Cooperative Mobility Systems and Services for Energy Efficiency

D550.59(D5.9)	**Report on test site operation** ***Verification and validation results***

SubProject No.	**SP5**	**SubProject Title**	**EcoTraffic Management and Control**
Workpackage No.	**WP5**	**Workpackage Title**	**Integration and verification**
Task No.	**T5.5.1**	**Task Title**	**Integrate the applications for specific test sites**
Authors		**Jaap Vreeswijk, Eric Koenders, Robbin Blokpoel, Paul Mathias, Isabel Wilmink, Zeriet Woldeab, Frederic Ambleton and Matthias Mann**	
Dissemination level PU/PP/RE/CO		PU	
File Name		D550.59(D5.9) Report on Test site operation-CLEAN	
Due date		31.08.2013	
Delivery date		19.03.2014	
Abstract	This deliverable describes the results from field verification and validation of the following applications and components: ecoBalanced Priority, ecoRamp Metering, ecoTruck Parking, ecoApproach Advice, ecoNetwork Prediction, ecoEmission Estimation, Driver Info Support and Driver Dialogue Manager.		

European Commission Information Society and Media	Project supported by European Union DG INFSO ICT-2009-6.1, ICT for Clean and Efficient mobility
Project reference	FP7-ICT-2009-4 IP Proposal - 247908
IP Manager	Jean Charles Pandazis, ERTICO – ITS Europe Tel: +32 2 400 0714 E-mail: jc.pandazis@mail.ertico.com

Control sheet

Version history			
Version	Date	Main author	Summary of changes
0.1	27-02-2013	J. Vreeswijk	Template
Draft	24-07-2013	J. Vreeswijk	Integration of inputs
Final	02-08-2013	J. Vreeswijk	Integration of inputs
	Name		Date
Prepared	J. Vreeswijk		26-07-2013
Reviewed	C. Bresser & J. Luessman		29-07-2013
Authorized	Jean-Charles Pandazis		19.03.2014
Verified	Manuela Flachi		19.03.2014

Circulation	
Recipient	Date of submission
Project partners	04.03.2014
European Commission	19.03.2014

Table of Contents

Table of Figures

Table of Tables

TERMS AND ABBREVIATIONS

Abbreviation	Definition
ASCII	American Standard Code for Information Interchange
CAN	Controller Area Nework
CIS	Central Information System
CO_2	Carbon dioxide
ecoATS	ecoAdaptive Traveller Support
ecoCAM	ecoCooperative Awareness Message
GPS	Global Positioning System
HTTP	Hypertext Transfer Protocol
ITM	Intersection Topology Message
LDM	Local Dynamic Map
MoE	Measure of Effectiveness
NHL	Night Hours Length
OBU	OnBoard Unit
OD	Origin-Destination
PI	Performance Indicator
RGT	Remaining Green Time
SL	Stop Length
SLAM	Speed and Lane Advice Message
SP	Sub Project
STDDEV	Standard Deviation
STMN	Stops of Trucks on the ASFA Motorway Networks
TC	Test Case
TEC	Traffic Event Compact
TFP	Traffic Flow Prediction
TLC	Traffic Light Controller
TMDB	traffic information database
TND	network a normal day
TNH	number of truck for the night hours
TNSSA	Total Number of Stops offered by Services Area
TPEG	Transport Protocol Experts Group
TPSA	Truck Places on Service Areas
TS	Test Setup
TTG	Time To Green
USN	number of Unsuccessful Stops
VS	Validation Scenario
XML	Extensible Markup Language

1 Introduction

This deliverable describes the results from field verification and validation of ecoTraffic Management and Control applications and components (SP5).

1.1. Relation to other SP5 deliverables

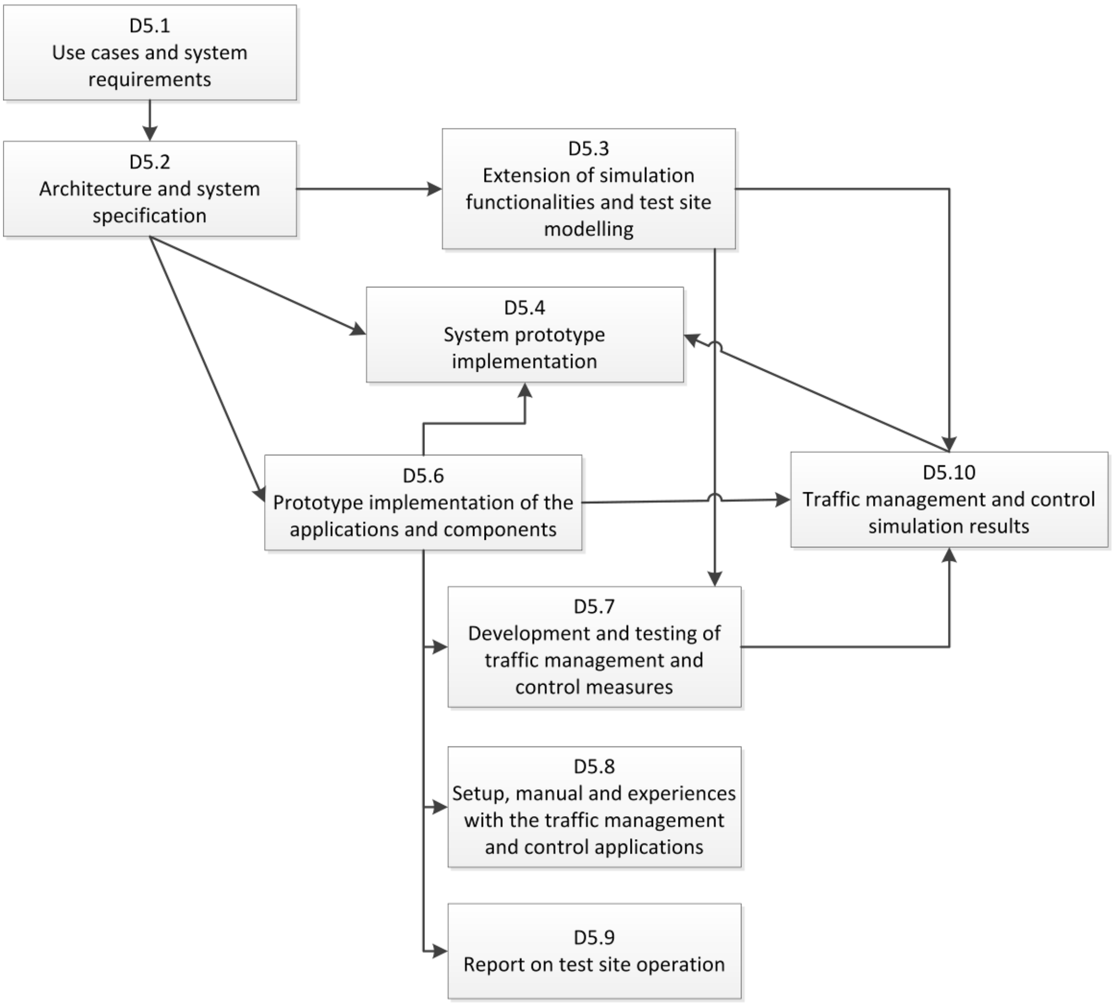


Figure 1 – Deliverables flow diagram

System concepts are described in D5.1 and further detailed in D5.2 towards system designs. The setup of the simulation environment and required extension are discussed in D5.3, while the actual implementation is described in D5.7. Following D5.2, there are two deliverables describing the prototype implementations. D5.6 presents the prototypes of individual applications and components and also includes verification plans. Results from laboratory verification tests are presented in D5.7, while results from field verification are discussed in D5.9. General information about the setup of applications, operational instructions and practical experiences are reported in D5.8. Validation results are discussed in two deliverables. D5.9 includes the results from field validation, while D5.10 is dedicated to impact figures coming from simulation activities. Finally, D5.4 addresses the integration of applications, both in terms of technology as in terms of synergies where impact is concerned.

1.2. Intended Audience

This document has been prepared to give the reader some understanding of how the applications and components have been verified and validated in the field. The content of this document may be of interest to a wide audience: road operators, traffic engineers, vehicle manufacturers, fleet and logistics, etc. The main purpose however, is to enable scientists responsible for evaluation (eCoMove subproject 6) to use the validation results for overall impact assessment.

1.3. Document Structure

Chapter 2 provides an overview of field *verification* of the following applications and components: ecoBalanced Priority, ecoRamp Metering, ecoTruck Parking, ecoApproach Advice, ecoNetwork Prediction, ecoEmission Estimation, Driver Info Support and Driver Dialogue Manager.

Chapter 3 provides an overview of field *validation* of the following applications and components: ecoBalanced Priority, ecoRamp Metering, ecoTruck Parking, ecoApproach Advice, ecoNetwork Prediction and ecoEmission Estimation.

2 Field verification of applications and components

This section presents the results from field verification of ecoBalanced Priority, ecoRamp Metering, ecoTruck Parking, ecoApproach Advice, ecoNetwork Prediction, ecoEmission Estimation, Driver Info Support and Driver Dialogue Manager.

Test plans for verification are described in [D5.6]. Results from verification in simulation are reported in [D5.7], while simulation results for validation are described in [D5.10].

2.1 Verification overview for ecoBalanced Priority

2.1.1 Summary test site operation

ecoBalanced Priority covered 14 signalized intersections in Helmond. The hardware of previous projects was re-used and the software upgraded to the latest standards and expanded with eCoMove applications.

Figure 2 – Overview Helmond ecoBalanced Priority intersections

2.1.2 *Verification Test Case 1: vehicle detection*

The log files show a vehicle approaching intersection 102 from the West.

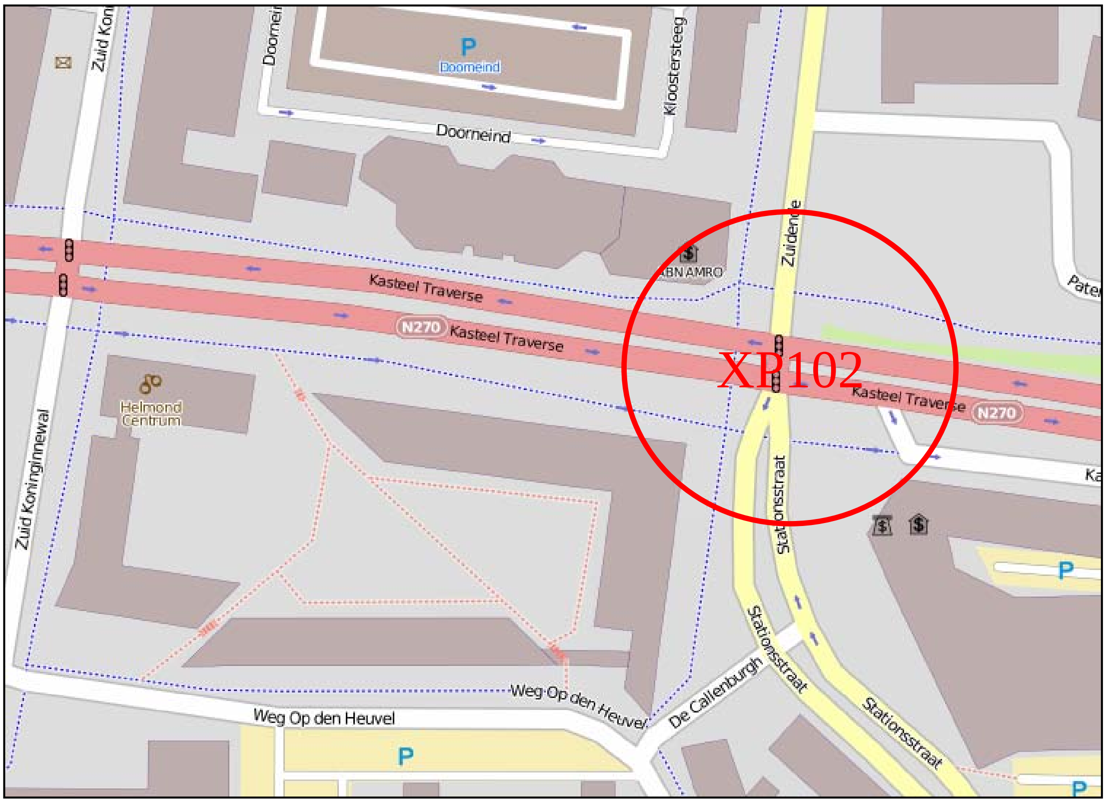
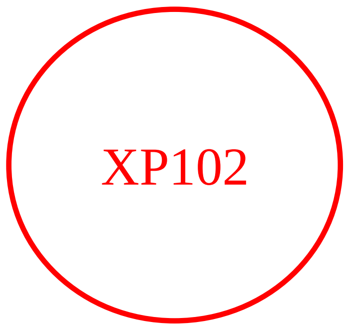


Figure 3 – Detail test site, intersection 102

The LDM logs the position, heading and speed of the vehicle. If possible the position is map-matched to a so called trail (reference track) giving the offset from the start of the trail and the distance to the trail.



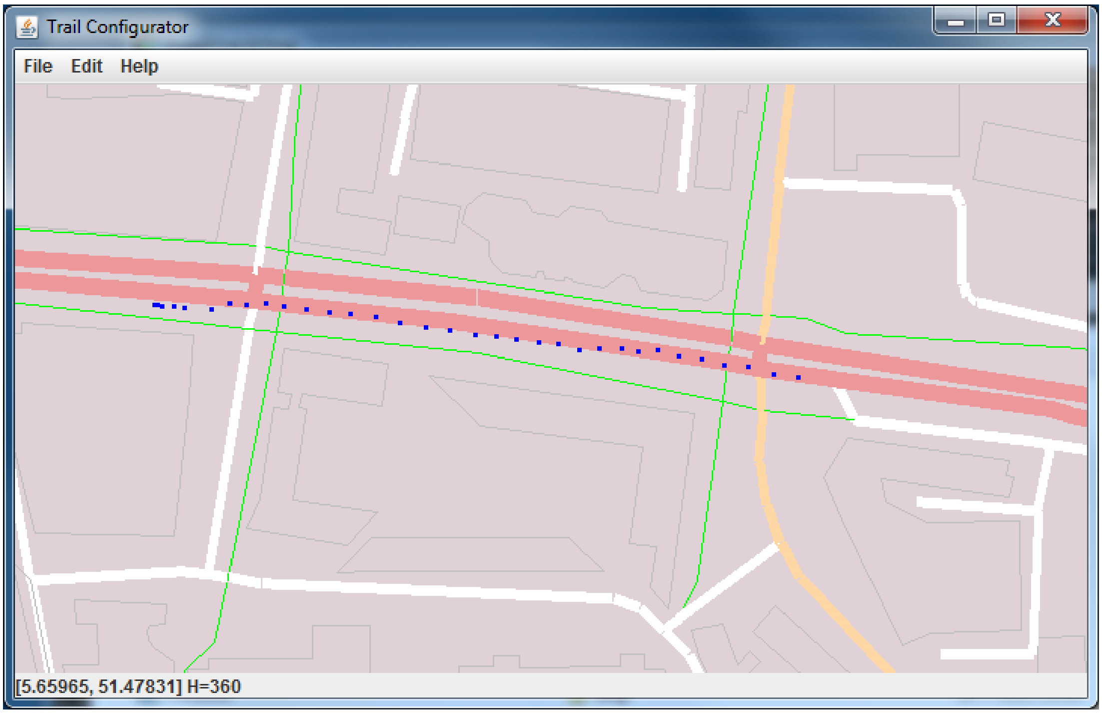


Figure 4 – Screenshot LDM log

```
time=20130404-
135213.992;action=vehicle;runnr=10;lon=5.6569107;lat=51.4776064;heading=97;speed=10;tr
ail=TrailPosition: Trail: 1 (null) STRAIGHT offset 233.08415587552577 distance
3.777469338225993;origin=Geonet
time=20130404-
135215.761;action=vehicle;runnr=10;lon=5.656968;lat=51.4776037;heading=93;speed=15;tra
il=TrailPosition: Trail: 1 (null) STRAIGHT offset 237.06127647505838 distance
3.781222500995104;origin=Geonet
time=20130404-
135215.972;action=vehicle;runnr=10;lon=5.6570253;lat=51.4776009;heading=97;speed=15;tr
ail=TrailPosition: Trail: 1 (null) STRAIGHT offset 241.03922520990645 distance
3.7960573063080587;origin=Geonet
time=20130404-
135218.702;action=vehicle;runnr=10;lon=5.65717;lat=51.4775954;heading=97;speed=21;trai
l=TrailPosition: Trail: 1 (null) STRAIGHT offset 251.0717562204664 distance
3.6594431751718473;origin=Geonet
```

Figure 5 – Sample of LDM vehicle data

2.1.3 Verification Test Case 3: priority request

The priority handler only gives priority to vehicles that transmit ecoCAM messages. When such a vehicle is found its position is retrieved from the LDM, including the parameter of the trail: the related signal head (FC08), the allowed vehicle type (minibus), how to sign-in and sign-out (busline, loopin, loopout) and the local speed limit (50). If all parameters are valid, the priority is accepted. When the vehicle arrives at the sign-in location a priority request is forwarded to the traffic controller. When the vehicle passes the stop line it is signed-out again.

```
time=20130404-
135210.961;action=ecocam;addr=geonet://0x000c426d5507:60949;id=10001;physType=0;lon=5.
6568677;lat=51.4776085
time=20130404-
135212.123;action=setlimit;runnr=10;speedlimit=50;roundedlimit=50;isdefault=true
time=20130404-
135212.123;action=ecocam;addr=geonet://0x000c426d5507:60949;id=10001;physType=0;lon=5.
6568677;lat=51.4776085
time=20130404-
135212.883;action=setlimit;runnr=10;speedlimit=50;roundedlimit=50;isdefault=true
time=20130404-
135212.883;action=trailparameters;runnr=10;vehtype=minibus;sgname=FC08;sgindex=7;busli
ne=353;loopin=7;loopout=8;speedlimit=50
time=20130404-
135212.883;action=setlimit;runnr=10;speedlimit=50;roundedlimit=50;isdefault=true
time=20130404-
135212.883;action=statechange;runnr=10;fromstate=stateIdle;tostate=stateAccepted;statu
s=accepted;reason=
135218.982;action=ecocam;addr=geonet://0x000c426d5507:60949;id=10001;physType=0;lon=5.
6572573;lat=51.477615
time=20130404-135219.969;action=signin;runnr=10;loop=TrailDetector(260.0,
377.0);distance=162;sgname=FC08;vehtype=minibus;priority=0
time=20130404-
135219.969;action=statechange;runnr=10;fromstate=stateAccepted;tostate=stateSignedIn;s
tatus=priogreen;reason=
time=20130404-
135219.969;action=ecocam;addr=geonet://0x000c426d5507:60949;id=10001;physType=0;lon=5.
6573433;lat=51.4776108
```

Figure 6 – Sample Priority Handler log

2.1.4 Verification Test Case 3: priority feedback

The traffic controller proxy handles all priority requests for various projects. The eCoMove hander is joined with the Contrast project. When a priority request is done, a priority sign-in is logged for the contrast user. When the request is accepted by the traffic controller the state of the signal and the time-to-green (ttg) and remaining-green-time (rgt) are logged until the vehicle is signed out.

```
time=20130404-
135219.971;action=priosignin;username=contrast;sgname=FC08;vehtype=minibus;level=0;bus
line=253;loopnr=7;runnr=5;result=true
time=20130404-135220.159;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=9;rgt=-1
time=20130404-135221.123;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=6;rgt=-1
time=20130404-135222.234;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=6;rgt=-1
time=20130404-135223.196;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=6;rgt=-1
time=20130404-135224.215;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=3;rgt=-1
time=20130404-135225.227;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=3;rgt=-1
time=20130404-135226.242;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=3;rgt=-1
time=20130404-135227.264;action=signalstate;runnr=5;sgname=FC08;state=3;ttg=3;rgt=-1
time=20130404-135228.226;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=-1
time=20130404-135229.191;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=12
time=20130404-135230.156;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=12
time=20130404-135231.175;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=12
time=20130404-135232.190;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=15
time=20130404-135233.158;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=15
time=20130404-135234.225;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=15
time=20130404-135235.144;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=8
time=20130404-135236.212;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=7
time=20130404-135237.185;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=8
time=20130404-135238.150;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=7
time=20130404-135239.170;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=8
time=20130404-135240.291;action=signalstate;runnr=5;sgname=FC08;state=1;ttg=-1;rgt=7
time=20130404-
135240.870;action=priosignout;username=contrast;sgname=FC08;vehtype=minibus;level=0;bu
sline=253;loopnr=8;runnr=5;cause=timeout;result=true
```

Figure 7 – Sample Traffic Controller Proxy log

2.2 Verification overview for ecoTruck Parking

2.2.1 Summary test site operation

Verification operations are concerning two main actions:

- On the ground verification of the functionalities of the application ecoTruckParking,
- Measurements and extrapolations of the consumption avoided by using the application.

The main functionalities of the ecoTruckParking Application to be verified are related to the following requirements:

REQ NR.	Description
SP5-9-0056	the number of places available on the park must be properly assessed
SP5-9-0057	Status of the truck parking area must correspond to reality
SP5-9-0058	Verify that a vehicle that sends its successive positions is properly positioned on a road, with a correct direction
SP5-9-0059	The available parking search engine must return truck parking area located downstream from the vehicle's position
SP5-9-0060	The system should give the TruckParking information to the relevant truck

Test area was French Motorways: A7, A9, A46. To resume the test site operations the test site was operated on the ground, on normal days and under traffic. The test site showed that the ecoTruckParking application is running quite well and give relevant results to users even if some parameters have been founded not tuned optimally. The test site operation showed that the ecoTruckParking application can be used easily, without disturbing a lot the driver (when the OBU is located close to the driver of course). The test site showed that the consumption measurement is a difficult process that requires precise operations. The test site showed that the consumption of trucks, operating a parking sequence without finding a place, is significant (more than 2 liters in average). Avoiding unfruitful stops by using an application such as eCoTruckParking is generating an important saving of fuel.

2.2.1.1 Test site description

Test sites where eCoTruckParking Application can be used:

The test sites are the French Motorways A7, A9 and A46 (approx 2 x 580 km) added with surrounding rest and services areas. Due to mapmatching process, the On Board Unit user must physically be on these motorways to make a request.

The measures have been done the 9th of May 2012 on:

- A46 - Communay Nord (GPS : 45°35'28.38"N - 4°49'35.58"E)
- A46 - Communay Sud (GPS : 45°35'18.95"N - 4°49'34.59"E)
- A7 - Saint Rambert d'Albon Est (GPS : 45°16'36.14"N , 4°49'40.47"E)

- A7 - Saint Rambert d’Albon Ouest (GPS : 45°16'33.44"N - 4°49'36.13"E)
- A7 - Vienne Ouest (GPS : 45°28'25.99"N - 4°49'57.17"E)
- A7 - Vienne Est (GPS : 45°28'41.00"N - 4°50'3.46"E)
- A7 – Roussillon (GPS : 45°24'20.45"N - 4°48'56.87"E)
- A7 – Pont d’Isère (GPS : 45° 1'2.14"N - 4°52'27.60"E)
- A7 – Latitude 45 (GPS : 45° 1'14.71"N - 4°52'36.72"E)

Figure 8 – Overview of the test site

2.2.1.2 Lessons learnt: problems reported and resolved

Tests of the Application:

In the first times when using the Application in normal conditions, on several tests, a restricted result (one area instead of several…) or no result was sent back to the OBU. That seems to be a malfunction. After studying the cases with the developers, we found that the scope range of the "Available Parking Search Engine" component was too restricted; areas status are sent back only when the areas are no more far away from the OBU of a maximum distance of 100km. So areas corresponding to the truck direction but 110km far way are not considered.

To correct this statement and solve the problem, the maximum range of this component has been extended to 500km that is a more suitable valueby tuning the concerned parameter.

Field consumption measurements:

The consumption measurements of the "Communay Nord" and Vienne Est truck parking failed:

- For Communay Nord : no record have been made due to a failure on CAN bus link
- For Vienne Est: No GPS track have been recorded for an unknown reason

For future, an in-situ debriefing of the measurements seems useful to take into account a potential lack of data and avoid the necessity of another measurement sessions.

Another important problem is that the recording process is difficult to launch because 3 different measurement software have to be started. Starting points and stopping points must also be in accordance with the software launchings and stops, that is complicating a little bit more the process. InFor future, an in-situ debriefing, this is possible to correct of the shift between the different measurements, but it takes extra time. That can be interesting for future measurements sessions to make seems useful to take into account a script that turn onpotential lack of data and off softwares synchronouslyavoid the necessity of another measurement session.

2.2.2 Verification Test Case A: number of places available on the park must be properly assessed

The test consists of a survey:

- a technician on the ground counts the truck parking places available
- a comparison with the "parking data collector manager" data is made to qualify the accuracy of the sensors

Tests have been done on three areas:

- Béziers Montblanc Sud (A9 Motorway)
- Loupian (A9 Motorway)

- Montélimar (A7 Motorway)

For **Béziers Montblanc** the results of the 14 real counts are presented below. This area of 30 places is equipped with sensors for each truck parking place. For each place, for each sensor, a technician reports the real occupancy.

Area name :	Béziers Montblanc Sud													
sensors number	30 parking places equipped													
statement	1		2		3		4		5		6		7	
date :	26/02/13		15/03/13		15/03/13		29/03/13		29/03/13		04/04/13		04/04/13	
hour :	17:39		16:15		17:00		01:50		02:35		22:50		23:35	
occupancy : / n° place :	real	system	real	system	real	system	real	system	real	system	real	system	real	system
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	0	0	0	0	1	0	1	0	1	1	1	1
3	1	1	0	0	0	0	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	1	0	1	0	1	1	1	1
5	1	0	0	0	0	0	1	1	1	1	1	1	1	1
6	0	0	1	0	0	0	0	0	0	0	1	1	1	1
7	1	1	0	0	0	0	1	1	1	1	1	1	1	1
8	1	1	0	0	0	0	1	1	1	1	1	1	1	1
9	1	1	0	0	0	0	1	1	1	1	1	1	1	1
10	0	0	0	0	0	0	1	1	1	1	1	0	1	0
11	0	1	0	0	0	0	1	1	1	1	1	1	1	1
12	1	1	0	0	1	0	1	1	1	1	1	1	1	1
13	1	1	1	1	0	0	1	1	1	1	1	1	1	1
14	0	0	0	0	1	1	1	1	1	1	1	1	1	1
15	1	1	0	0	1	0	1	0	1	0	1		1	
16	1	1	0	0	0	0	1	1	1	1	1	1	1	1
17	1	1	0	0	0	0	1	0	1	0	1	1	1	1
18	0	0	0	0	0	0	1	1	1	1	1	0	1	0
19	1	1	0	0	0	0	1	1	1	1	1	1	1	1
20	0	0	0	0	0	0	1	1	1	1	1	1	1	1
21	1	1	0	0	0	0	1	1	1	1	1	1	1	1
22	1	1	0	0	1	0	1	1	1	1	1	1	1	1
23	1	1	0	0	0	0	1	1	1	1	1	1	1	1
24	0	0	0	0	0	0	1	1	1	1	1	1	1	1
25	0	0	0	0	0	0	1	1	1	1	1	1	1	1
26	0	0	0	0	0	0	1	1	1	1	1	1	1	1
27	0	1	0	0	0	0	1	1	1	1	1	1	1	1
28	0	0	0	0	0	0	1	1	1	1	1	1	1	1
29	0	0	0	0	0	0	1	1	1	1	1	0	1	0
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1

number of Trucks	17	18	4	3	6	3	29	25	29	25	30	26	30	26
	57%		13%		20%		97%		97%		100%		100%	

true positifs	16	3	3	25	25	26	26
true negatifs	11	26	24	1	1	0	0
false negatifs	1	1	3	4	4	3	3
false positifs	2	0	0	0	0	0	0
problem	0	0	0	0	0	1	1

detection rate:	90,0%	96,7%	90,0%	86,7%	86,7%	89,7%	89,7%
tendancy :	-3,3%	3,3%	10,0%	13,3%	13,3%	10,3%	10,3%
availability rate :	100,0%	100,0%	100,0%	100,0%	100,0%	96,7%	96,7%

average detection rate. :	90%
average tendancy:	8%
average avaibility rate	99%

Figure 9 – Determination of the average detection rate for "Béziers Montblanc" truck parking area

The average detection rate for this session is 90% (real occupancy / occupancy given by the system). Example of calculation of the detection rate of the counting n°1 (26 February 2013):

- 17 parking places occupied enumerated by the technician, and 13 empty places
- 18 parking places red by the system and 12 empty.
- After analysis : 3 states are wrong : 1 false empty place and 2 false occupied places
- So 3 on 30 places have got a wrong state, detection rate is 90%

For Loupian area (110 places), the system of truck counting is based on entrance/exit counting. 8 counting sessions are reported below.

Area Name :	Loupian		number of truck places :		110			
Date :	13/02/2013	13/02/2013	13/02/2013	13/02/2013	15/03/2013	15/03/2013	15/03/2013	15/03/2013
statement:	1	2	3	4	5	6	7	8
date :	21/02/13	26/02/13	06/03/13	15/03/13	18/03/13	29/03/13	01/04/13	04/04/13
heure :	18:17	18:04	09:15	17:50	15:30	02:50	17:22	23:50
occupancy : real	8	13	28	6	5	27	0	38
occupancy : syst.	6	12	28	3	6	22	0	38

performance :	98,2%	99%	100%	97%	99%	95%	100%	100%
days spent from reset :	8	13	21	30	3	14	17	20

average performance from beginning
99%

Figure 10 – Determination of the average detection rate for "Loupian" truck parking area

The average detection rate (real occupancy / occupancy given by the system) for this session is reported at 99%.

For Montélimar area, the counting system is based on toll gates in entrance/exit. It's a little bit different from the previous ones because of possible human interactions on the toll gate system that potentially generate error on counting.

Area Name :	Montélimar Est				number of truck places :				152							
Date :	06/02/2013		13/02/2013		13/02/2013		15/03/2013		19/03/2013		19/03/2013		19/03/2013		19/03/2013	
statement:	1		2		3		4		5		7		8		9	
date :	13/02/13		27/02/13		15/03/13		19/03/13		27/03/13		04/04/13		11/04/13		18/04/13	
heure :	00:52		14:00		15:21		12:00		09:00		20:25		08:50		21:13	
occupancy :	réelle	syst.	réelle	syst.	réelle	syst.	réelle	syst.	réelle	syst.	réelle	syst.	réelle	syst.	réelle	syst.
	70	59	13	6	8	6	10	11	24	30	35	40	25	32	27	24

performance :	92,8%	95%	99%	99%	96%	97%	95%	98%
days spent from reset :	7	14	30	4	8	16	23	30

performance moyenne :
97%

Figure 11 – Determination of the average detection rate for "Montelimar Est" truck parking area

For this 152 truck places parking, the detection rate (real occupancy / occupancy given the system) is 97%.

2.2.2.1 Evaluation of verification Test Case A

The detection rates are between 90% and 99%, we consider these performances sufficient for generate a parking status in terms of "free"or"full". ASFA has chosen to work on this information instead of giving the number of place.

The requirement of the test Case A is verified.

2.2.3 Verification Test Case B: Status of the truck parking area must correspond to reality

The test consist of comparing the status given by the "parking data collector manager" to the real state of the parking read on the ground by technicians.

2.2.3.1 Evaluation of verification Test Case B

This test is actually trivial because the parking status is defined only if the occupancy is above or below a value (value depending of the total number of places). The value is also chosen to take into account the performances of the average detection rate of each parking.

Technician never found a problem on deducing a status from the parking occupancy.

2.2.4 Verification Test Case C: vehicle is properly positioned on a road, with a correct direction

Driving on the motorways, pushing the request button, sending the last 3 GPS positions, map matching the data are the actions to determine motorway and direction.

