COOPERS

Co-operative Networks for Intelligent Road Safety

D6100

Final report on demonstration

Version
1.0

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1	ATE	AustriaTech – Gesellschaft des Bundes für technologiepolitische Maßnahmen	Austria
2	HIT	Vereinigung High Tech Marketing	Austria
3	ARS	ARS Traffic and Transport Technology B.V.	Netherlands
4	SWA	Swarco Europe GmbH	Austria
5	EYI	Ernst and Young Financial – Business Advisors S.p.A.	Italy
6	ASF	ASFINAG - Autobahnen- und Schnellstraßen-Finanzierungs- Aktiengesellschaft	Austria
7	ORF	Österreichischer Rundfunk	Austria
8	-	Left intentionally blank	
9	TUW	Technische Universität Wien	Austria
10	ASC	Ascom Switzerland Ltd	Switzerland
11	TRG	University of Southampton	United Kingdom
12	PWP	pwp-systems GmbH	Germany
13	OBB	Oberste Baubehörde im Bayerischen Staatsministerium des Innern	Germany
14	DOR	Dornier Consulting GmbH	Germany
15	GEW	GEWI Hard- und Software Entwicklungsgesellschaft mbH	Germany
16	BRE	Autostrada del Brennero	Italy
17	VEG	VEGA Informations-Technologien GmbH	Germany
18	-	Left intentionally blank	
19	LOD	Politechnika Lodzka	Poland
20	TRA	TRANSVER GmbH	Germany
21	FHG	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung E.V.	Germany
22	EFM	EFKON Germany GmbH	Germany
23	EFK	EFKON AG	Austria
24	VTI	Statens väg- och transportforsknings-institutet	Sweden
25	KTH	Kungliga Tekniska Högskolan	Sweden
26	NET	TeamNet International S.A.	Romania
27	INO	INESC Inovação – Instituto de Novas Tecnologias	Portugal
28	APP	LGAI Technological Center S.A.	Spain
29	ICI	National Institute for Research Development in Informatics	Romania
30	TUC	Technical University of Crete	Greece
31	KYB	Kybertec, s.r.o.	Czech Republic
32	JAS	JAST Sàrl	Switzerland
33	BMW	Bayerische Motoren Werke Aktiengesellschaft	Germany
34	NAV	Navteq B.V.	Netherlands
35	-	tbd1	
36	-	TBD2	
37	ARC	Austrian Research Centers GmbH	Austria
38	ASA	ASFA – Association professionelle des Sociétés Françaises concessionnaires ou exploitantes d'Autoroutes ou d'ouvrages routiers	France
39	TSB	TSB – FAV, Technologiestiftung Berlin – Forschungs- und Anwendungsverbund Verkehrssystemtechnik Berlin	Germany
40	MIZ	MIZAR Automazione	Italy
41	TEL	TELARGO d.o.o., Informacijske rešitve v prometu in tranportu	Slovenia
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General limitation of this document:

The information concerning test site 2 given in this deliverable may be outdated, as the partner responsible for Site 2 (ARS) did not provide the requested information, or declined to confirm the validity of the information provided in previous documents.

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Abbreviations

3G	3rd Generation Networks
4G	4th Generation Networks
AADT	Annual Average Daily Traffic
AASHTO	American association of state and highway transportation officials
AB	Abbiege-Unfall
ABS	Antilock Braking Systems
ACC	Automated Cruise Control
ADAS	Advanced Driver Assistance Systems
AETR	European Agreement Concerning the Work of Crews of Vehicles Engaged in International Road Transport
AG	Aktiengesellschaft
AIDE	adaptive integrated driver-vehicle interface
AIDER	Innovative Vehicle-Infrastructure Telematics for Rescue Operations
AIS	Abbreviated Injury Scale
AIS/ISS	Abbreviated Injury Scale/Injury Severity Scores
AKTIV	Adaptive und Kooperative Technologien für den Intelligenten Verkehr
AP	Action Point
API	application programming interface
ART	Article
ARTS	Advanced Road Telematics in the South-West
ASRB	automotive safety restraints bus
ASV	Advanced Safety Vehicle
AUTOSAR	Automotive Open System Architecture
AVCSS	Advanced Vehicle Control and Safety Systems
AVI	Automatic Vehicle Identification
BASt	Bundesanstalt für Straßenwesen
BMVBW	Bundesministerium für Verkehr, Bau- und Wohnungswesen
BMVIT	Bundesministerium für Verkehr, Innovation und Technologie
BS	British Standard
BSI	Bundesamt für Sicherheit in der Informationstechnologie
CA	Collision Avoidance
CA	Consortium Agreement
CALM	Communication Air-interface Long and Medium range
CALM M5	Continuous Air interfaces - Long and Medium Range - Microwave 5 GHZ
CAN	CAN-Bus (Controller Area Network)
CARE	Community database on Accidents on the Roads in Europe
CAREPLUS	Citizens Active in Reading Education Plus
CARTALK-2000	Safe and comfortable driving based upon inter-vehicle communication
CCTV	Closed Circuit Television
CDC	Collision Deformation Classification
CDMA	Code division multiple access
CDRG	Centrally Determined Route Guidance
CE	Communauté Européenne
CEN	European Committee for Standardisation
CENELEC	European Committee for Electro technical Standardisation
CENTRICO	Central European region transport telematics implementation co-ordination
CHAMEL-EON	Pre-crash application all around the vehicle
CICAS	Cooperative Intersection Collision Avoidance Systems
CO	Coordinator

COOPERS	Co-operative systems for Intelligent Road Safety
CORBA	Common Object Request Broker Architecture
CORVETTE	Co-ordination and validation of the deployment of advanced transport telematic systems in the Alpine area
COST	Coopération européenne dans le domaine de la recherche scientifique et technique
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CS	Cost statement
CSMA/CA	Carrier Sense Multiple Access - Collision Avoidance
CT	Communication Tool
CVIS	Cooperative Vehicle-Infrastructure Systems
CW	Collision Warning
D	Deliverables
D&E	Dissemination and exploitation
DAB	Digital Audio Broadcasting
DAB/ DVB	Digital audio broadcasting/ digital video broadcasting
DARC	Data Radio Channel
DART	Dutch Accident Research Team
DATEX	Data exchange
DC	Dissemination committee
DG	Direction General
DG INFSO	Directorate General Information Society and Media
dGPS	Differential Global Positioning System
DIS	Driver Information System
DML	Demonstration management leader
DOT	departments of transportation
DSRC	Dedicated Short-Range Communication
DVB	Digital video broadcasting
DVR	Deutscher Verkehrssicherheitrat
e.g.	for example
E/E/PE	Electrical/Electronic/Programmable Electronic
EASIS	Electronic architecture and system engineering for integrated safety systems
EC	European Commission
eCall	emergency Call
ECE	Economic Commission for Europe
ECU	electronic control unit
EDIFACE	Electonic Data Interface
EEA	European Environment Agency
EEC	European Economic Community
EEG	Electroencephalogram
EES	Equivalent energy speed
EFC	Electronic Fee Collection
EFCD	Enhanced floating car data
EFTA	European Free Trade Association
EK	Einbiegen-/Kreuzen-Unfall
EMC	Electromagnetic Compatibility
E-MERGE	European Mountain lake Ecosystems: Regionalisation, diaGnostics and socio-economic Evaluation
EMI	Electromagnetic Interference
EN	European Norm
ERI	Electronic Registration Identification
ESA	European Space Agency

ESC	Electronic Stability Control
ESP	Electronic stability program
ESS	Environmental Sensor Stations
ETA	Estimated time of arrival
ETSI	European Telecommunications Standards Institute
EU	European Union
EUC	Equipment Under Control
EVTA	Event tree analysis
EWG	Environmental Working Group
FCD	Floating Car Data
FM	Frequency Modulation
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FMSCA	Federal Motor Carrier Safety Administration
FP	Framework Programme
FRAME	Framework architecture made for Europe
FStrAbG	Fernstraßenausbaugesetz
FSV	Forschungsgemeinschaft Strasse und Verkehr
FTA	Fault Tree Analysis
FTDMA	Flexible Time Division Multiple Access - bandwidth partitioning by time slicing
G	generation
GDF	Geographic Data Files
GHR	Gazis-Herman-Rothery
GIS	Geographical information system
GM	General Motors
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global system for mobile communications
GSSF	Galileo system simulation facility
GST	Global System for Telematics
HANNIBAL	High Altitude Network for the Needs of Integrated Border-Crossing Applications and Links
HAZOP	Hazard and Operability analysis
HGV	Heavy Goods Vehicles
HL	high level
HMI	Human Machine Interface
HOV	High Occupancy Vehicle
HUDs	Head-Up Displays
HW+SW	Hardware + Software
I	Infrastructure
I/O	input/output
I2V	Infrastructure to Vehicle
ICD	International Classification of Diseases
ICT	Information and Communications Technology
ICTSB	ICT Standard Board
ID	Identification
IEC	International Electronical Commission
IEEE	Institute of Electrical and Electronics Engineers
INS	Institut national de Statistique
INVENT	Infrastructure for Virtual Enterprises
IOG	Infrastructure operator group

IP	Integrated project
IR	Internal report
IRTAD	International Road Traffic and Accident Database
ISA	Intelligent Speed Adaptation
ISDN	Integrated services digital network
ISO	International Organization for Standardization
ISP	Industry and Component Suppliers Panel
IST	Information society technologies
ISTAT	Istituto Centrale di Statistica
IT	Information Technology
ITS	Intelligent Transport Systems
ITSSG	Intelligent Transport Systems Steering Group
ITU-T	International telecommunication Union – Terminals for telematic services
IVHW	Inter Vehicle Hazard Warning
IVI	Intelligent vehicle infrastructures
J2EE	Java 2 platform enterprise edition
J2SE	Java 2 platform standard edition
JK	Jahreskarte
KAREN	Keystone architecture required for European networks
KD	Unfallkostendichte
KFV	Kuratorium für Verkehrssicherheit
KL	Unfallsbelastungskosten
KPI	Key performance indicators
KR	Unfallkostenrate
kW	kiloWatt
LACOS	Large Scale Correct Systems
LAN	Local area network
LATERAL-SAFE	Lateral driver assistance applications
LCS	Line Control Systems
LDRG	Locally Determined Route Guidance
LDW/A	Lane Departure Warning/Avoidance
LDWS	Lane Departure Warning Systems
LED	Light Emitting Diode
LIN	Local interconnect network
LOS	Level of Service
LV	Unfall durch Längsverkehr
LVD	Low Voltage Directive
M	Milestone
MALSO	Manoeuvring Aids for Low Speed Operation
MOST- Bus	Media oriented systems transport bus
MOT	Multimedia object transfer protocol
MT	Management team
MTM	Methods Time Measurement
NGOs	Non-Governmental Organizations
OBU	Onboard Unit
OEM	Original Equipment Manufacturer/Manufacturing
OSGi	open services gateway initiative
PAC	Policy advisory panel
PAD	Portable Application Description
PATH	Program for Advanced Transit and Highway

PC	Project Coordinator
PCI	peripheral component interconnection
PCMCIA	personal computer memory card international association
PDA	Personal digital assistant
PDAC	plan-do-act-control
PDT	Peripheral Detection Task
PM	Person months
PMT	Project Management Team
PPP	Public private partnership
PReVENT	Preventive and Active Safety Applications
PROSPER	Project for Research on Speed adaptation Policies on European Roads
PSAPs	Public Safety Answering Points
PT	public transport
PTPS	Public Transportation Priority System
R	Reports
R&D	Research & development
RACM	Reasonably available control measures
RAMSS	Reliability, Availability, Maintainability, Safety & Security
RDCW	Road Departure Crash Warning
RDS	Radio Data Systems
RDS-TMC	Radio Data System - Traffic Message Channel
RFID	Radio Frequency Identification Device
RMI	Road monitoring infrastructure
RM-ODP	Reference Model – Open Distributed Processing
RPN	Risk Priority Number
RPU	Robust Positioning Unit
RRS	Road Restraint Systems
RSE	roadside equipment
RSU	roadside unit
RTA	Road Traffic Advisor
RTD	Round trip delay
RTLX	Raw Task Load indeX
RTTT	Road Transport and Traffic Telematics
RV	Unfall durch ruhenden Verkehr
RX	Receiver
SA	System architecture
SAE	System Architecture Evolution
SAE	Society of Automotive Engineers
SAFELANE	Situation Adaptive system For Enhanced LANE keeping support
SafeSpot	Cooperative vehicles and road infrastructure for road safety
SARTRE	Social Attitudes to Road Traffic Risk in Europe
SBAS	Satellite Based Augmentation System
SCB	Statistics Sweden
SCOM	Steering committee
SERTI	Southern European Road Telematic Implementations
SIG	Special Interest Group
SIKA	Statens Institut för KommunikationsAnalys
SIL	Safety Integrity Level
SMS	Short message service
SNRA	Swedish National Road Administration
SO	Sonstiger Unfall

SRA	Swedish Road Administration
SRB	Safety research board
STRADA	Swedish Traffic Accident Data Acquisition
STREETWISE	Seamless Travel EnvironmEnt for the Western Isles of Europe
STVO	Straßenverkehrsordnung
StVUnfStatG	Straßenverkehrsunfallstatistikgesetz
SVD	Selective Vehicle Detection
SWOV	Stichting Wetenschappelijk Onderzoek Verkeersveiligheid
SWP	Sub Work Package
SWPL	Sub-work package leaders
TCC	Traffic Control Centres
TCT	Technical co - ordination team
TDMA	Time Division Multiple Access - bandwidth partitioning by time slicing
TEN	Trans European network
TEN-MIP	Trans European network-multi annual programme
TEU	Traffic eye universal
TIC	Traffic Information Centre
TICS	Traffic Information and Control Systems
TISP	Traffic information service provider
TIWS	Traffic Impediment Warning Systems
TLT	Thematic leader team
TMC	Traffic Message Channel
TMIC	Traffic management and information centres
TMT	Thematic leader teams
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
TPEG	Transport Protocol Experts Group
TRMM	Trunk Road Maintenance Manual
TTI	Tactical traffic image
TTI	Traffic and Traveller Information
TTP(/C)	Time-Triggered Protocol (/ Dependability Level C)
TX	Transmitter
U	Unfälle
UD	Unfalldichte
UDP	user datagram protocol
UL	Unfallbelastung
UML	Unified modelling language
UMTRI	University of Michigan Transportation Research Institute
UMTS	Universal mobile telecommunications system
UR	Unfallrate
US	United States
ÜS	Überschreiten-Unfall
USDOT	United States department of transportation
UTMS	Universal Traffic Management Society
V	Vehicle
V2I	vehicle to infrastructure
V2V	Vehicle to Vehicle
VAS	Value added service
VEESA	vehicle e-safety architecture
VII	vehicle infrastructure integration
VIKING	Co-ordination of ITS implementation in northern Europe

VMS	Variable Message Sign
VMT	Vehicle mile traveled
VRUs	Vulnerable Road Users
VSL	Variable Speed Limit
VTPI	Voorhees Transportation Policy Institute
VTTI	Virginia Tech Transportation Institute
WBS	Work breakdown structure
WBT	Web based training
WILLWARN	Wireless Local Danger Warning
WLAN	Wireless local area network
WP	Work Package
WPL	Work Package Leader
WüStV	Wiener Übereinkunft über den Straßenverkehr
XFCD	Extended Floating Car Data
XGDF	eXtended Geographic Data Files
XML	eXtensible Markup Language
ZIP	Zone Improvement Plan

1 Executive summary

This document describes how the field tests at the various test sites have been

- planned,
- prepared
- and executed.

In order to be able to execute the field tests, first the test sites had to be prepared: the existing highway infrastructure had to be upgraded and adapted in order to be able integrate the components of the Coopers system; the installation had to be carried out (without disrupting ongoing highway operations); the installed system needed to be tested and verified.
Then the execution of the field test had to be planned and prepared: the testing procedures had to be determined (taking into account the local research agenda of the test sites); required premises, documents, equipment etc. had to be allocated, drivers and staff needed to be recruited and scheduled.
Finally the field tests had to be executed and monitored, logfiles and test data had to be collected, and forwarded to WP7000 for assessment and analysis.

The present deliverable describes how these steps were carried out within WP6000. Chapter 2 starts with a generic overview of the test sites, outlining their properties, why they were selected to host the field tests, and introducing the expectations and motivations of the involved highway operators. All these factors influenced the technical solution adopted by the test sites for the implementation of the Coopers system, as well as the methodology and testing procedures employed for the execution of the field tests.

The technical solution adopted by the various sites depended mainly on the existing infrastructure, as well as the communication technology selected. At the beginning of the project, an extensive analysis of the transmission technologies available was performed; based on their technical properties, as well as availability at the various test sites, three core technologies were selected for implementation (CALM-IR, DAB, and GSM/GPRS). Chapter 3 outlines which modifications the test sites made to their infrastructure, which technology they selected, and how the coopers components could be integrated into the existing highway infrastructure; an in-depth description can be found in the final demonstration report of the various test sites (IR 6200 / IR 6300 / IR 6400 / IR 6700: Final demonstration evaluation report).

During the planning stage, other than determining the technical solution to be adopted, it was also necessary to elaborate the testing procedures to follow during the execution of the field tests, as this would influence all further preparations. The testing procedures needed to follow a common methodology, elaborated within the project (in order to guarantee comparability of the data acquired during the field tests), but also take into account the local research agenda of the test sites (in order to address also the local interests of the stakeholders).

