REDUCTION
2011-2014

Deliverable 4.3.1
Report on second pilot
(to be used for field study 2)

28-08-2014
D4.3.1 [Report on second pilot (to be used for field study 2)]

Public Document
D4.3.1 [Report on second pilot (to be used for field study 2)]

Project acronym: REDUCTION

Project full title: Reducing Environmental Footprint based on Multi-Modal Fleet management Systems for Eco-Routing and Driver Behaviour Adaptation

Work Package: 4


Document subtitle: Software architecture in phase 2 of field trails

Version: 1.4

Official delivery date: August 31, 2013

Actual publication date: ________________

Type of document: Report

Nature: Public

Authors: A. Lois, M. Morssink, W. Pover, A. Haddu, D. Zweijtzer, N.T. Larsen, C.J. Nielsen, J. Grabocka, K. Mouskos

Approved by: ________________

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Sections Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>31/07/2013</td>
<td>Initial version</td>
</tr>
<tr>
<td>1.1</td>
<td>26/08/2013</td>
<td>Added input from partners</td>
</tr>
<tr>
<td>1.2</td>
<td>__________</td>
<td>Review comments processed</td>
</tr>
<tr>
<td>1.3</td>
<td>29/01/2014</td>
<td>Review comments processed</td>
</tr>
<tr>
<td>1.4</td>
<td>28/08/2014</td>
<td>Interim remote review processed</td>
</tr>
</tbody>
</table>
Table of Contents

1. INTRODUCTION ......................................................................................................................... 8
   1.1 SCOPE OF WORK PACKAGE 4 ......................................................................................... 8
       1.1.1 Overview of WP1, WP2, WP3 and their tasks ......................................................... 9
   1.2 SCOPE OF DELIVERABLE 4.3.1 ...................................................................................... 9

2. TARGETED FUNCTIONALITIES ............................................................................................... 10

3. FLEXDANMARK FIELD TRIAL ............................................................................................... 11
   3.1 MULTI-MODAL TRANSPORT ......................................................................................... 11
   3.2 CHANGING MODALITY ................................................................................................. 14
   3.3 TRIP-BASED DATA ........................................................................................................ 17
   3.4 CHALLENGES SECOND FIELD TRIAL ........................................................................ 19
   3.5 EXPERIENCES FROM THE DAILY USE OF TRIP BASED DATA COLLECTED CONTINUOUSLY ........................................................................................................ 20
   3.6 MULTI-MODAL TRANSPORT IN ACTION ....................................................................... 21

4. TRAINOSE FIELD TRIAL ......................................................................................................... 23
   4.1 MULTIMODAL WEB SITE – SHORT DESCRIPTION ...................................................... 23
   4.2 UPDATING THE MULTIMODAL WEB APPLICATION .................................................... 26

5. NICOSIA FIELD TRIAL .......................................................................................................... 39
   5.1 ARCHITECTURE OF THE OSEL AND CPO FLEET FIELD TRIAL PROTOTYPE SYSTEM ......................................................................................................................... 41
   5.2 SPECIFICATIONS OF THE OSEL FLEET TRIAL TECHNOLOGIES .................................. 44
       5.2.1 DELPHI OBU V2X/CCU Technical Data Summary .................................................. 44
       5.2.2 DDE OBU Installation Requirements ....................................................................... 45
   5.3 COSTAS PAPAELLINAS ORGANIZATION (CPO) FLEET TECHNICAL SUMMARY ............ 45
       5.3.1 CPO Installation Requirements .............................................................................. 48
   5.4 OBSTACLES IN RUNNING THE FIELD TRIAL ............................................................... 49

6. TRINITÉ FIELD TRIAL ............................................................................................................. 51
   6.1 REDUCTION APP FIRST IMPLEMENTATION ............................................................... 51
       6.1.1 REDUCTION App – drawbacks .............................................................................. 52
   6.2 REDUCTION APP SECOND IMPLEMENTATION .......................................................... 52
       6.2.1 Overview ATM architecture ................................................................................... 54
       6.2.2 Origin – Destination relationship .......................................................................... 55
       6.2.3 REDUCTION App data .......................................................................................... 55
       6.2.4 REDUCTION app push messages eco driving ......................................................... 56
       6.2.5 Resolve the first field test drawbacks .................................................................... 56
   6.3 INTEGRATING TRAFFIC INFORMATION FROM PARTNERS ........................................ 57
       6.3.1 Interface description ............................................................................................... 58
   6.4 FUTURE PLANS .................................................................................................................. 60

7. RISK ASSESSMENTS .............................................................................................................. 62
8. CONCLUSION ................................................................................................................................. 63
GLOSSARY ........................................................................................................................................... 65
REFERENCES ....................................................................................................................................... 66
APPENDIX - XSD INTERFACE DESCRIPTION .................................................................................... 68

List of tables

Table 1: Tasks academic partners ........................................................................................................... 9
Table 2: Summary table of deliverable 4.3.1 ............................................................................................ 9
Table 3: Associations of technologies and partners versus field trials ..................................................... 10
Table 4: Comparison of Digital Network for Vehicles types. ................................................................. 13
Table 5 Application description Web TRAINOSE .................................................................................. 25
Table 6 Interoperability .......................................................................................................................... 58
Table 7 Risk overview ............................................................................................................................ 62

List of figures

Figure 1 Architecture overview of Implementation .................................................................................. 11
Figure 2: Digital Network for Rails Northern Jutland, Denmark, Map from Google ............................... 12
Figure 3: Digital Road Network for Busses, Northern Jutland, Denmark. Map from Google ............... 13
Figure 4: The Annotated Graph .............................................................................................................. 15
Figure 5: Annotated Graph with Weights ............................................................................................... 16
Figure 6: The joining of Independent Graphs using Location Edges (the black Arrows) ....................... 17
Figure 7: Finding Trips on a Route ......................................................................................................... 18
Figure 8: Using High-Frequent GNSS Data to Identify Intersections ..................................................... 19
Figure 9: A vision about flextrips .......................................................................................................... 21
Figure 10: Operation of communication path .......................................................................................... 28
Figure 11: Basic architecture diagram of multi modal service ................................................................. 29
Figure 12: Zones of the city .................................................................................................................... 30
Figure 13: Selection of origin and destination ......................................................................................... 31
D4.3.1 [Report on second pilot (to be used for field study 2)]

Figure 14: Selection of the train schedule ......................................................... 32
Figure 15: Seat selection .................................................................................... 32
Figure 16: Registration and extra services .......................................................... 33
Figure 17: City zone selection ........................................................................... 34
Figure 18: Taxi booking ...................................................................................... 35
Figure 19: Payment .............................................................................................. 36
Figure 20: Previous operational state ................................................................. 37
Figure 21: Current operational state ................................................................. 37
Figure 22: Cyprus Fleet Field Trial Pilot System Architecture diagram .............. 42
Figure 23: CPO OBD Guard ............................................................................... 46
Figure 24: REDUCTION App first implementation ............................................ 51
Figure 25: Screen App ....................................................................................... 51
Figure 26: REDUCTION App implementation architecture diagram ................. 53
Figure 27: Area Traffic Manager architecture ................................................... 54
Figure 28: Routes inside ATM ......................................................................... 55
Figure 29: REDUCTION system architecture .................................................... 57
Executive Summary

The REDUCTION project follows a multidisciplinary approach to the challenge of reducing the CO2 emissions via intelligent transportation systems. The project is composed of several main pillars: eco-routing, multi-modal eco-routing, eco-driving and distributed data mining. Consortium partners (UHI, UTH, AU, AAU, DDE) offer methodological contributions in the Work Packages 1-3, while industrial partners (CTL, TRAINOSE, FlexDanmark) will test the developed methodologies in three concrete field trials, as described in Work Package 5.

The consortium is committed to accomplish four field studies. The FlexDanmark field trial (Task 5.2) will enable verifying the efficiency of the eco-routing algorithms developed in Work Package 3, while the test-bed will be the taxi routing platform of FlexDanmark. Similarly the TRAINOSE field trial (Task 5.3) is dedicated to elaborating multi-modal eco-routing techniques and applies them to a train-bus hybrid traffic topology. Finally the Nicosia field trial (Task 5.4) will enable the validation of the eco-driving and distributed data mining approaches of Work Package 2 and the communication device and protocols designed by Work Package 1. The study will analyse the data and vehicular communication of a public bus fleet in Nicosia. In addition to the three field trials covered by the tasks of Work Package 5, a new field trial will be organised by Trinité with a focus on eco-routing for individual users through a portable “iPhone” eco-routing application.

Work Package 4 is devoted to the development of several modules elaborated in the life-span of the project and their integration. In this deliverable (D4.3.1) the primary focus will be on describing the advances in the prototype as described in the previous deliverable (D4.2). The software architecture and communication protocols to be used will be elaborated more extensively, which can be used for the field trials of Work Package 5.

The architectural description will follow a modular fashion. All field studies (FlexDanmark, TRAINOSE and Nicosia) utilise specialised software stacks that implement the methodologies tailored for the focus of analysis. Naturally, the software stacks of each use case comply with the technical requirements imposed by the underlying infrastructure of the field trial companies and interact with the support systems of the respective provided services. The specific software architecture to be used in all the field trials (FlexDanmark, TRAINOSE, Nicosia and Trinité) is covered in depth throughout this deliverable, as well as the inter-modal communication and interaction between modules that is carried through web-service technologies.
1. Introduction

The reduction of CO2 emissions is a great challenge for the transport sector nowadays. Despite recent progress in vehicle manufacturing and fuel technology, still a significant fraction of CO2 emissions in EU cities is resulting from road transport. Therefore, additional innovative technologies are needed to address the challenge of reducing emissions. The REDUCTION project focuses on advanced ICT solutions for managing multi-modal fleets and reducing their environmental footprint. REDUCTION collects historic and real-time data about driving behaviour, routing information, and emissions measurements that are processed by advanced predictive analytics to enable fleets enhance their current services as follows:

1) Optimising driving behaviour: supporting effective decision making for the enhancement of drivers education and the formation of effective policies about optimal traffic operations (speeding, braking, etc.), based on the analytical results of the data that associate driving-behaviour patterns with CO2 emissions;
2) Eco-routing: suggesting environmental-friendly routes and allowing multi-modal fleets to reduce their overall mileage automatically; and
3) Support for multi-modality: offering a transparent way to support multiple transport modes and enabling co-modality.

REDUCTION follows an interdisciplinary approach and brings together expertise from several communities. Its innovative, decentralised architecture allows scalability to large fleets by combining both V2V and V2I approaches. Its planned commercial exploitation, based on its proposed cutting edge technology, aims at providing a major breakthrough in the fast growing market of services for "green" fleets in EU and worldwide, and present substantial impact to the challenging environmental goals of EU.

1.1 Scope of work package 4

The main objective of WP4 is to have a real-time publish-subscribe distributed middleware with generic functionalities. The functionalities from WP1, WP2 and WP3 will be integrated based on different interfaces.

Requirements on software level for the envisaged final software product are collected and the software architecture is defined. The software architecture will be based on the principles of i) publish-subscribe, and ii) distributed middleware. Such architecture provides higher levels of abstraction, hiding the complexity of dealing with a variety of platforms, networks and low-level process communications. Application developers may concentrate only on the current requirements of the software to be developed, and use lower-level services provided by the middleware when necessary.

The software development of the case studies in WP5 will use the system design and architecture in this work package as a framework to integrate different functionalities.
1.1.1 Overview of WP1, WP2, WP3 and their tasks

WP1, WP2, WP3 are mainly contributed by the academic partners. The academic partners and their tasks are shown in Table 1.