2.2.4.1 Evaluation of verification Test Case C

We must notice that the method "3 GPS locations" has "normal" limits where it is not possible to determination a direction:

- request made on a roundabout,

- request made on an area where the driver doesn't respect strictly the defined driving direction,
- request made on an areas mixing the traffic flow from the motorway two directions,
- on roadwork sections when the reference on the maps are temporally modified on the ground.

Without these particular cases, the map matching works perfectly.

2.2.5 *Verification Test Case D: "Downstream Truck Parking Areas are sent to the OBU*

Driving on the motorways, pushing the request button, and receiving result on the OBU.

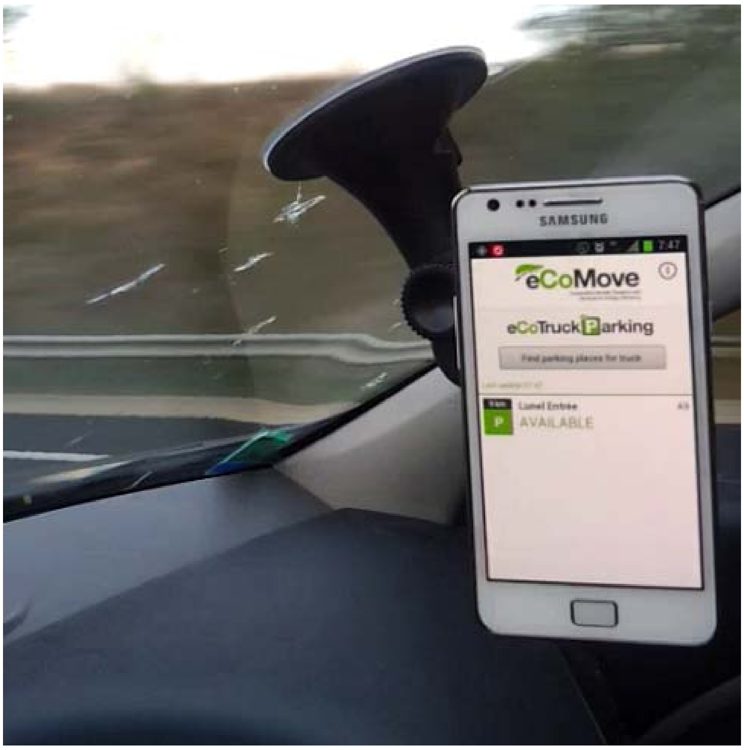


Figure 12 – Illustration of eCoTruckParking on OBU

Several other verification have been done like these exposed on D5.7. No major problem encountered.

2.2.5.1 Evaluation of verification Test Case D

At final, we just regret that only 4 truck areas are plugs to the application and because results are most of the time composed by one area. The benefits of the EcoTruckParking application proved to be high enough to justify the investment of rolling out the application on other areas. We are thinking about plugging other areas that have been developed since the start of the project.

2.2.6 Verification Test Case E: The system should give the TruckParking information to the relevant truck

Two OBU are equipped and receive “their” information. We haven’t notice any problem of inversion or such as. See next paragraph for explanation.

2.2.6.1 Evaluation of verification Test Case E

The ecoTruckParking application call a web service under GPRS communications. So, the application is using internet principles: a client (the OBU) initiate a dialogue with a server (the ASFA server), the server replies to the client under the dialogue opened. Each session of dialog opened on the server is unique and by conception information cannot be mixed because each dialog is treated independently.

2.3 Verification overview for ecoApproach Advice

2.3.1 Summary test site operation

ecoApproach Advice covered 14 signalized intersections in Helmond. The hardware of previous projects was re-used and the software upgraded to the latest standards and expanded with eCoMove applications.

Figure 13 – Overview Helmond ecoApproach Advice intersections

2.3.2 Verification Test Case 1: speed and lane advice message

There is only one verification test case for this application. For this test case multiple subjects are discussed that follow the setup of [D5.6]. These include the prerequisite conditions, test inputs, expected test results, test procedure and evaluation of the results.

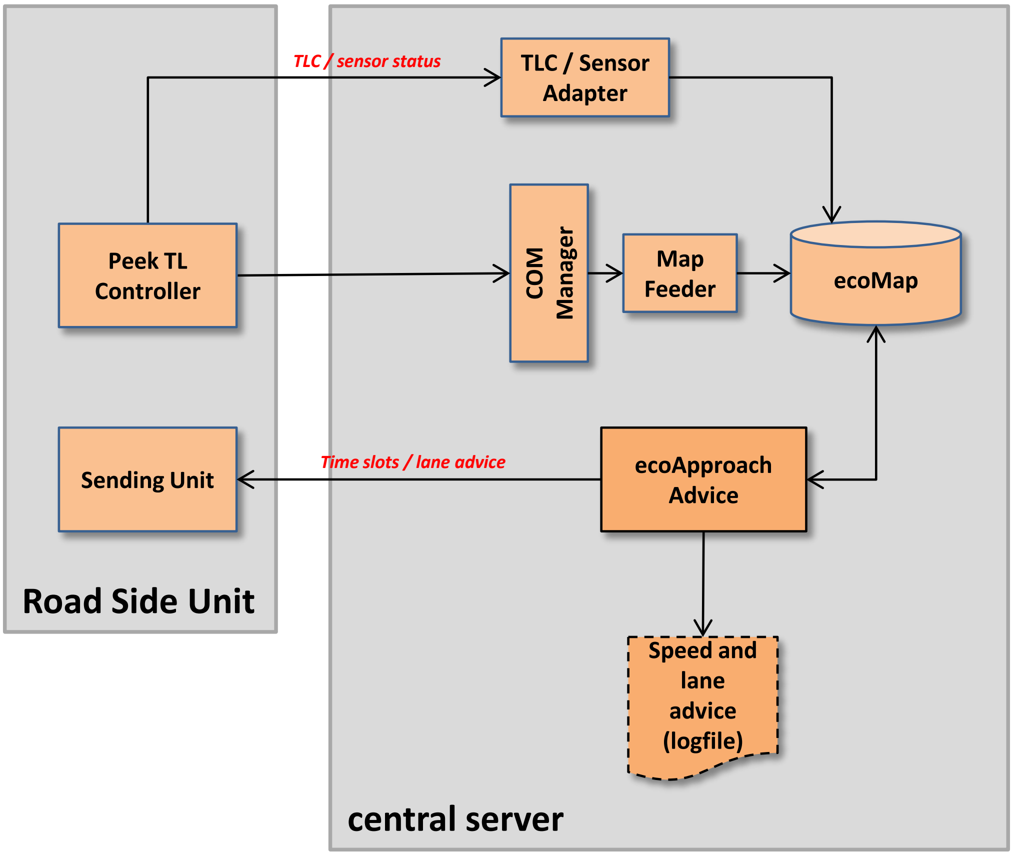


Figure 14 - Original architecture for ecoApproachAdvice

For the prerequisite conditions the following can be stated:

- The hardware and software configuration is as stated in [D5.6] with the exception of the ecoMap component. Since there were no other components on site demanding data from the ecoMap, there was no need for it. The application was directly coupled to the TLC/Sensor Adapter. See Figure 14 for reference to the original architecture.
- The static data about the topology and distances between intersections is directly acquired from the ITM generation application that works with latitude, longitude references. Because the ITM to ecoMap would need translation from (lat, lon) to ecoMap format and later again from ecoMap format to SLAM format to saves two translation operations. SLAM and ITM use the same reference for locations and no conversions are necessary.
- Saturation flow can be included in the ITM application, but wasn't necessary as all signal groups with advice were the same, two lanes with 1800 vehicles per hour. In the future this can actually be connected to the dynamic measurement of saturation flow of the traffic light control algorithm, which is already available on the webpage of the traffic light controller.
- Vehicle data is logged by the vehicle.

The test inputs could be either logged or followed real-time during operation by logging in to the OSGI environment of the RSU. There were commands to follow signal group status with prediction to next change, detector status and cooperative vehicle locations.

The expected test results can all be covered except the lane advice; this will be discussed further with the evaluation. Lane advice is still planned, but a camera is required to have lane level accurate queue measurement. Such a camera has been installed at one of the intersections in spring 2013. Unfortunately, soon after the host-pc of the roadside unit became defect (repair planned for end of 2013) which hindered extensive usage of the camera footage before the end of eCoMove project.

In the test procedure the ecoMap step is skipped, a direct connection to the ITM application and the TLC adapter came in place of this as explained before. The ecoApproach Advice application has been active since June 2012 and is still active. There is no need to bring the application offline in the near future, but maintenance shall be carried out at least until all validation work is done. In [D5.6] it is stated that only registered vehicles will receive advice. However, the real application had plenty of processing resources available to calculate advice for all vehicles and is therefore more extensive. Logging facilities were abundant and used whenever they were required.

For verification a number of specific advice messages have been analyzed in more detail. Logging of the signal group statuses, queue model state and resulting advice was used. The queue model state is an enhanced version of the detection information. The queuing model itself is part of the traffic light controller algorithm and is already extensively verified and validated. Also flags would be raised in case certain conditions were met. Per criterion from [D5.6] the results are discussed in the sequel:

- *Calculated time slot during the green phase is free (not occupied by queued vehicles).*
  Numerous advice messages have been analyzed and there were no wrong advices. However, in simulation the real situation could be compared with the situation in the queuing model. In some situations the queuing model was slightly wrong and naturally the advice was wrong too in those cases. When the queue was underestimated the vehicle still had to stop and in case of overestimation there would be a too big gap.
- *Lane advised is in the direction of travel & Lane advised has smaller queues than other lanes going in the same direction.*
  As explained before the camera is not yet installed and this is not yet possible.
- *Speed advice complies with the local (speed) regulations.*
  A flag was set in case this would happen, but it never happened.
- *Formation of platoons in case of a high penetration rate, i.e. consecutive arrival at the stop line.*
  This was only visible in simulation, because only there enough penetration was available. With 100% penetration this was something that always happened. Where the tipping point lies will be determined in the traffic simulations reported in [D5.10].

Except for the camera related verification criteria, the verification can be concluded successful.

2.4 Verification overview for ecoNetwork Prediction and ecoEmission Estimation and Prediction [Munich]

Based on various static network attributes, dynamic capacity related information, road side sensor data and - above all - vehicle generated data (positions, speed, routes), the component ecoNetwork Prediction estimates the current, future and ideal/desired traffic state for the road network in terms of traffic flows, travel times, link emission values and OD-route distribution schemes.

The verification procedure mainly consists in comparing estimated / determined model values with corresponding detector values that has not been provided to the ecoNetwork Prediction model before. When optimisation is involved (determination of desired traffic states) it will be examined whether the overall network emission of the optimised scenario is less than the real scenario (as is estimated by the model).

According to [D5.6] for the component “ecoNetwork Prediction” three tests were foreseen that refer to different aspects of the component’s functionality (see sub-chapters below). The verification also concerns some test case independent features. These verification results are presented in a first sub-chapter.

The following sub-chapters refer to the two concerned eCoMove test sites Munich and Helmond separately.

2.4.1 General verification independent of test cases

In this chapter the general setup of the real test site Munich is described together with the eCoMove system that has been installed there in order to estimate current and ideal traffic states for this network on the basis of dynamic data.

As can be seen from the following figure below, the test site Munich covers the north area of Munich.

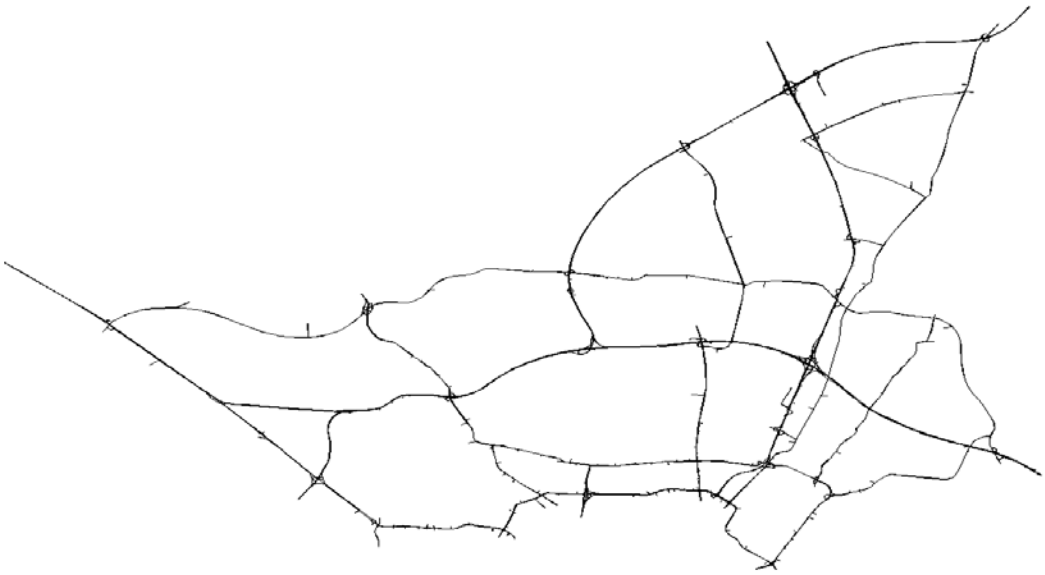


Figure 15 - The traffic road network of the eCoMove test site Munich.

The network of the test site Munich has this size:

- 7294 links
- 86 zones that serve as origins and destinations
- 107 signalized intersections (fixed time control)

In eCoMove sub-system that has been installed in Munich to run the ecoNetwork Prediction is presented in the following figure.

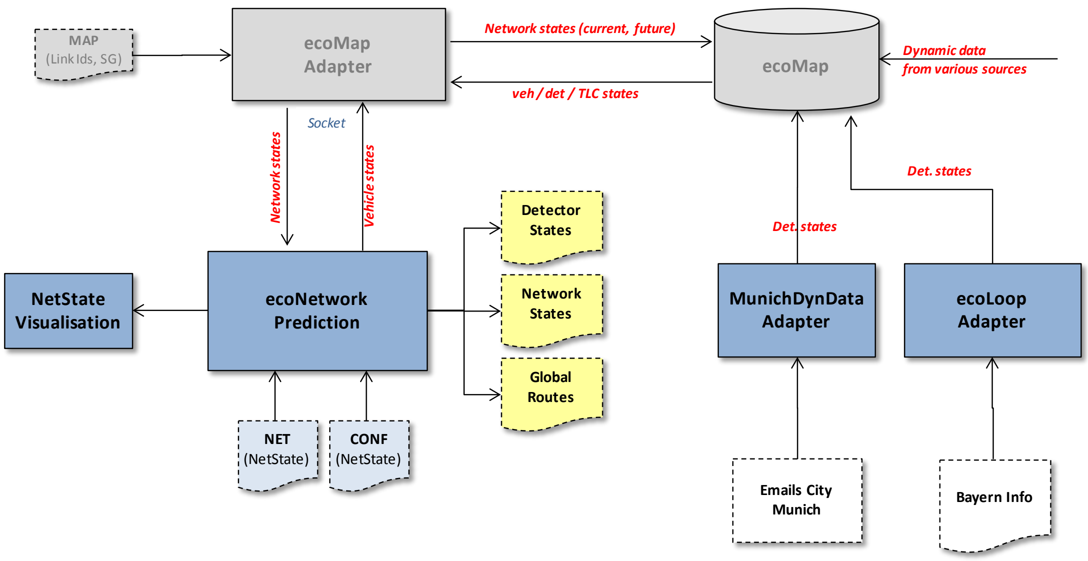


Figure 16 - The ecoNetwork Prediction sub-system for the real test site Munich.

The system comprises the central database ecoMap that contains all dynamic data coming from the test site. This data is provided by two adapters that feed and pre-process dynamic detector data.

<u>Input: Static network configuration data</u>

The model network was directly derived from the VISSIM network, as

(1) the VISSIM file contains all links of the real test site network,

(2) the ids of detectors are the same in VISSIM and ecoMap.

(3) there exists a mapping file “VISSIM link id → ecoMap Link Id” that can be used to write model results into the ecoMap.

In order to derive the model network the tool “NetStateConverter” has been developed.

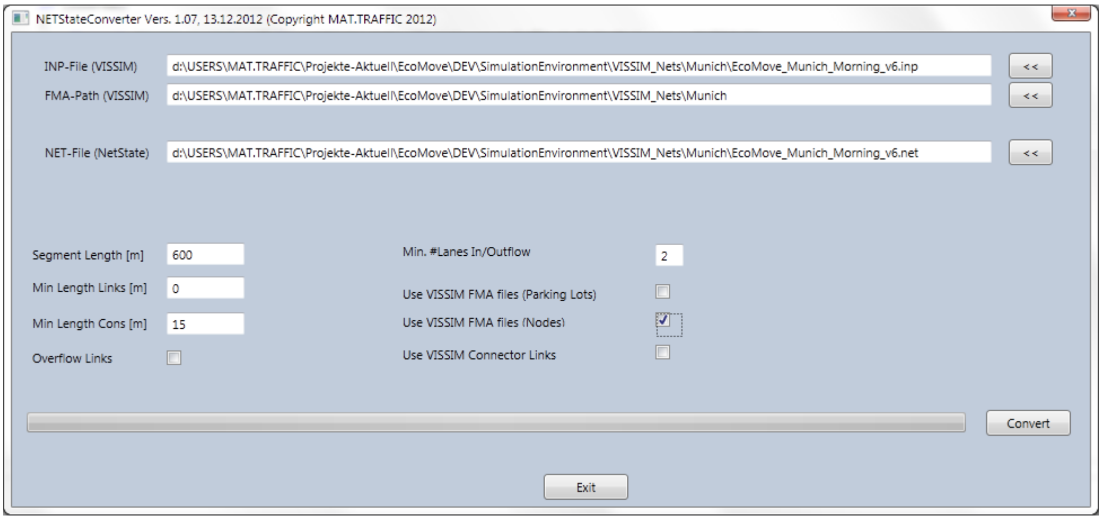


Figure 17 - NetStateConverter

Input: Dynamic signal group states

Contrary to earlier project planning it turned out that it is not possible for Munich to provide dynamic signal group states to the test site. Therefore, the capacity values of signalized intersection links have been set to fixed values that reflects an average green window of the TLC at this intersection.

Input: Dynamic detector data

Within the test site Munich dynamic detector data comes from two different sources.

(1) From the city of Munich (every 15 minutes aggregated values): 125 Strategic detectors for main roads and 675 TLC detectors that are located in the approaches of intersections. From the 125 + 675 detectors unfortunately only a small minority of about 10 detectors could be used because there was no configuration file available which maps the detector ids to ecoMap road elements.

(2) From the management center of Munich: 69 strategic detectors for motorways. All these detectors values are written periodically (every 15 minutes) into the ecoMap by the adapters “ecoLoop” and “MunichDynDataAdapter”.

The total number of detectors (10 + 69 = 79) is rather small for a network of this size. This means that the internal o-d-matrix correction does not have much data to work with; and also the traffic assignment quality is limited, for the model has to complete the state data for many links in the network. This mainly concerns to the estimation of current and short-term predicted traffic states. The determination of desired network states on the other hand does not use detector values because the routes of the vehicles may not predefined. But the consequence here is that the emission comparison of the desired states with the baseline (the current network state) is weak as the current state comes with significant uncertainties, and in fact the current and desired states cannot be expected to be far apart from each other. Therefore, the results here in the real test site of Munich are of limited significance. More accurate and meaningful results are gained in the eCoMove simulation environment, where the very same component ecoNetwork Prediction is implemented.

It has been successfully proved by means of the Knopferfish bundle "DynamicMapDump" (which presents the content of the ecoMap in table form) that the detector values from the management center of Munich are periodically written into the ecoMap. Example of the entries:

Road Element 576300162-, offset 156.6300048828125: Sensor 41722 Lane=2 Status=true Timestamp=1363965780000 Speed=125.0 Flow=1260.0

Road Element 576300162-, offset 156.6300048828125: Sensor 41721 Lane=1 Status=true Timestamp=1363965780000 Speed=121.0 Flow=780.0

Road Element 576300162-, offset 156.6300048828125: Sensor 41723 Lane=3 Status=true Timestamp=1363965780000 Speed=133.0 Flow=1020.0

Road Element 576300160+, offset 199.2100067138672: Sensor 41704 Lane=4 Status=true Timestamp=1363965780000 Speed=124.0 Flow=1160.0

Road Element 576300160+, offset 199.2100067138672: Sensor 41701 Lane=1 Status=true Timestamp=1363965780000 Speed=106.0 Flow=60.0

The component "ecoMapAdapter" reads periodically the values from the ecoMap and sends them to the ecoNetwork Prediction component via socket. Also this part of the data flow has been proved successfully (the ecoNetwork Prediction component writes the received detector values into the ASCII log file "Traffic_States(det_flow_ns)__*.csv"). Example (tiny part of the log, the unit of the flow is vehicles per second):

Time;NsId=0;NsId=2;NsId=5;NsId=9;NsId=13;NsId=14;NsId=16;NsId=17;NsId=18;...

36566;0.101771;0.0829002;0.0471658;0.0426159;0.0687533;0.0525623;0;0.122216;0;...

<u>Visualisation: Topology and traffic states</u>

A tool has been developed that is able to visualise the network states of the test site online. The following values can be presented per link:

- Average traffic flows together with capacity values,
- Average speed values,
- Average emission values,
- The sum of emissions for the network.

A sample view of the network state for the real test site Munich can be seen in the figure below.

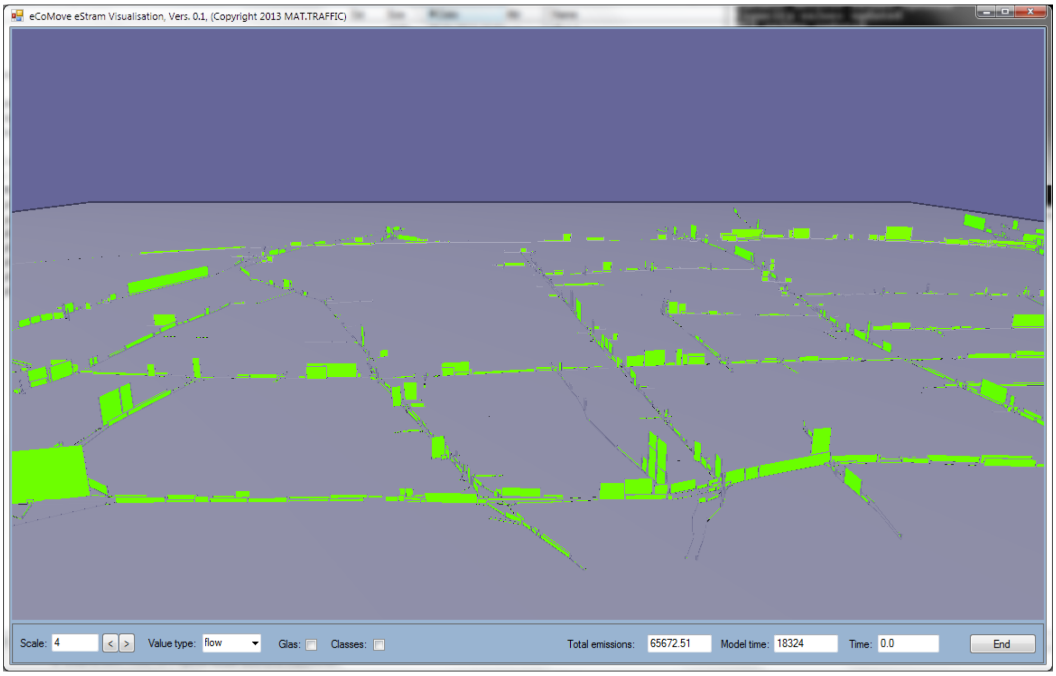


Figure 18 - The Tool "eCoMove eStram Visualisation" that can dynamically visualise different state values of the traffic network.

It must be mentioned that it has not been possible to do comprehensive verification tests, for the complete static database was only available at a late stage of the project. Thus, the tests have been restricted to the most relevant once in order to do a basic verification. Moreover, the dynamic database is much smaller than expected at the beginning. The number of detectors available for the model is comparatively small (79) with respect to the size of the network (7294 links) and dynamic states of the TLC have not been available at all. Also, with the small number of detectors a precise adjustment of OD-matrices was hard to accomplish. Also, no vehicle generated data have been available that could serve to improve the model results. A more comprehensive verification and evaluation of the modelling has been performed in a microscopic simulation environment. Nevertheless, as can be seen in the following sub-chapters, certain emission reduction effects can be shown even in this restricted modelling scenario.

More accurate and meaningful results are in fact gained in the eCoMove simulation environment, where typical traffic situations can be modelled very realistically, and where the very same component ecoNetwork Prediction is implemented.

2.4.2 Munich test case 1: Estimation / adjustment of traffic OD-matrices

Reference to main requirements: SP5.11.65, SP5.11.66

In real test sites the traffic demand information is based on given time dependent OD-matrices that reflect general characteristic situations (usually without large events and incidents). This original static traffic demand is given in form of OD-matrices in hour slices (from 5:00 until 21:00). While operation this original matrix information needs adaptation according to dynamic detector values. Therefore, the purpose of the test case “Estimation / adjustment of traffic OD-matrices” is to verify the proper adjustment of the matrices according to these detector values encountered at the time of testing. Here, the model shall adjust the network inflows that are measured by detectors (or combinations of detectors)

The online adjustment of predefined origin-destination-matrices works as follows: The model identifies all network inflow links (origins) the traffic flow of which is uniquely determined through one or the combination of several detector values. The inflow values are adjusted / updated cyclically (every 60-300 seconds) according to the detector values.

As in the test site Munich only a very small number of dynamic detector values were available (79 detectors), there could only be performed a very limited verification test for the estimation / adjustment of traffic OD-matrices.

The verification test consists in the following procedure:

- Wait until a OD-adaptation step has been performed
- For all network inflows that can be determined through detector values: Compare the current network inflow with the combination of detector values from which the inflows has been derived.

Results of the verification test:

link id model	orig. inflow	adj. inflow	sum det. Values
3103	0.051	0.071	0.071
3143	0.031	0.023	0.023
3145	0.024	0.024	0.024
3225	0.028	0.019	0.019
3227	0.017	0.02	0.02
3247	0.038	0.028	0.028

link id model	orig. inflow	adj. inflow	sum det. Values
3103	0.051	0.071	0.071
3143	0.031	0.023	0.023
3145	0.024	0.024	0.024
3225	0.028	0.019	0.019
3227	0.017	0.02	0.02
3247	0.038	0.028	0.028

Table 1 - The adjusted network inflows (origin flows) and the corresponding combination of dynamic detector values

Only 6 inflow locations of the network could be assigned to detectors. For these it was verified exemplarily that the sum of the assigned detector values is identical to the update values that are assigned to the inflow links.

2.4.3 Munich test case 2: Estimation of current traffic states

Reference to main requirements: SP5.11.68, SP5.11.69

The estimation of current traffic states in the eCoMove simulation environment and real test sites is based on detector states and shall deliver time dependent link state values in terms of average flows, travel times, fuel consumption or emissions.

The verification of the estimation of current and future traffic states consists mainly in the comparison of model results with archived detector values that has been withhold from the model while operating.

As for the current traffic state the verification has been performed as explained in the following:

- The test time periods are 4 hour slides (5:00, 8:00, 12:00, 17:00), representing AM Peak, Off Peaks, and PM Peak.
- For each hour 4 strategic detectors has been disabled for the model (their data was not available, but has been stored in a database). These detectors are visualised in the figure below.
- 3 test runs have been performed on 3 different days of a week (Tuesday, Wednesday and Friday)
- After each test run the model results have been compared with the detector values for the according links. For this the following time points were chosen: 05:15, 08:15, 12:15, and 17:15.

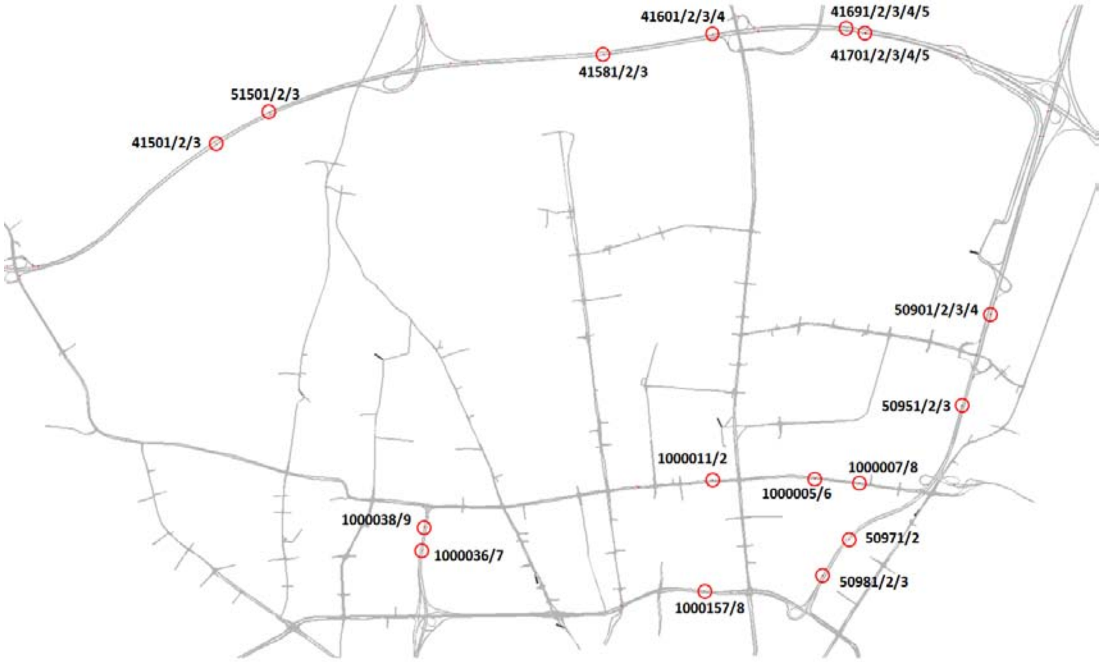


Figure 19 - The Munich network with the detector locations that has been chosen for the verification tests.

time	1. hidden detector (id)	2. hidden detector (id)	3. hidden detector (id)	4. hidden detector (id)	day of week	difference det. 1 (%)	difference det. 2 (%)	difference det. 3 (%)	difference det. 4 (%)
05:00	51501/2/3	41691/2/3/4/5	50971/2	1000036/7	Tuesday	22.25	26.24	12.32	20.04
					Wednesday	0.62	12.29	6.29	9.20
					Friday	45.26	34.24	10.20	9.47
08:00	41501/2/3	41701/2/3/4/5	50981/2/3	1000038/9	Tuesday	20.39	8.37	6.34	13.31
					Wednesday	4.15	24.13	16.17	53.09
					Friday	12.36	17.26	19.26	25.23
12:00	41581/2/3	50901/2/3/4	1000157/8	1000007/8	Tuesday	6.20	9.11	26.21	12.12
					Wednesday	16.24	6.18	36.24	8.16
					Friday	8.43	42.29	38.37	7.27
17:00	41601/2/3/4	50951/2/3	1000011/2	1000005/6	Tuesday	15.32	25.21	14.12	33.11
					Wednesday	41.09	18.11	44.11	20.07
					Friday	18.18	8.19	6.15	13.12
					Avg.	17.54	19.30	19.65	18.68
					Std.dev.	13.69879563	11.40879979	13.45358796	13.33955885

time	1. hidden detector (id)	2. hidden detector (id)	3. hidden detector (id)	4. hidden detector (id)	day of week	difference det. 1 (%)	difference det. 2 (%)	difference det. 3 (%)	difference det. 4 (%)
05:00	51501/2/3	41691/2/3/4/5	50971/2	1000036/7	Tuesday	22.25	26.24	12.32	20.04
					Wednesday	0.62	12.29	6.29	9.20
					Friday	45.26	34.24	10.20	9.47
08:00	41501/2/3	41701/2/3/4/5	50981/2/3	1000038/9	Tuesday	20.39	8.37	6.34	13.31
					Wednesday	4.15	24.13	16.17	53.09
					Friday	12.36	17.26	19.26	25.23
12:00	41581/2/3	50901/2/3/4	1000157/8	1000007/8	Tuesday	6.20	9.11	26.21	12.12
					Wednesday	16.24	6.18	36.24	8.16
					Friday	8.43	42.29	38.37	7.27
17:00	41601/2/3/4	50951/2/3	1000011/2	1000005/6	Tuesday	15.32	25.21	14.12	33.11
					Wednesday	41.09	18.11	44.11	20.07
					Friday	18.18	8.19	6.15	13.12
					Avg.	17.54	19.30	19.65	18.68
					Std.dev.	13.69879563	11.40879979	13.45358796	13.33955885

Table 2 - The differences between hidden detector values and the corresponding values the model estimated for the detector locations.