Once the planning of the technical solution and the overall testing procedures was completed, it was possible to proceed with the preparation of the test sites; some components of the Coopers system were developed by the test sites themselves in co-operation with third-party providers, the majority however (RoadSide-Units, CALM-IR transceivers, OnBoard-Equipment) were delivered by project partners to the testsites. Unfortunately the project experienced sensible delays in this regard, as the delivery of a functioning OBE (OnBoard-Equipment, consisting of CGW and APC) was postponed several times. Various issues in the communication chain and the functionality of the APC became evident in the first prototypes presented, which could be solved only partially. The envisaged delivery date was repeatedly delayed by several months, impacting significantly on the preparation efforts of the test sites (especially Site 1 and Site 3). Therefore, in order not to jeopardize the execution of the field tests, different countermeasures had to be taken, a.o. the development of an alternative APC solution. This effort proved to be successful, however preparation of the testsites, the testing of the system, and the execution of the field tests could only proceed with substantial delays (the issues related to the APC also caused test site 2 to interrupt communication with the consortium, therefore only limited information concerning the field tests at Site 2 can be provided in this deliverable; the missing data could however be compensated for by the other test sites). Refer to Chapter 6 for the overall time schedule and a description of the delays/countermeasers in more detail.

During the preparation stage, other than installing and testing the infrastructure, it was also necessary to allocate the premises, documents, equipment, etc. required for the field tests. Resuming, the following activities had to be carried out by all test sites:

- Preparing the infrastructure (according to the technical solution): upgrade the existing highway infrastructure; install and integrate the Coopers components.
- Preparing the test cars: testsites had to equip vehicles with Coopers equipment (OBE) and telemetry sensors to be used during the field tests.
- Allocating premises: offices had to be prepared for the reception the probands, the tutoring of the test driver, the fitting of the biometric sensors, and the filling out of the questionnaires.
- Preparing the documents: recruitment forms for the selection of the drivers, formal documents to be signed by the probands before the field tests (insurance, legal documents, privacy issues, etc.), the tutorial material for the drivers, and the questionnaires had to be prepared.
- Recruitment of test drivers: test drivers needed to be recruited on voluntary basis, following a predefined user profile.
- Recruitment and training of staff: for the execution of the field tests, a continuously working team was necessary. The required personnel had to be recruited/appointed and trained.
- Testing the system: before proceeding with the field tests, the functionality of the system had to be verified (in the laboratory and in the field).

A detailed description of the preparation efforts are given in Chapter 4.

Finally, after the Coopers system had been installed and tested at the various testsites, the testing procedures had been prepared, all required equipment had been allocated, and drivers as well as staff recruited and trained, the test sites could commence the field tests, which were executed between January and June 2010: test site 1 executed the field tests between January and April, Site 3 between March and April, and Site 4 finally in June (the APC for Site 4 was especially complex to develop, as it included a.o. a vectorized map of the entire French motorway); logfiles and data collected during the tests were forwarded to WP7000 as soon as available. The facts and figures concerning the execution of the field tests are provided in this deliverable (Chapter 5), while the results are included in the deliverable of WP7000.

Conclusively, it can be said the road operators involved in the field tests consider the Coopers project a success. The system has been demonstrated in daily operation, under real traffic conditions, and first results show that the expectations concerning safety and user acceptance have been fulfilled.

2 Introduction

The scope of the Coopers project was the development and demonstration of a system that links vehicles with road infrastructure via continuous wireless communication to exchange data and information relevant for the specific road segment to increase overall safety and enable co-operative traffic management.

The project has been organized into different workpackages with the following sequence. After an analysis phase in WP2000, the specification of the system architecture in WP3000, and the development and testing of the required components in WP4000 and full system validation and testing in WP5000, the Coopers system was demonstrated along some heavily used sections of European motorways in the context of the WP6000. The logfiles acquired during these field tests were analyzed by WP7000, for final dissemination of the results in WP 8000.

Within WP6000, the Coopers system has been demonstrated in four test sites spanning five different countries (Germany, Austria, Italy, France, and the Netherlands). In order to be able to execute the tests, the demonstration sites had to be prepared accordingly; the highway infrastructure had to be adapted and equipped with the Coopers system; furthermore, the tests had to be organized and executed. The preparation and execution of the tests was done according to a common methodology and testing procedures (to ensure that results from the single test sites are comparable), taking additionally into account their local research agenda (expectations and aspirations of the local stakeholders).

Based on the local research agenda, the test sites also executed local technical tests in addition to the overall Coopers field tests.

The present deliverable gives a brief overview about the Coopers architecture and the common methodology, then outlines how the Coopers field tests were planned, prepared, and executed at the various test sites, taking into account similarities, differences, and coordination issues. Detailed information about the single test sites can be found in the following Internal Reports:

- IR 6200: Field demonstration evaluation report (Site 1).
- IR 6300: Field demonstration evaluation report (Site 2).
- IR 6400: Field demonstration evaluation report, IR 6400: Resulting data report (Site 3).
- IR 6700: Field demonstration evaluation report, IR 6700-1: Services evaluation report, IR 6700 -2: Systems evaluation inputs (Site 4).

This document has the limitation that the demonstrations of site 4 have not been done yet, the preparations of the equipment, the adaptation of the OBU with full functionality are confirmed but the demonstration drives will be finalized before the project review and first results presented and discussed.

3 Test site overview

The Coopers system has been demonstrated along some heavily used sections of European motorways. Four different test sites (see Figure 1) have been equipped with COOPERS equipment, and extensive field tests were carried out from January to June 2010.

- Demonstration site 1: the Brenner Corridor from Nuremberg to Verona.
- Demonstration site 2: the Rotterdam-Antwerp corridor.
- Demonstration site 3: the Berlin city highway.
- Demonstration site 4 - Section 1 & 6: the French corridor from Chamonix to Valence, and the Paris area[1].

Figure 1: The Coopers Test sites

A detailed description of the planning, preparation and execution of the Coopers field tests can be found in the Internal Reports associated to the different test sites:

- Site 1: IR 6200 - Final demonstration evaluation report.
- Site 2: IR 6300 - Final demonstration evaluation report.
- Site 3: IR 6400 - Final demonstration evaluation report.
- Site 4: IR 6700 - Final demonstration evaluation report.

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[1] Site 4 evaluates a wide range of research questions, which is reflected in the existence of 6 different test sections; Coopers field tests are performed in sections 1 & 6; sections 2-5 feature local technical tests (according to the local research agenda from Site 4).

Test site 2 and 4 also performed several local tests, according to their local research agenda. These tests are described in:

- Site 2: IR 6400 - Resulting data report.
- Site 4: IR 6700 -1 Services evaluation report.
- Site 4: IR 6700-2: Systems evaluation inputs.

3.1 Test site 1

The demonstration site 1 lies along the "Brenner corridor", traversing the cities of Munich, Innsbruck and Trento. It involves 3 highway operators from different countries:

- ASFINAG (Austria)
- Autostrada del Brennero (Italy)
- OBB (Germany)

Therefore the demonstration site 1 is composed of **three different sections** operated by the above mentioned infrastructure operators. In the remainder of this document the three sections are referred to as:

- Test site 1 - AT (operated by ASFINAG)
- Test site 1 - IT (operated by Autostrada del Brennero)
- Test site 1 - D (operated by OBB)

Figure 2: Demonstration Site 1

Demonstration site 1 was selected as test site for Coopers due its strategic importance in the European highway network (the Brenner corridor is embedded in the European Route E45), its topological diversity (lowlands as well as mountainous area), and the fact that three different countries collaborate in one single test site. The three involved operators cooperate tightly in daily highway operation.

Basically the Demonstration Site 1 focused on short and mid-range communication. For this reason the testsite did not implement a continuous message supply, but single hotspots that are connected through the use of the same technical set-up on the road side and the same on-board equipment. The means of communication were infrared in Italy and Austria and local DAB in Bavaria. But even though the three "hotspots" are disjoint, they still qualify as one single test site, as they lay along the same corridor, the involved operators have similar expectations and motivations, use the same testing methodology, and collaborate tightly in the execution of the field tests (a.o. supporting international service handover).

Each operator performed an accurate analysis and evaluation of its entire infrastructure, and selected the most suited segment to carry out the Coopers field tests. For a detailed synopsis of the entire Brenner corridor (from Nuremberg to Verona) refer to "IR 4100-1: Interim Report on COOPERS Demonstrations Planning"; the selected test segments are described below.

3.1.1 Test site 1 - IT

The Brenner Motorway (A22) starts at the border between Austrian and Italy (Brenner) and ends near the city of Modena (at the interconnection to the A1 motorway). At present, it is 314 km long and crosses the provinces of Bolzano, Trento, Verona, Mantova, Reggio Emilia and Modena. In the northern part (from Brenner to Rovereto) it has two lanes, in the southern part (from Rovereto to Modena) three lanes per direction; it intersects two other highways (the A4 Motorway near the city of Verona, and the A1 Motorway near the city of Modena), and can be entered/exited through one of 23 tolling stations.

The Brenner highway is characterized by a very high number of tunnels and viaducts (29 tunnels and 101 bridges/viaducts), traffic peaks during holiday season, and a so called "dynamic lane" (hardshoulder that can be opened to the traffic in case of necessity) between the cities of Trento and Rovereto.

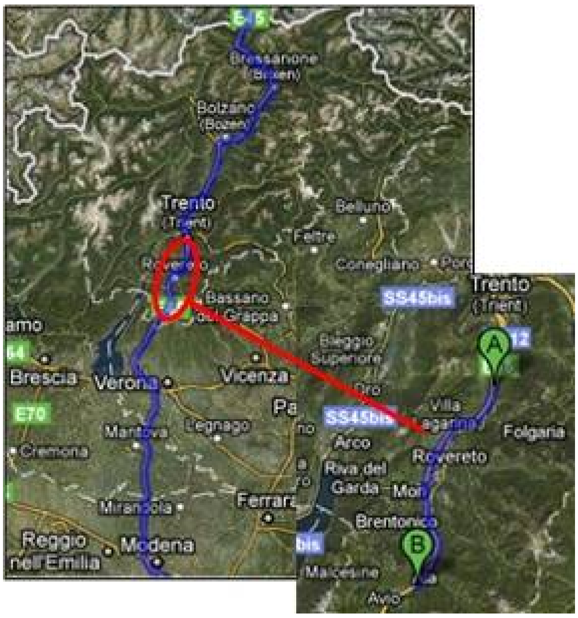


Figure 3: Test site 1 - IT

The segment from km 145 to km 179[2] (for an overall length of 34 km) was selected to carry out the Coopers field tests; it lies between the highway exits "Trento Centro" (km 136) and "Ala-Avio" (km 179), and crosses the highway exits "Rovereto Nord" (km 158) and "Rovereto Sud" (km 166). It was selected due to the following reasons:

- It is one of the best equipped sections in terms of infrastructure (a VMS gantry every 2 km, with access to Gigabit Ethernet network every 500-2000m).
- Presence of a so called "dynamic lane": in this section, the hardshoulder can be opened to the traffic in case of necessity (e.g., traffic jam), increasing the number of driving lanes from 2 to 3.
- Traffic peaks at specific periods. The Brennero highway is one of the main routes used during holiday traffic, with the segment around Rovereto being a particular hotspot.

3.1.2 Test site 1 - AT

As the demonstration site 1 focuses on the highly frequented “Brenner corridor” from Germany to Italy, the Austrian part of this testsite is the transit connection between Germany and Italy, namely the A12 “Inntal Autobahn” from the German border at Kiefersfelden to Innsbruck and the A13 “Brenner Autobahn” from Innsbruck to the Italian border at Brenner. A12 and A13 are among the best equipped motorways in the ASFINAG network, having multiple variable message signs, sensors and highly automated traffic management.

ASFINAG decided to test all services on a section of the A12 in the Innsbruck direction. The test section lies between the highway exits "Vomp" (km 52) and "Hall West" (km 70), for an overall length of around 17 km. The highway exits "Wattens" and “Hall Mitte” lie within the test section. The highway has a configuration of 2 lanes (plus the hardshoulder) at the test site.

[2] Measurement starts from Brennero at km 0.0

The site was chosen due to its vicinity to the state capital Innsbruck, thus having considerable traffic, a lot of traffic events in general, and a high density of sensors and VMS.

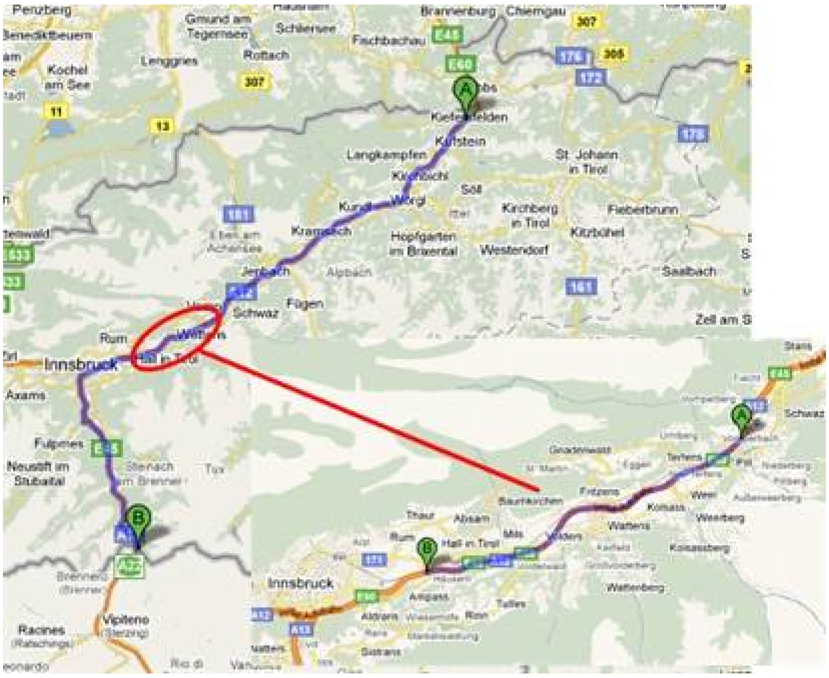


Figure 4: Test site 1 - AT

3.1.3 Test site 1 - D

The choice for the Bavarian test section was made according to the following criteria:

- Gantries in both directions available.
- DAB broadcast available.
- Local road maintenance office have road works trailers with GPS equipment in their vehicle fleet.
- Sufficient amount of real messages can be expected.

In the Bavarian test section, the A9 Autobahn in the North of Munich was chosen to test the Coopers systems, due to a high potential for messages, availability of LCS in both directions, and a high density of sensors. Another reason was that the southern Bavarian TCC is close to the test section. So the access to first-hand information from the operators and also a suitable starting point for the test drives was available.

Figure 5: Test site 1 - D

The test track started at the TCC in Freimann and ended at the intersection Eching on the highway A9/E45.

3.2 Test site 2

Figure 6: Test site 2

The Demonstration site 2 lies along the Rotterdam – Antwerp corridor that traverses the city of Rotterdam, Netherlands and Antwerp, Belgium. The 80 km corridor from Rotterdam (NL) to Antwerp (B) is one of the most intensively used road networks in Europe. During the last 20 years several serious incidents have occurred resulting in casualties and injuries. Both as a result of general safety policy and anticipating on specific local conditions, the main road network has been equipped with a wide variety of safety systems, including fog warning systems and incident detection systems (MTM). Continuous developments on infrastructure and ITS instruments attempt to maximize the capacity of this road section and the efficiency of its use with a maximum road safety.

Two road operators are involved in this field demonstration:

- Department Rijkswaterstaat, Dutch Ministry of Transportation and Water Management, and
- Division of Traffic Centre, Department Mobility and Public Works, Flemish Government.

The test-drive will take on the A16 between Dordrecht, Holland and Brecht, Belgium vice versa.

3.3 Test site 3

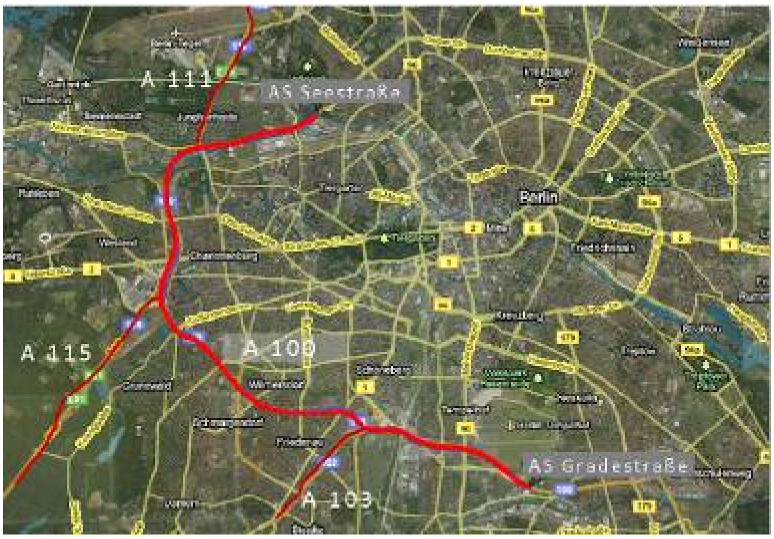


Figure 7: Test site 3

The demonstration site 3 aims at extending the spectrum of road networks on which Coopers services are tested. While the focus of COOPERS is mainly on highways, the common goal of demonstration site 3 is to extend this service towards secondary roads and urban environment. The extension of the COOPERS focus shall demonstrate that the designed concept of cooperative systems between infrastructure and cars is also feasible beyond highways.

Therefore demonstration site 3 includes the city of Berlin as well as the region Darmstadt. The focus of demonstration site 3 lies in testing the Coopers services on highways in urban environment on the Berlin inner-city motorways; however, in addition to the Coopers field tests in Berlin, additional local tests will be performed on secondary roads in the region

Darmstadt. The Coopers field tests in Berlin are outlined in this deliverable, and described in detail in IR 6400 - Final demonstration evaluation report; for a description of the local tests in Darmstadt refer to IR 6400 - Resulting data report.

Figure 7 shows the demonstration route in Berlin; it is located on the inner-city motorway ("Stadtautobahn") A 100, one of the most frequented motorways in Europe with peak average daily traffic volumes of 150.000 vehicles / 24h, and has a length of about 17 km.