<table>
<thead>
<tr>
<th>University Thessaly (WP1)</th>
<th>Wireless communication including V2I and V2V</th>
<th>Duration from M1 to M30</th>
</tr>
</thead>
<tbody>
<tr>
<td>University Hildesheim (WP2)</td>
<td>A predictive model to educate drivers to improve driving</td>
<td>Duration from M1 to M36</td>
</tr>
<tr>
<td>University Aalborg and University Aarhus (WP3)</td>
<td>Eco-routing algorithm, based on fuel consumption and GHG emission models</td>
<td>Duration from M1 to M36</td>
</tr>
</tbody>
</table>

Table 1: Tasks academic partners

1.2 Scope of deliverable 4.3.1

Deliverable 4.3.1 aims to describe the pilot software and the relevant functionalities that will be offered in the second phase of the field studies. Such deliverable will cover a detailed description of the software architecture of the various modules contained by the modules of each work package. The internal dependencies and interactions of functionalities inside the module of each field trial will be elaborated. In addition interfaces to connect between functionalities across field trials will be covered through inter-connecting web-services. A summary of the objectives of this deliverable is given in Table 2.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>To describe the extended and more detailed functionalities for WP1, WP2 and WP3, to be used for phase 2 of the field trials.</td>
<td>The functionalities are described in chapter 3, 4, 5 and 6.</td>
</tr>
<tr>
<td>To describe the software and system architecture that is needed for phase 2 of the field trials.</td>
<td>The architecture is described in chapter 3, 4, 5 and 6.</td>
</tr>
<tr>
<td>To show the relationships and interoperability between the different field trials.</td>
<td>The relationships and interoperability is described in §6.3.</td>
</tr>
</tbody>
</table>

Table 2: Summary table of deliverable 4.3.1
2. Targeted functionalities

Primarily the methodologies developed in the REDUCTION projects will be validated through the four designed field trials namely: FlexDanmark, TRAINOSE, Nicosia and Trinité. The technologies to be deployed together with the corresponding field trial where they will be tested are depicted in Table 3. A tick (+) denotes that the respective technology of the first column will be deployed on the field trial, whose column contains the tick.

<table>
<thead>
<tr>
<th>Technology (Partner(s))</th>
<th>Work Packages</th>
<th>Field Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicular Communication (DDE)</td>
<td>WP1</td>
<td>FlexDanmark</td>
</tr>
<tr>
<td>P2P Communication and Analytics (UTH, UHI)</td>
<td>WP1,WP2</td>
<td>TRAINOSE</td>
</tr>
<tr>
<td>Eco-Driving (UHI, TRI)</td>
<td>WP2</td>
<td>Nicosia</td>
</tr>
<tr>
<td>Eco-Routing Taxi Fleet (AU, AAU, FlexDanmark)</td>
<td>WP3</td>
<td>Trinité</td>
</tr>
<tr>
<td>Eco-Routing Individual (TRI)</td>
<td>WP4</td>
<td></td>
</tr>
<tr>
<td>Multimodal Eco-Routing (TRAINOSE)</td>
<td>WP5</td>
<td></td>
</tr>
</tbody>
</table>

*Table 3: Associations of technologies and partners versus field trials*

The reproducibility of the technologies across sites is not highly spread, as Table 3 shows. This however is not going to be a problem, since the technology of every work package will define standardised output on CO2 emission, fuel consumption and travel time, to be used as input definition of the integral software architecture of WP4. In other words, the technologies developed in the different field trials are loosely coupled to the integral software architecture of WP4.

The architecture of the software to be used in the first phase of the mentioned field trials is described in each of the following dedicated chapters:

- Chapter 3 – **FlexDanmark** field trial, second pilot architecture description
- Chapter 4 – **TRAINOSE** field trial, second pilot architecture description
D4.3.1 [Report on second pilot (to be used for field study 2)]

- Chapter 5 – Nicosia field trial, first and second pilot architecture description
- Chapter 6 – Trinité field trial, second pilot architecture description

3. FlexDanmark Field Trial

The following main issues will also be addressed in the second field trial for FlexDanmark advancing the prototype.

- Multi-modal transport using buses and mini-buses/taxis/trains will be covered in detail.
- Using a set of trips will be large and cover a larger geographical area; ideally the second field trial should look at one year of trips from FlexDanmark covering all of Denmark.
- A number of minor technical changes that will not be covered in this deliverable.

Compared to the first field trial at FlexDanmark the software prototype is extended with functionality to handle specialised digital road maps as described in D3.1. These specialised maps describe where buses and trains can stop. The overall architecture of the prototype is unchanged for details on the software architecture please see D4.2.

![Figure 1 Architecture overview of Implementation](image)

**3.1 Multi-modal Transport**

The digital networks used for trains, buses, and taxis are quite different. In addition, these networks are not digitally interconnected; special links need to be generated to connect the taxi digital
network to the corresponding bus and train networks, respectively in order to achieve the use of multi-modal transport, e.g., taxi + bus and/or train or bus + train. This is illustrated in Figure 2 and Figure 3 that outlines the rail network and bus network for Northern Jutland, Denmark. These two networks can be compared to the much larger and finer grained network for taxi, which can use all roads in the underlying digital network shown in both Figure 2 and Figure 3.

Figure 2: Digital Network for Rails Northern Jutland, Denmark, Map from Google.
D4.3.1 [Report on second pilot (to be used for field study 2)]

The networks are compared in the Table 4 below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Detail Level</th>
<th>Vehicle Types</th>
<th>GNSS Data</th>
<th>CANBus Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>Coarse</td>
<td>Trains only</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Buses</td>
<td>Medium</td>
<td>Buses, minibuses</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Taxi/person car</td>
<td>Fine</td>
<td>Taxi, minibuses, buses, trucks</td>
<td>Large</td>
<td>Medium</td>
</tr>
</tbody>
</table>

*Table 4: Comparison of Digital Network for Vehicles types.*

Table 4 shows that the detail level of the train network is coarse and in fact is a special network. The train network is only used by trains and for the second field trial neither GNSS data or CANBus data is available for estimating travel time or fuel consumption of the trains.

For buses the level of detail of the digital network is medium. By buses we mean buses that drives...
on specific routes to pick up passengers typically according to a schedule. The digital road network used by buses and minibuses is typically a subset of the complete road network used by person cars/taxis with the addition of a number of roads that can only be used by buses (“traps” in road network such that taxis and person cars cannot use the special bus roads). Table 4 shows that for the second field trial a medium set of GNSS data and CANBus data is available.

For taxi/person cars Table 4 shows that a very detailed digital road network is used. This road network is used by most vehicle types. For taxis/person cars a very large set of GNSS data is available and a medium set of CANBus data.

From Table 4, Figure 2, and Figure 3 the following challenges must be addressed in the second field trial.

- Find the digital road network for trains and buses.
- Estimated the travel-time for trains from the train schedule.
- Estimate the fuel consumption of trains from the literature.
- Enable multi-modal routing.

The multi-modal routing is clearly the biggest challenge for the second FlexDanmark field trial. However the challenge with finding train/bus networks and the fuel consumption is non-trivial. The multi-modal routing will therefore focus on the route from the city of Aalborg to the city of Frederikshavn (both larger cities in Northern Jutland Denmark). The Aalborg-Frederikshavn route has been chosen for the following reasons.

- It is a route that is often used.
- It is serviced by train, buses, speedy-buses, and taxis.
- There is a substantial difference on the travel-time experienced by train compared to taxi and bus.

### 3.2 Changing Modality

The major new item explored in the second FlexDanmark field trials is the multi-modality, which is currently not supported in the software prototype developed. In this prototype the fundamental data structure used for computing travel-time and eco-routes is a directed graph. Graphs are very well-supported data structure in the software used and graphs can be very efficient to use. For these reasons the second field trial will reuse the graphs as the underlying fundamental data structure. However, the graph data structure must be annotated with additional information. This is illustrated in Figure 4.
In Figure 4, the yellow road network illustrates the taxi/person car currently used. The green parts of the graph illustrate the bus road network (or bus routes) that are added to the complete graph. Finally, the blue parts of the graph illustrate the train routes. Note that is possible to change

- from taxi to bus in nodes A, C, D, and E, and
- from taxi to train in nodes A and F, and
- from bus to train in node A.

Annotating the graph makes it possible to retain the idea from the first field trial where eco-weights are added to all edges in the underlying graph. This is illustrated in Figure 5 where fuel weights have been added to all edges for all three networks.

*Figure 4: The Annotated Graph*
To implement the joined annotated graph illustrated in Figure 5 a set of independent graphs will be joined by creating locations where it is possible to change modality. The locations are basically new edges added to the joined graph. The idea with these new locations is illustrated in Figure 6. Here the upper green taxi/person car graph (or road network) is joined with the train network (Figure 2), and the bus network (Figure 3). The black edges in Figure 6 are the new locations.

Note that location edges must be manually annotated with travel time. As an example, one location edge can be annotated with a 30 minutes travel-time to illustrate that changing from a taxi to a bus takes considerable time because the bus drives according to a fixed schedule and the passenger has to walk from the taxi stop to the bus stop and wait for the bus to arrive.
3.3 Trip-based Data

The first field trial looked at point-based measurements (low-frequent GNSS data). Where high-frequent GNSS data is available such data will be integrated in the second field trial. The main benefits of trip-based GNSS data are that real-world effects such as turn-time and signal coordination can be taken into consideration for both the travel-time and the fuel consumption. The extra data provides more accurate estimations.

Figure 7 shows how trips created from high-frequent GNSS tracks on the street Vesterbro in Aalborg, Denmark can be identified using start (S) and end (E) markers on a digital map. When the user clicks on the blue route between the start and end points the actual trip information about the route will be shown. In Figure 7, the pop-up box shows that 350 trips are found on Vesterbro on a 1,241 meter road stretch with an average travel-time of 165 seconds. The fuel consumption is here listed as Not-Available (N/A) because we for this road have plenty of GNSS data but currently no CANBus data.
Figure 7: Finding Trips on a Route

To enable the user of the system to study the influence of, for example, signalised light intersections, Figure 8 shows the speed details for the latest ten trips on Vesterbro in Aalborg (not exactly the same part of the road as shown in Figure 7). Figure 8 clearly shows where vehicles often stop (or lower the speed) due to traffic lights or roundabouts. The columns to the right allow the user to filter the trips examined, by for example only selecting Wednesdays between 8:00 and 9:00 in the years 2010-2013 to show the effect of morning congestion. Note that the route picked Figure 7 may contain both left and right turns.
3.4 Challenges Second Field Trial

The multi-modal scheduling is the main new issue explored in the second field trials. Here there are a number of challenges that need to be addressed; these are the following.

- Penalty for changing modality?
- How many times can a passenger change modality on a trip?
- From which modality are switches allowed?
  - Taxi → train → taxi? Makes sense
  - Taxi → bus → taxi? Probably does not make sense!
- How will the bus/train schedule be taken into consideration?
  - This will be handled in a simplified manner in the field trial to avoid having to
D4.3.1 [Report on second pilot (to be used for field study 2)]

integrate with the complete train/bus schedule systems.

3.5 Experiences from the daily use of trip based data collected continuously

The following are the main experiences and lessons learned from the field trial.

- More efficient routes and more precise driving times.
- Reduction of disputes with drivers who disagree with the estimated driving time; more objective.
- Ability to produce an ecological estimate of the trip GHG emissions and fuel consumption.
- Set-up the framework such that in the future the GHG-emissions can be reduced based on more efficient GHG-routes.
- Generally positive experiences when it comes to drivers and companies.