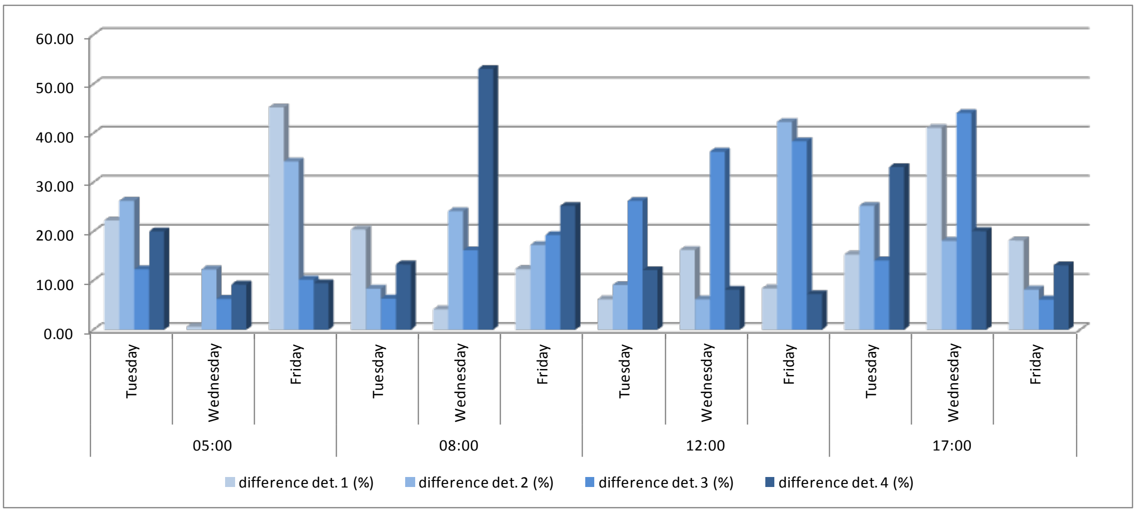


Figure 20 - The differences between hidden detector values and the corresponding values the model estimated for the detector locations in diagram form.

The verification tests show:

- The average difference of all value comparisons is 18.79 %
- The results of the model reflect the detector values reasonably well, which means that the model can roughly reconstruct the overall traffic situation,
- The results are not of high quality as the difference between model value and detector value is in many cases big (> 20%),
- The results fluctuate considerably, which means that the standard deviation “Std.dev.” of the differences is quite high.

The main reason for the results to be of rather low quality is what has been mentioned already at the beginning of this chapter: the very small number of detectors that deliver dynamic values and the entire lack of any dynamic signal group and vehicle states. In a controlled environment with simulation data far better results were obtained as is described in [D5.7 and D5.10].

2.4.4 Munich test case 3: Estimation of eco-optimal traffic states

Reference to main requirements: SP5.11.67, SP5.11.70

The estimation of eco-optimal traffic states in form of routing schemes in real test sites is based on OD-matrices and signal group states and shall deliver time dependent origin-destination route distributions and overall fuel consumption / emission values for the normal and optimised routing scheme.

The verification shall be carried out by comparing the time-dependent overall emission values of the network in the normal traffic situation with the optimised traffic situation (both having different routing schemes). The overall emission values of the network are computed by using the macroscopic ecoEstimation Prediction component.

The verification tests are defined as is described in the following:

- Two instances of the model have been running: one that considers dynamic detector values and the other one that does not. The model stores the emission values per link in a separate log file.
- The test time period has been 4 separate hour slices (5:00, 8:00, 12:00, 17:00)
- On three different days of a week (Tuesday, Wednesday and Friday) test runs have been performed.
- The emission values per link are used to compute the overall emissions for the network for the different points in time.
- The overall emissions have been compared in order to find out what the rate of reduction is. For this the following time points were chosen: 05:15, 08:15, 12:15, and 17:15.

Summary of the verification test:

time	day of week	% emission reduction
05:00	Tuesday	0.44
	Wednesday	2.10
	Friday	2.22
08:00	Tuesday	1.19
	Wednesday	2.74
	Friday	3.27
12:00	Tuesday	3.23
	Wednesday	3.01
	Friday	2.72
17:00	Tuesday	2.87
	Wednesday	2.64
	Friday	2.05
	Avg.	**2.37**
	Std.dev.	**0.845117887**

Table 3 - The emission reduction according to ecoNetstate Prediction results over several time points.

It turns out that there is only a relatively small reduction of emissions. Taking the particular circumstances into account (only 79 detectors), it is quite clear and has been expected that the delta of the two scenarios (with and without detector consideration) is small. But it could be shown that the ecoNetwork Prediction model in the eco-optimal traffic state mode works as it should, i.e. it reduces the total amount of emissions. More detailed and reliable results are expected from the eCoMove simulation environment.

2.5 Verification overview for ecoNetwork Prediction and ecoEmission Estimation and Prediction [Helmond]

In Helmond, the implementation in the field of a combination of the components ecoNetwork Prediction and ecoEmission Estimation and Prediction has been named

the 'ecoStrategic Model'. The verification of the ecoStrategic Model largely follows the verification plan as documented in [D5.6] for the component: ecoNetwork Prediction. In addition to that, the inclusion of the estimation of emissions and the identification of emission hotspots has been verified.
The main functional blocks that have been verified are the following:

1. Estimation and adjustment of the origin-destination (OD) matrices
2. Estimation of current and future traffic states
3. Estimation of ideal traffic state
4. Estimation of emission states
5. Estimation of hotspot severity

In practice, this meant that the whole chain of modules of the ecoStrategic Model has been checked to see if input data are processed in the correct way and that the estimated values are realistic (i.e. within a certain range of values that are deemed realistic). In words: this means verifying that input data from loop detectors (numbers of vehicles) was collected, OD estimation (for the current and predicted OD-matrix) was performed, estimation of current, predicted and desired traffic state for all links in the network was carried out, output data was provided to the ecoEmission Estimation and Prediction component, and data that the ecoEmission Estimation and Prediction component returns (emissions) was processed into hotspot severity values.

The verification was carried out for an off-line version of the ecoStrategic Model. Due to data collection problems and time and budget constraints, it was not possible to implement an on-line version, although technically this is feasible with the current set-up (of the data collection and the model itself).

Currently, the ecoStrategic Model runs on pc, using data stored on a server. The software environment used includes Java, Matlab, and the Dynasmart model extended with a small number of executables (such as for the OD estimation and the Predicted and Desired State).

2.5.1 Verification test cases for the ecoStrategic Model

Several requirements were formulated early on in the project, and for these verification test cases were set up. The ecoStrategic Model was initially part of SP2 (and thus a core technology), but there was an overlap with the SP5 application ecoNetwork State and Prediction, and a clear link with the SP5 component ecoEmission Estimation and Prediction, and thus it was decided to include it in the SP5 verification and validation reporting. However, the requirements listed in Table 4 are numbered in SP2 fashion.

Four test cases are discussed below:

- Helmond test case 1: Data collection and processing
- Helmond test case 2: Traffic State Estimation and Prediction
- Helmond test case 3: ecoEmission estimation module
- Helmond test case 4: Hot spot identification Module
- Helmond test case 5: Calculating the Desired State

Some of the requirements below fall outside the scope of the four test cases and are discussed in Table 4. Test case 1 and 3 were not originally addressed in the eStraM requirements but are discussed in this chapter because those are important functions of eStraM.

Table 4 - Requirements ecoStrategic Model

Name	**Type**	**Technology / Application**	**Performance Indicator ID → Requirement desciption**	**Test cases**
SP2.4.4.2.0001	F	ecoStrategic Model	The ecoStrategic model has to output a current state network view to the ecoMap, which includes speed (km/h) and flow (veh/h) for every link in the network, for a given time-slice	Part of test case 2 – output was generated but not to the ecoMap. Efforts were made to obtain the ecoMap, which was a prerequisite for linking eStraM to it, but there were legal obstacles that took too much time to overcome. As it was not needed for validation, it was decided to produce generic output that can eventually be incorporated into the ecoMap.
SP2.4.4.2.0002	F	ecoStrategic Model	The ecoStrategic model has to output a predicted state network view to the ecoMap, which includes speed (km/h) and flow (veh/h) for every link in the network for a prediction horizon of X minutes	see SP2.4.4.2.0001
SP2.4.4.2.0003	F	ecoStrategic Model	The ecoStrategic model has to output a desired state network view to the ecoMap which includes speed (km/h) and flow (veh/h) for every link in the network for the ideal distribution of traffic over the different routes in the network for a prediction horizon of X minutes.	see SP2.4.4.2.0001

SP2.4.4.2.0004	F	ecoStrategic Model	The ecoStrategic model has to output hotspots and the corresponding severities to the ecoMap for every traffic state view.	see SP2.4.4.2.0001 and test case 4 below.
SP2.4.4.2.0005	P	ecoStrategic Model	The output eStraM should be consistent with microscopic model (eSiM) in both ways, provided a few common measures of effectiveness/MoE	This link has not been built and therefore has not been verified. However, the information could be used by eSiM so in that sense it is consistent.
SP2.4.4.2.0006	F	ecoStrategic Model	eStraM should be capable of modeling traffic management and control strategies at network and route level on larger city area	Not specifically part of a test case. However, eStraM is capable of modeling traffic management and control strategies at network and route level on larger city area, as has been shown for the city of Helmond (traffic light control was included).
SP2.4.4.2.0007	F	ecoStrategic Model	Capable of modeling traffic control systems	See SP2.4.4.2.0006.
SP2.4.4.2.0008	F	ecoStrategic Model	eStraM needs to be fast enough to update network views for regional/urban networks every X minutes	The runtime of eStram for a 15 minute interval when run on "*Intel(R) Core(TM)i7-2760QM CPU-2.40Ghz" is* around 2 minutes.
SP2.4.4.2.0009	F	ecoStrategic Model	eStraM needs to fuse different datasources to deliver accurate O.D. estimates (data fusion module), provided these sources are made available	The current version of eStraM only uses loop detector data. All the detector data have been successfully aggregated to serve as input for the OD estimation (see test case 1 for further information).
SP2.4.4.2.0010	F	ecoStrategic Model	eStraM can be installed on a test site	The modules of eStraM are currently deployed and can be run on different machines.

SP2.4.4.2.0011	P	ecoStrategic Model	eStraM can run online	This requirement has not been met, due to data collection and processing problems which took much time to resolve. Most elements are in place for online running though, so the additional effort needed is not large.
SP2.4.4.2.0025	F	ecoStrategic Model	The Multi Criteria Routing Module should be able to compute an ideal traffic state in which traffic is distributed ideally over the network with regard to emissions.	See test case 5.

F = Functional; P = Performance

2.5.2 Helmond test case 1: Data collection and processing

Covers SP2.4.4.2.0009

Traffic data from loop detectors at the intersections shown in Figure 21 was collected by a server from Imtech Traffic & Infra and delivered to the server of TNO. Tools were developed to acquire and aggregate in 5minutes interval, and adjust the data according to the format required by the Dynasmart simulation model. The collected loop data was matched through a lookup table prepared in an excel sheet, and a Java program was developed to aggregate and match the recorded detector data to the appropriate link flows. The recorded traffic count measurements from the detectors were analyzed and checked for realistic values. The analysis showed most of the traffic count data in the final dataset (used for verification and validation) to be realistic and representative of actual traffic conditions. Additionally, manual checkups were done at a few intersections to identify if there are any mismatches between the raw and the processed data, and the results indicated that the look-up table, link matching to the Dynasmart simulation model and the algorithm processing the data are working as specified. It should be noted that it took a long time before all detectors were providing data reliably to the server. The problems had to do with accessing the traffic data , transferring it to a server on which eStraM was working, and processing it so it could be used in eStraM. Extensive programming was needed to make sure that the right data were extracted for the right locations in the network that was used in eStraM, and that time stamps were matching properly. During the course of the project, there were also some changes in the format of the data coming in which meant more programming was needed. Then, when data collection was underway, there were missing data for some intersections, which took some time to discover and correct because we checked a sample soon after data collection started and that sample contained all required data. Eventually, all the extra work needed led to time and budget constraints, which meant that the final dataset was smaller than was hoped for. Since similar problems have occurred elsewhere (in and outside the eCoMove project), this seems to be an implementation issue that should be taken into account for any (future) field implementation using (urban) traffic data.

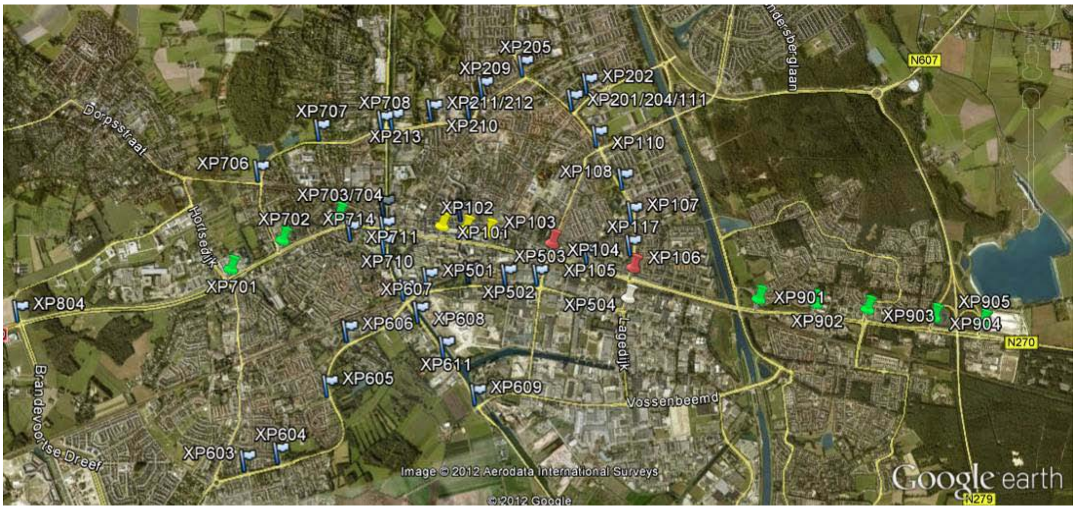


Figure 21 - Intersections with available loop detector data at Helmond

2.5.3 Helmond test case 2: Traffic State Estimation and Prediction

Covers SP2.4.4.2.0002, SP2.4.4.2.0008

The Traffic state estimation module works by estimating the OD-matrix from the most recent processed observed link flows using a tool prepared for this purpose. An iterative process is subsequently performed to develop a calibrated simulation model. The traffic prediction works by taking the most recent traffic state estimation, and patterns in historical data. Prediction captures thus both real-time observation trend and historical pattern and self-calibrates using prior knowledge (calibration of a previous time-step) when the time moves ahead. Then the predicted OD is assigned to the network to obtain the resulting traffic state (prediction). For more information refer to [D2.10]. The objective of the traffic state estimation verification is to verify the consistency level between the estimated OD-matrix and the observed link traffic flow and the availability of data in all the links of the network at all-time slices.

The estimated link flows were compared to the observed link flows, the results showed that the mapping made from the loop counts to the simulation model showed no strange results, and realistic data was present for all time slices and all links of the network, although there seemed to be many missing values (this is not a problem for the ecoStrategic Model).

Another verification requirement for the traffic state prediction module is to observe how fast the prediction module runs (in view of future online use) and to make sure if the predicted traffic state is realistic as compared to the historical data. The computation time for the prediction module alone was less than 30 seconds, this gives enough time to predict for 15 minute time horizon and to apply appropriate traffic measures. Moreover the results obtained from the module were found out to be realistic, no strange results were observed.

2.5.4 Helmond test case 3: ecoEmission estimation module

The ecoEmission estimation model calculates the CO_2 emission values in gram/second or total amount of grams for each link in the network for a specified interval of time. A program which prepares the output of the simulation module for the emission calculations has been prepared in a java environment. All the modules that need to be run before the ecoEmission Estimation component can be run are shown in Figure 22, this figure also shows the connections between all the modules in the ecoStrategic model.

The verification requirement for this module is to observe how fast the ecoEstimation module runs and check if the emission results are realistic. The verification indicates that the ecoEstimation Estimation component runs relatively slow when compared to the other modules. But the run time, which is on average around one minute for a two hour simulation (which is expected to be reduced to only 30 minutes in an online environment), is within the required time horizon to apply the required traffic measures (about 10 minutes). CO_2 emission results of the module are reasonable and no strange results were be observed.

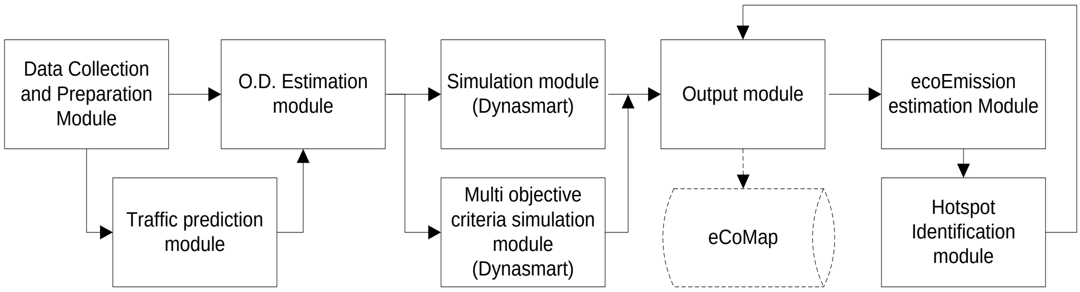


Figure 22 - Modular structure of the ecoStrategic Model

2.5.5 Helmond test case 4: Hot spot identification Module

Covers SP2.4.4.2.0004

The hotspot identification module finds locations in the network (road segments or intersections) where CO_2 emissions are higher than they could be (ideally). The Hotspots are identified by a percentage difference between the current/predicted situation and the average situation on the link under consideration, on that day and time of the week. Figure 23 shows an example of hotspots represented by red lines in the network at a specific interval.

The objective of verifying the Hotspot identification was to investigate if the hotspots identified by the module represent actual traffic induced hotspots, and to check if the hotspots identified could happen in reality.

The hotspots identification module proved to be identifying the CO_2 emission hotspots according to the requirements specified. Fine tuning was made to decide on the right percentages/levels of emissions at which a hotspot is identified. Rush hour traffic was the main reason for most of the hotspots identified, other than this hotspots were observed at roads joining the motorway, this was mainly caused by the longer queues waiting for the green light at the intersections.

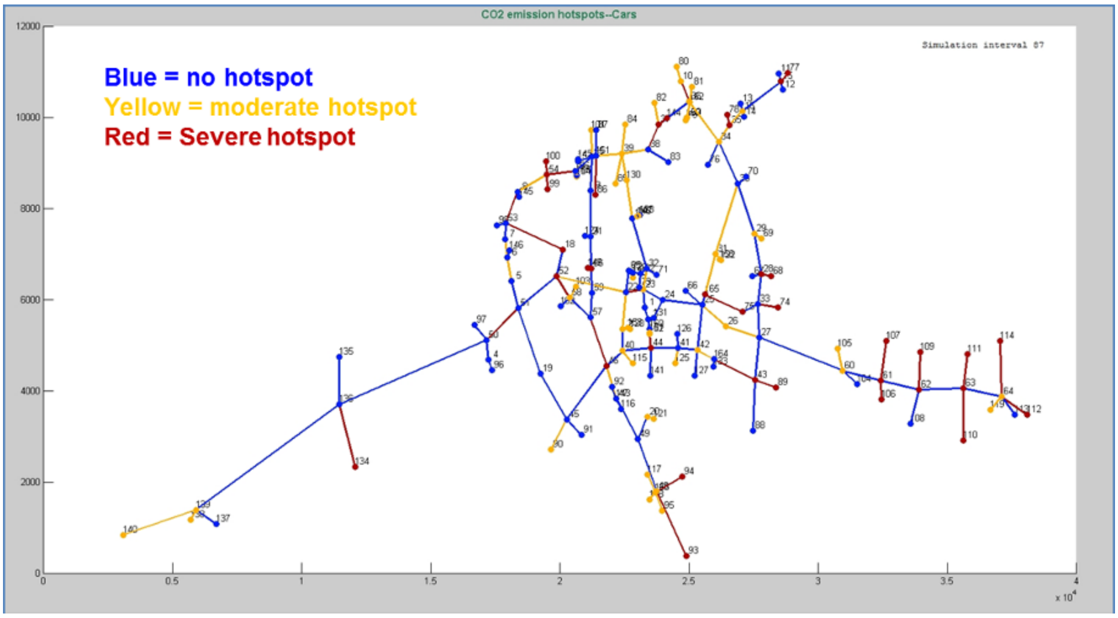


Figure 23 - Illustration of hotspots in the Helmond network

2.5.6 Helmond test case 5: Calculating the Desired State

Cover SP2.4.4.2.0025

The Desired State Module was built to be able to compute an "ideal" or desired traffic state in which traffic is distributed ideally over the network with regard to emissions. For each prediction horizon, we assign the predicted OD matrix to the network and obtain the predicted traffic state. We then introduce the traffic emission into the routing cost component and iterate to ensure that the perceived (input) cost (with travel time and emission) is the same as experienced, which means that no further improvement in travel/routing could further be achieved. This is what we call the Desired State.
For each time stamp (say 7:15, 7:20, etc.), we obtain several Key Performance Index/KPI, such as Travel Time, Emission and Trip Complete Rate. And we plot these KPI along the time stamps (say from 7:15 till 9:00), to be able to observe how the Optimal State evolves following the time. The Desired State Module works as designed and provides the required KPI for each time slice it was run for.

2.6 Verification overview for: Driver Info Support and Driver Dialogue Manager

The Driver Info Support and Driver Dialogue Manager (in the following named as ecoATS) support drivers and service providers to choose or calculate an optimal route based on latest information from traffic management as traffic state and prediction, information on events or road works and route recommendations as part of the strategic traffic management.

The goal of this verification tests is to assess that the Info Support and Driver Dialogue Manager are working as described in Deliverable 5.6. Specifically the tests are aimed at the following requirements.

Table 5 – Requirements ecoATS and verification approach

REQ NR.	Description	Verification approach
SP5-14-0084	The infrastructure system provides traffic (and signal) states to the vehicles	See SP5-14-0087 and SP5-14-0088 for traffic state.
SP5-14-0085	The infrastructure (traffic operator) provides forecast information to the vehicles and other service provider	See SP5-14-0087 and SP5-14-0088
SP5-14-0086	The infrastructure (traffic operator) should provide tailored information to the vehicles	See SP5-14-0093
SP5-14-0087	ecoTraffic State can be converted to ecoMessages (TPEG-TFP)	Verification Compare logs from ecoMap showing traffic state with TPEG TFP
SP5-14-0088	ecoTraffic forecast can be converted to ecoMessages (TPEG-TFP)	Verification Compare logs from ecoMap showing traffic state forecast with TPEG TFP
SP5-14-0089	ecoStrategies can be converted to ecoMessages (TPEG-TEC, detour recommendation)	Verification Visual analysis. Comparing Strategy editor with TPEG TEC message
SP5-14-0092	The infrastructure system provides ecoMessages (TPEG-TEC, TPEG-TFP) to the vehicles and fleet operators or navigation service providers.	Verification Show existing interface to ecoATS and messages provided on request
SP5-14-0093	The vehicle and fleet operators or navigation service providers can request tailored information (TPEG-TEC, TPEG-TFP) from the infrastructure system	Verification Show existing interface to ecoATS and messages provided on request
SP5-14-0094	The location reference of the information provided by the infrastructure system is map independent, unambiguous and accurate regarding the position	Verification Visual analysis of AGORA-C and OpenLR locations
SP5-14-0096	ecoMessages are map independently referenced	Verification Show TPEG message in XML format using location references AGORA-C and OpenLR

All verification tests are made based on basic functionalities of the ecoATS system.

2.6.1 *Verification Test Case 1: request handling*

2.6.1.1 Test inputs:

The following table describes relevant inputs (parameter) for the request of traffic information from the ecoATS service.

Table 6 – Input parameter for ecoATS

Parameter	**Description**	**Domain**
Protocol format	Message format (binary or XML)	TPEGML, TPEGBIN
Information type	Type of the requested information	TEC, TFP
Location reference type	Type of the requested location reference method	OpenLR, AgoraC
Location	Current position (WGS84)	Longitude, Latitude
Relevance area	Radius around current position	[0 .. 9999] km

2.6.1.2 Evaluation criteria:

The verification of this test case consists of the following:

- The logging information confirms that the incoming request has been interpreted correctly and triggered the appropriate functions.

2.6.1.3 Evaluation:

The verification test was performed using a standard web browser offering a developer tool for interacting with ecoATS that supports sending HTTP requests, setting the entity body, and content type.

The following two figures show the initialisation request to the ecoATS service where the client is setting its preferences with regards to (a) protocol format (marked in green), (b) location referencing (marked in red), (c) information type (marked in blue), the size of the relevance area (marked in lavender) shown in Figure 24 - post init request to ecoATS service and position (marked in magenta) shown in Figure 25 - post get message request to ecoATS service.

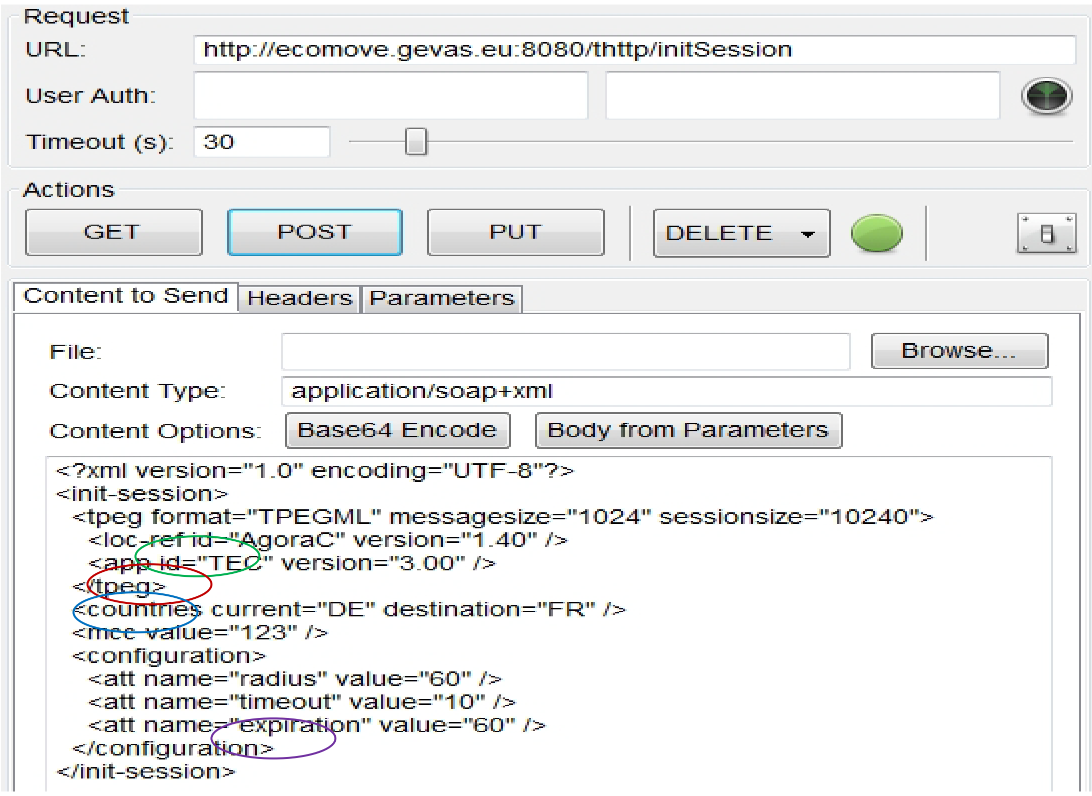


Figure 24 - post init request to ecoATS service

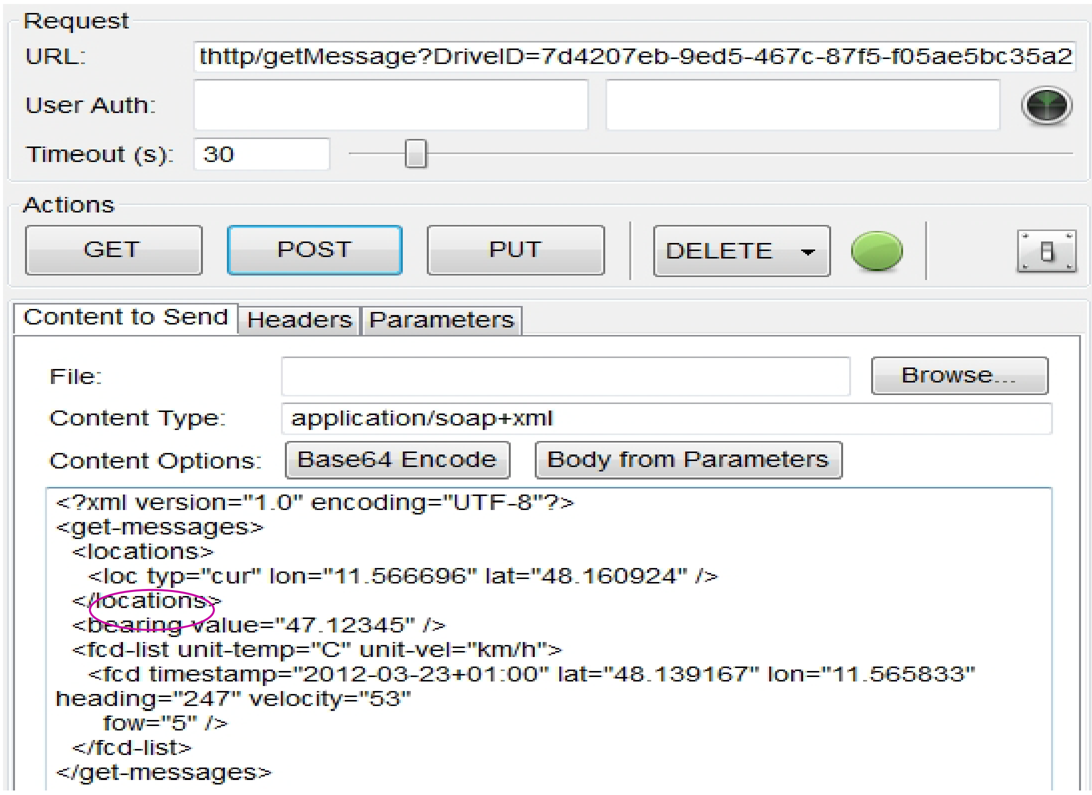


Figure 25 - post get message request to ecoATS service

Looking at the response of the ecoATS service it can be seen, that the parameters are interpreted as defined. The application data returned is marked in blue and the method used for location referencing is marked in red.

