Deliverable D5.3: Evaluation and results of demonstration activities
PROJECT INFORMATION

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Web site: www.seeits.eu

PROJECT PARTNERS

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Deliverable D5.3: Evaluation and results of demonstration activities

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Abstract: The current deliverable presents the role of the demonstration activities in the development and deployment of ITS solutions, providing a detailed description of the activities related to the demonstration activity execution and their evaluation. The main scope is to define a handbook with the most significant guidelines for the demonstration activities and to describe in detail the seven demonstration implementations scheduled in the project.
EXECUTIVE SUMMARY

The objective of WP5 is to implement ITS demonstrations through feasibility studies and the development of interoperable traffic management systems and intermodal traveller information services along corridors and urban networks in seven areas of the SEE region.

The SEE-ITS demonstration activities will provide data for the impact assessment of ITS, in order to prove their benefits. These results will, at the same time, contribute to the cooperation, harmonization and interoperability of the ITS implementations in the SEE area, by allowing all related stakeholders to identify potential benefits and deployment prospects of similar ITS solutions in other cities, regions and countries.

The current deliverable presents the role of the demonstration activities in the development and deployment of ITS solutions, providing a detailed description of the activities related to the demonstration activity execution and their evaluation. The main scope is to define a handbook with the most significant guidelines for the demonstration activities and to describe in detail the seven demonstration implementations scheduled in the project.

A major task was to include the elaboration of detailed specifications for the equipment purchased during the activity. The report also contains the details of the purchase and the setup of this equipment.

The structure of the report is based on the template 5.1 prepared by CERTH-HIT and filled by the project partners. The following countries were participating in the activity: Greece (CERTH-HIT) as the project leader, Hungary as the demonstration leader, Greece (ADEP S.A.), Austria, Bulgaria, Romania, and Italy as project partners.
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Figure 106: Correlation between questions 6 (Part B) and 6 (Part A)

Figure 107: Correlation between questions 6 (Part B) and 12 (Part A)

Figure 108: Correlation between questions 6 (Part B) and 13 (Part A)

Figure 109: Correlation between questions 6 (Part B) and 4 (Part A)

Figure 110: Correlation between questions 5 (Part A) and 4 (Part A)

Figure 111: Correlation between questions 6 (Part B) and 10 (Part A)

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### Abbreviations and Terminology

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD</td>
<td>Origin Destination</td>
</tr>
<tr>
<td>BKK</td>
<td>Centre for Budapest Transport Co.</td>
</tr>
<tr>
<td>GTFS</td>
<td>General Transit Feed Specification</td>
</tr>
<tr>
<td>HTA</td>
<td>Hungarian Transport Administration (KKK in Hungary)</td>
</tr>
<tr>
<td>MÁV</td>
<td>Hungarian State Railways Co.</td>
</tr>
<tr>
<td>TUK (Tömegközlekedési Útvonaltervező Kerékpárosoknak)</td>
<td>Public Transport Route Planner for Cyclists</td>
</tr>
<tr>
<td>TUKMobile</td>
<td>Android mobile phone application</td>
</tr>
<tr>
<td>TUKAdmin</td>
<td>Operator desktop program to load the updated GTFS databases</td>
</tr>
<tr>
<td>VOLÁN</td>
<td>Hungary's major bus service provider</td>
</tr>
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</table>
1. **INTRODUCTION**

1.1. **Purpose and Scope of this Report**

The scope of the present activity (activity 5.3), which is part of the 5th WP of SEE-ITS project, is to evaluate the demonstration activities of the seven pilot sites that have taken part in the framework of the project. The evaluation is being held in terms of:

- Technical performance of the developed systems, according to the purpose that they serve. The systems that have been developed and tested in the pilot sites are examined in terms of their technical reliability, accuracy and operability
- Transportation system impact of the developed systems. The effectiveness of the systems is examined concerning their impact on both the individual user and the society
- Cost evaluation of the demonstration activities
- Institutional impacts evaluation of the developed systems. The systems are examined concerning their influence on the overall ITS policy in the demonstration areas

Therefore, to examine the areas mentioned above, several actions and methods have been used so as to evaluate the performance of the systems and quantify their effectiveness. These are in line with the wider European framework for Intelligent Transport Systems’ evaluation, as it has been formed by several ITS-related projects and described in major ITS consolidated reports.

The general conclusions and the specific performance indicators derived from this project-activity will be used in further assessment activities of the project such as the studies of impact assessment at regional level (act. 6.1) and the cost benefit analysis (act. 7.1). The results are also expected to contribute to the cooperation, harmonization and interoperability of the ITS implementations in the SEE area, by allowing all related stakeholders to identify potential benefits and deployment prospects of similar ITS solutions in other cities, regions and countries.
1.2. **Evaluation Design and Approach**

1.2.1. *Evaluation framework*

Evaluation is the process of determining the value, the importance and the quality of a thing, of a process and of a project based on predetermined criteria.

When the scope of an evaluation process is to assess the performance of ITS, the development of an integrated framework includes: the verification of the quality of the system and of the services provided, the identification of the value and of the importance of the system for the transport sector (by quantifying the positive effects to the individual user and to the society) and the recognition of the potential weaknesses and the possible improvements and future extensions.

In the context of the SEE-ITS project, an integrated evaluation framework process has been established aiming to answer to the following objectives:

- The systems’ evaluation (technical performance, cost evaluation)
- The direct positive effects’ identification and quantification
- The socioeconomic impact assessment of the systems
- The assessment of the wider contribution of the systems

The framework consists of three steps and is accomplished gradually in three project activities. These steps are:

- The basic evaluation process (Activity 5.3)
- The impact assessment of ITS applications in SEE, at local, regional and national level (Activity 6.1)
- The economic feasibility of the systems with the use of a cost-benefit analysis. (Activity 7.1)

The first step, which is the basic evaluation, aims to evaluate the systems and their direct impacts. Therefore the direct impacts of the demonstration activities on traffic management, road safety, driver’s behaviour and environment are being identified, quantified and evaluated. Moreover, since the demonstration activities have been developed within the project it was judged that it would be useful the technical validation of the system to be integrated into the overall evaluation context, since the proper operation and especially the accuracy of the methodology adopted adds value to the system and underlines its importance. This step is fulfilled by the present project activity and aim to answer mainly to the first and the second evaluation objectives.

The second evaluation step is related to the assessment of ITS applications in terms of achieving their objectives and estimating their likely impacts on the economic, environmental and social fields at regional level, extracting wider conclusions. This step, which will be covered in activity 6.1 of the project, will outline advantages and disadvantages of each ITS
solution and will examine possible synergies and trade-offs. The examination of synergies will be following an area type evaluation, namely for each type of area level (local, national, regional) all possible interrelationships will be explored and analysed, setting the basis for further more technical procedural integration. This step will answer mainly to the third and the fourth evaluation objectives.

The third evaluation step, which will be accomplished in 7.1 activity of the project, is related to a detailed cost-benefit analysis of the integrated traffic & mobility management and traveller information systems. More specifically, the overall benefits and costs from the implementation of the systems will be estimated, for each demo case. The adequate techniques for the transformation of qualitative criteria (environmental, social) will be also identified and applied for the computation of the external effects. The computation of costs and benefits will follow the analytical CBA procedure, namely the analysis will be composed by three different perspectives: the user perspective, the operator's perspective and the government's perspective. The overall welfare of the society for each different country (demo case site) will be the sum of the three separate perspectives. The output of this step is the analytical recording of all costs and benefits, along with the overall impact to social welfare for each demo case. This evaluation step will answer mainly to the third and the fourth evaluation objectives.

In order to fulfil these steps and to answer to the objectives of the evaluation of the systems and services, the most important element is the criteria set. The criteria, that should be in accordance with the four major framework objectives, have been allocated to the evaluation steps and have been specified in such a way so as to answer to the initial scope; the determination of the systems and services value, importance and quality.

After the identification of the criteria, the valuation of them is performed with the following tools:

- With simulation tools
- With technical validation tests
- With Field Operational Tests (FOTs)
- With questionnaire surveys to drivers
- With internal evaluation processes
- With a questionnaire survey to experts, the results of which have already been presented in previous work packages of the project

According to the nature of each criterion, a qualitative or quantitative description is performed, so as to answer to the specific objectives and to provide the necessary indicator for the next assessment steps. The overall evaluation process of the SEE-ITS project is presented in a schematic way Figure 1 in Figure 1.
The demo activities of the SEE-ITS project include services and systems that cover multidimensional aspects of ITS and therefore due to the specificities of each case, different evaluation tools are adopted. Nevertheless, the overall evaluation steps and the criteria set are mutual for all cases and therefore common evaluation results can be extracted.

Table 1 summarizes the evaluation objective areas, the criteria and the sub-criteria of each area, the methods and the evaluation steps that are adopted in the SEE-ITS project. For each evaluation step, sub-criteria used are marked with the ‘Yes’ indication. If the valuation of a criterion is carried mainly within a specific step, ‘Yes’ indication is marked with bolt.
### Table I: Evaluation steps and criteria identification

<table>
<thead>
<tr>
<th>Evaluation objective area</th>
<th>Criterion</th>
<th>Sub-Criterion</th>
<th>Evaluation tool</th>
<th>Indicators</th>
<th>Evaluation Steps</th>
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<td>Project Budget &amp; Estimated</td>
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<td>Maintenance Costs</td>
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<td>Traffic efficiency and traffic</td>
<td>FOTs / Users’ Survey /</td>
<td>Quantitative / Performance Indicators</td>
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<tr>
<td>identification and</td>
<td>management</td>
<td>Simulation</td>
<td></td>
<td></td>
<td></td>
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<td>evaluation</td>
<td>Impacts to mode shifting and</td>
<td>Users Survey / Simulation</td>
<td>Quantitative / Performance Indicators</td>
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<td></td>
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<td></td>
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<tr>
<td></td>
<td>Impacts on the environment and</td>
<td>FOTs / Simulation / Users’</td>
<td>Quantitative / Performance Indicators</td>
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<tr>
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<td>Survey</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>FOTs / Simulation / Users’</td>
<td>Quantitative / Performance Indicators</td>
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<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
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<td>Quantitative / Performance Indicators</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Survey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drivers’/Users’ acceptance/perce</td>
<td>Users’ Survey / FOTs</td>
<td>Quantitative / Performance Indicators</td>
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Deliverable D5.3: Evaluation and results of demonstration activities
<table>
<thead>
<tr>
<th>Socioeconomic impact assessment</th>
<th>Mobility</th>
<th>Combination of criteria</th>
<th>Integrated evaluation</th>
<th>Qualitative / Quantitative</th>
<th>Economic efficiency</th>
<th>Combination of criteria</th>
<th>Integrated evaluation</th>
<th>Qualitative / Quantitative</th>
<th>Sustainability</th>
<th>Combination of criteria</th>
<th>Integrated evaluation</th>
<th>Qualitative / Quantitative</th>
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<td>Wider Effects</td>
<td>Institutional impact evaluation</td>
<td>Improvement interoperability</td>
<td>Internal evaluation / Experts’ survey</td>
<td>Qualitative</td>
<td>Promotion of ITS</td>
<td>Internal evaluation / Experts’ survey</td>
<td>Qualitative</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Deployment of ITS standards</td>
<td>Internal evaluation / Experts’ survey</td>
</tr>
</tbody>
</table>
1.3. **Organization of this Report**

This report is organised in such a way so as to clearly present the basic evaluation results of each demo activity that has taken place. First, for each pilot site, the evaluation methods that have been used are presented independently, since there are differences among the demo activities of the pilot sites, concerning the nature of the developed systems and the methods that have been adopted for their evaluation. Subsequently, the results of the evaluation activities are presented in a common structure, answering to the basic criteria set and resulting to the necessary for the next steps indicators.
2. **Thessaloniki Demo Site**

2.1. **Project/System Technical Description**

The demo activities in Thessaloniki are focused on the development and the implementation of Advanced Traveller Information Services (ATIS), based on real-time traffic data. The outcome of the data fusion combined with the use of Dynamic traffic assignment and simulation software for the estimation of the traffic conditions of the road network results to the provision of real-time information to the end users. This information is twofold:

- Real-time travel times for the most important routes of the city road network
- Dynamic qualitative and quantitative description of the road network traffic conditions

2.1.1. **Previous ITS Infrastructure and services development**

In the framework of three previous ITS-related actions and projects (Thessaloniki Ring Road Traveller Information System, Mobithess: Thessaloniki’s Intelligent Urban Mobility Management System and EasyTrip: GR-BG E-mobility solutions), ITS infrastructure have already been installed in Thessaloniki and ITS services and applications regarding information provision, have been deployed.

More specifically:

The Thessaloniki Ring Road Traveller Information System that has been developed by the Region of Central Macedonia (RCM) was related to the implementation of a system for the real-time information of the users of the Thessaloniki’s Ring Road through Variable Message Signs (VMS), that have been installed in selected points within the road axis, as well via the internet (http://rrits.damt.gov.gr). The services, which have been developed within the project, are using data collected with CCTV cameras that have been installed to gather real-time traffic conditions information and accident detection along the Ring Road.

Mobithess, the Urban Mobility Centre of Thessaloniki (www.mobithess.gr) is one of the two separate, however complementary and parallel service Centres of the “Intelligent Urban Mobility Management System for the city of Thessaloniki” project. The other component of the system is related to the traffic adaptive control of signalized intersections. In the context of the project, roadside ITS infrastructure has been installed. More specifically, ten point-to-point Bluetooth technology detectors in important locations of the urban network collecting real time traffic data and five Variable Message Signs (VMS), in central locations of the primary road network informing travellers about real-time traffic conditions. The operation of the Traffic Control Centre that has been developed (including the VMS operation) is under the responsibility of the Region of Central Macedonia (RCM).
The EasyTrip project aimed to support cross-border accessibility between the areas of Northern Greece and Southern Bulgaria, through the development of web-based tools offering e-mobility services. An internet platform, which can be accessed at www.easytrip.eu, and an EasyTrip smartphone application (available both for iOS and Android platforms for free) have been developed, providing various e-mobility services. In the framework of the project eight point-to-point detectors have been installed in Thessaloniki’s road network as well as a VMS.

The SEE-ITS project took advantage of the previously installed ITS infrastructure (point-to-point detectors and VMSs), it used the VMSs for the information provision, and expanded the point-to-point detectors network in order to cover most of the important paths of the city and implement the project’s services. To this end, in the framework of SEE-ITS project, 25 devices have been installed in selected locations of Thessaloniki area, extending the geographical area where the drivers are tracked, providing travel time for new routes, while at the same time increasing the density of detectors in the city centre providing better accuracy in vehicles’ tracking and the estimation of travel times.

2.1.2. **Point-to-point detectors’ location selection methodology**

The sensor location problem is of particular importance when planning the allocation of limited field equipment intended to be used for advanced traffic management and traveller information systems. The intersections and locations within a network that satisfy specific goals need to be carefully selected, based on predefined goals related to the detection of traffic volumes. The detection of traffic volumes is mainly associated with two purposes:

1. travel time estimation and
2. origin–destination (OD) trip matrix estimation

Information about travel times is important for travellers when there is a significant variation of travel times during the day or during certain periods within the day and also when several cases exist where certain parts of the network (links or intersection) are affected by closures, incidents, works or other events that significantly affect the capacity and the operational performance of the network.

An important aspect related to the variation of travel times in Thessaloniki is the construction of the new metro line and the impacts of work zones on daily traffic. Therefore, the provision of information regarding travel times is significant for the daily trips of the citizens.

Another important aspect of travel time’s information provision is the actual usefulness related to route choice decisions of travellers. Information should be provided to travellers at locations within the network that provide them with options for deviating from their initial itinerary and for using alternative paths.
OD trip matrix estimation is important for the development of a reliable traffic assignment models. Therefore, monitoring of traffic volumes at representative locations of the road network can lead to models with significantly improved validity. Such models can be used by planners for the mobility plans of the city, by public transport authorities for improving their services and by traffic management authorities for analysing daily traffic patterns and dynamics, in order to identify measures for reducing traffic congestion.

A measuring network comprised of ten Bluetooth detection devices has been installed in selected locations of the central part of Thessaloniki within the framework of the project “Intelligent urban mobility management and traffic control system for the improvement of urban environment quality in the central area of Thessaloniki agglomeration”. This network provides data for estimating and monitoring travel times along 22 paths of the centre of Thessaloniki. Besides the estimation of travel times for informing travellers through an advanced traveller information system, estimates for travel times are also being used by the underlying traffic assignment model that has been developed for traffic state estimation and prediction at network level.

In order to expand the coverage of the network that is currently being monitored, it has been decided to install twenty five additional devices in the wider area of Thessaloniki, as shown below. The green coloured area is currently being monitored with the existing devices, while the blue and red areas are those that will be covered by the new proposed installation of devices, covering the wider area of Thessaloniki as well as the peripheral ring road respectively.

![Study area of Thessaloniki](image)

*Figure 2: Study area of Thessaloniki*
In order to identify the most significant intersections for installing the new twenty five Bluetooth devices, the following methodological steps have been followed:

- Identification of the road links comprising the network of the study area
- Identification of all possible and candidate locations that a device could be installed
- Identification of the major paths of the network
- Definition of an optimization model to select sensor locations
- Implementation of the optimization model
- Results and heuristic improvements

- Identification of the road links comprising the network of the study area

The first step entails the selection of the links of Thessaloniki’s road network that comprise the road network of the study area, which is a subset of all physical links. This procedure aims to exclude links with limited capacity, which may not be included in travellers’ route choices. The network is selected to include only significant links which are connected to major intersections. The links that have been selected based on the above criteria are presented below.
The entire physical road network of the study area in Thessaloniki is comprised of 137852 links, while the selected network includes 3073 links.

- Identification of all possible and candidate locations that a device could be installed

The intersections that constitute the nodes of the defined network are all possible and candidate locations where the devices will be installed. The total number of intersections of the selected network is 252, as shown below.
In order to analyse the characteristics of the selected intersections (candidate sensor locations) and in order to define comparison mechanism, the most significant (major) paths in Thessaloniki have been defined. Major paths are defined as those that serve a significant number of trips in the city of Thessaloniki. These paths have been selected based on a grid approach, including the main vertical and horizontal axes of the study area.

- Horizontal paths
The horizontal paths cover all trips from the main east-to-west and west-to-east gates of the city, as shown next.

**Figure 5**: Horizontal paths of the network

The following table highlights the main characteristics of the horizontal.
Table 2: Characteristics of Thessaloniki’s horizontal paths

<table>
<thead>
<tr>
<th>Path id</th>
<th>No. of intersections included in the path</th>
<th>Main Streets</th>
<th>Length (kms)</th>
<th>Average Travel Time (min)</th>
<th>Average Daily Traffic</th>
</tr>
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<tbody>
<tr>
<td>H.1</td>
<td>30</td>
<td>PATHE RR, Stathmou, Nikis, M.Alexandrou, Papandreou, Andrianoupoleos, G.Sxolis</td>
<td>21</td>
<td>25</td>
<td>36.000</td>
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<tr>
<td>H.2</td>
<td>30</td>
<td>A25, K.Karamanli, Egnatia, Monastiriou</td>
<td>19</td>
<td>23</td>
<td>57.500</td>
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<tr>
<td>H.3</td>
<td>33</td>
<td>Eth.Antistaseos, B.Olgas, Tsimiski, Politexniou, PATHE RR</td>
<td>19</td>
<td>27</td>
<td>41.500</td>
</tr>
<tr>
<td>H.5</td>
<td>18</td>
<td>A25, Peripheral Ring Road</td>
<td>22</td>
<td>19</td>
<td>101.500</td>
</tr>
<tr>
<td>H.6</td>
<td>16</td>
<td>A25, E90</td>
<td>25</td>
<td>15</td>
<td>118.500</td>
</tr>
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<td>H.7</td>
<td>20</td>
<td>A25, Egnatios Odos</td>
<td>31</td>
<td>25</td>
<td>115.000</td>
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<td>H.8</td>
<td>20</td>
<td>M.Alexandrou, Papandreou, Sofouli, K.Gkoni, Pontou, K.Karamanli, Dimokritou</td>
<td>8</td>
<td>16</td>
<td>20.000</td>
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<tr>
<td></td>
<td>Average</td>
<td></td>
<td>19.3</td>
<td>21.75</td>
<td>64.812</td>
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</tbody>
</table>

It is noteworthy to highlight that the horizontal paths which satisfy the condition of crossing from-to east to-from west are not many. Initial conclusions based on their main characteristics can be drawn as follows:

- The average speed along the peripheral ring road is ranging between 70 – 100 km/h, resulting to journey times of approximately 20 minutes for traveling along, with observed traffic volumes in the order of 110.000 vehicles on average per day.
- The average speed along the main roads crossing the city centre is ranging between 40 – 50 km/h and the trip durations are 25 minutes on average, with traffic volumes of approximately 45.000 vehicles per day.
- When roads of lower hierarchy are also considered, the average speed drops to 25 - 30 km/h with traffic volumes are on average 25.000 vehicles per day.

о Vertical paths

20 vertical paths have been defined, as shown and described next. Vertical paths connect the main horizontal axes and thus produce several combinations, serving the entire city.
Figure 6: Vertical paths of the network
Table 3: Characteristics of Thessaloniki’s vertical paths

<table>
<thead>
<tr>
<th>Path id</th>
<th>No. of intersections included in the path</th>
<th>Main Streets</th>
<th>Length (km)</th>
<th>Average Travel Time (min)</th>
<th>Average Daily Traffic Volume</th>
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<tbody>
<tr>
<td>V.1</td>
<td>10</td>
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<td>30.000</td>
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<td>V.2</td>
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<td>3</td>
<td>9</td>
<td>24.000</td>
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<td>V.3</td>
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<td>7</td>
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<td>V.4</td>
<td>14</td>
<td>Katsimidi, Paraskeuopoulou</td>
<td>2.5</td>
<td>7</td>
<td>41.500</td>
</tr>
<tr>
<td>V.5</td>
<td>10</td>
<td>Katsimidi, Kyriaki, 3 Speptevriou, Stratou, Evzonon</td>
<td>2.7</td>
<td>8</td>
<td>43.500</td>
</tr>
<tr>
<td>V.6</td>
<td>9</td>
<td>Katsimidi, 3 Speptevriou</td>
<td>2.3</td>
<td>7</td>
<td>47.500</td>
</tr>
<tr>
<td>V.7</td>
<td>6</td>
<td>Agelaki, Eth.Aminis, E.Zografou</td>
<td>3</td>
<td>7</td>
<td>69.500</td>
</tr>
<tr>
<td>V.8</td>
<td>7</td>
<td>E.Zografou, Eth.Aminis</td>
<td>3.4</td>
<td>8</td>
<td>65.000</td>
</tr>
<tr>
<td>V.9</td>
<td>9</td>
<td>PP.Germanon, Iasonido, Arianou, Armenopoulou, Gounari, Ag Dimitriou, El.Zografou</td>
<td>3.6</td>
<td>10</td>
<td>42.500</td>
</tr>
<tr>
<td>V.10</td>
<td>14</td>
<td>Antheon, Akropoleos, Kasandroutou, I.Dragoumi</td>
<td>4</td>
<td>13</td>
<td>28.500</td>
</tr>
<tr>
<td>V.11</td>
<td>14</td>
<td>Venizelou, Akropoleos, Antheon</td>
<td>3.8</td>
<td>11</td>
<td>28.500</td>
</tr>
<tr>
<td>V.12</td>
<td>10</td>
<td>K.Ntil, Ermou, Ag.Sofias, Ag.Dimitriou, El.Zografou</td>
<td>3.6</td>
<td>9</td>
<td>34.500</td>
</tr>
<tr>
<td>V.13</td>
<td>10</td>
<td>Lagada, Egnatia, Dodekanisou, Salaminos</td>
<td>5.6</td>
<td>13</td>
<td>61.000</td>
</tr>
<tr>
<td>V.14</td>
<td>8</td>
<td>Papandreou, Venizelou, Neoxoriou, Lagada, Egnatia Dodekanisou, Salaminos</td>
<td>4.7</td>
<td>11</td>
<td>49.500</td>
</tr>
<tr>
<td>V.15</td>
<td>7</td>
<td>Ag.Stratiotis, Davaki, Lagada, Dodekanisou, Salaminos</td>
<td>4.8</td>
<td>10</td>
<td>55.500</td>
</tr>
</tbody>
</table>
Some important observations are the following:

- Vertical paths located at the eastern part of Thessaloniki have an average length of 2–4 kms and 7-9 minutes of journey time.
- Vertical paths located at the central area of the city have an average length of 3-4 kms and 10 minutes of journey time.
- Vertical paths located at the western part of Thessaloniki have an average length of 4–6 kms and 10 minutes of journey time.

**Local paths**

13 additional paths have been defined at selected local areas, as shown below. These local paths serve the connection of small but also significant trips that are generated mainly in the city centre, to the city and at level of municipalities.
Figure 7: Local paths of the network
Table 4: Characteristics of Thessaloniki’s local paths

<table>
<thead>
<tr>
<th>Path id</th>
<th>No. of intersections included in the path</th>
<th>Main Streets</th>
<th>Length (km)</th>
<th>Average Travel Time (min)</th>
<th>Average Daily Traffic Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1</td>
<td>15</td>
<td>Delfon, Stratou, Tsimiski</td>
<td>4.5</td>
<td>11</td>
<td>19.000</td>
</tr>
<tr>
<td>L.2</td>
<td>4</td>
<td>Kostantinoupoleos</td>
<td>1</td>
<td>3</td>
<td>10.500</td>
</tr>
<tr>
<td>L.3</td>
<td>13</td>
<td>Kazantzidi, Pselou, Papanastasiou</td>
<td>5</td>
<td>11</td>
<td>29.000</td>
</tr>
<tr>
<td>L.4</td>
<td>15</td>
<td>Pr.Ilia, Anaximandrou, Kanari, K.Karamanli, Egnatia</td>
<td>5</td>
<td>9</td>
<td>32.000</td>
</tr>
<tr>
<td>L.5</td>
<td>13</td>
<td>Lampraki, K.Karamanli, Egnatia</td>
<td>4</td>
<td>9</td>
<td>73.000</td>
</tr>
<tr>
<td>L.6</td>
<td>6</td>
<td>Venizezolou, Mitropoleos, Paulou Mela</td>
<td>1.5</td>
<td>4</td>
<td>12.500</td>
</tr>
<tr>
<td>L.7</td>
<td>12</td>
<td>Aggelaki, Svolou, Keramopoulou, Ermou</td>
<td>2</td>
<td>6</td>
<td>17.500</td>
</tr>
<tr>
<td>L.8</td>
<td>6</td>
<td>Olimpiados, Kassandrou, Ifestionos</td>
<td>1.7</td>
<td>5</td>
<td>27.500</td>
</tr>
<tr>
<td>L.9</td>
<td>6</td>
<td>Olimpiados, Ifestionos</td>
<td>1.8</td>
<td>5</td>
<td>18.000</td>
</tr>
<tr>
<td>L.10</td>
<td>14</td>
<td>Sofouli, Kerasountos, Chilis, Plastira, Atlantidos, Kountoyriotou, Brioulon, Makedonias, Karamanli</td>
<td>4.8</td>
<td>11</td>
<td>8.500</td>
</tr>
<tr>
<td>L.11</td>
<td>9</td>
<td>Aigeou, Metamorfozi, Chilis, Plastira</td>
<td>2.2</td>
<td>6</td>
<td>24.500</td>
</tr>
<tr>
<td>L.12</td>
<td>12</td>
<td>Raktivan, Proxenon, Agoniston, In.Dragoumi, Ag. Sofias, Makenzi King, P. Mela</td>
<td>2.1</td>
<td>7</td>
<td>22.000</td>
</tr>
<tr>
<td>L.13</td>
<td>3</td>
<td>Karaoli &amp; Dimitriou</td>
<td>2</td>
<td>5</td>
<td>27.000</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>3</td>
<td>7</td>
<td>25.000</td>
</tr>
</tbody>
</table>

Definition of an optimization model for solving the sensor location problem

In order to formulate the optimization problem, the objective function and the constraints need to be defined. The overall objective is to identify the set of intersections (sensor locations) that maximize the observed daily traffic volumes. Thus the decision variable $x_i$ is binary and defined as follows:
\[ x_i = \begin{cases} 1 & \text{when the intersection is selected} \\ 0 & \text{otherwise} \end{cases} \]

with \( i \) being the index for each intersection.

The objective function of the optimization model is defined as:

\[
\max \sum_{i=1}^{n} h_i x_i
\]

with \( h_i \) corresponding to the average hourly traffic volume that can be detected at the intersection \( x_i \). In order to calculate the total hourly traffic volume for each intersection, entering and exiting traffic volumes of all corresponding to each intersection links have been used. These values have been calculated for each hour of the day and for the whole day with the following expression:

\[
h_i = \frac{1}{2} \sum_{j=1}^{A_i} a_{ij}
\]

Where,

\( A_i \) is the number of legs of intersection \( i \)
\( a_{ij} \) is the volume on leg \( j \) of intersection \( i \)
The three main issues that should be taken into account and correspond to models constrains are:

- the maximum number of constrains that can be used
- the selection of intersections of the existing network
- the corresponds neighbourhood constraint

From the coordinates of each intersection a distance matrix was calculated, expressing the Euclidean distances between two intersections.
Deliverable D5.3: Evaluation and results of demonstration activities

Figure 9: Equation of Euclidean distances

\[ d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \]

A sample of the distance matrix can be seen below:

**Table 5: Sample of the distance matrix**

<table>
<thead>
<tr>
<th>param dist</th>
<th>2</th>
<th>3</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>1695</td>
<td>7092</td>
<td>5338</td>
<td>3188</td>
<td>2962</td>
<td>4113</td>
<td>4610</td>
<td>3276</td>
</tr>
<tr>
<td>3</td>
<td>1695</td>
<td>0</td>
<td>5911</td>
<td>4517</td>
<td>1886</td>
<td>2366</td>
<td>3668</td>
<td>4346</td>
<td>3079</td>
</tr>
<tr>
<td>5</td>
<td>7092</td>
<td>5911</td>
<td>0</td>
<td>2176</td>
<td>4028</td>
<td>4245</td>
<td>3636</td>
<td>3843</td>
<td>4451</td>
</tr>
<tr>
<td>6</td>
<td>5338</td>
<td>4517</td>
<td>2176</td>
<td>0</td>
<td>2751</td>
<td>2377</td>
<td>1483</td>
<td>1693</td>
<td>2350</td>
</tr>
<tr>
<td>7</td>
<td>3188</td>
<td>1886</td>
<td>4028</td>
<td>2751</td>
<td>0</td>
<td>1313</td>
<td>2325</td>
<td>3079</td>
<td>2186</td>
</tr>
<tr>
<td>8</td>
<td>2962</td>
<td>2366</td>
<td>4245</td>
<td>2377</td>
<td>1313</td>
<td>0</td>
<td>1302</td>
<td>1993</td>
<td>882</td>
</tr>
<tr>
<td>9</td>
<td>4113</td>
<td>3668</td>
<td>3636</td>
<td>1483</td>
<td>2325</td>
<td>1302</td>
<td>0</td>
<td>754</td>
<td>902</td>
</tr>
<tr>
<td>10</td>
<td>4610</td>
<td>4346</td>
<td>3843</td>
<td>1693</td>
<td>3079</td>
<td>1993</td>
<td>754</td>
<td>0</td>
<td>1343</td>
</tr>
<tr>
<td>11</td>
<td>3276</td>
<td>3079</td>
<td>4451</td>
<td>2350</td>
<td>2186</td>
<td>882</td>
<td>902</td>
<td>1343</td>
<td>0</td>
</tr>
</tbody>
</table>

Using the distance matrix the relationship among intersections is determined. Intersections with distances lower than 4 kms are defined as neighbouring intersections. The neighbour indicator matrix is used for ensuring that neighbouring intersections will not be selected. However the intersections where the ten existing devices are located have been excluded from this procedure.

Parameter \( n_{ij} \) is equal to 1 when the distance between intersections \( i \) and \( j \) is lower than 4 kms.

Constraint 1 express this rule can be specified:
\[ \sum_{i=1}^{n} \sum_{j=1}^{n} x_i n_{ij} x_j \leq 0 \]

Constraints 2 express the limitation of available devices

\[ \sum_{i=1}^{n} x_i \leq Q \]

Where Q=35 available devices.

Since the first constraint is quadratic the optimization model is a Quadratic Programming Model which was coded in AMPL and the CPLEX Solver was used to solve it. (see Annex I)

- Results and heuristic improvements

The intersections determined by the model are presented below.
The solution of the objective function of the model is equal to 98.972, which is the total traffic that can be detected by the selected intersections. The result shows that 15 devices are required in order to achieve the optimal solution. Therefore, the neighbour matrix has been recalculated by using the distance of 1.5 kms instead of 4 kms. An additional constraint has been added, guarantying that the existing locations will be included in the solution.

\[ \sum_{i=1}^{n} x_i y_i \geq D \]
Where $D=10$ is the number of existing devices and parameter $y_i$ expresses that the intersection $i$ belongs to the existing network of detectors. It is interesting to highlight the following:

$$\sum_{i=1}^{n} y_i = D$$

The results of the modified model are presented next.

**Figure 11**: Optimal sensor locations based on the quadratic model 2
The optimal solution of the model is 189.718 and every additional intersection can increase the detected traffic by 2200 on average.

In order to guarantee that the selected locations (intersections) cover the most significant paths, further heuristics improvements have been applied to the model.

The first step of these heuristic improvements is to exclude from the model the intersections located outside the initial study area (intersections located at the external peripheral ring road). The result of this decision is illustrated next.

The value of objective function is 172.741 hourly traffic counts and every additional device increases this value by 750 counts.
Other heuristic improvements include the comparison of each selected intersection with its neighbours and in relation to the paths defined.

These heuristics are based on the following principles:

- Selection of intersections that are common to as many paths as possible
- Selection of intersections that can provide information for alternative paths in route choice perspectives.

**Figure 12:** Optimal located intersections based excluding intersection of external ring road
Form the heuristic procedure and the examinations of each intersection, 50% of the final set of intersections were not modified, as shown below.

**Figure 13:** Intersection that were examined to be valid from heuristic improvements

The intersections that were replaced belong to 17 paths and the intersections that were selected instead belong to 29 paths.
The following maps show the modification where the intersections with yellow were replaced with the ones with blue.

**Figure 14**: Intersection that were modified from heuristic improvements

The final result of the selected intersections can be seen in the final map below.
Figure 15: Final Selection of intersections
➢ Sensitivity analysis

Testing the robustness of the results of sensor location problem it is necessary to perform sensitivity analysis. Sensitivity analysis aims to validate the coherence of the uncertainties of the input of the model with the respected produced uncertainties in the output, which in our case are the value of the objective function as well as the significant level of the selected locations. Sensitivity analysis is almost performed by running the model for a large number of times using varieties for the input data.

Therefore in our case we have run the model for each hour of the day as well as for two representative scenarios. The first scenario was defined by using the average traffic volumes of the whole day, and respectively the second scenario as an average volume and for the internal of 7:00am to 8:00 p.m. hour. The second scenario is accounted to be as most representative of the phenomena since it is related to the period that most citizens are travelling.