A full implementation in two out five regions was to go countrywide in June, 2013; yet we are waiting for the go ahead which is expected towards the end of 2013. FlexDanmark is not in control of whether the Danish traffic companies will use the described methods but are continuously encouraging them to adopt them.

The REDUCTION results could potentially be used in the future in following settings.

- In tenders, there can be up to 10 – 12 a year
- Driving behaviour
  - Used by taxi companies today
  - Electrical cars
  - Bonus and punishment

For FlexDanmark there will, of course, always have to be a very tight balance between achieving ecological goals and revenue. FlexDanmark’s main right for existence lies in us being able to secure transport as cheap as possible within the parameters politically decided.

In terms of achieving more eco-friendly driving, no matter which method chosen, it will probably be necessary with either national incentives or restrictions. As stated earlier, we have to provide the cheapest possible transport within the parameters set and if GHC reduction is one of them we will adapt to that.

The results so far from REDUCTION that enabled us to provide much more accurate driving times
have in fact made us interested for also handling ambulances in and out of our system in an efficient manner. That is a significant step forward and a sign that we are on the right track.

### 3.6 Multi-modal Transport in Action

We are engaged in a continuous process to provide safe, punctual and secure multi-modal transport in every corner of Denmark. To do so we have ventured into a project, this is briefly visualised in Figure 9 below.

![Figure 9: A vision about flextrips](image)

The final goals for FlexDanmark are to provide transport with the following characteristics.

- A better service in rural areas
- That customers makes **one** order for **one** multi-modal trip and gets **one** bill
- A better overview and understanding of multi-modal trips
- Have continuous real-time information
- Automatic trip rescheduling when delays occur
D4.3.1 [Report on second pilot (to be used for field study 2)]

In the REDUCTION project, the fundamental steps for fulfilling these goals will be taken. This is in particular better support of rural areas using multi-modal transport and a better overview and understanding of multi-modal transport.

A goal of the second field trial is to add at least two specialised maps one for trains and one for buses. The GNSS data and CANBus data from the first field trial should be reused in the second field trial, but updated such that any new data received is also taken into consideration. The trips used to evaluate multi-modal trial should at least be the approximately 53,000 trips used in the first field.
4. TRAINOSE Field Trial

The second field trial for TRAINOSE is about the improvement and advancing the prototype over the proposed multimodal web-application and algorithms from the first trial. Fields where the improvement took place were:

1. Updating the Multimodal Web Application
2. Updating the network
3. Updating the network features though the usage of external sources (or daemons)
4. Introduction of Demand-Responsive Transit (DRT) systems
5. Apply DRT systems for the TRAIN-TAXI multimodal service in Thessaloniki

In the following sections, each one the above mentioned improvements will be described in more details. But first a short description of the site is given.

4.1 Multimodal Web Site – Short Description

The Web Multimodal Application is one of TRAINOSE’s contributions along with locomotive drivers driving behaviour models and TRAIN-TAXI Service.

The application offers multimodal transportation information to TRAINOSE customers when they seek for travel information in Greek Territory. Application described shortly in the following table:

<table>
<thead>
<tr>
<th>Application Purpose</th>
<th>To offer multimodal transportation information to TRAINOSE customers in an ECO way.</th>
</tr>
</thead>
</table>

User interface is quite simple, since it has to be "light" enough and not confusing for its purpose. There are two main webpages.

1. Input Web Page. This web page is devoted to users input. Page is divided to two areas. Right area is dedicated to users’ input information via the following UI elements.
   1.1. "Travel Calculation". Travel calculation is used for the definition of how users choose to define Origin, Destination points. (it can be by address, by lat/lon pairs, by transportation Point)
   1.2. "Travel Date". This field describes the desired travel date.
   1.3. "Way of travel". Users can choose among ECO, Cheapest, Fastest way of traveling.
   1.4. Search Button. User clicks on this button in order to get trip results.

Right area contains graphical elements for better visualization of the Origin/Destination Points.

2. Results Web page. This webpage contains trip results as the result of trip calculation in the Input Web Page. It is divided into three parts.
   2.1. The Header part contains (Graphical / Text) information of how user can reach the nearest transportation station form his/her origin point.
   2.2. The middle part contains detailed information related to multimodal trip, and transportation (Bus, Train, Ferry etc.) means that have been used for the trip.
   2.3. The footer part contains information of how user can reach his/her destination address from the last trip leg station.
### Functionalities

Application functionalities divided to concealed and unconcealed functionalities.

- Unconcealed functionalities are for application users, and they are related to trip calculations and trip information.
- Concealed functionalities devoted to application administrators and their main purpose is the updating/deletion/insertion of:
  1. Time tables for bus, trains, and ferries.
  2. Schedules for bus, trains, and ferries.
  3. Network Nodes.
  5. Ticket prices for bus, trains, and ferries.
  6. CO2 emissions.

### Application Data

Application data pool contains the following data.

1. Nodes (Bus/Train/Ferry Stations)
   1. 105 Central Bus Stations
   2. 365 Train Stations
   3. 8 main Ports
   4. 2 mains Airports
2. Links. 685 links each one with its own
   1. Timetable
   2. Ticket price
   3. Travel time
   4. Travel distance
   5. CO2 emissions

### Types of Trips

Depending on user's selection from the “way of traveling” UI element, application can produce the following trip results.

1. Minimum cost trips. Usually these trips are Train trips since trains are cheaper than busses in Greek territory.
2. Minimum time Trips. Usually these trips are bus trips since train trips suffering from low to medium transfer delays between different lines.
3. Minimum CO2. These trips always use trains when it is possible since the average CO2 per KM is significantly lower for trains than for busses.

*Table 5 Application description Web TRAINOSE*
4.2 Updating the Multimodal Web Application

1. The Web application improved in the following fields
   - Maps operation updated to a newer version in order to support Greek set character.
   - The CO2 emissions for each network arc can be defined in a discrete way for every arc. By using this methodology we can use as many arcs we wish for the same pair of origin and destination depending of the vehicle type, time, traffic conditions etc.
   - Updating the way where somebody can visit each transportation organization when this transportation organization is presented to the detailed route schedule.

2. Updating the Network
   - New arcs and nodes have been added to the application database
     - Nodes.
       - Airports. Two main airports of Greece have been included (Thessaloniki, Athens)
       - Ports. Main Ports of Greek islands have been included.
         - Port of Piraeus
         - Port of Chania (Crete)
         - Port of Heraklion (Crete)
         - Port of Mykonos (Cycladic)
         - Port of Rhodes
         - Port of Santorini
     - Arcs
       - All arcs connecting ports of Port of Piraeus to other ports
       - All arcs connecting airports to central train stations
3. **Updating the network features through the usage of external sources (or info daemons).**

In order to keep updated (travel time, CO2 emission, distance etc.) our multimodal application, we have to establish a procedure capable of updating the system in real-time. The idea behind this is that other modules of the project should update the application in real-time. So the main question is what kind of solutions could be used? Various solutions can be proposed but any proposed solution should “obey” to the following preconditions:

- *To be independent of various IT systems.*
- *To use a well-known and standardised communication tech.*
- *To ask just for small changes that will not affect current services offered by transportation organizations or other entities who use road networks.*

In order to fulfil these requirements, we choose Web-API services as the main communication technology. This technology:

- *Uses standard http, https protocols, used everywhere (clients or servers)*
- *Offers Complete isolation from the local systems and databases*
- *It is quite easy way to implement it.*

The operation of the communication path presented in the following chart.
Any Http client (curl? web browser? etc.) initiates http calls (see Figure 10). These calls update networks arcs for the CO2 emission and any other arc feature (travel time, distance, vehicle type, etc.)

Any update is recorded for statistical reason and for post-processing study.

The above mentioned procedure is operational and can be tested any time. The following link presents the URL call for the updating procedure.

http://194.177.200.85/link/UpdateLink - This is the absolute path

http://194.177.200.85/links/UpdateLink/YYY - this is the absolute path along with the arc number (YYY).

http://194.177.200.85/link/UpdateLink/YYY?co2cost=XXXX. – This is the absolute path along with the arc number (YYY) and the appropriate CO2 cost number.

The above mentioned URL links describe the general model that will be used in order to provide updating paths for the entire database tables.

For each updating procedure we have to define the updating protocol. This protocol defines the type of information that has to be exchanged between external sources and the database. A simple algorithm can be defined in order to describe the whole updating process.

| Step 0. Standardization of the updating protocol |
| Step 1. Design of the minimum set of webapis for updating |
| Step 2. Execute some trials in order to test "onlines" nature and synchronization |

4. **Introduction of DRT Taxi system as a cooperative system with trains.**

DRT (demand responsive transportation systems) can operate additionally to multimodal application. Especially in areas where the main transportation means from the train central station to the city centre (or bus stations) is the taxi. Generally speaking these systems facilitate personal mobility needs where no fixed transportation lines are available, while providing high quality services at a relatively low cost. The proposed TRAIN-TAXI system is based on the idea of grouping users’ trip in such a way that the cost of the system is reduced without deviating too much from the shortest path of each user.

5. **Train-taxi prototype.**

Train-TAXI service is based on a combination of trains and taxis. Right now this service is available
for the city of Thessaloniki. The idea behind this multimodal service is quite simple. Each passenger who likes to travel to the city of Thessaloniki by train can ask for a taxi to reach his/her home destination. Web Application, books the train ticket and the taxi ride. The taxi fare is fixed and it is lower than the official ones. The background process is the application of “dial a ride” algorithms in order to match more than one customer to one taxi-ride. Taxis Itinerary delivered to taxi drivers, while passenger informed about his/her ride taxi number.

The basic architecture of this multimodal service can be described by the following Figure 11.

6. Description of the test site.

Test site for the second field trial is the city of Thessaloniki. City is divided in 17 zones (see Figure 12). Each zone has its own tariff. Tariff calculation was based on the average tariff for each area reduced by 20%.
Taxis fleet has 25 taxis and their start position is the central station in Thessaloniki. Passenger after they disembark from the train goes to a predefined point for taxis parking station. Passengers present their train-taxi ticket and take the appropriate taxi for their home destination. The original home address is irrelevant to the system since passengers pay only for the zone price.

7. Site description

Train taxi service offered to passengers via the original TRAINOSE web site. Passenger enters to the site, and books his/her trip. If the destination is the city of Thessaloniki then the service of train taxi popups. Following Figure 13 until Figure 19 present the exact booking procedure for TRAIN-TAXI Service.

Step 1: Selection of Origin, Destination
D4.3.1 [Report on second pilot (to be used for field study 2)]

Figure 13: Selection of origin and destination

After the selection of the origin point (destination is Thessaloniki) passenger proceeds next, where train selection should be made.
Step 2: Selection of the train schedule

Figure 14: Selection of the train schedule

Step 3: Seat Selection

Figure 15: Seat selection
Next Step is the Passenger Registration and the extra services (train-taxi) if any

Step 4: Registration and Extra services

Figure 16: Registration and extra services
If passenger makes the choice for extra services then, goes directly to the train taxi service.

Step 5: City Zone Selection

Figure 17: City zone selection
Next step is the booking for train taxi

Step 6: Taxi Booking

With our TRAINOTAXI service you can cover the last mile to your destination at rates lower than the taxi fare and operate in Katerini, Edessa and Xanthi.

**Figure 18: Taxi booking**
Last step is the payment

**Step 7: Payment**

![Payment screenshot](https://tickets.train-taxi.gr/dromologio/)

**Figure 19: Payment**

**TRAIN-TAXI service in Thessaloniki first results.**

Our study on this, related to reduce oil consumption as the result of the DRT operation. Clearly the way we apply our service leads to less oil consumption.