Status: 200 OK


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?><ns1:TpegMLDocument
xmlns:ns1="http://www.tisa.org/TPEG/TpegMLDocument_3_0"
xmlns:ns2="http://www.tisa.org/TPEG/AbstractDataTypes_3_0"
xmlns:ns3="http://www.tisa.org/TPEG/MessageManagementContainer_3_0"
xmlns:ns4="http://www.tisa.org/TPEG/TrafficEventCompact_3_0"
xmlns:ns5="http://www.tisa.org/TPEG/LocationReferencingContainer_3_0"
xmlns:ns6="http://www.tisa.org/TPEG/ParkingInformation_3_0"
xmlns:ns7="http://www.tisa.org/TPEG/TrafficFlowAndPrediction_3_0"
xmlns:ns8="http://www.tisa.org/TPEG/ServiceAndNetworkInformation_3_0"
ns1:timeStamp="2013-07-29T11:37:48Z" ns1:version="0" ns1:docType="fullRepository">
<ns1:TransportFrame xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:type="ns1:ServiceFrameML"><ns1:EncryptionIndicator>0</ns1:EncryptionIndicator>
<ns1:ServiceComponent xsi:type="ns1:ServiceComponentML">
<ns1:ServiceComponentIdentifier ns1:minorVersion="0"
ns1:majorVersion="3">1</ns1:ServiceComponentIdentifier><ns1:ApplicationRootMessage>
<ns1:ApplicationRootMessageML xsi:type="ns4:TECMessage"><ns4:mmt>
<ns3:messageID>53942341</ns3:messageID><ns3:versionID>1</ns3:versionID>
<ns3:messageExpiryTime>2099-12-31T11:00:00Z</ns3:messageExpiryTime>
<ns3:cancelFlag>false</ns3:cancelFlag></ns4:mmt><ns4:event><ns4:effectCode
ns4:table="tec001_EffectCode" ns4:code="6"/>
<ns4:startTime>2013-07-24T09:04:05Z</ns4:startTime>
<ns4:stopTime>2099-12-31T11:00:00Z</ns4:stopTime><ns4:cause
xsi:type="ns4:DirectCause"><ns4:mainCause ns4:table="tec002_CauseCode"
ns4:code="1"/><ns4:warningLevel ns4:table="tec003_WarningLevel" ns4:code="2"/>
<ns4:unverifiedInformation>false</ns4:unverifiedInformation></ns4:cause></ns4:event>
<ns4:loc><ns5:method xsi:type="ns5:AgoraCLocationReference">
<ns5:Version>3.0</ns5:Version>
<ns5:LocationReference>ASkBMAAlAiAGBBYVxCwiQPgIM5PeCAepQAECBURhY2hhBAgH0QwR5+AgMA==
</ns5:LocationReference></ns5:method></ns4:loc></ns1:ApplicationRootMessageML>
</ns1:ApplicationRootMessage><ns1:ApplicationRootMessage>
<ns1:ApplicationRootMessageML xsi:type="ns4:TECMessage"><ns4:mmt>
<ns3:messageID>53943407</ns3:messageID><ns3:versionID>2</ns3:versionID>
<ns3:messageExpiryTime>2099-12-31T11:00:00Z</ns3:messageExpiryTime>
<ns3:cancelFlag>false</ns3:cancelFlag></ns4:mmt><ns4:event><ns4:effectCode
```


Figure 26 - get messages response from ecoATS service

The verification test case was performed with all allowed combinations of parameter settings. For the evaluation of the correct interpretation of messages in a binary format the commercially available tool TPEG Analyser from Bayerische Medien Technik GmbH was used.

All tests were performed successfully. The ecoATS service is able to handle incoming requests for traffic information in time and according to the given requirements. Nevertheless some minor drawbacks were identified:

(a) A circle might be not the smartest way to describe the area of interest. It might include a lot of irrelevant information such as traffic events which are upstream of the vehicles route. An oval or even a corridor around a proposed route seems to be more appropriate.

(b) The response time of the service takes up to five seconds for a the initial data request the succeeding request are handled within a second.

(c) The performance – handling many data requests in parallel – of ecoATS service was not tested explicitly. During verification tests were realized with a maximum of ten requesting clients in parallel.

2.6.2 Verification Test Case 2: ecoMap synchronisation

During the implementation of the ecoATS system we did change the architecture a little. In the original plan we decoupled the ecoMap holding the traffic information from the traffic information database (TMDB) as data source for the ecoATS service. This implementation would allow the integration of various data sources for traffic information within the ecoATS system and give the ecoATS system full control on merging or prioritizing the different data sources. This was originally necessary as we had at least TomTom as a second data source for the ecoATS system in mind. With the decision, that TomTom would not provide traffic data for TS Munich we could simplify the system allowing direct access from the ecoATS system to the eCoMove CIS where amongst other components the ecoMap can be found. With this direct access to relevant traffic information as traffic state and prediction as well as traffic events stored within the ecoMap a verification for the ecoMap synchronization was obsolete.

2.6.3 Verification Test Case 3: location referencing

2.6.3.1 Test inputs:

The following test inputs are relevant:

- Information as e.g. geometry, road name, road class on road elements stored in map database of the ecoATS system
- Encoded location references either as AGORA-C or OpenLR

2.6.3.2 Evaluation criteria:

The verification of this test case consists of the following:

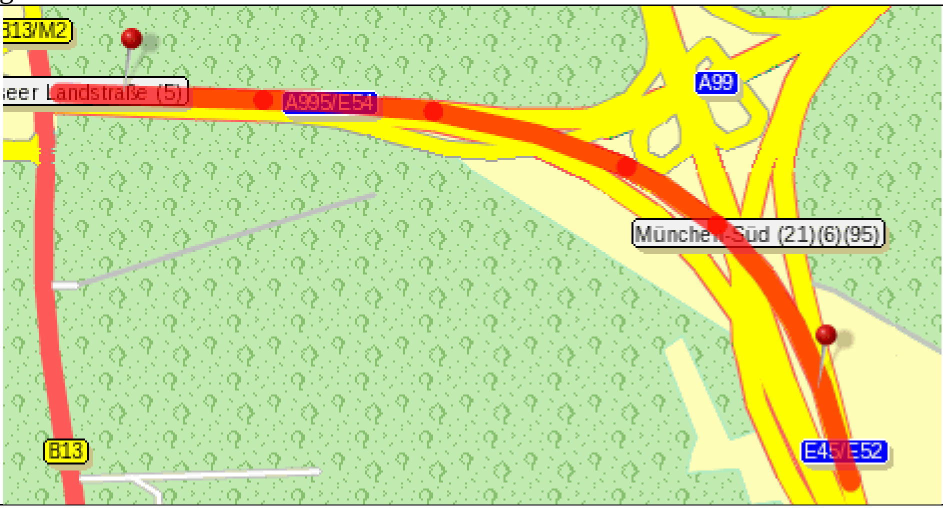
- Visual comparison of decoded location references

2.6.3.3 Evaluation:

The verification test were performed using tools which were able to decode location references provided as AGORA-C or OpenLR string and present the resulting locations in a map.

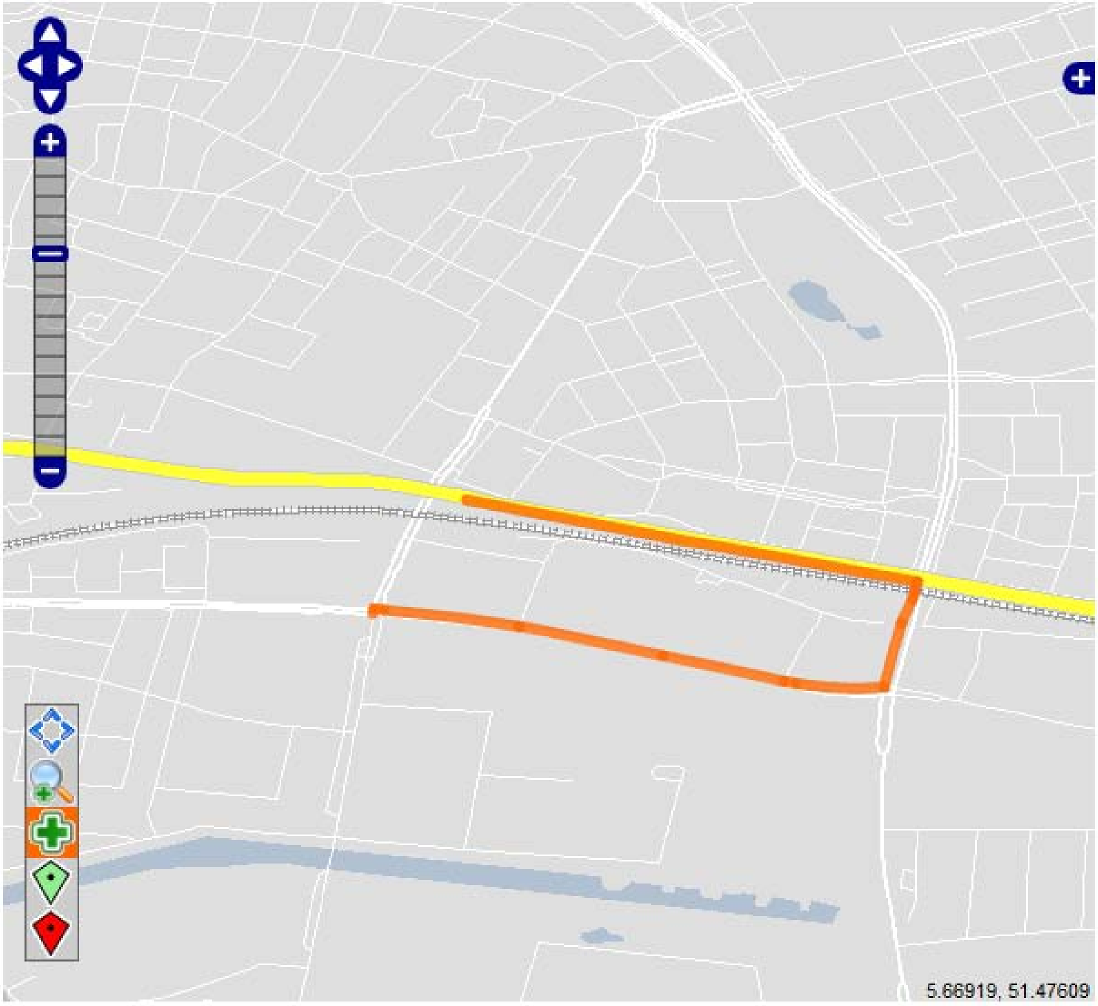
The following two tables show examples for AGORA-C and OpenLR.

Table 7 - Sample location in Bavaria (Intersection München Süd on highway A995) using AGORA-C as method for map independent location referencing.

Descriptor	Bavaria-3-3-1
Location description:	Munich, Bavaria, A995
Location coordinates:	48.02448, 11.65844 48.02709, 11.64839
AGORA code:	AVwBMABYAiAGBBcWhCwISy4iJYfsSBXNQAABAQVBdXRvYgQIB9EI3FPsWA0EBwbIQP9RAL0EERDITP4+AHnCSAPQQARBOTk1BAgH0QjuAcJIKAQKCYhM/wQAC8JgUA==
Decoding map:	

The fixing pins mark the start and end points of the original (encoded) location while the light red dots mark intermediate shape points used within the location reference. The red line highlights the result of the AGORA-C decoding.

Table 8 - Sample location in Helmond (N270, Lagedijk, Engelseweg) using OpenLR as method for map independent location referencing.

Descriptor	Helmond-1-1-7
Location description:	Helmond N270 / Lagedijk / Engelseweg
OpenLR code:	CwQILySa/hKJG/+P/x0iQAc=
Decoding map:	

Unfortunately the fixing pins marking the start (upper left with expected green pin) and end (lower left with expected red pin) points of the original (encoded) location are not shown within the drawing above. The light red dots mark intermediate shape points used within the location reference. The red line highlights the result of the OpenLR decoding.

It can be seen in the two examples that complex locations can be encoded and decoded correctly. As this verification test were conducted using random samples only we cannot guarantee a 100% match, but during our test we did not face errors and there were no issues mentioned by SP3. A reason for this successful verification is certainly, that the maps used are all based on standard products and thus do not deviate from each other regarding the topology of the network.

2.6.4 Verification Test Case 4: ecoMessage generation

The generation of ecoMessages is based on data available within the ecoMap. The generation of the following ecoMessages is triggered:

- TPEG-TEC ML
- TPEG-TEC Binary
- TPEG-TFP ML
- TPEG-TFP Binary

2.6.4.1 Evaluation criteria

The verification of this test case consists of the following:

- The structure of the message is according to the specification. All relevant information is provided correctly

2.6.4.2 Evaluation:

The verification tests were performed together with the tests described in 2.6.1. Neither looking at the syntax of the messages nor looking at the content of a message errors or inconsistencies could be identified. No inconsistencies were reported by SP3 as well.

2.6.5 Verification Test Case 5: ecoRoute Advice

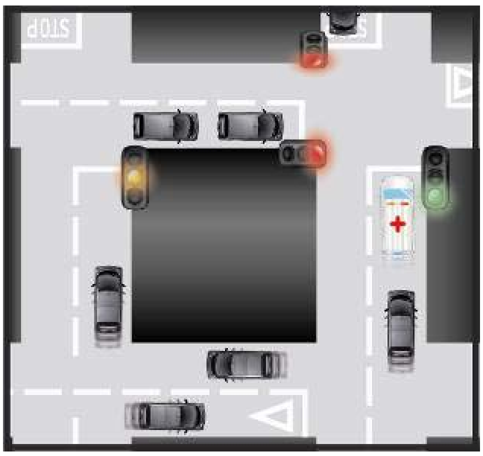
The connection of the ecoRoute Advice to the ecoATS system was not implemented. There was no vehicle available in TS Munich to request and interpret a route recommendation provided by a central service.

3 Field validation of applications and components

3.1 Validation Scenario 2.1 - Traffic Signal Control

The table below describe validation scenario 2.1. [for details see WD6.3.3].

Table 9 - Validation scenario 2.1 – Traffic signal control.

Scenario ID	VS_2_1
Name:	Traffic signal control
Description:	Several aspect related to traffic signal control are addressed: - Analyze the effects of dynamic green waves (i.e. coordination of traffic lights in combination with platoon shaping) on the performance of traffic light controlled corridors. - Analyze the effects of cooperative traffic light control on the performance of traffic light controlled intersections. - Analyze the effects of balanced priority for (groups of) vehicles on the performance of traffic light controlled intersections. - Analyze the effects of cooperative control and advice measures at metered motorway on-ramps.
Objective:	
Validation Categories:	Environment and Mobility
Applications covered:	ecoGreen Wave, ecoBalanced Priority, ecoApproach Advice, ecoRamp Metering
Cartoon:	

3.1.1 Test Case 2.1.2 - Traffic light control optimization

The table below describe test case 2.1.2 [for details see WD6.3.3].

Table 10 – Test case 2.1.2 – Traffic signal control optimization**Validation Test Case ID**	VS_2_1_TC_2
Validation Test Case Name	Traffic light control optimization
Belongs to Validation Scenario	Traffic Signal Control
Test case description	Traffic light control algorithm is implemented for a series of intersections and its performance is compared to a state-of-the-art algorithm while increasing the amount of information available. Besides, cooperative vehicle(s) approaches a controlled intersection and is treated with priority for green. Situation is made increasingly complex with priority vehicles from different direction and increasing market penetration.
Hypotheses	
Success Criteria	The average fuel consumption and CO2 emissions of priority vehicle(s) and network is reduced, while the delay times of others and the network do not increase disproportionately.
Minimum Set of Performance Indicators	ECOM-PI 101 Fuel consumption for a passenger car per trip ECOM-PI 103 Fuel consumption for a truck per trip ECOM-PI 107 Fuel consumption for all traffic in network ECOM-PI 201 Travel time individual OD ECOM-PI 202 Travel time of the network
Summary of Test Procedure(s)	Type of test: x field test □ driving simulator x traffic simulation. Data collection: x objective measurement subjective measurement Short summary of test setups (two sentences max):

Test Setups:	2.1.2.1 Balanced Proirity / TUM / Munich / Simulation 2.1.2.2 Traffic Light Control Optimization & Priority/ PEEK / Helmond / Field Test 2.1.2.3 Traffic light control optimization & Priority / PEEK / Helmond/ Simulation

This test case involves ecoBalanced Priority. 14 signalized intersections at the test site of Helmond were used. A connected truck drove the route 10 times with and 10 times without the application. The aim of the test case was to evaluate the effect of traffic light priority on driving behaviour and resulting fuel consumption.

3.1.1.1 Test Setup 2.1.2.2 - Traffic Light Control / Helmond / Field Test

The table below describe test case 2.1.2.2 [for details see WD6.3.3].

Table 11 – Test setup 2.1.2.2

Validation Test Setup ID	VS_2_1_TC_2_TS_2
Test Setup Name	Traffic Light Control Optimization & Priority/ PEEK / Helmond / Field Test
Method	Field Test
Location	Initially 3 intersections (number 101, 102 and 103). Later 14 traffic light controlled intersections on the N270.
Applications, components and core technologies (software) used	ecoBalancedPriority
Hardware description	Roadside units at the intersections and eCoMove vehicles
Experimental setup (incl. number of test runs and drivers)	Vehicles will drive the route 10 times with and 10 times without the application. The effect of the traffic light priority on driving behavior and resulting fuel consumption will be assessed in different conditions.

Test route or Network description (incl. Picture)	N270 from Eindhoven to Deurne. 
Baseline	Situation without the system.
Control Factors (they can be changed)	n/a
Situational Variables (are just there, but influence the outcome)	Traffic conditions, distance to stop line when the advice is received, actual speed advice, and the queue length at the intersection.
Sensors and data loggers	eCoMove datalogger

The effects on fuel consumption, travel time, number of stops and velocity profile are discussed below.

Table 12 – ecoBalanced Priority, fuel consumption of a vehicle [litres/100km]

Baseline/ Treatment	Mean	Standard deviation	Median	Percentile P25	Percentile P75	t-Test
Baseline	23.83	1.24	23.83	22.96	24.71	< 0.05
Treatment	20.21	0.76	20.40	19.84	20.62	

* t-Test: statistical significance at p <0.05 (95% confidence interval)

The table above and the figure below clearly show a reduction in fuel consumption. On average this reduction was 15.19% with statistical significance. This finding confirm the hypothesis that ecoBalanced Priority reduce fuel consumption.

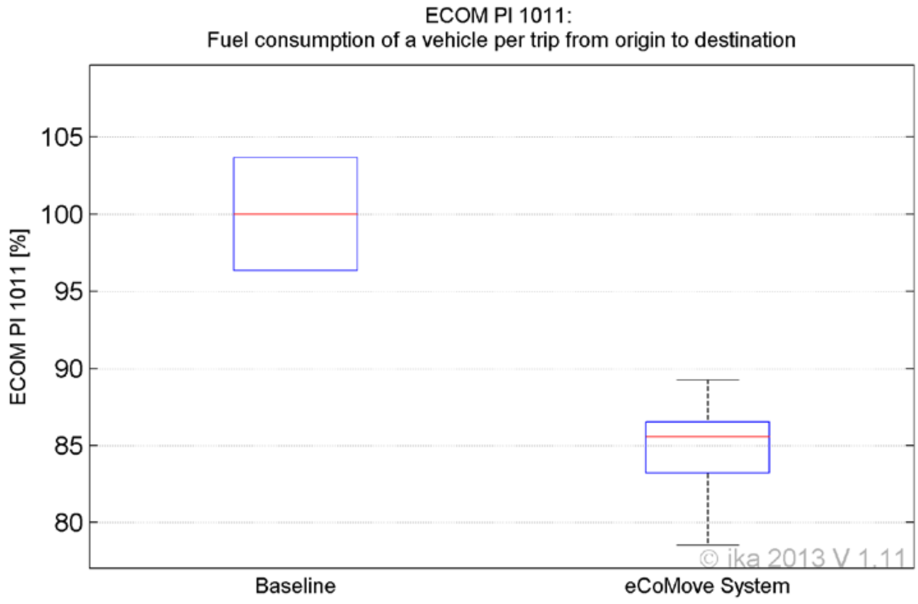


Figure 27 - ecoBalanced Priority, fuel consumption of a vehicle [litres/100km]

Table 13 – ecoBalanced Priority, total travel time of a vehicle [seconds]

Baseline/ Treatment	Mean	Standard deviation	Median	Percentile P25	Percentile P75	t-Test
Baseline	1554.33	223.85	1554.33	1396.05	1712.61	> 0.05
Treatment	1446.65	590.23	1648.60	1545.97	1716.21	

* t-Test: statistical significance at p <0.05 (95% confidence interval)

The table above and the figure below show that there was no statistically significant effect on the total travel time. This was unexpected. On average the reduction measured was 6.93%. As traffic lights turned to green earlier one would expect a reduction in travel time. This can only be explained by the large standard deviation which suggests that green priority was not equally successful in all runs and at all intersections. Local traffic conditions and the current phase of the traffic lights on arrival of the vehicle might be the reason for this. With a larger sample it is expected to find a statistically significant reduction in travel time as shown by the simulation results reported in [D5.10].

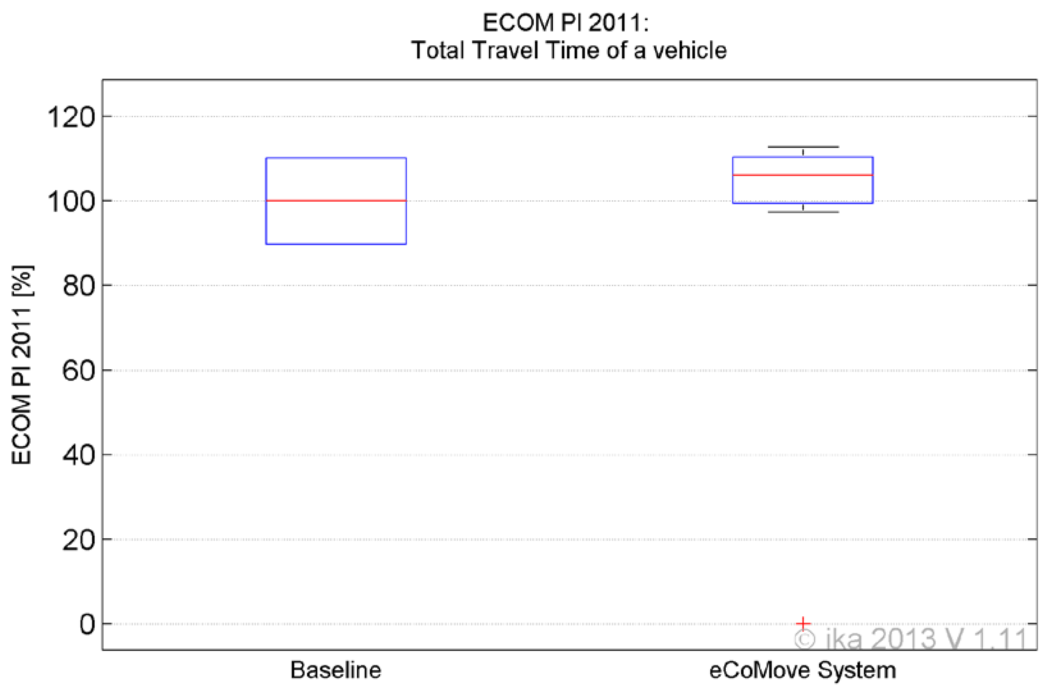


Figure 28 - ecoBalanced Priority, total travel time of a vehicle [seconds]

Table 14 – ecoBalanced Priority, number of stops [integer]

Baseline/ Treatment	Mean	Standard deviation	Median	Percentile P25	Percentile P75	t-Test
Baseline	12.50	0.71	12.50	12.00	13.00	> 0.05
Treatment	11.63	1.6	11.50	10.00	13.00	

* t-Test: statistical significance at p <0.05 (95% confidence interval)