Before validating the results of the sensitivity analysis it was necessary to validate the variability of the input data. Therefore we have visualized this by using the box plot of each traffic counts of each path which shows the five significant statistics of the distribution. (25% & 75% percentile, median, min & max).

As it is shown in the graph below the variability of traffic isn’t significant for most paths in the area.
Figure 16: Volume Variability within the day

From the graph below the variability of the objective function of the model can be seen in coherent to the two scenarios tested.
However from the box plots of each scenario on the right it is can be seen that the variability is significantly lower when we are referring to the duration from 7:00 to 20:00.

In order to verify the above result we have also tested the percentage of changes in the decision process by validating the result of the location of sensors.

In the following graph the significance of each selection of a location of a sensor can be validated by the percentage of usability for each time interval.
In all scenarios there are 38 candidate sensor locations and 15 of them are selected in all scenarios. Also 25 of them are selected in more than 95% of scenarios.

The final locations of the BT detectors installed in the SEE-ITS project are presented in Table 6.
<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Ag. Pavlos hospital (Kalamaria)</td>
</tr>
<tr>
<td>32</td>
<td>Panorama Interchange (Ring road)</td>
</tr>
<tr>
<td>33</td>
<td>Gr. Labraki (Perevou)</td>
</tr>
<tr>
<td>34</td>
<td>Toumpa Interchange (Diagora)</td>
</tr>
<tr>
<td>35</td>
<td>City Centre Interchange (Ring road)</td>
</tr>
<tr>
<td>36</td>
<td>Ag. Pavlos Interchange (Ring road)</td>
</tr>
<tr>
<td>37</td>
<td>Kaftatzoglio stadium (Katsimidi Intersection)</td>
</tr>
<tr>
<td>38</td>
<td>Eptapirgio Interchange (Ring road)</td>
</tr>
<tr>
<td>39</td>
<td>Neapoli Interchange (Ring road)</td>
</tr>
<tr>
<td>40</td>
<td>Papageorgiou Interchange (Ring road)</td>
</tr>
<tr>
<td>41</td>
<td>Stauroupoli Interchange (Ring road)</td>
</tr>
<tr>
<td>42</td>
<td>Neapoli (bus terminal)</td>
</tr>
<tr>
<td>43</td>
<td>Ag. Therapondas (M. Botsari)</td>
</tr>
<tr>
<td>44</td>
<td>Stauroupoli City Hall (Lagada)</td>
</tr>
<tr>
<td>45</td>
<td>Ieestionos (Ag. Dimitriou)</td>
</tr>
<tr>
<td>46</td>
<td>Eleftherias Square-Venizelou str.</td>
</tr>
<tr>
<td>47</td>
<td>Bank of Greece-Tsimiski str.</td>
</tr>
<tr>
<td>48</td>
<td>Dikastiria Intersection</td>
</tr>
<tr>
<td>49</td>
<td>Airport Intersection</td>
</tr>
<tr>
<td>50</td>
<td>Theagenio hospital</td>
</tr>
<tr>
<td>51</td>
<td>M. Botsari (M. Alexandrou)</td>
</tr>
<tr>
<td>52</td>
<td>Adrianoupolos (Kidonion)</td>
</tr>
<tr>
<td>53</td>
<td>V. Olgas (Delfon str.)</td>
</tr>
<tr>
<td>54</td>
<td>Martiou (Delfon str.)</td>
</tr>
<tr>
<td>55</td>
<td>K. Karamanli (Voulgari)</td>
</tr>
</tbody>
</table>
2.1.3. **Integration with previous ITS infrastructure**

After the integration with the detectors of the previous projects (Mobithess, EasyTrip), the network that has been created in Thessaloniki is presented in Figure 19 and the exact location of the detectors in Table 7.

![Figure 19: Network of BT detectors in Thessaloniki](image)

**Table 7: Locations of the detectors**

<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Lagada (Ag. Panton)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>12</td>
<td>V. Olgas (Sxoli tiflon)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>13</td>
<td>Lefkos Pircos</td>
<td>Mobithess</td>
</tr>
<tr>
<td>14</td>
<td>YMCA</td>
<td>Mobithess</td>
</tr>
<tr>
<td>15</td>
<td>K. Karamanli (Ipokratio)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>16</td>
<td>Sindrivani</td>
<td>Mobithess</td>
</tr>
<tr>
<td>17</td>
<td>Dimokratias Sq. (Dodekanisou)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>18</td>
<td>Evangelistria</td>
<td>Mobithess</td>
</tr>
<tr>
<td>19</td>
<td>D. Isodos (Koleti)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>20</td>
<td>Monastiriou (KTEL Makedonia)</td>
<td>Mobithess</td>
</tr>
<tr>
<td>21</td>
<td>St. Kazantzidi (Farm school)</td>
<td>EasyTrip</td>
</tr>
<tr>
<td>22</td>
<td>Moudanion Highway (M. Antipa Interchange)</td>
<td>EasyTrip</td>
</tr>
<tr>
<td>23</td>
<td>G. Sxolis Ave. (M. Antipa Intersection)</td>
<td>EasyTrip</td>
</tr>
<tr>
<td>24</td>
<td>Thermi (Panarama Intersection)</td>
<td>EasyTrip</td>
</tr>
<tr>
<td>31</td>
<td>Ag. Pavlos hospital</td>
<td>SEE-ITS</td>
</tr>
</tbody>
</table>
2.1.4. **Travel times estimation methodology**

The detectors of Bluetooth technology, that have been installed in the city creating a network of infrastructure-based sensors, are able to provide reliable, real-time point to point measurements for the most significant routes of Thessaloniki. The use of point to point measurements in the development of information provision services is broad since they provide an important picture of the spatial fluctuation of traffic conditions. This is the most important advantage of Bluetooth technology Monitoring Sensors compared to conventional single-point measurement solutions (e.g. inductive loops) where only temporal data are available for a specific spots of the network.
Bluetooth detectors scan and record traveller’s Bluetooth devices’ (car equipment and mobile phones) MAC identity and timestamp and travel times are estimated using an algorithm that has been developed by CERTH/HIT for the calculation of real-time travel times along pre-defined paths between two detectors.

The recording of MAC identity by successive detectors creates the path that each device has followed. Multiple recordings and the data processing methodology developed by CERTH-HIT calculate the estimated travel times. The basic steps of the methodology are:

- Data transmitted from the detectors through GPRS connection is stored in the CERTH/HIT database
- MAC addresses mutually used by group of fleets and addresses that are commonly used (00:00:00:00:00:00, 11:11:11:11:11:11), referred to as taboo list, are excluded so as each address that is stored in the database is unique
- The itinerary (the group of intersections equipped with Bluetooth detectors) followed by each MAC-ID is built using the recorded times of the day and travel times of each path are calculated
- For each predefined path all travel times are gathered.
- Travel times for each path are calculated with the use of trimmed average over the valid travel times and with the exclusion of travel times that are not considered as valid.

The steps of the developed methodology are described in Figure 20.

![Figure 20: Methodology for the estimation of travel time](image-url)
As a direct output of the measurements, travel times are calculated. Since the paths are specific and predefined, the calculation of travel times can enable in parallel the identification of the average speed for each path.

Moreover, the travel times that are being estimated are also used for a qualitative description of the network’s traffic conditions. The qualitative description of the real time condition is based on the methodology of the Highway Capacity Manual. Free flow travel times for every path have been calculated. Then, current travel times are normalised over the free flow travel times and therefore the values that occur are assigned to specific traffic conditions (Low traffic, Medium traffic, High traffic). The description of traffic conditions is visualised in a road network map with the use of different colours (Green-Low traffic, Yellow-Medium traffic, Red-High traffic).

2.1.5. Information Provision

Main objective of the demo activities in Thessaloniki is to provide Advanced Traveller Information Services (ATIS to the road network users). These services aim to cover both pre-trip and en-route phase of the trip. To fulfil this purpose, the services that have been developed, are provided through the internet and via roadside ITS infrastructure (e.g. Variable Message Signs – VMS).

A web based platform (available at www.greece.seeits.eu) has been developed so as to inform users about travel times and traffic conditions for the most important routes of the city, in real-time. The value of the platform is consisted on the provision of a dynamic network description allowing users to effectively plan their trips taking into account the information that is being provided and adjusting their trip or even postponing it, if necessary. The platform’s interface is presented in Figure 21.

![Figure 21: SEE-ITS web platform interface](image-url)
The information is also transmitted to the public via the VMSs which are installed in five points of the urban road network. VMSs, which are operated by the Region of Central Macedonia (RCM), are providing to the drivers real-time travel times for specific pre-defined routes. The value of the system is consisted on the contribution to the overall effective traffic management since drivers are informed for traffic conditions and have the possibility to alter their route when deviations from usual travel times are displayed. Figure 22 presents a VMS installed at the western entrance of the city displaying real-time travel time for a specific route.

![VMS displaying real-time travel times](image)

**Figure 22:** VMS displaying real-time travel times
2.2. **Specific evaluation**

The multidimensional positive effects of relevant ITS systems that have been implemented worldwide, both on the individual user and on the society, have been clearly identified and formulated in the relevant literature. To determine the systems’ positive effects, a number of evaluation criteria have been suggested, arising from the goals that the systems seek to accomplish. It is therefore advisable to determine the broader goal context that the systems have to serve. The main objective of ITS is to contribute making transport more efficient by improving mobility and enhancing the sustainability and the economic efficiency of the sector. The achievement of these goals requires the existence of a well-functioning system, which is useful for the users and can bring positive results to them and to the society.

The evaluation framework for the SEE-ITS demo activities, described in the section 1.2.1 of the report, placed the criteria and the evaluation steps and underlined the methods for their quantification. The evaluation methods that have been adopted in Thessaloniki’s pilot site are:

- Traffic simulation modelling
- Technical validation tests for the assessment of the technical reliability and accuracy of the system
- Field Operational Tests (FOTs) for the identification of the transportation system impact
- A questionnaire survey for the assessment of the system from the user’s perspective
- Internal evaluation processes

2.2.1. **Traffic Simulation Modelling**

The traffic micro-simulation model AIMSUM has been used in the evaluation processes of the demonstration activities in Thessaloniki. AIMSUN is traffic micro simulator, whose modelling logic is based on three sub models; the car following model (modified Gipps model), the lane changing model and the gap acceptance model. The model updates vehicle’s position for each temporal step, dictating the longitudinal and the lateral driver’s behaviour. As a result, detailed trajectories for all vehicles of the simulated network are extracted. The interface of the AISMUM model, depicting the simulated Thessaloniki’s road network, is presented in the following figures.
Figure 23: The road network of Thessaloniki’s agglomeration used in Aimsun software

Figure 24: Traffic assignment of a major intersection of Thessaloniki’s road network
2.2.2. Technical Validation Tests

The system has been tested so as to configure its technical performance and adequacy. For this purpose a twofold process was adopted in order to examine:

- The system’s reliability
- The system’s accuracy

Regarding the system’s reliability, validation tests with a private car were performed. The scope of the tests was to identify if the detectors are able to detect and record various types of BT devices and if they transmit the recorded data properly. Therefore, a private car equipped with several devices enhancing BT technology (mobile phones, tablets), made multiple routes near the locations of the detectors. Tests were carried out on the 26th and the 27th of May 2014. The routes were designed in a way to test the temporal and spatial range of detections. Participants in the test recorded the accurate time they passed from a detector’s location and the way (near, far) the detector was approached. At the end of the tests, configuration of the recordings with the relevant data stored in database was performed. More specifically it was checked if all MAC addresses of the test devices were recorded properly by all the detectors and if the time stamp of detection that appeared in the database was in line with the participant’s recordings.

As regards the system’s accuracy, it was configured within the same test described before. The scope was to determine if the methodology adopted for the estimation of travel times is correct and corresponds to reality. The test routes were designed in such a way, so as to be in accordance with the paths for which the system estimates travel times. Therefore travel times have been measured and the results have been compared with the estimated ones.

2.2.3. Field Operational Tests

ITS can influence the behaviour of individual users, but are also able to contribute to better traffic management. The two interventions that have been implemented in Thessaloniki have the goal of achieving a more efficient transport system. By improving discrete user’s patterns and by contributing to the effective traffic management, a number of parameters are affected; each of them participates with a different way to the overall goal achievement. More specifically, travel times, driver’s comfort, vehicle’s operation, fuel consumption and emissions, noise, safety and network’s efficiency are the influenced, by the systems parameters. The way and the rate of this influence are the determining factors of the overall benefits.

In order to identify these impacts, Field Operational Tests (FOTs) were performed in Thessaloniki. Drivers, with the use of mobile devices to provide them with real-time travel times’ information for the available links of the road network, and non-equipped drivers, were asked to drive from the same predefined Origins and to the same predefined Destinations (ODs). For each indicated OD, the first driver was informed about the real time
traffic conditions using the SEE-ITS platform and the other was not. Therefore the non-informed driver followed a sequence of links so as to accomplish the targeted OD, according to his sense about traffic conditions. The informed, with the use of the application, had the ability to specify his route taking account the real time traffic conditions. The informed and the non-informed driver started from the same origin. Arriving at the destination, the roles were changed and the informed driver was converted to non-informed for the next OD and conversely for the other driver. Either the informed or the non-informed driver had to choose by themselves the path, without any route identification. After the accomplishment of each OD, the test participants had to complete a questionnaire in which they reported the route they followed, the distance they covered, and the travel time they achieved. Moreover, they had to answer in a number of questions that targeted to identify the parameters that influenced their route choice.

Drivers have been selected with the criterion of being frequent users of Thessaloniki’s road network. Moreover, the routes have been selected in such a way, so as to cover the important links of Thessaloniki’s road network that accumulate the bulk of daily transport activities. In the predefined ODs, several driving environments (e.g. urban, motorway) and various types of roads were combined. Moreover, each OD could be executed by various alternative paths. The ODs selected contain a number of sub trips, for which travel times and traffic description are provided by the system. The informed users had a clear picture regarding the real-time traffic condition and had many alternatives to plan and make their trip. The non-informed drivers were based on their sense and knowledge regarding the traffic conditions that they had to anticipate. The test routes per OD are presented in Table 8.

### Table 8: Routes of the test described per OD

<table>
<thead>
<tr>
<th>ID</th>
<th>Origin</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6th km Charilaou-Thermi rd. (CERTH)</td>
<td>Giannitson 244 (Interurban bus terminal)</td>
</tr>
<tr>
<td>2</td>
<td>Giannitson 244 (Interurban bus terminal)</td>
<td>Kaftatzoglio National stadium</td>
</tr>
<tr>
<td>3</td>
<td>Kaftatzoglio National stadium</td>
<td>M. Alexandrou Avenue (Kyrilos and Methodios church)</td>
</tr>
<tr>
<td>4</td>
<td>M. Alexandrou Avenue (Kyrilos and Methodios church)</td>
<td>Ag. Dimitriou (Dodeka Apostolon church)</td>
</tr>
<tr>
<td>5</td>
<td>Ag. Dimitriou (Dodeka Apostolon church)</td>
<td>6th km Charilaou-Thermi rd. (CERTH)</td>
</tr>
<tr>
<td>6</td>
<td>6th km Charilaou-Thermi rd. (CERTH)</td>
<td>Ag. Dimitriou (Saint Dimitrios Church)</td>
</tr>
<tr>
<td>7</td>
<td>Ag. Dimitriou (Saint Dimitrios Church)</td>
<td>Giannitson &amp; Koletti (City Gate Mall)</td>
</tr>
<tr>
<td>8</td>
<td>Giannitson &amp; Koletti (City Gate Mall)</td>
<td>Terpsihtees (Lidl Toumpas)</td>
</tr>
<tr>
<td>9</td>
<td>Terpsihtees (Lidl Toumpas)</td>
<td>Stauroupoli City Hall</td>
</tr>
<tr>
<td>10</td>
<td>Stauroupoli City Hall</td>
<td>6th km Charilaou-Thermi rd. (CERTH)</td>
</tr>
</tbody>
</table>
2.2.4. Questionnaire Survey

As it has been mentioned above, Advanced Travellers Information Services (ATIS) can have an important role in the overall traffic strategy and management, contributing to the accomplishment of the goals for cleaner, safer and more efficient transport system. In ATIS, where effectiveness strongly depends on how the final user assesses, accepts and acts according to the information provided, the identification of these three behavioural parameters is of great importance. Therefore an integrated evaluation approach of the performance and of the impact of an ATIS demands the verification of how the network user adapts his traffic-related behaviour according to the information provided. This adaptation is important for the assessment of the overall traffic impact since traveller information systems act on the individual user while his decision and action affects the whole transportation system (marginal user approach).

The execution of a survey serves the scope of this identification in order to evaluate the impact of the services, which have been developed in the framework of the pilot activities of the SEE-ITS project from the user’s perspective. In terms of users’ assessment, it is examined users consider the services provision useful and the information provided reliable. In terms of users’ acceptance, it is examined if users take into account the information provided and in terms of users action it is examined if they adapt they route and if they change their traffic-related behaviour in general.

The survey is an important step of the overall ITS evaluation process since it provides the necessary indicators for the –wide scale- assessment of the performance of the implemented system, the identification of the user’s acceptance and the recording of the potential impact of a system that will be implemented. The results from a survey will be used; in conjunction with the field operation tests (FOTs) for the extrapolation of useful data that will be used in the final steps of the evaluation process such the cost benefit analyses. In addition, the results of the surveys are an important parameter for the identification of travel demand because they are a variable source of information regarding the trip generation, the allocation of trips to the network and the modal shift.

This evaluation method is adopted in Thessaloniki’s demo site aiming to assess the performance of ATIS from the user’s perspective.

The survey took place on typical days (21, 22, 23 & 26/05/2014), during morning hours and in locations in proximity to the Variable Message Signs that exist in the Thessaloniki Urban Area so as to ensure that the respondents would be familiar and would recognize the system that they were asked to evaluate. People who took part in the survey were in possession of, at least, a European category B driver’s license, due to the fact that the presented technologies are addressing drivers’ needs. Therefore, the survey participants were male or female drivers, walking in the vicinity of the Variable Message Signs and older than 18 years old.
For the successful execution of the survey a total number of 600 drivers responding to the questionnaire have been considered necessary. The identity of the survey is summarized in Table 9.

**Table 9: Questionnaire Survey identity**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Answers Category</th>
<th>Frequency (N %)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-25</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>26-53</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>36-45</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>46-55</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>56-65</td>
<td></td>
<td>07</td>
</tr>
<tr>
<td>65+</td>
<td></td>
<td>02</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>31</td>
</tr>
<tr>
<td><strong>Education level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school</td>
<td></td>
<td>02</td>
</tr>
<tr>
<td>Secondary or High school</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>Technological education</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>(TEI)</td>
<td></td>
<td>31</td>
</tr>
<tr>
<td>University (AEI)</td>
<td></td>
<td>09</td>
</tr>
<tr>
<td>Postgraduate studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Car dependence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td></td>
<td>06</td>
</tr>
<tr>
<td>A little</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Sufficiently</td>
<td></td>
<td>47</td>
</tr>
<tr>
<td>Very</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td><strong>Technology Familiarity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any</td>
<td></td>
<td>05</td>
</tr>
<tr>
<td>A little</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>Very</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Smart phones</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>A little</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>Very</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td><strong>Income level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1.000 €</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>1.000-2.000 €</td>
<td></td>
<td>43</td>
</tr>
<tr>
<td>2.000-3.000 €</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>3.000-5.000 €</td>
<td></td>
<td>06</td>
</tr>
<tr>
<td>&gt;5.000 €</td>
<td></td>
<td>04</td>
</tr>
</tbody>
</table>
2.2.5. **Internal Evaluation Processes**

The internal evaluation process is adopted in cases where:

- The previously gained experience is adequate to describe the influence of the system in a specific field (Mainly in technical and economic fields)
- Internal structures, functions and processes are examined
- Internal weaknesses need to be identified and corrected

So, when a criterion or a process is included in the previously mentioned cases, then the evaluation is performed by the participants of the project and by qualified personnel.
2.3. **System Performance Evaluation**

2.3.1. **The Project/System Development Process and Timeline**

The initial system timeline was introduced and presented in the activity 5.1 of the project. The figure below shows the timeline of the demonstration activities before the implementation.

![Timeline](image)

**Figure 25:** Initially estimated Timeplan of Thessaloniki demo activities

Due to some minor delays in the tendering process and in the finalization of the technical activities that were necessary in order the system to be fully operational and able to be evaluated all of the activities regarding the demo were slightly changed. The implemented timeplan is presented in the figure below.

![Timeline](image)

**Figure 26:** Original Timeplan of Thessaloniki demo activities

2.3.2. **System Reliability and Accuracy**

The technical validation tests described in section 2.2.2 confirmed the technical reliability and accuracy of the system and this was also supplemented by the users’ perception.
More specifically in terms of reliability, the results of the validation tests regarding the confirmation of the detections and the confirmation of the time stamp recording revealed proper operation for the majority of the detectors and appropriate data transmission. The conclusions that were extracted are:

- The majority of the detectors record properly several types of BT devices
- The majority of detectors has the proper position in the road infrastructure ensuring the desirable spatial range of detections
- The data recorded are transmitted properly to the database and the timestamp of the detection is confirmed.

Table 10 summarizes these results for each of detector.

**Table 10: Detection confirmation per BT detector**

<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
<th>Detection confirmation</th>
<th>Time stamp recording confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>Ag. Pavlos hospital (Kalamaria)</td>
<td>Not for all devices</td>
<td>√</td>
</tr>
<tr>
<td>32</td>
<td>Panorama Interchange (Ring road)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>33</td>
<td>Gr. Labraki (Perevou)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>34</td>
<td>Toumpa Interchange (Diagona)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>35</td>
<td>City Centre Interchange (Ring road)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>36</td>
<td>Ag. Pavlos Interchange (Ring road)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>37</td>
<td>Kaftatzoglio stadium (Katsimidi Intersection)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>38</td>
<td>Eptapirglo Interchange (Ring road)</td>
<td>Not for all devices</td>
<td>√</td>
</tr>
<tr>
<td>39</td>
<td>Neapoli Interchange (Ring road)</td>
<td>Not at all</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>Papageorgiou Interchange (Ring road)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>41</td>
<td>Stauroupoli Interchange (Ring road)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>42</td>
<td>Neapoli (bus terminal)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>43</td>
<td>Ag. Theraponda (M. Botsari)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>44</td>
<td>Stauroupoli City Hall (Lagada)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>45</td>
<td>Ifestionos (Ag. Dimitriou)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>46</td>
<td>Eleftherias Square-Venizelou str.</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>47</td>
<td>Bank of Greece-Tsimiski str.</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>48</td>
<td>Dikastiria Intersection</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>49</td>
<td>Airport Intersection</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>50</td>
<td>Theagenio hospital</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>51</td>
<td>M. Botsari (M. Alexandrou)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>52</td>
<td>Adrianoupolos (Kidonion)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>53</td>
<td>V. Olgas (Delfon str.)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>54</td>
<td>Martiou (Delfon str.)</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>55</td>
<td>K. Karamanli (Voulgari)</td>
<td>Not for all devices</td>
<td>√</td>
</tr>
</tbody>
</table>
The mismatches that appeared were either caused by technical problems of the detectors or were attributed to the road element on which the detectors had been installed. Moreover this conclusion was confirmed by the continuous monitoring of the recordings for each detector. The detectors that were problematic displayed an overall incorrect recording pattern compared to the others. These weaknesses were corrected by replacing the problematic detectors and by relocating the detectors that presented fluctuations in the recordings.

In terms of accuracy the developed methodology for travel time’s estimation was tested with the validation tests described also in section 2.2.2. For the paths that have been covered, the measured travel times and the relevant estimations of the system are provided indicatively in Table 11.

**Table 11:** Confirmation of Travel times measured and estimated

<table>
<thead>
<tr>
<th>Path ID</th>
<th>Path description</th>
<th>Measured times (min)</th>
<th>Estimated travel times (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>Airport - M. Antipa</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>97</td>
<td>M. Antipa - Ag. Pavlos</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>105</td>
<td>Delfon – V. Olgas (Arch. Mousiou)</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>V. Olgas (Arch. Mousiou) – Plata CHANTH (CHANTH)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>95</td>
<td>Stavroupoli City Hall - Ag. Panton</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>93</td>
<td>424 Intersection - RR Lagada</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>110</td>
<td>Lagada Intersection - Staurusoplo City Hall</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>Plata Dimokratias (Vardaris) - Lefkos Pyrgos</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>107</td>
<td>Lefkos Pirgos – Mpotsari</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

The results presented in the table above, are a sample of routes for which travel times are provided by the system. The tests showed a good correlation between the travel times that the algorithm estimated and the travel times that have been measured. The differences that occur are attributed to the fact that the system estimates the mean travel time per path, which can vary (within some limits) with the travel time of an individual vehicle. But it is a fact that for the majority of routes, the accordance of time recorded and estimated is at satisfactory levels, confirming system’s accuracy. This is depicted in Error! Reference source not found. where the measured travel times are plotted over the estimated. It is considered that if the dots in the graph are within the limit of 2 minutes (an interval indicated by two lines of 45 degrees each), then the estimations are accurate. This 2 minutes interval is adopted to compensate the potential time stamp recording errors of the tests measurements.
The conclusions that are extracted are:

- The methodology developed can provide travel times in a high level of accuracy
- Variances that occur are attributed to the specific traffic conditions that the individual vehicle faces
- After the tests no changes were made to the methodology

The accuracy and the reliability of the system are also confirmed by the user’s perspective in the questionnaire survey. Analysis of the results concerning the reliability of the VMS information that is provided, indicate that 74% of drivers consider the service as reliable. In the case of the reliability of the SEE-ITS internet platform, answers are split between users judging the online platform as reliable (43%) and users not answering the question (40%). This indicates that users are unaware of the service’s existence or that they are not using it. Overall, the percentage of users assessing the services as unreliable is small in both cases. This overall picture is depicted in Figure 28.
2.3.3. **Compatibility**

Through the internal evaluation process that have taken place, as described in 2.2.5, it was confirmed that the system is fully compatible with the already implemented information provision platforms (Easy Trip, Mobithess) since traffic data are derived from detectors of the same technology and there are available in a common format. The processing of all data is done by CERTH/HIT and provision of them is implemented with the use of mutual interfaces. Moreover the SEE-ITS system is able to feed the road infrastructure of VMSs (which are under the operation of RCM) with travel times’ estimations and support with data provision the functions of the Urban Mobility Centre of Thessaloniki. These allow the continuity of SEE-ITS services beyond the end of the project and the further exploitation of the project’s results. As a next step a viable solution could be the integration of the different platforms in a unique one, a fact that will increase the accuracy of information provided, will strengthen and unify the individual services and will provide the ability for the development of extended multimodal routing services, which can cover a wider geographic area. Possible synergies can be achieved with the public transport traveller information system of Thessaloniki, operated by OASTH. The integration in a common platform has already been examined by two studies of CERTH/HIT.

2.3.4. **Scalability**

The extension of the previous BT detectors network ensures the continuity of the data provision in a common format and the possible integration of the services provided in a common platform for the area of Thessaloniki. Moreover the implementation of systems that use the same technology at the areas of Kavala, Chalkidiki and Serres, allows the extension and the creation of a unique platform, beyond Thessaloniki’s borders.
2.4. **Cost Evaluation**

2.4.1. *Project Budget & Estimated Development Costs*

For the development of the Thessaloniki’s pilot demo activities, funds of the SEE-ITS project were used. The budget was allocated to the purchase of 25 BT detectors, the purchase of simulation software, the purchase of the necessary servers, the development of the SEE-ITS platform and the creation of the proper interfaces for the connection with RCM’s ITS infrastructure (VMS). These costs are summarized in the following table.

**Table 12: Development costs**

<table>
<thead>
<tr>
<th>Cost</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of investment (purchase of the equipment, cost of installation, any other related costs for the development of the system etc.)</td>
<td>Purchase and installation per unit (including guaranty and maintenance costs for 3 years)</td>
<td>2.300,00 €</td>
</tr>
</tbody>
</table>

During the implementation process, it was not required an adjustment in the initial budget since it was sufficient to meet the objectives of the program. Considering that this budget was sufficient to equip Thessaloniki with an extensive network of detectors that provide point to point measurements, the overall investment is considered as cost effective. The overall economic feasibility of the system will be determined in the next evaluation steps of the project and especially in the 7.1 activity.

2.4.2. *Estimated Operations & Maintenance Costs*

The installation of the system and the few months of the system’s operation provide us with indications for the future operation and maintenance costs. The operation of the internet platform includes a cost at an annual basis. BT detectors transfer the data recorded through 3G connection, which implies an operational monthly cost. Moreover, the operation and monitoring of the system demands the existence of adequate and skilled staff. The fact that the system is integrated into the mobility centre of the area eliminates this cost.

The technical malfunctions that occur, especially regarding the BT detectors, enable a cost. The experience gained within these months of the demonstration activities allows us to make estimations of the costs. These are presented in Table 13.
### Table 13: Operation and maintenance costs

<table>
<thead>
<tr>
<th>Cost</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Operational costs (direct costs such as power supply etc., salary of personnel necessary for the system operation, indirect costs etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Telecommunications costs &amp; power supply per unit, per month</td>
<td>7,00€ - 9,00 €</td>
</tr>
<tr>
<td></td>
<td>Personnel Costs</td>
<td>0,00 € (the system is integrated into the mobility centre of the area)</td>
</tr>
<tr>
<td></td>
<td>Maintenance costs (personnel costs, cost of consumables and any other cost related to the system maintenance)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annually Maintenance costs per unit, (after the first 3 years) including possible replacements of various parts (batteries, wires etc.)</td>
<td>60,00 € – 130,00 €</td>
</tr>
<tr>
<td></td>
<td>Personnel Costs</td>
<td>0,00 € (the system is integrated into the mobility centre of the area)</td>
</tr>
</tbody>
</table>
2.5. **Institutional Impacts Evaluation**

2.5.1. **Impacts to Operations and Maintenance Procedures and Policies**

No additional impacts to the operations and maintenance of the already developed systems were identified.

2.5.2. **Impacts to Staffing/Skill Levels and Training**

The whole demonstration process was a valuable experience and a reason of skills increase since the activities combined advanced technical aspects, traffic engineering challenges and impact assessment processes.

2.5.3. **Impacts to the Competitive Environment**

The development of such a service is able to create all the necessary perspectives for the involvement of several stakeholders in the deployment of mutual platforms especially in cases of other transport means. The concept of an ATIS platform development could be beneficial for railway, airport and port activities.

2.5.4. **Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS**

Greece has adopted the ITS Directive 2010/40/EC through its transposition into the national legislation and has already drafted a National ITS Action Plan. The development of Advanced Traveller Information Services in Thessaloniki is in line with the EU and the national legislative initiatives for ITS. More specifically the demonstration activities answer to the majority of the priority areas of the National ITS Action Plan and contribute mainly to the third, the fourth and the sixth areas which are:

- The information provision and the design of the multimodal passenger mobility
- The passenger information provision at urban mobility centres
- The strengthening of research and entrepreneurship.

The system fulfils the strategic targets that have been set by the Greek State regarding the ITS areas that should be promoted. Moreover, it lays the foundations for the integration of the existing platforms and the extension at SEE-regional level. So the system’s demonstration activities and evaluation processes provide an important test-bed regarding the implementation of the National ITS Action Plan and of the European transport policy. The importance of such a development has already been identified within the framework of the project and especially in activity 4.2 where experts’ opinions were asked. Specific functions that are met in the developed system are distinguished by their presumed benefits by experts.
and the need for their accession to integrated national initiatives is underlined. The system at a national level can play an important role in the integration of ITS to the overall national strategic plan for transport.

The system is also able to influence the local transport policy. The integrated transport policy in Greece is structured by the Ministry of Infrastructure, Transport and Networks. The Regions of the country (as administrative bodies) have limited possibilities of strategic planning. This is due to the problematic conception of their role, to the fragmented exploitation of opportunities and initiatives undertaking. In this context, the impact of the SEE-ITS system development on local planning is judged as beneficial for RCM because:

- It enhances RCM’s ITS infrastructure through the availability of more traffic data
- It consolidates the use of ITS as an effective tool for traffic management
- It contributes to the operational and strategic integration of ITS to the overall regional transport policy
- It highlights the positive contribution of the systems to the targets’ achievement
- It is a good example of Community funds use
2.6. **Transportation System Impacts Evaluation**

The framework of the evaluation process and the criteria that have been set can be quantified by the FOTs that have taken place and are confirmed by the questionnaire survey to drivers’ results. Both tests and surveys provide the appropriate estimations and indicators regarding the potential effectiveness of the system on the individual user and on the transport system in general. The indicators derived will be used as input to further evaluation steps where the value and the wider influence of the system can be determined. Table 14 presents the sub-criteria that are integrated to the criterion of the transportation impact evaluation, their valuation indicators and the scale that the results are extracted.

**Table 14:** Transportation system impact evaluation criteria and indicators

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Sub-Criteria</th>
<th>Valuation Indicator</th>
<th>Unit</th>
<th>Impact per OD</th>
<th>Local impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on traffic efficiency and traffic management</td>
<td>Vehicle Hours Travelled</td>
<td>VHT</td>
<td>% impact</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vehicle Kilometres Travelled</td>
<td>VKT</td>
<td>% impact</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased number of informed travellers</td>
<td>%</td>
<td>-</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td>Impacts to Mode Shifting and Intermodalism</td>
<td>People shift to public transport means</td>
<td>%</td>
<td>-</td>
<td>% shift</td>
<td></td>
</tr>
<tr>
<td>Impacts on the environment and fuel consumption</td>
<td>Fuel consumption</td>
<td>lt</td>
<td>% impact</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emission</td>
<td>Kg</td>
<td>% impact</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td>Impacts on driving behaviour</td>
<td>Pre-trip Route change</td>
<td>%</td>
<td>-</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>On-trip Route change</td>
<td>%</td>
<td>-</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trip postpone</td>
<td>%</td>
<td>-</td>
<td>% impact</td>
<td></td>
</tr>
<tr>
<td>Drivers/Users acceptance/perceptions</td>
<td>Responses regarding acceptance and perception</td>
<td>%</td>
<td>% impact</td>
<td>% impact</td>
<td></td>
</tr>
</tbody>
</table>

2.6.1. **Impacts on traffic efficiency and traffic management**

- Vehicle Hours Travelled (VHT)

For each OD the travel time of the informed driver is recorded. Then it is compared with the travel time that the non-informed driver had achieved for the same OD. After multiple tests, the total travel time reduction is calculated and the average travel time for OD is extracted.
Based on the results of the FOTs, it is expected that there will be a 2% reduction of the vehicle hours travelled.

- **Vehicle Kilometres Travelled (VKM)**

Vehicle kilometres are expected to increase by 5% for the drivers using the service based on the results of the FOTs. An increase was expected since drivers in the users’ acceptance survey ranked the fastest route as the most important factor influencing their route choice. This trend was confirmed by the FOTs as well. The test drivers that were presented with the traffic condition and the predicted travel times pre-trip chose routes with lower travel times or better traffic conditions, which are not necessarily the routes with the shortest distance. For each OD the distance covered by the informed and the non-informed users is calculated.