The following Figure 20 present the previous and the current operational state.
D4.3.1 [Report on second pilot (to be used for field study 2)]

**Previous State**

![Previous State Image]

*Figure 20: Previous operational state*

However if we apply dial-a-ride algorithms then many trips can be merged in a more profitable way. The following Figure 21 presents one possible outcome as the result, after the use of dial-a-ride algorithms.

**Current State**

![Current State Image]

*Figure 21: Current operational state*
Some Metrics: based on real data from TRAINOSE Database Logs

1. **One Day Experiment**
2. **95 taxi trips**
3. **136 Persons**
4. **Total Number of KM for all trips:** 3930 KMs!
5. **Total Oil Consumption:** 275 lts (7 litres per 100Kms for city trips)

Same Day, after Dial a Ride algorithms application

1. **Total Number of KMs:** 1122 KMs
2. **Fleet:** 8 Vehicles (24 hours availability)
3. **Average Distance Deviation:** 5%
4. **Average Time Deviation:** 11%
5. **Total Oil Consumption:** 79 lts (7 litres per 100Kms for city trips)
6. **CO2 Reduction? Yes. How Much?**
7. **2.68 KGs/Lt* (275-79)Lt = 525 Kgs per Day**

The above mentioned results show clearly that the application of TRAIN-TAXI service can improve significantly the CO2 emissions.
5. Nicosia Field Trial

The Nicosia fleet field trial architecture is described in D4.2. Since the fleet field trial has not yet started, it is incorporated here as well that describes also the addition of the Costas Papaellinas Organization (CPO) (in addition to the OSEL bus company) that operates a fleet of 120 vehicles. For completeness the architecture is repeated here in this section as well.

The main objectives of the field trial are:

1. Demonstrate the Delphi Delco Electronics GMBH (DDE) Vehicle to Vehicle and Vehicle to Infrastructure (V2V/V2I) device capabilities
2. Demonstrate a fuel efficiency and/or emissions reduction through a driver bus and delivery fleet monitoring system using the REDUCTION technologies:
   a. Read, store and send to a server CANbus data
   b. Analyse the driving pattern of fleet drivers (bus and delivery)
   c. Develop a fleet drivers’ eco-guide to reduce fuel consumption and emissions
   d. Validate the drivers’ eco-guide at a field trial.

Based on the changes to organization of the field trial and the involvement of Cyprus Papaellinas Organization (CPO) as reported in Deliverable 5.2, the Cyprus fleet field trial is expected to be carried out on two different fleet types:

1) The Nicosia OSEL bus driver behaviour field trial will be conducted to test the capabilities of the DELPHI OBU V2X/CCU devices (On Board Unit) in retrieving CANbus fuel consumption, GHG emissions and GPS vehicle location and speed data, storing them on its solid state disk and disseminating this data remotely to a server for post processing. The bus field trial is conditional on the ability of the OBU devices to read the CITARO Mercedes-Benz CANbus data.
   a. A preliminary test that was conducted in March 2013 was not successful in reading the CITARO bus CANbus data.
   b. DDE in cooperation with CTL will conduct one more test using the CITARO bus and try to read the CANbus data via the buses’ fleet management port in August 2013. If the second bus trial is not successful then the 5 OBU (On Board Unit) devices will be installed at 5 fleet vehicles of the CPO Company.

2) The Cyprus CPO fleet field trial will involve up to 68 delivery vehicles from the company CPO with the support of IST. A selected set from these 68 vehicles will be utilised by CTL and its REDUCTION partners to analyse the driving behaviour of the drivers to develop fuel-efficient driving guidelines for the CPO drivers. A preliminary data collection will start in
August 2013 and is expected to continue until February 2014 for both phases of the field trial. As stated earlier, if it is found that it is not feasible to read the CANbus data from the OSEL Citaro buses then the five OBU devices will be installed at five CPO vehicles such that the objectives set for the field trial are fulfilled. Further, the REDUCTION consortium will decide whether to extend the field trial beyond February 2014 as necessary.

Recently through the aid of IST, CPO has installed a fleet management system at 68 vehicles of its fleet with the aim to improve the driving record both in terms of safety and fuel efficiency.

- CPO will provide up to 68 vehicles equipped with its fleet management system to be utilised for REDUCTION
- CPO will assist the REDUCTION partners in carrying out the fleet trial via the IST system integrator
- CPO will provide feedback on the results of the field trial.

Nicosia OSEL Bus Field Study Summary

REDDUCTION contribution to OSEL field trial: This architecture is all new for OSEL.

Test Bed: Nicosia Greater Region
Number of Buses: 5 Mercedes-Benz CITARO buses
Number of Routes: 5 buses operating on the following potential routes with final destination the centre of the City at Solomou Square which is the main bus terminal: 116 (Syn. Strovolou), 158 (Pera Horio Nesou), 160 (Geri), 110 (Pano-Lakatameia), 112 (Tseri), 157 (Aredniou)
Operational times: ranging from 5:00 to 21:00 and frequencies of 15 to 30 minutes during weekdays and up to 90 minutes on the weekends.
Length of route: ranges from 4 to 20 Km as most of the routes cover communities outside the greater Nicosia region while all arriving at the centre of the City of Nicosia at the main bus terminal of Solomou Square.
Clients: five (5) OBU devices; to be installed at each bus.
Servers: one server and one back-up server provided by Istognosis Ltd. Company
Wireless communication: From/To OBU devices, To/From server via 3G MTN network

Development of OSEL fuel-efficient driving profiles: REDUCTION contribution to OSEL.

Nicosia CPO Fleet Field Trial Summary

REDDUCTION contribution to CPO field trial: The CPO already implemented a fleet management system. The main new aspect of the CPO field trial will be the development of fuel-efficient driving profiles that will be based on the methodologies that will be developed by the REDUCTION partners.

Test Bed: Nicosia Greater Region with potential of utilizing the entire Cyprus region
Number of delivery vehicles: up to 68
Number of deliveries per day p
D4.3.1 [Report on second pilot (to be used for field study 2)]

Operational times: ranging from 7:00 to 18:00
Length of routes: ranges from 2 to 110 Km; where the longer trips refer to deliveries from Nicosia to Paphos area and the shorter trips within the Nicosia region.
Clients: up to 68 FMS devices; already installed by the system integrator Istognosis Ltd. Company (external to REDUCTION)
Servers: one server and one back-up server provided by Istognosis Ltd. Company (external to REDUCTION)
Wireless communication: From/To FMS devices, To/From server via 3G MTN network (external to REDUCTION)
Development of CPO fuel-efficient driving profiles: Main REDUCTION contribution to CPO.

5.1 Architecture of the OSEL and CPO fleet field trial prototype system

The advances in the architecture of the OSEL Bus and CPO Fleet Field trial system will be based on the paradigm of client server realised in four layers, namely: data capture layer that will be realised by a number of clients, application layer, database layer and web interface as an additional layer. A detailed pictorial description of the architecture used to conduct the Nicosia field trial is shown in Figure 22.

System’s clients will mainly concentrate on data capture activities through monitoring the on-board sensors via sniffing the transmission lines of the bus’s local area network. Each client will be composed of a number of modules. Depending whether the transmission of the monitored data will be realised in real-time or batch mode the analogous data transmission modules will be activated on the clients. Specifically for real time transmission a 3G mobile network will be utilised. For batch processing the data will be stored on the clients’ data store and uploaded on the data server using an ftp connection with the server-side, upon entering the Wi-Fi zone of the bus depot. Client sub-systems will be installed on five OSEL CITARO Mercedes-Benz buses. Clients will be equipped with the Delphi Delco Electronics GMBH (DDE) DDE DELPHI OBU V2X/CCU device (OBU). The CPO has already installed its own fleet management system. Under REDUCTION, an API software will be installed that will gather CANbus data from each CPO delivery vehicle and send to the CPO server.

Data sniffing will be achieved through the OBU that reads data indirectly from the wiring of the buses LAN and via the Fleet Management wirings since the OBD port of the CANbus can only be hooked to a proprietary CITARO Mercedes-Benz device. A potential alternative is to read the data via the Citaro Fleet Management System port; this approach will also be explored. The CANBus data that will be read by the OBU are: GNSS, fuel consumption and GHG emissions. The CANBus data that will be read by the CPO FMT are: GNSS at 10 sec time steps, fuel consumption at 2-second time steps; no GHG emissions are readily available.
The server side of the architecture will mainly address the data warehousing functionality and will be composed of: (a) a web server for real time communication with the clients, (b) an application server accountable for data analysis and visualization using (c) an embedded GIS subsystem and (d) UI functionalities. The back end of the architecture will mainly focus on data storage and retrieval functions along with data replication. Pre-processing of the raw data from the on-board sensors will be performed by the clients hence the data will be ready for storage upon arriving to the data server. Data transmitted to the server via 3G will be compared with batch-mode data, firstly for validation purposes, secondly to test the robustness of the communications network and thirdly to check the capabilities of OBU to operate in real-time environments. The populated data warehouse will be mined using relevance analysis and association rules techniques to identify possible links between driving behaviours and fuel/CO2 emission plus, the identification of driver profiles using cluster analysis.
Data Processing:

The main data processing functions that will take place at the server-side include:

1) All GNSS, fuel consumption and GHG emissions data will be temporarily stored at the OBU SSD and if feasible will be sent in real-time using a 3G wireless service connection to the webserver; similarly all data read by the CPO API software will be sent to the CPO server for data analysis.

2) Data stored at the OBU SSD will be uploaded to the webserver periodically using an ftp connection on a daily basis (at a specific time at night); the data from the CPO delivery vehicles will be uploaded at one-minute time intervals using the MTN 3G network.

3) All GNSS data will be map-matched to the Nicosia GIS (obtained from the Ministry of Communications and Works) and will be also superimposed on Google maps. The openGIS software will be used; the GIS will be divided into links and nodes to represent intersections and roadway links. The links will form the basis for setting up the fuel consumption profiles for each driver.

4) Evaluate the V2V/V2I capabilities of the OBU device and the wireless communication system based on the data quality, route black spots and data recording by the Webserver. The V2V communications test will be conducted on a closed course under a controlled experiment. It is noted that the CPO fleet management system does not have V2V communication capabilities.

   a. V2I Communication: Data transmitted from the OBU to the Webserver

      i. Identify "dead spots" of the GNSS and/or the wireless service,

      ii. Report all communication "errors" as reported by the OBU

      iii. Compare the data stored at the SSD with the data send in real-time to the web-server via 3G.

   b. V2V Communication: Data from one My-FI installed in one bus to the OBU of other buses operating at the same time. It is emphasised that the V2V evaluation will be limited to data transmission, as no V2V actions will be undertaken due to the limited budgetary constraints for this field trial.

      i. Compare messages sent from one OBU and stored to another OBU.

5) Development of a set of driving profiles per driver using vehicle location, speed fuel consumption and GHG:
D4.3.1 [Report on second pilot (to be used for field study 2)]

a. Vehicle Speed Profile (Distance vs. Vehicle Speed)

b. Vehicle/Driver Fuel Consumption (Distance vs. Fuel Consumption); aggregated at the link level

c. Vehicle/Driver GHG Consumption (Distance vs. Fuel Consumption); aggregated at the link level

6) Identification of efficient and non-efficient driving patterns for specific roadway sections with respect to fuel consumption and GHG emissions.

