systems in Europe, that was input to the ETSI Technical Committee on ITS.

Throughout the project lifetime CVIS partners were actively involved in the work of standards development within the main European and global bodies. In ETSI TC ITS, CVIS contributed to defining the set of basic applications and the cooperative awareness message format in WG1, and to the network and architecture in WG2 and WG3 (WG2 was led by the CVIS Chief Architect). CVIS also contributed to international standardisation work in ISO, IEEE and CEN.

The project also promoted its reference platform and other results, such as findings on deployment barriers and solutions, to other initiatives[6] through reciprocal cooperation agreements: in exchange for evaluating the CVIS platform and/or other results, the projects REALSAFE, CERES/VAS, SMARTFREIGHT, ANEMONE, WiseCar, SISCOGA, GeoNet, Test Site Trondheim, FREILOT and PRECIOSA, as well as the companies Telefónica I+D and SP Technical Research Institute of Sweden, should report on their experiences to the CVIS consortium and should promote CVIS results.

1.5. Interoperability

During the last year, the three main EC-funded projects in the field of cooperative systems, CVIS, SAFESPOT and COOPERS, agreed to demonstrate a number of common scenarios showing interoperability.

The common scenarios were demonstrated in the "Cooperative Systems on the Road" event in Helmond, the Netherlands, in May 2009 and later at the ITS World Congress in Stockholm (September 2009), and also finally at the Cooperative Mobility Showcase in March 2010 in Amsterdam, jointly organised by the three IPs.

The successful cooperation with SAFESPOT resulted also in CVIS using the Local Dynamic Map (LDM) as developed by SAFESPOT. Joint development was done on defining and testing a "cooperative awareness message" (CAM), the heartbeat of V2V and V2I communications which was later incorporated in the draft ETSI standards.

[4] http://www.coopers-ip.eu/

[5] http://www.comesafety.org/

[6] http://www.cvisproject.org/en/about_cvis/third_party_cooperation/

1.6. Cooperative Mobility Showcase 2010

During 2008, the three projects CVIS, SAFESPOT and COOPERS co-organised a call for expressions of interest to host a Cooperative Systems Showcase in 2010. The selection process was finalized in January 2009 with the decision to hold the event in Amsterdam alongside InterTraffic 2010, the world's largest exhibition of traffic management systems. The showcase featured extensive on-road demonstrations, a linked thematic exhibition, a "cooperative traffic management centre of the future" and a three-day conference. More details are presented below.

1.7. Deployment enablers

Alongside the technical work in CVIS, the Deployment Enablers sub-project (DEPN) was investigating seven topics of potential deployment barriers and solutions for cooperative systems (Topic 1 was DEPN management):

2. Openness and interoperability;
3. Safe, secure and fault-tolerant design;
4. Utility, usability and user acceptance;
5. Costs, benefits and business models;
6. Risks and liability;
7. CVIS as a policy tool; and
8. Deployment road-maps.

Topic 2 drafted recommendations for development of CVIS applications and relevant standards as well as specific requirements for openness and interoperability for CVIS applications. A cooperation architecture was described based on various levels of interaction, comprising business models, business cases in the form of services offered, business protocols represented by contracts, service deployment and interconnection protocols. The CVIS cooperation architecture comprises a "cooperation stack" of services and contracts together with more generic, supplementary standards and services like (open) standards, a semantic model sharing service and secure interoperability by proper identity services. Validation assessed to what extent the recommendations resulted in an open and interoperable system.

The requirements to embed safety, security and fault tolerance in the design of CVIS were defined by the Topic 3 team. These results were input to the e-Security Working Group of the *e*Safety Forum[7]. For the utility analysis of the principal stakeholders in CVIS, a questionnaire was designed to understand CVIS market/deployment aspects from a manufacturer's point of view. Also an on-line survey was launched while 10 "face-to-face interviews" were carried out with vehicle experts.

For Topic 4, a number of studies were made. User acceptance of the CVIS system was investigated by an internet based questionnaire distributed to 13 Automobile clubs in 12 countries, asking around 8,000 European motorists how useful several CVIS applications were. The results showed that CVIS applications were generally well accepted by the end user, with over 50% of respondents finding them quite or very useful. CVIS also investigated the utility, usability and acceptance of cooperative systems for road operators through a survey to more than 200 professionals.

In Topic 5, a methodology was adopted to identify potential value models and business models for cooperative systems. Cost-benefit analysis and business model methodologies were examined for 16 core CVIS applications and services.

An inventory of risks and liabilities was created in Topic 6, mapping the legal exposure of each actor in the CVIS deployment and operational service chain. Significant external risks and threats were divided into different categories: e.g. competition, costs, data privacy, environment, legal/regulatory, political, etc.

In Topic 7, a workshop on the benefits of cooperative systems for policy authorities was organised in Helmond, the Netherlands, in May 2009, with the objective to exchange experience of developing the Dutch Policy Plan on Cooperative Systems to other national, regional and local authorities. Participants also shared views on cooperative systems potential and obstacles with regards to transport policy goals and deployment. In addition, transport policy-makers and advisors throughout Europe have been interviewed to complete CVIS overview report on this topic.

Finally, to ensure that CVIS core technologies and applications are fundamentally deployable and that all above-mentioned non-technical showstoppers have been identified, in Topic 8, a generic framework was developed in the form of a roadmap for Cooperative Systems deployment in Europe, aggregating together all key factors for deployment. This roadmap covers the main elements and stakeholders needed for a working CVIS system distributed in terms of costs, benefits, risks, liabilities and control over policy decisions. External influences driving the needs for cooperative services were identified, from public demand for safe and efficient traffic of people and goods, to commercial transport needs and individuals' need for personal mobility.

Finally, CVIS took the lead in a collaboration between the deployment activities of the 3 IPs to prepare a white paper on "Addressing Deployment challenges of Cooperative systems". The result was a common view on the most important challenges and possible solutions for cooperative systems deployment.

1.8. Dissemination highlights

Through extensive and sustained efforts in dissemination CVIS succeeded in achieving a high

[7] http://www.esafetysupport.org/en/esafety_activities/esafety_working_groups/esafety_working_groups.htm

awareness amongst the ITS community and also the general public. Highlights of the project's last period include large-scale public demonstrations, including "Cooperative Systems on the Road" event in Helmond (NL), on 12-14 May 2009; "CVIS Live!" at the ITS World Congress in Stockholm (21-25 September 2009) and the "Cooperative Mobility Showcase" in Amsterdam on 23-26 March 2010.

The common thread of those events was a mix of closed-track demonstrations and demo drives on public roads, where participants could experience at first hand a series of cooperative services scenarios.

The project ensured a strong presence at key conferences & events (presentations, where available, can be downloaded from the CVIS website – see link hereunder), as well as in media ranging from scientific publications to general interest news websites.

Moreover, CVIS organised a number of training workshops aimed at e.g. transport engineering students and public authority professionals.

In addition to a final video, a final general brochure was released as well as one targeted at urban transport planners, each giving a full overview of the project's results as basis for further exploitation.

All publicly available material, from brochures to deliverables and other reports can be freely downloaded from the CVIS website at http://www.cvisproject.org/en/public_documents.