- **Increased number of informed travellers**

Based on the results of the questionnaire survey, 72% of the drivers questioned are willing to use the SEE-ITS online service for planning their trip.

![Figure 29: Drivers’ willing to use the online service for route planning](image)

Moreover, most drivers (91%) state that they frequently observe the information provided by the Variable Message Signs.
2.6.2. **Impacts to Mode Shifting and Intermodalism**

In the users’ questionnaire survey, participants were asked if they would take into account for their trip planning the information presented in the online service. 74% of drivers answered positively. Participants that answered negatively or did not answer to the previous question were excluded from the next question, regarding the extent to which they would change their initial route choice. Therefore, 435 out of the 600 drivers answered this question. Out of them, only 4% would choose a different transport mode. It is obvious from the results that the online service has the capability to influence the route choice and redistribute car traffic in a more efficient way in the network. However, the service shows a weak ability to shift drivers from private cars to other modes of transport. This situation might have to do with the fact that users of the online service are only presented with the car traffic conditions and travel times even if major roads of the network in the city centre have lanes dedicated to public transport, which are offering lower travel times. Moreover, Egnatia Street, which is a major road that crosses the city centre and leads to the test destination and is used by all public bus lines terminating at test destination, has currently reduced capacity capabilities. At several parts, the road is limited to one lane per direction of travel due to the construction works for the Thessaloniki Metropolitan Railway that are in progress.

2.6.3. **Impacts on the environment and fuel consumption**

Systems belonging to the category Advanced Travellers’ Information Systems contribute both to changing the traffic behaviour of drivers and to the broader effort of traffic management. Specifically these systems:

- affect the driving pattern
- contribute to trip planning
- bring positive consequences in safety
- support the use of public transport

![Figure 30: Frequency of VMS information observation](image-url)
• promote communication between users and their interaction with the transport network infrastructures
• help to avoid congestion and play an important role in the success of traffic measures

All these parameters mentioned above, have a direct or indirect effect on fuel consumption and emissions because they improve the efficiency of the transport system. The direct effectiveness of these systems regarding fuel consumption and emissions is related to the avoidance of congestion. In a congested traffic environment the frequent accelerations and idling times are the variables that affect energy consumption and emission.

Avoiding congested areas, vehicles dynamics are decreased, a fact which is depicted on the discrete driving pattern. Research suggests that 20% more fuel consumption and air pollution is caused by impeded traffic and stop-and-go traffic (Montemayor-Aldrete, et al., 2006). Examining traffic in a more macro scale level, the improved driving pattern affects the average speed, which is increased. This traffic variable is able to depict the changes in the driving pattern, because the avoidance of stop and go traffic leads in general to less vehicle dynamics and consequently to higher average speeds. The dependence of fuel consumption and emissions has been reported by (Ntziachristos and Samaras, 2000) where speed dependant emission factors are examined. Increase in the average speed leads to a reduction of fuel consumption and emissions in general. The next diagram depicts that trend and shows that for average speeds at 60-70 km/h the lower emissions occur.

![Figure 31: Average Speed and CO2 emissions. Source: (Barth & Boriboonsomsin, 2009)](image)

The average speed approach as it is included in the EMEP/EEA methodology is adopted in the present study for the estimation of fuel consumption. CO₂ emissions pattern is proportional to the fuel consumption one. Low travel speeds and stop-and-go are characteristics of adverse traffic conditions.
The comparison between the mean velocities of informed and uninformed test drivers showed that informed drivers travelled overall with a mean velocity increased by 4.4km/h (from 26.6km/h to 31km/h) compared to the un-informed drivers. Also, since the service provides traffic condition information and the acceptance rate was 70%, it is safe to assume that informed drivers chose routes with better traffic conditions. Using the average speed approach for a typical vehicle, fuel consumption is estimated to be reduced by 4%. The same pattern is followed by CO₂ emissions as well and a 4% reduction of CO₂ emissions is expected.

2.6.4. Impacts to Traffic Safety and Accident Reduction

No impacts are expected in this field.

2.6.5. Impacts on driving behaviour

- Route change

Out of the 600 drivers taking part in the users’ questionnaire survey, 40% would change their route pre-trip. This corresponds to 62% out of the 435 drivers that answered question concerning the extent they would change their route.

- Trip postponement

An 8% of drivers responding to the question concerning the extent they would change their route replied that they would postpone their trip.

2.6.6. Drivers/Users satisfaction/acceptance

- Users’ satisfaction

Analysis of the results of the questionnaire survey concerning the usefulness of the real-time travel time information service, 89% of drivers find the provision of such a service either fairly or very useful (Figure 32). Such results depict that users consider such a service as useful and needed for their daily mobility needs.
Moreover, assessing the reliability of the information that is provided, 74% of drivers consider VMS provided information as reliable, whereas 43% of the respondents consider the online platform information as reliable.

- Users’ Acceptance

The results of the FOTs that were conducted suggest that in 70% of all cases the driver will adjust his route according to the information provided by the online service.

Users’ acceptance of the information provided by the services can be assessed from the correlation between questions 12 and 13 of the questionnaire survey. 59% of all drivers...
would accept the system information, would take into account the information provided by
the service and, at the same time, would make use of the service for route planning.

**Figure 34:** Correlation of the willingness to use the online service for route planning with
drivers taking into account the information provided
3. **Patras Demo Site**

3.1. **Project/System Technical Description**

The demo activities in Patras are focused on the development and the implementation of Advanced Traveller information Services (ATIS), based on real-time traffic data. The outcome of the data fusion combined with the use of Dynamic traffic assignment and simulation software for the estimation of the traffic conditions of the road network results to the provision of real-time information to the end users. This information is twofold:

- Real-time travel times for the most important routes of the city
- Dynamic qualitative and quantitative description of the road network traffic conditions

In the framework of SEE-ITS project, 8 devices have been installed in selected locations of Patras area, extending the geographical area where the drivers are tracked, providing travel time for new routes, while at the same time increasing the density of detectors in the city centre providing better accuracy in vehicles’ tracking and the estimation of travel times.

3.1.1. **Point-to-point detectors’ location**

Considering that there were not any other detectors in the road network of Patras, The 8 detectors where installed in 8 of the most important intersections of the network in a way to cover all major routes passing through the central area of the city. The following figure depicts the exact location of the eight detectors.
The final locations of the BT detectors installed in the SEE-ITS project are presented in Table 15.

**Table 15:** Locations of BT detectors installed by SEE-ITS

<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>Panagioti Kanelopoulou</td>
</tr>
<tr>
<td>65</td>
<td>Kalavritianou Olokaytomatos</td>
</tr>
<tr>
<td>66</td>
<td>Neo Limani</td>
</tr>
<tr>
<td>67</td>
<td>Trion Symmaxon</td>
</tr>
<tr>
<td>68</td>
<td>Plateia Nikis</td>
</tr>
<tr>
<td>69</td>
<td>Papaflessa</td>
</tr>
<tr>
<td>70</td>
<td>Marina Patras</td>
</tr>
<tr>
<td>71</td>
<td>Plateia Basileos Georgiou</td>
</tr>
</tbody>
</table>
3.1.2. **ITS infrastructure**

The network that has been created in Patras is presented in Figure 36.

![Figure 36: Network of BT detectors in Patras](image)

3.1.3. **Travel times estimation methodology**

The detectors of Bluetooth technology, that have been installed in the city creating a network of infrastructure-based sensors, are able to provide reliable, real-time point to point measurements for the most significant routes of Patras. The use of point to point measurements in the development of information provision services is broad since they provide an important picture of the spatial fluctuation of traffic conditions. This is the most important comparative advantage of Bluetooth technology Monitoring Sensors compared to conventional single-point measurement solutions (e.g. inductive loops) where only temporal data are available for a specific spot of the network.

Bluetooth detectors scan and record traveller’s Bluetooth devices’ (car equipment and mobile phones) MAC identity and timestamp and travel times are estimated using an algorithm that has been developed by CERTH/HIT for the calculation of real-time travel times along pre-defined paths between two detectors.

The recording of MAC identity by successive detectors creates the path that each device has followed. Multiple recordings and the data processing methodology developed by CERTH-
HIT calculate the estimated travel times. This methodology is similar to the one that is described in HCM and the basic steps are:

- Data transmitted from the detectors through GPRS connection is stored in the CERTH/HIT database
- MAC addresses mutually used by group of fleets and addresses that are commonly used (00:00:00:00:00:00, 11:11:11:11:11:11), referred to as taboo list, are excluded so as each address that is stored in the database is unique
- The itinerary (the group of intersections equipped with Bluetooth detectors) followed by each MAC-ID is built using the recorded times of the day and travel times of each path are calculated
- For each predefined path all travel times are gathered.
- Travel times for each path are calculated with the use of trimmed average over the valid travel times and with the exclusion of travel times that are not considered as valid.

The steps of the developed methodology are described in Figure 37.

![Figure 37: Methodology for the estimation of travel time](image)

As a direct output of the measurements, travel times are calculated. Since the paths are specific and predefined, the calculation of travel times can enable in parallel the identification of the average speed for each path.

Moreover, the travel times that are being estimated are also used for a qualitative description of the network’s traffic conditions. The qualitative description of the real time condition is
based on the methodology of the Highway Capacity Manual. Free flow travel times for every path have been calculated. Then, current travel times are normalized over the free flow travel times and therefore the values that occur are assigned to specific traffic conditions (Low traffic, Medium traffic, High traffic). The description of traffic conditions is visualized in a road network map with the use of different colours (Green-Low traffic, Yellow-Medium traffic, Red-High traffic).

3.1.4. **Information Provision**

Utmost objective of the demo activities in Patras is to provide Advanced Traveller Information Services (ATIS to the road network users). These services aim to cover both pre-trip and en-route phase of the trip. To fulfill this purpose, the services that have been developed, are provided through the internet.

A web based platform (available at www.greece.seeits.eu) has been developed so as to inform users about travel times and traffic conditions for the most important routes of the city, in real-time. The value of the platform is consisted on the provision of a dynamic network description allowing users to effectively plan their trips taking into account the information that is being provided and adjusting their trip or even postponing it, if necessary. The platform’s interface is presented in Figure 38 below.

![Figure 38: Methodology for the estimation of travel time](image)
3.2. **Specific evaluation**

The multidimensional positive effects of relevant ITS systems that have been implemented worldwide, both on the individual user and on the society, have been clearly identified and formulated in the relevant literature. To determine the systems’ positive effects, a number of evaluation criteria has been suggested, arising from the goals that the systems seek to accomplish. It is therefore advisable to determine the broader goal context that the systems have to serve. The main objective of ITS is to contribute making transport more efficient by improving mobility and enhancing the sustainability and the economic efficiency of the sector. The achievement of these goals requires the existence of a well-functioning system, which is useful for the users and can bring positive results to them and to the society.

The evaluation framework for the SEE-ITS demo activities, described previously, placed the criteria and the evaluation steps and underlined the methods for their quantification. The evaluation methods that have been adopted in Patras’ pilot site are:

- Technical validation tests for the assessment of the technical reliability and accuracy of the system
- Field Operational Tests (FOTs) for the identification of the transportation system impact
- A questionnaire survey for the assessment of the system from the user’s perspective
- Internal evaluation processes

### 3.2.1. **Technical Validation Tests**

The system has been tested so as to configure its technical performance and adequacy. For this purpose a twofold process was adopted in order to examine:

- The system’s reliability
- The system’s accuracy

Regarding the system’s reliability, validation tests with a private car were performed. The scope of the tests was to identify if the detectors are able to detect and record various types of BT devices and if they transmit the recorded data properly. Therefore, a private car equipped with several devices enhancing BT technology (mobile phones, tablets), made multiple routes near the locations of the detectors. Tests were carried out on the 8th and the 9th of September 2014. The routes were designed in a way to test the temporal and spatial range of detections. Participants in the test recorded the accurate time they passed from a detector’s location and the way (near, far) the detector was approached. At the end of the tests, configuration of the recordings with the relevant data stored in database was performed. More specifically it was checked if all MAC addresses of the test devices were recorded properly by all the detectors and if the time stamp of detection that appeared in the database was in line with the participant’s recordings.
As regards the system’s accuracy, it was configured within the same test described before. The scope was to determine if the methodology adopted for the estimation of travel times is correct and corresponds to reality. The test routes were designed in such a way, so as to be in accordance with the paths for which the system estimates travel times. Therefore travel times have been measured and the results have been compared with the estimated ones.

### 3.2.2. Field Operational Tests

ITS can influence the behaviour of individual users, but are also able to contribute to better traffic management. The SEE-ITS platform has the goal of achieving a more efficient transport system. By improving discrete user’s patterns and by contributing to the effective traffic management, a number of parameters are affected; each of them participates with a different way to the overall goal achievement. More specifically, travel time, driver’s comfort, vehicle’s operation, fuel consumption and emissions, noise, safety and network’s efficiency are the influenced, by the systems parameters. The way and the rate of this influence are the determining factors of the overall benefits.

In order to identify these impacts, Field Operational Tests (FOTs) were performed in Patras. Drivers, with the use of mobile devices to provide them with real-time travel information for the most important links of the road network, and non-equipped drivers, were asked to drive from the same predefined Origins and to the same predefined Destinations (ODs). For each indicated OD, the first driver was informed about the real time traffic conditions using the SEE-ITS platform and the other was not. Therefore the non-informed driver followed a sequence of links so as to accomplish the targeted OD, according to his sense about traffic conditions. The informed, with the use of the application, had the ability to specify his route taking account the real time traffic conditions. The informed and the non-informed driver started from the same origin. Arriving at the destination, the roles were changed and the informed driver was converted to non-informed for the next OD and conversely for the other driver. Either the informed or the non-informed driver had to choose by themselves the path, without any route identification. After the accomplishment of each OD, the test participants had to complete a questionnaire in which they reported the route they followed, the distance they covered, and the travel time they achieved. Moreover, they had to answer in a number of questions that targeted to identify the parameters that influenced their route choice.

Drivers have been selected with the criterion of the well knowledge of the road network of Patras. Moreover, the routes have been selected in such a way, so as to cover the important links of Patras’ road network that accumulate the bulk of daily transport activities. In the predefined ODs, several driving environments (e.g. urban, motorway) and various types of roads were combined. Moreover, each OD could be fulfilled by many alternative paths. The ODs selected contain a number of sub trips, for which travel times and traffic description are provided by the system. The informed users had a clear picture regarding the real time traffic condition and had many alternatives to plan and make their trip. The non-informed drivers
were based on their sense and knowledge regarding the traffic conditions that they had to anticipate. The test routes per OD, are presented in Table 16:

<table>
<thead>
<tr>
<th>ID</th>
<th>Origin</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zaimi 2 (KTEL)</td>
<td>Kalavriton (Saint Andrew Hospital)</td>
</tr>
<tr>
<td>2</td>
<td>Kalavriton (Saint Andrew Hospital)</td>
<td>Akti Dimeon (New Port)</td>
</tr>
<tr>
<td>3</td>
<td>Akti Dimeon (New Port)</td>
<td>Ir. Politechniou (Railroad Station)</td>
</tr>
<tr>
<td>4</td>
<td>Ir. Politechniou (Railroad Station)</td>
<td>Agias Sofias (Nikis Square)</td>
</tr>
<tr>
<td>5</td>
<td>Agias Sofias (Nikis Square)</td>
<td>Panagioti Kanellopoulou</td>
</tr>
<tr>
<td>6</td>
<td>Intersection Venizelou &amp; G. Papandreou</td>
<td>Maizonos (City Hall)</td>
</tr>
<tr>
<td>7</td>
<td>Maizonos (City Hall)</td>
<td>Agias Sofias (Nikis Square)</td>
</tr>
<tr>
<td>8</td>
<td>Agias Sofias (Nikis Square)</td>
<td>National Road Patras-Athens (Archeological Museum)</td>
</tr>
<tr>
<td>9</td>
<td>National Road (Archeological Museum)</td>
<td>Patras-Athens</td>
</tr>
<tr>
<td>10</td>
<td>Zaimi 2 (KTEL)</td>
<td>Akti Dimeon (New Port)</td>
</tr>
</tbody>
</table>

### 3.2.3. Questionnaire Survey

As it has been mentioned above, Advanced Travellers Information Services (ATIS) can have an important role in the overall traffic strategy and management, contributing to the accomplishment of the goals for cleaner, safer and more efficient transport system. In ATIS, where effectiveness strongly depends on how the final user assesses, accepts and acts according to the information provided, the identification of these three-behavioural parameters is of great importance. Therefore an integrated evaluation approach of the performance and of the impact of an ATIS demands the verification of how the network user adapts his traffic-related behaviour according to the information provided. This adaptation is important for the assessment of the overall traffic impact on how traveller information systems act on the individual user while his decision and action affects the whole transportation system (marginal user approach).

The execution of a survey serves the scope of this identification in order to evaluate the impact of the services, which have been developed in the framework of the pilot activities of the SEE-ITS project from the user’s perspective. In terms of users’ assessment, it is examined users considering the services provision useful and the information provided reliable. In terms of users’ acceptance, it is examined if users take into account the information provided and in terms of users action it is examined if they adapt the route and if they change their traffic-related behaviour in general.
The survey is an important step of the overall ITS evaluation process since it provides the necessary indicators for the wide scale assessment of the performance of the implemented system, the identification of the user’s acceptance and the recording of the potential impact of a system that will be implemented. The results from a survey will be used; in conjunction with the field operation tests (FOTs) for the extrapolation of useful data that will be used in the final steps of the evaluation process such as the cost benefit analysis. In addition, the results of the surveys are an important parameter for the identification of travel demand because they are a variable source of information regarding the trip generation, the allocation of trips to the network and the modal shift.

This evaluation method is adopted in Patras’ pilot site aiming to assess the performance of ATIS from the user’s perspective.

The survey took place on typical days (8, 9, 10, 11 & 12/09/2014), during morning hours and in the centre of the city of Patras. People who took part in the survey were in possession of, at least, a European category B driver’s license, due to the fact that the presented technologies are addressing drivers’ needs. Therefore, the survey participants were male or female drivers, walking in the main streets of the city and some basic residential areas around down town.

For the successful conduct of the survey a total of 100 drivers responding to the questionnaire have been considered necessary. The identity of the survey is summarized in Table 17.

<table>
<thead>
<tr>
<th>Table 17: Respondents’ characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size: N=100, Status: Drivers</td>
</tr>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>18-25</td>
</tr>
<tr>
<td>26-53</td>
</tr>
<tr>
<td>36-45</td>
</tr>
<tr>
<td>46-55</td>
</tr>
<tr>
<td>56-65</td>
</tr>
<tr>
<td>65+</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Education level</td>
</tr>
<tr>
<td>Primary school</td>
</tr>
<tr>
<td>Secondary or High school</td>
</tr>
<tr>
<td>Technological education (TEI)</td>
</tr>
<tr>
<td>University (AEI)</td>
</tr>
<tr>
<td>Postgraduate studies</td>
</tr>
<tr>
<td>Car dependence</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>A little</td>
</tr>
<tr>
<td>Sufficiently</td>
</tr>
<tr>
<td>Very</td>
</tr>
<tr>
<td>Frequency (N %)</td>
</tr>
<tr>
<td>02</td>
</tr>
<tr>
<td>17</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>04</td>
</tr>
<tr>
<td>02</td>
</tr>
<tr>
<td>67</td>
</tr>
<tr>
<td>33</td>
</tr>
<tr>
<td>06</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>28</td>
</tr>
<tr>
<td>35</td>
</tr>
<tr>
<td>03</td>
</tr>
<tr>
<td>01</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>68</td>
</tr>
<tr>
<td>21</td>
</tr>
<tr>
<td>Internet Technology familiarity</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Internet</td>
</tr>
<tr>
<td>Smart phones</td>
</tr>
<tr>
<td>Income level</td>
</tr>
<tr>
<td>&lt;1.000 Euro</td>
</tr>
<tr>
<td>1.000-2.000 Euro</td>
</tr>
<tr>
<td>2.000-3.000 Euro</td>
</tr>
<tr>
<td>3.000-5.000 Euro</td>
</tr>
<tr>
<td>&gt;5.000 Euro</td>
</tr>
</tbody>
</table>
3.3. **System Performance Evaluation**

3.3.1. *The Project/System Development Process and Timeline*

The duration of the pilot is of 7 months. The tenders for the acquisition of the necessary equipment were published in late August 2013 and the purchase was finalized by September 2013. The equipment was installed during September 2013 and the system was tested and verified during October 2013. The pilot lasted from September 2013 to March 2014, where all data were collected and the pilot performance monitored in order to assure the quality and quantity of the databases. Before the end of the pilot the evaluation activities started, defining the methodology for evaluating the data, performing the monitoring of the pilot and after the end of the pilot phase analysing the data collected. The activities of the pilot are presented in the table below.

**Table 18: Time plan of the Patras pilot**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Jun13</th>
<th>Jul13</th>
<th>Aug13</th>
<th>Sept13</th>
<th>Oct13</th>
<th>Nov/Jan14</th>
<th>Feb/Apr14</th>
<th>May/ Sep14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tender preparation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tender Publication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offer Evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase and Insta.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilot Evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The traffic conditions during the months covered by the pilot operation are representative of the whole year; therefore the results are easily extrapolated to the whole year.

3.3.2. **System Reliability and Availability**

The technical validation tests described in section 3.2.1 confirmed the technical reliability and accuracy of the system and this was also supplemented by the users’ perception.

More specifically in terms of reliability, the results of the validation tests regarding the confirmation of the detections and the confirmation of the time stamp recording revealed proper operation for the majority of the detectors and appropriate data transmission. The conclusions that were extracted are:

- The majority of the detectors record properly several types of BT devices
- The majority of detectors has the proper position in the road infrastructure ensuring the desirable spatial range of detections
• The data recorded are transmitted properly to the database and the timestamp of the detection is confirmed.

Table 19 summarizes these results for each of detector.

<table>
<thead>
<tr>
<th>ID</th>
<th>Location</th>
<th>Detection confirmation</th>
<th>Time stamp recording confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>Panagioti Kanelopoulou</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>65</td>
<td>Kalavritianou Olokaytomatos</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>66</td>
<td>Neo Limani</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>67</td>
<td>Trion Symmaxon</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>68</td>
<td>Plateia Nikis</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>69</td>
<td>Papaflessa</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>70</td>
<td>Marina Patras</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>71</td>
<td>Plateia Basileos Georgiou</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

The mismatches that appeared were either caused by technical problems of the detectors or were attributed to the road element on which the detectors had been installed. Moreover this conclusion was confirmed by the continuous monitoring of the recordings for each detector. The detectors that were problematic displayed an overall incorrect recording pattern compared to the others. These weaknesses were corrected by replacing the problematic detectors and by relocating the detectors that presented fluctuations in the recordings.

In terms of accuracy the developed methodology for travel time’s estimation was tested with the validation tests described also in section 3.2.1. For the paths that have been covered, the measured travel times and the relevant estimations of the system are provided indicatively in Table 20.

<table>
<thead>
<tr>
<th>Path ID</th>
<th>Path description</th>
<th>Measured Travel time (min)</th>
<th>Estimated travel time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>147</td>
<td>Plateia Basileos Georgiou-Kalavritianou Olokaytomatos</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>144</td>
<td>Neo Limani-Panagioti Kanelopoulou</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>149</td>
<td>Plateia Nikis-Plateia Basileos Georgiou</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>150</td>
<td>Panagioti Kanelopoulou-Plateia Nikis</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>148</td>
<td>Kalavritianou Olokaytomatos-Neo Limani</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>153</td>
<td>Marina Patras - Trion Symmaxon</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
3.3.3. Compatibility

The Municipality of Patras acting as the main stakeholder that develops and implements the Urban Development Policy, is involved in a series of interventions that complement one to each other and all together consist an integrated approach for Patras in order to operate as a Smart City with the usage of advance technologies or systems, in the field of Intelligent Transportation Systems. These platforms or systems are described next.

- **Signalling system**

A Control Centre for the Traffic Light system that was firstly introduced at the early ‘90s with a capacity to operate wireless with 30 out of the 109 signal controllers installed the city. The Region of Western Greece has initialized a new project of modernization of the existing signalling system with a modern Control Centre that will use of open communication protocols. The new system is planned to cover the whole area of Western Greece and will be funded by the Regional Operational Programme 2007-13. The city of Patras will benefit the biggest part of the investment and it will be the operational centre of the new modern system. It is estimated that the project will reach the 2 MEuro.

- **Street parking**

An on-street parking control scheme has been installed in the central area since 2007. It uses conventional technology pay-and-display devices ("parking meters"), on which payment is
acceptable only in cash. The system covers an estimated capacity of 1,500 parking seats. The system is operated by the Technical Services of the Municipality and controlled by the Municipal Police. The control procedure is based on manual surveillance by officers who move on feet. Although the system was highly successful in the first period after implementation (in terms of obeisance and prevention of illegal parking), it suffers a considerable decline during the last two years. As a result, the Municipal Government is considering several options for reviving it, including decrease of the payment rates, establishment of dedicated areas for area habitants, more strict enforcement, etc.

The related ITS-based projects that complement and enhance the 2 systems already in operation are briefly presented below:

- **Advanced mobility management information system based on ICT (summit)**

  The city of Patras, through its development enterprise (ADEP S.A.), is a Lead Partner of project SUMMIT that is financed by the O.P. Greece-Italy 2007-2013. The project aims to develop new intelligent systems that assist the driver to avoid accidents, to provide drivers with real time information to avoid congestion, and optimise a journey or the engine performance to improve energy efficiency but also with the study of Route optimization systems for local public transport.

- **Project “Kathodigos”**

  The city of Patras, through its development enterprise (ADEP S.A.), is a Partner of project ‘KATHODIGOS’ that is financed by General Secretariat for Research & Development, Greece. The project aims to implement a Pilot system of real time traffic monitoring with wireless sensors and cameras. Moreover, Parking spaces status is going to be monitored with wireless sensors and an integrated ITS system will be finally delivered.

- **Modernization of the public transportation by using real time information systems**

  The project aims to install VMS screens in more than 50 bus stops for giving information about estimation of arrivals of buses, the bus routes, combinations with regional rail or other transportation means. Real time information of the public transportation through mobile devices (smartphones, tablets, laptops, GPS's etc.) will be also provided. The project is financed by Operational Programme “Enhancement of Accessibility”, Greece.

- **Smart Roads (Kanakari St. & Korinthou St.)**

  The project aims to traffic and Incidents monitoring by installing several wireless devices (Bluetooth and Wi-Fi sensors, infrared cameras etc.). A Central Control System is also installed for the operation of the whole system and wireless sensors are put in 200 Parking Space in the streets Kanakari and Korinthou for monitoring their availability and status. The project is financed by Regional Operational programme of Western Greece 2007-2013.
3.3.4. Scalability

The infrastructure installed within the SEE-ITS project is part of an integrated strategy of the city of Patras in order to install smart technologies and services in the city centre. The Bluetooth devices are going to be installed along with a central system that will monitor their operation and will also collect all the traffic data in a central information system. This system will be able to communicate for data exchange with the other Traffic Management systems of the Municipality of Patras, as well as with the CERTH-HIT in Thessaloniki, in order to use its travel estimation algorithms and related features. Such an endeavour will set a reliable and well-tested basis for a nationwide system in case that other Greek cities are willing to join and collaborate.
3.4. **Cost Evaluation**

3.4.1. *Project Budget & Estimated Development Costs*

For the development of the Patras’ pilot demonstration activities, funds of the SEE-ITS project were used. The budget was allocated to the purchase of BT detectors and their installation and the development of the SEE-ITS platform. These costs are summarized on Table 21.

<table>
<thead>
<tr>
<th>Cost of investment (purchase of the equipment, cost of installation, any other related costs for the development of the system etc.)</th>
<th>Purchase and installation per unit (including guaranty and maintenance costs for 3 years)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2.300,00 €</td>
</tr>
</tbody>
</table>

During the implementation process, it was not required an adjustment in the initial budget since it was sufficient to meet the objectives of the program. Considering that this budget was sufficient to equip Patras with an extensive network of detectors that provide point to point measurements, the overall investment is considered as cost effective. The overall economic feasibility of the system will be determined in the next evaluation steps of the project and especially in the 7.1 activity.

3.4.2. *Estimated Operations & Maintenance Costs*

The installation of the system and the few months of the system’s operation provide us with indications for the future operation and maintenance costs. The operation of the internet platform includes a cost at an annual basis. BT detectors transfer the data recorded through 3G connection, which implies an operational monthly cost. Moreover, the operation and monitoring of the system demands the existence of adequate and skilled staff. The fact that the system is integrated into the mobility centre of the area eliminates this cost.

The technical malfunctions that occur, especially regarding the BT detectors, enable a cost. The experience gained within these months of the demonstration activities allows us to make estimations of the costs. These are presented in Table 22.

<table>
<thead>
<tr>
<th>Cost</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational costs (direct costs such as power supply per unit, per month)</td>
<td>Telecommunications costs &amp; power supply per unit, per month</td>
<td>7,00€ - 9,00 €</td>
</tr>
<tr>
<td>etc., salary of personnel necessary for the system operation, indirect costs etc.)</td>
<td>Personnel Costs</td>
<td>0,00 € (the system is integrated into the mobility centre of the area)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Maintenance costs per unit, (after the first 3 years) including possible replacements of various parts (batteries, wires etc.)</td>
<td>Annually Maintenance costs</td>
<td>60,00 € – 130,00 €</td>
</tr>
<tr>
<td>Personnel Costs</td>
<td>Personnel Costs</td>
<td>0,00 € (the system is integrated into the mobility centre of the area)</td>
</tr>
</tbody>
</table>
3.5. **Institutional Impacts Evaluation**

3.5.1. *Impacts to Operations and Maintenance Procedures and Policies*

No additional impacts to the operations and maintenance of the systems already developed were identified.

3.5.2. *Impacts to Staffing/Skill Levels and Training*

The whole demonstration process was a valuable experience. The skills of the municipal staff have been enhanced, given that the pilot activities combined advanced technical aspects, traffic engineering challenges and impact assessment processes.

3.5.3. *Impacts to the Competitive Environment*

The development of the piloted service is able to create all the necessary perspectives for the involvement of several stakeholders in the deployment of mutual platforms especially in cases of other transport means. The concept of an ATIS platform development could be beneficial for railway, airport and port activities, given that all of those actors operate in the city and the metropolitan area of Patras.

3.5.4. *Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS*

Greece has adopted the ITS Directive 2010/40/EC through the adaptation of its national legislation and has already drafted a National ITS Action Plan. The development of Advanced Traveller Information Services in Patras is in line with the EU and the national legislative initiatives for ITS. More specifically the demonstration activities answer to the majority of the priority areas of the National ITS Action Plan and contribute mainly to the third, the fourth and the sixth areas, namely:

- Information provision and design of the multimodal passenger mobility
- Passenger information provision at urban mobility centres
- Strengthening of research and entrepreneurship.

The system fulfils the strategic targets that have been set by the Hellenic government regarding the ITS areas that should be promoted. Moreover, it lays the foundations for the integration of the existing platforms and the extension at SEE-regional level. Consequently, the system’s demo activities and evaluation processes provide an important test-bed regarding the implementation of both the National ITS Action Plan and of the European transport policy. The importance of such a development has already been identified within the framework of the project and especially in activity 4.2 where experts’ opinions were...
asked. Specific functions that are met in the developed system are distinguished by their expected benefits by experts and the need for their accession to integrated national initiatives is underlined. The system at a national level can play an important role in the integration of ITS to the overall national strategic plan for transport.

The system is also able to influence local transport policy. The integrated transport policy in Greece is defined by the Ministry of Infrastructure, Transport and Networks. The Regions of the country (as administrative bodies) have limited jurisdiction for strategic planning. This is due to the conception of their role, as well as to the fragmented exploitation of opportunities and initiatives undertaking. In this context, the impact of the SEE-ITS system development on local planning is judged as beneficial for RCM because:

- It enhances RCM’s ITS infrastructure through the availability of more traffic data
- It consolidates the use of ITS as an effective tool for traffic management
- It contributes to the operational and strategic integration of ITS to the overall regional transport policy
- It highlights the positive contribution of the systems to the targets’ achievement

It is finally a good example of efficient use of Community shared funding.
3.6. Transportation System Impacts Evaluation

3.6.1. Impacts on traffic efficiency and traffic management

- Vehicle Hours Travelled (VHT)

For each OD the travel time of the informed driver is recorded. Then it is compared with the travel time that the non-informed driver had achieved for the same OD. After multiple tests, the total travel time reduction is calculated and the average travel time for OD is extracted. Based on the results of the FOTs, it is expected that there will be a 5.50% reduction of the vehicle hours travelled.

- Vehicle Kilometres Travelled (VKM)

There are no differences observed in the distances between the informed and the non-informed driver. This occurred because the routes that the drivers follow in the centre of the city are specific and there are not alternative choices. From the answers in the questionnaire, it can be concluded that both drivers followed the same route, except for one case, in OD-ID 5, where the two drivers moved from the origin to the destination point in a different way. In this route, although the travel time was the same, the distance was 1.3km longer for the non-informed driver. The conclusions concerning the impact of the system in km travelled per OD is presented in detail in Error! Reference source not found.

- Increased number of informed travellers

Based on the results of the questionnaire survey, 82% of the drivers questioned are willing to use the SEE-ITS online service for planning their trip.

![Diagram](image)

**Figure 40:** Drivers willing to use the online service for route planning
3.6.2. **Impacts to Mode Shifting and Intermodalism**

In the users’ questionnaire survey, participants were asked if they would take into account for their trip planning the information presented in the online service. 76% of drivers answered positively. Only 1% would choose a different transport mode. It is obvious from the results that the online service has the capability to influence the route choice and redistribute car traffic in a more efficient way in the network. However, the service shows a weak ability to shift drivers from private cars to other modes of transport. This situation might have to do with the fact that users of the online service are only presented with the car traffic conditions and travel times even if major roads of the network in the city centre have lanes dedicated to public transport, which are offering lower travel times. Nonetheless, the system does not provide information on travel times of alternative modes, hence the low willingness to modal shift. In the event of enhancing the system with such intermodal information, we should expect higher modal shifts.

3.6.3. **Impacts on the environment and fuel consumption**

Systems belonging to the category Advanced Travellers’ Information Systems contribute both to changing the traffic behaviour of drivers and to the broader effort of traffic management. Specifically these systems:

- affect the driving pattern
- contribute to trip planning
- bring positive consequences in safety
- support the use of public transport
- promote communication between users and their interaction with the transport network infrastructures
- help to avoid congestion and play an important role in the success of traffic measures

All these parameters mentioned above, have a direct or indirect effect on fuel consumption and emissions because they improve the efficiency of the transport system. The direct effectiveness of these systems regarding fuel consumption and emissions is related to the avoidance of congestion. In a congested traffic environment the frequent accelerations and idling times are the variables that affect energy consumption and emission.