3.4 Test site 4

Test site 4 comprises several sections of the French motorways, involving four different motorway companies (ASF, ATMB, SANEF, SAPN). These motorways operators have a robust background of traffic management systems based on extended infrastructure based monitoring and information services. The perspective of having vehicles and the traffic control centres communicate offers the possibility to considerable improve traffic management. Therefore the COOPERS demonstrations have the main objective to investigate the future of traffic management for road operators. The demonstration is focused in principal on traffic management techniques and the impact on the efficiency of the infrastructure. The goal is to learn about the benefits and difficulties in the integration of new COOPERS services in existing information systems.

Site 4 evaluates a wide range of research questions, which is reflected in the existence of 6 different test sections (see Figure 8). The Coopers field tests will take place in Sections 1 and 6, which consist of:

- The Paris area.
- The A7 motorway between Vienne and Valence, operated by ASF, with a length of about 70 km.
- The A40 motorway between La Fayet and Chatillon-en-Michaille, operated by ASF and ATMB, with a total length of about 110 km.

Figure 8: Test site 4

Sections 2-5 complement the Coopers field tests by investigating security issues not strictly related to the Coopers technology and services, but which provide useful information in the final overall safety assessment of cooperative services.

The Coopers field tests in France (Sections 1 and 6) are outlined in this deliverable, and described in detail in IR 6700 - Final demonstration evaluation report; for a description of the local tests on sections 2-5 refer to IR 6700 - 1 and IR 6700-2.

Figure 10: Site 4 - Section 6

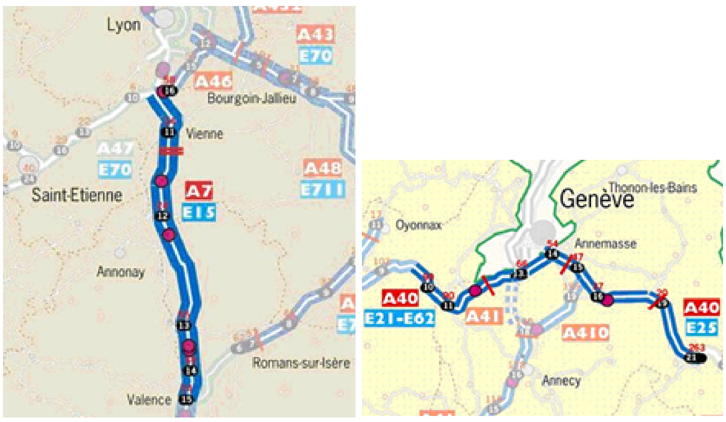


Figure 9: Site 4 - Section 1

3.5 Expectations and motivations

Although all testsites agree on the common vision of the Coopers project, to increase road safety and enable co-operative traffic management, the local stakeholders and project partners involved at each site model the expectations and motivations according to their local situation. This section describes the specific research topics addressed by the field work in the different demonstration sites, reflecting the aspirations, motivations and expectations from the point of view of each test site.

3.5.1 Site 1:

The main expectations and motivations of the stakeholders in Site 1 (Autostrada del Brennero, Asfinag and OBB) are an increase of safety and an improvement in the delivery of advanced traffic information. In addition to these two primary goals, the operators also expected an improvement of the cooperation and information exchange between the various road operators (and possibly between road operators and car- as well as device manufacturers). In the long term, systems like COOPERS might also lead to a reduction of VMS (financial advantage).

Therefore the stakeholders of site 1 were interested in performing:

- Technical tests - i.e., a proof of concept - to demonstrate that COOPERS can deliver safety-related information in a timely and accurate fashion to the driver (with advantages over traditional technologies, such as VMS or RDS-TMC).
- An analysis of the user acceptance, which is expected to have a strong influence on the potential market impact of COOPERS and on the "user compliance rate" (i.e. the driver behaviour in terms of compliance).
- An analysis of the user compliance rate, and the changes in the driver behaviour.
- An analysis of the possible risks of COOPERS (e.g. HMI distraction, increased stress or sudden scaring of the driver due to the messages).

Furthermore, the Austrian and German stakeholders were interested in evaluating the possibility of broadcasting traffic information with several different communication technologies and protocols (TPEG over DVB-H, tests with 802.11p; TPEG TAP-DEC and TPEG RTM over DAB, etc.)

For a more detailed description concerning the stakeholders expectations and motivations refer to IR 6200: Final demonstration evaluation report.

3.5.2 Site 2:

The declared objectives from the Rotterdam – Antwerp demonstration were to evaluate the effectiveness of in-vehicle traffic management systems, from a traffic management, a driver and a system perspective. The envisaged demonstration on the Rotterdam-Antwerp corridor was expected to yield insight in the migration from the current situation (in which road safety is primarily determined by road infrastructure based systems) to the future situation in which road infrastructure based systems as well as vehicle-based systems are present. Interest lied particularly on the safety effects in the transition period in which not all vehicles are equipped with all safety systems and road infrastructure safety systems are non-homogeneously available on the road network. The results of the demonstration should include an evaluation of the safety effects of in-vehicle traffic management services and recommendations on the introduction strategy for the transition period, in particular for the road operators.

Answers to the following research questions were sought from the demonstrations:

- What state-of-the-art i2v technologies are effective in delivering COOPERS services, compared with infrastructure based technologies (including aspects as standardization and scalability) ?
- What is the added value of the COOPERS services to the users, compared with VMS (and navigation systems with traffic info) ?
- What are the consequences of a hybrid introduction period, or alternatively a big-bang approach for the introduction of in-car traffic management ?
- What is the business case for in-car traffic management and how can this business case be enhanced, e.g. by exchange of FCD and personalization of the services ?
- What are the logical roles of road operator and industry and what are the liability impacts and how can the business case be positively influenced?

Site 2 also planned a WiMAX based test of a selected number of COOPERS services in the Amsterdam area. Generally GPRS is used as transmission technology for traffic information into the demonstration vehicles.

3.5.3 Site 3:

The role of the infrastructure operator has changed during the last years. New tasks have to be established besides the key aspects of construction, operation and maintenance. Traffic information and traffic management therefore belong to the main functions. The management of the traffic flow is consisting of traffic control systems with their variable message signs (VMS). VMS are often used within the context of an Incident Warning System (IWS), with the purpose of warning drivers of any hazards along the road ahead. The expected effects are that road users reduce speed, increase headways and general alertness, and possible diversion to an alternative route. Besides effects on traffic management, it is also expected that the information provides a contribution to safety.

The main objective of the Berlin infrastructure operator is the enhancement of safety and improvements in management of the traffic flow. Therefore the Berlin operator supports activities regarding new technology developments which strive to these goals. The analysis of the user compliance rate therefore belongs to a main task because the management of traffic through information is very dependent on the user's acceptance. The interrelation with the HMI distraction is obvious. As a result of these interdependencies field test with volunteers is seen as an important contribution to assess the driver behaviour in terms of compliance. It is therefore of great interest to interpolate the analysed effects to macroscopic changes.

The following research objectives will be analysed by the means of user behaviour analysis:

- Analysis of changes in driver behaviour - Analysis of the user compliance rate.
- Assessment of the macroscopic effects on traffic flow and safety.
- Assessment of the driver distraction arising from in-vehicle traffic management services.
- Analysis of the willingness to pay.

For a more detailed description concerning the stakeholders expectations and motivations refer to IR 6400: Final demonstration evaluation report.

3.5.4 Site 4:

Site 4, which involves four different motorway companies (ASF, ATMB, SANEF, SAPN), evaluates a wide range of research questions, which is reflected in the existence of 6 different test sections (see Figure 8).

The main Coopers tests will be performed in section 1 and section 6; sections 2-5 complement the Coopers field tests by investigating security issues not strictly related to the Coopers technology and services, but which provide useful information in the final overall safety assessment of cooperative services.

Issues investigated by sections 1 and 6 (main Coopers field tests):

- A technical investigation of the Coopers services.
- The construction of a dynamic speed database integrated with a static speed limit database, able to take as much parameters as possible in account (roadwork, speed regulation, violent wind, pollution).
- Efficiency: comparing the Coopers information chain with VMS and radio 107.7.
- Safety: identifying the potential safety impact of the tested COOPERS services.
- User acceptance: estimating user acceptance using the COOPERS questionnaire, the context of the test drives, and interviews by a psychologist.

Issues investigated by the sections 2-5 (in the context of local tests):

- Section 2 investigates the impact of an on-board SOS/AID system: creation of an automated information chain, bringing car emergency call data directly to the TCC, and comparing its performance to traditional SOS boot, patrols and cellular phone call; speeding up the processing of accident/incident detection; reducing impact of accident situation, improving safety and traffic fluidity.
- Section 3 evaluates the accuracy of the information provided to the driver and the impact of having "influence zones" of different size (5km, 10km, 15km, etc.), using a simple transmission chain (real events on the highway are sent to the cellphone of the driver).
- Section 4 tries to improve the signalling of roadworks, by allowing the service vehicles to transmit data related to roadworks directly to the TCC. The goal is to reduce the risks when signalling roadworks (increasing the safety of workers and drivers).
- Section 5 evaluates the efficiency of alerting users inside tunnels in case the Coopers equipment is not functional (if no transmission link to TCC), using traditional evacuation technology (radio, loudspeakers, light guiding systems).

For a more detailed description concerning the stakeholders expectations and motivations, refer to “IR 6700: Final demonstration evaluation report” (for the Coopers field tests in sections 1 and 6), as well as “IR6700-1: Services evaluation report “ and “IR6700-2: Services evaluation inputs “ (for local tests in sections 2-5).

4 The Coopers system

4.1 Coopers services

The following table shows the COOPERS services demonstrated at the various demonstration sites, specifying also the main communication technology that is used to link infrastructure and vehicles (as explained in more detail in Chapter 4.3, it was one of the requirements to the Coopers system to be hardware independent and independent from the transmission technology employed; therefore the various testsites focussed on different technologies to test the Coopers system).

COOPERS Service		Site 1			Site 2	Site 3	Site 4
		I	A	D	NL/B	D	F
S1a	Accident warning	IR	IR	DAB	GPRS	DAB	GPRS
S1b	Incident warning	IR	IR	DAB	GPRS	DAB	GPRS
S1c	Wrong-way driver warning	IR	IR	DAB	GPRS		
S2	Weather condition warning	IR	IR	DAB	GPRS	DAB	GPRS
S3	Roadwork information	IR	IR	DAB		DAB	GPRS
S4a	Lane banning	IR	IR	IR (*)	GPRS	DAB	
S4b	Lane keeping	IR	IR	IR (*)	GPRS	DAB	
S4c	Auxiliary lane accessibility	IR	IR		GPRS		
S5	Legal speed limit	IR	IR	IR (*)	GPRS	DAB	GPRS
S6	Traffic congestion warning	IR	IR	DAB	GPRS	DAB	GPRS
S7	Recommended speed limit	IR	IR		GPRS	DAB	GPRS
S8	International service handover	IR	IR		GPRS		
S9	Road charging		IR (*)				
S10	Estimated journey time		IR (*)		GPRS	DAB	GPRS
S11	Recommended next link				GPRS	DAB	
S12	Map update						

Table 1: The Coopers services tested at the various test sites

Services (*) were tested in local technical tests; all other services during the Coopers field tests.

4.2 Coopers ITS system architecture

An overview of the defined Coopers ITS system architecture is provided in the figure below, the following elements are part of the physical viewpoint, for detailed functional descriptions and defined subsystems and modules please relate to deliverable D13 – B-IR3100-2 Report on ITS Reference Architecture. The COOPERS system consists of the following elements:

- TCC – Traffic Control Centre
- CSC – COOPERS Service Centre
- RSU –Road Side Unit and
- OBE – on-board equipment set (CGW communication Gateway, Automotive PC and in-vehicle HMI

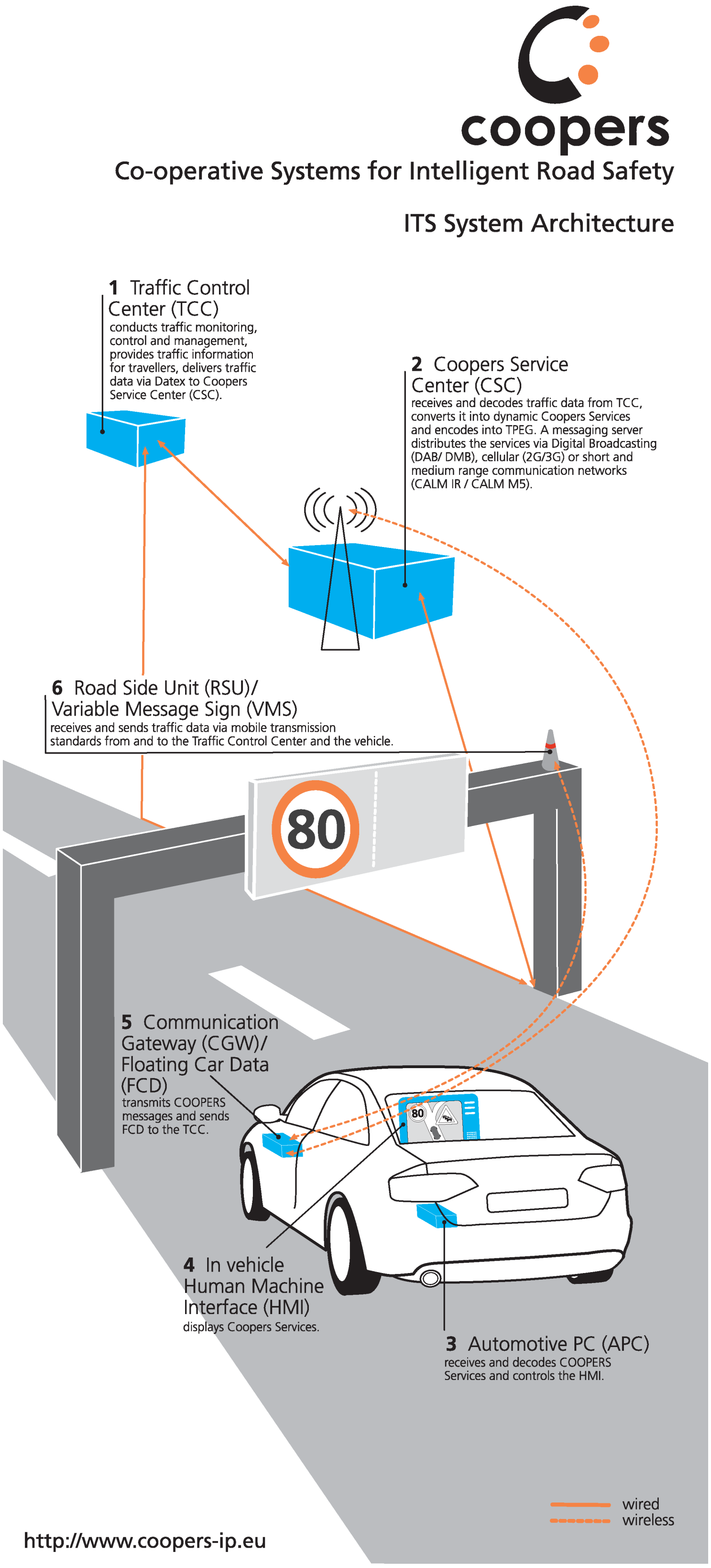


Figure 11:The Coopers ITS system architecture

4.3 Technical solution adopted

When designing the COOPERS system, one of the key requirements was that it should be hardware independent and - most of all - independent from the transmission technology employed. The reason for this requirement is the finding (documented in SWP3300 report) that no single existing communication technology fullfills the requirements of the traffic scenarios on motorways. Therefore complementing options have to be tested and validated in the demonstrations.

As there is no single transmission technology agreed-upon in Europe (in fact, the various countries favour different technologies), the ease of implementation of the COOPERS system is considered crucial for its acceptance among the European highway operators. In other words, the COOPERS services and protocols should be easy to implement (independent from the computer platform used), and the system should satisfy the minimal technical requirements (both stability and performance issues) independent from the transmission technology currently available.

Therefore, WP3000 did an extensive analysis of the transmission technologies available (at the moment the COOPERS system was designed), examining the following technologies (for a detailed description of these technologies refer to "IR 3300-2 Analysis of impact on communication links"):

- IR-MR
- CEN DSRC
- CALM IR
- Bluetooth
- GSM/GPRS
- UMTS
- DAB/DMB
- DVB-H
- Wireless LAN
- WiMAX

Based on their technical properties (performance issues, suitability to be used in a vehicular environment, etc) as well as availability at the various test sites, the following technologies were selected for implementation:

- CALM IR (from the group of short-range communication technologies)
- DAB (from the group of mid-range communication technologies)
- GSM/GPRS (from the group of wide-range communication technologies)

DAB was selected over DVB-H due to its strong diffusion in German countries; WiMax was a desired candidate, but could not be selected due to the lack of standardization (at the time the COOPERS system was designed). Recently WiMax has undergone substantial development, therefore it was decided to include a technical test concerning the usability of WiMax technology for COOPERS at Site 2 (usage of WiMax in the field tests was not yet possible).

In order to be able to examine the performance of the COOPERS system with respect to the different transmission technologies selected, the various testsites focused on different technologies for implementation:

- Site 1: CALM-IR and DAB
- Site 2: GPRS
- Site 3: DAB
- Site 4: GPRS

Although the different transmission technologies are likely to lead to performance differences at the various testsites, due to the facts that all system are guaranteed to satisfy the minimum technical requirements defined by WP5000 and that the tests at the various sites are performed according to a common methodology, the data produced by the various test sites has the same level of suitability and affordability concerning the user acceptance and driver behaviour evaluation, but with the additional advantage to be able to examine the advantages and disadvantages of the different technologies.