The table above and figure below show that there was no statistically significant effect on the number of stops. This was unexpected. On average the reduction measured was 7%. Again the large standard deviation in the treatment stands out. The same arguments as mentioned for travel time apply.

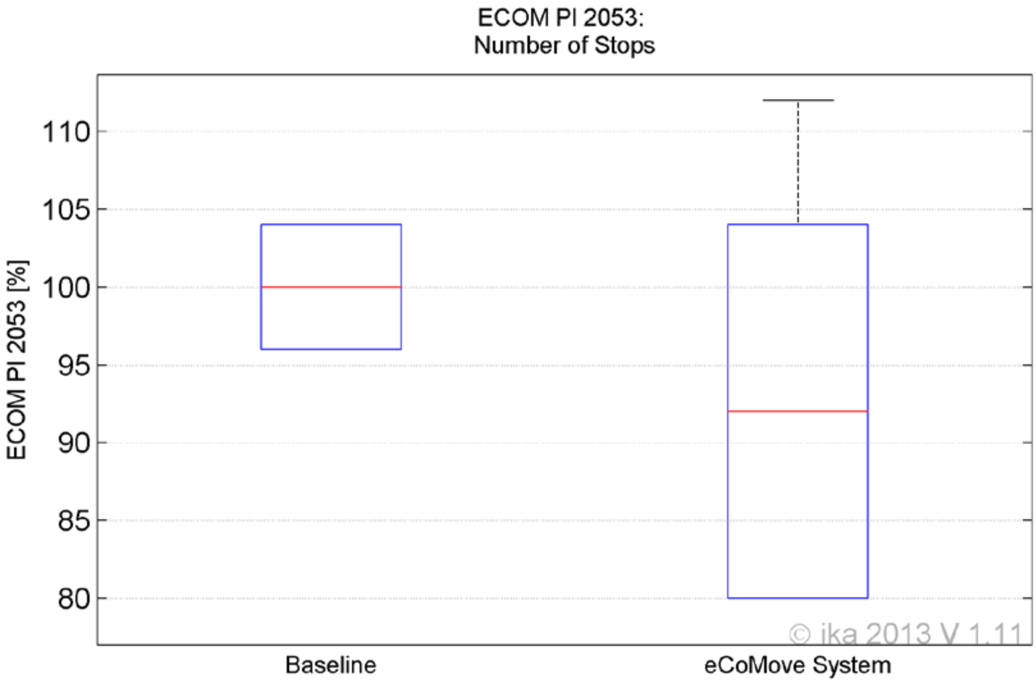


Figure 29 - ecoBalanced Priority, number of stops [integer]

Table 15 – ecoBalanced Priority, standard deviation of velocity [km/h]

Baseline/ Treatment	Mean	Standard deviation	Median	Percentile P25	Percentile P75	t-Test
Baseline	7.49	0.15	7.49	7.39	7.59	< 0.05
Treatment	6.04	0.20	6.00	5.89	6.20	

* t-Test: statistical significance at p <0.05 (95% confidence interval)

The table above and the figure below clearly show a reduction in the standard deviation of velocity. On average this reduction was 19.38% with statistical significance. This finding best explain the reduction in fuel consumption as a result of ecoBalanced Priority.

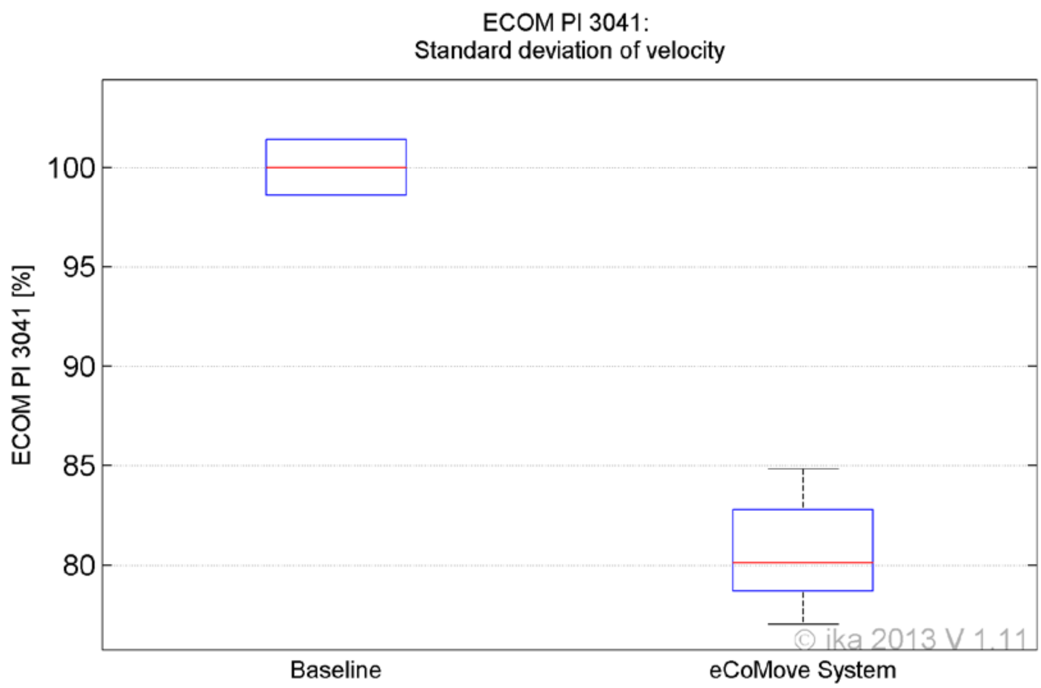


Figure 30 - ecoBalanced Priority, standard deviation of velocity [km/h]

Overall it can be concluded that ecoBalanced Priority reduced fuel consumption by approximately 15%, primarily by reducing the standard deviation of velocity. It seems that the earlier switch to green did not enable the vehicle to reduce travel time, but mainly helped the vehicle driver to smoothly pass the intersection.

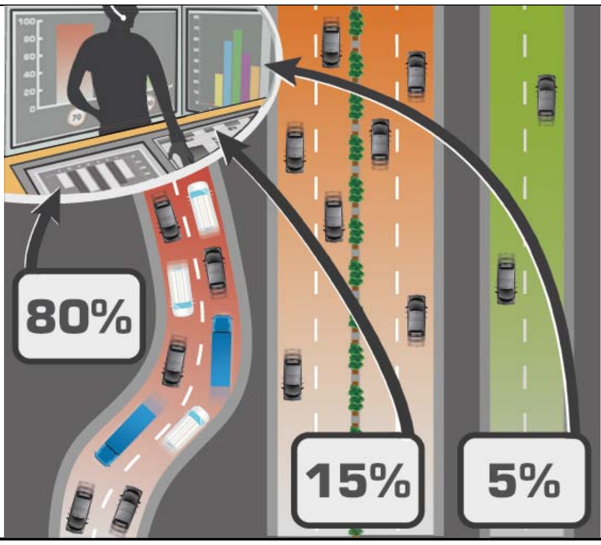
3.2 Validation Scenario 2.2 - Network Usage

3.2.1 Test Case 2.2.1 - State estimation, predication, optimization and distribution

The table below describe validation scenario 2.2. [for details see WD6.3.3].

Table 16 - Validation scenario 2.2 – Network Usage.

Scenario ID	VS 2.2
Name:	Network usage
Use Case Covered:	UC_SP5_2 Improve network usage
Description:	In this scenario, we look at traffic management and control from a network perspective. The network usage can be improved by knowing the state of traffic and fuel consumption/CO2 in the network and, in case of inefficiencies, trigger traffic management and control measures in such a way that fuel consumption and emissions are reduced overall (system optimum). The validation consists of checking whether this goal (of emission reduction) has been achieved, and what the consequences are for the travel times of the traffic in the network (individual and overall).
Objective:	Analyse the accuracy of actual, predicted and desired traffic states of the traffic network (i.e. flows, speeds and travel times), and analyse the effects of using traffic strategies derived from

	these states and translate them in uniform control targets.
Validation Categories:	Environmental and Mobility
Applications covered:	ecoNetwork State, ecoEmission Estimation and ecoTraffic Strategies.
Cartoon:	

The following test case was derived for validation scenario 2.2 and implemented in the field (see Table 14):

Table 17 - Validation test case 2.2.1

Validation Test Case ID	VS_2_2_TC_1
Validation Test Case Name	Network state estimation, optimization and distribution
Belongs to Validation Scenario	Network usage
Test case description	eStraM provides information about the current and predicted (15 minutes ahead) state of traffic and emissions on all links that are part of the test site network. eStraM also provides an optimised state, in which traffic has been redistributed over the network in order to reduce total CO2 emissions. What we test here is (1) whether the current and predicted states are accurate and (2) whether the optimised state has the potential to reduce CO2 emissions (that info can be used by route guidance applications).
Hypotheses	eStraM can calculate the current state of traffic accurately, and can also predict the state 15 minutes ahead in time accurately enough so that it is useful to other eCoMove applications.

	The total network CO2 emissions resulting from the optimised state provided eStraM are substantially lower than the total network CO2 emissions resulting from the non-optimised state (current/predicted).
Success Criteria	The accuracy of the current and future estimated network states is such that in the simulation environment on average the estimated and real (observed) LOS of 90% of the (observed) links are identical. There shall be three LOS levels: 1=free flow, 2=heavy traffic, 3=congestion The total fuel consumption of the vehicles in a congested road network is reduced on average by 5% by the eCoMove system.
Minimum Set of Performance Indicators	ECOM-PI-108 CO2 emissions of all traffic, in (part of) a network ECOM-PI-201 Travel time individual per OD Test case specific PI (not in eCoMove list): traffic flow (veh/h) for observed links in the network (per time period, e.g. of 5 minutes).
Summary of Test Procedure(s)	Type of test: x field test □ driving simulator x traffic simulation. Data collection: x objective measurement □ subjective measurement Short summary of test setups (two sentences max): Observed traffic flows are compared to calculated/predicted flows, and the total network CO2 emissions from optimised flows are compared to the total network CO2 emissions from non-optimised flows.
Test Set ups:	Test setup 2.2.1.1: eStraM/ MAT TRAFFIC/Munich/Field Test setup 2.2.1.2: State Estimation / MATT TRAFFIC /Munich/Simulation Test setup 2.2.1.3: State Estimation /TNO/ Helmond/ Field Test

3.2.1.1 Test Setup 2.2.1.1 - eStraM / Munich/ Field Test

The validation of the ecoNetwork Prediction in the real test sites Munich refers to the quality of the estimated current and eco-optimal traffic states. As is already stated in chapter 2, during the tests only dynamic data from 79 detectors (instead of the originally expected 869 detectors) have been available. Also vehicle generated data and dynamic signal group states were not available. As a consequence the functioning and accuracy of the ecoNetwork Prediction model was limited. The outcomes of the tests do not reflect the capabilities that would have been achievable in case of a better data basis. Another consequence is that it was not possible to test the model with any vehicle penetration rate.

The evaluation refers to (1) the traffic state estimation quality, and (2) the eco optimized traffic states.

Estimated current traffic states:

The validation of the estimated current traffic states is fully identical with the corresponding verification (see chapter 2.4.3.).

Eco-optimal traffic states:

The validation of eco-optimal traffic states has been performed by comparing the time dependent overall emission values of the network of the normal with the optimised traffic situation (both having different routing schemes). The overall emission values of the network are computed by using the macroscopic ecoEstimation Prediction component with an eco-optimal objective function.

Several tests has been executed and evaluated for different time points (5:00, 8:00, 12:00, 17:00) and days (Tuesday, Wednesday and Friday). The time points 5:00 and 12:00 represent off-peak traffic situations whereas 8:00 and 17:00 stand for AM- and PM-peak situations. The results are listed below.

time	**day of week**	**% emission reduction**
05:00	Tuesday	0.44
	Wednesday	2.10
	Friday	2.22
08:00	Tuesday	1.19
	Wednesday	2.74
	Friday	3.27
12:00	Tuesday	3.23
	Wednesday	3.01
	Friday	2.72
17:00	Tuesday	2.87
	Wednesday	2.64
	Friday	2.05
	Avg.	**2.37**
	Std.dev.	**0.845117887**

time	**day of week**	**% emission reduction**
05:00	Tuesday	0.44
	Wednesday	2.10
	Friday	2.22
08:00	Tuesday	1.19
	Wednesday	2.74
	Friday	3.27
12:00	Tuesday	3.23
	Wednesday	3.01
	Friday	2.72
17:00	Tuesday	2.87
	Wednesday	2.64
	Friday	2.05
	Avg.	**2.37**
	Std.dev.	**0.845117887**

Table 18 - The overall emission reduction and travel time results over several time points. The difference is applied over the real and optimised traffic states.

The results are also visualised in diagram form below.

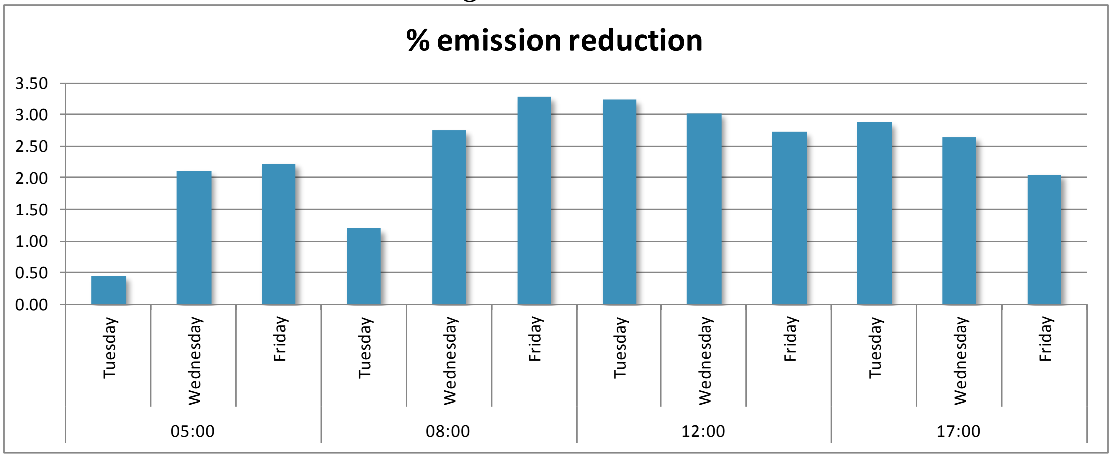


Figure 31 - This diagram shows the emission reduction rates (in %) for several days and times.

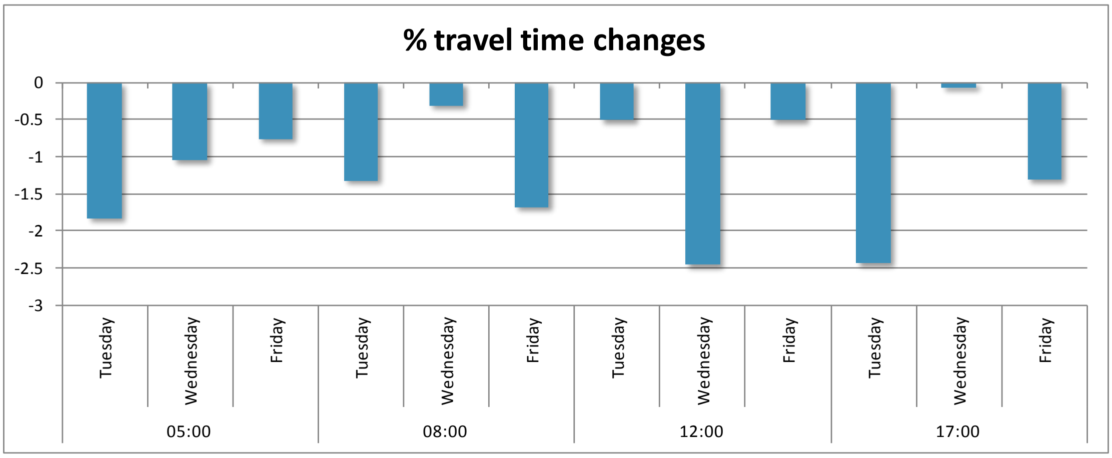


Figure 32 - This diagram shows the travel time change rates (in %) for several days and times (values > 0 means the travel time is longer than before).

Furthermore, an evaluation per origin-destination-relationship has been performed. The table and diagram below show the results in terms of average emission reduction and average changes of travel time.

o-d-relation	% emission reduction	% traveltime reduction	o-d-relation	% emission reduction	% traveltime reduction	o-d-relation	% emission reduction	% traveltime reduction	o-d-relation	% emission reduction	% traveltime reduction
1	3.89	-0.96	23	1.07	-1.46	45	3.64	-1.6	67	2.26	-1.46
2	2.27	-0.39	24	1.58	-2.12	46	0	0	68	0	0
3	4.22	-2.3	25	4.18	-0.65	47	0	0	69	0	0
4	2.12	-0.02	26	4.01	-0.18	48	3.59	-0.41	70	0	0
5	0	0	27	0	0	49	0.85	-0.15	71	2.58	-0.22
6	2.25	0.03	28	0	0	50	1.81	-1.87	72	0	0
7	3.42	-0.64	29	4.9	-1.47	51	4.99	-1.06	73	2.14	-1.08
8	0	0	30	0.53	-1.37	52	0	0	74	0	0
9	3.71	-0.63	31	2.2	-1.67	53	1.76	-2.32	75	3.89	-2.3
10	1.12	-0.33	32	3.2	-1.22	54	5.27	-1.61	76	3.12	0.12
11	4.56	-2.01	33	4.52	-0.33	55	0.95	-2.36	77	5.85	-0.57
12	2.91	-0.97	34	3.35	-0.56	56	1.57	-1.93	78	3.54	-1.86
13	0	-0.75	35	3.47	-2.14	57	0	0	79	0	0
14	5.35	-2.26	36	2.72	-1.14	58	3.67	-2	80	0	0
15	2.28	-0.24	37	0	0	59	1.75	-0.92	81	3.76	-0.34
16	0	0	38	4.31	-0.58	60	3.81	-2.3	82	3.28	-1.1
17	4.82	-2.5	39	2.89	-1.1	61	2.73	-1.34	83	4.2	-0.27
18	2.38	-0.34	40	0	-0.04	62	4.04	-1.16	84	3.5	0.05
19	3.05	-1.41	41	4.81	-0.16	63	2.25	-1.84	85	0	0
20	0	0	42	4.2	-2.22	64	3.89	-2.09	86	4.38	-1.43
21	0.98	-0.84	43	3.69	-1.77	65	3.3	-1.83			
22	1	-1.25	44	1.07	-0.53	66	4.38	-2.06			

Table 19 - The averaged overall emission reduction and travel time results for 86 OD-relations of the network. The difference is applied over the real and optimised traffic states.

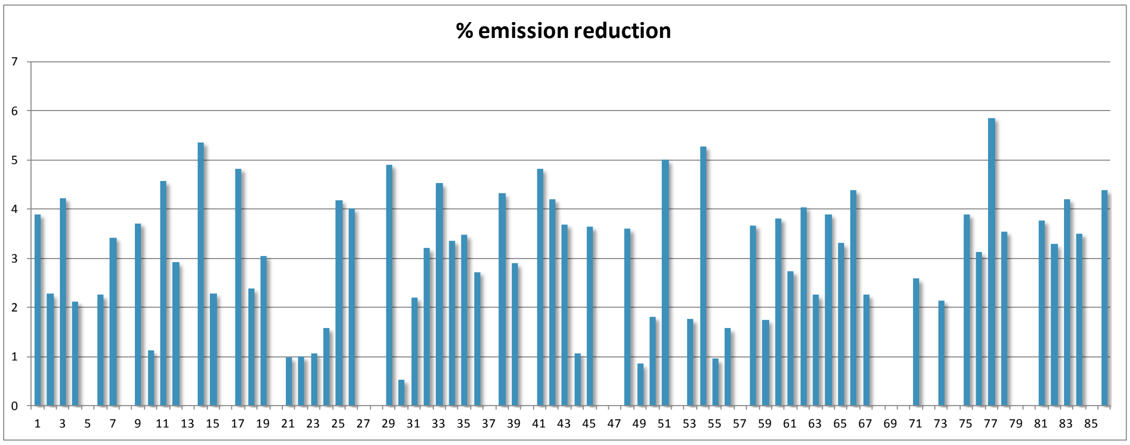


Figure 33 - The average of emission reduction over all times and days per OD-relation in diagram form.

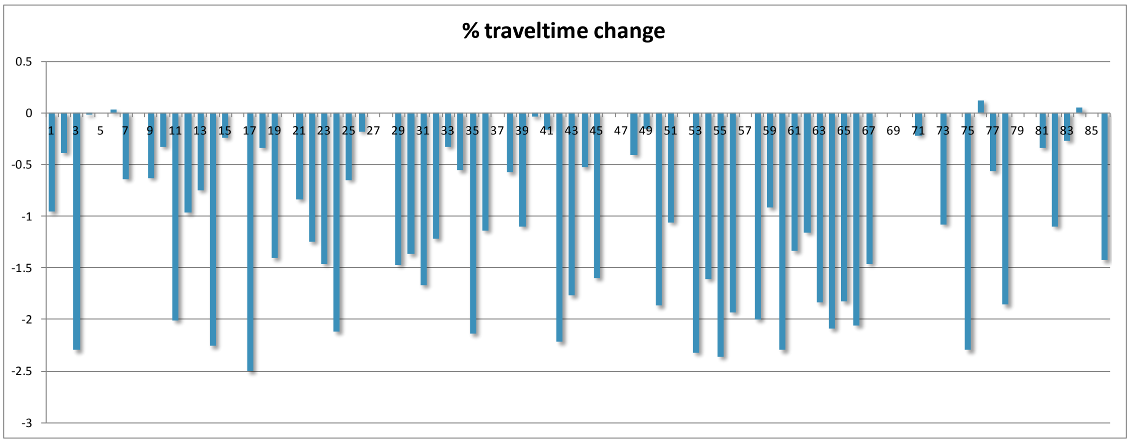


Figure 34 - The average of travel time changes over all times and days per OD-relation in diagram form.

<u>Summary:</u>

The effect of eco-optimised routing schemes on the overall emission of the network is rather small (only about 2.4 %). The reason for this is the fact that the model could only work with a small number of traffic detectors and without vehicle generated data (see also the notes in chapter 2.4.1 referring to this lack of data). With such a data basis it is hard for the model to estimate the real traffic states in the test site Munich. In the eCoMove simulation environment the data basis is much more complete. It is expected that there the results are more significant and meaningful.

3.2.1.2 Test Setup 2.2.1.3 - eStraM / Helmond/ Field Test

Table 17 contains the general test set-up for the field test with the ecoStrategic Model in Helmond.

Table 20 - Validation test set-up VS_2_2_TC_1_TS_3 - State Estimation / TNO / Helmond / Field Test

Validation Test Setup ID	VS_2_2_TC_1_TS_3
Test Setup Name	State Estimation / TNO / Helmond / Field Test
Responsible	TNO
Participant partners	TNO, Peek
Method	Field Test
Location	Helmond
Applications, components and core technologies (software) used	ecoStrategic Model, ecoEmission Estimation and Prediction
Hardware description	Peek server provides count data from loop detectors. TNO server receives these and runs eStraM.

Experimental setup (incl. number of test runs and drivers)	Procedure 1) eStraM will be run (in combination with the ecoEmission Estimation component) for a period of time (e.g. the morning peak hour). It will produce traffic states (current and predicted). The predicted states (up to 15 minutes ahead, time slices of 5 minutes) can be checked against the observed states for those locations that are equipped with detectors, or for certain routes on which equipped vehicles travel. This can be done for all time slices and/or for all test drives on the selected routes. The objective is to analyse how close the predicted states are to observed states for that time slice. In terms of number of test runs: we expect to analyse least two weeks of data (a peak period of 2 hours generates 24 five minute slices for all links in the network, of which a certain share also produces observed values). Procedure 2) eStraM will also produce desired states, i.e. predicted, theoretical states in which the traffic is assigned in a more energy efficient way. For each time slice, the total CO2 emissions of the desired state can be compared to the total CO2 emissions of the predicted state. The objective is to analyse by how much the CO2 emissions are reduced (in %, for the total network).
Test route or Network description (incl. Picture)	There was no opportunity to synchronise the running of the ecoStrategic Model with the runs done by eCoMove test vehicles.
Baseline	There are different baselines for procedures 1 and 2: *Procedure 1: the baseline is the observed state (flows, speeds, travel times) on selected links for each time slice.* *Procedure 2: The baseline is the total CO2 emissions in the network (current state).*
Control Factors (they can be changed)	See table below
Situational Variables (are just there, but influence the outcome)	Unfortunately, we had no data on situational variables (such as large incidents, large events, large road works, very bad weather conditions).
Performance Indicators	Flows (number of vehicles on a link, per 5 minute time slice); total network travel time (s - ECOM-PI-202), total network CO2 emissions (kg - ECOM-PI-108)
Measurements	The ecoStrategic Model uses observations from loop detectors (flows, speeds) We did not use data from cameras or vehicles. It was investigated whether such data could be obtained to enhance the loop data set, but this was not feasible within this project.
Sensors and data loggers	Loop detectors. In future perhaps license plate cameras and data from vehicles.

Table 18 shows the specific test set-ups that were planned for the ecoStrategic Model implementation in Helmond, reflecting different traffic conditions and penetration rates of equipped vehicles. In practice, however, an initial OD-matrix was only available for the morning peak period, and market penetration on the road is currently 0%, so validation was only carried out for test set-up TS 2.2.1.3a.

Table 21 - Specific test set-ups for the ecoStrategic Model (X = carried out, X = not carried out)

Test Setup	Traffic demand		Market penetration	
	AM Peak or PM Peak	Off Peak	0%	< 5%
TS 2.2.1.3a	X		X	
TS 2.2.1.3b	X			X
TS 2.2.1.3c		X	X	
TS 2.2.1.3d		X		X

3.2.1.2.1 Results of the validation of eStraM field implementation in Helmond

Procedure 1 – Predicted vs. observed states

Data have been processed for 9 days (weekdays and weekend) days from 10-06-2013 to 18-06-2013. Predicted and observed flows for a time slice were compared (for the observed links in the network and all time slices in the morning peak period in that period).