Avoiding congested areas, vehicles dynamics are decreased, a fact which is depicted on the discrete driving pattern. Research suggests that 20% more fuel consumption and air pollution is caused by impeded traffic and stop-and-go traffic (Montemayor-Aldrete, et al., 2006). Examining traffic in a more macro scale level, the improved driving pattern affects the average speed, which is increased. This traffic variable is able to depict the changes in the driving pattern, because the avoidance of stop and go traffic leads in general to less vehicle dynamics and consequently to higher average speeds. The dependence of fuel consumption and emissions has been reported by (Ntziachristos and Samaras, 2000) where speed dependant emission factors are examined. Increase in the average speed leads to a reduction of fuel
consumption and emissions in general. The next diagram depicts that trend and shows that for average speeds at 60-70 km/h the lower emissions occur.

Figure 41: Average Speed and CO2 emissions. Source: (Barth & Boriboonsomsin, 2009)

The average speed approach as it is included in the EMEP/EEA methodology is adopted in the present study for the estimation of fuel consumption. CO2 emissions pattern is proportional to the fuel consumption one. Low travel speeds and stop-and-go are characteristics of adverse traffic conditions.

The comparison between the mean velocities of informed and uninformed test drivers showed that informed drivers travelled overall with a mean velocity increased by 4.4km/h (from 26.6km/h to 31km/h) compared to the un-informed drivers. Also, since the service provides traffic condition information and the acceptance rate was 70%, it is safe to assume that informed drivers chose routes with better traffic conditions. Using the average speed approach for a typical vehicle, fuel consumption is estimated to be reduced by 4%. The same pattern is followed by CO2 emissions as well and a 4% reduction of CO2 emissions is expected.
3.6.4. **Impacts to Traffic Safety and Accident Reduction**

Travel information usually enhances the feelings of security while driving. An informed driver is in principle less stressed than the uninformed driver. Given that stress is an important cause of traffic incidents in the urban environment, it is assumed that the piloted system will contribute to the overall improvement of urban traffic safety, despite the lack of concrete evidence from the survey.

3.6.5. **Impacts on driving behaviour**

- **Route change**

Out of the 100 drivers taking part in the users’ questionnaire survey, 21% would change their route pre-trip.

- **Trip postponement**

8% of drivers responding to the question concerning the extent they would change their route replied that they would postpone their trip.

- **Users’ satisfaction**

Analysis of the results of the questionnaire survey concerning the usefulness of the real-time travel time information service, 65% of drivers find the provision of such a service either fairly or very useful (Figure 42). Such results depict that users consider such a service as useful and needed for their daily mobility needs.

![Figure 42: Usefulness of Real-Time Travel Time Information](image)

- Not at all
- A little
- Sufficiently
- Very
- N/A
• Users’ Acceptance

The results of the FOTs that were conducted suggest that in 70% of all cases the driver will adjust his route according to the information provided by the online service.

Users’ acceptance of the information provided by the services can be assessed from the correlation between questions 12 and 13 of the questionnaire survey. 59% of all drivers would accept the system information, would take into account the information provided by the service and, at the same time, would make use of the service for route planning.

![Willingness to Use the Online Service for Route Planning](image)

**Figure 43:** Correlation of the willingness to use the online service for route planning with drivers taking into account the information provided.
4. **RESULTS FROM GREEK PILOT SITES**

4.1. **Results from the two systems’ evaluation**

Within the framework the SEE-ITS project, the demonstration activities in Thessaloniki and in Patras are of the same nature. Therefore mutual evaluation conclusions are extracted, considering a unique pilot demonstration in Greece. Therefore for the criteria that has been set a qualitative and quantitative description of them is summarized on a common basis.

Both in the two pile sites, the same ex-ante evaluation tools have been used. More specifically the two ATIS platforms have been evaluated through:
- Field Operational Tests (FOTs)
- Questionnaire survey’s to drivers
- Internal evaluation processes

The present section summarizes the indicators of performance that are related to the impacts on the transportation system and on the effect on user’s satisfaction. Regarding the impacts on the transportation system, VHT are expected to decrease in the range of 2-5%, VKT are expected to increase in the range of 0-5%, while fuel consumption and CO2 emissions are estimated to decrease, in the range of 0-4%.

Since the population of each pilot site is different, a weighted average based on the population distribution is implemented, in order a single number to occur for the integrated evaluation. The samples that have already been used in the driver’s questionnaire survey are proportional and representative of the cities’ population. The population of each pilot site is represented on the table below.

<table>
<thead>
<tr>
<th></th>
<th>Thessaloniki</th>
<th>Patras</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>788.952</td>
<td>168.034</td>
</tr>
<tr>
<td>Percentage</td>
<td>82%</td>
<td>18%</td>
</tr>
</tbody>
</table>

- **Increased number of informed travellers**

<table>
<thead>
<tr>
<th></th>
<th>Thessaloniki</th>
<th>Patras</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential use of the platform</td>
<td>72%</td>
<td>82%</td>
<td>74%</td>
</tr>
</tbody>
</table>

- **Impacts to mode shifting**

<table>
<thead>
<tr>
<th></th>
<th>Thessaloniki</th>
<th>Patras</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode shift</td>
<td>3%</td>
<td>1%</td>
<td>3%</td>
</tr>
</tbody>
</table>

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• Impacts on Driving behaviour

<table>
<thead>
<tr>
<th>Answer</th>
<th>Thessaloniki</th>
<th>Patras</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Trip entire route change</td>
<td>20%</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>Pre-trip Partial route change</td>
<td>51%</td>
<td>44%</td>
<td>50%</td>
</tr>
<tr>
<td>Departure time change</td>
<td>7%</td>
<td>13%</td>
<td>8%</td>
</tr>
</tbody>
</table>

• User’s satisfaction (Based on the usefulness of the service as provided by the questionnaire survey to drivers)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Thessaloniki</th>
<th>Patras</th>
<th>Integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very &amp; Sufficiently</td>
<td>89%</td>
<td>65%</td>
<td>85%</td>
</tr>
</tbody>
</table>
5. **VIENNA DEMO SITE**

5.1. **Project/System Technical Description**

For the demo site Vienna a system offering C-ITS services to mobile end-users was realised with the aim to provide a solution which is overall low cost, flexible to adapt, easy to implement by different organisations, and transferable to other cities or countries.

5.1.1. **The Framework as basis for further Developments**

The system developed within SEE-ITS for the demo site Vienna covers the complete ITS service chain from the import of traffic data to handling and visualisation of data on a mobile end-user device. Its main components are the SEE-ITS server and the end-user application, which is based on a software development framework (see Figure 42). All these components are available as open source. The server can be connected to a traffic data source via an import adapter, rendering this solution easily transferable to cities and regions with other data sources.

![System overview Vienna demo-site](image-url)
5.1.2. Combine independent packages for individual services

When developing C-ITS applications and dealing with TPEG messages, certain tasks are to be dealt with repeatedly. These include amongst others activating a GPS location service, fetching and managing TPEG messages, and dealing with maps on which the traffic data is shown to end-users. The purpose of the SEE-ITS software development framework is to provide corresponding functionalities, and enable developers to focus on the core purpose of their apps. The framework provides the following functionalities:

- The GPS manager handles incoming GPS location data and notifies the underlying application of incoming data.
- The TPEG manager takes care of all TPEG messages, either already present or new ones incoming. This includes sorting of new messages, updating of already existing ones, deleting timed out ones, filtering only relevant messages, and message search functionalities. It also provides an application programming interface (API) with which relevant TPEG message elements can be retrieved without the need to deal with the raw format.
- The TPEG server connector establishes a connection to a TPEG server, requests and receives TPEG messages (pull and push service is available), and provides these messages for further processing.
- The background map module supports Google Maps and OpenStreetMap. The provided functional scope is the same for both maps. Besides loading and caching of map tiles, this module also allows displaying the position of active events on the map. Additionally, the street section where the event is located can be highlighted by using the underlying routing feature.
- The global configuration module allows the configuration of certain options according to user preferences, such as the IP-address of TPEG servers, the radius around the vehicle position in which messages are requested, message polling intervals, TPEG message filters, and map parameters.
- The feedback module comprises an active and a passive feedback feature. With the passive feedback it is possible to collects various anonymous information such as user interactions, while the active feedback option enables users to fill out a questionnaire or to send a direct message. This should support the evaluation and validation phase of applications and on the other side provide ways and means to directly engage with the end-user.

In case the TPEG server is not the SEE-ITS server, true TPEGml format is used and managed by the framework. This can also be achieved by setting a flag when requesting data from the SEE-ITS Server. In case the flag is not set, the SEE-ITS framework returns a light-weight JSON transformation containing the most relevant aspects of a TPEG message. This should make it easier for everybody to start out and understand the format right away.

The framework itself is organized into different and independent packages. A delegate pattern is used to notify the invoking context of occurring events. There is also a DEMO
application which serves to provide insight into how the framework and its components can be used. During development, and depending on the application needs, different framework components can be imported and underlying APIs used. The API returns an immediate result, updates certain settings, or initiates an asynchronous task. Some require a listener in order to return the results (see delegate interfaces).

The framework is targeted at Android platforms (currently API level 14 and above). It is a library project, and as such can easily be added to a new Android project. It was developed with Java for Android. While there are multiple ways to organise the development environment, most developers will probably feel most comfortable with the Eclipse IDE.
5.1.3. **The server – an easily transferable solution**

For import, distribution, and management of traffic messages a server module has been developed. It is able to create TPEG messages on the basis of traffic data, manage them, and distribute them to the end-user devices. Additionally, the requests from end-user devices are tracked for evaluation purposes.

The server allows to create TPEG messages manually (as xml files) or to import data from an external data provider (e.g. infrastructure operator). For the import of traffic data, the server supports the use of import adapters, which fetch data from an external server. These data are converted into TPEG messages by the server afterwards. For developers it is possible to include their own adapter, so that TPEG messages can be imported in a fast and efficient way. In this way the SEE-ITS system can be connected to various data sources and is therefore easily transferable to other cities and regions. For the demo site Vienna traffic data from the Austrian Automobile, Motorcycle and Touring Club ÖAMTC is imported. To additionally emphasise the easy transferability an import adapter for traffic data from Slovenia has also been developed.

The server provides functionalities for the management of traffic messages, such as adding, removing, or updating of messages. This can be handled automatically with the import adapter or manually over the web interface. The position and details of each message/event can be viewed and edited directly in the web interface (See Figure 45). For the visualisation OpenStreetMap as well as Google Maps are available and can be switched during operations to compare views and presentation modes.

Messages are organised in message sets, i.e. each message set is allocated to a specific set of messages (e.g. messages for a specific area such as the inner City of Vienna or messages of a specific information provider). The owner of the set has the possibility to add members, who are allowed to edit the data. End-user applications can access the data from a specific message set in a secure way via a public key authentication.
The server provides access to traffic messages via pull service. By using the pull service, the app sends its current position and the diameter of the area around this position for which traffic messages are requested, and the server sends back all messages within this area. The update interval of messages can be adjusted in the application individually.

For evaluation purposes the server provides tracking services in a static and in a dynamic version. The static track functionality just stores the requests of the end-user devices, while the dynamic track functionality plots the positions of the selected session in a web interface. The dynamic track functionality is shown in Figure 46. With every request of the end-user application its current position is plotted on the map. If a pop-up message is displayed on the end-user device also the type and the position of the message is shown in the list below. These functions can be used to support the evaluation of end-user tests as well as in regular operation for assessing the degree of usage of traffic information services.
The server was developed with Ruby on Rails.
5.1.4. The end-user application / mobile client

The SEE-ITS end-user application was created to evaluate and to demonstrate the functionality of the software development framework and of the server solution. The main focus of the application is not to provide a fully matured solution to the end-user, but to give developers an overview on the possibilities of the framework. Traffic information is transferred from external traffic information providers to the SEE-ITS server and coded in TPEG format via an import adapter. From the SEE-ITS server the messages are distributed to end-user applications.

![SEE-ITS-Demo](image)

**Figure 47**: End-user application - overview screen

The following ITS services have been provided with the SEE-ITS end-user application in the area of Vienna:

- In-vehicle signage: informs drivers about speed limits
- Hazardous location notification – provides information on hazardous locations such as oil on the road or black ice
- Traffic jam ahead warning – warns drivers of traffic jams
- Road works warning – informs drivers about road works
- Park & ride information – provides information on the availability of park and ride facilities
- Floating car data – submission of current position data of the end-user devices to the SEE-ITS server, in order to improve the available data about the current traffic status.

The services are presented to the end-user as follows:

- On an overview screen the locations of all current messages in a certain area around the current position of the end-user device are displayed (Figure 47). The type of the message (e.g. road works, other danger, park & ride information) is indicated with a
respective pictogram. The area in which messages are received can be selected individually by the user inside the preferences view (see Figure 50).

![Test tpeg - traffic congestion](image)

**Figure 48:** End-user application – pop-up message

- More details for a specific message are shown after tapping on the respective symbol (see Figure 48). A pop-up at the bottom of the screen provides text information on the event as well as the name of the road where the event is located.

- If the vehicle approaches an event and the distance to this event decreases beyond a threshold (warning distance), information on this event pops up automatically (Figure 48). The threshold levels can be adjusted with the framework facilities.

- If the vehicle leaves the area of the event, the pop-up message is removed automatically.

- The full information available for this event can be accessed by tapping the information symbol ("i"). This information will usually not be relevant for the end-user; it is implemented to facilitate test and validation activities. It includes several data elements, such as message ID, version ID or expiry time of the event (see Figure 49).

This basic framework for the visualisation of C-ITS information can be extended and adapted to different routing engines, styles and visualisation elements and further aspects needed to make a mobile application useful and attractive for specific user groups.
Figure 49: end user application – API configuration

Figure 50: end-user application – detailed information

Test tpeg - SlipperyRoad
- Slippery road
- Südosttangente, Österreich

Message ID: 21849
Version ID: 2
Expiry time: 2014-11-13T09:22:00
Generation time: 2014-11-03T15:06:35

Effect: null
Main cause: Slippery road
Sub cause: null
Warning level: informative
5.2. System Performance Evaluation

5.2.1. The Project/System Development Process and Timeline

A development timeline of the demo site Vienna is shown in Figure 51. The main steps have been:

- Development of the concept for demo site Vienna

The first step has been the development of the concept of the demo site. For this concept the system components and their interfaces have been specified as well as possible data sources and the geographical area of demonstration. Also additional requirements and options concerning communication, evaluation, devices and open source character have been defined.

- Obtaining offers from companies

Based on the concept several companies have been contacted and asked for offers.

- Selection and assignment of winning offer

The offer with the best price-performance ratio has been selected and assigned.

- Development of software development framework, end-user application and server

This phase started with the development of the server, as the server was also used as a source for test messages during the development of the software development framework and the end-user application. During the development of the server also the development of the software development framework and the end-user application have been started. For all components methods of agile software development have been used.

- Development of import adapters

The import adapters have been developed in each case after agreements with ÖAMTC (Austrian Automobile, Motorcycle and Touring Club), TIC (Traffic information centre for state roads, Slovenia), and FTA (Finnish Transport Agency) have been reached.

- Validation of functionalities

Although tests of new versions of the single components have been carried out frequently, specific validation tests have been carried out according to a comprehensive test plan between CW 31 and CW 33.
Friendly user tests

Friendly end-user tests have been carried out from CW 30 to CW 35 with about ten test users.

Evaluation

The Evaluation was carried out with regard to transferability of the solution, suitability of the software development framework for the development of C-ITS solutions, correct functioning of the single components, and usability.

<table>
<thead>
<tr>
<th>Development of concept</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of concept</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtaining of offers from companies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selection and assignment of winning offer</td>
<td>May</td>
<td>May</td>
</tr>
<tr>
<td>Development of software development framework, server and end-user application</td>
<td>Jun</td>
<td>Jun</td>
</tr>
<tr>
<td>Validation of functionalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friendly user tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software adaptations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 51:** Vienna demo site timeline

5.2.2. **System Reliability and Availability**

Generally reliability and availability depend on both the hardware and software used. Additionally also compatibility issues between software and hardware could have negative effects. In the following the experiences gained during the test-phase are presented for the selected elements.

During the test phase the server wasn’t operational several times for a few minutes. The reasons were several connection issues between the server and source of the traffic messages. Thanks to the automatic restart in a case of a connection failure, the offline time was never more than a few minutes. Since the app needs the server to be available in order to get the traffic messages, the app also was not operational at the time the server connection was lost. Apart from these minor issues the whole system was available and worked without considerable problems during the test phase of 3 months.

For the test system no special efforts to reach high hardware reliability and availability were carried out. A rent server offering standard performance was used, as this was sufficient for the demo site. If the system is used in regular operation to provide traffic information to a high number of end-users appropriate measures have to be taken to ensure high reliability and availability.
In order to achieve a high reliability, a special server-hardware could be used, which is constructed to operate 24 hours 7 days a week. Part of this hardware could also be a system with RAID levels 0, 2, 5 to prevent data loss in a case of hard disk failure. This guarantees that there won't be any loss of traffic messages or testing data like log files, and that the server is available even if one hard disk is down. Additionally, several software related techniques could contribute to high system reliability. For example an automatic restart in case of a failure regarding the server or adapter connections.
5.2.3. **Compatibility and Transferability**

A key element of the Vienna demonstrator was to make the system easily transferable to other cities, regions, or countries. As shown in Figure 52 the Vienna demo site system includes two interfaces: the first interface between the traffic data source and the server and the second between the server and mobile end-user application. This architecture and the use of standard data formats shall facilitate easy transferability of the system to other locations:

- **Interface traffic data source – server:** The connection to traffic data sources is not integrated directly in the server software but is realised with an import adapter. Thus only a new import adapter has to be provided, if new data sources should be added and no changes at the server side are necessary. To prove this import adapter concept, import adapters for different data sources and for different data formats have been realised, tested, and demonstrated in the project:
  - Austrian traffic data: Data source ÖAMTC - Austrian Automobile, Motorcycle and Touring Club; data format GeoRSS
  - Finnish traffic data: Data source FTA Finnish Transport Agency; data format DATEX II
  - Slovenian traffic data: Data source TIC Traffic information centre for state roads; data format GeoRSS

  The overall low development efforts for the adapters is shown by the fact that the development time for the GeoRSS adapter was about one person day, and for the DATEX II adapter about two person days. If an adapter is already available for one data format it can easily be adapted to different data sources: After a GeoRSS adapter has already been developed for the Austrian traffic data from ÖAMTC it took a few hours to adapt it to the Slovenian data from TIC.

- **Interface traffic server – mobile end user application:** Transferability and compatibility between different server and end-user applications shall be facilitated by using the standard message format TPEG. If the software development framework is used for the development of the end-user application the respective modules for the connection with the server and for TPEG message management are available so that there is no additional effort necessary. Beyond that the software development framework offers an easy format for message exchange, if the end-user application is used together with the server developed in the project.
Deliverable D5.3: Evaluation and results of demonstration activities

Figure 52: Interfaces of the demo-site Vienna system

- **Open source:** Implementing C-ITS solutions is very complex. Several problems have to be solved until the end-user can receive information that is really beneficial. It is necessary to have correct data, to have precise information on the location, the information has to be up to date, it has to be transmitted to the end-user in a timely manner and also presented in an appropriate way. Therefore (also the financial) barriers for starting the implementation of C-ITS solutions are currently quite high. In order to lower these barriers the Vienna SEE-ITS system provides a solution that covers most of the information chain and is available as open source. It can therefore be implemented for a quick and cheap evaluation of possible C-ITS services with traffic data that is already available in a specific city or region.

- **Maps and their use:** Another element to improve the transferability is to make it independent from single map providers. Therefore the software development framework as well as the server supports Google Maps as well as OpenStreetMap, so that map information and routing can be obtained at least from two different providers.

- **Functionalities supporting test and validation:** Due to the complexity of C-ITS systems a lot of test and validation work is currently necessary. In order to support this work various functions for testing are provided by the server and by the software development framework.

### 5.2.4. Scalability

Scalability should be no big issue in this kind of system architecture. Because the server transfers traffic messages to all correctly configured apps, the server is the only leverage point, when talking about scalability. Depending on the amount of users (apps), the server...
infrastructure has to be strong enough to transmit the traffic messages to all apps in a correct way and in an acceptable amount of time. With the appropriate hardware and additional software measures (which should not be a high effort) it should be no problem to address a high number of users however this was not tested due to the limited budget of the project.

5.3. Cost Evaluation

5.3.1. Constraints & Assumptions

The provision of C-ITS services to end-users is very complex, as there are many different components necessary. One of them is the provision of traffic information, which was not realised by the SEE-ITS project, but taken from ÖAMTC. Therefore it is not possible to evaluate the costs for the whole system that provides traffic information to end-users but only for the part of the system which takes the information from e.g. a road operator and distributes and presents it to the end-user (as described in Chapter 5.2).

5.3.2. Project Budget & Estimated Development Costs

The costs for the development of the software development framework, the mobile end-user application, the server, as well as for planning and setting up the Vienna demo site including testing and validation have been about EUR 100,000. If the system is used as it is available now, the only additional development costs for transferring it to new countries/cities/data sources would be the development costs for a new import adapter. As mentioned above for the development of an adapter between one and two person days were necessary. The adaptation of one adapter to another data source (with the same data format) can be carried out in just a few hours.

5.3.3. Estimated Operations & Maintenance Costs

In the current configuration only costs for hosting the server application arise. Basically these costs will depend on the data generated due to the distributed traffic messages and the logging activities carried out for e.g. evaluation purposes. The costs of the server part for operation of the Vienna demo site are about 40 EUR per month (of course the requirements concerning the number of users have been low). Additionally, there are costs for data for each end-user, which depend on the selected rates. The amounts of data are mainly determined by map data transfer as this is significantly higher than for the traffic messages.
5.4. Institutional Impacts Evaluation

As the system developed for the demo site Vienna depends on the availability of high quality traffic data sources, which are the basis for providing services to end-users, it is not possible to assign the described impacts directly to the system. Nevertheless the fields on which the system has an impact are described below.

5.4.1. Impacts to Operations and Maintenance Procedures and Policies

In general the provision of good traffic information services (not depending on if there are e.g. VMS available) can change the way to influence traffic, and therefore contribute to a new way of traffic management. If this information could be transferred to all vehicles, VMS could be reduced and therefore also costs for operation and maintenance. Nevertheless this is not realistic for the next years.

For providing traffic information as shown at the demo site Vienna only few operations and maintenance procedures will be necessary. It has to be monitored continuously that the server is working properly. Additionally, it has to be checked periodically, if the messages are interpreted correctly, to avoid problems when changes at the data source are carried out (e.g. new kinds of messages/formats). In case of an update of message formats at the data source the adapters have to be updated accordingly. For the end-user application it has to be assured that updates of the operating system of the mobile device do not affect the function of the end-user application.

For all three parts, for the server, the software development framework, and for the end-user application there has to be a procedure to implement updates of TPEG when they are available.

5.4.2. Impacts to Staffing/Skill Levels and Training

For the continuous checks described above only technical base level skills are necessary. Also the time necessary for these checks is estimated to be less than half of a full time equivalent. Necessary changes in data formats or at the end-user application can be carried out by external software developers.

5.4.3. Impacts to the Competitive Environment

As there are too much open issues to be solved until e.g. VMS or similar systems can be replaced by C-ITS services there will be no major impacts on the competitive environment at present.
5.4.4. *Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS*

The developed system can be used to easily provide C-ITS services on the basis of already existing traffic data sources, so it can quickly be assessed if the quality of the data sources is sufficient and if such services are accepted by end-users. Therefore the developed solution could contribute to the deployment of C-ITS solutions. By lowering the effort for developing C-ITS end-user applications the software development framework can furthermore contribute to a higher number of end-user applications and therefore increase the probability of innovative and good solutions being developed.
5.5. **Transportation System Impacts Evaluation**

As already pointed out in the previous chapter the system developed for the demo site Vienna depends on the availability of (high) quality traffic data sources, which are the basis for providing services to end-users. The quality of the data sources has a high influence on the actual impact. Therefore it is not possible to calculate the impact for the part of the developed system only (which covers only the information chain behind the data sources). Moreover, it is also not possible within this project to conduct a thorough evaluation with a lot of test users (even projects with a significantly higher budget have been facing problems with end-user evaluations). Therefore possible impacts of C-ITS services are only described on a general qualitative level.

5.5.1. **Impacts on traffic efficiency and traffic management**

C-ITS have great potential to open up new possibilities in traffic management. On one side it provides access to single vehicles independently from their current position (in contrast to e.g. variable message signs) and therefore facilitates new forms of traffic management. On the other side it improves the information on the current traffic situation in the traffic management central system by using the vehicles as sensor (probe vehicle data).

By being able to give more precise directions (adapted to the current position of the vehicle) on the basis of more precise information on the traffic situation, traffic management and efficiency can be improved. Due to the complexity of the traffic system and to the limited number of users compared to overall travellers, it is not possible to provide an evaluation on the amount of these effects within the project.

5.5.2. **Impacts to Mode Shifting and Intermodalism**

Information on traffic jams on the route ahead and at the same time on park and ride facilities nearby can encourage car drivers to change to public transport. The number of drivers switching to public transport will depend on various aspects (e.g. parking restrictions in the city, city tolls). Aigner et al. used for calculations a conservative estimation of 1% of the drivers switching permanently to public transport for a similar system set-up in the Vienna region (Aigner, Walter; Plank-Wiedenbeck, Uwe; Pfister, Jörg; Schildorfer, Wolfgang: Cooperative systems roll-out in Austria and Middle-Germany: key impacts on environment - first calculations, accepted paper for the ITS World Congress, Vienna 22-26 October, 2012).

5.5.3. **Impacts on the environment and fuel consumption**

C-ITS services can contribute to the reduction of fuel consumption via an optimised traffic management (which is described in Error! Reference source not found.) but also by causing a more relaxed driving style due to information on the events ahead. A detailed evaluation of the effects is not in the scope of the project.
5.5.4. *Impacts to Traffic Safety and Accident Reduction*

If drivers are informed on the situation on the road ahead (e.g. traffic jams, slippery road) they are able to adapt their driving style accordingly. This will contribute to traffic safety and accident reduction. A detailed evaluation of the effects is not in the scope of the project.

5.5.5. *Impacts on driving behaviour*

As described above the information on the situation on the road ahead allows the drivers to adapt their driving style. A detailed evaluation of these impacts is not in the scope of the project.

5.5.6. *Drivers/Users acceptance/perceptions*

As already mentioned, the end-user application was developed to demonstrate the functionalities of the software development framework. Therefore the HMI was not in the main focus of the evaluation.

Nevertheless end-user tests have been carried out with a small number of users. Generally the users had a positive attitude to validate mobile ITS services and give feedback to the information received. A main aspect of the end-user feedback was the wrong presentation of events in certain circumstances, which has already been corrected. Analyses revealed that to some test users it is really important that only such information is presented that is located on the intended route, as too much information is distracting. To achieve this in an urban environment, it would be necessary to enter the destination of the trip, so that the end-user application can calculate which traffic messages are relevant.

The main impact is expected from the software development framework in terms of simplifying the development of C-ITS end-user applications. This could cause a greater variety of end-user applications and increase the probability for good and innovative solutions being developed.
5.6. **Conclusions and Recommendations for Vienna Site**

The aim of the SEE-ITS demonstrator in Vienna is to provide an open source development framework, which is easily transferable to interested European cities and regions. The software framework supports processes that are usually distracting developers from the core purpose of their apps. By providing clean APIs, developers can concentrate on the end-user service and on the presentation of the information, instead of dealing with the background tasks of the app. Therefore the barriers for developing a C-ITS application are reduced and the field is opened for additional developers. This should lead to new ideas and contribute to taking the next step in the deployment of C-ITS. As a first step to evaluate the usability of the developed components, the system was tested by a software developer who was not involved in the project. The result was that it is easy to use and well documented.

The system comprises also a server which can import, manage, and distribute traffic data in TPEG format. The use of import adapters for connecting the server to different data sources makes the server independent from the properties of data sources and makes the solution easily transferable to different cities and countries. The transferability was shown by connecting the server to different data sources with different data formats and from different countries. The system successfully connected with data sources from Austria (GeoRSS), Slovenia (GeoRSS), and Finland (DATEX II). Additionally the server supports both Google Maps and OpenStreetMap to make it independent from one specific Map solution. Due to the complexity of C-ITS systems testing and validation work is very important. This work is supported by several functions of the server.

The functionalities of the framework are demonstrated with a mobile end-user application providing C-ITS services in Vienna, so that the main focus of the app is not the end-user itself, but developers which can get an overview on the possibilities of the framework. Therefore the end-user app was more an instrument of evaluation for the framework and for the server. The app showed that the software development framework and the server are well designed and work properly.

The SEE-ITS system covers wide parts of the service chain and therefore allows implementing different applications:

- The software development can be used for the development of C-ITS end-user applications.
- The server can be used for providing TPEG messages in the development and testing phase of C-ITS apps but also for providing messages to a system in real operation.
- The server and the end-user application can be used as a quick and easy solution for providing C-ITS services based on available data sources (only an additional import adapter is needed):
  - For providing services
  - For feasibility checks and for testing of data sources
  - For carrying out first end-user tests
• The system can also be used as free reference solution for C-ITS systems.

Additional next steps could be implementing the system in other projects and the development of new functionalities. As a final conclusion the use of the system could contribute to the further development of C-ITS.
6. **SOFIA DEMO SITE**

6.1. **Project/System Technical Description**

The demo activities in Bulgaria are focused on the installation and the implementation of Bluetooth Information System (BTiS). Provided services, based on real-time traffic data captured by six Bluetooth sensors.

This Pilot BTiS serve following basic information:
- Journey Time and
- Origin/destination matrix data

So far, in Bulgaria there were no pre-installed ITS infrastructure, services and applications. Because no previous installation - no need additional effort for integration.

The locations of the BT sensors installed in the SEE-ITS project are presented in the following table and figure.

**Table 23: BT sensors locations**

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<tr>
<th>Sensor #</th>
<th>ID</th>
<th>Location</th>
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<th>Lon</th>
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<td>42,62558</td>
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</tr>
</tbody>
</table>
The Bluetooth Technology

The Bluetooth channel is used for data transmission for a limited amount of data; the channel is efficient and cost effective. Bluetooth communication is used by mobile telephones, hands-free sets, GPS navigators and more. All these Bluetooth emitting devices leave a unique digital footprint. As the vehicles circulate the Bluetooth Sensor will pick up these signals and track the path of the vehicles. With a significant percentage of the passing vehicles providing a Bluetooth signal the sensors will provide very, very accurate traffic information.

For the purposes of this pilot project we are using BT sensors and software form Traffic Network Solutions S.L. installed and handled by Bulgarian company Transport Research Institute Ltd.

The result is fully integrated “turn-key cloud” solution that provide all information services by web-based interface.

Bluetooth sensors scan and record traveller’s Bluetooth devices’ MAC identity for the calculation of real-time travel times along pre-defined paths between two sensors.
Recorded data from BT sensors transmitted via GPRS to the Bluetooth algorithms server (database) and Journey Time and O/D matrix data come back by Cloud and Virtual Control Centre (VCC) to the users of BTiS. This process is shown on the figure below:

**Figure 54:** The Bluetooth capturing

The BTiS cloud solution (based on the Virtual Control Centre) is shown on the next figure.

**Figure 55:** BTiS cloud solution
Outputs form BTiS and web interface are shown to the next figures.

**Figure 56:** BTiS Live Information

**Figure 57:** BTiS Historic data
**Figure 58: BTiS O/D matrix data**
6.2. **Specific evaluation**

The evaluation methods that have been adopted in Bulgaria’s pilot site are:

- Technical validation tests for the assessment of the technical reliability and accuracy of the system
- A questionnaire survey for the assessment of the system from the user’s perspective

6.2.1. **Technical Validation Tests**

The system has been tested so as to configure its technical performance and adequacy. For this purpose a twofold process was adopted in order to examine:

- The system’s reliability
- The system’s accuracy

Regarding the system’s reliability, validation tests with a test car were performed.

The scope of the tests was to identify if the BT sensors are able to detect and record all types of BT devices and if they transmit the recorded data properly. Therefore, a test car equipped with several BT devices, made multiple routes near the BT sensors.

Tests were carried out on the 13th of June 2014. The results are:

- All MAC addresses of the test BT devices are recorded properly by all the BT sensors
- The time stamp correspond to the ratio of existing travelled distances between BT sensors and current speed of test car that recorded separately

6.2.2. **Questionnaire Survey**

The survey is an important step in order to provide the necessary indicators for the wide scale-assessment of the performance of the implemented system, the identification of the user’s acceptance and satisfaction of a system that will be implemented. The results from a survey will be used; in conjunction with the field operation tests (FOTs) for the extrapolation of useful data that will be used in the final steps of the evaluation process such as the cost benefit analysis.

The questionnaire survey covered 11 experts in field of transport such as scientists and representatives of organizations which build such and/or similar systems and asses the user’s acceptance and satisfaction of the BTiS.

The Questions concerning specific route from Dragichevo to Pernik, that include the pilot section, namely:

**Q1:** To what extent do you find the calculation and of travel time at road segments of highways useful for monitoring traffic?

- Really useful (it depicts the real traffic conditions to full extent)
• Useful (it can depict real time traffic conditions to sufficient extent)
• Quite useful (it can partially depict real time traffic conditions but additional applications are necessary for the surveillance of a road segment)
• Not useful at all

Q2: Based on your previous experience, how much cost efficient in calculating real time travel times and average speed of vehicles do you think this system is, in relation to other systems (CCTVs, loop detectors etc.)?
• 80-100% cost efficient
• 60-80% cost efficient
• 30-60% cost efficient
• 0-30% cost efficient

Q3: How efficient do you believe the process needed for detecting possible traffic congestion could be in monitoring and managing traffic incidents in time?
• 80-100% efficient
• 60-80% efficient
• 30-60% efficient
• 0-30% efficient

Q4: How satisfy would you be in terms of effective traffic monitoring if the system was extended to a significant number of roads in Bulgaria?
• Very satisfied
• Quite satisfied
• Little satisfied
• No satisfied at all

Results from the survey are shown in the following table and figure.

<table>
<thead>
<tr>
<th>No</th>
<th>Question</th>
<th>Answer 1 (%)</th>
<th>Answer 2 (%)</th>
<th>Answer 3 (%)</th>
<th>Answer 4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To what extent do you find the calculation and of travel time at road segments of highways useful for monitoring traffic?</td>
<td>27.27</td>
<td>63.64</td>
<td>9.09</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Based on your previous experience, how much cost efficient in calculating real time travel times and average speed of vehicles do you think this system is, in relation to other systems (CCTVs, loop detectors etc.)?</td>
<td>36.36</td>
<td>54.55</td>
<td>9.09</td>
<td>-</td>
</tr>
</tbody>
</table>
How efficient do you believe the process needed for detecting possible traffic congestion could be in monitoring and managing traffic incidents in time?