5.2 Specifications of the OSEL Fleet Trial Technologies

The system architecture depicted in Figure 22 will be used as the blueprint for the realization of the pilot system. The components used in this architecture represent generic subsystems whose details are described below:

5.2.1 DELPHI OBU V2X/CCU Technical Data Summary

On board features:

- Industrial grade hardware compliance
- Standard x86 architecture INTEL® ATOM 1GHz with ext. temp. range -40°C to ~85°C
- On-board 1GB DDR2 RAM
- On-board 4GB Solid State Disk
- 1x DSRC radio
- 1x GPS (Fastrax)
- antenna setup:
  - dual-antenna support for DSRC
  - (can be reconfigured for standard 802.11a/b/g/n WLAN)
  - Enclosure prepared for multiple antennas (e.g. GPS, DSRC, 3G/4G/LTE)
- wide-range power supply (8 ~ 32V, 20W)
- internal protection against wrong polarity on connector
- customised enclosure for enhanced heat dissipation
- automotive grade connectors
- Operating System:
  - customised & ruggedized DELPHI-blend Linux
  - customised & ETSI compliant 11p stack and drivers

Exposed interfaces (via automotive connector):

- 1x IEEE 802.3 ETHERNET (10/100 Mbit)
- 1x USB2.0
D4.3.1 [Report on second pilot (to be used for field study 2)]

- 1x CAN (High-Speed)
- power supply lines (PWR, GND, IGN)

5.2.2 DDE OBU Installation Requirements

The DELPHI OBU V2X/CCU devices will be connected to the CANbus of the Citaro Mercedes-Benz through the OBD port.

**Hardware needs:**
- Five OSEL Citaro Mercedes-Benz buses or
  - Five CPO delivery vehicles
- Five DELPHI OBU V2X/CCU devices
- Five hard disks of 10 TB each (one for each bus)
- One PC server to receive the wireless data from the five DELPHI OBU V2X/CCU devices
- Multi-meter (voltage/amperes/resistance)
- Oscilloscope (optional)
- Soldering iron and solder
- Pliers, knife, isolation tape
- 0.8 sqr-mm copper-wire

**Software installation needs:**
- DELPHI OBU V2X/CCU device customised software to read the CANbus data from the Citaro Mercedes-Benz buses and send them
- Data plan with the MTN cellular telephony company operating in Cyprus

**Personnel needs:**
- DDE: DELPHI OBU V2X/CCU device expert
- OSEL: five bus drivers, one manager
- CTL: One manager, one IT expert
- UTH: One Communications scientist
- UHI: Project Manager, One data mining expert
- MCW-PWD: One official representative

5.3 Costas Papaellinas Organization (CPO) fleet technical summary

CPO’s involvement in the field trials will concentrate on the analysis of driving patterns of fleet drivers with the aim to reduce fuel consumption and emissions. The technologies used by CPO for this purpose are detailed below:

*CPO Fleet Management System*
D4.3.1 [Report on second pilot (to be used for field study 2)]

- OBD Guard (see Figure 23)
  - OBD-II Reader (Castel Group)
  - Optional GPS module (uBlox)
  - GSM/GPRS module (Telit)

![OBD Guard diagram]

**Figure 23: CPO OBD Guard**

- GSM/GPRS Specification
  - GSM module: Telit
  - GSM/GPRS: Quad band 850/900/1800/1900Mhz
  - Communication protocol: Embedded TCP/IP protocol

- GPS Specification
  - GPS chipset: SIRF Star III u-Blox
  - Channels: 20
  - Receiver frequency: 1575.42MHz
  - Cold start: approx 42s
  - Warm start: approx. 38s
  - Hot start: approx. 1s
  - Antenna: Built-in ceramic antenna

- Protocol Supported for ODB-II
  - J1850-VPW, J1850-PWM, KWP2000, ISO9141-2, CAN-BUS

- Features
  - OBD-II compliant.
  - Integrated GSM/GPRS, GPS optional.
  - Real-time vehicle diagnostic for monitoring and reporting.
  - Integrated 300 hrs of data storage. Data is stored on remote servers.
  - Built-in 3-axis acceleration G-Sensor module for towing alarm.
D4.3.1 [Report on second pilot (to be used for field study 2)]

- Alarms can be send via SMS.
- User access via USB or via web platform.
- Alarms
  - Speeding alarm setting
  - Hard acceleration alarm setting
  - Hard braking alarm setting
  - Temperature alarm setting
  - High RPM alarm setting
  - Low-voltage alarm setting
  - Extended Engine Idling alarm setting
  - Quick change line alarm setting
  - Sharp turn alarm setting
- PIDs
  - Engine Coolant Temperature(°C)
  - Engine RPM(rpm)
  - Vehicle Speed Sensor(km/h)
  - Mass Air Flow Sensor(g/s)
  - Calculated Load Value(%)
  - Intake Manifold Absolute Pressure(kPa)
  - Intake Air Temperature(°C)
  - OBD Require To Which Vehicle Designed
  - Distance Travelled While MIL Activated(km)
  - Fuel Rail Pressure(gauge)(10kPa)
  - Commanded EGR(%) 
  - Fuel Level Input(%) 
  - Barometric Pressure(Kpa)
  - Accelerator Pedal Position D(%) 
  - Accelerator Pedal Position E(%) 

- Software
  - API to read CANbus data from the OBD port
- Wireless Communication Data Plan
  - The MTN 3G network will be utilised to send the data from each fleet vehicle to the server
  - Frequency: from 2 to 10 seconds (the data plan will be decided by the end of August, 2013); currently the data frequency as set-up by IST for the CPO is one minute. The same data plan will be utilised for both OSEL and CPO.
5.3.1 CPO Installation Requirements

The CPO fleet management devices have been installed independently from REDUCTION by IST on the CPO delivery vehicles during July 2013. Under REDUCTION, IST will install an API to read the raw data from the vehicle CANbus using the OBD port. IST will purchase this API and CTL will reimburse them at a cost of $1000 (756 euro).

**Hardware needs:**
- Up to 68 CPO fleet vehicles equipped with the fleet management system
- Data storage server. The IST storage data server will be utilised, which is the same that it will be used for the CPO fleet management system.

**Software installation needs:**
- The API interface will be installed by IST to read and store the CANbus data for each fleet vehicle.
- CTL will assist IST throughout the API installation and testing
- UTH and UHI will assist in finalizing the data that will be gathered from the CANbus via the API software and the data storage

**Personnel needs:**
- DDE: DELPHI OBU V2X/CCU device expert (if the CPO fleet is utilised instead of the OSEL buses)
- CTL: One manager, one IT expert
- IST: One IT expert with the CPO fleet management system
- CPO: Up to 68 fleet drivers, one manager
- UTH: One Communications scientist
- UHI: Project Manager, One data mining expert
- MCW-PWD: One official representative.

**CPO Fleet Coverage area:**
- The greater Nicosia network will be the primary focus of the field study
- Additional routes for all delivery destinations covered by the 68 fleet management equipped vehicles may be added. The final list of the vehicles that will be covered for REDUCTION by the end of August, 2013; this list will determine also the coverage area.

**Data to be extracted from the OBD port:**
- GNSS data: vehicle location, speed; Frequency: every 10 sec (default); if feasible they will be gathered every 2 sec.
- Fuel Consumption Frequency: every 2 sec (to be gathered by the API)
- GHG emissions: GHG emissions are not readily available from the data list provided by the vendor; if feasible they will be included in the messages that will be retrieved from the CANbus.
5.4 Obstacles in running the field trial

The Nicosia OSEL bus field trial has been delayed due to the following reasons: OSEL requested that REDUCTION should provide a guarantee that the installation of the DDE devices on the OSEL Citaro Mercedes-Benz buses would not negate the Warranty of the buses. DDE explained that without the cooperation of Mercedes-Benz it would have been difficult if not impossible to be able to read the CANbus data from the Citaro Mercedes-Benz buses. By the end of October 2012 it was decided that such cooperation with Mercedes-Benz is not possible. DDE then informed CTL that there was a possibility that the CANbus data could be read indirectly by “sniffing” them from the bus wiring system. It was therefore agreed to proceed with the test using OSEL buses if OSEL would agree to participate. CTL in November 2013 informed OSEL whether they will participate in the field trial, based on the advice from DDE that the installation and testing of the devices will not be intrusive to their operation. After several discussions, CTL, DDE and OSEL agreed to conduct the “sniffing” diagnostic test in early March, 2013 – the time that all parties were available to do this test.

First OSEL Buses Diagnostic Test; 6th of March 2013: DDE during this test with the cooperation of OSEL and CTL tried to gather data streams by sniffing data from the bus wiring system. This test was not successful.

Second OSEL Diagnostic Test: As mentioned earlier, the first diagnostic test conducted by DDE and CTL on two OSEL buses in Cyprus on the 6th of March 2013 was not successful. However, it revealed that there was a possibility to read the data via the fleet management port of the Citaro Mercedes-Benz buses. DDE therefore, suggested that it was worthwhile to try once more by developing a connector that could fit with the Citaro fleet management connector. This second test is expected to be conducted in August 2013.

Back-up solution to the OSEL bus field trial, the use of CPO delivery company: Given this setback, in March 2013, CTL and DDE decided that we needed to find an alternative fleet to carry out the Nicosia fleet trial as a back-up solution. CTL therefore conducted the following potential participants: 1) Travel Express (an intercity taxi/minivan) company. 2) the EMEL Limassol bus company; 3) The CPO company. Among them the CPO was selected as the best potential solution since it was ready to install its own fleet management system that included GNSS and fuel data.

IST informed CPO in May 2013 of the desire of CTL to utilise their fleet management system, once installed, for the purposes of REDUCTION and specifically for the development of bus driver profiles using fuel consumption as the main parameter. IST during the months of May, June and July kept on updating CTL on the progress of the installation of the CPO fleet management system. IST also informed CTL in early July that CPO was looking favourably towards a potential cooperation with REDUCTION. Given these assurances, CTL informed the REDUCTION consortium at the Volos, Greece meeting (9-10/7/2013) that an alternative company has been found which could be used for carrying out the fleet field trial regardless of the outcome of the second diagnostic test using the OSEL buses. CTL subsequently met with CPO and IST and received a verbal agreement from CPO at
D4.3.1 [Report on second pilot (to be used for field study 2)]

A meeting conducted at the offices of CPO in mid-July, 2013. CTL proceeded to provide final confirmation to DDE that indeed we could utilise the CPO delivery company as a backup in case the second diagnostic test using OSEL Citaro Mercedes-Benz buses fails. Given these changes the Cyprus fleet field trial is expected to start in early August and be completed by Mid-March, 2013.
6. Trinité Field Trial

6.1 REDUCTION APP first implementation

The first implementation of the REDUCTION APP (see Figure 24) was focusing on the calculation of CO2 emission and fuel consumption. This information combined with GPS data is used to calculate a green eco-friendly route and optimizing driving behaviour to be used by individual users and fleet/freight companies.

Feedback for the users is calculated and delivered to the user when the location is reached. The travel time, fuel consumption, distance and CO2 emission is shown.

While driving the driver receives feedback on his driving behaviour, through CO2 emission rate, fuel consumption and current speed. Information about the current route is shown on the App the user gets presented the most Eco-friendly route (green line), most economical route (purple line), fastest route (blue line) and shortest route (red line).
6.1.1 REDUCTION App – drawbacks

The Field trial revealed some Technical problems.

- Power consumption of the App, by constant communication by sending the GPS location.
- User-unfriendly way of selecting route destinations.
- A lot of data is being stored that needs to be computed.