It should be noted that the prediction worked with a very limited historical data set, so there were no high expectations for the accuracy of the predictions. This validation procedure has still been carried out to show it is possible to obtain predictions that are useful (also for the calculation of the desired state, which takes the predicted state as a starting point). The results do not, however, give definitive insight into how accurate such prediction can be in the Helmond implementation.

A first check was done to see if predictions were given for the various links and time slices and to see if the patterns emerging matched visually. Figure 35 shows this for a selection of observations and predictions. Although the patterns are not completely matching, they do show the same trends.

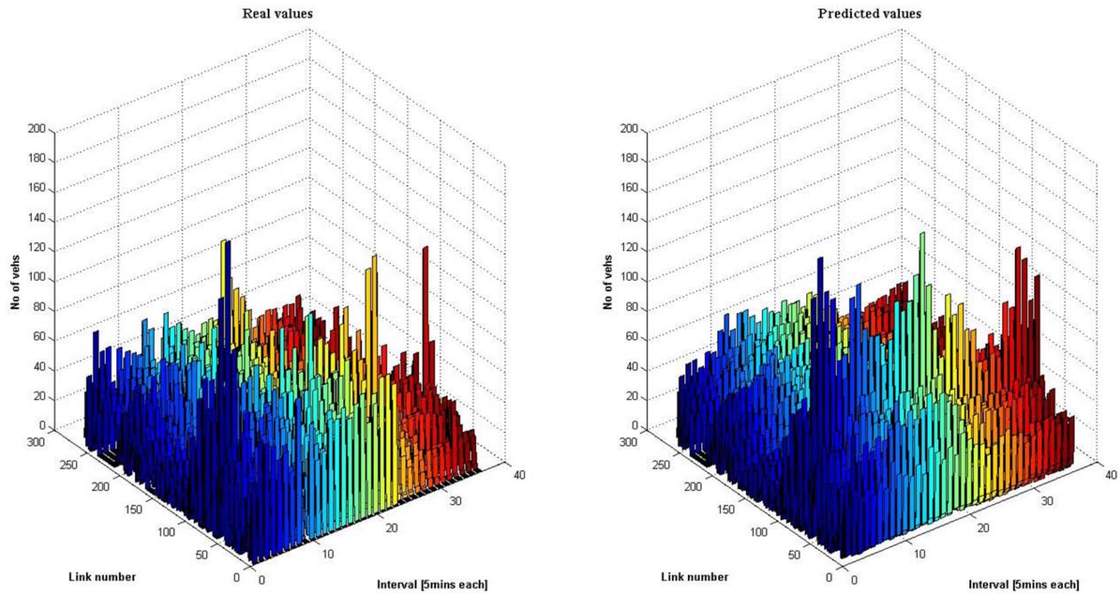


Figure 35 - Graphical representation (example) of comparison between real (observed) and predicted values.

The next step was to check what the absolute difference was between the predicted and real count values (see Table 19).

Table 22 - Difference between observed and predicted values.

Data set	Absolute mean difference	Standard deviation
all observations	4.99	8.69
observations > 34 vehicles (links with 'busy' traffic)	13.1	15.77

This shows that the predictions get relatively more accurate at higher link counts, which are the more important situations from the point of view of the ecoStrategic Model (as hotpots are often related to heavy use of certain links in the network).

Percentage-wise, the differences between observed and predicted values are usually within an acceptable range (plus or minus 15 %) but can in some cases get quite large (see Figure 36). This is especially the case at low count values (a difference between a flow of 2 or 5 vehicles will lead to a large difference percentage-wise), although in that case it has no consequences for hotspot identification, as low counts will invariably result in a 'no hotspot' categorisation. It is hoped that the differences will go down as more historical data, and situational variables such as the occurrence of incidents, will become available for inclusion in the model.

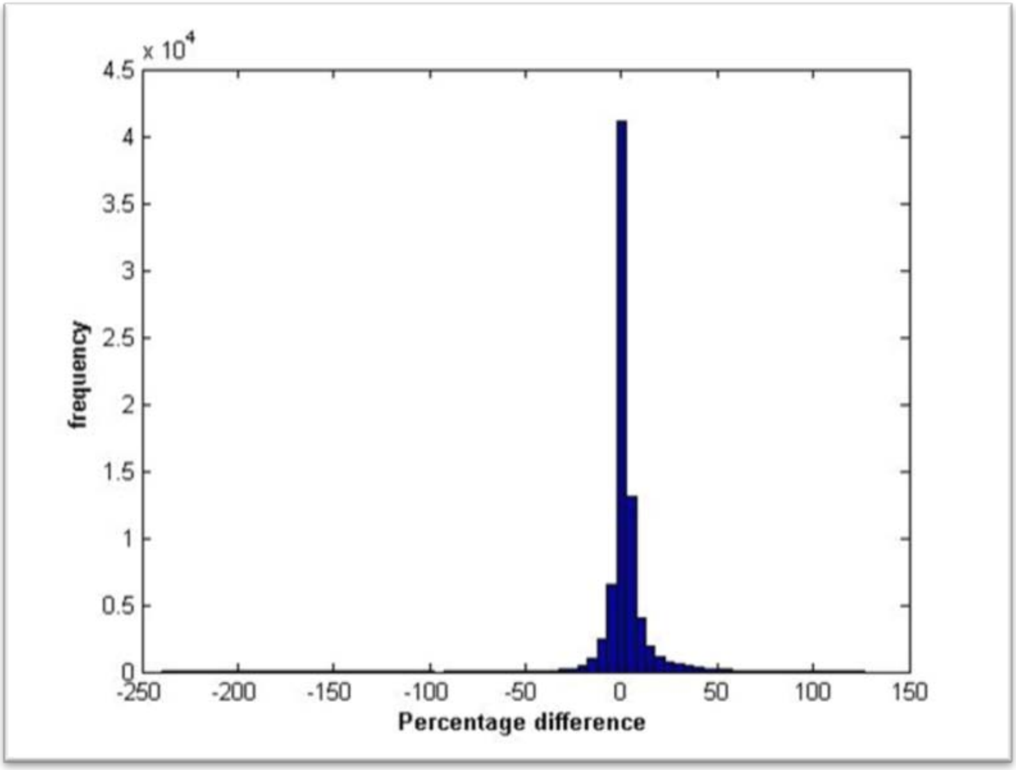


Figure 36 - Histogram of percentage difference between real (observed) and predicted link flow values.

Another option is to increase the length of the time slices (e.g. from 5 to 10 minutes) as Figure 37 shows that most observations are of quite low flow count values. Finally, longer piloting of the data collection and processing module is likely to result in fewer missing observations which should also increase overall accuracy.

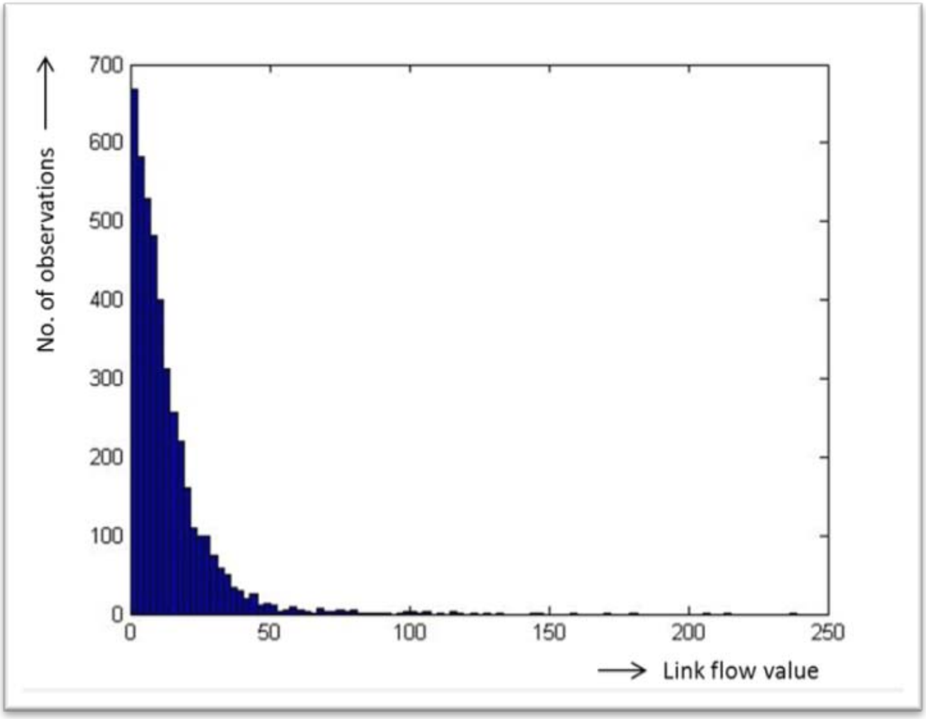


Figure 37 - Frequency of link flow values observed.

Procedure 2 – Desired vs. predicted states

In procedure 2, the desired states were added to and compared to the predicted states. The desired state is also determined for 15 minutes ahead (so measures may be taken to reroute traffic to achieve the desired state), and reflects a state in which traffic is assigned by the simulation model in a more energy efficient way. This was done by adding a term to the cost function so that the costs of CO_2 emissions (or fuel consumption) play a more important role in the assignment.

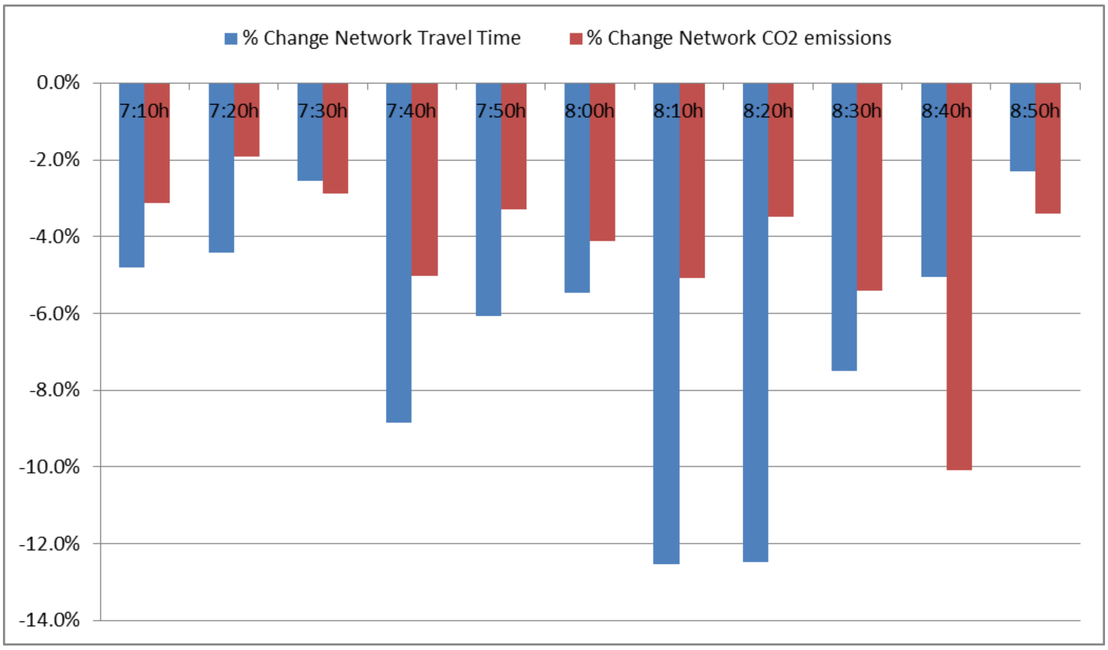
Two indicators are important to compare here, for the desired vs. the predicted state:

- total network CO_2 emissions (kg - ECOM-PI-108);
- total network travel time (s - ECOM-PI-202).

The first indicator will show whether the inclusion of a term for CO_2 emissions in the cost function indeed results in a different and more energy efficient assignment over the network. The second indicator will show whether this is at the expense of travel times or not.

Given below in Figure 38 is a graphical representation of the differences in emission and travel time indicators between predicted and desired states for all time slices of a typical morning peak period. It can be concluded that the inclusion of (relatively high) costs of CO2 emissions in the cost function indeed leads to lower overall CO2 emissions. Also, and perhaps unexpected, overall travel time decreases. Therefore, for the network as a whole it appears that a win-win situation can be achieved. However, the changed distribution over the network will result in longer travel times for some drivers (as this is basically a change from a user equilibrium towards a network optimum, which is not always optimal from the individual traveller’s point of view). Unfortunately, the data set did not give individual travel times for the predicted and desired states that could be compared, but it seems unlikely that individual drivers will have a substantially longer travel time (say over 3 minutes longer than originally).

Figure 38 - Differences between predicted and desired state values for emissions and travel time (% change), for a typical morning peak hour.



3.3 Validation Scenario 2.3 - Driving Behaviour

The table below describe validation scenario 2.3. [for details see WD6.3.3].

Table 23 - Validation scenario 2.3 – Driving Behaviour.**Scenario ID**	VS_2_3
Name:	Driving Behaviour
Description:	This scenario covers the different fields of driving behaviour to reduce CO2 emissions/fuel consumption. The focus is on a) traffic induced driving behaviour (e.g. traffic congestion or shock wave damping), b) traffic signal induced driving behaviour (e.g. traffic light or toll barrier) and c) driver/road induced driving behaviour situations in which the system providing informatio to the driver to take certain action (e.g. accelerate, brake, shift gear, etc.). The related question is concerning the potential of ecoInformation to change the driving behaviour in positive sense i.e. follow the recommendations.

Objective:	The research objective is mainly on reducing the fuel consumption considering the acceptance of system and the compliance by the driver to performe in a envisaged way. Additionally safety issues when using the system are in the scope of the validation scenario.
Validation Categories:	Enviromental, Driver Performance, Safety, User Acceptance, Driver Compliance and/or Mobility
Applications covered:	List of applications covered on this scenario
Cartoon:	

3.3.1 *Test Case 2.3.2 - Traffic Signal induced*

The table below describe test case 2.3.2 [for details see WD6.3.3].

Table 24 – Test case 2.3.2 – Traffic signal induced.

Validation Test Case ID	VS_2_3_TC_2
Validation Test Case Name	Traffic Signal induced
Belongs to Validation Scenario	Driving Behaviour
Test case description	Evaluation of the correctness and effectiveness of driving behavior advice on the approach of traffic signals. Typical situations are at traffic lights, ramp metering installation and toll barriers. Advice involve speed, acceleration and lane recommendations, from either in-

	vehicle or infrastructure systems.
Hypotheses	The eCoMove system can accurately calculate speed, acceleration and lane advice. The expected fuel savings are in the range of 10-15%. In addition, positive effects on travel time are expected.
Success Criteria	The average fuel consumption and CO_2 emissions of cooperative vehicle(s) and network is reduced, while the delay times do not increase or even reduce.
Minimum Set of Performance Indicators	ECOM-PI 101 Fuel consumption for a passenger car per trip ECOM-PI 103 Fuel consumption for a truck per trip ECOM-PI 107 Fuel consumption for all traffic in network ECOM-PI 201 Travel time individual OD ECOM-PI 202 Travel time of the network
Summary of Test Procedure(s)	Type of test: x field test x driving simulator x traffic simulation. Data collection: x objective measurement x subjective measurement Field tests and simulation are balanced. In field tests, drivers drive on defined route course and are provided with the advice. All drivers will test different system settings with the system ON and OFF. After each run drivers will be asked to complete a questionnaire. In simulation the network effects are assessed.
Test Setups:	Test Setup 2.3.2.1 DAF Traffic light driver / DAF / Helmond / Field Test Test Setup 2.3.2.2 DAF Long Drive / DAF / Helmond / Field Test Test Setup 2.3.2.3 Short Term / FFA / Helmond / Field Test Test Setup 2.3.2.4 ecoDrivingSupport/ CRF / Torino / Field Test Test Setup 2.3.2.5 Approah Advice/ TUM / Munich/ Simulation Test Setup 2.3.2.6 Traffic signal - SLAM /PEEK / Helmond/ Field Test Test Setup 2.3.2.7 Traffic signal - SLAM / PEEK / Helmond/ Simulation Test Setup 2.3.2.8 Traffic signal / Vialis / Badhoevedorp / Simulation Test Setup 2.3.2.9 Traffic signal / Vialis / France/ Simulation

	Test Setup 2.3.2.10 Traffic signal / PEEK / Network / Simulation Test Setup 2.3.2.11 Traffic signal / PTV / France / Simulation

This test case involves ecoApproach Advice which broadcasts Speed and Lane Advice Messages at signalized intersections. 14 signalized intersections at the test site of Helmond were used. A connected vehicle drove the route 10 times with and 10 times without the application. The aim of the test case was to evaluate the effect of traffic light speed advice on driving behaviour and resulting fuel consumption.

3.3.1.1 Test Setup 2.3.2.7 - Traffic signal-SLAM / Helmond/ Field Test

The table below describe test setup 2.3.2.7 [for details see WD6.3.3].

Table 25 – Test setup 2.3.2.6

Validation Test Setup ID	VS_2_3_TC_2_TS_6
Test Setup Name	Traffic signal - SLAM / PEEK / Helmond/ Field Test
Method	Field Test
Location	Initially 3 intersections (number 101, 102 and 103). Later 14 traffic light controlled intersections on the N270.
Applications, components and core technologies (software) used	ecoApproach Advice, ecoDriving Support, camera detection for queue estimation
Hardware description	Roadside units at the intersections and eCoMove vehicles
Experimental setup (incl. number of test runs and drivers)	Drivers will drive the route 10 times with and 10 times without the application. The effect of the advice on driving behavior and resulting fuel consumption will be assessed in different conditions.

Test route or Network description (incl. Picture)	N270 from Eindhoven to Deurne. 
Baseline	Situation without the system.
Control Factors (they can be changed)	Distance to stop line when advice is received, actual speed advice and the queue length at the intersection.
Situational Variables (are just there, but influence the outcome)	Traffic conditions, distance to stop line when the advice is received, actual speed advice, and the queue length at the intersection. ECOM-SV-006
Sensors and data loggers	eCoMove datalogger

The data presented below were collected in collaboration with SP3. Validation results of SP3 are presented in greater detail in [D6.3]. Only the most notable findings from a traffic management perspective were extracted to discuss here.

Figure 39 shows that the traffic light speed advice clearly reduced fuel consumption. On average the fuel consumption reduced by 16% with statistical significance.

ECOM_PI_1011N **Fuel consumption of passenger car**

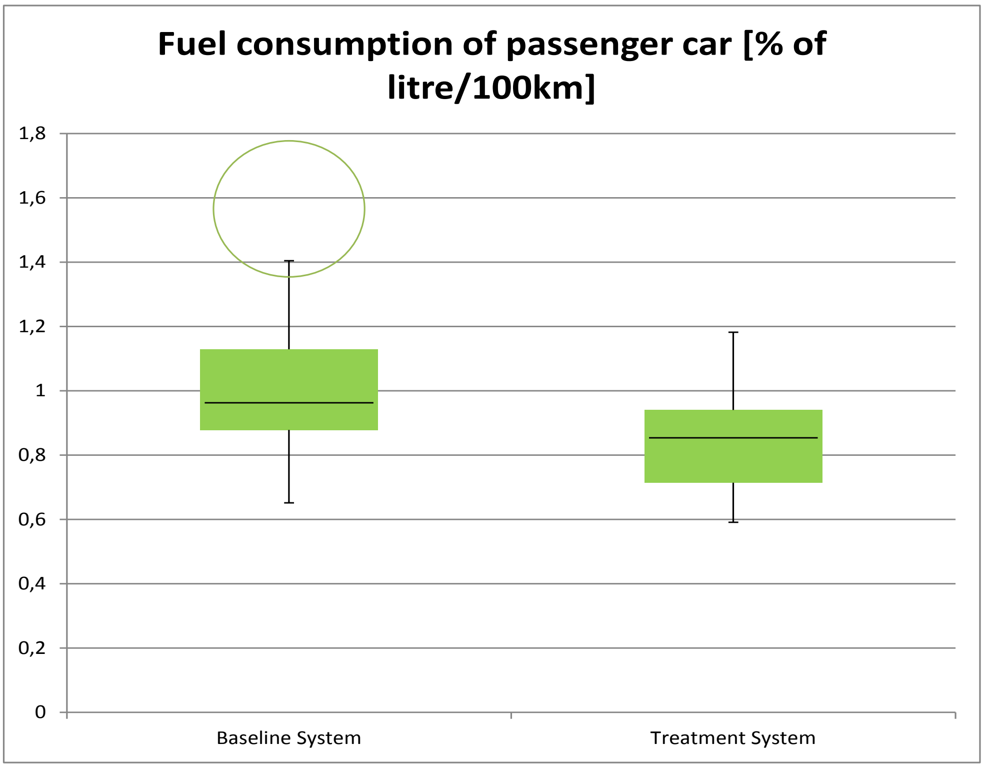
Description: Fuel consumption of a passenger car per trip (OD: Origin - Destination)

Unit: % of litre / 100 km

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,18	0,96	0,88	1,12	p= 3,0E-10	d= 0,98
Treatment System	0,84	0,14	0,85	0,71	0,94	T= 6,67	r= 0,44

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 39 - ecoApproach Advice, effect on fuel consumption

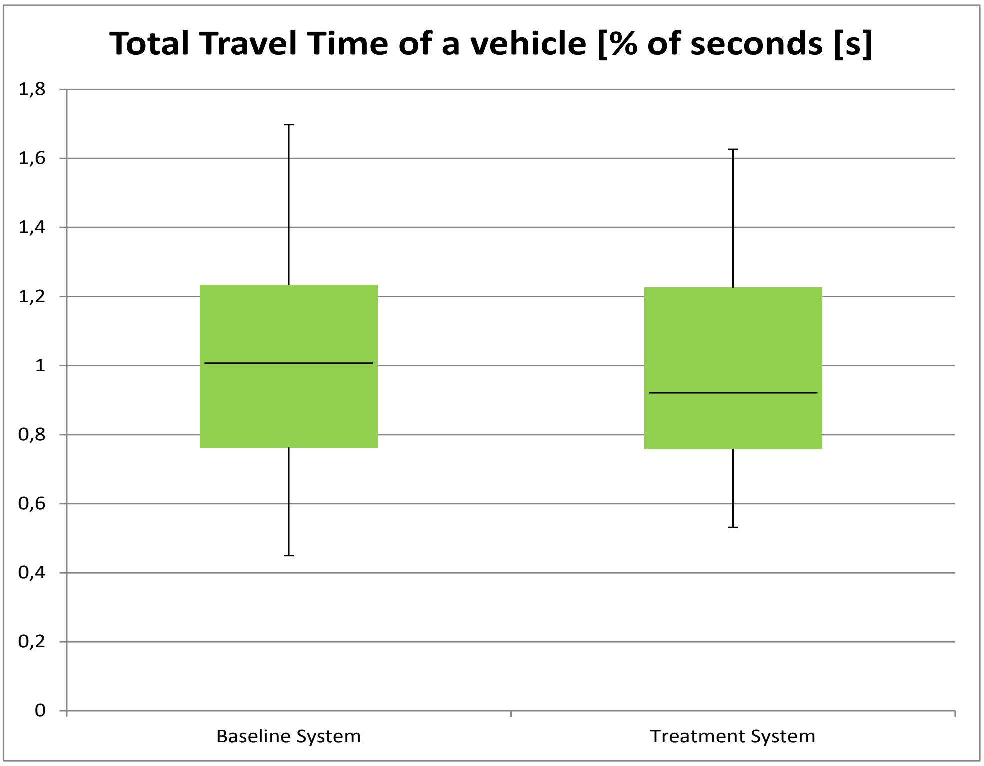
Figure 40 shows that traffic light speed advice did not affect the total travel time. This is logical as the signal timing itself was not affected.

ECOM_PI_2011N	**Total Travel Time Car**
Description:	Travel time of an individual vehicle (truck or car) with given OD between baseline and test scenario
Unit:	% of seconds [s]

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,30	1,01	0,76	1,23	p= 7,8E-01	d= 0,04
Treatment System	0,99	0,28	0,92	0,76	1,23	T= 0,29	r= 0,02

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 40 - ecoApproach Advice, effect on travel time

Figure 41 shows that traffic light speed advice reduced the number of stops. On average the number of stops reduced by 9% with statistical significance.

ECOM_PI_2053N **Num_stops**

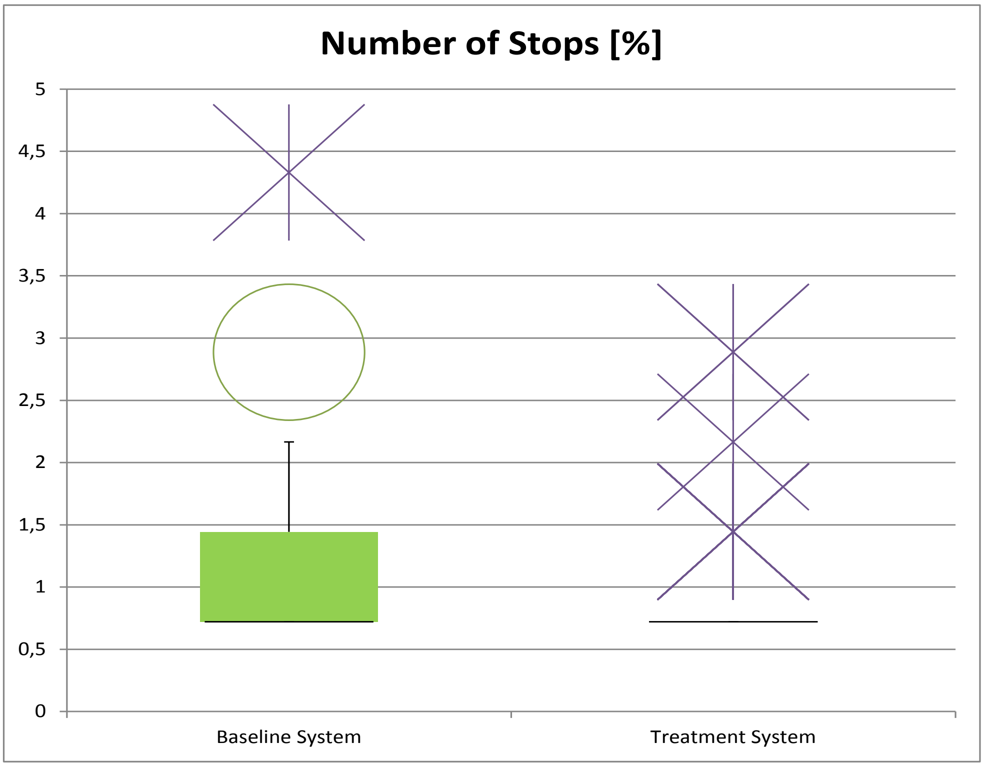
Description: Number of stops, considering a stop when the vehicle speed less than X km/h

Unit: %

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,57	0,72	0,72	1,44	p= 2,5E-01	d= 0,17
Treatment System	0,91	0,43	0,72	0,72	0,72	T= 1,14	r= 0,08

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 41 - ecoApproach Advice, effect on number of stops

In line with other findings, **Figure 42** shows that the standard deviation of velocity reduced. Hence, the vehicles approached and the signalized intersections with a smoother velocity profile. On average, the standard deviation of velocity reduced by 14% with statistical significance.

ECOM_PI_3041N **Standard deviation of velocity**

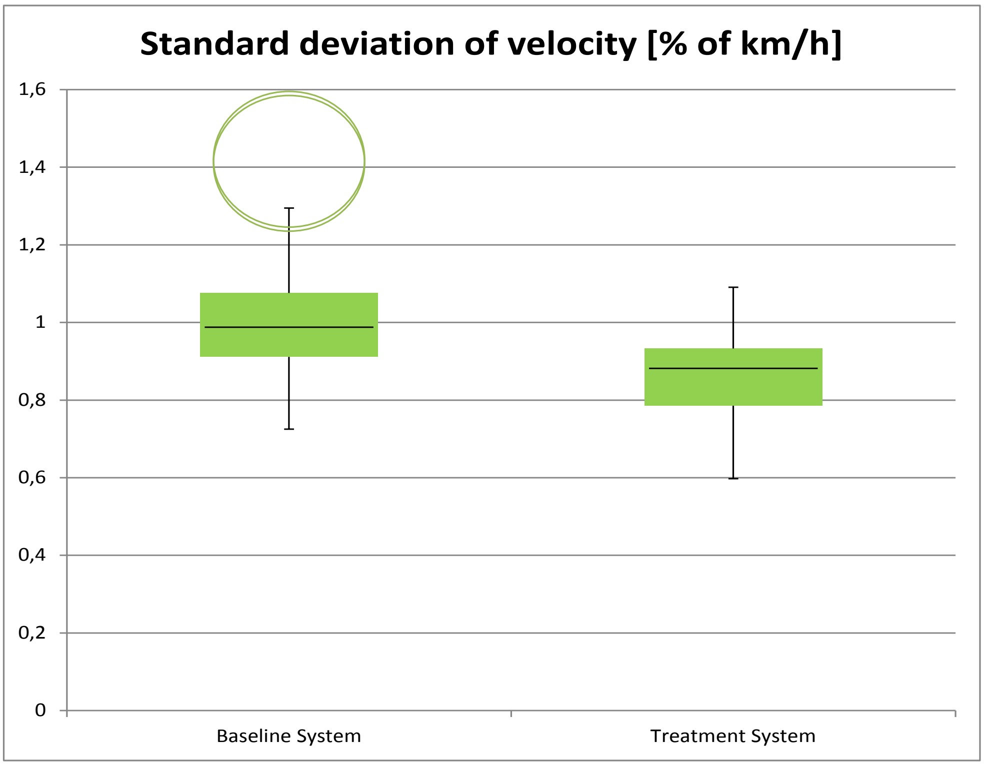
Description: Should be used over equivalent time or distance epochs, discrete value for a certain distance/time, but can be treated as continuous measure if calculated as rolling average

Unit: m/s

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,13	0,99	0,91	1,07	p= 9,4E-13	d= 1,13
Treatment System	0,86	0,11	0,88	0,79	0,93	T= 7,69	r= 0,49

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 42 - ecoApproach Advice, effect on standard deviation of velocity

Similar to **Figure 42**, **Figure 43** shows that the average acceleration reduced by 17% with statistical significance. Also the standard deviation of the average acceleration reduced which is another sign of smoother driving.

ECOM_PI_3051N **Average acceleration**

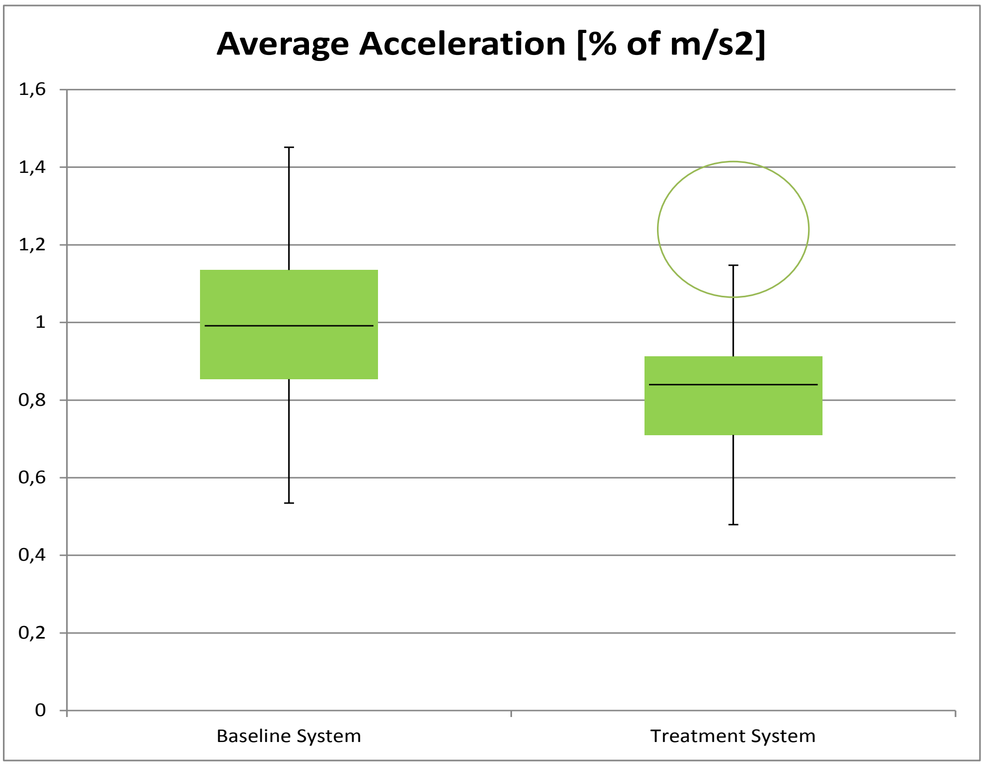
Description:

Unit: % of m/s2

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,20	0,99	0,86	1,13	p= 4,2E-10	d= 0,97
Treatment System	0,83	0,15	0,84	0,71	0,91	T= 6,61	r= 0,44

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 43 - ecoApproach Advice, effect on average acceleration

Similar to **Figure 42**, **Figure 44** shows that the average acceleration reduced by 17% with statistical significance. Also the standard deviation of the average decelleration reduced which is another sign of smoother driving.

ECOM_PI_3061N **Average deceleration**

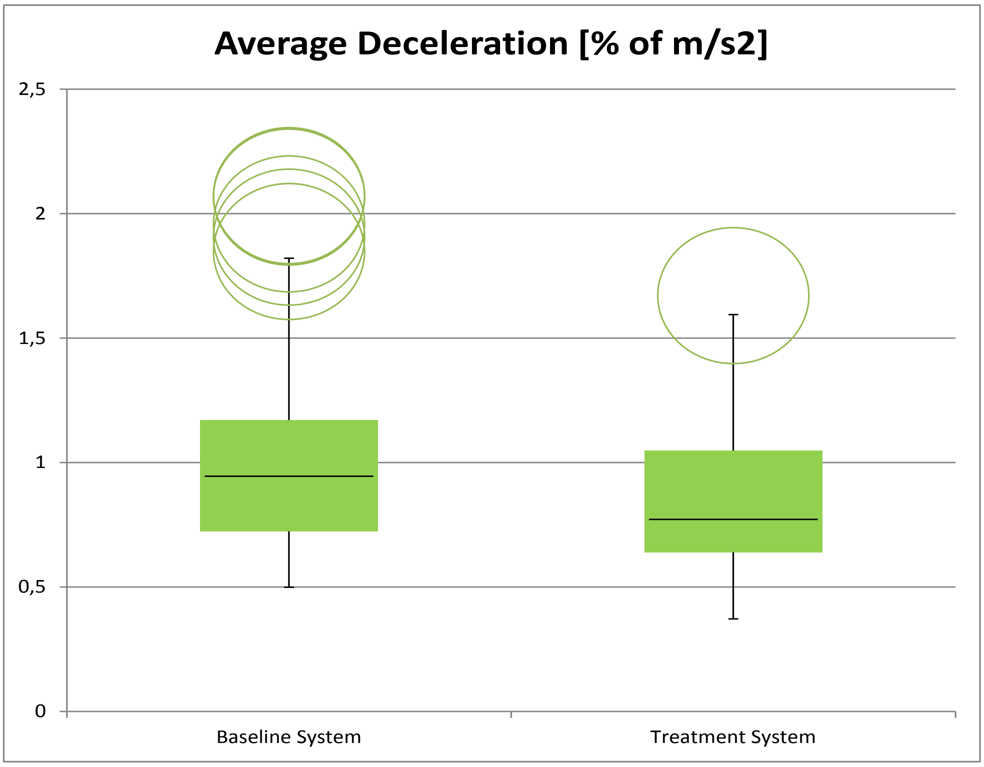
Description:

Unit: % of m/s2

Results:

Situation	Mean	Std. dev.	Median	P25	P75	t-Test p & T	effect size d & r
Baseline System	1,00	0,38	0,95	0,73	1,16	p= 2,1E-03	d= 0,46
Treatment System	0,85	0,28	0,77	0,64	1,04	T= 3,12	r= 0,22

Graphical presentation of data analysis:



Comments:

Traffic Light equipped intersections

Figure 44 - ecoApproach Advice, effect on average deceleration