<table>
<thead>
<tr>
<th>3</th>
<th>How satisfy would you be in terms of effective traffic monitoring if the system was extended to a significant number of roads in Bulgaria?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>27.27%</td>
</tr>
</tbody>
</table>

**Figure 59:** Results from the users’ acceptance and perceptions survey for the Sofia pilot site

As it can be seen from both the Table and Figure the level of acceptance and satisfaction of the demo system from the interviewed experts is quite good.
6.3. **System Performance Evaluation**

6.3.1. **The Project/System Development Process and Timeline**

ITS Bulgaria started the implementation of the activities for the development and implementation on 01.07.2013 by subcontracting with an external expert the preliminary activities for defining the objectives, system structure, specifications and selecting and proposing an appropriate location for the Bulgarian pilot site. At this stage the preparation and research for the following was started:

- Legal and administrative aspects;
- Research for the available equipment on the market;
- Specification preparation;

While the above mentioned activities were in progress a financial barrier prevented the further development of the activities as preliminary planned, which led to a budget relocation in December, changing the concept of implementation of the activities. The new concept did not include purchase of the necessary equipment, but purchase of the necessary data to perform the defined objectives.

In January 2014 the external expert had the new task to select and propose a subcontractor to implement the relevant site, according to the project assignment and provide data, using the same technology as initially planned for the period of WP5.

6.3.2. **System Reliability and Availability**

The technical validation tests described in section 6.2.1 confirmed the technical reliability and accuracy of the system and this was also supplemented by the users' perception. The following table shows the results.
Table 25: Results of technical validation

<table>
<thead>
<tr>
<th>Section</th>
<th>Between sensors</th>
<th>Length (m)</th>
<th>Travel time (sec)</th>
<th>deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>measured</td>
<td>estimated</td>
</tr>
<tr>
<td>#02</td>
<td>BTS#04 BTS#01</td>
<td>900</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>#03</td>
<td>BTS#01 BTS#02</td>
<td>950</td>
<td>52</td>
<td>53</td>
</tr>
<tr>
<td>#04</td>
<td>BTS#02 BTS#01</td>
<td>600</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>#05</td>
<td>BTS#04 BTS#02</td>
<td>550</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>#07</td>
<td>BTS#04 BTS#03</td>
<td>700</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>#08</td>
<td>BTS#03 BTS#04</td>
<td>1200</td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>#09</td>
<td>BTS#02 BTS#03</td>
<td>1100</td>
<td>79</td>
<td>81</td>
</tr>
<tr>
<td>#10</td>
<td>BTS#03 BTS#02</td>
<td>700</td>
<td>42</td>
<td>43</td>
</tr>
<tr>
<td>#11</td>
<td>BTS#03 BTS#06</td>
<td>3100</td>
<td>120</td>
<td>122</td>
</tr>
<tr>
<td>#12</td>
<td>BTS#06 BTS#03</td>
<td>3100</td>
<td>101</td>
<td>100</td>
</tr>
<tr>
<td>#13</td>
<td>BTS#06 BTS#05</td>
<td>14600</td>
<td>506</td>
<td>499</td>
</tr>
<tr>
<td>#14</td>
<td>BTS#05 BTS#06</td>
<td>14600</td>
<td>568</td>
<td>563</td>
</tr>
<tr>
<td>#15</td>
<td>BTS#01 BTS#03</td>
<td>1000</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>#16</td>
<td>BTS#03 BTS#01</td>
<td>1000</td>
<td>32</td>
<td>32</td>
</tr>
</tbody>
</table>

6.3.3. **Compatibility**

N/A

6.3.4. **Scalability**

The current pilot shows easy plug&play installation of BTiS and opportunities for further extension in a common ITS platform for the area of Sofia and Pernik Municipality or Bulgarian Road Administrations – Road Infrastructure Agency or National Company for Strategic Infrastructure Projects.
6.4. **Cost Evaluation**

6.4.1. **Constraints & Assumptions**

With the exception of minor technical and administrative obstacles, whose mentioning is unnecessary the general constraint was financial. It could be examined in two different aspects.

First one was very significant and led to budget relocation for ITS Bulgaria's scenario of implementing the activities. According to Bulgarian legislation the expenses for equipment are not fully eligible, but only the depreciation costs, which is a very small amount of the actual expense.

On the other hand, the terms in which the expenses are being reimbursed caused serious financial problems, especially to non-profit organizations, such as our case is. The lack of quick reimbursement causes delays in the implementation of commitments undertaken within the given deadlines and time limits.

6.4.2. **Project Budget & Estimated Development Costs**

ITS Bulgaria's budget underwent transformation from its primary version. The initial version consisted of the following budget lines:

- **Equipment** - 20 000 Euros
- **External expertise and services** - 10 000 Euros

In the course of the project implementation it became clear that according to the Bulgarian law not all the costs for the equipment would be eligible but only the depreciation costs for the equipment for the period of time left till the end of the project. This scenario was almost impossible for ITS Bulgaria and it was a serious obstacle threatening the further participation of ITS Bulgaria in the project. This led to budget relocation and change in the preliminary plans to purchase the equipment, but instead to select a provider of the service with the same performance parameters as the initially planned. The budget was transformed into the following:

- **External expertise and services** - 10 000 Euros + 20 000 Euros

ITS Bulgaria hired an expert to develop all the necessary assignments and specifications, obtain all permits and perform research to find the most appropriate service provider. The following table includes the final expenses for the development and realization of the pilot site:
Table 26: Final expenses for the development and realization of the Sofia Region pilot site

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert to guide the activities through their implementation</td>
<td>€ 2 139,34</td>
</tr>
<tr>
<td>Implementation of the pilot site and data provision for the period of time the work package is active, including the preparation of the deliverable “Evaluation and results of demonstration activities”</td>
<td>€ 9 203,25</td>
</tr>
</tbody>
</table>

The following table presents information about the financial resources which are needed for a system building, operational costs and costs for its maintenance under the conditions we accomplished the pilot site in Sofia region under the SEE-ITS project.

Table 27: Costs of the Sofia region pilot site

<table>
<thead>
<tr>
<th>No</th>
<th>Type of costs</th>
<th>Total costs (Euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Purchase and installation per unit (including guaranty and maintenance costs for 3 years)</td>
<td>€ 2 100</td>
</tr>
<tr>
<td>2</td>
<td>Operational costs (direct costs such as power supply etc., salary of personnel necessary for the system operation, indirect costs etc.)</td>
<td>€ 3.5</td>
</tr>
<tr>
<td>2.1</td>
<td>Telecommunications costs &amp; power supply per unit, per month</td>
<td>€ 3.5</td>
</tr>
<tr>
<td>2.2</td>
<td>Personal cost</td>
<td>€ 0.0</td>
</tr>
<tr>
<td>3</td>
<td>Maintenance costs</td>
<td>€ 40-60</td>
</tr>
<tr>
<td>3.1</td>
<td>Annually Maintenance costs per unit, (after the first 3 years) including possible replacements of various parts (batteries, wires etc.)</td>
<td>€ 40-60</td>
</tr>
<tr>
<td>3.2</td>
<td>Personal cost</td>
<td>€ 0.0</td>
</tr>
</tbody>
</table>

6.4.3. Estimated Operations & Maintenance Costs

The operational and maintenance cost include:

- power supply cost
- row data transfer to the cloud
- data processing cost
- sensor and software maintenance costs
- user interface and data receive maintenance cost

All these costs are included in the lease contract with the TRI Ltd.
6.5. **Institutional Impacts Evaluation**

This pilot project is too small to be assessed the influence of institutional perspective.

Upon execution of larger projects could be assessed:

- the impact on the environment, in term of emissions reduction as a result of better traffic management
- travel time savings by different users
- time/effort savings on the process of planning, modelling and traffic management by the administration - state or municipal

In term of Institutional impact project interesting for road authorities and municipalities. BTiS outputs have direct positive impact on daily work concerning planning and management of traffic and in particular in the identification of travel demand on working days and weekend. Origin/Destination data is very important too. BTiS O/D solution saves Institutions time and money to conduct questionnaire survey on the site.
6.6. **Transportation System Impacts Evaluation**

Since the project covers an intersection, it is difficult to assess the impact on overall transport system.

The purpose of this project is to show (by small example – one junction) the possibilities of improvement the processes associated with the traffic planning and using of the current transport systems.

6.6.1. **Impacts on traffic efficiency and traffic management**

For traffic modelling and forecasting is very important. The managers usually do this based on the origin-destination traffic distribution. This pilot project shows the possibility of obtaining O-D matrix, which subsequently can be used to setting or changing the current traffic management, either through traffic light retiming or infrastructure modernization - new lane expansions, bottlenecks improvement etc.

<table>
<thead>
<tr>
<th>Table 28: Example of BTIS O/D matrix data</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS01 - BTS02 - BTS03 - BTS04 - BTS05 - BTS06</td>
</tr>
<tr>
<td>SN2011008 - SN2011011 - SN2011011 - SN2011005 - SN2011011 - SN2011008</td>
</tr>
<tr>
<td>9 - 0 - 8 - 2 - 2 - 7</td>
</tr>
<tr>
<td>BTS01 - SN2011008</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>BTS02 - SN2011011</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>BTS03 - SN2011011</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>BTS04 - SN2011005</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>BTS05 - SN2011011</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>BTS06 - SN2011008</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>100.00% - 100.00% - 27.27% 72.73% - -</td>
</tr>
<tr>
<td>25.00% - - - - 75.00%</td>
</tr>
<tr>
<td>33.33% - - - - -</td>
</tr>
<tr>
<td>66.67% - - - - -</td>
</tr>
<tr>
<td>100.00% - - - - -</td>
</tr>
<tr>
<td>60.00% - 40.00% - - -</td>
</tr>
</tbody>
</table>
Opportunity for data history allows BTiS to be used for different management scenarios on:
- AM peak
- PM peak
- between peaks
- weekend time

6.6.2. Impacts to Mode Shifting and Intermodalism

N/A

6.6.3. Impacts on the environment and fuel consumption

The project is a demo and shows best practices for better organization of mobility and therefore a reduction of harmful emissions into the atmosphere.

Through it:
- promote the beginning of vehicle to infrastructure communication
- help to avoid congestion and play an important role in the success of traffic measures

The direct effectiveness of systems like BTiS regarding fuel consumption and emissions is related to the avoidance of congestion. In a congested traffic environment the frequent accelerations and idling times are the variables that affect energy consumption and emission. This will enable to the transport operators to reduce the fuel consumption and harmful emissions.

6.6.4. Impacts to Traffic Safety and Accident Reduction

In this case it is not applicable, but the BT technology offers this possibility in general. This is demonstrated and shown to the Road Administrations.

6.6.5. Impacts on driving behaviour

On the larger scale project impact on driving behaviour could be evaluated, but on the one junction, the behaviour of the driver before and after system implementation does not change significantly.

6.6.6. Drivers/Users acceptance/perceptions

The analysis of the results of the questionnaire survey concerning the usefulness of the calculation of travel time for traffic monitoring shows that 90,91% of interviewed experts
evaluate that this is useful (27.27% - really useful and 63.64% - useful) which means that experts consider such service as useful and needed for their daily mobility needs (Figure 60).

![Figure 60: Usefulness of the calculation of travel time for traffic monitoring](image)

According to the results from the survey majority of the interviewed (54.55%) assess the system as 60-80% cost efficient and another 36.36% of them evaluate the system as 80-100% cost efficient, which for systems from that category is a good result (Figure 61).

![Figure 61: Cost efficient in calculating real time travel times and average speed of vehicles of the system in comparison with other technology](image)

Evaluation of the results shows that majority of the experts (72.73%) assess the system as very efficient (80-100% efficient) when we are talking about the detection of possible traffic...
congestion in monitoring and managing traffic incidents in time in comparison with other technology used (Figure 62).

**Figure 62:** Efficiency of the process for detecting possible traffic congestion in monitoring and managing traffic incidents in time

Based on the experts’ answers for their satisfaction of effective traffic monitoring in case the system is extended to a significant number of roads in Bulgaria the conclusion which could be made is that they would be quite satisfied (72,73 %) if such system is extended to a significant number of roads in Bulgaria (Figure 63)

**Figure 63:** Users' satisfaction of effective traffic monitoring if the system is extended to a significant number of roads in Bulgaria
As a result of analysis the conclusion is that experts accept the system and think that it would be very useful in terms of traffic monitoring and management. But it is necessary the system to be combined with other technologies (for example CCTVs, loop detectors etc.) in order to provide maximum benefit to its users - Local authority, road administrator, traffic police, transport services provider and etc.

Based on the results of the tests, the survey and the evaluation of them following two indicators are relevant to the Sofia pilot site:

<table>
<thead>
<tr>
<th>IMPACTS</th>
<th>Impact Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency in detecting traffic fluctuations on real-time basis</td>
<td>90%</td>
</tr>
<tr>
<td>Cost efficiency in relation to other more expensive equipment (CCTVs etc.)</td>
<td>82% more efficient</td>
</tr>
</tbody>
</table>
7. **ROMANIA DEMO SITE**

7.1. **Project/System Technical Description**

7.1.1. *Previous ITS infrastructure and services development*

The Romanian Pilot within the SEE ITS Project is a multimodal traveller information and voyage planning solution that covers four different modes of transport. The pilot proposes to combine together relevant traffic information and routing strategy from public transport, railroad, road transport and inland waterway transport.

The Romanian Pilot will encompass a trip that will cross the entire country from west to east for a travel distance of about 800 Km. The actual implementation consists of a web-based journey planning application involving information about the following modes:

- Public transport
- Urban and inter-urban road transport
- Railway transport
- Inland waterway transport

One of the aims is to make a set of recommendations for the adoption of multimodal traffic information services. Impact and credibility of exploitable project results are significantly enhanced by early involvement of key stakeholders into drafting an intermediate exploitation plan as well as clearly-structured validation procedures. These recommendations are based on inputs from the stakeholder analysis performed, the lessons learnt from the demonstration site as well as the experiences of the involved stakeholder groups.

The services that will be pilot implemented will follow a corridor approach starting from a location in Timisoara and ending at a location in Constanta, as depicted in the figure below.
A web-based application has been developed that allows the user to get information about travel times on the selected corridor at any time, using different combinations of transport modes. The application is designed to provide real-time data, however if it is not available for a certain mode of transport, then static data can be used.

From Timisoara the journey planning will start with using a public transport service to get from the defined location to the railway station. The demonstrator uses data about travel times of local transport from the public transport management system (PTMS) of Timisoara. The user has the possibility to select the quickest route or the one with the lowest number of interchanges.

The next link of the voyage is a train from Timisoara to Bucharest. The application will provide information about available connections with the possibility to select a priority for the cheapest route or the fastest. The system will also allow the user to select the amount of time he/she is willing to wait for transport mode changes.

After arriving in Bucharest the user is expected to take a car and drive from the railway station towards Constanta. The application will calculate and display the estimated time of travel.

The link between Bucharest and Constanta will be split in the city of Cernavoda. This means that the user will have the possibility to stop in the port of Cernavoda and from there board a vessel (passenger or ferry) to sail on the Danube-Black Sea Canal all the way to Constanta. The system will again calculate and display the estimated time of arrival for the inland waterway link between port of Cernavoda and Constanta.

The Timisoara-Danube pilot is an innovative application developed entirely within the framework of the SEE-ITS project. It aims to be a proof of concept for multimodal journey planning involving four modes of transport, as well as connections between urban and inter-urban transport links. The objective of the pilot is to develop a system concept and the
necessary algorithms for a multi-modal journey planning service. The pilot demonstrates how ITS systems for different modes of transport can be interoperable in order to provide seamless services along a transport corridor. Based on the results of the pilot, the necessary measures for a large scale implementation of such services will be identified and documented in Activities 6.1 and 7.3.

7.1.2. **Information Provision**

The pilot system is implemented as an on-line web application. The main interface is shown in the figure below. It is split into two major areas:

- The map on the right-hand side
- The information panel on the left-hand side

Initially the information panel allows the user to select the options for the journey planning. The following are available:

- Departure or arrival date and time
- Voyage planning options:
  - “Transit&Train&Car” which means the route will be calculated using public transport, railway transport and road transport
  - “Transit&Train&Car&Ferry” which means the route will be calculated using public transport, railway transport, road transport and inland waterway transport from Cernavoda to Constanta
- Selection of either quick trip or fewest transfers
- Selection of maximum walking distance and walking speed

![Figure 65: Main interface of the pilot web application](image-url)
After the user chooses the journey planning options, he/she has to select the start and end points by right-clicking on the map. Then, after pressing the “Plan Your Trip” button from the information panel, the application will calculate and display the route. An example is shown in the figure below.

The journey information is displayed both graphically on the map and also as a step-by-step list in a dedicated tab of the information panel. This tab remains open until the user chooses to close it, therefore it is easy to quickly compare the result when selecting different journey options for the same origin and destination points.

Figure 66: Journey information for the selected route
7.2. Specific evaluation

The evaluation framework for the SEE-ITS demo activities, described in section 1.2 of the present report, placed the criteria and the evaluation steps and underlined the methods for their quantification. The evaluation methods that have been adopted in Romania’s pilot site are:

- Technical validation tests for the assessment of the technical reliability and accuracy of the system
- A questionnaire survey for the assessment of the system from the user’s perspective
- Internal evaluation processes

Because of the trip length (about 800km from west to east of the country), the evaluation was done on sections. No actual field trip was performed from the beginning to the end.

7.2.1. Technical Validation Tests

Several technical validation tests were done for each section of the multimodal trip path. The aims of the validation tests were to determine both system’s reliability and results accuracy. Multiple trips were generated from different source locations to different destination locations. Several times of day were used as “Departure time” for generating these trips.

System reliability tests consisted in manual analysis of the routes proposed by the system. For each of the four sections of the trip: public transport, train, car and ferry, the route proposed by the system was analysed in order to check the route correctness. It was checked that the proposed routes for public transport/train/ferry were according to the vehicles’ schedule. Transfers between different means of transport were checked to see if they respect the maximum set walk distance and also that the time between arrival in a station and the departure time of the next vehicle is sufficient in order to walk the transfer distance.

Evaluation of accuracy was done by comparing the results proposed by the system with alternative means of computing routes for each of the sections. In the City of Timisoara, the results were compared with the public transport routing system already in place.

For the railway section of the route the results were compared with the railway timetable and checked for accuracy.

For the car section of the route, the proposed route was compared with other routing solutions like Google Maps and HERE (former Nokia Maps).

The ferry section of the route proposed by the system was compared with the ferry timetable.
7.2.2. Questionnaire Survey

This evaluation method is adopted in Romania’s pilot site aiming to assess the performance of the multimodal information service from the user’s perspective. In terms of users’ assessment, it is examined if users consider the services provision useful and the information provided reliable.

The survey took place in Timisoara, as the departure point in computing the multimodal route. The people were asked to use the system in order to generate a route from a departure point in Timisoara and an arrival point near Constanta.

Then the respondents were asked to complete a survey with questions on the following main topics:
- the correctness of the route generated from their point of view
- the usefulness of the application from their point of view
- contribution of the application to their initial level of information about the travel time and routing options for a chosen journey
- the interface ergonomics and ease of use
- willingness to use such a voyage planning application for their daily trips

We have conducted the survey on a total of 20 respondents. The identity of the survey is summarized in table below.

**Table 29: Identity of the survey**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Answers Category</th>
<th>Frequency (N %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18-25</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>26-35</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>36-45</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>46-55</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>56-65</td>
<td>03</td>
</tr>
<tr>
<td></td>
<td>65+</td>
<td>02</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>42</td>
</tr>
</tbody>
</table>

7.2.3. Internal Evaluation Processes

The internal evaluation process is adopted in cases where:
- The previously gained experience is adequate to describe the influence of the system in a specific field (Mainly in technical and economic fields)
- Internal structures, functions and processes are examined
- Internal weaknesses need to be identified and corrected
Our experts have done an internal evaluation of the demonstrator based on desk research and the results gained from the technical validation and questionnaires. The main goals of this evaluation method were to:

- Evaluate the system performance beyond strictly technical parameters
- Evaluate the impacts of the system which cannot be directly measured

In general an ITS system like a multimodal voyage planning and information application can contribute to a range of criteria impacting the overall performance of the transport process at a local, regional and even country level. However, it is difficult to directly measure or estimate the actual magnitude of such impacts based on a pilot implementation which serves only as a proof of concept and has a limited functional and geographical scope. Therefore, we have employed an internal evaluation process where our experts have analysed the pilot and used their expertise to judge the impact of the more profound criteria that are linked with this type of system and cannot be derived from other evaluation methods.
7.3. **System Performance Evaluation**

7.3.1. *The Project/System Development Process and Timeline*

The Romanian demonstrator was implemented in the timeline set by the SEE-ITS project, more specifically Activities 5.1 and 5.2. The duration of the actual software development was three months.

7.3.2. *System Reliability and Availability*

The technical validation tests described in section 6.2 confirmed the technical reliability and accuracy of the system and this was also supplemented by the users’ perception.

7.3.3. *Compatibility*

Based on the internal evaluation process, we have assessed that the system is compatible, in terms of information provision and input data used, with other voyage planning systems, either single or multimodal. The system also has the possibility to receive real-time information from Public Transport Management Systems and Traffic Management Systems.

7.3.4. *Scalability*

The Romanian demonstrator was implemented on a “corridor” starting from Timisoara and ending in Constanta. Based on the pilot results, it is clear that the system can be scaled to other cities and transport corridors and even at a national level so as to provide multimodal voyage planning within any two points of the country. Of course such extension would require significant further development of the pilot application.
Cost Evaluation

Constraints & Assumptions

The development and operations costs are related to the pilot system and are also a good estimate for a real system implemented at regional/corridor level. However, it is difficult to estimate the costs for a national system as further analysis has to be made on, for example, availability of map data, of adequate public transport information, of transport graph etc.

Project Budget & Estimated Development Costs

For the development of the Romanian pilot demonstration activities, funds of the SEE-ITS project were used. The available budget of 15 kEUR was allocated to the purchase of cloud storage and 1 year web hosting services and to the overall software development of the application. During the implementation process, it was not required an adjustment in the initial budget.

Estimated Operations & Maintenance Costs

The operation costs can be calculated on a yearly basis and consist of:
- cloud storage and web hosting services
- personnel costs in order to ensure the regular operation of the software application

The maintenance costs have also been estimated on a yearly basis and consist of:
- Software and/or OS updates
- Map and transport graph updates

The estimated maintenance costs include both the actual software licenses and the personnel costs related to software development.

The operation and maintenance costs are presented in the table below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Annual Cost (EUR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td></td>
</tr>
<tr>
<td>Cloud storage and web hosting</td>
<td>2,100</td>
</tr>
<tr>
<td>Personnel costs</td>
<td>1,800</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Software and/or OS updates</td>
<td>750</td>
</tr>
<tr>
<td>Map and transport graph updates</td>
<td>2,400</td>
</tr>
</tbody>
</table>
7.5. **Institutional Impacts Evaluation**

7.5.1. **Impacts to Operations and Maintenance Procedures and Policies**

No such impacts were detected.

7.5.2. **Impacts to Staffing/Skill Levels and Training**

No such impacts were detected.

7.5.3. **Impacts to the Competitive Environment**

No such impacts were detected.

7.5.4. **Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS**

The Voyage Planning and Information System pilot developed in Romania is in line with the EU and the national legislative initiatives for ITS. Romania has adopted the ITS Directive 2010/40/EC through its transposition into the national legislation in 2012. The Romanian demo in the framework of SEE-ITS project answers directly to the first Priority Action of the ITS Directive and contributes to the national policy objectives on ITS implementation expressed in several key documents like:

- National Transport Masterplan
- The “National Strategy for a sustainable transport system for 2007 – 2013 and 2020,2030”
- The “National Strategy for intermodal transport 2020”
7.6. **Transportation System Impacts Evaluation**

7.6.1. **Impacts on traffic efficiency and traffic management**

The Voyage Planning and Information System pilot developed in Romania is in line with the EU and the national legislative initiatives for ITS. Romania has adopted the ITS Directive 2010/40/EC through its transposition into the national legislation in 2012. The Romanian demo in the framework of SEE-ITS project answers directly to the first Priority Action of the ITS Directive and contributes to the national policy objectives on ITS implementation expressed in several key documents like:

- National Transport Masterplan
- The “National Strategy for a sustainable transport system for 2007 – 2013 and 2020,2030”
- The “National Strategy for intermodal transport 2020”

7.6.2. **Impacts to Mode Shifting and Intermodalism**

The impact was estimated at urban level. As confirmed by the questionnaire, the application is likely to determine the travellers to use public transport services instead of their private cars. **A shift of 20% from road transport by private car to public transport is expected** in cities where such an application would be implemented.

7.6.3. **Impacts on the environment and fuel consumption**

An ITS application like a multimodal voyage planner is likely to have an indirect impact on reduction of fuel consumption and reduction of CO$_2$ emissions. These are a consequence of better informed travellers avoiding congestion as well as being determined to shift from private car usage to public transport. The impacts were estimated based on internal evaluation, correlated with the results obtained from the pilot and the questionnaire. As such, **a 10% reduction of the daily fuel consumption has been estimated at urban level.**

7.6.4. **Impacts to Traffic Safety and Accident Reduction**

No such impacts were detected.

7.6.5. **Impacts on driving behaviour**

No such impacts were detected.

7.6.6. **Drivers/Users acceptance/perceptions**

The following impacts have been observed:
- Users’ satisfaction

According to the questionnaire, 80% of the responders find the application either useful or very useful for planning their trip. Also, 75% of the responders rated the interface ergonomics and ease of use as either good or very good.

![Figure 67: Usefulness of the application](image)

![Figure 68: Interface ergonomics and ease of use](image)

- Users’ acceptance
According to the questionnaire, 90% of the responders declared that they would be willing to use the application for planning their daily trips.

**Figure 69**: Willingness to use the application
8. **EMILIA ROMAGNA DEMO SITE**

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### 8.1. Project/System Technical Description

The pilot project should pursue in-depth knowledge and aimed to assess the conditions of risk arising from emergencies due to accidents involving the transport of dangerous goods. The primary goal is to develop a centre for real-time monitoring of the transit of dangerous goods.

To this end it is useful to determine points and directions of the transport network more related to the occurrence of events linked to the themes of the project. The ultimate goal is therefore to reduce the risk resulting from the movement of dangerous goods and the impact due to this particular type of roads transit transport systems using ICT tools.

At its bare minimum, the pilot project will read the vehicle’s number plate carrying dangerous goods and the Orange Slate with the UN number and Kemler classification.

As above stated the dangerous goods monitoring ITS pilot system we intend to propose is simple and basic:

---

![Diagram of the pilot project system](image-url)
See in the figure above the basic elements needed in a good dangerous goods monitoring and identification ITS system:

1. System to detect Plates and Orange Slates. This system’s part reads the license plates of the vehicle and the orange Slate, with an OCR engine processes the images by extracting the figures present on these items. Send images to the central when asked, trying to use as little as possible the communication between stations in the field and the train station.

2. Peripheral Connection Devices. This system’s part is the one that deals with the sending of data toward the central station. It also handles any other peripheral devices that can be added (Bluetooth, vehicles count, other)

3. Central Station. This part of the system receives data from the field and processes them. Provides an interface to the outside, both to other ITS systems that to users connected to the network. In Central Station is installed the main system DB.

The main requirement of such a system must be the capacity of acquiring high quality images of proceeding vehicles, both during day and night, and of processing such images with OCR algorithms in order to extract plate number, Kemler and ONU codes of transported dangerous good (see figure: the orange slate). That also in unfavourable environment conditions, such as reduced visibility, rain, fog, smoke, fume, against the light and so on.

The system we propose, simple and effective, recognizes the transits either through the capture of an external event (triggered by coils of photocells) or in a free-flow pattern, where the transit detector is inside the OCR software.

The detecting station, thanks to a sophisticated OCR software, can analyses and identify vehicles moving up to a speed of 200 Km/h for plates and of 140 Km/h for Kemler/ONU codes.

The plate recognition OCR library allows recognizing plates of most European countries.

The image processing is done on-site. An ANPR (Automatic Number Plate Recognition) module, embedded in the camera, scans the images; the recognition result is sent, along with plate and orange panel/slate images, to the station software module. The station software module stores such images and the plate/orange panel pair in its DB.

All modules comprising the system are described in detail in the next chapters.
8.2. Camera

The proposed camera can read simultaneously ONU-KEMLER codes and the correspondent vehicles plates, with OCR executed (installed) on the camera itself. The data needed for locating vehicles transporting dangerous goods (at least camera id, direction of travel, transit id, dangerous good code and detection datetime) will be acquired and stored in the central DB.

Codes and images, before being transferred to the central unit, can be stored (in case of server disconnected) on local memory displayable and downloadable from a browser.

The camera offers a top recognition percentage, along with high reliability. Designed to work under any weather and light conditions, it performs High Definition images capturing (1280 x 960 pixel), providing the best plate recognition both during the day (thanks to zoom adjustment) and in complete dark situations (thanks to the powerful IR integrated lighting).

The high frame frequency allows getting multiple readings of the same plate with perfectly focused images also in presence of vibrations and oscillations, detecting speeds up to 140 km/h. At 24 V DC the power consumption does not exceed 7W. Operating temperature is between -30°C and +55°C. Maintenance requires the same standard procedures designed for similar height-installed devices.

The provided box guarantees an IP66 protection level. Good-looking and characterized by lightness and small size (3.8 kg and 470x144x135 mm), it is easily installable on a pole or on a portal. The camera is connected through an Ethernet RJ45 connector. After installation, correct orientation on the lane to be monitored, and connection, the camera can be activated simply configuring some basic parameters, using a user-friendly web interface.

Maintenance operations consist of the periodic box and lens external cleaning, and of the positioning and integrity of the connections.

Using a camera with an ANPR module integrated provides the following benefits:

1. better recognition performances (you do not need to send vehicles pictures in Central Station, as the license plate and Orange Slate recognition takes place in the local installation: everything is faster)
2. less computing resources needed (inside the camera there is dedicated resident firmware, optimized for such process)
3. better reliability (the system is very compact)
4. very low maintenance costs (there are fewer devices running)
5. less devices installation time (it’s enough just to install the camera)
6. less energy consumption (it’s all contained inside the device, all the components have a low energy consumption)

The proposed camera, besides reading plates and orange panels, has an integrated microprocessor used to perform video analysis and to avoid the following potential problems:

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shadow</td>
<td>Elimination of any shadow shape (vertical or oblique, weak or strong contrast) from plate or panel</td>
</tr>
<tr>
<td>Overexposure</td>
<td>Infrared lighting auto regulation for plate reading, based on overexposed plate reflectance</td>
</tr>
<tr>
<td>Double reflectance</td>
<td>Correct exposition in plates with new reflective parts and old non-reflective parts</td>
</tr>
<tr>
<td>Smeering</td>
<td>Elimination of light bands reflected by chromium-plated or high-reflecting objects which make characters non-readable</td>
</tr>
<tr>
<td>Motion blur</td>
<td>High acquisition speed global shutter sensor to get pictures without motion blur and a perfect and clean reading</td>
</tr>
<tr>
<td>Damage compensation</td>
<td>Correct reading also of characters and figures deformed, scratchy, crumpled or partially damaged</td>
</tr>
<tr>
<td>Dirt</td>
<td>Elimination of problems due to the deposit of snow, soil, dust, insects etc. on plate and panel</td>
</tr>
</tbody>
</table>
The main features of the proposed camera (see the costs in the relevant section) are:

<table>
<thead>
<tr>
<th>Plates Reader Sensor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensor</strong></td>
<td>1.3 COLOUR Megapixel - High Definition progressive Global Shutter</td>
</tr>
<tr>
<td><strong>Frame rate</strong></td>
<td>60 Fps full resolution</td>
</tr>
<tr>
<td><strong>Regulation</strong></td>
<td>Auto Exposure</td>
</tr>
<tr>
<td><strong>Lens</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Serial Lens</strong></td>
<td>IR verifocale 5-55 mm (11x)</td>
</tr>
<tr>
<td><strong>Coupling</strong></td>
<td>CS – interchangeable lens</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>LAN-Ethernet 10/100 Mbit - RJ45</td>
</tr>
<tr>
<td><strong>M3G</strong></td>
<td>Gprs/Umts + GPS module (optional)</td>
</tr>
<tr>
<td><strong>SID o WID</strong></td>
<td>Rs232/485 - Wiegand (optional)</td>
</tr>
<tr>
<td><strong>CI</strong></td>
<td>Relè and Digital I/O</td>
</tr>
<tr>
<td><strong>PLCI</strong></td>
<td>Remote Control via TCP/IP - ADAM model</td>
</tr>
<tr>
<td><strong>Protocols</strong></td>
<td>TCP/IP, RTP/RTSP, HTTP, FTP, M2M XML</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical / Physical Properties</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voltage</strong></td>
<td>220 Vac or 24 Vdc</td>
</tr>
<tr>
<td><strong>Consumption</strong></td>
<td>25 Watt</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>From -25°C To +50°C</td>
</tr>
<tr>
<td><strong>Package</strong></td>
<td>Painted aluminium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IR Illuminator for license plate reading</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IR LED</strong></td>
<td>n. 10 high power</td>
</tr>
<tr>
<td><strong>regulation</strong></td>
<td>from 0% to 100%</td>
</tr>
<tr>
<td><strong>Pilotation</strong></td>
<td>pulsed in a controlled setting</td>
</tr>
<tr>
<td><strong>Max Range</strong></td>
<td>25 mt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Width Opening</strong></td>
<td>3 ~ 5 mt</td>
</tr>
<tr>
<td><strong>Height Opening</strong></td>
<td>4 ~ 8 mt</td>
</tr>
<tr>
<td><strong>Installation Distance</strong></td>
<td>5 ~ 20 mt</td>
</tr>
<tr>
<td><strong>Min Character Height</strong></td>
<td>20 pixel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intelligence inside</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KEM</strong></td>
<td>Reading KEMLER/ONU Tables</td>
</tr>
<tr>
<td><strong>OCR</strong></td>
<td>characters recognition</td>
</tr>
<tr>
<td><strong>ASC</strong></td>
<td>Eliminates shadows</td>
</tr>
<tr>
<td><strong>AS&amp;B</strong></td>
<td>Anti smearing and blooming</td>
</tr>
<tr>
<td><strong>ADC</strong></td>
<td>Remove defects and irregular characters</td>
</tr>
<tr>
<td><strong>SAC</strong></td>
<td>Angles compensation</td>
</tr>
<tr>
<td><strong>ASE</strong></td>
<td>Delete symbols and emblems</td>
</tr>
<tr>
<td><strong>ADRC</strong></td>
<td>Removes double reflectance</td>
</tr>
<tr>
<td><strong>APA</strong></td>
<td>Predictive analysis</td>
</tr>
<tr>
<td><strong>NNI</strong></td>
<td>Neural network training</td>
</tr>
<tr>
<td>ACC</td>
<td>Exposure adaptive function</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Characters Reading (OCR)</td>
<td>on-board camera</td>
</tr>
<tr>
<td>Recognition</td>
<td>Plates, tab Kemler</td>
</tr>
<tr>
<td>Syntax Reading</td>
<td>Sintax free</td>
</tr>
<tr>
<td>Catching Synchronism</td>
<td>Automatically, without loops or similar</td>
</tr>
<tr>
<td>Catching Speed</td>
<td>over 200 Km/h for plates and 140 Km/h for the Orange Slate</td>
</tr>
<tr>
<td>Internal Memory</td>
<td>over 60,000 images (optional card if needed)</td>
</tr>
<tr>
<td>Precision</td>
<td>&gt;95% plates - 75% Orange Kemler/ONU slates</td>
</tr>
<tr>
<td>Plates reading – Recognized Nations</td>
<td>Albania, Austria, Azerbaijan, Belarus, Belgium, Bosnia-Herzegovina, Belarus, Bulgaria, Cyprus, Vatican City, Croatia, Denmark, Estonia, Finland, France, Georgia, Germany, Great Britain, Ireland, Iceland, Italy, Kazakhstan, Kosovo, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Czech Rep., Rep. S. Marino, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, Hungary, Turkey</td>
</tr>
</tbody>
</table>
8.3. **Data Acquisition (peripheral) Unit**

Every detecting site includes a Data Acquisition Unit (DAU), properly designed for road monitoring applications: it allows integrating in a unique physical device all the requested functionalities, avoiding external components.