4.3.1 Site 1

The main reason why test site 1 selected CALM-IR and DAB (as short/mid-range communication technology), executing the tests on three “separate” hotspots, was that no single broadcast medium that covered the entire test site could be identified. Austria expressed interest in DVB, Germany in DAB, but neither of them were available on the Italian test site. A standardized WiMax transceiver was not available. Interest in GPRS was very low, a.o. because operators in Site 1 favoured a communication medium which could be entirely controlled by the operator and did not have additional costs associated with message transmission other than the initial installation costs; furthermore, Site 2 and Site 4 already focussed on GPRS, thus Site 1 wanted to focus on a different medium, so that the Coopers system is tested with as many different communication technologies as possible (a.o. to confirm the pretension of Coopers of being hardware and communication-technology independent). Therefore, the three operators in Site 1 focused on CALM-IR and DAB as short- and mid-range communication technology, and equipped three different “hotspots” with Coopers Technology: the Italian and Austrian hotspot with CALM-IR, the German hotspot with DAB.

Italian and Austrian test segment (Site1-IT, Site1-AT)

As Site1 - IT and Site1 - AT focussed on CALM-IR as main communication technology, Autostrada del Brennero and Asfinag equipped the gantries along their test section with CALM-IR transceivers. The transceivers are controlled by RSUs (RoadSide-Units) located directly on the gantries; the RSUs are connected via Ethernet with the CSC (Coopers Service Center) located at the TCC. The RSUs have no link with the other equipment mounted on the gantries (cameras, sensors, VMSs, etc.); they only communicate with the CSC (and IR-transceivers).

The Coopers Service Center is responsible for the generation of the Coopers services, and connected to the servers of the TCC, from where it acquires all data required for the generation of the Coopers messages. The TCC servers inform the CSC about events on the highway. Based on this information the CSC generates the Coopers messages and forwards them to the RSUs (RoadSide-Units), where they are inserted in a message buffer, waiting to be transmitted to passing vehicles.

Whenever a test car approaches such an IR-transceiver, the RSUs transmit the relevant Coopers messages to car; simultaneously, the car can send FCD data back to the RSU (which forwards it to the CSC for further processing).

The TCC server generates events based on the information from the connected infrastructure sensors, or directly from manual input from the TCC operators; these events are then passed to the CSC. Additionally, the TCC operators also have a direct interface to the CSC; this allows them to monitor the status of the Coopers system and intervene in the message management (generation, transmission to RSU, deletion, etc.). Operators can also trigger Coopers messages manually in case of necessity.

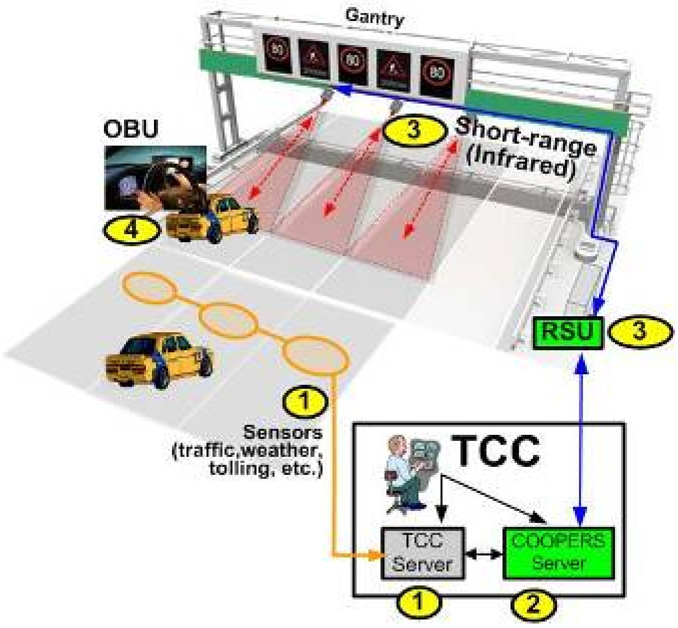


Figure 13: System structure at Site 1-IT/AT

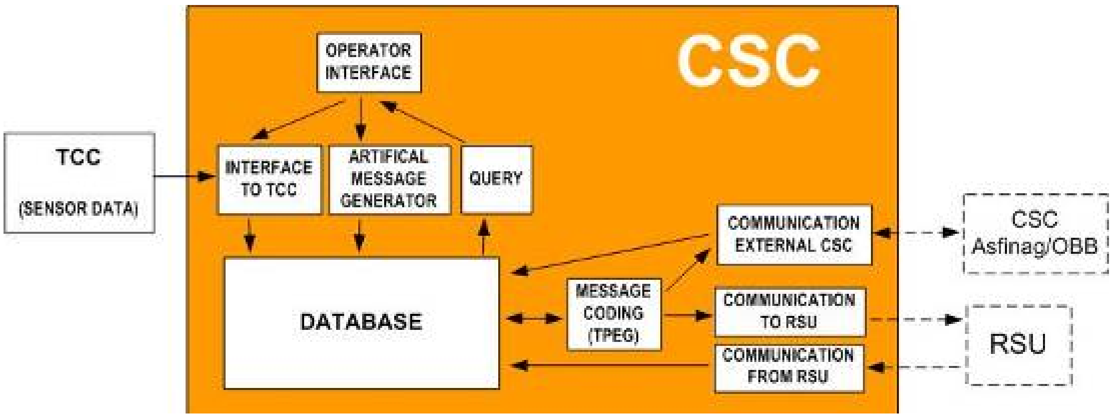


Figure 12: Structure of the Coopers CSC (example: Site1-IT)

German test segment (Site 1 - D)

As the Italian as well as the Austria section of Site 1 already provided two extensive segments equipped with CALM-IR, the Bavarian testsite decided for only a reduced use of IR during the field tests, and focussed on the use of DAB (IR was tested in the context of technical tests; during the field tests the main communication tecnology was DAB). For OBB one of the main objectives in the COOPERS project was to continue the work of the previous projects DIWA (Direct Information and Warning Applications), which focused on wide-range transmission (via DAB) of traffic messages from public sources, integrating all public sources of traffic information like road-side sensors, police messages, road work information and weather messages into one common content platform. Therefore the Traffic Information Agency Bavaria (VIB) founded in 2006 was included it the COOPERS processing chain as source for all services.

However, as the COOPERS system employs TPEG-RTM for encoding, while DIWA relied on TPEG-TEC, OBB decided to include local tests concerning the transmission of Coopers services via TPEG-TEC (in addition to the Coopers field tests where TPEG-RTM was used). Furthermore, OBB wanted to test two special cases of CALM-IR transmission: from TLS-gantries (gantries connected to the TCC via TLS, a monodirectional proprietary communication bus) and from roadwork-trailers. These tests were limited to local technical tests, due to technical limitations of the gantries and the roadwork trailer employed.

This results in the technical setup shown in Figure 14 (excluded the local tests of TPEG-TEC transmission over DAB). The data source for the Coopers field test is the Traffic Information Agency Bavaria (VIB); it generates its content by combining the messages from the TMC channel, road works information from the Highway Administration, weather warnings and data from on-road sensors. A special interface within the VIB has been developed to transmit the data to the Institute for Broadcast Technology (IRT) that used a TPEG Encoder from Fraunhofer First to encode these messages. The interface developed by the VIB was derived from the interface the VIB uses to transmit to and receive messages from the police warning center (Landesmeldestelle). The DAB antenna to broadcast the Coopers services is located in the north of Munich, and operated by IRT.

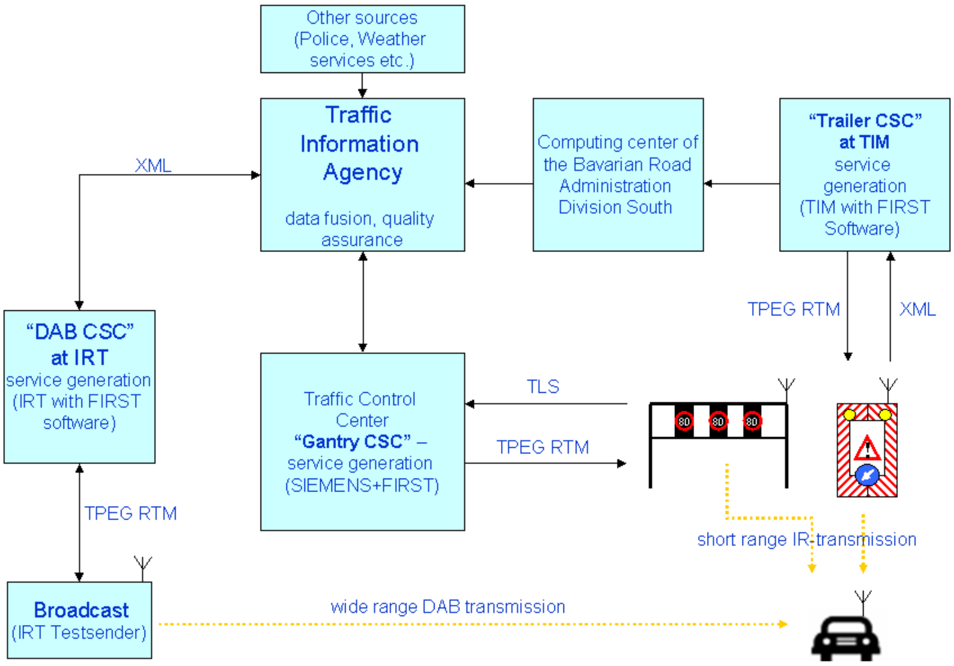


Figure 14: Technical setup at Site 1 - D

For a more detailed description of the technical setup on Site 1 refer to "IR 6200: Final demonstration evaluation report".

4.3.2 Site 2

During the demonstration, traffic in the vicinity of the demo vehicle will be registered by road side sensors. Real and artificial COOPERS messages will be submitted at precisely predetermined situations. COOPERS services will be either triggered from the local TCC and TIC (via the CSC) or simulated as a plausible traffic event at a plausible location and time.

To facilitate data exchange during the COOPERS field experiments, a COOPERS Service Centre (CSC) is available to relay information from the road operator side by its established TCC/TIC to the demonstration environment, without affecting the critical TCC/TIC environment during the demonstration. The CSC receives FCD from the APC through the CGW. The CSC may also be used to generate simulated COOPERS events that will be sent as TPEG messages to the OBU parallel to real events from the TCC/TIC.

Figure 15 represents the system architecture at test site 2.

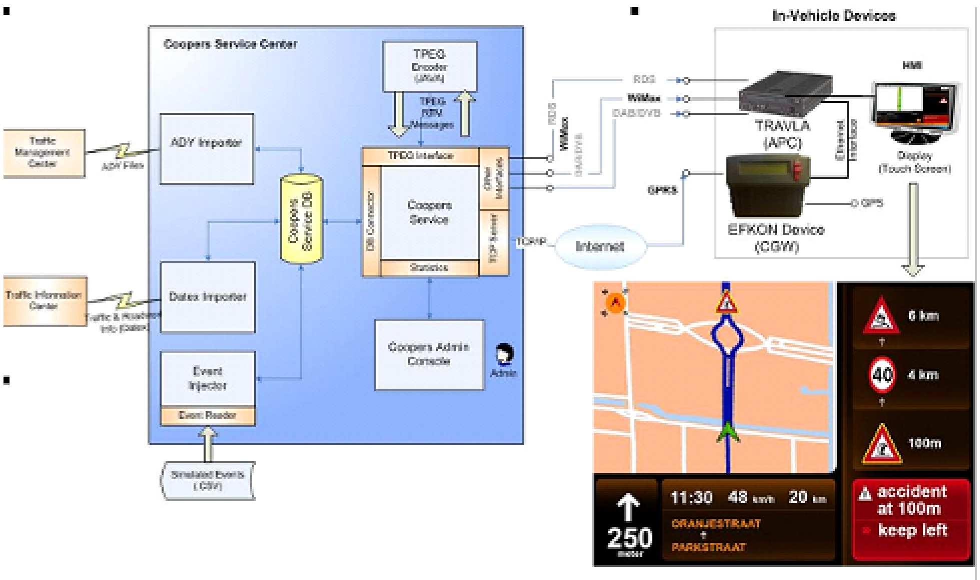


Figure 15: Technical setup at Site 2

4.3.3 Site 3

One of the main challenges of the COOPERS project is to develop an overall architecture that allows the integration and processing of different formats of traffic information by using established communication technologies. The available data sources from VMZ are used to generate COOPERS services and transmit them via digital broadcast to the vehicle. Figure 16 shows the overall communication structure used in Berlin.

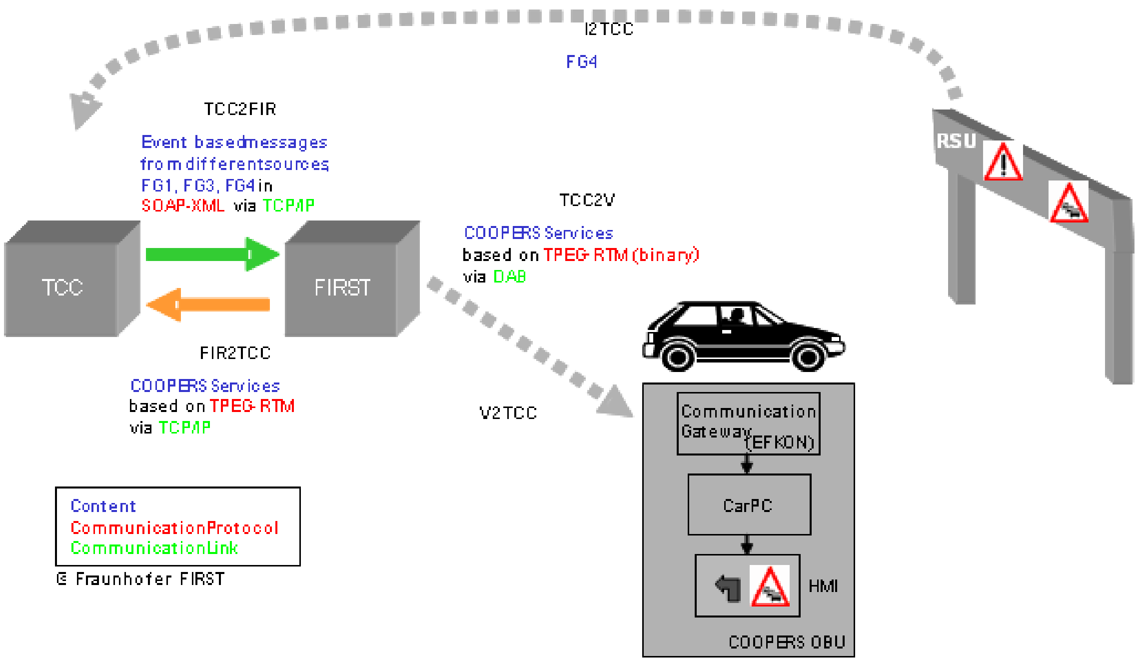


Figure 16: Communication Structure in Berlin

The Traffic Control Centre acquires and analyzes the raw data of the connected individual traffic management systems, and enhances it with its own sensor data. For the COOPERS project, a COOPERS Service Centre (CSC) has been installed at project partner Fraunhofer (FhG FIRST). All relevant data variables are translated into COOPERS services. Fraunhofer sends out the coded TPEG-messages via DAB to the COOPERS OBU. For data acknowledgement and for transmission of xFCD data from the vehicles to the CSC a back channel is organised via GSM/GPRS.

Therefore the communication setup in COOPERS for realising the driver Information consists of three components with the following functionalities:

- **COOPERS Service Center in Berlin**
    - Data fusion: Check for redundancy and consistency.
    - Generation of synergetic traffic information → COOPERS-services.
    - Server-side message management.
- **TPEG Encoder/Decoder Software**
    - Java based TPEG en/decoder components according to the CEN ISO TS 18234 Standard series.
    - Client-side traffic data management including location- and context-based filtering strategies; priority management.

- **DAB-Transmission in Berlin**
  - After creating the COOPERS services they will be send out via DAB to the COOPERS OBU.

For a more detailed description refer to "IR 6400: Final demonstration evaluation report".

4.3.4 Site 4

Site 4 uses GRPS as transmission technology, so that the COOPERS Service Centre (CSC) has a direct (bidirectional) communication link with the OBUs. The information chain of Site 4 (sections 1 and 6) is depicted in Figure 17.

The filtering of the messages is based on the concept of "influence zones": the CSC is connected to various data sources, from which it receives a list of active events. The OBU periodically sends their GPS position to the CSC. Each event is associated with an influence zone, representing the area in which the driver should be alerted about the event. The CSC continuously compares the positions of the connected vehicles to the influence zones of the stored events; as soon as a vehicle enters the influence zone (the GPS positions match), the CSC generates a Coopers message from the event, and sends it to the vehicle.