To resolve the drawbacks the design of the App is extended in order to solve the problems. Besides the technical problems the field test showed that there is a need to inform the driver more active, not only by showing the different routes, but also advising the driver actively about the area he is driving in and what possibility's the area has to offer in order to drive a more Eco-friendly, faster or more economical route.

6.2 REDUCTION App second implementation

The advances prototyping the second implementation of the REDUCTION App integrates the App in a middleware services that will act as enablers of decentralised algorithms and applications faced with the difficult task of sharing real-time streams of UTF mission-critical critical data and information over intermittently connected vehicular networks. Following REDUCTION’s decentralised computing approach, this middleware platform service components will be distributed on vehicles to tackle the real-time data movement needs of the overlaid analysis algorithms and applications. In addition, the platform will include a back-end server for the benefit of the UTF’s access to real-time fleet data as well as for longer-term data analysis and reporting.

The Area Traffic Manager (ATM) uses the real-time information to calculate the most economic and Eco-friendly route. Since the Area Traffic Manager also communicates with neighbouring Digital Road Authorities (ATM's) information about the route can be shared in order to optimise the network (Figure 26).
**D4.3.1 [Report on second pilot (to be used for field study 2)]**

**Figure 26: REDUCTION App implementation architecture diagram**

**DSS Datapool** Dynamic Subscribe System (DSS) Datapool is a real-time publish-subscribe distributed middle-ware. It provides a level of abstraction, by hiding the complexity of a variety of platforms, networks and low-level process communication. Application developers may concentrate on the current requirements of the software to be developed, and use lower-level services provided by the middle-ware when necessary.

**Desktop** A standard DSS user-interface, which is presenting DSS visual objects. It can be used in both personal computers and smart phones via a web application.

**MySQL-bridge** The interface between the DSS Datapool and database. DSS uses it to read/write...
D4.3.1 [Report on second pilot (to be used for field study 2)]

data from/to database. MySQL Database Bridge is used within the Trafficlink environment.

**PNB** Push Notification Bridge is the interface between DSS Datapool and the APNS.

**ATM** The Area Traffic Manager gets real time information. This information is used to calculate route information. The route information can be calculated from historical and/or real time data. Information gathered is coming from various kinds of sensors including CO2, weather, travel time, speed etc. The route information can be sent to in-car equipment but also to neighbouring ATM’s in order to optimise the network. The ATM consists of a number of sub-networks and calculates the performance of the combined sub-networks with real-time data. The routes are defined within each ATM. The ATM manages the set of routes from one origin to one destination. It gets GPS data and CO2 emission data from the App and other. It also gets real-time data of links through signal updates. The Eco-routing algorithms in T3.3 will be applied in the route object.

6.2.1 Overview ATM architecture

The Area Traffic Manager architecture is a hierarchical structure. ATMs are not road-section related, but Area related. In this way the whole of Amsterdam can be viewed as an Area Network, which is divided in several smaller areas (sub-networks Figure 27).

![Figure 27: Area Traffic Manager architecture](image)

Each area can communicate to its neighbours and ask for specific traffic services e.g. ‘reduce inflow’ and ‘reduce outflow’. In each area routes are defined and the ATM monitors the routes. The main purpose of the ATM is to keep the performance of the routes as good as possible. The ATM is responsible for optimal traffic flow. To create an optimal traffic flow the ATM can deploy various
measures. With each measure the ATM can actively control the traffic flow. (E.g. Green time traffic light, ramp-measuring device)

Each area has input and output entry points called AccessPoints. Between AccessPoints, routes are defined. (Figure 28).

6.2.2 Origin – Destination relationship
Between AccessPoints a matrix is defined. With the CO2-Emission and fuel matrix the most eco-friendly route can be calculated. The calculation for mapping the AccessPoints and GPS location is handled by the phone. Passing an AccessPoint will trigger the App to send his information to the ATM.

6.2.3 REDUCTION App data
The ATM’s collect all available information in their own area to inform traffic-controllers about the status of the roads inside the area. The ATM also uses the App data. When a driver passes an AccessPoint the App will send a signal to the system in order to inform the ATM that it has entered the area. When the App exits the ATM another signal will be send. With this information an ATM knows what Apps are inside his Area. This information can be used to actively inform drivers while driving inside the ATM area.
6.2.4 REDUCTION app push messages eco driving

Each area can inform drivers by sending a push message to the App. The ATM has several routes inside which are continuously monitored inside its boundaries. Based on the traffic information the ATM can calculate the most eco-friendly route. If a traffic jam is detected this information can be passed to the App users to inform the drivers to take a different route. The ATM will not only send the information to its own 'apps' but also to neighbouring ATM(s) so that the App users in that area are informed in advance. The calculated route can be adjusted based on the traffic information.

6.2.5 Resolve the first field test drawbacks

In the first field test a few drawback were encountered. In the second implementation of the App these points were minimised.

- Power consumption of the App

By reducing the communication between the App and the system battery life is enhanced. The App only sends a message when passing an AccessPoint. The calculation for mapping the AccessPoints and GPS location is handled by the phone.

- User unfriendly way of selecting route destinations

A new interface will be designed to enter the destination of the ride by using the zip code in combination with the house number. With this information the best route can automatic be calculated by the system based on real time traffic information.

- A lot of data is being stored that needs to be computed

Reducing the communication between app and ATM reduces the information stored by the system.
6.3 Integrating traffic information from partners

The DSS Datapool is optimised for data handling from many different sources. The European standard for traffic systems to exchange data is Datex II. In the next field-test all REDUCTION partners will be connected to the DSS Datapool. The ATM can use all the information from the partners to calculate an optimised Eco-friendly route (see Figure 29). Using the distributed middleware limitations are solved by breaking down the problem in several objects starting from measuring information to road segment to road to area.

Figure 29: REDUCTION system architecture
In *Table 6 Interoperability*, an overview is given of the different field trials and their functionalities.

<table>
<thead>
<tr>
<th>Case study</th>
<th>Details</th>
<th>Interoperability</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlexDanmark</td>
<td>Eco-routing,</td>
<td>Via DatexII</td>
</tr>
<tr>
<td>TrainOSE</td>
<td>Multi modal eco-routing</td>
<td>Via DatexII</td>
</tr>
<tr>
<td>Nicosia</td>
<td>Eco-driving and distributed data mining</td>
<td>Via DatexII</td>
</tr>
</tbody>
</table>

*Table 6 Interoperability*

### 6.3.1 Interface description

In this chapter the interface communication protocol is defined, to connect the different work packages of the REDUCTION partners to the DSS architecture.

The interface description is based on the Datex II definition. There are some information fields needed for this interface that are not defined in the Datex II standard. For those fields some information records are defined on top of the standard.

For security and authentication the standard VPN connection between two communicating systems is proposed.

There are two messages defined that needs to be exchanged between two communicating systems:

- A data message, containing data values that needs to be exchanged and
- A message reply, indicating the data message has been received successful or not successful.

The essential information that is exchanged within the data message is:

- CO2 emission, fuel consumption, travel time and velocity
- Identifier of the measured route, to relate the same route in two different systems.
- Location, length and geographical form of the route, to allow display on a geographical map.

The data message structure makes it possible to exchange one or more routes within one message and for each route one or more measurements.

The data message contains the following structure and field definition:
D4.3.1 [Report on second pilot (to be used for field study 2)]

<table>
<thead>
<tr>
<th>XML Name (DatexII)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Record: REDUCTIONInformation</strong></td>
<td></td>
</tr>
<tr>
<td>ModelVersion</td>
<td>(integer) Fixed value &quot;1&quot;</td>
</tr>
<tr>
<td>SequenceNr</td>
<td>(Int64) sequence number</td>
</tr>
<tr>
<td><strong>Record: ReductionSupplierIdentification</strong></td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>(string) Two letter country identification. &quot;nl, du, fr&quot;, etc</td>
</tr>
<tr>
<td>NationalIdentifier</td>
<td>(string) Fixed value: &quot;REDUCTION&quot;</td>
</tr>
<tr>
<td>Language</td>
<td>(string) Fixed value: &quot;en&quot;</td>
</tr>
<tr>
<td>MeasurementType</td>
<td>Enumeration with values: traject or point</td>
</tr>
<tr>
<td>SensorType</td>
<td>Enumeration with values: CO2 detector, calculated, ...</td>
</tr>
<tr>
<td><strong>Record: PollutionMeasurement</strong></td>
<td></td>
</tr>
<tr>
<td>PublicationTime</td>
<td>(datetime) Current time</td>
</tr>
<tr>
<td>StartTime</td>
<td>(datetime) Start time of the measurement series</td>
</tr>
<tr>
<td>EndTime</td>
<td>(datetime) End time of the measurement series</td>
</tr>
<tr>
<td><strong>Record: ReductionLocation (there can be multiple locations or trajects)</strong></td>
<td></td>
</tr>
<tr>
<td>LocationId</td>
<td>(string) Identifier of the location</td>
</tr>
<tr>
<td>TrajectDistance</td>
<td>(double) Unit: km. Distance of the measurement traject. Only filled in when it is a traject</td>
</tr>
<tr>
<td><strong>Record: ReductionLocationForDisplay (a location can have multiple points when it is a traject. This can be used to visually display the traject)</strong></td>
<td></td>
</tr>
<tr>
<td>Latitude</td>
<td>(double) Latitude of the coordinate in WSG84</td>
</tr>
<tr>
<td>Longitude</td>
<td>(double) Longitude of the coordinate in WSG84</td>
</tr>
<tr>
<td>Zvalue</td>
<td>(double) Height in meters above sea level (optional)</td>
</tr>
<tr>
<td><strong>Record: GeneralComment (multiple comments possible per traject)</strong></td>
<td></td>
</tr>
<tr>
<td>Comment</td>
<td>(string) Free text field</td>
</tr>
<tr>
<td>DateTime</td>
<td>(DateTime) Datetime of the comment</td>
</tr>
<tr>
<td>CommentType</td>
<td>(enum) Type of the comment</td>
</tr>
<tr>
<td><strong>Record: ReductionMeasuredValue (multiple measurement records possible, for multiple start times). Each traject can have one measurement record for each minute or other time scale. The measurements are over the whole track.</strong></td>
<td></td>
</tr>
<tr>
<td>CO2Emission</td>
<td>(double)</td>
</tr>
</tbody>
</table>
### D4.3.1 [Report on second pilot (to be used for field study 2)]

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FuelConsumption</td>
<td>(double)</td>
<td>(double) Speed in km/hour, of the measured vehicle</td>
</tr>
<tr>
<td>Velocity</td>
<td>(double)</td>
<td>(double) Traveltime over the traject in seconds.</td>
</tr>
<tr>
<td>TravelTime</td>
<td>(double)</td>
<td>(double) Specific exhaust value in ? Of the measured vehicle</td>
</tr>
<tr>
<td>VehicleType</td>
<td>(enum)</td>
<td>(enum) Typ of vehicle. Enum with the values: Car, Bus, Truck</td>
</tr>
<tr>
<td>MeasurementStartTime</td>
<td>(datetime)</td>
<td>(datetime) Start of the specific measurement</td>
</tr>
<tr>
<td>MeasurementEndTime</td>
<td>(datetime)</td>
<td>(datetime) End of the specific measurement. (optional) when not filled in the start and end time are the same.</td>
</tr>
</tbody>
</table>

The message reply is the answer to the previous data message, indicating that the data is received. The result can be an acknowledge or an error. In case of an error, the reason field can be used to give more information about the error condition that occurred.