The DAU acquires all data related to the vehicles carrying dangerous goods and detected by the ONU-KEMLER cameras, through a proper network switch.

It is also possible to have, in each unit, an integrated Bluetooth devices sensor, able to detect such devices when passing near the site; this improves the system capacity to map the vehicle routes and to enhance the accuracy of the O/D (Origin/Destination) matrix.

The proposed network is fully compatible with the ANAS detecting network, not only because of the used components but above all for the uniformity of detected data, 100 % compatible with ANAS schemas and protocols.

The diagnostics functionalities implemented in the DAU monitor continuously all the peripheral site main parameters and send them to the Central Unit. Among these parameters are:

1. buffer battery tension
2. supply tension
3. buffer battery load current
4. internal temperature
5. portal access gate status
6. transmission data module reset number
7. central unit reset number
8. transmission data module registration status
9. transmission data signal strength
10. PPP communication status
11. cameras communication status

This way a complete snapshot of each peripheral site status is provided to the Control Room, allowing more efficient and easier control operations and maintenance interventions.

DAU has a large 2GB Solid State (SD) memory (up to 32GB optional) to temporarily record the pending information transmission. DAU is directly powered by mains voltages (230 VAC) or with optional solar panel (12/24 VDC). Through the integrated charging regulator, DAU...
charges the backup battery that automatically takes over in case of temporary lack of power. The battery charge is handled with optimum charging profiles while preserving battery life. The consumption is low, at only 0.8 W. DAU uses only "extended range" components type, that provide operating temperatures between -40 °C to + 80 °C, relative humidity between 0 and 100% non-condensing. All the offered features are integrated in an enclosure in ABS IP67 waterproof. IP68 front panel connectors make connections quick, safe and simple. The size is very compact with 286x172x97 mm, facilitating the insertion slots in reduced size. For connecting peripherals, the device has a number of serial interfaces, analog and digital:

1. 1 RS485 for connection of up to 8 sensors traffic "above ground" (optional);
2. 1 USB port for local connections;
3. 1 Ethernet 10 / 100T for network connections;
4. 8 inputs for inductive sensors (optional);
5. 1 RS485 to 1 temperature sensor and road conditions and precipitation sensor 1 / visibility (optional sensors);
6. 8 analog inputs with A / D converter 12-bit for weather sensors (sensors and connector optional);
7. 8.4 digital inputs including 1 contact opening / closing door;
8. 4 relay contacts, 2 of which trade and NA 2.

The device is characterized by its modularity with the possibility to be expanded / integrated functionally in successive moments. The clock synchronization is done automatically via the NTP protocol. The "real time clock" and the "watchdog" integrated further increase the degree of operation reliability, as well as ensure smooth resumption of operation when the power returns, if for any reason this had failed completely. The operating system is open source. In addition to the ANPR cameras UN-Kemler, the DAU can optionally support a wide range of sensors, such as: of traffic (a non-intrusive microwave, intrusive to inductive loops, weight in motion, and so on), weather conditions (direction and wind speed, air temperature and humidity, ...), measuring road conditions, measurement of precipitation and visibility, cameras context.
8.4. Data transmission System

The DAU must be equipped with a high-performance transmitting system and at the same time with reduced power consumption. The DAU module integrates a modem GRPS / UMTS / HSDPA with the following features:

1. GSM quad band up to 2100 MHz;
2. Internet services: TCP, UDP, HTTP, FTP, SMTP, POP3, SSH, Telnet;
3. Operating temperature range: -40 °C to +60 °C.

This system also allows guaranteeing transmission intervals programmable from a minimum of 5 min up to 1440 min.
8.5. Central Station

The prototype central station is designed to be a simple and efficient management station of the entire system. Its scalability ensures any future upgrade, if the bulk of the traffic would increase. The devices for the realization of the central station are listed below.

<table>
<thead>
<tr>
<th>Device Description</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Desktop PC</strong></td>
<td></td>
</tr>
<tr>
<td>Third Generation Intel® Core™i7 3770 Processor di, quad-core, 3.2 GHz with Turbo Technology, 8 MB. Microsoft Windows 7 Professional and Office 2013 Professional Suite preinstalled. <strong>3-years Warranty, Next business day support, 3-year data protection service: “Keep Your Hard Drive”.</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>LCD Monitor for Desktop PC</strong></td>
<td></td>
</tr>
<tr>
<td>1920x1080 pixel. 3-years Warranty, Next business day support.</td>
<td>1</td>
</tr>
<tr>
<td><strong>UPS for Desktop PC and Server</strong></td>
<td></td>
</tr>
<tr>
<td>The proposed Static Group is represented by a single UPS in the mechanical room from 6KVA for the PC and Server.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Server</strong></td>
<td></td>
</tr>
<tr>
<td>Allows you to manage data overload situations and expand virtual environments by exploiting processing power and a very high memory density. Intel Xeon bi-processor at 2.20 GHz and E5-4620 16M cache. 16 banks of RDIMM memory at 1600 MHz. <strong>3 years on-site warranty with intervention within 4 working hours.</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>16 port Switch managed Gigabit</strong></td>
<td></td>
</tr>
<tr>
<td>Fast Ethernet wire-speed Solution with high performance 16 port. Secure Switching with advanced authentication, with 802.1x, Private VLAN, over SNMPv3. Security with ACL MAC and IP flow based, MAC security port based, remote RADIUS and TACACS authentication +, SSL/SSH cryptography.</td>
<td>1</td>
</tr>
<tr>
<td>Needed for 1Gb LAN installation for workstations and server</td>
<td></td>
</tr>
<tr>
<td>All that will be necessary for the proper functioning of the internal LAN (braces, connectors, sockets network, etc.).</td>
<td>1</td>
</tr>
<tr>
<td><strong>A.C. Router to realize internet HDSL connectivity</strong></td>
<td></td>
</tr>
<tr>
<td>The model to be used strongly depends on the type of line you have.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Access Point, LAN speed 1000 Mbps, Wireless superior 600Mbps.</strong></td>
<td></td>
</tr>
<tr>
<td>Innovative dual-radio dual-band offering data rates similar to those of the wired network, up to 450 Mb / s per radio (900MB / s total).</td>
<td>1</td>
</tr>
</tbody>
</table>
8.6. Stake

In the neighbourhood of each monitoring point identified, will be offered a portal support, complete with base and the cockpit, which will generally be formed by a straight pole and one pole to reach with adequate length so as to position each camera centrally to lane obtaining the best shooting condition (see the diagram of the structure attached). The solution provided is made up of the particular feature of the pole that stood apart from the function of supporting the UN- Kemler cameras, GPRS and Bluetooth antennas, will serve as a seat for housing electronic equipment (modem control MRoad with GRPS / UMTS / HSDPA, Bluetooth detector and integrated charge controller, battery backup devices for data transmission to the centre and switch) through two segments, which, equipped with special vandal-proof doors with lock and magnetic proximity switches that signal to the central opening attempts (authorized or not) offer maximum protection from vandalism. This feature reduces the external dimensions to "0" (boxes, street cabinets, etc...). The entire station is also more compact, elegant with less impact from the visual point of view and the environment, while also offering a high protection in terms electrostatic acting as a Faraday cage in the event of discharges from lightning.

The stake is treated with hot-dip zinc coating to ensure a long life of the building over time. The temperatures inside the doorways offered reflect, in cold weather, quite faithfully the outside temperatures although with a slight hysteresis. In warm periods instead appear to be highest with respect to the external ones, however the provision of electronic components "extended range", allows the full operation of the apparatuses provided without any influence on the temperature up to 80 °C, avoiding the need to adopt cooling systems resulting in reduction of energy consumption.
8.7. \textbf{System Performance Evaluation}

8.7.1. \textit{The Project/System Development Process and Timeline}

In the development process of an ITS system it’s important to consider a lot of different requirements. The proposed ITS system is based on a telematics architecture following, both physically and logically-functionally, these design criteria:

- \textbf{Distributability:} the functionality of the peripheral concentrators can be made accessible on the outside, ensuring secure access by username and password, according to the policies defined by the centre itself. Here, for example, other centres and / or operators may have access to certain features of the platform fleet management and control via the web through Internet.

- \textbf{Data protection:} All the associations accessing the system, for example, have their own database for storing historical data and master data, not shared by other associations. Besides the physical architecture proposal, including appropriate allocation in terms of network devices, allows a high degree of protection against any external access.
Such a system requires approximately 7-8 weeks of implementation, including following phases: Planning (5d), Realisation (28d), Start Up (6d), Operational Management (8d) and Project Management (26d). Please find below the hypothesis of effort per sub-phase.

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 - Planning</td>
<td>10g</td>
</tr>
<tr>
<td>A1.1 - Analysis Requirement</td>
<td>1g</td>
</tr>
<tr>
<td>A1.2 - System Architecture</td>
<td>1g</td>
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<tr>
<td>A1.3 - Technical Requirement Definition</td>
<td>1g</td>
</tr>
<tr>
<td>A1.4 - Physical Data Specification</td>
<td>1g</td>
</tr>
<tr>
<td>A2 - Realisation</td>
<td>28g</td>
</tr>
<tr>
<td>A2.1 - Software Development</td>
<td>29h</td>
</tr>
<tr>
<td>A2.2 - Installation and Configuration</td>
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</tr>
<tr>
<td>A2.3 - External System Integration</td>
<td>4g</td>
</tr>
<tr>
<td>A2.4 - Testing</td>
<td>7g</td>
</tr>
<tr>
<td>A3 - Start Up</td>
<td>6g</td>
</tr>
<tr>
<td>A3.1 - DB Setting</td>
<td>9g</td>
</tr>
<tr>
<td>A3.2 - Training</td>
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</tr>
<tr>
<td>A3.3 - Acceptance</td>
<td>1g</td>
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<tr>
<td>A4 - Operational Management</td>
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</tr>
<tr>
<td>A4.1 - Assistance</td>
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</tr>
<tr>
<td>A4.2 - Maintenance</td>
<td>1g</td>
</tr>
<tr>
<td>A4.3 - Monitoring</td>
<td>5g</td>
</tr>
<tr>
<td>A5 - Project Management</td>
<td>26g</td>
</tr>
<tr>
<td>A5.1 - Planning</td>
<td>5g</td>
</tr>
<tr>
<td>A5.2 - Project Tasks Coordination</td>
<td>8g</td>
</tr>
</tbody>
</table>

8.7.2. System Reliability and Availability

Communications Security: All information exchanged between the peripheral points and the central station flow through a private APN ensuring, by means of a direct connection between the mobile operator and the ITS system service provider, protection from external accesses who could intercept and/or corrupt the data.

In addition, all the information exchanged, are subject to authenticate with its management policy, which in encryption by using SSL connections between the server data exchange.

The technical solution proposed is based on the principle of reliability and robustness of both the SW component that HW.

8.7.3. Compatibility

The design and technical solutions proposed were based on criteria aimed at reducing the burden of maintenance. In particular are favoured solutions to reduce the time and costs associated with troubleshooting, optimizing the accessibility and interchangeability of components (hardware and software), thereby reducing the cost of any repairs and periodic inspections. That applies both at the level of the overall system and at the level of peripheral subsystem and individual components of the project. The system provides a standard interfaces to the outside.
Services for data interchange exposed will take advantage the main protocols currently available:

- **SOAP**: The Simple Object Access Protocol (SOAP) is an XML-based protocol that allows two applications to communicate with each other on the Web. SOAP defines the format of messages that the two applications can exchange using Internet protocols such as HTTP, to provide information and request processing. The protocol is independent from the hardware and software platform and is independent of the programming language used to develop the communicating applications. With this protocol, the concept of the Web as a platform for the publication of documents containing information usable by humans changes radically. You can combine the classic publication of Web pages with a publication of information for applications. This new type of publication is the so-called Web services. A Web service is an application that provides functionality to Web in a manner independent of the platform used. In fact, a message of this type is no more than an XML document that describes a processing request or the result of processing. A SOAP message consists of the following elements:
  - Envelope: represents the envelope of the message
  - Header is an optional element that contains global information about the message. The header specifies the language of the message reference, the date of mailing, etc...
  - Body: Represents the processing request or response derived from a processing

- **RESTful**: Defines a template design or software architecture, elegantly, an "architectural style". The basic idea is to see the REST of the Web (as well as other "systems") as a platform for distributed processing of the data. And the Web has everything you need, i.e., the infrastructure that is based on the HTTP protocol and the information that become real resources. A resource is any object element on which it is possible to perform operations and is uniquely identifiable (through the concept of URI - Uniform Resource Identifier). The first step is to identify the resources to be exposed through Web services, where their representation "external" to the client does not always reflect the implementation or the internal model of the web. The interactions between client and server must be stateless, stateless communication respecting the native HTTP protocol. The management of the state (if necessary) is done on the client, optimizing server performance should not treat the state of a session and can be performed with the use of session keys, such as cookies. Unlike what happens in most of the web applications, where the application state is often maintained by the server along with the status of the communication, the application state in a RESTful architecture is the result of collaboration between client and server, each with their roles and responsibilities. It should be noted that only defines the SOAP message structure not their content. The tags to describe a request to process or outcome are defined in a specific pattern and used within the structure using the SOAP namespace mechanism.

RESTful and SOAP have an approach to Web Services, in some ways, the opposite. Precisely for this reason it was decided to adopt them both to exploit the potential of both the protocols and make the prototype much more interfaced.
8.8. Integration

In what has just been said, it should be emphasized the fact that the general orientation of the project towards the use of solutions of sharing web data-oriented service (SOAP / XML) enables and ensures the possibility to integrate additional external systems such as any business management systems that may be beneficial to further operational to transport dangerous goods or any other public actor.
8.9. **Optimization**

The solution described uses a Map Server (as well as for the management of other shared resources) for the integrated management of basic maps installed at the central station ITS, effectively reducing maintenance costs, upgrades and license of cartography itself.

Despite being installed at the central station ITS, the centralization of shared resources does not imply an admixture or the collapse of the functionalities, nor the failure to ensure the confidentiality of data managed. This choice also avoids mismatches between the risk map kept at the central level and the geo-referencing system mapping systems that may be used by peripheral device (vehicles).

8.9.1. **Scalability**

Each subsystem under construction must be easy to replicate and expand. This effectively sets no limit to the increase in size of the system that could certainly be expanded and connected to other companies / associations. The advantages of the service-oriented result in greater flexibility of the system: the solution can be used from any computer connected to the Internet, without the need to install proprietary software on client machines; updates are available in real time on all the computers of end users, avoiding loss of time for the maintenance of computer systems. All this involves a significant reduction in costs both with regards the development (management code, data structures and applications support are unique for all the customers of the service) and for the maintenance of the software.
8.10. Cost Evaluation

8.10.1. Constraints & Assumptions

The problem to control transportation of dangerous goods using ITS systems has been addressed in recent years by a number of funded projects, both at regional, national and European level.

Below we listed the most important, among those made in Italy and in Europe.

The major projects at regional / national level were: Alpcheck 1 and 2 (Veneto - Val d’Aosta), Danger (ASI, 2004), Destination (Piedmont), EasyLog (Lombardia), Lose (Lucca, Genoa and French), PICOGE, SCUTUM (using EGNOS for the detection and tracking), Sectram (Liguria), SILOS (Friuli), System Autovie Venetian, SITIP, Space2Land, Tramper, UIRNet, Ulysses.

While at European level we can mention: MENTOR, M-Trade, Transcontrol (France), GRAIL CHEM (France-Germany rail transport), SISTTEMS (France), TR @ IN MD (France: rail transport), ARTS VISU TMD (France-Spain, the only experimental), MITRA, SEE MARINER. Many of these projects have experienced only the first phase of the study; others have come to a more complete realization. None of them, to date, comprehensively solves the problem of complete management of the transport of dangerous goods.

The system proposed by ITL has the opportunity to be the final link in the chain, either because the bodies which propose such a study can serve as a driving force towards the market and also by taking advantage of all the experiences to date already made in Italy and in Europe.

In our view, the ITS system must be the final tool used by every company in Italy carrying dangerous goods and at the same time serve as the central control point for all this type of transport.

It should be first and foremost a system that will meet the needs of a company carrying out such transport:

Check that the load is properly placed and tied (this is for the transportation of packages, with regard to tankers and bulk is not applicable, even if the risk in such cases is much higher).

Easy production of paper documents which must accompany transport, both for domestic and European routes (the laws of the various countries are different).
The ride provided by the system must be compatible with the type of material transported and its packaging.

The journey must be controlled as much as possible, whether the vehicle communicates its position or when is known, however, only the path (start and end points, milestones)

Provide a range of information in real time taking into account, where the vehicle is traveling: this is a useful thing for all transports, but even more stringent for those who transport dangerous goods.

The central station has the stronger need to intervene as much effectively as possible in case of accidents, other destructive events or simple anomalies, as well as communicate effectively and at low cost with operators in the field.

The proposed solution is characterized by a scalable and easy to use structure for all the actors of the system. The experience gained over the years in this area will allow the creation of a robust, complete, reliable, focused on ease of use, simplicity of representation of information, and disclosure of that information.

In particular, to those on the ground (drivers) must be provided mobile applications designed specifically for use in the simplest way possible. In summary, the system can be represented as the union of three subsystems: subsystem board, subsystem peripheral, central subsystem. The subsystem consists of edge devices mounted on the vehicle and be able to connect to the central subsystem for mission planning, to send the same subsystem, the position of the vehicle (or any other physical quantity) and will be able to communicate any abnormalities that the driver wishes to transmit (or send in some cases without the human intervention).

This subsystem will be characterized by a number of features of low economic impact, will not have the hardware features of particular value. The peripheral subsystem will be characterized by a set of devices and equipment suitably located in the territory: these devices will primarily have the task of detecting and recognizing license plates and placards ADR and communicate them to the central subsystem. The sub-station will be the true heart of the system, in it will be managed and maintained the missions and tracking data from the on-board equipment. This system will take care of mission planning taking into account the static and dynamic risk map, provide dashboard summaries for the monitoring mission, the management of the anomalies, and the alarm condition; the central system will be able to send messages to the various on-board equipment, the institutions, transport companies, logistics nodes and where appropriate to other actors in the system to communicate events, anomalies, situations, statistics, journalistic and other punctual communication that in the normal use of the system can be useful and sometimes necessary. This subsystem will be strongly characterized by modules and services for interfacing with other heterogeneous systems. The natural evolution (compatible with system that we propose) subsystem board is the use of general purpose devices such as Smartphone (mostly) or Tablet that, with specific applications or web portals developed specifically for the mobile mode, will allow for all the operations designed and manufactured for custom devices that may be installed on vehicles.
board. This feature will allow for greater flexibility and scalability of the resources of the various transport companies and the economic and technological impact subside further, since the use of these devices is now widespread and their cost is included: the cost of a great device is a few hundred Euros.

In any case, to achieve the goal of using the platform in a large scale, in Italy in 2014 two basic points are required:

- Low economic impact
- Ease of use

These needs emerge from the state of economic emergency in which the transport company are working, now operating in a market exacerbated by costs and restrictions and have the need to simplify the way they operate.

In the prototype we decided to provide, as already explained above, only the peripheral subsystem and the central subsystem. This is the fundamental basis of this system: its adoption does not limit anything for the future, but fosters the development.

8.10.2. Project Budget & Estimated Development Costs

We proceed with a detailed costs estimate.

8.10.2.1. HW Cost for each peripheral point

Needed devices (as already described):

- Camera to read vehicle plates and the Orange Slate
- DAU
- Stake
- Transmission System Unit

The total equipment cost for each peripheral point will not exceed € 10.000,00 (ten thousand).

8.10.2.2. HW Cost for Central System

Fundamental needed Devices (as already described):

- PC Desktop
- Server
- UPS
- Switch

The total cost of the hardware prototype for the central station will be around € 20.000,00 (twenty thousand).
8.10.2.3. SW Cost

- SW Central System Operational Management: Description and Costs

This is the heart of the system.

The software operates in several distinct phases and complementary concerning the transport of dangerous goods.

- In a preliminary phase of transportation planning, with support for the choice of the route and the path to the suggestion of minimal risk.
- During the performance of the carriage with the monitoring of the vehicle, its location, the integrity of the cargo and of the conditions of transport networks allowing the operator in the event of changes in the state of the road network, to execute a new schedule of itinerary.
- In emergency management guiding the operator of the system in warning Competent Authorities which will be made available all relevant information to the management of the emergency itself.

According to the paradigm of service-oriented architectures (SOA), distributed resources that the central station comprises of different domains, are susceptible to the following classification.

⇒ Communication Service. The information needed to expose the macro-planned architecture logic, persistence purchase through the exchange of data with the outside world, particularly with external subsystems (if any) to receive monitoring data, and with the traffic management centres to receive updated information on mobility.

⇒ Management Service of the risk map of the region. The hardware / software system guarantees the import of risk map at each new edition published by the supplier. The risk map is subject to a constant update reflecting on changes in the road system, its use and the degree of land use.

⇒ Service Plan delivery. The subsystem, drawing on spatial data and transport terms contained in the risk map, and of appropriate algorithms, provides an estimate of the level of risk associated with the transport of dangerous goods.

⇒ Service Localization of means. With the aid of a WebGIS platform complete, the subsystem ensures the representation of digital mapping of the situation concerning the transport of dangerous goods, using the best available data.

⇒ Management Service Anomalies. The subsystem stores and analyses data related to the known location of the vehicle by detecting deviations from the planned route and reporting hazardous conditions caused by a change in the weather and the road network.
Service of Emergency Management. The subsystem has the task to detect in manual or automatic mode emergencies happening on the ground and provides support as complete as possible to the operator station to activate the intervention of rescue forces. Puts the operator in terms of providing basic information on the emergency in place such as the type of accidental event, the class of goods and the quantity transported, the event's location if known. It also allows access to additional information useful to emergency management, such as product data sheets, the thematic mapping of the area affected by the event, the location and type of other transport of dangerous goods in the area.

The cost of the SW Operational Management system in Central Station is about € 25,000.

- Diagnostic System: Description and Costs

The diagnostic system as the first thing keeps under control the most important parameters of the terminal device, and displays them in the Control Room.

Among the parameters monitored continuously by the diagnostics include:
- Voltage of the backup battery
- supply voltage
- battery charging current buffer
- internal temperature
- The status of the "gateway" to the portal
- Number of data transmission module reset
- the number of reset control unit
- registration status of data transmission module
- signal strength data transmission
- Communication status PPP
- Communication status Cameras

In this way is supplied to the control room a comprehensive description of the state of each terminal device, making it more efficient and easy control operations and maintenance.

Second, the diagnostic software will start up a check on the functioning of the whole system, displaying the operator clear message about any problems.

The cost of the Diagnostic System is about € 5,000.

The total cost of the software will be around € 30,000,00 (thirty thousand).

8.10.2.4. Telematic Costs

The system is designed to provide containment bandwidth consumption for data communication towards the central station. The cameras KEMLER-UN proposed perform algorithms recognition (OCR) inside itself.
This allows you to not send images or video streams at the central station, something that would lead to a high demand for bandwidth for communication.

In the solution presented is sent only strings of data table of the means by UN-KEMLER detected (and the plates), leading to significant savings in bandwidth usage of communication available and costs for SIM cards data that will be used for the transmission modem (about 8 € / month for each SIM). The central system will still be able to have also the image associated with the string, depending on his needs.

8.10.2.5. Timing of implementation and Configuration Management

The timing of the design and implementation of the system apart from the rest also cover visits and site inspections at the possible locations where the cameras will be installed.

At this point it needs to proceed with the installation of mechanical and civil works. We list below the time required for the realization of the prototype of the ITS system:

- Installation and testing HW part (central and peripheral point): 15 days
- Installation and Verification SW part (central and peripheral point): 15 days
- Implementation SW interface for each external system: 10 days

The first two activities listed above may not go in parallel. The third is independent.

- Installation and Verification HW and SW part of any additional peripheral point: 5 days

In addition to the times outlined above for the proper management and implementation of the prototype of future systems that will result from it will require a system configuration management, which will ensure:

- that all the functional and physical characteristics of the prototype (HW + SW + telematics) are identified and documented through configuration items;
- that the changes in these features are implemented through a controlled process;
- The documentation set includes all the information about the project and implementation are necessary and sufficient to define and describe each component of the product;

The system configuration management must be based on a system of any existing standard procedures and configuration management should cover the following activities:

- Planning the configuration
- Configuration identification
- Configuration control
- Reporting Configuration
- Planning and execution of functional and physical configuration audits
- Management of data and documents
The description of the configuration management processes that will be applied throughout the life cycle of the project will be described in the management plan of the configuration. The goal of identifying the configuration is to define, describe and represent the physical and functional characteristics of the prototype. The objective of configuration control is to ensure that all the changes, deviations and waivers are processed and controlled in a traceable way. The control configuration ensures that all changes to the baseline configuration are agreed with the program/project stakeholders, approved by the customer and accepted by suppliers.

8.10.3. Estimated Operations & Maintenance Costs

8.10.3.1. Operational Costs

There must be an operator inside the Central Station. This resource can be named the Operation Manager of the system. The operator must carefully understand the complexity of the entire ITS system and must be able to:

- Supervise the processes of operation of the ITS system
- Send messages to operators able to intervene in case of problems or accidents in the area
- Decode all diagnostic messages, both from the field and from the Central Station and inform the maintenance team on possible malfunctions

It is not a high profile resource: its costs are around € 20,000.00 (twenty thousand) per year.

Then we have to add the monthly cost for the data transmission from the branch offices to the central station, in addition to the power supply, even if everywhere, both in headquarters and in the peripheral points, we use equipment with low energy consumption.

8.10.3.2. Maintenance Costs

There must be a figure able to maintain the peripheral stations: one person (technical HW / SW) with knowledge of both the hardware devices that the characteristics of the system software installed.

In addition, a portion of time the System Manager at the central station has to be dedicated to the management of the system:

- Maintenance machines
- DB System Management

For these activities are estimated:
Technical HW / SW: about € 8,000 a year (the activity is assumed to be not full-time)
System Manager Central: € 2,500 (again, the activity is not full-time)
8.11. Institutional Impacts Evaluation

8.11.1. Impacts to Operations and Maintenance Procedures and Policies

A first management model is that Emilia Romagna Region handles this class of systems, for a number of reasons that we list.

This approach to a regional guide has guided the choice of the simple technology proposed to be used in these sections of automatic detection of dangerous goods. For the prototype we have taken account of similar investments made by the managers of the road network in this region, but not all. In particular, we point out how the proposed technology in the system is compatible with that used by ANAS (a company 100% owned by Ministry of Economy) all over the country, and especially in the Italian regions of Piedmont and Emilia Romagna. This factor is a key trigger for the quality of the prototype as the system you will achieve will natively and therefore perfectly compatible with the systems in operation in these areas.

Moreover, if (as we believe) you were able to establish collaborative arrangements for the exchange of data, this could be done at no additional cost to anyone. Investments that the Ministry of Transport are entering into the project UIRNet (in fact the majority of public spending in this area has focused on this project) suggest that anyone thinking of a model of public management of transport, in particular that of dangerous goods, may reasonably be plan to use the services provided by UIRNet. In this case the master can be represented by UIRNet SpA, with which body the Emilia Romagna can think of to offset the investment.

UIRNet is investing around three million Euros in the creation of a system of management of dangerous goods, in which everyone, public or private, will have to face.

In any case, such a system must be open to Transport Operators (service providers) who wish to develop and deliver services to value-added payment innovative and / or specific for that industry.

The method to attract the service providers is to offer inside the system services with detail information (and tool) at several levels: Institutional, National / International, Regional and Local / Urban.

8.11.2. Impacts to Staffing/Skill Levels and Training

No impacts

8.11.3. Impacts to the Competitive Environment

No impacts
8.11.4. Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS

No impacts
8.12. Transportation System Impacts Evaluation

8.12.1. Impacts on traffic efficiency and traffic management

An action that is proposed, very useful for the calculation of regional flows of dangerous goods and all other traffic flows in Emilia Romagna (then again a regional scale that goes to reinforce the idea of who should be the manager of this system), provides for the adoption of a detection module of Bluetooth devices (installed on the control unit data acquisition situated within the support structures for the cameras) that are located on board of vehicles transiting in the vicinity of the sites of detection dangerous goods on offer. With this technology it is possible to intercept these devices using the unique ID that distinguishes them, every time they pass near the portals offered. This allows you to implement algorithms on journey times and the matrices of Origin / Destination between a data point and another (the portals with the cameras on board). It is clear that more data points are available, the greater the accuracy of the calculation of travel times and the matrix Origin / Destination. In this regard, we want to make it known that many of the sites belonging to Anas SpA, have already installed the sensing device or will do soon: of course, also those located in Emilia Romagna region.

8.12.2. Impacts to Mode Shifting and Intermodalism

No impacts

8.12.3. Impacts on the environment and fuel consumption

No impacts

8.12.4. Impacts to Traffic Safety and Accident Reduction

In summary, the pilot will serve to:

- Increase the security level in the region where the installation resides:
  o To provide vehicles tracking in a specific site / section. In particular, it’s important to know about the presence and the quantity of dangerous goods crossing in geographical areas closed to the city boundaries
  o A Real Time tracking at the vehicles passing. A real-time tracking provides the exact knowledge of how much Dangerous Goods are contained on a certain geographical area, making possible more rapid response actions and some planning, aiming to avoid disaster
  o To provide an alert message (in Real Time) signalling the presence of two or more vehicles carrying different types of dangerous goods with a potential damage if they meet each other
- Improve the goods flows logistic:
  o To Check the passing vehicles or dangerous goods in points / sections of interest
  o Logistic Management Support
• Improve traffic analysis in the region covered by the installation:
  o Matrix Analysis O/D
  o Matrix to analyses the potential travelling time
  o Tracking passage for dangerous goods
  o Traffic Management in critical section in road network
• Emergency response improvement: to reduce the effects of any accidents, optimizing the emergency operations on the basis of precise information on the types of substances involved, linked to the exact accident location. In management of emergency situations, the ITS system communicates to relief agencies in charge and other users neighbours, any anomalies / incidents / adverse weather conditions, suggesting alternative routes to reduce the risk
• Improved logistics standards to support carriers, for example with better road paths for the transport of dangerous goods (i.e. lower risk paths) while warning them of all the necessary documentation to produce and all the rules for the proper transport. For example the loading constraints
• Disseminate project results and raising awareness of the objectives and topics of the stakeholders involved
• Take advantage of the data provided by the pilot to create a protocol book and to negotiate new rules in logistics of dangerous goods

Finally, the pilot project must achieve a recognition level of the binomial orange panel - vehicle plate equal to: (Greater) than 95% in case of a vehicle arrest at the barriers, at least 75% (range 75% - 80%) in the case of a moving vehicle (at an estimated speed of around 60 km/h, even if technologies’ makers guarantee more, till 140km/h).

At the current state of the art no ITS system is capable to read the hazard label placed on top of the square: this is important while transporting packaged dangerous goods. This feature positively reduces the social risks and environmental disasters.

8.12.5. Impacts on driving behaviour

No impacts

8.12.6. Drivers/Users acceptance/perceptions

No impacts.
8.13. Conclusions

Despite its simplicity, the pilot project is the first step towards the solution of various problems related to the transport of dangerous goods, which can be attributed to the following aspects, many of which have already been partly solved by the pilot project:

- **Knowledge of phenomenon**: a system to enable real-time control of the transport of dangerous goods on the region main infrastructure
- **Homeland security**: reducing the risk of accidents in the area for events related to the transport of dangerous goods which, as noted, can have particularly serious consequences, even outside the network road. All monitoring and controlling continuously and in real-time both the vehicle state and the load
- **Improving emergency response**: reducing the effects of accidents, optimizing the nature of the emergency on the basis of precise information on the types of substances involved and the exact location of the accident
- **Improvement of the Public Administration actions**: accurately identifying the items for the drawing of the map of the risks associated with the transport of dangerous goods and the use of organic measures aimed at risk reduction, including the structural one
- **Improved standards of logistics support carriers with directions on how effective is the transport of dangerous goods, as an indication of routes with lower risk, facilitating trading system
- **Inter-regional cooperation on policies**: to have a close co-operation with neighbouring regions to implement uniform policies in the field of mobility and the control and protection of land. One of the goals of the pilot project is to ensure the interoperability of system control at a supra-regional level. The project will, therefore, monitor the traffic in general.
9. **BUDAPEST DEMO SITE**

9.1. **Project/System Technical Description**

With the creation of TUK, a professional route planning engine has been made available, but due to the highly specialized task definition of serving the public transport needs of cyclists, the associated TUK program satisfies the demands of only a very narrow group of users. If however high-quality timetable data and additional user features (public transport support for pedestrian, Volán coach information, timetable browsing) were provided, such an application being capable of serving mass demands would be put in place that is expected to be used extensively on a day-to-day basis, and therefore would strengthen the public recognition of HTA as a service provider. This chapter discusses the main directions that are worth considering for any development based on the current capabilities of TUK.

9.1.1. **Installation of the program**

For the installation and use of the program, such an Android-based mobile device is needed that conforms to the specifications of the previous chapter. During installation and database download (update), the device needs to have Internet access.

Manufacturers often redesign the Android operating system for their own preferences (e.g. HTC Sense, Samsung TouchWiz, Sony Xperia UI, etc.). This document describes the methods actually used in the basic version of Android issued by Google. If your device does not include any management tool at the places described here, you can ask your telephone manufacturer or dealer where to find the required function.

Many telephones offer the option for final users to change the user interface originally put in place by the manufacturer. The operation of specific program managers may also differ from those described in this documentation. In the description of the system functions, the availability of the basic user interface provided by Google, "Holo" is presumed, with the use of the Android version 4.4.2.

Checking the Android version
With the following procedure, the Android version running on the mobile device can be checked:

**STEP1:** Enter the telephone settings menu. It can be done by clicking "Settings" from among the icons dropping down from the upper right corner, or the menu items appearing after the use of the menu button.
Scroll to the bottom of the menu that appears, and select the "About the phone" item. Scroll to the bottom of the displayed menu to find the "Android version" item. If it is 4.2, 4.3 or 4.4, in this respect the device is suitable for the installation of TUKMobile (third digits potentially displayed are not to be taken into account). If it is 4.0 or 1.4, it is likely that TUKMobile can be installed, but the program may not start, or certain functions may not work as expected.