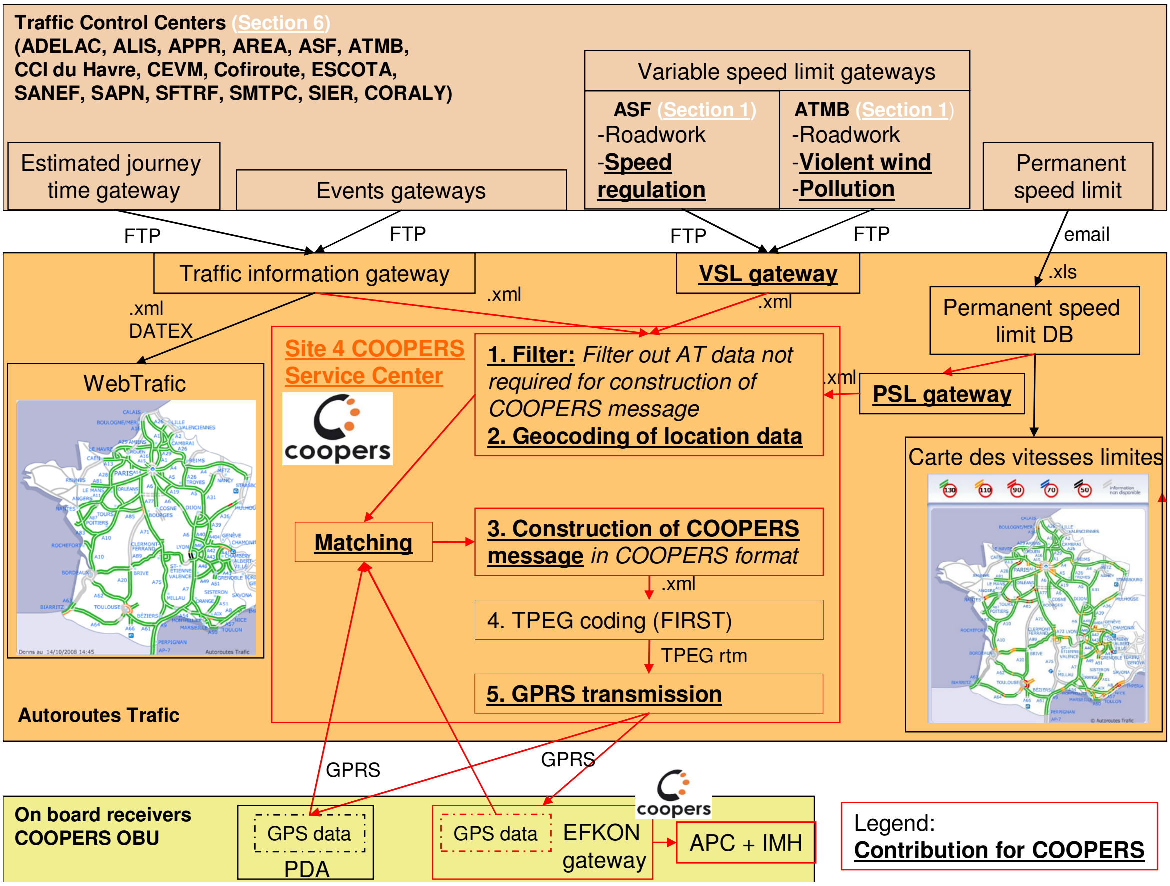


Figure 17: Technical setup at Site 4

For a more detailed description refer to "IR 6700: Final demonstration evaluation report".

5 Planning and preparation of the field tests

5.1 Common methodology and testing procedure

For the planning and execution of the field tests, a common testing procedure has been determined according to the general methodology defined by WP 2300, in order to ensure that the results from each test site are comparable. The test sites planned the tests on their sections according to this procedure, which is described in detail in SWP 2300 (Kölbl, R, Birgit Kwella, Norbert Pieth, Gerd Kock, Matthias Schmidt, Wolfgang Zimmer, Susanne Fuchs, Philipp Gilka (2008) SWP2300 Evaluation of demonstration sites/ methodology Version 3.0 Status Final), and resumed below.

The test is centered on a comparative test drive, where the same test section is traversed twice by the driver, one time with the Coopers system activated, and the other time with the Coopers system deactivated[3] (to compare the behaviour of the driver with and without the system); car telemetry and user biometric data is recorded during both drives. Additionally, the driver is accompanied by an assistant on the back seat of the car, to monitor the test, observe the driver, and to provide assistance if required. Before and after the test a questionnaire is filled out by the user.

- **PRE-TEST (staff from the test sites introduces and prepares the driver)**
  1. Welcome: the driver is greeted at the premises allocated for the test.
  2. A short introduction to the COOPERS system and an explanation concerning the test procedure will be given to the driver, according to guidelines developed in SWP 2300 (the guidelines ensure that the drivers are conditioned as less as possible before filling out the questionnaires and performing the test).
  3. Pre-questionnaire: the test driver will be asked to fill out a pre-drive questionnaire, which mainly focuses on the expectations and assumptions of the driver concerning the system. Both pre- and post-questionnaire are standardized, and have been developed by the project partner Hitec Marketing. For a detailed description of the questionnaires please refer to SWP 6600, respectively IR 6600 data collection for service assessment and market impact.
  4. Biometric sensors fitting: test site 1 and test site 3 monitor the driver with biometric sensors during the test, to get important information about user behaviour (gaze direction, heart rate, etc). For this reason the user wears an eye-tracking system and a heart rate monitor provided by TUB during the test drive (site 2 and site 4 do not monitor the driver).
  5. Test car initialization: the user enters the car; the biometric sensors (fitted on the user) are calibrated, and the in-car equipment (OBU, in-car sensors, recording equipment, etc.) is activated.
- **TEST DRIVE (on test section)**
  6. Familiarization drive: before starting the test, the user makes a short familiarization drive to get used to the test car.
  7. First test drive: the user traverses the test segment for the first time. Coopers messages are displayed to the driver, and the behaviour of car and driver are monitored[3].

[3] For statistical reasons during some drives the order is switched; i.e., the Coopers system is deactivated during the first drive and activated during the second.

8. Return drive: after the user has reached the end of the test segment, the user exits the highway, driver and assistant switch seats, and the assistant drives the car back to the starting point (this allows the driver to relax before the second drive).
9. Second test drive: the user traverses the test segment for the second time. During this comparative drive, no Coopers messages are displayed to the driver (user and car are continued to be monitored)[3].
10. Return drive: after the second test drive, the user itself drives the car back to the premises.

- **POST-TEST (at premises)**
  11. Test car shutdown and data collection: the systems of the test car are shut down; the data recorded is collected (for later uploaded into a common database).
  12. Biometric sensor removal: the user can remove the eye-tracking system and hear rate monitor.
  13. Pre-questionnaire: the test driver fills out a second (post-drive) questionnaire, focusing on the experience she had with the COOPERS system (this allows a.o. to verify whether the COOPERS system was able to fulfil the expectations of the user).

There will be slight variations in the implementation and execution of these procedures at the various test sites, due to their differences in structure, topology, infrastructure, etc. Details can be found in the Final Demonstration Evaluation Report (IR 6200/6300/6400/6700) of the single test sites.

In order to be able to carry out tests according to the procedures mentioned above, the following tasks had to be planned:

- **Preparing the infrastructure:** the infrastructure on all test sites had to be prepared according to the technical solution described in Chapter 4.3.
- **Preparing the test cars:** all testsites had to equip at least one vehicle with Coopers equipment (On-Board-Unit and APC/HMI) and telemetry sensors to be used during the field tests.
- **Allocating premises:** offices had to be prepared for the reception the probands, the tutoring of the test driver, the fitting of the biometric sensors, and the filling out of the questionnaires.
- **Preparing the documents:** recruitment forms for the selection of the drivers, formal documents to be signed by the probands before the field tests (insurance, legal documents, privacy issues, etc.), the tutorial material for the drivers, and the questionnaires had to be prepared.
- **Recruitment of test drivers:** test drivers needed to be recruited on voluntary basis, following a user profile as defined by SWP 2600/2700.
- **Recruitment and training of staff:** for the execution of the field tests, a continuously working team was necessary. The required personnel had to be recruited/appointed and trained.
- **Prepare logging of test data:** during the test drives, vehicle side data (OBU/HMI logfiles, telemetry sensors), driver-side data (biometric equipment) and roadside-data (CSC and RSU logfiles) needed to be logged. After the test drives the logfiles had to be collected and forwarded to WP7000 for evaluation.

5.2 Preparation of the field tests

5.2.1 Preparation of the infrastructure

In order to execute the field tests, the infrastructure on all test sites had to be prepared according to the technical solution described in Chapter 4.3. Therefore, the following steps had to be planned:

- Where required, upgrading of the existing infrastructure (ev. installing additional sensors).
- Development and installation of the Coopers Service Center (CSC).
- Connecting the CSC to the Traffic Control Center (TCC) and sensor network of the test segment (ensure availability of data required to generate the Coopers messages).
- Installation of the Roadside-Units (RSU) and CALM-IR transceivers (Site 1 only).
- Connecting the CSC to the communication channel used for message transmission:
    - Connection of the CSC to the RoadSide-Units/CALM-IR transceivers (Site 1).
    - Connection of the CSC to a DAB-antenna (Site 1, Site 3).
    - Connection of the CSC to a GPRS service provider (Site1, Site 4).

5.2.1.1 Test site 1

The Coopers Service Center (CSC)

The CSC is the central component of the Coopers System, responsible for generating the Coopers messages (and then forwarding them to the communication channel used to transmit the messages to the vehicles).

The three operators involved in Site 1 (BRE, ASF, OBB) equipped their test section with such a CSC:

- At Site1 - IT and Site1 - AT the CSC was connected directly to the servers of the TCC, from where it acquired all data required for the generation of the Coopers messages (see Figure 13); i.e. the TCC servers informed the CSC about events on the highway.
- At Site1 - D the CSC was connected to an external data provider (see Figure 14 and Figure 19).

The Coopers Service Centers were developed in 2008; first versions were installed in January 2009. The CSCs were continuously enhanced during the whole duration of the project.

For a detailed description of the CSC structure and data chain at the three sections, refer to the Final demonstration evaluation report of Site 1 (IR 6200).

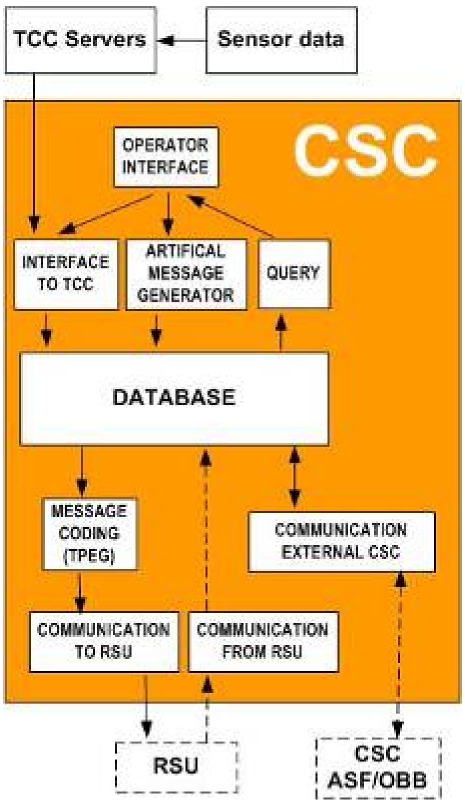


Figure 18: CSC structure at Site1-IT/AT

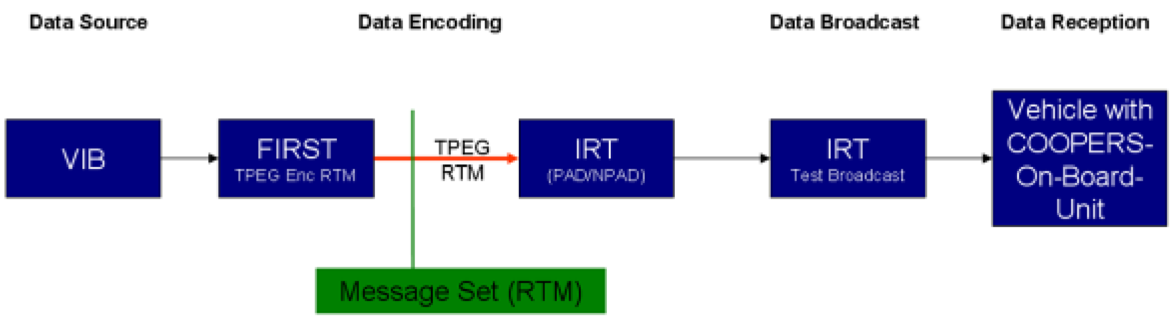


Figure 19: CSC structure at Site1-D

Roadside infrastructure: VMS gantries / RoadSide-Units / CALM-IR Transceivers

Both Site1-IT and Site1-AT used CALM-IR as communication medium. The CALM-IR transceivers, provided by project partner Efkon, had to be mounted on the overhead gantries present along the test sections (one transceiver per driving lane, centered above the lane). The RoadSide-Units controlling the CALM-IR transceivers were installed in shelters/cabinets near each gantry, and connected to the TCC via Ethernet (all shelters/cabinets provided access to the power/data network of the highway infrastructure).

- On the Italian test section, 10 overhead gantries were equipped with three CALM-IR transceivers each, as depicted in Figure 21.
- On the Austria test section, 8 overhead gantries were equipped with two CALM-IR transceivers each, as depicted in Figure 20.

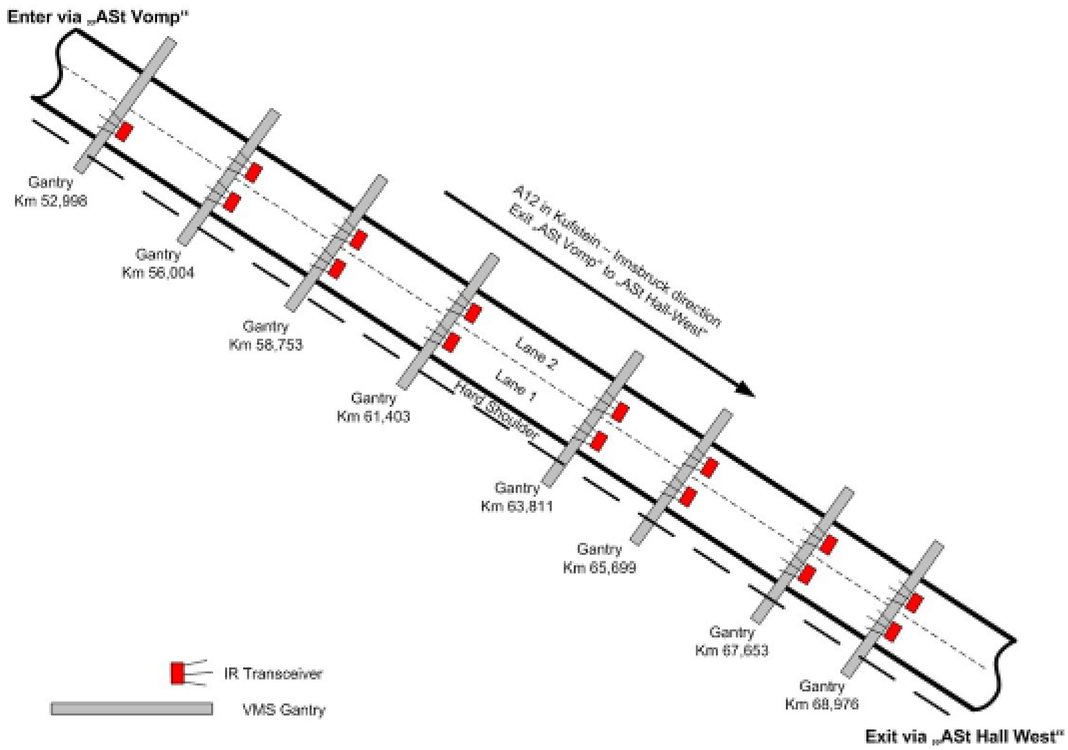
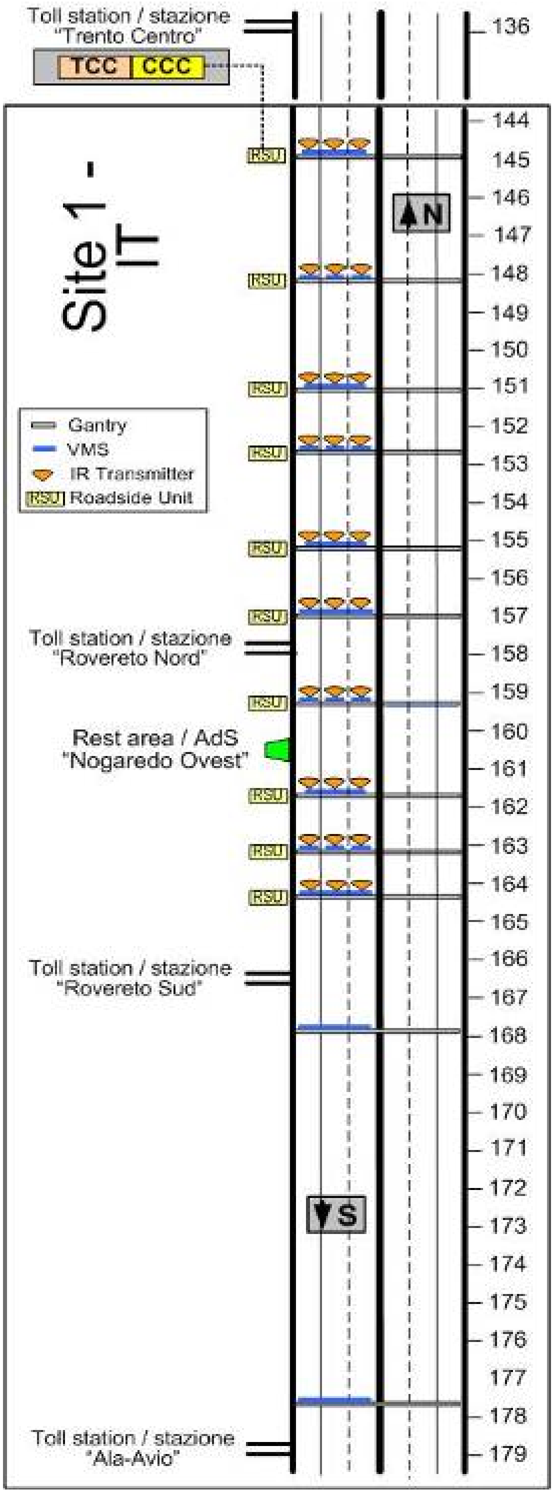


Figure 20: Location of VMS gantries / IR-transceivers on Site 1 - AT



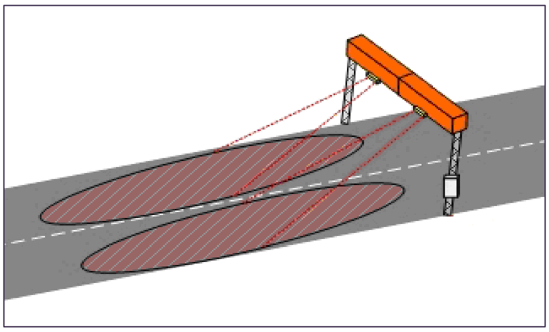


Figure 21: Location of gantries on Site1 - IT

Roadside infrastructure: DAB antenna

As Site 1 - D used the DAB antenna operated by IRT to broadcast the Coopers messages, data connection between the CSC located at Fraunhofer First and the DAB antenna had to be ensured.