3.4 Validation Scenario 2.4 - Parking Guidance

The table below describe validation scenario 2.4. [for details see WD6.3.3].

Table 26 - Validation scenario 2.4 – Parking Guidance.

Scenario ID	VS_2_4
Name:	Park Guidance
Use Case Covered:	UC_SP3_4 UC_SP5_1
Description:	The system indicates a paking place and guides the driver to it through the most efficient path.
Objective:	Analyze effects of parking availability and accessibility on route choice behavior in an urban and motorway environment (UC_SP5_1).
Validation Categories:	Mobility
Applications covered:	ecoParkAdvice ecoTruck Parking
Cartoon:	

3.4.1 Test Case 2.4.2 - Parking Motorway

The table below describe test case 2.4.2 [for details see WD6.3.3].

Table 27 – Test case 2.4.2 – Parking Motorway

Validation Test Case ID	VS_2_4_TC_2
Validation Test Case Name	Parking Motorway
Belongs to Validation Scenario	Park Guidance
Test case description	Truck driver is making a stop and go in truck area in.The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place finded - acceleration and exit from the area
Hypotheses	
Success Criteria	Fuel consumption for unnecessary stop and go is avoided by informing in advance the truck driver with the ecotruckparking application Security is improved by avoiding unnecessary search by trucks on rest area. Anarchic parckage when the rest area is full can also be reduced by using the ecoTruckParking Application. The maximum driving period for truck driver can be better respected with eCoTruckparking Application
Minimum Set of Performance Indicators	ECOM-PI 101 Fuel consumption for a passenger car per trip ECOM-PI 103 Fuel consumption for a truck per trip ECOM-PI 107 Fuel consumption for all traffic in network ECOM-PI 201 Travel time individual OD ECOM-PI 202 Travel time of the network
Summary of Test Procedure(s)	Type of test: x field test □ driving simulator □ traffic simulation. Data collection: x objective measurement □ subjective measurement Truck driver is making a stop and go in truck area in different slopes. The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place found - acceleration and exit from the area

Test Setups:	Test Setup 2.4.2.1 Parking Positive Slope / ASFA / France/ Field Test Test Setup 2.4.2.2 Parking Negative Slope / ASFA / France/ Field Test Test Setup 2.4.2.3 Parking Normal 1 / ASFA / France/ Field Test Test Setup 2.4.2.4 Parking Normal 2 / ASFA / France/ Field Test Test Setup 2.4.2.5 Parking big parking area / ASFA / France/ Field Test

The field measurements took place on truck areas of the ASFA network. A Volvo Truck was equipped with a consumption probe.

The generic test procedure is to make a stop and go in truck parking areas:

- deceleration from the motorway
- enter the area
- search using the road along the truck parking
- no place found
- acceleration and exit from the area

We suppose that the consumptions are different by considering the topology of the areas. So, different tests have to be done.

3.4.1.1 Test Setup 2.4.2.2 - Parking Negative Slope / France/ Field Test

Table 28 – Validation Test case VS_2_4_TC_2_TS_2 - Parking Negative Slope / ASFA / France/ Field Test

Validation Test Setup ID	VS_2_4_TC_2_TS_2
Test Setup Name	Parking Negative Slope / ASFA / France/ Field Test
Responsible	ASFA
Participant partners	VOLVO
Method	Field Test
Location	French Motorways
Applications, components and core technologies (software) used	ecoTruckParking Application
Hardware description	Vehicle: VOLVO TRUCK

Experimental setup (incl. number of test runs and drivers)	Number of runs: 1 run Truck driver is making a stop and go in truck area in negative slope (Communay Nord truck parking area on A46 motorway , close to Lyon).The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place found - acceleration and exit from the area
Test route or Network description (incl. Picture)	route on "Communay Nord" rest area
Baseline	ecotruckparking application off
Control Factors (they can be changed)	
Situational Variables (are just there, but influence the outcome)	Traffic can influence the test run. If the conditions (e g a long stop due to other trucks blocking the route) the test run must be invalided
Performance Indicators	
Measurements	Fuel consumption
Sensors and data loggers	

Nota: negative slope is defined when the altitude is decreasing significantly in the direction of the traffic.

- ➔ Unfortunately due to the failure of this specific test run, we cannot conclude anything. The log was launched but nothing was recorded. When debriefing, it was too late to do another run.

We estimate that the "Negative Slope Parking" is the less represented topology in the ASFA network (less than 5%). To face this measurement failure, by assimilating "Negative Slope Parking" to "Normal Parking", we think that final results will not be significantly affected. Moreover, a truck in negative slope mostly brakes with the engine and continues to consume fuel, we suppose that’s not so different from a normal situation.

3.4.1.2 Test Setup 2.4.2.2 - Parking Positive Slope / France/ Field Test

Table 29 – Validation Test case VS_2_4_TC_2_TS_1 - Parking Positive Slope / ASFA / France/ Field Test

Validation Test Setup ID	VS_2_4_TC_2_TS_1
Test Setup Name	Parking Positive Slope / ASFA / France/ Field Test
Responsible	ASFA
Participant partners	VOLVO
Method	Field Test
Location	French Motorways
Applications, components and core technologies (software) used	ecoTruckParking Application
Hardware description	VOLVO TRUCK
Experimental setup (incl. number of test runs and drivers)	Number of runs: 1 Truck driver is making a stop and go in truck area in positive slope (Communay Sud truck parking area on A46 motorway , close to Lyon).The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place finded - acceleration and exit from the area
Test route or Network description (incl. Picture)	route on "Communay sud" rest area
Baseline	ecotruckparking application off
Control Factors (they can be changed)	
Situational Variables (are just there, but influence the outcome)	Traffic can influence the test run . If the conditions (e g a long stop due to other trucks blocking the route) the test run must be invalided
Performance Indicators	
Measurements	Fuel consumption

Sensors and data loggers	

The altimeter profile recorded and presented below confirms that the situation is a real positive slope, great enough to play a role on a truck consumption (more than 170m on half a kilometer long).

Nota: positive slope is defined when the altitude is increasing significantly in the direction of the traffic ..

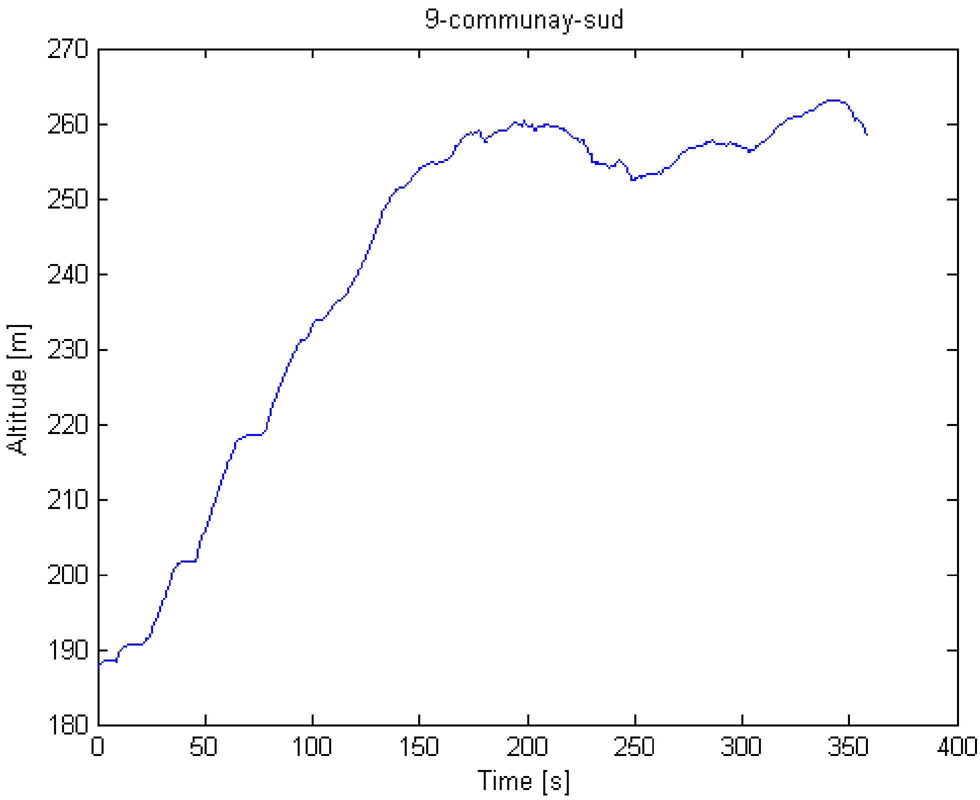


Figure 45 - Altitude profile of “Communay Sud” area

See below the GPS trace of the search

Figure 46 - GPS trace on "Communay Sud" Area

The Speed measure presented below teach us that the truck can't start the measure sequence at the supposed cruise speed of 90km/h. Surely due to the slope the truck cannot reach 90km/h, but finally we can consider the start of the measure by the entrance of the truck on the area.

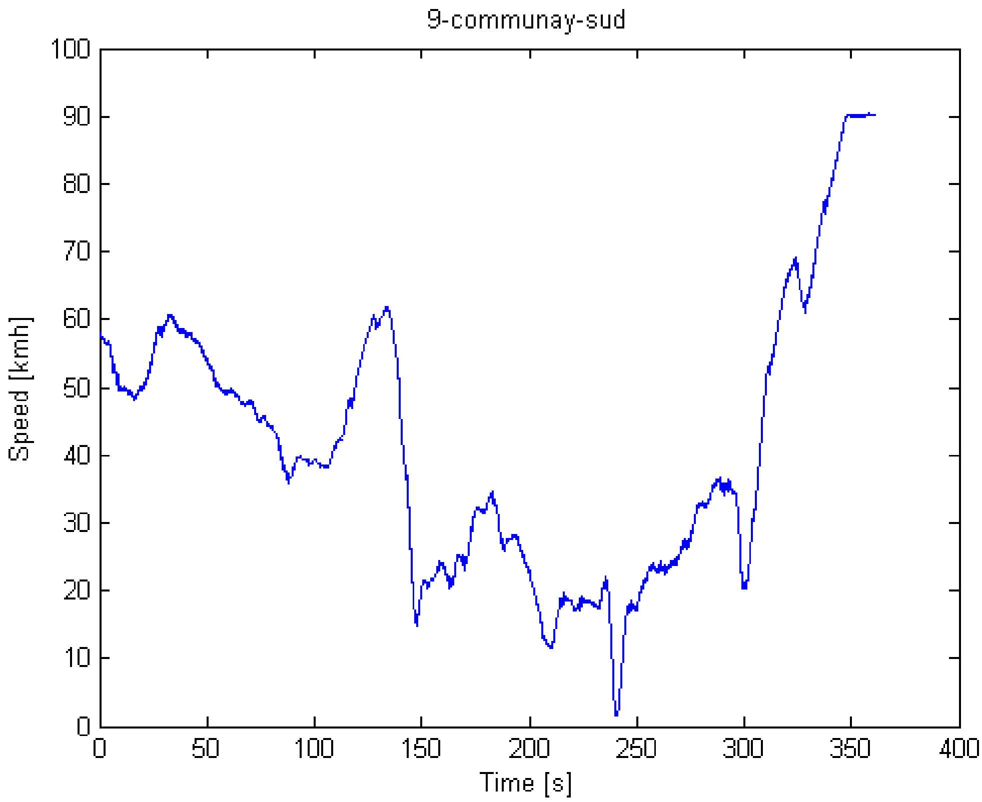


Figure 47 - Speed profile of "Communay Sud" area

The consumption is high (1,9 l) compare to the distance done.

3.4.1.3 Test Setup 2.4.2.3 - Parking Normal 1 / ASFA / France/ Field Test

Table 30 – Validation Test case VS_2_4_TC_2_TS_3 - Parking Normal 1 / ASFA / France/ Field Test

Validation Test Setup ID	VS_2_4_TC_2_TS_3
Test Setup Name	Parking Normal 1 / ASFA / France/ Field Test
Responsible	ASFA
Participant partners	VOLVO
Method	Field Test
Location	French Motorways

Applications, components and core technologies (software) used	ecotruckParking Application
Hardware description	Vehicle: VOLVO TRUCK
Experimental setup (incl. number of test runs and drivers)	Number of runs: 1 Truck driver is making a stop and go in typical truck area (Saint Rambert d'Albon truck parking area on A7 motorway , south of Lyon).The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place found - acceleration and exit from the area
Test route or Network description (incl. Picture)	Route on "Saint Rambert d'Albon" rest area A7 motorway
Baseline	ecotruckparking application off
Control Factors (they can be changed)	
Situational Variables (are just there, but influence the outcome)	Traffic can influence the test run . If the conditions (e g a long stop due to other trucks blocking the route) the test run must be invalided
Performance Indicators	
Measurements	
Sensors and data loggers	

Nota: To extend the panel of measurements, extra measurements have been done on “Saint Rambert Ouest”, “Saint Rambert Est”, “Vienne Ouest” and “Vienne Est”.

Here below the GPS trace of the measures.

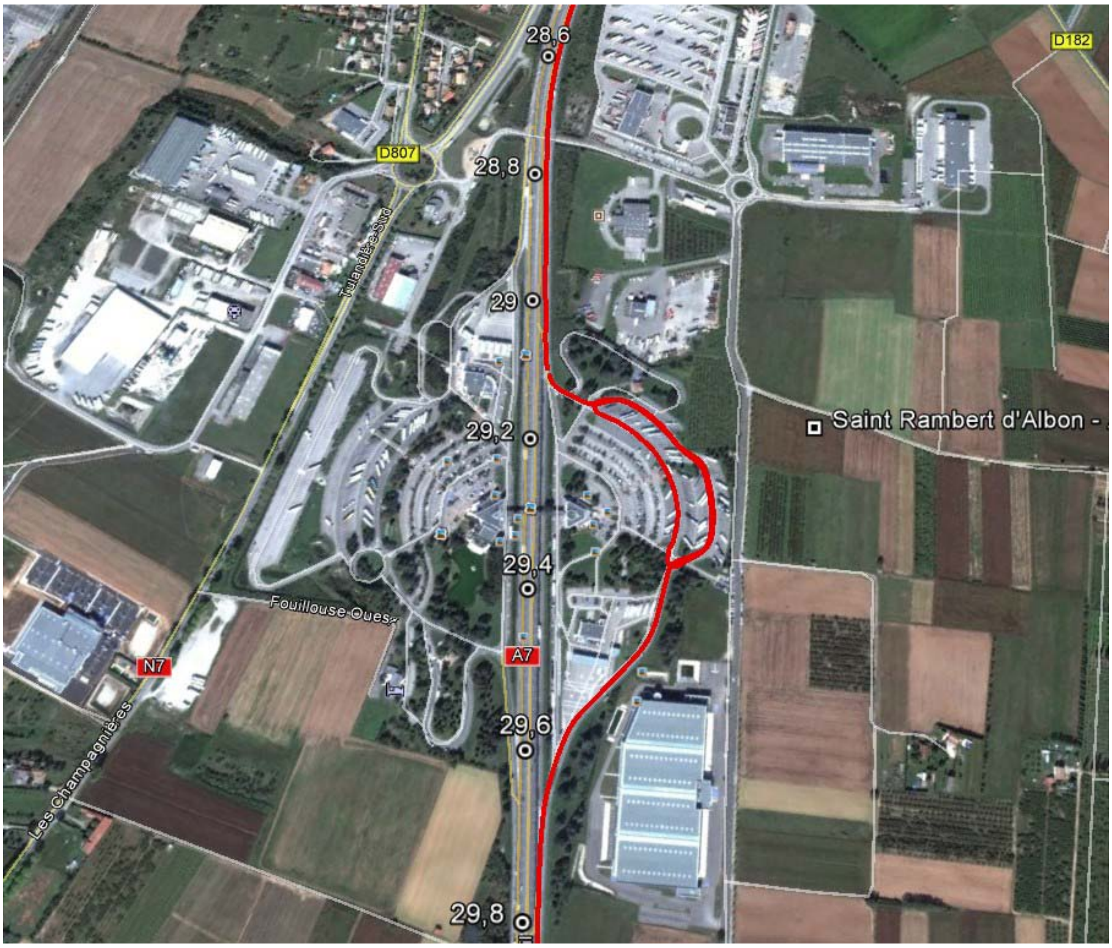


Figure 48 - Saint Rambert Est

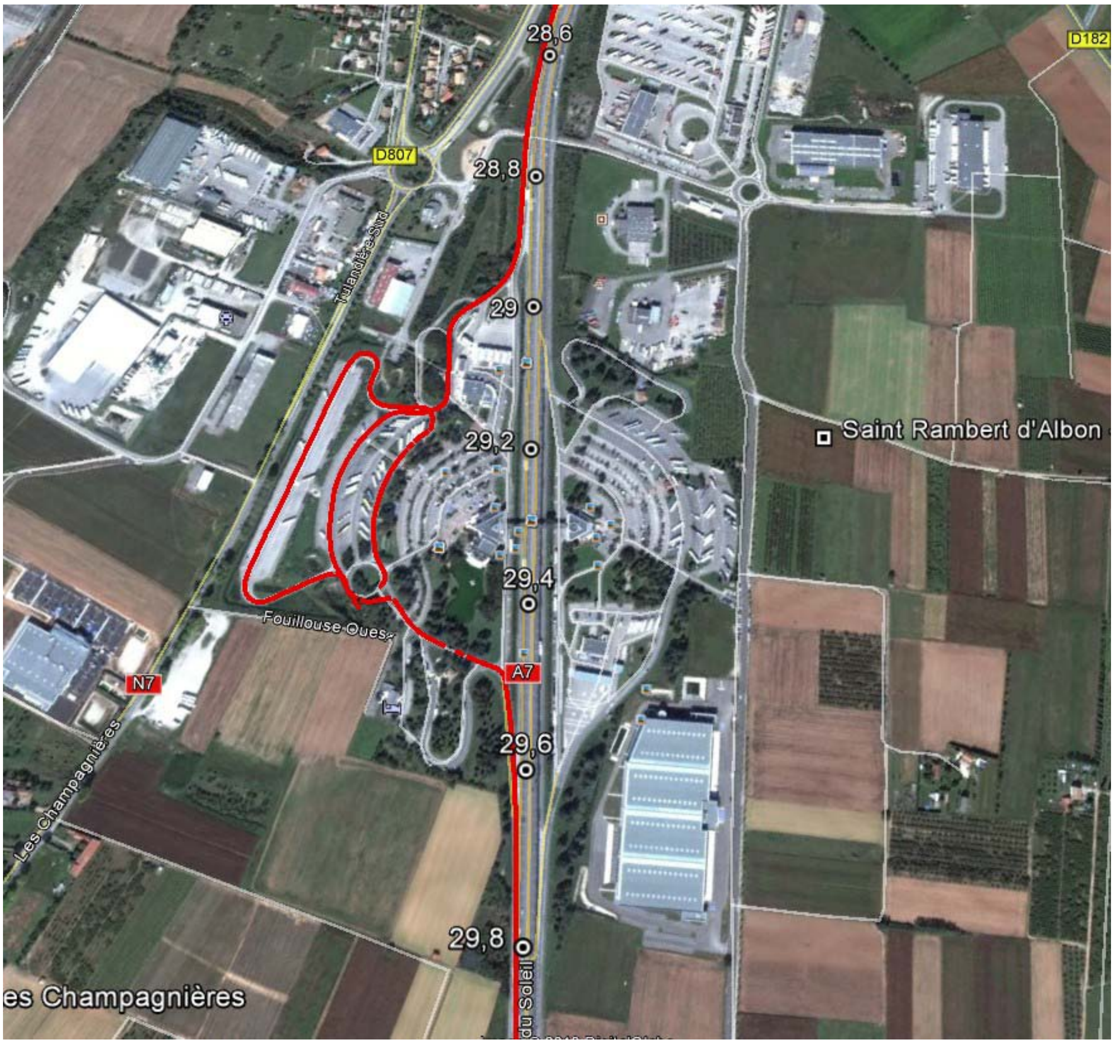


Figure 49 - Saint Rambert Ouest

Here below the speed measures

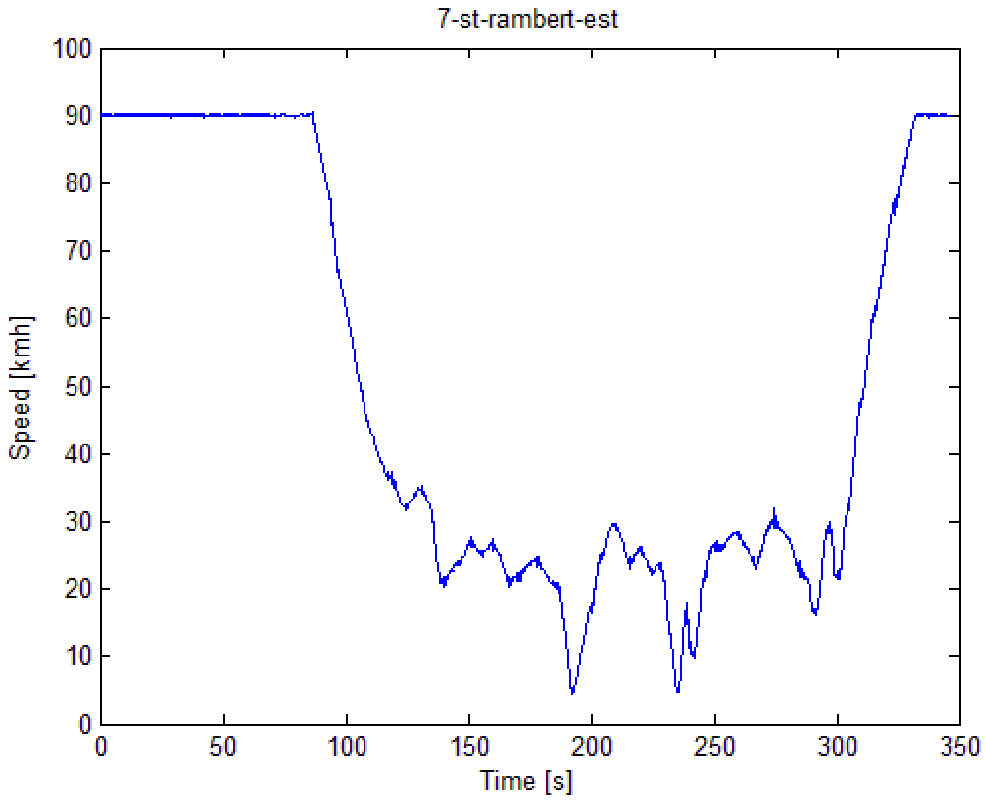


Figure 50 - Speed profile Saint Rambert Est

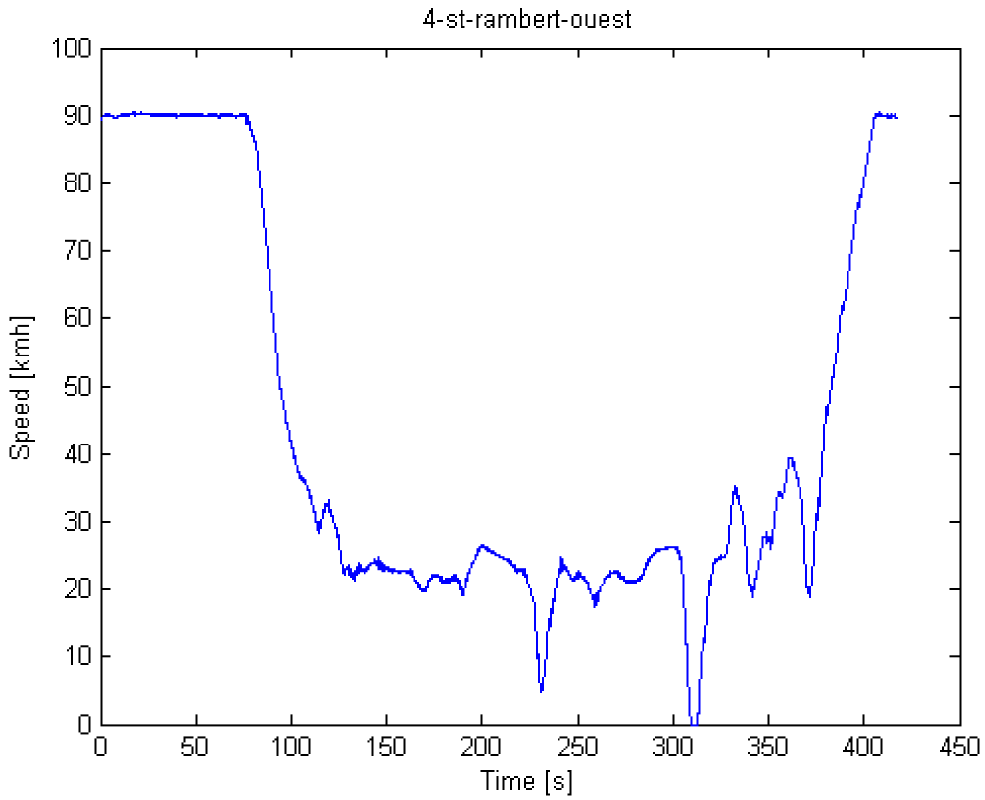


Figure 51 - Speed profile Saint Rambert Ouest

The measurements are quite similar and give very close consumptions. This is a good reference for the “Normal Area” status.

For the “Normal Area” tests, two other measures have been done, one for Vienne Ouest area and another for Vienne Est Area. As we will see below, only the Vienne Ouest has been recorded. But, the GPS Trace, here below, shows us that the measurement was started too early inducing a too important and wrong consumption.

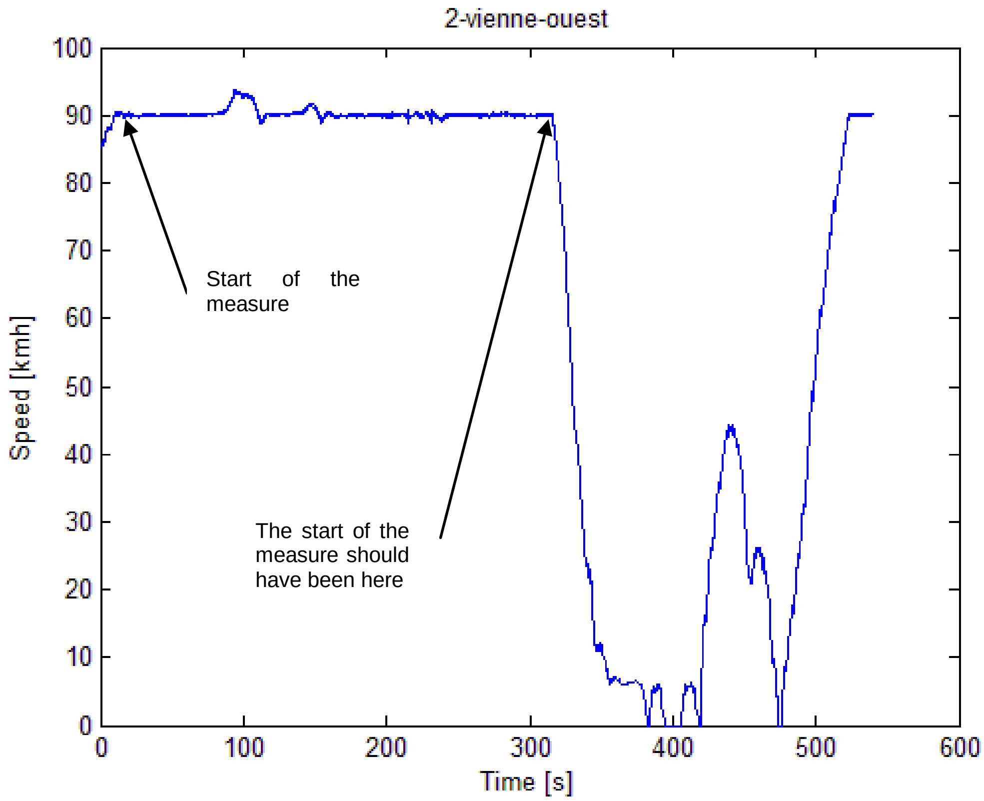


Figure 52 - Speed profile Vienne Ouest

The instructions given to realize the measurement on this area should have been more precise to avoid this.

3.4.1.4 Test Se arking Normal 2 / France/ Field Test

Start of the measure

Table 31 – Validation Test case VS_2_4_TC_2_TS_4 - Parking Normal 2 / ASFA / France/ Field Test

The start of the measure should have been here

Validation Test Setup ID	VS_2_4_TC_2_TS_4
Test Setup Name	Parking Normal 2 / ASFA / France/ Field Test
Responsible	ASFA
Participant partners	VOLVO
Method	Field Test
Location	French Motorways
Applications, components and core technologies (software) used	ecoTruckParking Application
Hardware description	Vehicle: VOLVO TRUCK
Experimental setup (incl. number of test runs and drivers)	Number of runs: 1 Truck driver is making a stop and go in typical truck area (Pond d'isère truck parking area on A7 motorway , south of Lyon).The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking- stop(motor on) - start(motor on) - search again - no place finded - acceleration and exit from the area
Test route or Network description (incl. Picture)	Route on "Pond d'isère" rest area A7 motorway
Baseline	ecotruckparking application off
Control Factors (they can be changed)	
Situational Variables (are just there, but influence the outcome)	Trafic can influence the test run . If the conditions (e g a long stop due to other trucks blocking the route) the test run must be unvalided
Performance Indicators	
Measurements	
Sensors and data loggers	

Nota: An extra measurements have been done on the "Latitude 45" area also classified as a normal parking. "Latitude 45" and "Pond d'isère" are presented below.

Here below the GPS trace of the measures.

Figure 53 - Area Latitude 45

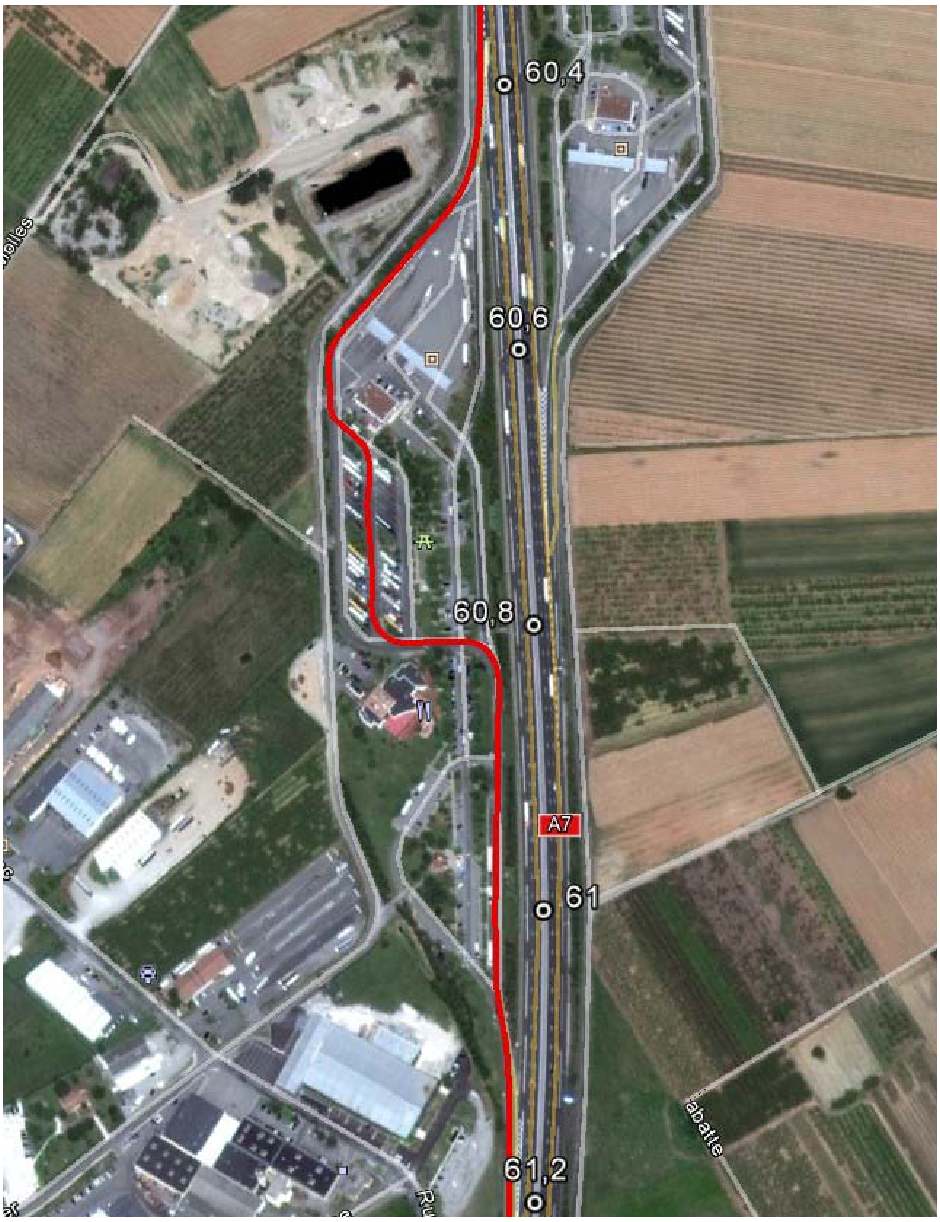


Figure 54 - Area Pont d'Isère

Approximatively, the two areas are generating a route of 1 km. The consumption is 1.4 liter for Latitude 45 and 0.7 liter for Pont d'Isère. These two values are radically different. Volvo explains this by a too short measurement compared to the others and to the area topology.

Here below the speed profiles (extracted from the CAN Bus) for Latitude 45 approximately 250 seconds and Pont d'Isère approximately 150 seconds that it effectively the shortest length. At this step, we think about omitting the Pont d'Isère measure for the extrapolation phase because we think it isn't representative: the other measures on "normal area" are close to Latitude 45 and Pont d'Isère still remind very different (see next §).

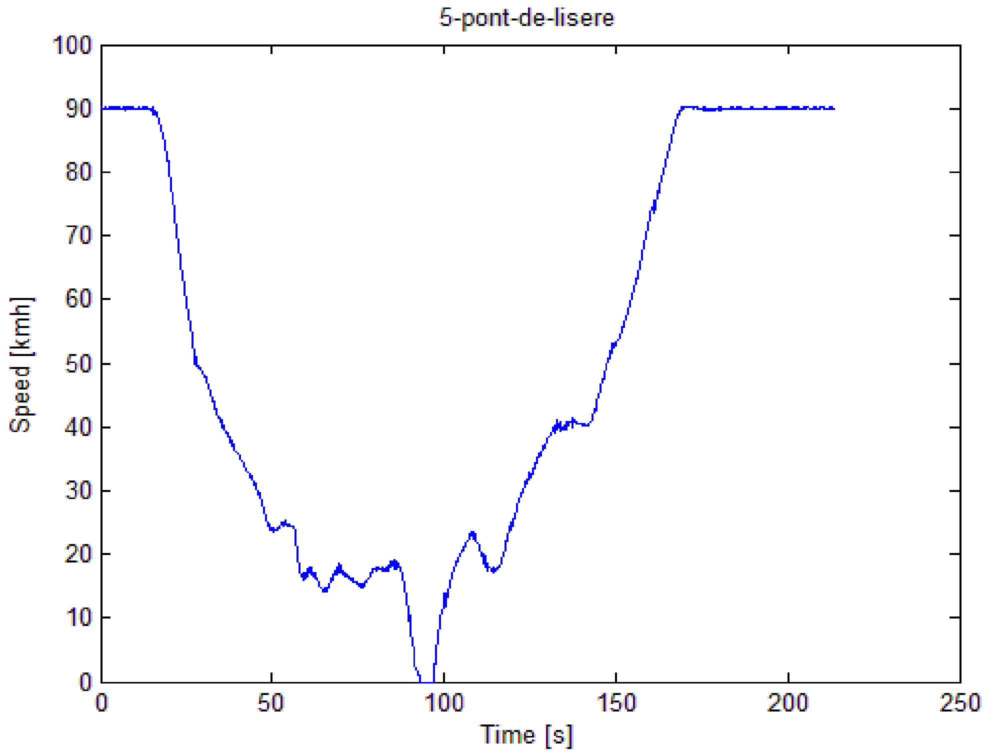


Figure 55 - Speed profile Area Latitude 45

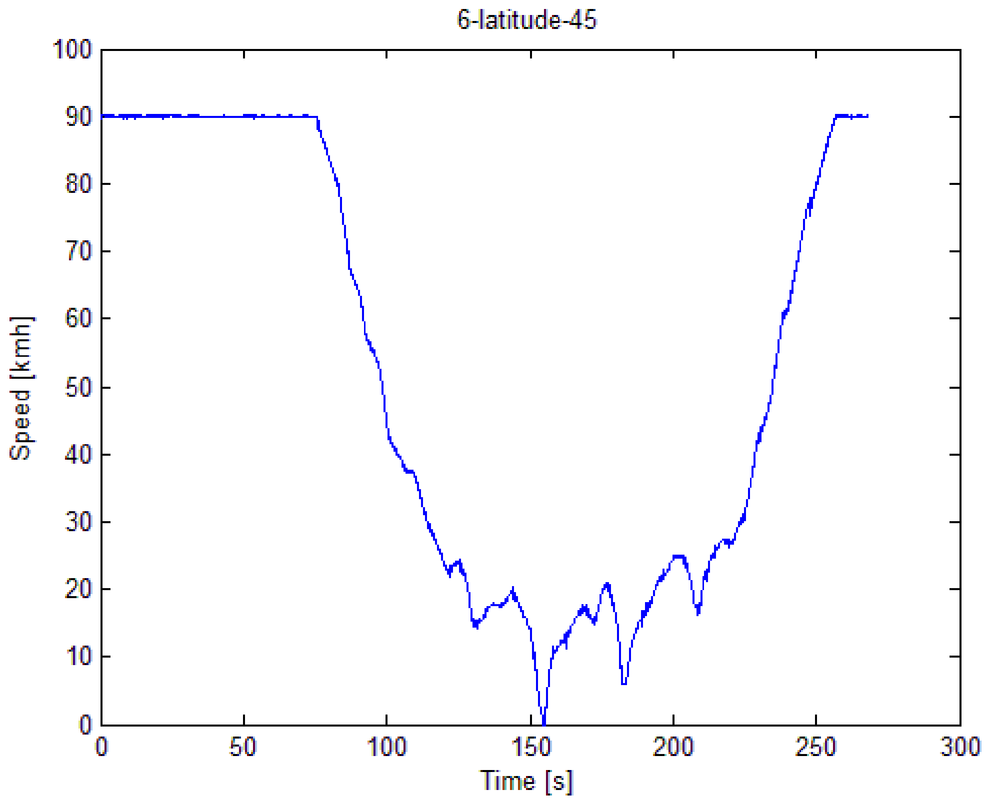


Figure 56 - Speed Profile Area Pont d'Isère

3.4.1.5 Test Setup 2.4.2.5 - Parking big parking area / France/ Field Test

Table 32 – Validation Test case VS_2_4_TC_2_TS_5 - Parking big parking area / ASFA / France/ Field Test

Validation Test Setup ID	VS_2_4_TC_2_TS_5
Test Setup Name	Parking big parking area / ASFA / France/ Field Test
Responsible	ASFA
Participant partners	VOLVO
Method	Field Test
Location	French Motorways
Applications, components and core technologies (software) used	eCoTruckparking Application
Hardware description	Vehicle: VOLVO TRUCK
Experimental setup (incl. number of test runs and drivers)	Number of runs: 1 Truck driver is making a stop and go in typical truck area (Roussillon truck only area on A7 motorway , south of Lyon).The truck consumption will be measured between a sequence of: deceleration from the motorway - enter the area - search using the road along the truck parking-stop(motor on) - start(motor on) - search again - stop(motor on) - start (motor on) - search again- no place finded - acceleration and exit from the area
Test route or Network description (incl. Picture)	
Baseline	ecotruckparking application off
Control Factors (they can be changed)	
Situational Variables (are just there, but influence the outcome)	Traffic can influence the test run. If the conditions (e g a long stop due to other trucks blocking the route) the test run must be invalided

Performance Indicators	
Measurements	Fuel consumption
Sensors and data loggers	

Here below the GPS trace of the truck:

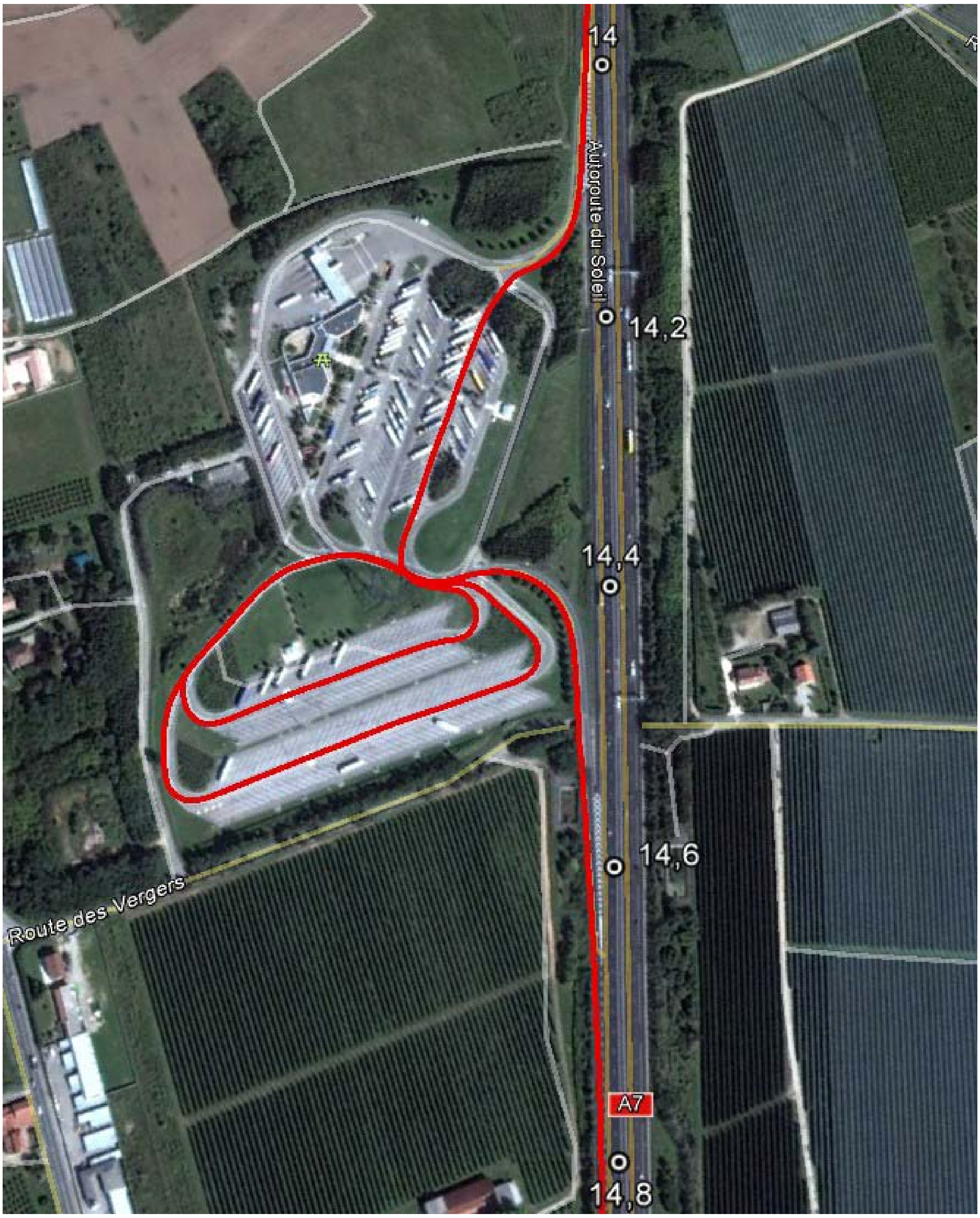


Figure 57 - Area Roussillon

The truck have done a long search session but compare to the trip planned (see below) the route haven't been totally completed.

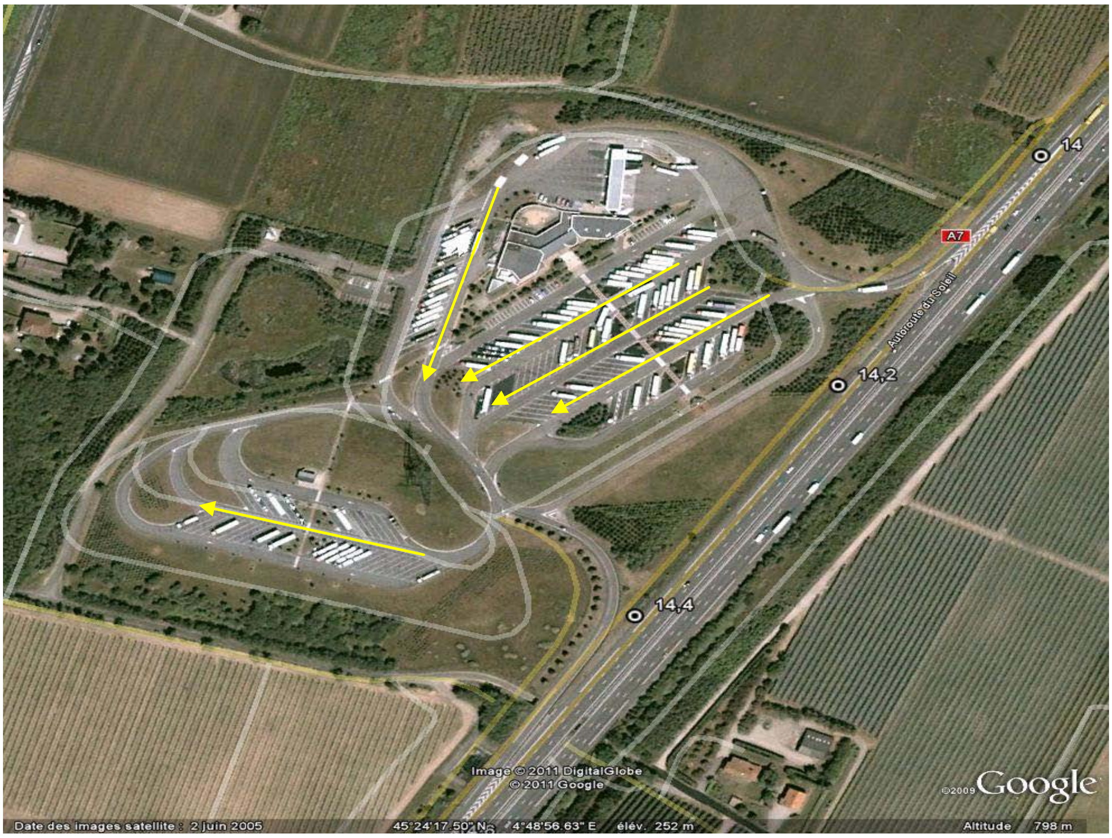


Figure 58 - Roussillon planned trip

It is this tricky to notice that this truck area has been extended between planning instructions and measurements session (see the left down part of the pictures). But finally, this modification on the planned route doesn't have too much effect because the truck drives less on the first part of the area and more on the second part, the effect is more or less the same.

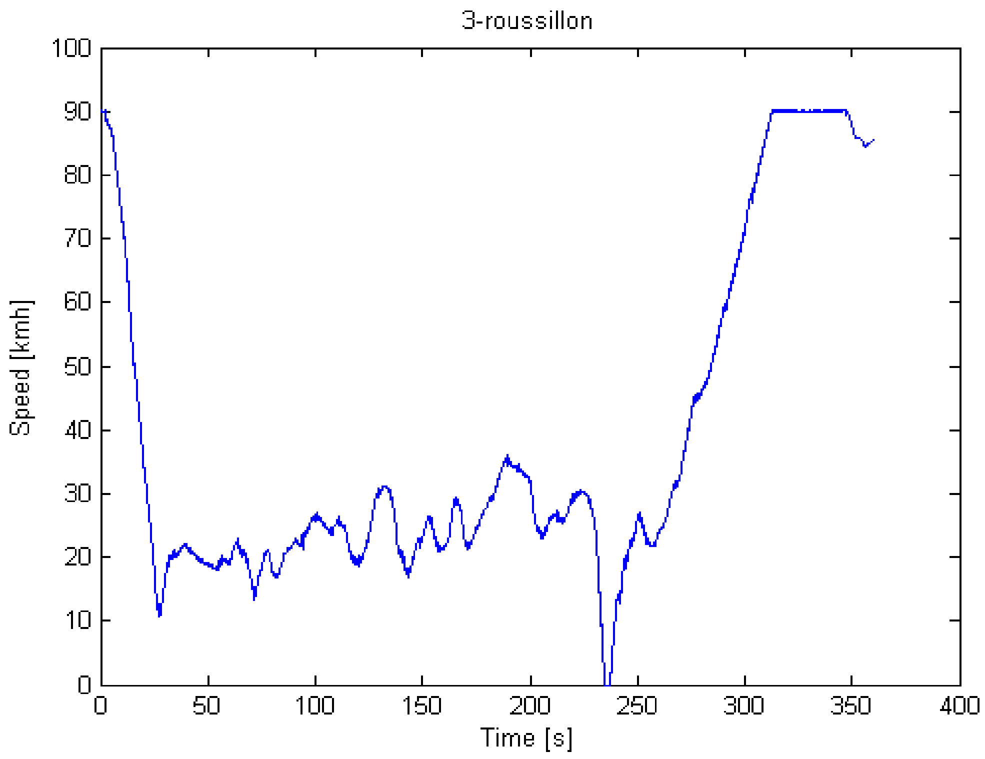


Figure 59 - Speed profile Roussillon

The consumption measured is obviously the most important that we have recorded (3,3 liters).

3.4.2 Parking Motorway conclusions