Figure 71: Screen of the “Settings”
The size of the memory provided with the device can be viewed in the same page. It should be minimally 1024 MB. The program would also start on devices with 512 Mb memories, as depending on concurrently running programs memory shortage may occur.

Downloading the installation kit
For the installation of TUKMobile applications, the mobile device has to have access to the Internet. It can be provided via mobile Internet or a WiFi network.

As the first of the installation, open an Internet browser. In the address line, enter the place where the application server can be accessed: www.cartosoft.hu/TUK (after 01.06.2014 has been changed).

The site has three installation kits for the TUK application, and for the mobile application the first one should be chosen. Click the "Download TUKMobile (Android)" option to start downloading the installation kit.
Before downloading, the Android operating system warns you that the .apk files downloaded from an unknown location may damage the system. Click the “OK” button, and choose the option to keep the file. Among the notification icons of the mobile device, the process of downloading is indicated.

Once downloading is complete, the notification shows that the "TUKMobile.apk" file has been successfully downloaded, and by clicking on the message the process of installation starts.

Enabling unknown sources
In the settings of the operating system, the installation of programs from locations outside Google Play is not enabled, and therefore the system displays a warning message.
In the dialog box, select the "Setup" option to display the settings of the device on the screen, particularly the "Security" section. Here, under "Device Control" enable the "Unknown sources" option.

Such authorization can be given by checking the check box at the end of the line. Then the system indicates the associated security risks, and the selection can be finalized by clicking the "OK" button.

This option is also available in Android's own settings menu, under "Security".

Installation
In the first window of installation, the system displays the usual list of the resources that the application will use. Click the "Install" button to enable these accesses for the program. Thereafter, the process of installation runs automatically.
The program needs the specific authorities for the following purposes:

- approximate and precise position: to list the nearby stops and for the operation of the compass
- Modification or deletion, reading of the contents of the SD Card: to download, manage the database
- Displaying network connections, full network access, viewing WIFI connections: to download the database
- Reading the configuration of Google services, access of other location provider commands: to manage the current situation with Google Play Location API, as based on the GPS and mobile network

After installation is complete, you can close the installation window ("Done" button), or the start of application. ("Open" button).

Most of the Android user interface managers allow users to automatically create an icon for the new program icon in the main window, but obviously the program can be started from among the "Installed Programs", which can be found under the name of TUK, and features a blue bike icon.
Updating the program
To update the application, Internet access (mobile Internet or WiFi connection) is required. To update the application, use the Internet browser to find the application server. To this end, enter the URL of the server in the address line of the browser: www.cartosoft.hu/TUK

Just like for installation, you need to download the installation kit (apk file). After downloading, in the notification area, click on the file name to start the update. The system may rename the file in case the previous installation kit is still available in the device. (E.g. as TUKMobile 1.apk)

In the course of the update, the system displays a message to show whether new authorities are needed for the resources of the device, and similarly to the process installation the update is completed.

While updating, the database downloaded earlier is retained, but always ensure if the new database version can be found on the server by clicking on the database update within the program.

Updating the database
To update the database, Internet access (mobile Internet or WiFi connection) is required.

The database can be updated within the application. In the main menu, select the "Database Update" menu item to display the interface of database update. In this interface, Internet address of the web service for updating the database can be found in the uppermost line (by default: www.cartosoft.hu/TUK). The Internet address of the web service (URL) can be freely entered in this line.

Upon clicking the "Start Updating" button, the application will communicate with the server, queries the current database version, and if any update can be found in the server, the new database is downloaded.
The results of the update are shown by the program to the user in the bottom section of the view.

Removal of the application

The application can be removed with the use of the Android operating system. In the “Settings” menu, click on the “Applications” line.

In the displayed list, find the "Public Transport Route Planner for Cyclists" application. Click on this line to execute the removal. Then, in the screen showing the detailed information of the application, click on the "Uninstall" button to remove the application and associated data.

At the same location, the database of the application can also be deleted (“Delete Data”) if due to any damage (e.g. resulting from a SD Card error) the program cannot be started. The program can be started even without the database, but in this case first execute the "Update the Database" process as described in the next chapter.
9.1.2. Use of the program

Updating the database
When starting the program, the main menu can be seen on the mobile phone, where the tablet displays the main menu on the left and the program description on the right side.

When the device is started for the first time, or the database has been deleted, at the bottom of the device screen the message: "No database, please run the database update!" is displayed for a few seconds.

To download the database, select the "Update the Database" option. The address of the Internet server can be seen in the top line of the displayed view. By default, it is kira.hov.hu/TUK. The web service through which the database can be downloaded to the device mobile runs at this address.

By clicking the "Start the Update" button, the automatic synchronization process is launched, and in the area under the start button the program continuously displays information. After the completion of the update, the program can be used instantly with the need to restart.
New route
The route can be planned by clicking on the new route menu item.

You can enter your starting location and destination by entering the names of the stops.

Once you have entered the first two letters, the program displays a list with the names of the stops that contain the given two letters. The list begins with the names of the stops whose names start with the letters entered, followed by those stops where the specific letters are the first characters. Click any element of the list for selection.

There is another option to enter your starting point: by clicking on the "nearby stops". Then, a list of the stops situated within max. 20 km of your current position is displays, accompanied by the respective distances to them. Any of its elements can be selected as a starting point.

The list of the optional starting points and destinations is based on the stops included in the public transport databases. TUK’s current database combines all such stops of BKK, MÁV and the Danube ferries that are associated with services allowing bicycle transportation.
It is important to note that the public transport databases involved in the first edition of the program have several known errors, which obviously affects the operation of the program. As far as it is possible, the Hungarian Transport Administration (HTA) endeavours to correct these errors. The new databases will be published, and are available with the use of the "Update the Database" feature of the TUK program.

In addition to the starting point and destination, the time of departure should also be set as with the timetable-based route planner it can significantly influence the route. The default start time is the current time and day.

After the parameters have been set, the "Start route planning" button is displayed in the middle of the animation. It can be used to initiate the process of route planning.

9.1.3. Route plan

The process of planning
The process of planning can take a few seconds at the maximum, and then the route appears. You can always return to this point via the "Route plan" item in the main menu.

Here you can see the step-by-step details of your planned route, with each step followed by the associated information:

The starting point can be found in the first line, while the destination stop in the second. The third line to the left shows the pictogram of the means of transport, currently with the following options:

- green bike: cycling
- blue bike over water: ferry
- MÁV symbol: train
• BKK vehicle symbol: suburban train, tram, bus, boat. (The displayed symbol corresponds to the given type of transport.)

• To the right side of the symbol, the departure and arrival time of the service can be seen.

The designation of the service can be viewed under the time details. For trains, the "SZ" indicates passenger trains, whereas "GY" stands for express trains.

If the service runs for more than one stop, the stops are also listed accompanied by the scheduled arrival times. To the right, the compass icon can be seen, which can be clicked to display the compass for the selected destination as the specific setting.
Compass

The compass is designed to help find the selected station. This is especially useful for navigating to the starting point, and also helps transfers. Obviously, it only works when the device is supplied with a magnetic directional sensor.

Most of the window is covered by the compass, showing the following information:

- Rotating compass that shows the direction to the north as based on the information from the magnetic sensor.
- Blue pointer on it to show the direction from the actual location toward the selected destination. If no destination is selected, the compass will not appear.
- In the upper left corner, you can see the momentary rotation of the device in relation to the magnetic north pole on the basis of the magnetic sensor in the device.
- In the upper right corner, you can see the perceived magnetic field. This is important because in large cities or near sources of electricity (e.g. in vehicles) often much stronger magnetic fields are formed than Earth's own magnetic field. In this case, the compass indicates their directions instead of earth magnetism. If the displayed value is over 10, then your device detects is unlikely to detect earth magnetism. Therefore, the program indicates the unreliability of the information in red letters.
- As depending on the fact whether the display is horizontal or vertical, the name of forthcoming stop and its GPS coordinates can be read under/next to the compass. By clicking on the name displayed in the appearing menu, you can choose any of the
starting and end points of your route, or stops in between. The compass points at the
direction of the selected stop.

- It will display the deadline, i.e. the time when the service leaves the given station that
  is the time until which the station has to be reached.
- The linear distance of station (as relative to our current location) and the time of the
  arrival calculated at 10 km/h (along the linear distance) average speed are displayed,
too.
- The actual position according to the GPS receiver and its accuracy, as well as the
current speed are all displayed in lowercase fonts.
Terms of use

Under this menu item, the important information associated with this program, as compiled by the Hungarian Transport Administration, can be read.
9.2. **Specific evaluation**

The Public Transport Route Planner for Cyclists (hereinafter as the TUK, “Tömegközlekedési Útvonaltervező Kerékpárosoknak”) program package was created on commission of the Hungarian Transport Administration, within the framework of the project entitled “Southeastern European Programme SEE/D/0099/3.2/X. SEE-ITS” on a research trial (pilot) basis. It aims to demonstrate that it is possible to create such an intermodal route planning application for use with today's generally available mobile phones of average capacities that satisfies the following conditions:

- Capability to take the timetables of more than one mode of public transportation into account, including the transfer options among them so that in between two closely situated stops potentially bicycles should be used.
- Ability to perform route planning from its own database offline (without Internet access).
- The program is expected to make up its own data base from the GTFS format national timetables of the railway services (MÁV), Budapest public transport services (BKK) and the Danube ferries (altogether 297 MB), with the use of such effective data storage where the combined size of the database should not exceed 10 MB.
- The route search operation should not take longer than a few seconds even with the use of the national database.

The TUK program package has been successfully completed; it meets the requirements, and thus proves that the task is technically feasible. The program package consists of the following components:

- TUKMobile: Android mobile phone application (main program)
- TUKAdmin: Operator desktop program to load the updated GTFS databases
- Server-side devices: Server modules running on the updating webserver.

During the test period, the task was to evaluate and take all the functions of the application into account, based on the testing method listed below:

1. Refining and improving the menu system of the user interface
   - Asking the opinion of five users concerning the appearance of the user interface
   - Collection and submission of opinions and demands to subcontractor

2. Functional expansion and optimization of the app
   - Asking the opinion of five users concerning the serviceability of the menu system
   - Collection and submission of opinions and demands to subcontractor
   - Arrangement of a meeting with the subcontractor in order to discuss the options and achievements in the additionally required development

3. Checking and testing the database upload software
- Uploading public transport timetables into the database by choosing different public transport lines
- Repeating the process until five subsequently correct results are received
- Submission of a report in relation to the results to the subcontractor

4. Testing the route planner function of the application (in office environment)
- Five users entering random starting points and destinations in the testing area
- Analysing the results by considering the optimal traveling time and distance. The goal is to find realistic results.
- Compilation and submission of the test results to the subcontractor

In the case of inappropriate results:
   (a) Algorithm problem

Responsibility: Subcontractor (Cartosoft Co.)
   (b) Improper timetable problem

Responsibility: Client (HTA)

5. Checking, correction and editing of the uploaded database
   Step 5.1 After receiving the opinion of the subcontractor – in case of database problem – make the GTFS files readable and editable in Excel.
   Step 5.2 Find, check and correct the incorrect records.
   Step 5.3 Check the completed files by running them in the “GTFS validator” software
   Step 5.4 After correcting the files due to the validation, upload them into the web-server database.
   Step 5.5 Refresh the database of the application

6. Testing the route planner function of the software (on field)
   (a) Traveling time test by bike
      o Checking the traveling time between the starting point and the first station
      o Optimizing the speed setup of the app in the light of the results
   (b) Speed measuring
      o Comparing the speed displayed by the application with the data in the speed measurement table of the bike
      o In case of any inaccuracy, sending a report to the developer in relation to the results
   (c) Distance measuring
      o Comparing the distance displayed by the application with the data in the distance measurement table of the bike
      o In the case of any inaccuracy, sending a report to the developer in relation to the results
   (d) Testing the appropriateness of GPS ground-marker coordinates
After reaching a marked station, the application should change to the next destination. This means that the GPS identification works properly. In the case of any deviation, the developer eliminates the problem.

(e) Testing the accuracy of the timetable data
- Comparing the timetables of the application with the real time data of the stations
- Preparing notes on the results

(f) Compass direction measurement
- Checking the accuracy of the compass between the starting point and the first station

In the case of any deviation, the developer eliminates the problem.

Map-based display
The user interface of the program could be made more appealing by adding a map-based display option to the TUK program. If the option of fully offline use is to be maintained, map management in sufficient details and high quality would substantially increase the costs of the development with respect to the technical needs and data demands, which would largely deteriorate the cost-to-benefit ratio. Yet, if for the time of map display online operation were allowed, it would become possible to use Google Maps in order to view stations and routes in the Android system. Obviously, it should be incorporated in the program so that route planning could still be operated offline, without network connection.

Browsing of timetables
The circle of potential users would similarly be significantly broadened in case the timetables included could be browsed in formats that passengers are accustomed to. Therefore, the program would be suitable for the automatic planning, as well as viewing timetables offline, during trips. Obviously, it is essential that the high-quality, complete and accurate timetables be available.

Geological obstacles
In certain cases, there may be such obstacles between two stations situated close to each other that fully render the transfer impossible (e.g. river, lake, large and enclosed objects). Although this aspect has not been part of the project, for pilot purposes TUK program has been designed to incorporate an obstacle management method that is based on a diagrammatic map. The program does not allow the use of bicycles in between two stops where the line connecting them intersects any other line on the map. This method can now prevent the generation of routes that would recommend the use of bicycle across River Danube without the availability of a bridge. HTA will able to add this map all the routes belonging to major Hungarian rivers, lakes, canals where there are no proper crossing facilities. Any further development of the function and the TUK program could focus on the weighting of the routes so as to handle objects (e.g. hills, forests) that do not render passage impossible, still hinders it significantly.
9.3. **System Performance Evaluation**

9.3.1. *The Project/System Development Process and Timeline*

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of the contract (developer)</td>
<td>22.11.2013</td>
</tr>
<tr>
<td>First version, test starting date</td>
<td>30.04.2014</td>
</tr>
<tr>
<td>Final version, end date of the contract</td>
<td>31.05.2014</td>
</tr>
<tr>
<td>First meeting (cooperation)</td>
<td>30.04.2014</td>
</tr>
<tr>
<td>Second meeting</td>
<td>10.05.2014</td>
</tr>
<tr>
<td>Third (last) meeting</td>
<td>29.05.2014</td>
</tr>
<tr>
<td>Evaluation</td>
<td>10.05.2014 - 30.06.2014</td>
</tr>
<tr>
<td>Starting date of 12 month warranty period</td>
<td>31.05.2014</td>
</tr>
</tbody>
</table>

9.3.2. **System Reliability and Availability**

Application available from HTA’s servers: 01.06.2014

The testing (demonstration) area is the northern section of the EuroVelo 6 bicycle network of Hungary, the Dunakanyar region, near the Danube and around Budapest.

The tests have confirmed that a route planning result was achieved within 5 seconds in more than 90% of the cases.

9.3.3. **Compatibility**

The TUKMobile application has been created for experimental purposes in order to verify that it is feasible to develop such an intermodal route planning application for use with today's generally available mobile phones of average capacities that takes the timetables of more than one mode of public transportation into account *simultaneously and offline*, including the use of bicycle in between stops. Main objective has been to develop a suitable, complex routing algorithm. This task needed to be implemented so as to ensure a small database tuned for the technical potentials of mobile phones, as well as fast operation in spite of the significantly weaker computing performance of mobile devices in comparison with the servers. The TUK application has well responded to these expectations, thereby proving that it is indeed feasible, and has been implemented. The program’s key strengths are:

- Reception of the GTFS databases for MÁV, BKK and Danube ferries, automatic structuring of the combined database.
- Support for the GTFS import format
- Web services-based updating function operating via the Internet
- Small, compressed database
- Offline route planning with the use of the local database
- Well-arranged user interface
- Differently optimized interfaces for mobile phones and tablets, as well as horizontal and vertical displays
- Battery-sparing management of GPS and network location identification, possible use of Google Play Location API
- Listing of stations situated in the surroundings of the user, planning from a selected starting point to a selected destination.
- Compass management and continuous navigation by displaying directional and distance data
- Time- and distance-based estimation of service availability
- Automated generation of transfer matrices, consideration of optional bicycle use
- Map-based definition options for transfer prohibitions
- Updating option of the GTFS databases
- Filtering for services where bicycles can be transported
- Support for multilingual display
- Support for all screens over 800x480 resolution
- Support for Android 4.2, 4.3, 4.4 (also works on most of the earlier, 4.0 and 1.4 operating system tools)

9.3.4. **Scalability**

TUK Mobile program can be run on any Android-based device that meets the following basic requirements:
- Minimum Android 2.4 operating system
- Display of 800x480, 1280x720, or 1920x1200 resolution
- Minimum 1 GHz processor
- Minimum 1 GB memory
- Minimum 20 MB free background storage space
- Google Play support
- GPS receiver, digital compass
- Internet access during installation and updating

The program may be operated on different hardware (Android 4.0, 1.4 operating systems, resolutions other than those specified, lower processor speed or smaller memory size), but it is not guaranteed.
9.4. Cost Evaluation

9.4.1. Constraints & Assumptions

As the pilot’s impact area is highly limited, thus the following assumptions have to be made for impact assessment:

- Impact assessment pertains to the time (year) when the scope of application is brought to a national level.
- For the expansion of the scope of application to a national level, it is necessary to make the related gtfs data continuously available, with regular updates. It can be achieved only with the cooperation of several organizations, such as at least MÁV, VOLÁN, BKK, and KKK.
- Geographical information is to be updated consistently and regularly, whereas objects that are impassable for cyclists (e.g. lakes, rivers, etc.) have to be managed on separate shapes.

An operating person/organization needs to provide for data input for information lacking gtfs (e.g. ferry schedules, routes), the establishment of data consistency and correction of errors, though full automation is not yet possible. The associated costs still cannot be listed among the costs of upkeep.

9.4.2. Project Budget & Estimated Development Costs

- Project budget: 200 140 EUR (Gross amount) during two years project length;
- Development cost: 33 200 EUR (Gross amount);

Assumed further development cost: 10 000 EUR (Gross amount) – not part of the project.

9.4.3. Estimated Operations & Maintenance Costs

Monthly work hours needed:

- database download - 1 h
- editing database - 4 h
- database testing - 1 h
- database upload - 0,5 h
- answering forum questions - 2,5 h
- operating a helpdesk - 3 h
- SUM: 12 h/month

Estimated operation costs (monthly): 110 EUR\(^1\)

\(^1\) Base on avg. salary of one engineer: 1700 EUR
Yearly costs: 1320 EUR
Five years maintenance: 6600 EUR
9.5. Institutional Impacts Evaluation

9.5.1. Impacts to Operations and Maintenance Procedures and Policies

The HTA (in the first year of operation, with the support of the developer) has undertaken to upkeep the application with the assistance of its IT team that proved to be competent in earlier similar projects and pilots, under a uniformly regulated order of procedures and policies. The pilot has no significant effects on the ‘Operation and Maintenance Procedures and Policies’.

9.5.2. Impacts to Staffing/Skill Levels and Training

The organizations involved will rely on the experience from the pilot, for example in the field of updating and developing bicycle registers, or positioning the planned intermodal route planner.

9.5.3. Impacts to the Competitive Environment

The pilot would have a significant impact on environmental factors only if it is brought to a national level in terms of expanse and wide-spread use.

9.5.4. Impacts to Local Planning Processes, Policy Development, and the Mainstreaming of ITS

The pilot does not significantly affect local planning processes.
9.6. **Transportation System Impacts Evaluation**

9.6.1. *Impacts on traffic efficiency and traffic management*

- **Input format**

For the purpose of TUK, HTA has determined GTFS as the input format, which is a Google-defined transport format created for Google Maps uploads. In Hungary, however, databases made in this format at appropriate standards are provided only by Budapest public transport services (BKK). The flaws of the railway (MÁV) and ferry databases strongly deteriorate the quality of routing results. For efficient operation, the TUK program converts databases into its own format and therefore with the modification of the conversion algorithms other optional input formats would become supportable. It would be reasonable to rely on the native formats used by the public transport companies as input formats. As a result, the conversion errors that are currently produced in generating GTFSs would be fully eliminated from the strings, and the reliability of the database and also the traffic efficiency would be substantially enhanced.

- **Transfer matrix**

For transfers in between the various services and stations, the TUK programs currently automatically generate transfer matrices that are mostly based on the distances between the individual stations. Nevertheless, in the absence of appropriate fundamental data is cannot base examined whether the calculated transfer time in between two locations is realistic. It is possible that the distance between two stations located 3 km away from each other can be quickly covered along well-constructed, high-quality bicycle road, or alternatively there may be a hill between the two points, which takes considerable time and energy to cross. In order to achieve proper operating results, the database should be reviewed and set manually to reflect more realistic transfer times for the traffic management also.

9.6.2. *Impacts to Mode Shifting and Intermodalism*

- **Circle of users**

On the basis of the decision of HTA as the client, TUK’s sole purpose is to serve the public transport demands of cyclists. When it is considered, however, that bicycles can be transported only on a few lines of public transportation in Budapest, while it is similarly unfeasible in a substantial proportion of MÁV trains, it drastically narrows down the circle of potential users. Such a version would be considerably more popular that considers the needs of pedestrians, and allows the use of all the public transport services.
In addition to trains, the long-distance public transport network in Hungary strongly relies on the use of coaches. TUK has not been designed to handle the timetables of Volán coach companies, because almost all of them prohibits bicycle transportation. Nevertheless, with minimum program development it would technically become able to handle coach timetables, while users rightly expect from an intermodal route planning device to take all the potential public transport modes into account.

- List of stops

Partly due to absence of Volán timetables, there are plenty of settlements not included in the list of stops, because they are not accessible by trains/BKK services/ferries that allow the carriage of bicycles. Therefore, the program could be materially improved with its extension to pedestrian traffic and the involvement of coach timetables. On the other hand, with minor changes the TUK program could be made capable of handling notable locations and sites, and consequently typical tourist destinations and popular excursion sites could be added to the database.

9.6.3. \textit{Impacts on the environment and fuel consumption}

With the implementation of the above extensions and developments, as well as the broadening of the scope of users such a form of application could be introduced whose wide scale spread would potentially result in a shift of characteristic transportation modes towards cycling. However, the pilot is still not suitable to achieve this effect.

Any small-scale or local modal shift towards cycling or other environmentally sparing modes of traveling could have a considerable effect on the decrease of fuel consumption and environmentally harmful emissions.

9.6.4. \textit{Impacts to Traffic Safety and Accident Reduction}

No impact.
As mentioned before, with the implementation of the above extensions and developments, resulting any small-scale or local modal shift towards cycling or other environmentally sparing modes of traveling could have a considerable effect on the traffic safety and accident reduction also.

9.6.5. \textit{Impacts on driving behaviour}

No impact.

9.6.6. \textit{Drivers/Users acceptance/perceptions}

No impact.

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10. ANNEX I

Quadratic Programming Model in AMPL for the sensors’ location problem

#################################################
#
# Sensor Location Problem     ##
# The model takes into account the distances   ##
# between intersections and their Neighbourhood  ##
#                                              ##
#                                              ##
#                                              ##
#                                              ##
#                                              ##
#                                              ##
#                                              ##
#                                            #
#                                            #
#                                            #
#################################################
#
set INTER;# the set of intersections

#Parameters

param h{INTER} >=0;
param Q;# MAximum number of detector to be located at intersections
param neig{INTER,INTER} >=0;
param dist{INTER,INTER} >=0;
param y{INTER} >=0;

#Variables

var x{INTER} binary;# is equal to 1 if a sensor is located at intersection i

#Objective function express the maximization of monitored traffic

maximize total_traffic_distance: sum{i in INTER}h[i]*x[i];

#constrains

subject to limitations_of_number_of_intersection : sum{i in INTER}x[i]<=Q;
subject to neighbor : sum{i in INTER}x[i]*sum{j in INTER} x[j]*neig[i,j]<=0;
subject to existing:sum{i in INTER}x[i]*y[i] >=10;
11. ANNEX II

Users’ assessment and acceptance questionnaire survey for the demo system of Thessaloniki

This report presents the SEE-ITS Thessaloniki pilot users’ assessment and acceptance questionnaire survey that has been conducted by the Hellenic Institute of Transport in order to assess the usefulness of the Advanced Travellers’ Information System that has been installed in Thessaloniki in the framework of the pilot activities of the SEE-ITS project.

The present report is organized as follows: After the present introductory part, the second part presents a detailed description of the survey that has taken place, its scope, methodology, the questionnaire that has been used in the survey and the execution procedure. In the third part of the report the results of the survey are being analysed and on the last one the results are being discussed and some useful conclusions are being extracted.
11.1. Survey's scope and methodology

Advanced Travellers Information Systems (ATIS) can have an important role in the overall traffic strategy and management, contributing to the accomplishment of the goals for cleaner, safer and more efficient transport system. In ATIS, where effectiveness strongly depends on how the final user assesses, accepts and acts according to the information provided, the identification of these three behavioural parameters is of great importance. Therefore an integrated evaluation approach of the performance and of the impact of an ATIS demands the verification of how the network user adapts his traffic-related behaviour according to the information provided. This adaptation is important for the assessment of the overall traffic impact since traveller information systems act on the individual user while his decision and action affects the whole transportation system.

The execution of the present survey serves the scope of this identification in order to evaluate the impact of the services, which have been developed in the framework of the pilot activities of the SEE-ITS project from the users’ perspective. In terms of the users’ assessment, it is examined if users consider the services’ provision useful and the information provided reliable. In terms of users’ acceptance, it is examined if the users take into account the information provided and in terms of the users’ action it is examined if they adapt their route and if they change their traffic-related behaviour in general.

The survey is an important step of the overall ITS evaluation process since it provides the necessary indicators for the wide scale assessment of the performance of the implemented system, the identification of the user’s acceptance and the recording of the potential impact of a system that will be implemented.

More specifically, the main objectives of the study were the following:
1. To evaluate the necessity of a real travel time information service.
2. To understand the drivers’ perspective, reactions and behaviour towards the pilot services.
3. To evaluate the reliability of the information provided through VMS and the SEE-ITS online service and their capability of influencing driver behaviour.
4. To determine the drivers’ opinion on the type of information they prefer to be provided.
5. To determine the utilization frequency and profile of the VMS service by the drivers.
6. To determine the weaknesses of the real time information services provided.
7. To evaluate the utilization perspectives of the SEE-ITS service.
8. To determine the degree the SEE-ITS online service is capable of influencing travel route choice.

To examine the possibility of developing a mobile application providing real travel time information.
The survey has been based on a questionnaire that has been designed by researchers of the Hellenic Institute of Transport especially for this survey.
11.2. Survey’s sample (location and time)

The survey took place on typical days (21, 22, 23 & 26/05/2014), during morning hours and in locations in proximity to the Variable Message Signs that exist in the Thessaloniki Urban Area (figure 1) so as to ensure that the respondents would be familiar and would recognize the system that they were asked to evaluate. Questionnaires were equally distributed to the 5 locations of the survey.

![Figure 72: Survey’s locations](image)

People who would take part in the survey should be in possession of, at least, a European category B driver’s license, due to the fact that the presented technologies are addressing drivers’ needs. Therefore, the survey participants were male or female drivers, walking in the vicinity of the Variable Message Signs and older than 18 years old.

For the successful conduct of the survey a total of 600 drivers responding to the questionnaire have been considered necessary.
11.3. Questionnaire

The main objective of the questionnaire design was to ensure the suitability of the questions in terms of meeting the targets of the study. The questionnaire comprises of two parts:

Part A: Evaluation information travel times in real time:
Includes questions regarding the necessity of the VMS and SEE-ITS online service, the drivers’ behaviour and reactions towards both services and the drivers’ opinion on the quality of the information provided. The second target is to evaluate the response of the drivers to the information provided through the SEE-ITS online service. Participants are provided with a map presenting the traffic state of the network and a travel scenario. Then, drivers are asked about their response towards the image. Drivers are also asked about the degree the information of the service would influence their travel. Finally there is a question regarding their willingness to pay for a mobile online application providing the same information with the internet service.

Part B: Participant’s Profile – Mobility Profile

This part includes questions regarding personal information of each participant and information regarding his/her everyday mobility. Participants are asked about the factors influencing their travel route choice and afterwards about personal information (age, gender, residence area, educational level, level of car dependency, familiarization rate with internet and smartphone technologies and monthly family income).

The questionnaire comprises of 23 questions and is included in Annex I. Its length is relatively short taking into account that participants are also presented with a small travel scenario, where more time was necessary for the participants to familiarize and understand the image and respond accordingly. Also participants were pedestrians that were stopped along the street; hence the questionnaire had to be short in order to avoid possible participants’ frustration and the possibility of participants dropping out before the end of the interview.

The following criteria were taken into account during the formulation of the questions:
1. Choices should be realistic for the participants
2. Choices should be related to their current experience
3. The exercise should be small and comprehensive

The survey would gather information about the user acceptance of two ITS services, the VMS and the SEE-ITS online service. Variable Message Signs are found in key positions of the city’s road network and their operation is well known to the commuting drivers. On the other hand the SEE-ITS online service is not well known to the public. Therefore questions regarding the VMS operation mainly focused on evaluating the reliability and accuracy of the real travel time information and the capability of the information provided to influence driver behaviour. On the other hand, questions regarding the SEE-ITS service mainly focused on
assessing the service’s future potentials and its comprehensiveness by the users, since participants were not expected to be familiar with the existence of the service. In order to evaluate the comprehensiveness of the information and of the means they are provided to the end user, a small exercise had to be designed with a fictional travel scenario. The travel scenario provided is a common, realistic trip through the urban area with a commonly known origin and destination.
11.4. Personnel recruitment, briefing and training on the survey conduct methodology

Five persons have been employed for the needs of the survey. They were all highly skilled interviewers, having taken part in other transportation surveys, origin – destination, roadside or stated preference surveys.

The interviewers have been trained by an experienced Transportation Engineer and the specific instructions that they received are presented below.

- Interviewers will approach pedestrians in the vicinity of the Variable Message Signs asking him/her in a polite manner if he/she is a driver.
- In case of a negative reply, the interviewer will politely explain to him/her the reason he/she is not able to take part in the survey and will continue his/her search of a new pedestrian.
- In case of a positive response the interviewer will ask him/her if he/she is willing to take part in the survey.
- Interviewers will read out the questions for the participants in order to help them go through the questionnaire more quickly. However, interviewers will not in any way influence the participants’ replies.
- Special attention must be paid in question 13 where interviewers will need to explain to the participants of the survey the information that is provided in the picture.
11.5. **Statistical Analysis**

In general, the processing and analysis of information collected by surveys, inventories, measurements, etc. aims at the systematic recording and investigation of all the information so that an insight can be gained in the existing situation and the characteristics of the surveyed topic can be evaluated. For this reason following the completion of the interviews, data was stored and processed in excel spreadsheets. Individual interviews were given a code number and the answers were stored in lists. The registration system that was formed was common for all questions so that the structure and content could be easily understood and accessible for any subsequent utilization.

A basic prerequisite for the analysis of data that were recorded, is the control for the correctness of the data, so that the most reliable sample for processing/analysis purposes is provided in order to reach reliable conclusions. The following steps were followed:

1. Completeness check of each type of collected information that was critical in one or more computational procedures in order to reach conclusions.
2. Use of a universal coding and registration system to ensure the possibility of bundled and systematic processing where necessary.
3. Control of logical correlation between different elements in order to identify and correct errors in registration.

The final sample used for the statistical analysis of the results comprises of 600 questionnaires. Due to the nature of the interviews all questionnaires were answered completely, meaning that there were no participants dropping out of the interview. Interdependencies among questions that led to false and contradictory entries were identified during the process of analysing the results and these answers were omitted from the survey.

Specifically:

1. In Part A, participants stating in the 5th question that they do not drive through VMS mounted positions, were, by default, omitted from questions 6 to 11.
2. In Part A, participants stating in question 6 that they do not observe the VMS information were, by default, omitted from questions 7 to 11.
3. In Part A, participants stating in question 7 that they do not compare travel time information that is provided in the VMS with the actual travel time were, by default, omitted from questions 8 to 9.
4. In Part A, participants not answering question 10 were assigned, by default, to the N/A choice in question 11.
5. In Part A, participants answering negatively in question 10 were given the choice to answer either negatively or “I do not change my route” in question 11.
6. In Part A, participants answering negatively or not answering question 13, were assumed not to be interested in the online service and therefore were excluded from answering questions 14 and 15.
7. In the 1st question of Part B, some drivers mentioned their own important factors. Due to the diversity of responses, they were omitted from analysis.

8. In the 4th question of Part B, drivers were asked about their residential area. False or vague answers were omitted. Participants that answered with a major street name were assigned to the municipality, to which the greater part of the street belonged to. Such answers however were few with no significant statistical influence. Participants answering with the name of the urban district or road they resided and that was shared by two municipalities or municipal communities were distributed to the municipalities or municipal communities according to the population size of each municipality/municipal community.

9. Questions of individual interviews that were left blank due to interdependencies with previous questions were omitted from the analysis of answers of the particular question.

10. Questions that were found to be unanswered in an interview due to the interviewers’ fault were omitted during the analysis of the answers of the specific question.

The next tables present the number of valid answers to each question asked

<table>
<thead>
<tr>
<th>Table 31: Sum of valid answers in part A of the questionnaire</th>
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</thead>
<tbody>
<tr>
<td><strong>Part A</strong></td>
</tr>
<tr>
<td><strong>Question</strong></td>
</tr>
<tr>
<td>Valid Answers</td>
</tr>
<tr>
<td><strong>Question</strong></td>
</tr>
<tr>
<td>Valid Answers</td>
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</tbody>
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<table>
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<tr>
<th>Table 32: Sum of valid answers in Part B of the questionnaire</th>
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</thead>
<tbody>
<tr>
<td><strong>Part B</strong></td>
</tr>
<tr>
<td><strong>Question</strong></td>
</tr>
<tr>
<td>Valid Answers</td>
</tr>
</tbody>
</table>

The large majority of the questionnaires was answered completely. Most blank answers exist due to the interdependencies that were defined among the questions. In the next pages the results of the survey are presented and analysed, following the structure of the questionnaire, for all 600 drivers that took part in the survey.

11.5.1. Part A of the Questionnaire

In the question concerning the usefulness of the real-time travel time information service, 89% of drivers find the provision of such a service either fairly or very useful (Figure 73). Such results depict that users consider such a service as useful and needed for their commute.
Analysis of the results concerning the reliability of the VMS information that is provided, indicate that 74% of drivers consider the service as reliable, whereas a smaller but equally important 63% of the drivers questioned admit that the information the service provides, is influencing their route choice to their destination. However, a quarter of them would not change their route choice. In the case of the reliability of the SEE-ITS internet platform, answers are split between users judging the online platform as reliable (43%) and users not answering the question (40%). This indicates that users are unaware of the service’s
existence or that they are not using it. The results are similar in the case of the SEE-ITS capability of influencing their route choice. Overall, the percentage of users assessing the services as unreliable is small in both cases, however when users are questioned about the services’ ability to influence route choice the negative responses rise for more than 10% in both cases. This rise shows that, although users find both services reliable, some of them would hesitate to make use of the information provided by the services.