Figure 22: DAB antenna of IRT

Roadside infrastructure: additional sensors

Although BRE, ASF and OBB had determined that the existing sensor infrastructure is sufficient for the generation of the Coopers messages during the field tests, some additional traffic sensors were installed to further increase the precision of the traffic data.

For a detailed description of the CSC structure and data chain at the three sections, refer to the Final demonstration evaluation report of Site 1 (IR 6200).

5.2.1.2 Test site 2

No information concerning the installation of the roadside infrastructure on Site 2 can be given in this document, as the partner responsible for Site 2 (ARS) did not provide the requested information, or declined to confirm the validity of the information provided in previous documents at the time of writing of this document.

5.2.1.3 Test site 3

As shown in the technical setup presented in Chapter 4.3.3, considerable effort was put into providing a functional message chain which considers all relevant details and extras of the Berlin situation with its complex and not always harmonized data allocation. Different data sources (induction loops, radar sensors, Traffic Eye Units, weather data and historical data) of varying quality as well as coordination with several partners responsible for separate areas (SIEMENS, VkRZ, VLB, VMZ Berlin, Radio Berlin-Brandenburg) had to be integrated in the process of processing data processing for the COOPERS project. As a result, a continuously data flow of traffic and safety relevant data for the test track A 100 could be realized.

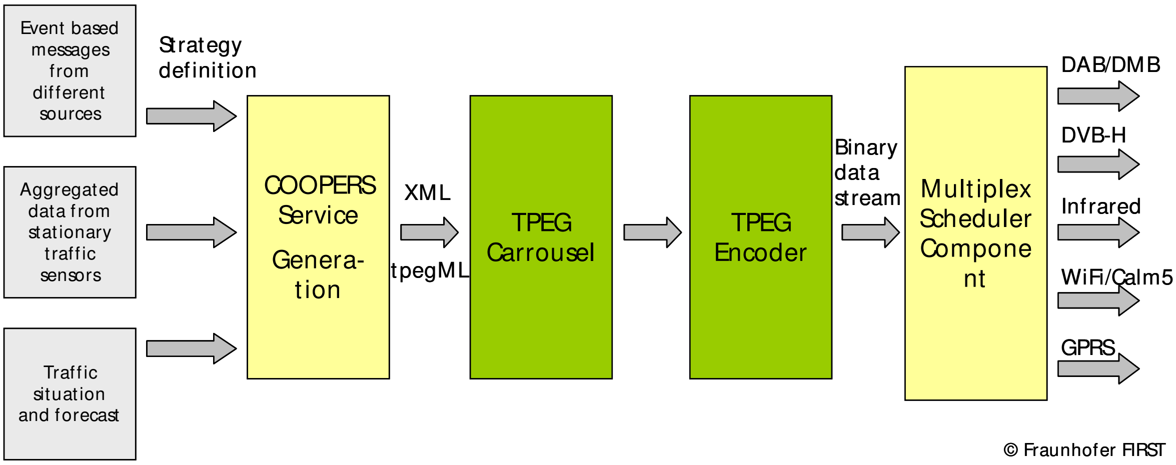


Figure 23: COOPERS encoding line (server side)

First, the COOPERS Service Center (CSC) at Fraunhofer FIRST was implemented; the CSC consists of different components and is responsible for the building of predefined COOPERS Services, their encoding into the TPEG-RTM application standard, and the handling and propagation of services. Then the CSC was connected to the VMZ, providing the online data for the generation of the Coopers messages. Figure 23 gives an overview of the relevant components to transform traffic information coming from different feeds to the transparent data transmission via DAB broadcasting.

As the messages have to fulfil several constraints concerning their propagation via DAB, the TPEG-encoded messages had to be processed by a Digital Multimedia Broadcasting (DMB) server chain operated by Fraunhofer FIRST in Berlin; therefore the CSC and the DMB server chain had to be connected, as shown in Figure 24.

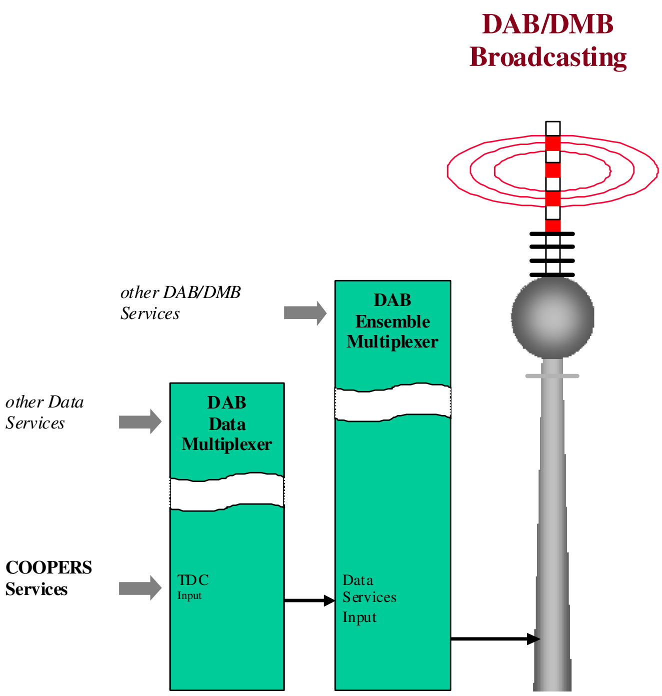


Figure 24: DMB data chain

The final tests on Testsite 3 COOPERS used the DAB infrastructure of the local broadcaster “rbb” (Rundfunk Berlin Brandenburg). The DMB data chain at Fraunhofer FIRST was connected to the DAB infrastructure at rbb; the latter polled the Coopers messages from FIRST and inserted them into the “regular” DAB transmission. Figure 25 shows the location of the DAB transmissters used for the Coopers field tests.

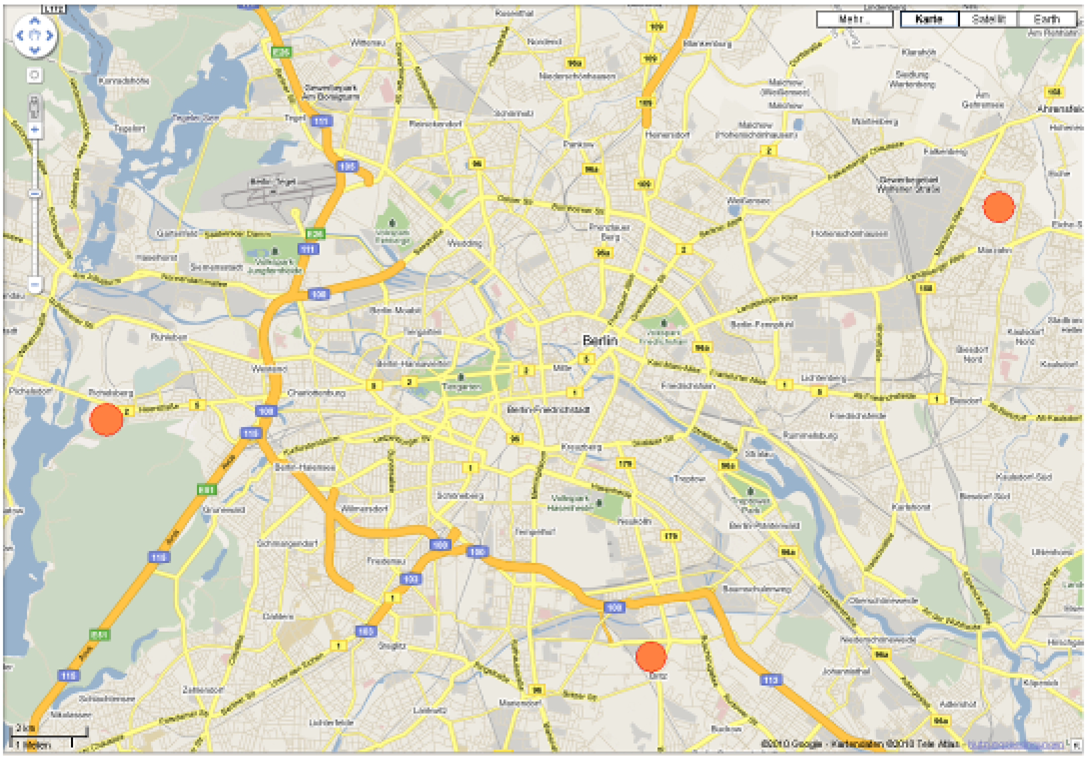


Figure 25: DAB transmitter locations of rbb

For a more detailed description refer to the Final demonstration evaluation report of Site 3 (IR 6400).

5.2.1.4 Test site 4

At test site 4, the CSC was implemented at Autoroutes Traffic, and connected to the data sources as shown in Figure 26. For this reason, a wide variety of interfaces and several data handling mechanisms had to be programmed into the CSC, to integrate all information in one information pool from which the generate the Coopers messages. Furthermore, the CSC had to be connected to a GPRS service provider, for direct bidirectional communication with the test vehicles (reception of GPS location for matching the influence zone, transmission of encoded Coopers messages to the vehicles).

Site 4 also provided the CSC employed during the Cooperative Mobility Showcase 2010 in Amsterdam. The CSC implemented at Autoroutes Trafic generated the Coopers messages, based on traffic information from a TCC in Amsterdam; the test vehicles in Amsterdam subscribed to the TCC, and received Coopers services via GPRS connection. See Figure 27 for a diagram of the information chain. As the test vehicles were located in Amsterdam, while the CSC was located in France, this setup demonstrates an international service handover on European level.

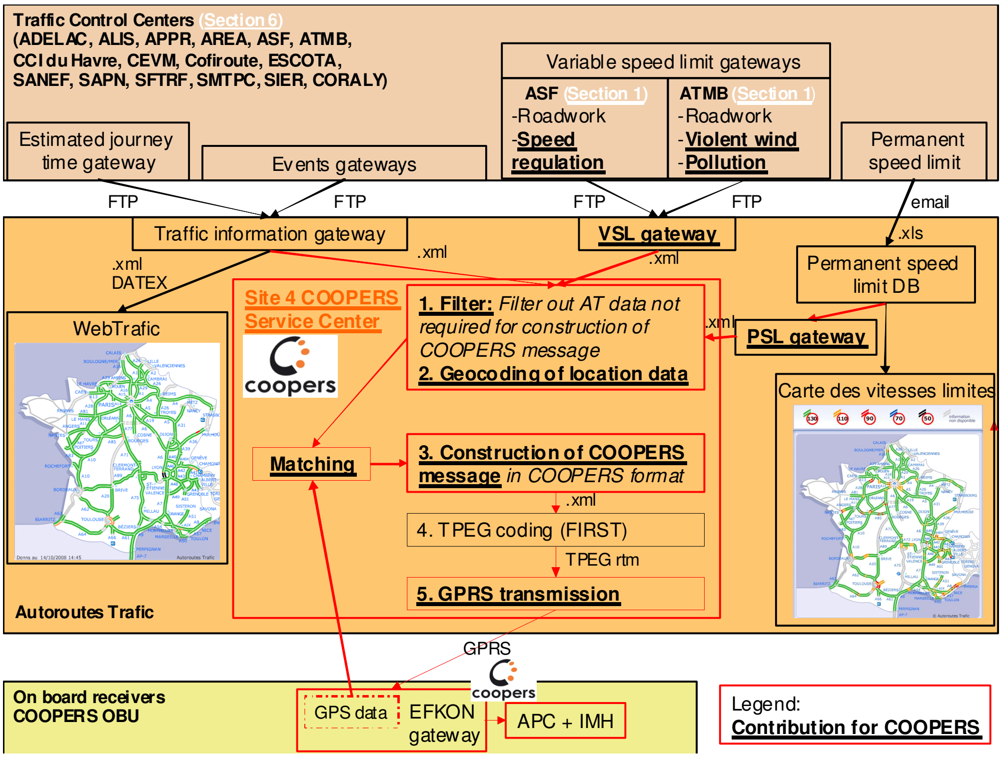


Figure 26: Information chain of Site 4

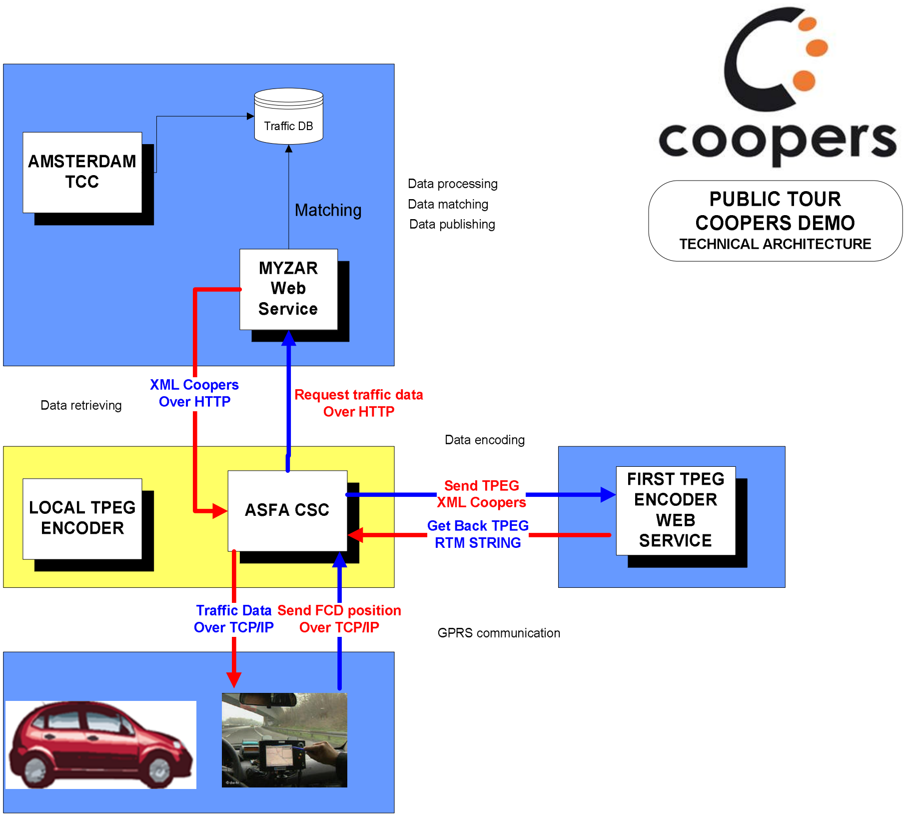


Figure 27: Information chain for the Amsterdam showcase

For a more detailed description refer to the Final demonstration evaluation report of Site 4 (IR 6700).

5.2.2 Preparation of test cars

All test sites prepared at least one test vehicle for the execution of the field tests.

- The three sections of Site 3 (Site1-IT, Site1-AT and Site1-D) and Site 3 decided to use a test vehicle provided by the Technische Universitaet Berlin (TUB), an Audi A4 shown in Figure 28, equipped with a multitude of sensors able to provide important information about driver behaviour. The TUB test car is able to record the data from the CAN-bus and is equipped with a stereo-camera capable of measuring the lane keeping behaviour, as well as with 2 LIDAR-Sensors capable of measuring the headway (to the preceding and the following vehicle). Furthermore, a traditional camera is mounted in the car to record the environment behind the car (rear-view). It was decided to share the above mentioned test vehicle as it would have been out of budget to equip each operator in Site 1 with such a vehicle. Therefore, Site1-IT, Site1-AT, Site1-D and Site 3 had to coordinate the use of this car.

  However, in order to minimize time constraints (due to sharing) and as alternative solution in case of car failure of the test car, Site1-IT, Site1-AT and Site1-D also equipped one vehicle of their own fleet with minimum Coopers OnBoard-equipment (OBU and APC/HMI) as backup solution.

  A detailed description of the car is provided in the Final demonstration evaluation report of Site 3 (IR 6400).

Figure 28: TUB test car

- As Site 4 does not log car telemetry data during the field tests, it equipped two cars (one rental car and one personal car of ASFA personnel) with minimum Coopers equipment (OBU and APC/HMI).

- No information can be provided about the test cars used by Site 2 for the field tests (information not provided by the partner responsible for Site 2).

5.2.3 Allocation of premises

Offices for the reception the probands, the tutoring of the test driver, the fitting of the biometric sensors, the filling out of the questionnaires, interviews to some of the drivers, and the removal of the biometric sensors had to be prepared.

5.2.4 Preparing of required documents

Each test site prepared the following documents for the field tests:

- **Recruitment form for volunteers**: drivers were selected on a voluntary basis, from a pool of candidates. The recruitment form contained all necessary information to perform the selection (according to the minimum requirements / age profile). Each test site prepared their own recruitment forms.
- **Formal documents to be signed by volunteers**: is was necessary that drivers and test cars were covered by insurance, that observation of the road traffic regulations was guaranteed, and that permission for treatment of personal data was given. Therefore legal documents to be signed by the driver before the test had to be prepared (declaration to be in possession of a valid driving licence, not to drive under influence of alcohol, permission of treatment of personal data, disclaimer of liability, etc.). These documents had to be prepared by all testsites separately, according to national laws.
- **Tutorial** for the test drivers: the tutorial material for the personal tutoring session before the test drives was provided by project partner TUW.
- **Pre-drive and post-drive questionnaires:** project parter HiTec provided the user acceptance questionnaire, project partner TRG the driver behaviour questionnaire in English language. They had to be translated into German / Italian / French / Dutch (drivers needed to be able to fill out the questionnaire in their mother tongue).