Results of Tests Case are the following (For Vienne Est and Communay Nord, the measurements failed). The "Reference truck log" is the real measures made by the Volvo Truck. An important parameter to consider when speaking about consumption is the load of the truck and so its global weight. To fit with the different categories found on motorway, Volvo use an homemade consumption simulator. The simulated information will be useful for network extrapolations and impact assessment. The entry parameters for the simulation are the GPS positions measured and the CAN bus data such as fuel injection, pedal position, speed.

Here below the results of measurements (Baseline 18 tons truck) and the extrapolations (Simulation 16 tons truck …)

The number of stops (when speed reach 0km/h) and the number of "close to Stop (speed goes down to 10km/h) are enumerated because that can be a good way to compare results.

The length of the measure in second is also reported.

	Area classification "a priori"	Nb of stop	Nb of "close to stop "	Total of stop	lenght of the measure (sec)	18 tons Reference truck log Consumption (liters)
M2_vienne_ouest	normal area	4	0	**4**	**400**	**2.6**
M3_roussillon	big area	1	1	**2**	**300**	**3.3**
M4_saint_rambert_ouest	normal area	1	1	**2**	**325**	**1.6**
M5_pont_de_lisere	normal area	1	0	**1**	**125**	**0.7**
M6_latitude_45	normal area	1	1	**2**	**175**	**1.4**
M7_saint_rambert_est	normal area	0	3	**3**	**235**	**1.8**
M8_vienne_est	normal area					
M9_communay_sud	positive slope	1	0	**1**	**350**	**1.9**
M10_communay_nord	negative slope					

Table 33 – Measurements details and facts

Consumption measured of simulated for different areas	Baseline 18t	Sim 16t	Sim 18t	Sim 25t	Sim 35t	Sim 44t
Area: Vienne Ouest [l]	2,6	2,6	2,7	3,3	3,9	4,4
Area: Roussillon [l]	3,3	1,4	1,5	1,8	2,1	2,4
Area: Saint_rambert_ouest [l]	1,6	1,8	1,9	2,2	2,7	3,0
Area: Pont_de_lisere [l]	0,7	1,1	1,1	1,3	1,4	1,6
Area: Latitude_45 [l]	1,4	1,4	1,5	1,8	2,2	2,6
Area: Saint_rambert_est [l]	1,8	1,6	1,7	2,0	2,3	2,5
Area: Communay Sud [l]	1,9	2,0	2,1	2,7	3,4	4,1

Table 34 - Consumption measured for a truck of 18t (baseline) and simulated for differents weight (Sim)

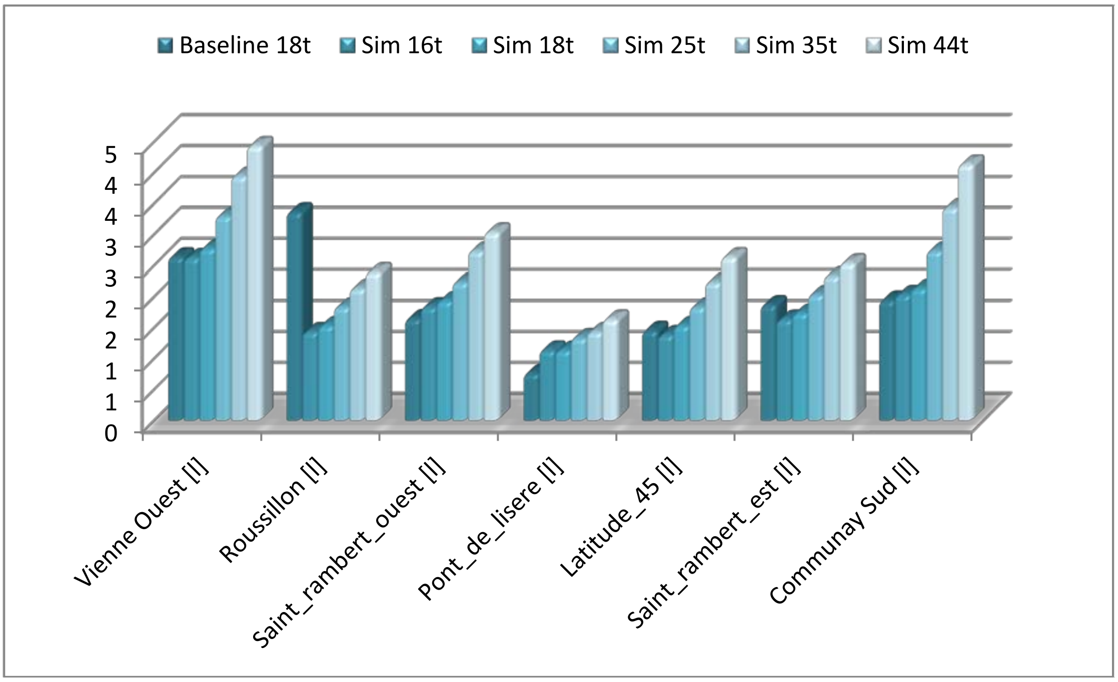


Figure 60 - Consumption measured for a truck of 18t (baseline) and simulated for differents weight (Sim)

	Consumption measured of simulated for different areas	Baseline 18t	Sim 16t	Sim 18t	Sim 25t	Sim 35t	Sim 44t
measure	Vienne Ouest [l]	100,0	99,6	105,4	125,4	150,4	169,2
	Roussillon [l]	100,0	42,1	45,1	54,1	63,1	70,9
	Saint_rambert_ouest [l]	100,0	111,8	118,1	136,7	167,8	186,4
	Pont_de_lisere [l]	100,0	151,5	151,5	179,1	192,9	220,4
	Latitude_45 [l]	100,0	95,2	105,8	126,9	155,1	183,3
	Saint_rambert_est [l]	100,0	87,3	92,8	109,1	125,5	136,4
	Communay Sud [l]	100,0	104,8	110,0	141,5	178,1	214,8

Table 35 – Simulated Consumption compared to baseline in percentage

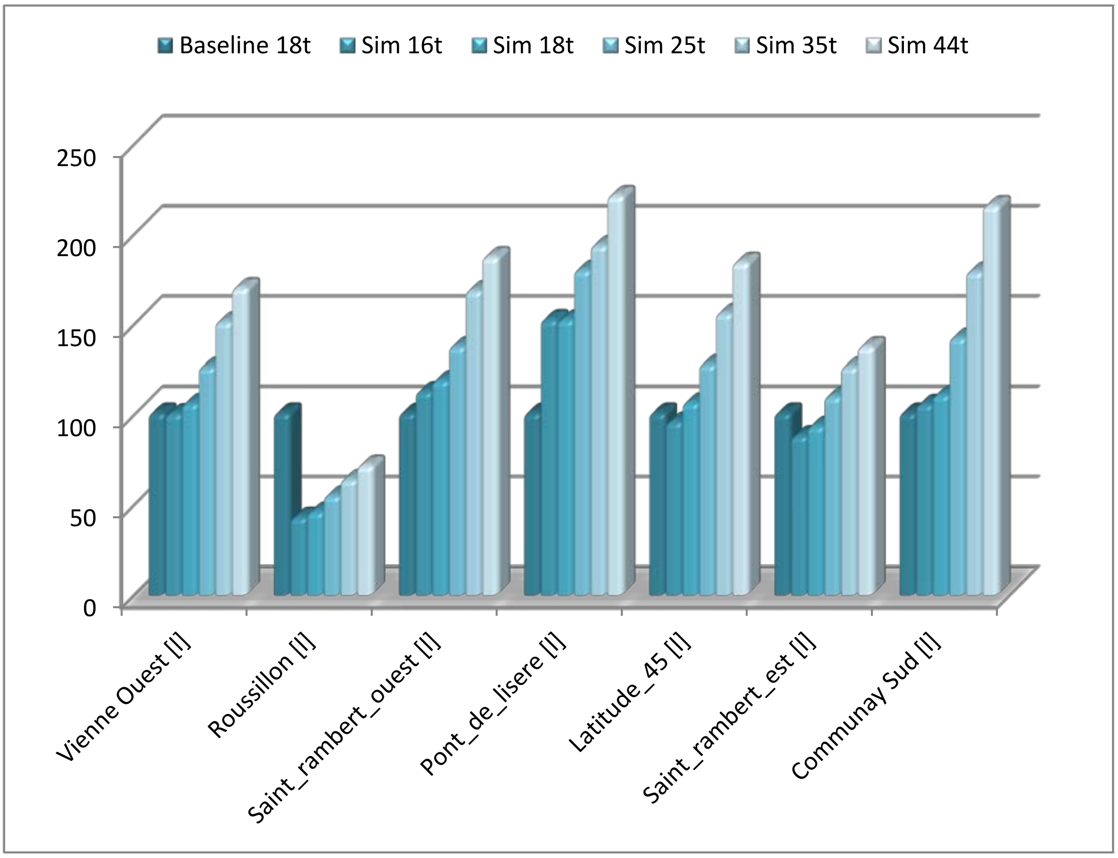


Figure 61 - Simulated Consumption compared to baseline in percentage

Consumption measured of simulated for different areas		Baseline 18t	Sim 16t	Sim 18t	Sim 25t	Sim 35t	Sim 44t
measure	Vienne Ouest [l]	0,0	0,4	-5,4	-25,4	-50,4	-69,2
	Roussillon [l]	0,0	57,9	54,9	45,9	36,9	29,1
	Saint_rambert_ouest [l]	0,0	-11,8	-18,1	-36,7	-67,8	-86,4
	Pont_de_lisere [l]	0,0	-51,5	-51,5	-79,1	-92,9	-120,4
	Latitude_45 [l]	0,0	4,8	-5,8	-26,9	-55,1	-83,3
	Saint_rambert_est [l]	0,0	12,7	7,2	-9,1	-25,5	-36,4
	Communay Sud [l]	0,0	-4,8	-10,0	-41,5	-78,1	-114,8

Table 36 - Reduction of percentage values compared to baseline

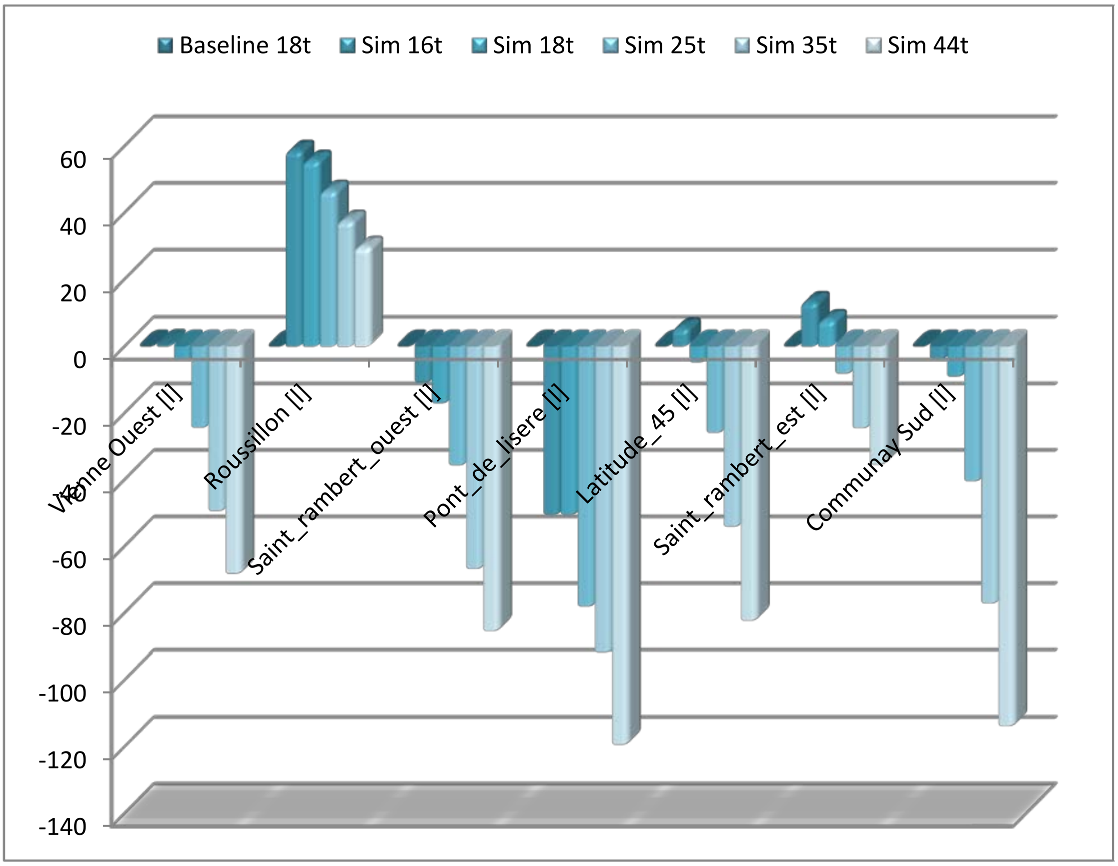


Figure 62 - Reduction of percentage values compared to baseline

3.4.2.1 Extrapolation of consumptions for different weights of truck

Recall of the extrapolated data:

		consumption in liter of fuel					
Area	Area classification "a priori"	Baseline 18t	Sim 16t	Sim 18t	Sim 25t	Sim 35t	Sim 44t
Vienne Ouest	normal area	2,6	2.6	2,7	3,3	3,9	4,4
Roussillon	big area	3,3	1,4	1,5	1,8	2,1	2,4
Saint Rambert Ouest	normal area	1,6	1,8	1,9	2,2	2,7	3,0
Pont-de-l'isére	normal area	0,7	1,1	1,1	1,3	1,4	1,6
Latitude 45	normal area	1,4	1,4	1,5	1,8	2,2	2,6
Saint Rambert Est	normal area	1,8	1,6	1,7	2,0	2,3	2,5
Communay Sud	positive slope area	1,9	2,0	2,1	2,7	3,4	4,1

Table 37 – Extrapolated data

After first analyzes, it seems important to adapt the extrapolated results for different reasons:

- We understand that the simulation model used doesn't give relevant results when a majority of speeds are very low (0 to 20km/h). That the case for the "Roussillon" extrapolation. The consumption of the truck is twice the simulation. The simulation model underestimates the consumption for low speeds. We cannot eliminate the "Roussillon" area measure because this is the only one from the "big area" type. We chose to correct the simulation by applying the same factor found between Baseline 18t and Sim18t (2.2).
- The "Vienne Ouest" measure took into account a set of data that has been made before the decided starting point. The "Vienne Ouest" area is the smallest but generates this huge consumption compare to others. We choose not to use this area for the next step of extrapolation, other normal areas are available and can be used.
- As we have seen it before, we also won't take into account the "Pont de l'Isère" data set because of a too short measurement.

The corrected set of value is exposed below:

		consumption in liter of fuel					
Area	**Area classification "a priori"**	**Baseline 18t**	**Sim 16t**	**Sim 18t**	**Sim 25t**	**Sim 35t**	**Sim 44t**
Roussillon	big area	3,3	3,1	3,3	3,7	4,6	5,3
Saint Rambert Ouest	normal area	1,6	1,8	1,9	2,2	2,7	3,0
Latitude 45	normal area	1,4	1,4	1,5	1,8	2,2	2,6
Saint Rambert Est	normal area	1,8	1,6	1,7	2,0	2,3	2,5
Communay Sud	positive slope area	1,9	2,0	2,1	2,7	3,4	4,1

Table 38 – Corrected data

The values for consumption need to be unique for each type of areas. We choose to average the values for the normal area type. The simulated consumptions are extrapolated from the baselines measured from the field. So, the consumption for "scale up process" will be :

	consumption in liter of fuel					
Area classification	**Baseline 18t**	**Sim 16t**	**Sim 18t**	**Sim 25t**	**Sim 35t**	**Sim 44t**
big area	3,3	3,1	3,3	3,7	4,6	5,3
normal area	1,6	1,6	1,7	2	2,4	2,7
positive slope area	1,9	2,0	2,1	2,7	3,4	4,1

Table 39 – Data for scale up process

3.4.2.2 "Scale up process"

The Scale up process aims to estimate the gain in terms of saved fuel by using the EcoTruckParking application at the scale of a national network. The ASFA motorway network gathers all the great majority of French motorways that are in capacity of implementing such an application.

ASFA network represents (figures of 2011):

- 8847.4km
- 365 services areas
- 625 rest areas

Measurements have been done considering different topologies of truck areas so we need to know the number of corresponding area of each type. By sorting the services areas regarding the number of truck places, we can say that:

- 68% of areas are from the "normal" size (less than 50 places),
- 27% from the "big size" (more than 50 places),
- 5% from the "positive slope" type.

Nota: "Negative slope" type have been merged with "Normal size" type to face the lack of dedicated measurements.

The total number of Truck Places on Service Areas for the ASFA network is 19235 (**TPSA**).

3.4.2.3 Determination of the unsuccessful number of stops

3.4.2.3.1 Number of truck stops offered by the network

ASFA has observed that only the night hours are rush hours to park a truck, and only on Services area. On the night hours, the drivers stopped for an average length of 8 hours and choose mainly to stop on service areas. Indeed, the service areas offer more comfort and adapted services than rest areas. Drivers choose to stop on rest area only if service areas are full:

- We define night hours as 10 hours between 20h and 6h -> Night Hours Length (NHL) = 10 hours
- We know that the stop length of a truck is approximately 8 hours -> Stop length SL = 8hours

We can estimate that a simple place can offer on the 10 hours of rush period, **TPS**= NHL/NL =10/8=1,25 stops.

So, the Total Number of Stops offered by Services Area on night hours / days (TNSSA) is:
TNSSA= TPS* TPSA= 1,25*19235=24043,75

24043,75 truck can stops in rush hours on service areas (amount of stops during peak hours).

3.4.2.3.2 Number of unsuccessful stop

To go further, we need to determine:

- How many trucks are present on the motorways on the night hours
- How many trucks really want to stop

Data from 2012 ASFA statistics teaches us that for the median (and not the average) days, 199 462 single trucks have made a toll transaction on the network, that is to say that 199 462 trucks are on the network a normal day (**TND**); Sunday is excluded. We suppose the presence of trucks on the network is uniform on 24h, so, the number of truck for the night hours (**TNH**) to be considered is:

TNH= **TND***10/24 = 199462*10/24=83109,45 trucks

At the stage, this is important to deal with the difference of behavior between national and foreign trucks. Indeed, studies have been made and say that when considering a normal travel, 75% of French trucks sleep at home, and we estimate that around 20% of foreign trucks do the same.

We also estimate that 80% of trucks spend the night on the motorway network, the others, after a travel on the network, go outside on truck centers or dedicated spots.

These information translated in figures:

	Number of Trucks on night times	Percent of truck that really make a stop for night	Percent of trucks that make a stop on the motorway network	Stops of trucks on motorway network
French Trucks	58176,62	25%	80%	11635,32
Foreign Trucks	24932,83	80%	80%	15957,01
	83109,45			**27592,33**

Table 40 – Overall stops by trucks

The number of Stops of Trucks on the ASFA Motorway Networks **STMN** =27592,33

We have calculated that TNSSA= 24043,75 trucks can stops in rush hours on service areas, so it's easy to deduced the estimation of unsuccessful stops made by night. Remember that drivers choose to stop on rest area only if service areas are full and so generate an unsuccessful stop (this considering that every truck success to stop at the second trial).

The number of Unsuccessful Stops made by Night , USN = STMN-TNSSA:

USN=27592,33-24043,75 = **3548,58**

So for a year (nights of Sunday are not included because of the restriction of truck traffic in France):

USY=USN*52*6=3548.58*52*6= **1 107 160,18**

USN estimation is backed up by real observations: we observe that around 50% of the rest areas trucks places offered are occupied on the night hours. There are 7280 truck places on rest area on ASFA network and we have just estimated USN at close to half this number.

3.4.2.4 Determination of wasted fuel linked to unsuccessful stop

Different consumptions have been determined for different topologies of areas. We will now combine these data with the number of services areas concerned and the different populations of trucks.

For the first point, we choose to retain three types of areas:

- Big area, areas with more than 50 truck places
- Normal area, areas with less than 50 truck places
- Positive slope area, estimation of 5% of all the areas

Nota: "Negative slope" type have been merged with "Normal size" type, to face the lack of dedicated measurements.

So the ASFA network can be sorted by 68% of areas of more than 50 truck places , 27 % of areas of less than 50 truck places and 5% areas in positive slope.

The whole population of trucks on the network can be sorted by weight using ASFA statistics. Considering the truck weight parameter, we need to adjust statistical data that are presented in the study with the weight simulated (see the table below)

Statistical data		
Total Weight of a Truck	Percentage of the whole population	Corresponding Weight Simulated
3,5 to 10 ton	**6%**	16 ton
10 to 20 ton	**29%**	18 ton
20 to 30 ton	**20%**	25 ton
30 to 40 ton	**24%**	35 ton
40 to 50 ton	**21%**	44 ton

Table 41 - Correspondance between statistical data and simulated weight

Now, the combination of the truck weight parameter, the area topology parameter and the annual number of unsuccessful stops will give us the annual total amount of wasted fuel. The distribution of stops is linearly done regardless the topology of the area:

	% of the whole population	nb of annual unsuccessful stops
Normal area	68,00%	752868,92
Big area	27,00%	298933,25
positive slope areas	5,00%	55358,01
Total	100,00%	**1107160,18**

Table 42 – Number of annual unsuccessful stops

Consumption is calculated by following the formula:

Consumption=number annual of stops for the topology of area considered * number of liter for the topology of area considered and the truck weight considered

Truck weight	**3,5 to 10 t**	**10 to 20 t**	**20 to 30t**	
% of truck population	6%	29%	20%	
Normal area	72275,41627	371164,3773	301147,5678	433652,4976
Big area	55601,58402	286079,1178	221210,6031	330022,3052
Positive slope area	6642,961054	33713,02735	29893,32474	45172,13517
Total	**134519,9613**	**690956,5225**	**552251,4956**	**808846,938**
				Consumption Gra total (l)

Table 43 - consumption associated to unfruitful stops in liter per year

The volume of fuel liters wasted annually by searching a truck place without finding it can be estimated, for the scale of a country like France (ASFA network), as 2 993 827,54.

3.4.2.5 Using eCoTruckParking application / conclusions

Drivers have been interrogated for an ASFA survey. They were 51% to consider that truck parking availability is an useful information to have on board and 24 others % said that this is very useful. We could say that 75% of drivers are interested by using eCoTruckParking application.

The penetration rate of such an application is difficult to approach and could considerably modify the conclusions of this study. Indeed the real use of the application must be considered when determining the total amount of saved fuel.

The following table shows the total amount of fuel calculated above, corrected by a supposed penetration rate of the application and a supposed percentage representing the number of effective uses of the application.

	Uses of the application			
penetration rate of the application	60%	70%	80%	90%
50%	**898 148**	**1 047 840**	**1 197 531**	**1 347 222**
40%	**718 519**	**838 272**	**958 025**	**1 077 778**
30%	**538 889**	**628 704**	**718 519**	**808 333**
20%	**359 259**	**419 136**	**479 012**	**538 889**

Table 44 – Total amount of fuel saved

References

Ref	Doc
[D2.10]	ecoStrategic Model (eStraM)
[D5.1]	Use cases and system requirements
[D5.2]	Architecture and system specification
[D5.3]	Extension of simulation functionalities and test site modelling
[D5.4]	System prototype implementation
[D5.6]	Prototype implementation of the applications and components
[D5.7]	Development and testing of traffic management and control measures
[D5.8]	Setup, manual and experiences with the traffic management and control applications
[D5.10]	Traffic management and control simulation results
[D6.3]	Validation results

Table 45 - Referenced finalised eCoMove deliverables