In the 3rd question, drivers were asked to state whether traffic conditions information is more useful than travel time information. Responses were split mainly between “Equally Useful” (37%) and “No” (35%). Results suggest that drivers wish both information to be provided to them, while travel time information is viewed as more important than the traffic conditions information. This is expected since travel time information is quantified, thus carrying a more direct and clear meaning for drivers, especially those familiar with the road network. At the same time, information concerning the traffic condition of the network carries a more important meaning for drivers that are not familiar with the network.

The next figure presents the willingness of the drivers to alter their route choice in response to a differentiation of the estimated travel time. 62% of all drivers would change their route if the difference in travel time is higher than 10 minutes, whereas, 31% would change their route if the travel time difference is between 5 and 10 minutes. At the same time only 6% of all drivers consider 1 to 5 minutes of differentiation able to influence their route choice. Results were expected. The higher the travel time difference, the more drivers are willing to alter their route. At the same time, time differentiations higher than 5 minutes are capable of influencing a significant numbers of drivers.

Figure 75: Is traffic conditions information more useful that travel time information?
In the 5th question drivers were asked how often they pass from the VMS locations. Results are presented in figure 6. 43.1% of the drivers state that they pass from a VMS location at least once a day while 40.2% of the drivers drive from a VMS location 2-3 times in a week.

The next figure presents how frequently drivers observe the information provided by the Variable Message Signs. 61% of drivers observe the information each time they drive through. However, 30% of all drivers observe the information only circumstantially. Only 6% observe the Variable Message Sign rarely while 3% make no observation at all. Findings
suggest that most drivers are aware of the information when they drive through a variable message sign position.

![Frequency of VMS information observation](image)

**Figure 78:** Frequency of VMS information observation

Figure 79 presents the results of the 7th question of part A of the survey, where drivers were asked how often travel times provided by the Variable Message Signs is being confirmed. 44% of drivers answered that predicted travel times are being confirmed on frequent basis. 16% of drivers answered that travel times are being confirmed at more than 90% of all cases. An important 28% answered that they never check if the predicted travel time was the same as their actual travel time, thus not being able to judge if the information provided was helpful for their journey. This result might be related to the fact that the time they spent on this route is small in comparison to their cumulative travel time. Another theory might suggest that this particular route was not the last part of their travel, thus they forget the travel time actually spent or they are not able to compare the travel time due to the fact that they were preoccupied with driving. Finally the assumption can be made that there have been no important differentiations in travel times on the basis that, if there have ever been any significant differentiations, drivers would have noticed them. Taking into account only the drivers comparing the predicted travel time to the real travel time, 61% confirmed the predicted travel time on a frequent basis, whereas 23% confirmed the predicted travel time in more 90% of cases. According to these results, the provided information seems to be accurate in most cases, however there is still space for further improvement.
The next Figure presents, in cases of time differentiations, actual traffic conditions as experienced by drivers. Results show that 53% of drivers experienced congestion in cases of travel time differentiation. 21% of drivers do not recall the traffic conditions on such occasions. 18% of drivers recall normal traffic conditions in cases of time differentiation, whereas only 8% recall sparse traffic. It is clear that the quality of the travel time information improves as traffic conditions improve.

In the 9th question, drivers were asked if time predicted was more than actual travel time. More than half of the drivers (55%) answered that the predicted travel time was more than the actual travel time. The rest of the drivers either did not remember (23%) or experienced
less travel time than the one predicted (22%). Findings suggest that in most cases travel time prediction tends to be less than normal. This increases driver frustration since drivers are presented with an optimistic forecast about their travel which afterwards turns out to be incorrect, and has the potential to affect negatively their behaviour towards the provided service in the future.

![Figure 81: Travel time prediction accuracy](image)

For the 10th question, drivers were asked if they would alter their travel route in response to the information provided by the Variable Message Sign. 54% of drivers answered positively, whereas 38% negatively. Results show that a very important percentage of all drivers chooses to ignore the information provided by the Variable Message Sign. Both results are different from the answers to the 2nd question where drivers were asked if the information presented by the VMS is capable of influencing their route choice. Comparing the 2 questions’ results, it is obvious that drivers recognize the potential of the information to affect the route choice in general, however when it comes to their personal travel route choice, the information is not able to have the same effect.

![Figure 82: Route choice in response to VMS information](image)
Drivers were also asked how their trip is affected when they alter their trip in response to the information provided (question 11). The question had two separate parts, the first regarding traffic congestion avoidance and the second regarding travel time reduction due to the utilization of the service. 49% of drivers answered that they avoid congestion, while 42% of them responded that their travel time is reduced. At the same time only 2% of drivers answered that they did not avoid congestion while 6% that their travel time was not reduced. 37% of drivers do not alter their route in the case of the congestion avoidance question while 38% of them do not change their route in the case of the travel time reduction. This insignificant difference might reside in the fact that two drivers did not understand the first question properly, hence answering negatively rather than stating that they do not alter their route choice. This statement is supported by the fact that negative answers from the 10th question match with the responses in the 11th question. Moreover drivers choosing not to answer the 10th question were classified to the N/A choice by default. Thus, in the case of congestion avoidance only 5% from the 12% are unaware if their choice was correct, whereas 7% from the 15% are unaware if their travel time was reduced. Results suggest that the information provided helps drivers to avoid congestion more than to reduce their travel time.

![Figure 83: Effects of trip adjustment](image)

In question 12 drivers were asked if they are willing to use the online service [www.greece.seits.eu](http://www.greece.seits.eu) before they start their trip in order to plan their route. 72% of drivers answered positively whereas 21% negatively and 7% gave no answer. The majority of the drivers states here that is willing to use the online service and compared to the results of the
2nd question, where only 40% judged the service as reliable, results suggest that drivers were unaware of its existence. Thus the assumption can be made that by informing the public of the service's existence and capabilities, the utilization of the service might increase, taking also into account that people taking part in a survey are usually enthusiastic at first about a new service or product that might interest them but when it comes to actually using it the interest is not that high.

![Figure 84: Willingness to use the online service for route planning](image)

In the 13th question, drivers were given a picture presenting traffic conditions in the city road network. Then they were given a travel scenario where they would begin their trip from the intersection of Karamanli Str. and Boulgari Str. and drive to the Regional Bus Terminal Station of Thessaloniki. The following map presents the origin and destination of the travel scenario.
Participants were asked if they would take into account for their trip planning the information presented in the map. 74% of drivers answered positively, while 13% negatively and 13% gave no answer. Here it has to be noted that this decision is only based on the presented traffic information. The online service that has been developed also provides real-time travel times per link, an element which was not presented to the people taking part in the survey, and which might have increased the amount of positive answers.

**Figure 85:** Origin-Destination of the travel scenario that was presented to the survey participants

**Figure 86:** Trip adaptation due to the presented traffic conditions information
The following figure (Figure 87) presents the results of the drivers’ answers when they were asked to what extent they would adapt their initial trip. Participants that answered negatively or did not answer to the previous question were excluded from this question. Therefore 435 out of the 600 drivers answered this question. 62% of them would alter their route to only avoid congested areas, 25% would change their initial route, 8% would change their departure time, 4% would choose a different transport mode and finally 1% would not change their route of choice. It is obvious from the results that the online service has the capability to influence the route choice and redistribute car traffic in a more efficient way in the network. However the service shows a weak ability to shift drivers from private cars to public buses. This situation might have to do with the fact that users of the online service are only presented with the car traffic conditions and travel times even if major roads of the network in the city centre have lanes dedicated to public transport, which are offering lower travel times.

![Route adaptation](image)

**Figure 87: Route adaptation**

In question 15 respondents that answered positively in question 13 were asked if they would be willing to pay for a mobile application capable of presenting them the same type of information as the online service. 61% are not willing to pay, 20% would pay less than 1€, 12% between 1€ to 3€, 6% between 3€ to 5€ and 1% would pay more than 5€. Results suggest that the development of a mobile application which will be offered to the users free of charge would have a higher penetration rate. However 39% of users would be willing to pay for such an application, which might suggest that a paid version of the application with extended features might be able to coexist with the free application on the market.
11.5.2. *Part B of the Questionnaire*

In the second part of the questionnaire drivers were asked information concerning their route choice and other demographic/general information.

In the 1st question of the second part drivers were asked to rank the most important factors influencing their route of choice. Results are presented in the graph below (Figure 89). The fastest route has the highest rating among most drivers followed by the shortest route. The most safe route is ranked third. Higher speed is in the fourth place, followed by route reliability (5th) and finally necessary intermediate stops influence route choice the least. Moreover, analysis of the standard deviations for each rating shows that the first three highest ranked alternatives gather inside the same range of values. Hence, results might suggest a trend towards travel time reduction and safety, but they are not definitive due the high values of the standard deviation.
The next diagram presents the age profile of the drivers that took part in the survey. Most drivers (32%) gather in the age range of 36-45 years. 24% of drivers are aged between 26 and 35 years, 22% are between 46 and 55 years, 12% are between 18 and 25 years, 7% between 56 and 65% and finally only 2% are older than 65 years.
The following diagram presents the gender distribution among the drivers questioned. 69% of them are male whereas 31% of them are female.

**Figure 91**: Gender distribution

Drivers were asked to fill in their residence area in the 4th question of the questionnaire. Responses varied greatly in terms of accuracy. Most drivers responded with the name of the district they reside. Some drivers gave vague responses such as filling in the name of a major street as their residence name which at some occasions belonged to different municipalities. However, the number of this type of responses was very low and they were assigned to the municipality that possessed the longest part of the street. In another case 3 drivers answered that they reside in ILIOUPOLI an urban district that is split between the municipalities PAVLOS MELAS and KORDELIO-EVOSMOS. Both municipalities have the same size, therefore 1 driver was assigned to KORDELIO-EVOSMOS the rest to PAVLOS MELAS. Also, there were 11 drivers that gave no answer and 2 drivers that gave completely vague or false responses. Answers were classified according to the municipality they belong to after the Kallikratis Reform. It was decided that the municipality of Thessaloniki should be divided into the formal municipal communities for a more efficient and correct statistical analysis. During the adaptation of this decision new problems arose due to the inaccurate responses of participants. Specifically, 8 drivers answered that they reside in AGIOU DIMITRIOU Str. which happens to be administrative border between the 1st and 3rd municipal community. Another 11 drivers responded that they reside in the area of IPPOKRATIO, which is actually the name of the hospital in that area and lies on the administrative border between the 4th and the 5th municipal community. In both cases, drivers were distributed proportionally according to the size of the population residing in each municipal community according to the results of the 2011 census. Results show that 56% of the drivers reside in the municipality of Thessaloniki. 88% of the drivers reside inside the formally defined Thessaloniki Urban Area, while 10% of the drivers comes from surrounding municipalities and 2% of drivers gave no
response. Most participants of the municipality of Thessaloniki reside in the east part of the city.
Figure 92: Municipal communities of the Municipality of Thessaloniki

Table 33: Residence of Participants

<table>
<thead>
<tr>
<th>RESIDENCE</th>
<th>PARTICIPANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th Municipal Community of Thessaloniki</td>
<td>191</td>
</tr>
<tr>
<td>4th Municipal Community of Thessaloniki</td>
<td>85</td>
</tr>
<tr>
<td>Kalamaria</td>
<td>60</td>
</tr>
<tr>
<td>Korodelio-Evosmos</td>
<td>46</td>
</tr>
<tr>
<td>1st Municipal Community of Thessaloniki</td>
<td>33</td>
</tr>
<tr>
<td>Pylaia Chortiatis</td>
<td>26</td>
</tr>
<tr>
<td>Neapoli-Sykies</td>
<td>25</td>
</tr>
<tr>
<td>Pavlos Melas</td>
<td>23</td>
</tr>
<tr>
<td>Outside of Thessaloniki</td>
<td>18</td>
</tr>
<tr>
<td>Ampelokipoi-Menemeni</td>
<td>15</td>
</tr>
<tr>
<td>Thermi</td>
<td>15</td>
</tr>
<tr>
<td>6th Municipal Community of Thessaloniki</td>
<td>13</td>
</tr>
<tr>
<td>Oraiokastro</td>
<td>12</td>
</tr>
<tr>
<td>N/A</td>
<td>11</td>
</tr>
<tr>
<td>3rd Municipal Community of Thessaloniki</td>
<td>6</td>
</tr>
<tr>
<td>2nd Municipal Community of Thessaloniki</td>
<td>5</td>
</tr>
<tr>
<td>Thermaikos</td>
<td>5</td>
</tr>
<tr>
<td>Chalkidona</td>
<td>4</td>
</tr>
</tbody>
</table>
The next diagram presents the level of education among the sample of drivers. 2% have only finished primary school, 36% of drivers have finished secondary school or high school, 31% have a university degree and 9% have completed postgraduate studies.
The next diagram presents the car dependency degree of the drivers in the sample. 28% of all drivers are very dependent on the car for their everyday mobility. 47% are fairly dependent, while 19% answered that they are depending a little on the car for their mobility. Finally, only 6% is completely independent from the car.
Drivers were asked about their familiarization with the internet and smartphones. Results are listed on the diagram below. Overall, drivers have a higher familiarization degree with the Internet compared to the smartphones which peak at 34% of drivers suggesting that they are mediocrely familiar with this technology. Overall, more than 78% of drivers have a higher than medium familiarization with the Internet, whereas the same percentage for smartphones is 63%. This difference in results is expected since the Internet is an older technology than smartphones which are being widely used only in the last years.

![Familiarization Grade of Drivers with the Internet and Smartphones](image)

**Figure 96:** Familiarization grade of drivers with the internet and smartphones

The last diagram presents the income distribution among the drivers. 43% of drivers have an income between 1000€ and 2000€, 28% of them have an income of less than 1000€. 19% of drivers earn between 2000€ and 3000€, 6% earns between 3000€ and 5000€ per month and finally 4% earns more than 5000€ per month.
11.5.3. Data Correlation

Further useful conclusions can derive from the correlation between different results and statements. The first diagram correlates the commute frequency through the VMS positions with the utility of travel time information in real time. Results suggest that the more frequent drivers commute the greater the need is for such a service, which in turn shows that the service is, indeed, necessary for the drivers.
The next diagram presents the connection between the commuting frequency through VMS positions and the reliability of the VMS as viewed by the drivers. It is concluded that the higher the commute frequency the more reliable the service is considered. Negative answers remain low; however, the number of users that did not answer rises proportionally in the category of rare commute. Most participants are frequent or occasional commuters. Therefore most drivers assess the service as reliable for their commute.

**Figure 99:** Correlation between questions 5 (Part A) and 2a (Part A)
In the next diagram the relationship between commute frequency through VMS positions and the service’s capability for route change is examined. Overall, drivers that drive through the VMS positions frequently also suggest that the service can influence route choice. This is very important, since this category of drivers is decisive for the success of the service.

**Figure 100: Correlation between questions 5 (Part A) and 2b (Part A)**

In the next diagram the connection between the frequency of commutes through the VMS positions and the information observation frequency is presented.
Figure 101: Correlation between questions 5 (Part A) and 6 (Part A)

Obviously, the higher the commute frequency, the more consistently the drivers observe the information. Overall, observation rates are very high at all occasions meaning that all drivers get informed about the predicted travel times.

The next diagram shows the relationship between observation frequency and information type that should be broadcasted. Generally users are split between finding both information equally useful and finding real time information more useful than traffic state information when it comes to higher observation frequencies. Only in the category of consistent observation, negative responses outweigh the “equally useful” responses, but only by a fraction. Moreover most users concentrate in the consistent observation category. Therefore a simultaneous broadcast of both information types will increase user satisfaction and might lead to a small increase in observation frequency.
The following series of diagrams will present the relationship among car dependency and the responses to several questions, since the services that are being evaluated are addressing drivers’ needs. The first diagram presents the correlation between car dependency and the utility of real time information service. Results suggest that all kinds of drivers find the service fairly or very useful.
In the next diagram the relationship between the car dependent participants and the commute frequency through VMS positions is being evaluated. Results show that all car dependency user categories commute through VMS positions, with increasing frequency as car dependency rate increases. This means that VMS are correctly and efficiently located in the road network of the city.

The next diagram compares car dependency with VMS information observation rate. All car dependency categories show the same distribution of observation rate responses, with
consistent observation outweighing all other responses. Proportionally, a small rise of lower observation rates at lower car dependencies can be noticed. Obviously the familiarization rate of the driver with the service, which is connected with the car dependency has a slight impact at the observation frequency. This is also connected with the importance degree of the information to each driver category. High car dependency rates suggest that drivers are also commuting more frequently with their car which also leads to increased time losses. Subsequently, travel time information becomes more important.

![Correlation Between Questions 6 (Part B) and 6 (Part A)](image)

**Figure 106:** Correlation between questions 6 (Part B) and 6 (Part A)

The next diagram compares car dependency with the utilization prospects of the SEE-ITS online service. Answers have a similar distribution among the driver categories. Results suggest a possible increase of the service’s utilization rate if drivers are informed about the service’s existence. Again the proportion of negative responses slightly increases as car dependency decreases, which is expected, as car dependent users value time and commuting expenses more than car independent users and are more willing to use an online service in advance.
This is also the case in the next diagram, where the results of the case study are related to car dependency. Car dependent participants, who are the majority in the sample, seem to react and adjust their route choice to the traffic state presented compared to the not dependent car users.
The next diagram presents the relationship between car dependency and the degree of travel time differentiation that would influence route choice. Generally, all categories follow the same distribution of responses and results are expected. 5-10 minutes differentiation response generally increases proportionally to the over 10-minute response as car dependency increases. A similar trend is not depicted in the category of 1-5 minutes differentiation, which seems to be unimportant for the majority of drivers.

Figure 109: Correlation between questions 6 (Part B) and 4 (Part A)

The same situation is depicted in the next diagram, where the correlation between commute frequency through VMS positions and the degree of travel time differentiation that would influence route choice is presented. Drivers seem to be more sensitive to higher time differentiations in comparison to lower; especially as their commute frequency is increasing. To sum up, differentiation of more than 10 minutes will have a serious influence to all driver categories.
The following diagram evaluates car dependency with route change in response to VMS information. Generally, the higher the car dependency, the higher the number of users changing route. However, the difference with the negative response is not overwhelming suggesting that drivers are not influenced by the information at a great extent. By taking into account the previous diagram, this might have to do with the fact that, differences higher than 10 minutes are unlikely to occur in our network, except if a major traffic situation occurs. Moreover, certain VMS positions have no alternate routes to show.
The next diagram evaluates the correlation between observation frequency and confirmation of predicted travel time. Through this relationship it is possible to evaluate the accuracy of the service in a more realistic way by weighing more the responses of drivers with higher observation frequency. It is concluded that, the accuracy of the service lies in the area of 60-80%. There is also a significant proportion of responses suggesting that the service is an accuracy of more than 90% which rises significantly in the case of the highest observation frequency. Therefore, the assumption can be made that the service’s accuracy reaches 70-80%.

**Figure 111:** Correlation between questions 6 (Part B) and 10 (Part A)
Figure 112: Correlation between questions 6 (Part A) and 7 (Part A)

The next diagram compares the accuracy of the VMS service and travel route adjustment rate. Results are more or less expected. Drivers that evaluated the accuracy as low will also not adjust their route. This applies also for drivers that do not confirm the travel time information after their journey and shows that since they are unaware of the service’s effects they are also negatively disposed towards the service. Users answering that travel time is confirmed at more than 60% of cases are also changing their route in response to the travel time information. Results show that a prediction accuracy of more than 60% is necessary to influence the majority of the drivers.
Correlation Between Questions 7 (Part A) and 10 (Part A)

The next diagram shows the relationship of the traffic state and the travel time prediction accuracy. Results show that in case of congestion and normal traffic flow predictions suggest less travel time, while in case of sparse traffic slightly more people answered that the predicted travel time is longer. The diagram reveals that the service is displaying weaknesses in its operation mainly in the case of congestion and adverse traffic states while it generally predicts a lesser travel time than reality.
The following diagram compares the answers between the 2\textsuperscript{nd} question where participants were asked how they evaluate the ability of the SEE-ITS online service to influence route change with the 12\textsuperscript{th} question which referred to the participants willingness to use the online service for route planning. From the initial results of question 2, it was concluded that the majority of the participants were unaware of the existence and capabilities of the service. However, reaching question 12, participants were informed about the service. Therefore the comparison will investigate the prospective users that will be attracted if the online service was advertised to the drivers. Results show that 71\% of participants that did not answer question 2 are now willing to use the online service. Also, 50\% of participants answering that the SEE-ITS online is not capable for route change are now willing to use the service to plan their route. Although their number was rather low (17.5\%), the potential is easily recognizable. Subsequently it can be concluded that informing the drivers of the service and its capabilities is of major importance for the utilization rate of the service and the effects it will have to the mobility of drivers inside the city.

**Figure 114:** Correlation between questions 8 (Part A) and 9 (Part A)
Correlation Between Questions 12 (Part A) and 2b (Part A)

The next diagram presents the relationship between familiarization level with smartphones and the willingness to pay for a mobile application. Distribution of answers among different degrees of familiarization is almost the same. More than half of the participants are at least sufficiently familiar with smartphones. Percentages of participants willing to pay for an application rise as familiarization rate increases, however this increase is not sufficient to justify the development of a standalone paid mobile application. Further analysis may investigate the possibility of developing a paid application with extended features which will coexist with a free version of the same application with limited features, since the proportion of participants willing to pay is a rather significant 39%.
The next diagram analyses the correlation between monthly income and the willingness to pay for a mobile application. Results are expected, since the higher the monthly income, the higher the percentage of participants willing to pay for a mobile application. Nevertheless, no income group manages to overcome the number of users not willing to pay for an application. Generally, a paid application would have a higher penetration rate if it was to be offered at around 1€.

**Figure 116:** Correlation between questions 7 (Part A) and 15 (Part A)
Figure 117: Correlation between questions 8 (Part A) and 15 (Part A)
12. ANNEX III

Field Operational Tests in Patras

ITS can influence the behaviour of individual users, but are also able to contribute to better traffic management. The SEE-ITS platform has the goal of achieving a more efficient transport system. By improving discrete user’s patterns and by contributing to the effective traffic management, a number of parameters are affected; each of them participates with a different way to the overall goal achievement. More specifically, travel time, driver’s comfort, vehicle’s operation, fuel consumption and emissions, noise, safety and network’s efficiency are the influenced, by the systems parameters. The way and the rate of this influence are the determining factors of the overall benefits.

In order to identify these impacts, Field Operational Tests (FOTs) were performed in Patras and took place in two typical days and during morning and afternoon peak hours. Drivers, with the use of mobile devices to provide them with real-time travel information for the most important links of the road network, and non-eqipped drivers, were asked to drive from the same predefined Origins and to the same predefined Destinations (ODs). For each indicated OD, the first driver was informed about the real time traffic conditions using the SEE-ITS platform and the other was not. Therefore the non-informed driver followed a sequence of links so as to accomplish the targeted OD, according to his sense about traffic conditions. The informed, with the use of the application, had the ability to specify his route taking account the real time traffic conditions. The informed and the non-informed driver started from the same origin. Arriving at the destination, the roles were changed and the informed driver was converted to non-informed for the next OD and conversely for the other driver. Either the informed or the non-informed driver had to choose by themselves the path, without any route identification. After the accomplishment of each OD, the test participants had to complete a questionnaire in which they reported the route they followed, the distance they covered, and the travel time they achieved. Moreover, they had to answer in a number of questions that targeted to identify the parameters that influenced their route choice.

Drivers have been selected with the criterion of the well knowledge of the road network of Patras. Moreover, the routes have been selected in such a way, so as to cover the important links of Patras’ road network that accumulate the bulk of daily transport activities. In the predefined ODs, several driving environments (e.g. urban, motorway) and various types of roads were combined. The ODs selected contain a number of sub trips, for which travel times and traffic description are provided by the system. The informed users had a clear picture regarding the real time traffic condition. The non-informed drivers were based on their sense and knowledge regarding the traffic conditions that they had to anticipate. The test routes per OD, are presented in the table below:
Table 34: Routes of the test described per OD

<table>
<thead>
<tr>
<th>ID</th>
<th>Origin</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zaimi 2 (KTEL)</td>
<td>Kalavriton (Saint Andrew Hospital)</td>
</tr>
<tr>
<td>2</td>
<td>Kalavriton (Saint Andrew Hospital)</td>
<td>Akti Dimeon (New Port)</td>
</tr>
<tr>
<td>3</td>
<td>Akti Dimeon (New Port)</td>
<td>Ir. Politechniou (Railroad Station)</td>
</tr>
<tr>
<td>4</td>
<td>Ir. Politechniou</td>
<td>Agias Sofias (Nikis Square)</td>
</tr>
<tr>
<td>5</td>
<td>Agias Sofias (Nikis Square)</td>
<td>Panagioti Kanellopoulou</td>
</tr>
<tr>
<td>6</td>
<td>Intersection Venizelou &amp; G. Papandreou</td>
<td>Maizonos (City Hall)</td>
</tr>
<tr>
<td>7</td>
<td>Maizonos (City Hall)</td>
<td>Agias Sofias (Nikis Square)</td>
</tr>
<tr>
<td>8</td>
<td>Agias Sofias (Nikis Square)</td>
<td>National Road Patras-Athens (Archeological Museum)</td>
</tr>
<tr>
<td>9</td>
<td>National Road Patras-Athens (Archeological Museum)</td>
<td>Zaimi 2 (KTEL)</td>
</tr>
<tr>
<td>10</td>
<td>Zaimi 2 (KTEL)</td>
<td>Akti Dimeon (New Port)</td>
</tr>
</tbody>
</table>

The two drivers live in the city of Patras and are familiar with the road network. They are both men, the first one between 26-35 years old and the other one 46-55.

The questionnaire was divided into two parts. In the first part, the questions were about the participant’s profile and specifically age, genre, familiarization with technology and priority of the factors that affect the route’s choice. In the second part, the drivers answered about the roads and routes they selected in order to reach their destination.

The following Tables show the results from the field measurements. The chosen routes are analysed to the roads the two drivers, finally, used in order to move from the origin to destination point.

Table 35: Field measurements (1st day - 08/09/2014)

<table>
<thead>
<tr>
<th>1st driver (26-35 years old)</th>
<th>2nd driver (46-55 years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informed (KTEL-Hospital)</td>
<td>Non-informed (KTEL-Hospital)</td>
</tr>
<tr>
<td>Iroon Politechniou Gounari</td>
<td>Iroon Politechniou Gounari</td>
</tr>
<tr>
<td>Kalavriton (Hospital)</td>
<td>Kalavriton (Hospital)</td>
</tr>
<tr>
<td>Distance: 2.7 km Time: 11 min</td>
<td>Distance: 2.7 km Time: 12 min</td>
</tr>
<tr>
<td>Non-informed (Hospital-New Port)</td>
<td>Informed (Hospital-New Port)</td>
</tr>
<tr>
<td>Kalavriton</td>
<td>Kalavriton</td>
</tr>
<tr>
<td>G. Papandreou</td>
<td>G. Papandreou</td>
</tr>
<tr>
<td>El. Venizelou</td>
<td>El. Venizelou</td>
</tr>
<tr>
<td>Akti Dimeon</td>
<td>Akti Dimeon</td>
</tr>
<tr>
<td>Distance: 3.8 km Time: 7 min</td>
<td>Distance: 3.8 km Time: 7.5 min</td>
</tr>
</tbody>
</table>
### Table 36: Field measurements (2nd day - 09/09/2014)

<table>
<thead>
<tr>
<th>1st driver (26-35 years old)</th>
<th>2nd driver (46-55 years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informed (Venizelou &amp; Papandreou-City Hall)</td>
<td>Non-informed (Venizelou &amp; Papandreou-City Hall)</td>
</tr>
<tr>
<td>Kalavriton (Hospital)</td>
<td>Kalavriton</td>
</tr>
<tr>
<td>Gounari</td>
<td>Orivatikou</td>
</tr>
<tr>
<td>Korinthou</td>
<td>P.P. Germanou</td>
</tr>
<tr>
<td>Votsi</td>
<td>Charalambis-25th Martiou</td>
</tr>
<tr>
<td>Mezonos (City Hall)</td>
<td>Votsi</td>
</tr>
<tr>
<td>Mezonos (City Hall)</td>
<td>Mezonos (City Hall)</td>
</tr>
<tr>
<td>Distance: 1.9 km</td>
<td>Distance: 1.9 km</td>
</tr>
<tr>
<td>Time: 6.5 min</td>
<td>Time: 6 min</td>
</tr>
<tr>
<td>Non-informed (City Hall-Nikis Square)</td>
<td>Informed (City Hall-Nikis Square)</td>
</tr>
<tr>
<td>Mezonos</td>
<td>Mezonos</td>
</tr>
<tr>
<td>Gounari</td>
<td>Gounari</td>
</tr>
<tr>
<td>Korinthou</td>
<td>Korinthou</td>
</tr>
<tr>
<td>Kilkis</td>
<td>Kilkis</td>
</tr>
<tr>
<td>Ag. Sofias (Nikis Square)</td>
<td>Ag. Sofias (Nikis Square)</td>
</tr>
<tr>
<td>Distance: 1.9 km</td>
<td>Distance: 1.9 km</td>
</tr>
<tr>
<td>Time: 9.5 min</td>
<td>Time: 9 min</td>
</tr>
</tbody>
</table>
Deliverable D5.3: Evaluation and results of demonstration activities

<table>
<thead>
<tr>
<th>Informed (Nikis Square-Archaeological Museum)</th>
<th>Non-informed (Nikis Square-Archaeological Museum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag. Sofias</td>
<td>Ag. Sofias</td>
</tr>
<tr>
<td>Kilkis</td>
<td>Kilkis</td>
</tr>
<tr>
<td>Korinthou</td>
<td>Korinthou</td>
</tr>
<tr>
<td>Patron-Athinon</td>
<td>Patron-Athinon</td>
</tr>
<tr>
<td>Archaeological museum</td>
<td>Archaeological museum</td>
</tr>
<tr>
<td><strong>Distance:</strong> 1.6 km <strong>Time:</strong> 4.5 min</td>
<td><strong>Distance:</strong> 1.6 km <strong>Time:</strong> 5 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Informed (Archaeological Museum-KTEL)</th>
<th>Non-informed (Archaeological Museum-KTEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patron-Athinon</td>
<td>Patron-Athinon</td>
</tr>
<tr>
<td>Amerikis</td>
<td>Ag. Sofias</td>
</tr>
<tr>
<td>Ell. Stratiotou</td>
<td>Konstantinoupolio</td>
</tr>
<tr>
<td>Ag. Sofias</td>
<td>Mezonos</td>
</tr>
<tr>
<td>Athinon</td>
<td>Zaimi (KTEL)</td>
</tr>
<tr>
<td>Norman</td>
<td></td>
</tr>
<tr>
<td>Iroon Politechniou (KTEL)</td>
<td></td>
</tr>
<tr>
<td><strong>Distance:</strong> 2.5 km <strong>Time:</strong> 7.5 min</td>
<td><strong>Distance:</strong> 2.5 km <strong>Time:</strong> 7.5 min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Informed (KTEL-New Port)</th>
<th>Non-informed (KTEL-New Port)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iroon Politechniou</td>
<td>Iroon Politechniou</td>
</tr>
<tr>
<td>Akti Dimeon</td>
<td>Akti Dimeon</td>
</tr>
<tr>
<td>New Port Entrance</td>
<td>New Port Entrance</td>
</tr>
<tr>
<td><strong>Distance:</strong> 6 km <strong>Time:</strong> 7 min</td>
<td><strong>Distance:</strong> 6 km <strong>Time:</strong> 8 min</td>
</tr>
</tbody>
</table>

As resulted from the answers to the questions of the field measurements survey, both drivers in most of the cases chose the same routes to reach their destination, either been informed or not.

In the city of Patras there are no alternative choices and as the two participants give priority to fastest and shortest route when using their car, they preferred main streets of the road network. Continuous flow of the vehicles and larger geometrical sizes recommend avoidance of the possibility of an exceptional fact that may cause delay in a smaller street.

For each OD the travel time of the informed driver is recorded. Then it is compared with the travel time that the non-informed driver had achieved for the same OD. After multiple tests, the total travel time reduction is calculated and the average travel time for OD is extracted. Based on the results of the FOTs, it is expected that there will be a 5.50% reduction of the vehicle hours travelled.
The detailed results are presented in the following Table.

**Table 37: Travel Time Variation**

<table>
<thead>
<tr>
<th>OD-ID</th>
<th>Average travel time</th>
<th>Travel time variation</th>
<th>% travel time variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Informed</td>
<td>Non-informed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>11'</td>
<td>12'</td>
<td>-1'</td>
</tr>
<tr>
<td>2</td>
<td>7.5'</td>
<td>7'</td>
<td>+0.5'</td>
</tr>
<tr>
<td>3</td>
<td>11.5'</td>
<td>12'</td>
<td>-0.5'</td>
</tr>
<tr>
<td>4</td>
<td>7.5'</td>
<td>7.5'</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>7'</td>
<td>7'</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>6.5'</td>
<td>6'</td>
<td>+0.5'</td>
</tr>
<tr>
<td>7</td>
<td>9'</td>
<td>9.5'</td>
<td>-0.5'</td>
</tr>
<tr>
<td>8</td>
<td>4.5'</td>
<td>5'</td>
<td>-0.5'</td>
</tr>
<tr>
<td>9</td>
<td>7.5'</td>
<td>7.5'</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>7'</td>
<td>8'</td>
<td>-1'</td>
</tr>
</tbody>
</table>

There are no differences observed in the distances between the informed and the non-informed driver. This occurred because the routes that the drivers follow in the centre of the city are specific and there are not alternative choices. From the answers in the questionnaire, it can be concluded that both drivers followed the same route, except for one case, in OD-ID 5, where the two drivers moved from the origin to the destination point in a different way. In this route, although the travel time was the same, the distance was 1.3km longer for the non-informed driver. The conclusions concerning the impact of the system in km travelled per OD is presented in detail in Table 6.

**Table 38: Vehicle Kilometres Variation**

<table>
<thead>
<tr>
<th>OD-ID</th>
<th>Average trip distance</th>
<th>Distance variation</th>
<th>% Distance variation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Informed</td>
<td>Non-informed</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.7km</td>
<td>2.7km</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3.8km</td>
<td>3.8km</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4km</td>
<td>4km</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>1.8km</td>
<td>1.8km</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2.8km</td>
<td>4.1km</td>
<td>-1.3km</td>
</tr>
<tr>
<td>6</td>
<td>1.9km</td>
<td>1.9km</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>1.9km</td>
<td>1.9km</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>1.6km</td>
<td>1.6km</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>2.5km</td>
<td>2.5km</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>6km</td>
<td>6km</td>
<td>0</td>
</tr>
</tbody>
</table>