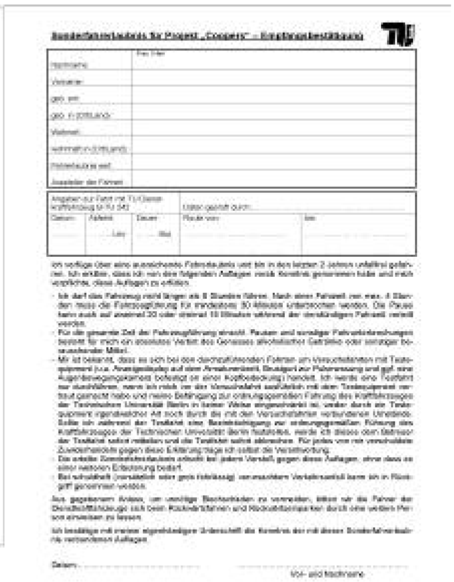


Figure 29: Example of tutorial material and car insurance

5.2.5 Recruitment of test drivers

For the recruitment of the test drivers, SWP 2300 specified a set of minimum requirements each test site should follow:

- Recruit at least 48 drivers.
- Age profile:
    - Up to 29 years: approx. 6 persons
    - 30-59 years: approx. 33 persons
    - 60 years and older: approx. 9 persons
- At least 3000 km driving experience per year.
- Balanced gender distribution (50% male, 50% female drivers)
- The participation at the field test shall be on a voluntary basis.

Test site 1 performed the recruitment of the drivers according to the above mentioned selection criteria:

- **Site 1 - AT**: test drivers were recruited a month prior to the test drives by an agency according to the demographic requirements of the COOPERS project. Specific ads were published in several media and every test driver was awarded EUR 50 for his or her time.
- **Site 1 - IT:** as on the Italian section all test drivers were recruited from personnel of Autostrada del Brennero, the recruitment process was carried out by the personnel office of BRE. A preliminary selection process (declaration of interest) was performed in 2009; the final selection and scheduling of the test drivers (from the pool of candidates) was carried out three weeks before the start of the field tests (January 2010), according to the requested age profile.
- **Site 1 - D:** the test drivers were recruited using a recruitment letter, which was circulated among the members of OBB, the Center for Traffic Management (ZVM), the Traffic Control Center, the VIB and the Pöyry Company.
- In total 120 drivers were selected for test site 1.

No information can be provided about the recruitment of the test drivers at Site 2, as the responsible partner declined to provide this information to WP6000 project partners.

Test site 3 performed the selection process approx. 1 month before the start of the field tests, following the requested age profile. 52 test drivers were recruited.

Due to the delays caused by the development and delivery of the APC/HMI at test site 4, only a limited amount of time is available for the execution of the field tests. Therefore, the field tests will be done with an initial set of 10 already recruited drivers to confirm the comparability of the acquired data with the data from the other demonstration sites.

5.2.6 Recruitment and training of staff

For the execution of the field tests, a continuously working team was necessary. After an analysis of the testing procedures, the following personnel was recruited and trained by the test sites:

- Field test manager: overall responsibility for the execution of the field tests (scheduling of drivers/personnel, availability/operability of equipment, execution of the tests, etc.). All test sites.
- Driver assistant / in-vehicle observer: at least one person was required to assist the driver before, during, and after the field test. Before the field test, the assistant gives the tutorial to the driver and helps with the questionnaire / fitting of the biometric equipment (where applied). During the test drives, the assistant accompanies the driver to provide help in case of need; furthermore, the assistant performs observational tasks, and drives back the car between the two consecutive drives. After the drive, the assistant helps with the removal of the biometric equipment and the filling out of the post-questionnaire.
- TCC personnel: the operators in TCC must be closely involved in the field tests, to ensure that for all relevant events on the highway Coopers messages are generated.
- Car and PME technician: as the test vehicle from TUB was equipped with very complex sensor technology, test site 1 and 3 required a specialized technician for support; furthermore, support was necessary to operate the PME-equipment. Test site 4 uses no car telemetry and biometric equipment during the field tests, therefore no specialized technician is required.
- CSC/RSU technician: a specialized technician had to be available for maintenance of the Coopers equipment (e.g. Coopers Service Center, Roadside-Units, etc.).

5.2.7 Preparation of data logging

In order to carry out the technical tests and be able to analyze the driver and vehicle behaviour, the following data needed to be recorded:

- **Vehicle-side data**: the Coopers onboard equipment (OBU/APC) automatically generated logfiles according the Log-Data-Dictionary[4]; no further preparations had to be taken by the testsites. The test vehicle from TUB employed at Site 1 and Site 3 (provided by TUB) is already equipped to record the data from the CAN-bus, cameras, and LIDAR-Sensors; no further preparations have to be carried out by the respective test sites. The vehicle used by Site 4 does not log car telemetry data, so no additional preparations are necessary.
- **Driver-side data**: on Site1 and Site 3, the driver was monitored with biometric equipment (eye tracking and heart rate). The PME-equipment was provided by TUW complete with data logging functionality; no further preparations had to be carried out by Site 1 and Site 3. No PME-equipment is used during the tests at Site 2 and Site 4, so no further preparations are necessary.

[4] All Coopers equipment (OBU, APC, HMI, CSC, RSU) was required to produce logfiles according to a common Log-Data-Dictionary, so that the log data can be compared. For a detailed description of the Log-Data-Dictionary refer to D7-D5300/5400/5600: Test bench for I2V interfaces, including test vehicle, testing environment and test database.

- **Roadside data**: the "roadside data" encompasses the sensor data used by the TCC to generate the Coopers messages (weather/traffic data, etc.), as well as the log data concerning the generation and transmission of the Coopers messages (recorded by the CSC and RSUs). During the tests the CSC generated a log file containing all details of the message generation (message content, source data, timestamp of generation, etc.) and the forwarding of the messages to the RSUs (Site 1) or DAB/GPRS transmission channel (Site2, Site3, Site 4). The RSUs (Site 1 only) in turn logged the reception of the messages from the TCC, the transmission to the test cars, and the reception of the acknowledges from the cars; at Sites 2/3/4 the acknowledgements were returned directly to the CSC. Testsites had to ensure that CSC and RSU produce logfiles according to the Log-Data-Dictionary[4,].

During tests, logfiles had to be collected, archived, and uploaded to the common database on a daily basis. Corresponding procedures were elaborated by all test sites.

5.2.8 Execution of technical tests

5.2.8.1 Local technical tests

After installing the Coopers equipment at the various test sites, extensive local technical tests were done to ensure proper functionality of all components in the COOPERS communication chain. It included testing the CSC, communication from the CSC to the RSU or DAB/GPRS transmission equipment, the RSUs itself (Site 1 only), as well as the OBU/APC. The APC solutions provided by ARS and Asfinag/Fluidtime were tested multiple times.

Furthermore, Site1-D and Site4 performed several additional tests according to their local research agenda:

- **The local tests on Site1-D included:**
  - Wide-range transmission of TIC contents via DAB with TPEG automotive.
  - Short-range transmission from TLS-gantries via infrared with TPEG RTM.
  - Short-range transmission of trailer contents via infrared with TPEG RTM.

  A detailed description of these local tests can be found in IR 6200: Final Demonstration evaluation report.

- **The local tests on Site4 included:**
  - Emergency call (on France test section 2; lead by ASF).
  - Influence zone (on France test section 3; lead by SAPN).
  - Real Time Roadwork Information (on France test section 4; lead by SANEF).
  - Alert in tunnel (on France test section 5; lead by ATMB).

  A detailed description of these local tests can be found in IR 6700-1: Services evaluation report and IR 6700-2: Services evaluation inputs.

Site 2 declared to have performed local WiMax tests, but the related data has not been made available to WP6000 partners.

5.2.8.2 Technical acceptance tests (WP5000)

In addition to the local technical tests performed separately by the three test sections, an official acceptance test had to be executed by WP5000, in order to certify the proper functioning of the entire Coopers communication chain, and the conformity of the produced logfiles to the Log Data Dictionary specifications.

The acceptance tests were performed by a team from the WP5000 leader (ARC) directly at the test sections; they consisted in three consecutive drives (using the same equipment later employed in the field tests) which were required to produce valid and identical results.

The tests on the Italian and Austrian section of Site were performed in November 2009; the tests on the German section in April 2010. Tests on Site 3 were performed in March and April 2010. Tests on Site 4 are currently being performed. No information can be given concerning Site 2.

A detailed description of the tests and their results is given in IR 5200/5300/5400/5500: Report on test results and possible improvements, testing of I2V & V2V; for a summary final report refer to IR 5100-2: Test report evaluations.

5.2.9 Execution of Pilot tests

Pilot tests were executed on the test sites, according to the COOPERS test procedures, in order to verify sequence and timing of the single steps, and refine the procedures for the later field tests. More detailed information can be provided in the Final Demonstration Evaluation Report of the single test sites (IR 6200 / IR 6300 / IR 6400 / IR 6700).

6 Execution of the field tests

After having planned and prepared the field tests (as described in Chapter 4), the test sites started the execution of the field tests, as outlined in the present chapter.

6.1 Site 1

Field tests on site 1 were executed between January and April 2010, as depicted in Table 2 in Chapter 6. In total 115 test drives were performed (47 drives at Site1-IT, 48 drives at Site1-AT, and 20 drives at Site1-D) during 43 test days; all drives were executed with the test vehicle from TUB, and employing the biometric equipment from TUW. The logfiles generated during the drive (CSC/RSU logfiles, OBU/APC logfiles, car telemetry data, biometric data, user questionnaires) were forwarded to WP7000 during and immediately after the tests for evaluation and assessment; the results will be presented in WP7000 and in the respective deliverables.

Site1-AT

ASF executed 48 successful test drives between 19.01.2010 and 06.02.2010. 50 drives were planned, scheduled from Monday to Saturday with three time slots a day, lasting 3 hours each, from 8-11h, 12-15h and 15-18h. One test driver didn't show up, one denied to sign the liability declaration, leaving 48 successful test drives during that timeframe.

During each drive, 7 messages of type S1a, S1c, S2, S3, S4b, S5, S6 were generated[5]. Additionally reduced speed limits (S5) were added from live feed.

Site1-IT

BRE executed 47 successful test drives between 8.02.2010 and 09.03.2010. 50 drives were planned, scheduled from Monday to Friday with three time slots a day, lasting 3 hours each (from 9-12h, 12-15h and 15-18h) and two time slots on Saturday (9-12h, 12-15h), with some exceptions due to organizational reasons. Three test drivers skipped the tests due to illness or work reasons, leaving 47 successful test drives during that timeframe.

During each drive, between 14 and 17 real[6] messages of type S1a[6], S2, S4, S4a, S5 were sent. A graphical representation is given in Figure 30.

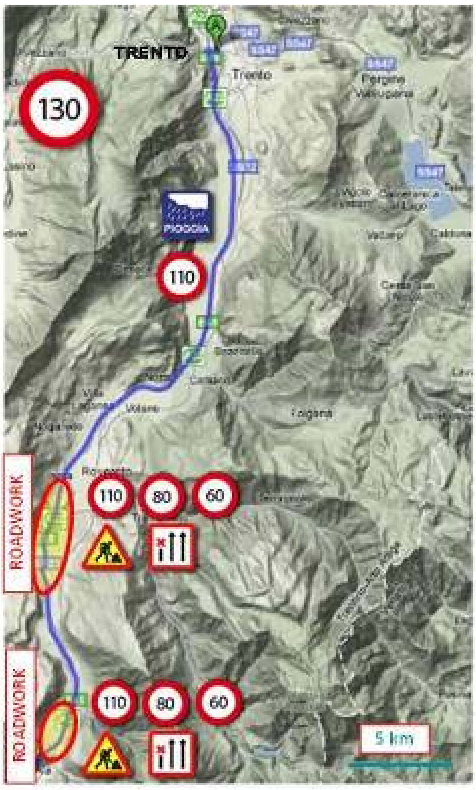


Figure 30: Messages at Site1-IT

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[5] Due to the absence of roadworks and low number of real events on the test track during the tests, events were generated in a plausible way for the driver.

[6] During three of the drives, a simulated accident messages was generated; all other messages were real.

Site1-D

Site1-D executed 20 successful test drives between 12th to 16th of April 2010.

During each drive, between 1 and 3 messages were generated (one simulated, and 1-2 real events), of service type S2 and S3.

Sample test drive

The following is an example of a typical test drive at Site 1 - AT (test drives on Site 1 - IT and Site 1 -D were analogous):

1. **Familiarization drive**: users made a short familiarization drive with the test car on the highway, in order to get familiar with the test car. They were picked up at Hall, entered the motorway at ASt Hall West (km 70) and drove to the road maintenance authority ABM Vomp at km 53 (ASt Vomp). The distance to be driven is about 18 kilometres. The users were accompanied by an assistant who was seated in the back seat of the car. Duration: approx. 15 minutes.
2. **Tutorial**: the driver was given a short description about the COOPERS system, focusing on the HMI and the type of messages (COOPERS services) the user would receive during the drive; furthermore the test procedure was explained in detail. Location: road maintenance area ABM Vomp. Duration: approx. 5 minutes.
3. **Pre-drive user questionnaire**: the test driver was asked to fill out a questionnaire, which mainly focused on the expectations and assumptions of the driver concerning the system. Location: road maintenance authority Vomp. Duration: approx. 15 minutes.
4. **Biometric sensors fitting**: the biometric sensors were fitted on the user and calibrated. Location: ABM Vomp. Duration: approx. 5 minutes.
5. **Test car initialization**: the biometric sensors fitted on the user were connected to the recording equipment in the test car. The eye-tracking system was calibrated to the user. Location: ABM Vomp: approx 5 minutes.
6. **Test drive**: Each test driver made two test drives, one with the COOPERS system, one without. Half of the test drivers had the COOPERS system activated on the first drive, the other half on the second drive.

   Test drive 1: After entering the highway at ASt Vomp, the test driver had to drive 0.5 km and then entered the test site at km 53, which ranges until km 70, for an overall length of 17 km. 8 overhead gantries (carrying VMS) along this section were equipped with 15 IR-transmitters, which transmitted COOPERS-messages to the vehicles as they passed. It took approximately 15 minutes to traverse the test section (depending on the traffic).

   Return drive: at the exit (ASt) Hall-West (at km 70), the user exited the highway. He changed to the passenger/back seat, while the assistant drove the car back to ABM Vomp at km 52 (travelling on the highway in east direction). Time required: Approximately 15 minutes.

   Test drive 2: back at the ABM Vomp, the assistant exited the highway, test driver and assistant switched place, and the test driver re-entered the highway in westward direction, to accomplish a second test drive. It took another 15 minutes to pass through the test section and reach the reversal point.

Return drive: after the second test drive, the assistant drove the car back to ABM Vomp. Duration: approx. 15 minutes.

Overall duration for the entire test drive: around 60 minutes, depending on traffic

7. **Test car shutdown, biometric sensor removal**: the systems of the test car were shut down, the biometric sensors removed from the test driver. Location: ABM Vomp. Duration: approx. 5 minutes.
8. **Post-drive user questionnaire**: the test drivers filled out another questionnaire, focused on the experience they had with the COOPERS system. In comparison with the pre-drive questionnaire, it was therefore possible to determine whether the COOPERS system was able to fulfil the expectations of the user. Location: road maintenance authority Vomp. Duration: approx. 15 minutes.
9. **Data / Log file transfer**: all log files, questionnaires and data regarding the test drive were put in a “Dropbox” folder and thus made available for WP5000 and WP7000.

The overall duration of the entire test was around 120 minutes or 2 hours.

For a more detailed description concerning the execution of the test drives at all three sections of Site 1 (Site 1 - IT, Site 1 - AT and Site 1 - D), including a description of the traffic/weather situation on the test section during the drives, a time schedule of the single drives, and statistics of the events generated during the drives, refer to IR 6200: Final demonstration evaluation report.

6.2 Site 2

No information concerning the execution of the test drives on Site 2 can be given in this document, as the partner responsible for Site 2 (ARS) did not provide the related information to WP6000, nor were any logfiles of the drives made available to partners in WP7000.

6.3 Site 3

Site 3 executed 43 successful test drives between 5.3.2010 and 19.3.2010, as well as between 27.4. and 29.4.2010. Between 2 and 4 test drives were done per day, from Monday to Saturday (time slots: 08:00 to 11:40, 10:50-14:30, 13:30-17:00, 16:00-19:40), with a duration of approx. 3:30h for the whole testing procedure.

Due to the fact that the Berlin test section lies on an inner-city highway, a high number of messages were generated during each drive: approx. 700 messages are generated automatically per day, resulting in an average of 25-50 messages per test drive. No simulated messages were used.

Sample test drive

The following is an example of a typical test drive at Site 3:

1. **Preparation phase (office)**: After the successful completion of the formalities, the pre-questionnaire was filled in by the volunteer using a Laptop. The purpose of this questionnaire was to measure expectations and gathering a comparison level for later measurements. Afterwards some of the drivers were interviewed.
2. **Preparation phase (in vehicle):** the driver entered the vehicle and adjusted seat position, mirrors, steering wheel, etc. Then the eye-tracking system was calibrated, and the in-vehicle sensors were activated.
3. **Familiarisation phase:** the user could familiarize with the vehicle for about 10-20 minutes on roads with low traffic volume, near the test site. Then the first drive started.
4. **First lap on demonstration site:** the first test drive lead to junction “Seestraße”. The distance from TIB to the motorway was approx. 6 km. This took approximately 10 Minutes. Then, after entering the motorway at “Seestraße”, the test drive started heading southwest. Based on a randomized approach the first test drive was done with-or-without the COOPERS system. During the drive car telemetry and user biometric data (vehicle video, eye movement, hear rate and CAN) were recorded. An assistant was present in the car, observing the driver behaviour with the help of an observational form. Depending on the day-time, different traffic situations were predominant, so besides speed limit warning also incident warnings and lane banning or roadwork information were displayed on the VMS. The probability of a similar traffic situation in both test drives (with and without COOPERS system) was quite high. At the junction “Gradestraße” (22) the test car left the motorway.
5. **Vehicle return:** on a parking place at “Gradestraße” the driver and the instructor changed seats and the instructor returns the vehicle to Seestraße. The instructor had to control the set up of the recording systems and especially of the eye-movement camera for the second round.
6. **Second lap on demonstration site:** at a parking place at Dohnagestell, close to AS Seestraße, the volunteer and test assistant changed seats again, to conduct the second run along the same test track. The instructor continuously monitored the driver behaviour and made notes in the standardised observational form.
7. **Vehicle return:** when reaching junction 22 (Gradestrasse) again, the volunteer stopped the car, and driver/instructor swapped seats again. The instructor returned the vehicle to the starting point of the experiment.
8. **Post-Test Questionnaire:** after reaching the test office at TIB, the test driver had to fill in the post-questionnaire; some drivers were additionally interviewed. This ended the test procedure.