The message reply contains the following structure and field definition:

<table>
<thead>
<tr>
<th>XML Name (DatexII)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledge</td>
<td>(Boolean) &quot;0&quot; (failed) or &quot;1&quot;</td>
</tr>
<tr>
<td>OrgSequenceNr</td>
<td>(Int64) sequence number of message for which this is a reply</td>
</tr>
<tr>
<td>Reason</td>
<td>(string) description of the error condition</td>
</tr>
<tr>
<td>DateTime</td>
<td>(DateTime) Time reply send</td>
</tr>
</tbody>
</table>

In chapter 10 Appendix – XSD Interface description, the complete XML definition (XSD) is. The partners of REDUCTION can use this XSD for implementation of the interface.

### 6.4 Future plans

In order to improve the REDUCTION App the integration of information for electric cars will be explored.

- Overview of electric charging points
- Availability of charging points
D4.3.1 [Report on second pilot (to be used for field study 2)]

- Making reservations for charging points
- Route information based on electric charging points.
7. Risk Assessments

The field trials involving FlexDanmark, Nicosia and TRAINOSE do not forecast deviations from the plan. The respective software stacks are being implemented, which means that the functionality is present in accordance with the description of work.

The Trinité field trial also doesn't forecast any deviations from the plan. Trinité detected drawbacks on the initial architecture like excessive power consumption, user-unfriendly way of operating the App and the large amount of data to be handled and stored and made the necessary modifications to the architecture to overcome the problems. The interface description has been added to connect different functionalities between the modules of the work packages. Interpretation differences on the interface description between the different partners could constitute a certain risk for future implementation and thus needs to be monitored seriously.

The delay experienced in the Nicosia field trial is expected to be fully covered and completed by the spring of 2014, within the boundaries of the REDUCTION project.

<table>
<thead>
<tr>
<th>Risk no.</th>
<th>Description</th>
<th>Impact</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>Problem with power consumption</td>
<td>Low</td>
<td>Modification in architecture.</td>
</tr>
<tr>
<td>2)</td>
<td>Data limitation.</td>
<td>Medium</td>
<td>Use of a layered architecture.</td>
</tr>
<tr>
<td>3)</td>
<td>Interface connection between the modules</td>
<td>Medium</td>
<td>Monitoring. Tuning of interaction in case interpretation differences.</td>
</tr>
<tr>
<td>4)</td>
<td>Delay Nicosia field trail</td>
<td>Low</td>
<td>Continue progress.</td>
</tr>
</tbody>
</table>

Table 7 Risk overview
8. Conclusion

Conclusions for the FlexDanmark field trial:

The field trail of FlexDanmark expands its architecture and geographical areas, based on the results of the first field study. Multi-modality is covered in detail and a larger set of trips, covering larger areas will be targeted. The experiments have shown that it is complex to work with CANbus data and that implementation of equipment to monitor the vehicles is not simple. The first field trials have also shown that we can gain valuable data from observing vehicles in operation. The experience of this round will be used to expand the number of vehicles and scope of the study in the next trial. The FlexDanmark field trial provides travellers serviced by FlexDanmark to select a route based on travel time, fuel consumption or emissions for taxis only or for multi-modal trips (taxi plus train, taxi plus bus/minibus).

Conclusions for the TRAINOSE field trial:

The second field trail of TRAINOSE has been improved on the following point:

1. Multimodal application has been improved and enriched in terms of:
   a. Operating features (algorithmic improvements and UI improvements)
   b. More coverage of the Greek territory. Airports (Athens, Thessaloniki), ports (Cyclades islands, Rhodes, Crete) were added as well.
   c. More coverage in terms of transportation means. Ferries, Urban busses, and metro lines in Athens.

2. Updating procedure for travel time and CO2 emissions has been defined and constructed. This updating procedure offers the communication path between external sources (Vehicle devices) and the multimodal application.

3. The introduction of an experimental DRT system for the City of Thessaloniki where the multi modal transportation of TRAIN, TAXI combination is an on-going process.

Conclusions for the Nicosia field trial:

The Nicosia field trial is comprised of two parts: The first part two different fleets are expected to be tested, the OSEL Nicosia bus fleet using five buses equipped with the DDE OBU devices and the Costas Papaellinas Organization delivery fleet (up to 68 vehicles – about 6 months of delivery route data) equipped with their own fleet management system. During the first part of the trial, the
driving profile of each of the drivers will be estimated using CANbus data (GNSS location, speed and acceleration; fuel consumption). The data will be analysed using data mining techniques to develop a set of guidelines for drivers in order to reduce fuel consumption. When these guidelines are developed after a satisfactory data sample is collected and analysed (about eight weeks) then the Second Phase of the field trial will start. The drivers will be instructed to follow the set-up guidelines and they will be monitored for another 8-week time period. The results will be summarised in a report. In addition, a feedback questionnaire will be distributed to the OSEL management, the CPO management, the OSEL and CPO drivers, and the Ministry of Communications - Public Works Department of Cyprus and summarised to capture the impact of the REDUCTION technologies as implemented in Cyprus for eco-driving.

**Conclusions for the Trinité field trial:**

The first field trial of Trinité showed some drawbacks on the REDUCTION App. The constant communication caused a significant amount of power consumption, selecting routes was not user friendly and a lot of data needs to be stored and computed. By adding the Area Manager to the architecture, vehicles can sign in and sign out when they are entering or leaving the area. This architectural change solves most of the drawbacks from the first field trial and is developed to be used in the second field trial. Also the interface description between the multi modal eco routing, eco driving, prediction and V2V communication system is being defined. This interface description can be implemented to integrate the information of CO2 emission, fuel consumption, location, speed and travel time into the DSS datapool architecture and Traffic Management System of Trinité Automation, TrafficLink. TrafficLink can be used to take active measures on the traffic flow of highways, provincial and urban roads, to reduce the CO2 emission in the designated areas.
Glossary

AAU  
Aalborg University

ATM  
Area Traffic Manager

AU  
Aarhus University

CANbus  
Controller Area Network bus

CO2  
Carbon dioxide

CTL  
Cyprus Transport Logistics

DDE  
Delphi Delco Electronics GMBH

DDM  
Distributed Data Mining

DSRC  
Dedicated Short Range Communication

DSS  
Dynamic Subscription Software

ETSI  
European Telecommunications Standards Institute

FD  
FlexDanmark

GHG  
Greenhouse gas

GIS  
Geographic Information System

GNSS  
Global Navigational Satellite System

GPS  
Global Positioning System

IVC  
Inter Vehicle Communication

M-GEMMA  
Genetic Map Matching Algorithm

P2P  
Peer to peer

TRI  
Trinité Automation

SSD  
Solid State Drive

SUMO  
The Simulator of Urban Mobility

UHI  
University of Hildesheim

UTH  
University of Thessaly

VANETS  
Vehicular Ad-hoc Networks

V2I  
Vehicle to infrastructure

V2V  
Vehicle to vehicle

VMS  
Variable Message Sign

WAVE  
Wireless Access in Vehicular Environments

WP  
Work package
References


D4.3.1 [Report on second pilot (to be used for field study 2)]

GLOBECOM. IEEE


Appendix - XSD Interface description

```xml
<x:schema elementFormDefault="qualified" attributeFormDefault="unqualified" version="2.2"
  targetNamespace="http://datex2.eu/schema/2/2_0_modified">
  
  <xs:complexType name="Comment">
    <xs:annotation>
      <xs:documentation>A free text comment with an optional date/time stamp that can be used by the operator to convey un-coded observations/information.</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="comment" type="D2LogicalModel:MultilingualString" minOccurs="1" maxOccurs="1">
        <xs:annotation>
          <xs:documentation>A free text comment that can be used by the operator to convey un-coded observations/information.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="commentDateTime" type="D2LogicalModel:DateTime" minOccurs="0" maxOccurs="1">
        <xs:annotation>
          <xs:documentation>The date/time at which the comment was made.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="commentType" type="D2LogicalModel:CommentTypeEnum" minOccurs="0" maxOccurs="1">
        <xs:annotation>
          <xs:documentation>A classification of the type of comment.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="commentExtension" type="D2LogicalModel:_ExtensionType" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
  
  <xs:simpleType name="CommentTypeEnum">
    <xs:annotation>
      <xs:documentation>Classification of comment types.</xs:documentation>
    </xs:annotation>
    <xs:restriction base="xs:string">
      <xs:enumeration value="abnormalValueNote">
        <xs:annotation>
          <xs:documentation>A free text human oriented note describing details of abnormal value associated with the Measurements.</xs:documentation>
        </xs:annotation>
      </xs:enumeration>
      <xs:enumeration value="dataProcessingNote">
        <xs:annotation>
          <xs:documentation>A free text human oriented note describing the way the information in the Record has been or should be processed.</xs:documentation>
        </xs:annotation>
      </xs:enumeration>
    </xs:restriction>
  </xs:simpleType>
</xs:schema>
```
D4.3.1 [Report on second pilot (to be used for field study 2)]

</xs:annotation>
</xs:enumeration>
<xs:enumeration value="description">
  <xs:annotation>
    <xs:documentation>A free text human oriented description of the measurement.</xs:documentation>
  </xs:annotation>
</xs:enumeration>
<xs:enumeration value="internalNote">
  <xs:annotation>
    <xs:documentation>A free text human oriented note that supports internal traffic control operations relating to the Record.</xs:documentation>
  </xs:annotation>
</xs:enumeration>
<xs:enumeration value="locationDescriptor">
  <xs:annotation>
    <xs:documentation>A free text human oriented description of the location of the elements defined by the Record.</xs:documentation>
  </xs:annotation>
</xs:enumeration>
<xs:enumeration value="warning">
  <xs:annotation>
    <xs:documentation>A free text human oriented warning relating to the Record.</xs:documentation>
  </xs:annotation>
</xs:enumeration>
<xs:enumeration value="other">
  <xs:annotation>
    <xs:documentation>Other than as defined in this enumeration.</xs:documentation>
  </xs:annotation>
</xs:enumeration>
</xs:restriction>
</xs:simpleType>