A more detailed description concerning the execution of the test drives, including a description of the traffic/weather situation on the test section during the drives, an time schedule of the single drives, and statistics of the events generated during the drives, can be found in IR 6400: Final demonstration evaluation report.

6.4 Site 4

Due to the delays described in Chapter 6, it was possible to provide a functioning APC/HMU to test site 4 only recently (see Table 2); therefore, the Coopers field tests at Site 4 (section 1 & 6) is not completed yet.

The local technical tests which Site 4 planned to execute in addition to the Coopers field tests (according to the local research agenda) could all be performed and assessed; their results are described in detail in IR 6700-1: Services evaluation report and IR 6700 -2: Systems evaluation inputs.

Furthermore, the Coopers infrastructure of Site 4 was already demonstrated during the Cooperative Mobility Showcase 2010 in Amsterdam (see Chapter 6.5).

The Coopers field tests however are currently in progress; therefore, no information concerning their execution can be provided now, but the field tests are scheduled to be finished in time for the project review and the results are included in WP7000 analysis.

6.5 Cooperative Mobility Showcase 2010

During the Cooperative Mobility Showcase (23-26 March 2010) the Coopers system was successfully demonstrated, including an international service handover. Other than the development partners Mizar, First, Efkon and Fluidtime[7], test site 4 was directly involved in the showcase as service provider for the Coopers messages.

The Coopers messages were generated by the CSC of Site 4 (located in France, at Autoroutes Trafic premises) from traffic information provided by the TCC in Amsterdam; the test vehicles in Amsterdam connected to the CSC via GPRS, and received Coopers messages concerning the test track in Amsterdam in real time.

Figure 31 shows the flow of information, and the system overview as employed during the showcase:

1. The test vehicles (in Amsterdam) connect to the CSC (in France) via GRPS, and subscribe to the Coopers services.
2. The vehicles repeatedly send their GPS position to the CSC (ASFA Gateway in France).
3. The CSC requests traffic data from the Amsterdam test track, filtered according to the GPS position of the vehicle (the data is provided by the Mizar Webservice in Amsterdam, which is interfaced directly to the TCC).
4. After receiving the requested information, the CSC (ASFA gateway) generates the Coopers messages and encodes them into TPEG-RTM (using the FIRST TPEG encoder).

5-6. The encoded Coopers message is then sent back to vehicle (via GRPS), and displayed to the driver.

[7] Fluidtime, the developer of the APC, is not a direct project partner, but subcontracted by Asfinag.

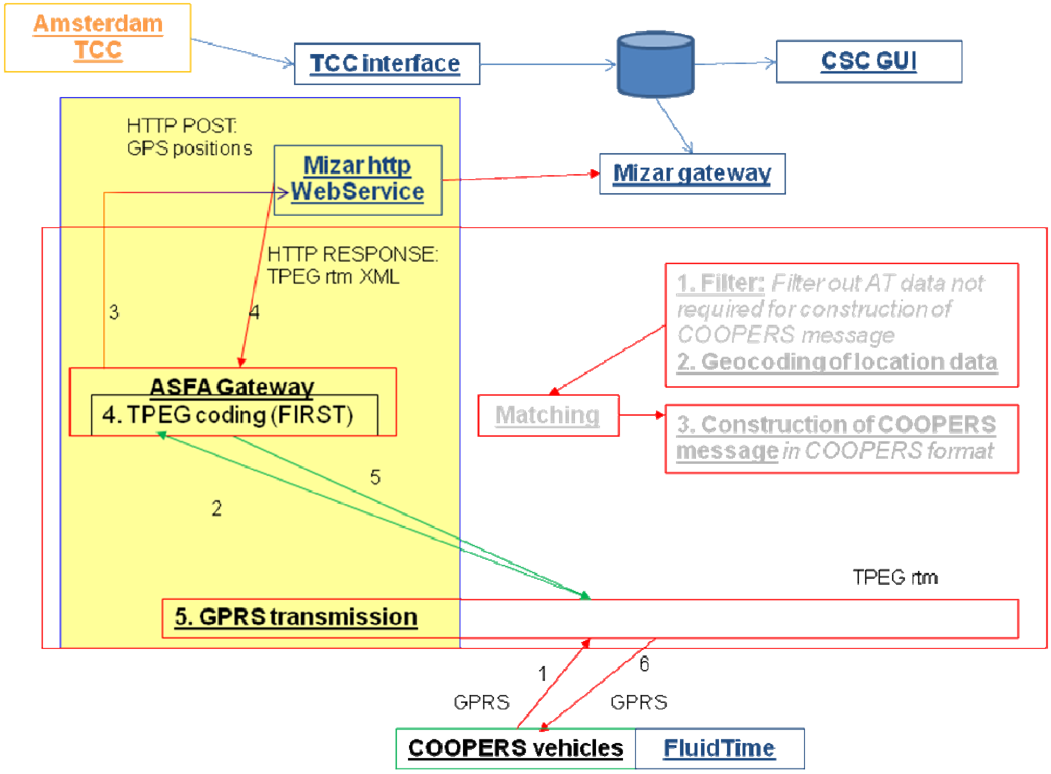

Figure 31: System overview and information chain at the Cooperative Mobility Showcase

Additionally, a CALM-IR transceiver was installed along the test track, so that the possibility of simultaneously receiving message from two different communication channels could be shown. This, and the fact that the CSC and test vehicles were located in different countries (demonstration of international service handover), showed the potential of the Coopers system to be employed on a European level.

Figure 32: HMI screenshot of the COOPERS APC

More information can be found in SWP 8300: Cooperative mobility 2010.

7 Coordination of the test sites

7.1 Overall schedule / Time plan

The following gives a rough overview about the overall time plan concerning the planning, preparation, and execution of the field tests at the different test sites. The late execution of the field tests was mainly determined by the delays concerning the deliverable of a functioning APC/HMI; the delivery date was postponed several times, resulting in frequent re-planning activities (see Chapter 7.2). The table below outlines only the key start/end points of the various activities; more detailed schedules can be found in the Final demonstration evaluation report of the single test sites (IR 6200 / IR 6300 / IR 6400 / IR 6700).

		2008								2009												2010					
ACTIVITY	SITE	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
		Y3									Y4												Y5				
Installation CSC	SITE1-IT									1-I																	
	SITE1-AT									1-A																	
	SITE1-D									1-D																	
	SITE2																										
	SITE3									3												3					
	SITE4									4																	
Installation RSU	SITE1-IT												1-I														
	SITE1-AT												1-A														
Installation APC	SITE1-IT																		1-I								
	SITE1-AT																		1-A								
	SITE1-D																						1-D				
	SITE2																										
	SITE3	Planning													Replanning								3				
	SITE4																									4	
WP5000 Tests	SITE1-IT																			1-I							
	SITE1-AT																			1-A							
	SITE1-D																								1-D		
	SITE2																										
	SITE3																						3				
	SITE4																									4	4
Field tests	SITE1-AT																					1-A					
	SITE1-IT																						1-I				
	SITE1-D																								1-D		
	SITE2																										
	SITE3																							3	3		
	SITE4																										4
		PLANNING / preparation								PREPARATION												EXECUTION					

Table 2: Overall time plan

7.2 Delays and countermeasures in the Coopers project

During the project, several events occurred which affected the planning of the field tests, the preparation of the test sites, as well as the execution of the field tests, leading to sensible delays, and frequent replanning acitivities. However, thanks to the combined effort of the consortium, it was possible to find effective countermeasures, which permitted to successfully execute the field tests.

Year 2006 / 2007

First delays were caused by the withdrawal of Lucent Technologies Network Systems GmbH, the company that was originally appointed to deliver the On-Board Unit (CGW and APC/HMI). Lucent however was bought by Alcatel and restructured, and withdraw from the project in spring 2007; therefore, the consortium lost the designated developer and supplier of the On-Board Unit.
This caused a delay of about 4 month concerning the planning activities for the test sites, and made it necessary to find a replacement for Lucent: the Coopers consortium unanimously decided to contract the partners ARS (ARS Traffic and Transport Technology B.V.) to develop and supply an APC, and EFK (EFKON AG) to develop and supply the CGW solution.

Year 2008

In the first months of 2008, ARS and EKF presented a combined On-Board Unit (APC and CGW), which was subject to first technical tests; at that moment, it seemed that the 4-month delay accumulated during the previous year was recovered.
However, due to the complexity of the Coopers information chain, which required the contribution of many different partners, the first tests were only partially successful, and several issues concerning the performance of the APC software and the communication chain became evident. The known bugs in the communication chain could be solved by the developers in the first half of 2008; several bugs in the APC however remained open.
This caused noticeable delays to the planning at the test sites, especially Site 1 and Site 3.

Another minor issue during year 2008 concerned the RoadSide-Units foreseen for Site 1: the first RSU solution proposed by the development team consisted of two separate components; the operators of test site 1 (Autostrada del Brennero and Asfinag) however requested an integrated solution consisting of one single component (due to higher cost and installation efforts of the two-component solution). However, this issue could be solved efficiently between the operators (BRE and ASF) as well as the developers (EFK, SWA, MIZ), causing eventually a delay of less than one month, whose impact on the planning of the field test can be neglected.

Year 2009 / 2010

During the first months of 2009, all test sites equipped their infrastructure with the required Coopers components (a Coopers Service Center was installed on all test sites; the Italian/Austrian section of Site 1 was equipped with RoadSide-Units; Site1-D and Site 3 assured availability of a DAB, Site2 and Site 4 of a GPRS transmission channel).

The successive testing of the installed infrastructure components (CSC and RSU) was however delayed substantially due to problems attributed to the APC software (necessary to be able to verify the entire Coopers communication chain: CSC ➔ RSU+IR / DAB / GRPS ➔ OBU).

The envisaged delivery date of the APC was repeatedly postponed by several months; some prototype versions were delivered, all however considered to be too faulty to be used for the user-tests. Several COOPERS test-sites (especially Site1 and Site3) were not satisfied with the results, and doubts were expressed concerning the commitment of ARS to solve the open issues related to the APC.

Therefore test site 1 partner Asfinag deemed it necessary to start the development of a backup APC solution (in cooperation with Fluidtime; using private Asfinag budget) in order to be able to continue with the field test preparations. Due to the good results shown by a prototype of the backup APC on Site1-AT, the PMT (Coopers Management Team) decided to finalize its development, and considered it necessary to introduce it on the entire test site 1, as well as on Site 3 and Site 4, in order to avoid endangering the whole COOPERS project. Test site 2 continued to rely on the ARS solution.

After the decision to finalize the development of the Asfinag-APC, a binding delivery date for the APC could be stated and met; after few months a functioning APC could be presented to Site1 operators, so that the preparation of the Italian and Austrian section of test site 1 could be successfully concluded in November 2009. Due to the efforts required to adapt the Asfinag-APC to DAB, the preparations for Site 3 were concluded in February 2010, and for Site1-D (German section) in April 2010. Site 4, other than an adaptation to the GPRS network, required also a vectorization of the map data, and the map coverage for the entire French motorway network, so the preparations were protracted until May/June 2010. The status of Site 2 could not be verified at the time of writing of this document, as the responsible project partner (ARS) declined to make the required data available to WP6000.

Therefore, due to the non-availability of the required components, Site 1, Site 3 and Site 4 were delayed by almost 12 months; however, thanks to re-arranging of resources, re-scheduling of activities, and subcontracting of critical tasks, they were able to react to the delay. Furthermore, the fact that an alternative APC solution could be provided in a relatively short time (considering the required time and effort) to Site 1, Site 3 and Site 4, was seen as proof of concept for the hardware/software-independence and openness of the Coopers system.

Availability of field test data from Site 2

Test site 2 declared to have executed the field tests as planned, however no test data has been made available to the consortium (respectively WP6000 and WP7000), presumably as reaction to the open dispute with the consortium concerning the APC.

However, as test site 4 employs GPRS as communication technology as well, the lack of GPRS test data from Site 2 can be compensated with data from Site 4.

8 Conclusion

The Coopers system, developed within the homonymous research project, is not just a laboratory prototype, but it has been tested under real conditions on heavily used sections of European motorways, on four different test sites.

During the planning, preparation, and execution of the field tests, the involved highway operators have gained important insights concerning the development, installation, and usage of co-operative systems, which are resumed below.

The following conclusions from the technical point of view (of the installed Coopers system) have been drawn:

- The installation requirements for the R&D prototypes of the Coopers system were very high, as they had to be integrated into an complex highway infrastructure during operation, and were required to withstand daily operation in a challenging environment. This concerned especially the:
    - Coopers Service Center,
    - Roadside-Unit,
    - CALM-IR transceivers,
    - but also the OBE (CGW and APC/HMI used during the tests).

  It was requested that the Coopers Service Center can be fully integrated into the running TCC traffic control and management systems; the outdoor components (especially RoadSide-Units and CALM-IR transceivers) furthermore had to withstand the often hostile environmental conditions, and fulfill the severe safety conditions of the highway operators concerning the installation and operation of roadside infrastructure in traffic conditions. Therefore the components had to match stringent power consumption limits, temperature and weather resistance, statical/structural and non-interference requirements, and guarantee duration of operation, easy maintenance, etc. The OBE had to be approved for use during driving activities.

  The components of the Coopers system delivered to the test sites and employed during the field tests were able to fulfill these requirements.

- Full installations of the Coopers equipment (CSC, RSU, IR-Transceivers, etc.) and the necessary extensions to the TCC and roadside infrastructure (to be able to integrate the Coopers components) have been contracted, and are working stable in daily operation since October 2009 in Site 1, and February 2010 in Site 3. Daily operation of the system at Site 4 has just started, but a demonstration has already been given in the setup, preparation, and during the Cooperative mobility showcase im Amsterdam, with the additional challenge of 12 vehicles operated in parallel; peak performance was execllent. The status of the Coopers system installed at Site 2 is unknown.

- The Coopers system installed have furthermore been certified by WP5000 (in laboratory tests as well as under real conditions).

- The coding of traffic information via TPEG works stable on all sites and with all communication technologies. The Coopers system fulfills the requirements of being hardware independent; it has been verified to work with CALM-IR, DAB, and GPRS during technical tests and in daily operation. Technical tests allow to presume also an easy porting to WiMax.

From the operative and organizational point of view (concerning the operation and co-operation of highway operators, and the potential future of the Coopers system in daily traffic operations) it can be said that:

- The definition of commonly agreed set of services (that can be employed on a European level) and the resulting specifications of the common software extensions in the TCC's and CSC were an important first step to harmonize the service quality of the provided traffic information services on motorways, and an important contribution towards a pan-European co-operative traffic information and management system.

- The costs of the installations and the running costs can be estimated much better now due to the first experiences made, but also the missing elements in the TCC functionality which will remain research topics (e.g., the detection of irregular traffic conditions via sensor fusion).

- The long demonstration phase for an R&D project made it possible to compare the new equipment with already installed systems, and compare their performance and stability of operations.

- The fact that the Coopers system has been successfully installed and demonstrated on four different test sites (other than at the Cooperative Mobility Showcase in Amsterdam), with substantially different infrastructure, permits to deduce that it can be ported to almost any highway in Europe.

- The communication exchange between neighbouring TCCs has been demonstrated at Site 1; the international transmission of services has been demonstrated at the Cooperative Mobility Showcase in Amsterdam. The co-operation of the highway operators involved in the field tests has improved due to the Coopers project.

- The software development contracts have partly been awarded to project partners, but mostly to external companies, with the consequence that R&D funding had a high impact and leverage on the market.

Furthermore, several insights for future field tests and research projects concerning co-operative systems have been gained:

- The efforts of generating high quality traffic information necessary for the demonstrations have been underestimated at project start. One of key problems was the timely detection and accurate localization of services; a message can be only as accurate and timely as the detection of the event is (accidents and traffic jams for example can only be detected accurately if the highway is equipped with a high density of traffic and AID sensor; for accurate weather warnings a large quantity of weather and road surface sensors is necessary).
  Except for critical sections, most highways have a rather sparse sensor network (mostly due to the costs of installation and maintenance of the sensors), permitting only a coarse detection of events. Therefore, for efficient co-operative services, highway operators will have to further increase the accuracy of their sensor network, and promote sensor fusion, as well as the inclusion of car xFCD data into their traffic models.

- The importance of the HMI concerning the acceptance of the system by the user has been underestimated as well. The intuitivity, easy of use, and "look & feel" of the HMI is as important as the timeliness and accuracy of the traffic information provided.

- And last, but not least, several open questions concerning legal problems will have to be solved before a roll-out of the system is possible, for example: liability problems in case of false or delayed/missing warnings, validity of compulsory warnings if timely transmission cannot be guaranteed for all vehicles (only vehicles equipped with a coopers OBU can receive the messages), etc.

Conclusively, it can be said the road operators involved in the field tests consider the Coopers project a success[8]. The system has been demonstrated in daily operation, under real traffic conditions, and first results show that the expectations concerning safety and user acceptance have been fulfilled.

[8] No statement has been issued by the operator from Site 2.