<xs:simpleType name="CountryEnum">
  <xs:annotation>
    <xs:documentation>List of countries.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:enumeration value="at">
      <xs:annotation><xs:documentation>Austria</xs:documentation></xs:annotation>
    </xs:enumeration>
    <xs:enumeration value="be">
      <xs:annotation><xs:documentation>Belgium</xs:documentation></xs:annotation>
    </xs:enumeration>
    <xs:enumeration value="bg">
      <xs:annotation><xs:documentation>Bulgaria</xs:documentation></xs:annotation>
    </xs:enumeration>
    <xs:enumeration value="ch">
      <xs:annotation><xs:documentation>Switzerland</xs:documentation></xs:annotation>
    </xs:enumeration>
    <xs:enumeration value="cs">
      <xs:annotation><xs:documentation>Serbia and Montenegro</xs:documentation></xs:annotation>
    </xs:enumeration>
    <xs:enumeration value="cy">
      <xs:annotation><xs:documentation>Cyprus</xs:documentation></xs:annotation>
    </xs:enumeration>
  </xs:restriction>
</xs:simpleType>
D4.3.1 Report on second pilot (to be used for field study 2)
D4.3.1 [Report on second pilot (to be used for field study 2)]
D4.3.1 [Report on second pilot (to be used for field study 2)]

```xml
<xs:documentation>Vatican City State</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs: enumeration value="other">
<xs: documentation>
<xs: annotation>
<xs: documentation>Other than as defined in this enumeration.</xs: documentation>
</xs: annotation>
</xs: enumeration>
</xs: restriction>
</xs: simpleType>

<xs: simpleType name="DateTime">
<xs: annotation>
<xs: documentation>A combination of integer-valued year, month, day, hour, minute properties, a decimal-valued second property and a time zone property from which it is possible to determine the local time, the equivalent UTC time and the time zone offset from UTC.</xs: documentation>
</xs: annotation>
<xs: restriction base="xs:dateTime"/>
</xs: simpleType>

<xs: simpleType name="Integer">
<xs: annotation>
<xs: documentation>An integer number whose value space is the set {-2147483648, -2147483647, -2147483646, ..., -2, -1, 0, 1, 2, ..., 2147483645, 2147483646, 2147483647}.</xs: documentation>
</xs: annotation>
<xs: restriction base="xs:integer"/>
</xs: simpleType>

<xs: simpleType name="Language">
<xs: annotation>
<xs: documentation>A language datatype, identifies a specified language by an ISO 639-1 2-alpha / ISO 639-2 3-alpha code.</xs: documentation>
</xs: annotation>
<xs: restriction base="xs:language"/>
</xs: simpleType>

<xs: simpleType name="MeasurementTypeEnum">
<xs: annotation>
<xs: documentation>Type of measurement. This enumeration indicates if the measurement are done on one point, or on a route, or in several related points in an area.</xs: documentation>
</xs: annotation>
<xs: restriction base="xs:string">
<xs: enumeration value="PointMeasurement"/>
<xs: enumeration value="TrajectMeasurement"/>
<xs: enumeration value="AreaMeasurement"/>
</xs: restriction>
</xs: simpleType>

<xs: complexType name="PollutionMeasurement">
<xs: annotation>
<xs: documentation>Record containing the overall time of the measurement.</xs: documentation>
</xs: annotation>
<xs: sequence>
</xs: sequence>
```
D4.3.1 [Report on second pilot (to be used for field study 2)]

<x:s:element name="PublicationTime" type="D2LogicalModel:DateTime"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="StartTime" type="D2LogicalModel:DateTime"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="EndTime" type="D2LogicalModel:DateTime"
minOccurs="1" maxOccurs="1"/>
</xs:sequence>
</xs:complexType>

<x:s:complexType name="ReductionInformation">
<x:s:annotation>
<x:s:documentation>Main reduction message, containing pollution measurements or calculations of several locations over several times</x:s:documentation>
</xs:annotation>
<x:s:sequence>
<x:s:element name="ModelVersion" type="D2LogicalModel:Integer"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="SequenceNr" type="D2LogicalModel:Integer"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="SupplierIdentification"
type="D2LogicalModel:ReductionSupplierIdentification"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="PollutionMeasurement" type="D2LogicalModel:PollutionMeasurement"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="MeasurementType" type="D2LogicalModel:MeasurementType"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="SensorType" type="D2LogicalModel:SensorType"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="Location" type="D2LogicalModel:ReductionLocation"
minOccurs="1" maxOccurs="UNBOUND"/>
</xs:sequence>
</xs:complexType>

<x:s:complexType name="ReductionInformationReply">
<x:s:annotation>
<x:s:documentation>Acknowledge reply to the ReductionInformation message</x:s:documentation>
</xs:annotation>
<x:s:sequence>
<x:s:element name="Acknowledge" type="D2LogicalModel:Boolean"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="OrgSequenceNr" type="D2LogicalModel:Integer"
minOccurs="1" maxOccurs="1"/>
<x:s:element name="Reason" type="D2LogicalModel:string"
minOccurs="0" maxOccurs="1"/>
<x:s:element name="PollutionMeasurement" type="D2LogicalModel:DateTime"
minOccurs="0" maxOccurs="1"/>
</xs:sequence>
</xs:complexType>

<x:s:complexType name="ReductionPointCoordinates">
<x:s:annotation>
<x:s:documentation>A pair of coordinates defining the geodetic position of a single point using the European Terrestrial Reference System 1989 (ETRS89)</x:s:documentation>
</xs:annotation>
<x:s:sequence>
D4.3.1 [Report on second pilot (to be used for field study 2)]

<xs:element name="latitude" type="D2LogicalModel:Float" minOccurs="1" maxOccurs="1">
<xs:annotation>
</xs:annotation>
</xs:element>

<xs:element name="longitude" type="D2LogicalModel:Float" minOccurs="1" maxOccurs="1">
<xs:annotation>
</xs:annotation>
</xs:element>

<xs:element name="Altitude" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1">
<xs:annotation>
<xs:documentation>Altitude is the Z-Value of the coordinate, the position in meters of the point above sea level.</xs:documentation>
</xs:annotation>
</xs:element>

<xs:complexType name="ReductionLocation">
<xs:annotation>
<xs:documentation>Location of a measurement device, or measurement route, with measurements attached to it</xs:documentation>
</xs:annotation>
<xs:sequence>
<xs:element name="LocationId" type="D2LogicalModel:String" minOccurs="1" maxOccurs="1"/>
<xs:element name="TrajectDistance" type="D2LogicalModel:Float" minOccurs="1" maxOccurs="1"/>
<xs:element name="LocationForDisplay" type="D2LogicalModel:ReductionPointCoordinates" minOccurs="1" maxOccurs="UNBOUND"/>
<xs:element name="GeneralComment" type="D2LogicalModel:Comment" minOccurs="0" maxOccurs="UNBOUND"/>
<xs:element name="MeasuredValue" type="D2LogicalModel:ReductionMeasuredValue" minOccurs="1" maxOccurs="UNBOUND"/>
</xs:sequence>
</xs:complexType>

<xs:complexType name="ReductionMeasuredValue">
<xs:annotation>
<xs:documentation>Single measurement or single calculation of CO2</xs:documentation>
</xs:annotation>
<xs:sequence>
<xs:element name="CO2Emission" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1"/>
<xs:element name="FuelConsumption" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1"/>
<xs:element name="Velocity" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1"/>
<xs:element name="TravelTime" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1"/>
<xs:element name="CO2Exhaust" type="D2LogicalModel:Float" minOccurs="0" maxOccurs="1"/>
<xs:element name="VehicleType" type="D2LogicalModel:VehicleType"
D4.3.1 [Report on second pilot (to be used for field study 2)]

```xml
<xs:complexType name="D4.3.1">
  <xs:sequence>
    <xs:element name="MeasurementStartTime" type="D2LogicalModel:DateTime"
                minOccurs="0" maxOccurs="1"/>
    <xs:element name="MeasurementEndTime" type="D2LogicalModel:DateTime"
                minOccurs="0" maxOccurs="1"/>
  </xs:sequence>
</xs:complexType>

<xs:simpleType name="SensorTypeEnum">
  <xs:annotation>
    <xs:documentation>If the measurement is based on a calculation or a measurement with a
device</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:enumeration value="CO2Sensor"/>
    <xs:enumeration value="CalculatedCO2"/>
  </xs:restriction>
</xs:simpleType>

<xs:simpleType name="String">
  <xs:annotation>
    <xs:documentation>A character string whose value space is the set of finite-length
sequences of characters. Every character has a corresponding Universal
Character Set code point (as defined in ISO/IEC 10646), which is an
integer.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:maxLength value="1024"/>
  </xs:restriction>
</xs:simpleType>

<xs:complexType name="SupplierIdentifierType">
  <xs:complexContent>
    <xs:annotation>
      <xs:documentation>Indentification of the manufacturer of the measurement data,
country, name and language</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Country" type="D2LogicalModel:CountryEnum" minOccurs="1"
                  maxOccurs="1"/>
      <xs:element name="ManufacturerIdentifier" type="D2LogicalModel:String"
                  minOccurs="1" maxOccurs="1"/>
      <xs:element name="Language" type="D2LogicalModel:Language"
                  minOccurs="1" maxOccurs="1"/>
    </xs:sequence>
  </xs:complexContent>
</xs:complexType>

<xs:complexType name="VehicleTypeEnum">
  <xs:annotation>
    <xs:documentation>Types of vehicle.</xs:documentation>
  </xs:annotation>
  <xs:restriction base="xs:string">
    <xs:enumeration value="agriculturalVehicle">
      <xs:annotation>
        <xs:documentation>Vehicle normally used for agricultural purposes, e.g. Tractor;
      </xs:annotation>
    </xs:enumeration>
  </xs:restriction>
</xs:complexType>
```
combined harvester etc. </xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="anyVehicle">
<xs:annotation>
<xs:documentation>Vehicle of any type.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="articulatedVehicle">
<xs:annotation>
<xs:documentation>Articulated vehicle.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="bicycle">
<xs:annotation>
<xs:documentation>Bicycle.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="bus">
<xs:annotation>
<xs:documentation>Bus.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="car">
<xs:annotation>
<xs:documentation>Car.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="caravan">
<xs:annotation>
<xs:documentation>Caravan.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="carOrLightVehicle">
<xs:annotation>
<xs:documentation>Car or light vehicle.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="carWithCaravan">
<xs:annotation>
<xs:documentation>Car towing a caravan.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="carWithTrailer">
<xs:annotation>
<xs:documentation>Car towing a trailer.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="constructionOrMaintenanceVehicle">
<xs:annotation>
<xs:documentation>Vehicle normally used for construction or maintenance purposes, e.g.
digger, excavator, bulldozer, lorry mounted crane etc.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="fourWheelDrive">
<xs:annotation>
<xs:documentation>Four wheel drive vehicle.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="highSidedVehicle">
<xs:annotation>
<xs:documentation>High sided vehicle.</xs:documentation>
</xs:annotation>
</xs:enumeration>
<xs:enumeration value="lorry">
<xs:annotation>
<xs:documentation>Lorry of any type.</xs:documentation>
</xs:annotation>
</xs:enumeration>
D4.3.1 [Report on second pilot (to be used for field study 2)]

<x:s:enumeration value="moped">
    <x:s:annotation>
        <x:s:documentation>Moped (a two wheeled motor vehicle characterised by a small engine typically less than 50cc and by normally having pedals).</x:s:documentation>
    </x:s:annotation>
</x:s:enumeration>

<x:s:enumeration value="motorcycle">
    <x:s:annotation>
        <x:s:documentation>Motorcycle.</x:s:documentation>
    </x:s:annotation>
</x:s:enumeration>

<x:s:enumeration value="motorcycleWithSideCar">
    <x:s:annotation>
        <x:s:documentation>Three wheeled vehicle comprising a motorcycle with an attached side car.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="motorscooter">
    <x:s:annotation>
        <x:s:documentation>Motorscooter (a two wheeled motor vehicle characterised by a step-through frame and small diameter wheels).</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="tanker">
    <x:s:annotation>
        <x:s:documentation>Vehicle with large tank for carrying bulk liquids.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="threeWheeledVehicle">
    <x:s:annotation>
        <x:s:documentation>Three wheeled vehicle of unspecified type.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="trailer">
    <x:s:annotation>
        <x:s:documentation>Trailer.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="tram">
    <x:s:annotation>
        <x:s:documentation>Tram.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="twoWheeledVehicle">
    <x:s:annotation>
        <x:s:documentation>Two wheeled vehicle of unspecified type.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="van">
    <x:s:annotation>
        <x:s:documentation>Van.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>

<x:s:enumeration value="vehicleWithCatalyticConverter">
    <x:s:annotation>
        <x:s:documentation>Vehicle with catalytic converter.</x:s:documentation>
    </x>s:annotation>
</x:s:enumeration>
Vehicle with catalytic converter.

Vehicle without catalytic converter.

Vehicle (of unspecified type) towing a caravan.

Vehicle (of unspecified type) towing a trailer.

Vehicle with even numbered registration plate.

Vehicle with odd numbered registration plate.

Other than as defined in this enumeration.