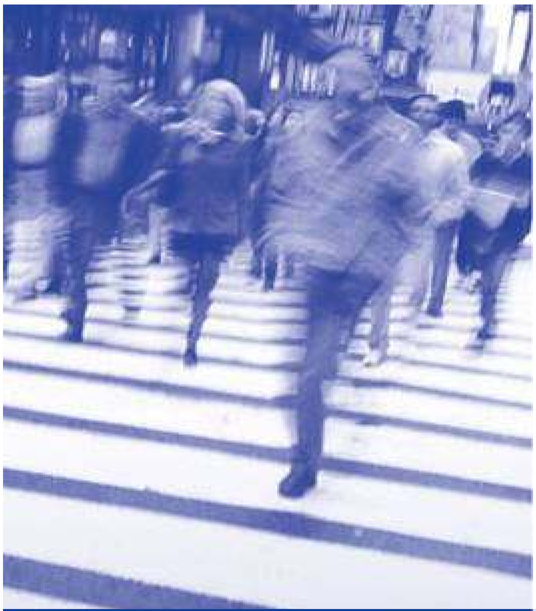

CIVITAS
Cleaner and better transport in cities

ARCHIMEDES
AALBORG • BRIGHTON & HOVE • DONOSTIA - SAN SEBASTIÁN • IAȘI • MONZA • ÚSTÍ NAD LABEM

D11.9 – Transport Telematics Studies

June 2011

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1. Introduction

1.1 Background CIVITAS

CIVITAS - cleaner and better transport in cities - stands for CIty-VITAlity-Sustainability. With the CIVITAS Initiative, the EC aims to generate a decisive breakthrough by supporting and evaluating the implementation of ambitious integrated sustainable urban transport strategies that should make a real difference for the welfare of the European citizen.

CIVITAS I started in early 2002 (within the 5th Framework Research Programme);
CIVITAS II started in early 2005 (within the 6th Framework Research Programme) and
CIVITAS PLUS started in late 2008 (within the 7th Framework Research Programme).

The objective of CIVITAS-Plus is to test and increase the understanding of the frameworks, processes and packaging required to successfully introduce bold, integrated and innovative strategies for clean and sustainable urban transport that address concerns related to energy-efficiency, transport policy and road safety, alternative fuels and the environment.

Within CIVITAS I (2002-2006) there were 19 cities clustered in 4 demonstration projects, within CIVITAS II (2005-2009) 17 cities in 4 demonstration projects, whilst within CIVITAS PLUS (2008-2012) 25 cities in 5 demonstration projects are taking part. These demonstration cities all over Europe are funded by the European Commission.

Objectives:

- to promote and implement sustainable, clean and (energy) efficient urban transport measures
- to implement integrated packages of technology and policy measures in the field of energy and transport in 8 categories of measures
- to build up critical mass and markets for innovation

Horizontal projects support the CIVITAS demonstration projects & cities by :

- Cross-site evaluation and Europe wide dissemination in co-operation with the demonstration projects
- The organisation of the annual meeting of CIVITAS Forum members
- Providing the Secretariat for the Political Advisory Committee (PAC)
- Development of policy recommendations for a long-term multiplier effect of CIVITAS

Key elements of CIVITAS

- CIVITAS is co-ordinated by cities: it is a programme “of cities for cities”
- Cities are in the heart of local public private partnerships
- Political commitment is a basic requirement
- Cities are living ‘Laboratories' for learning and evaluating

1.2 Background ARCHIMEDES

ARCHIMEDES is an integrating project, bringing together 6 European cities to address problems and opportunities for creating environmentally sustainable, safe and energy efficient transport systems in medium sized urban areas.

The objective of ARCHIMEDES is to introduce innovative, integrated and ambitious strategies for clean, energy-efficient, sustainable urban transport to achieve significant impacts in the policy fields of energy, transport, and environmental sustainability. An ambitious blend of policy tools and measures will increase energy-efficiency in transport, provide safer and more convenient travel for all, using a higher share of clean engine technology and fuels, resulting in an enhanced urban environment (including reduced noise and air pollution). Visible and measurable impacts will result from significantly sized measures in specific innovation areas. Demonstrations of innovative transport technologies, policy measures and partnership working, combined with targeted research, will verify the best frameworks, processes and packaging required to successfully transfer the strategies to other cities.

2 Participant Cities

The ARCHIMEDES project focuses on activities in specific innovation areas of each city, known as the ARCHIMEDES corridor or zone (depending on shape and geography). These innovation areas extend to the peri-urban fringe and the administrative boundaries of regional authorities and neighbouring administrations.

The two Learning cities, to which experience and best-practice will be transferred, are Monza (Italy) and Ústí nad Labem (Czech Republic). The strategy for the project is to ensure that the tools and measures developed have the widest application throughout Europe, tested via the Learning Cities' activities and interaction with the Lead City partners.

2.1 Leading City Innovation Areas

The four Leading cities in the ARCHIMEDES project are:

- Aalborg (Denmark);
- Brighton & Hove (UK);
- Donostia-San Sebastián (Spain); and
- Iasi (Romania).

Together the Lead Cities in ARCHIMEDES cover different geographic parts of Europe. They have the full support of the relevant political representatives for the project, and are well able to implement the innovative range of demonstration activities.

The Lead Cities are joined in their local projects by a small number of key partners that show a high level of commitment to the project objectives of energy-efficient urban transportation. In all cases the public transport company features as a partner in the proposed project.

2.2 Aalborg

The City of Aalborg, with extensive experience of European cooperation and having previously participated in CIVITAS I (VIVALDI) as a 'follower' city, is coordinating the consortium and ensures high quality management of the project. The City has the regional public transport authority (NT) as a local partner, and framework agreements with various stakeholder organisations.

Aalborg operates in a corridor implementing eight different categories of measures ranging from changing fuels in vehicles to promoting and marketing the use of soft measures. The city of Aalborg has successfully developed similar tools and measures through various initiatives, like the CIVITAS-VIVALDI and MIDAS projects. In ARCHIMEDES, Aalborg aims to build on this work, tackling innovative subjects and combining with what has been learned from other cities in Europe. The result is an increased understanding and experience, in order to then share with other Leading cities and Learning cities.

Aalborg has recently expanded its size by the inclusion of neighbouring municipalities outside the peri-urban fringe. The Municipality of Aalborg has a population of some 194,149, and the urban area a population of some 121,540. The ARCHIMEDES corridor runs from the city centre to the eastern urban areas of the municipality and forms an ideal trial area for demonstrating how to deal with traffic and mobility issues in inner urban areas and outskirts of the municipality. University faculties are situated at 3 sites in the corridor (including the main university site). The area covers about 53 square kilometres, which is approximately 5 % of the total area of the municipality of Aalborg. The innovation corridor includes different aspects of transport in the urban environment, including schools, public transport, commuting, goods distribution and traffic safety. The implementation of measures and tools fit into the framework of the urban transport Plan adopted by the Municipality.

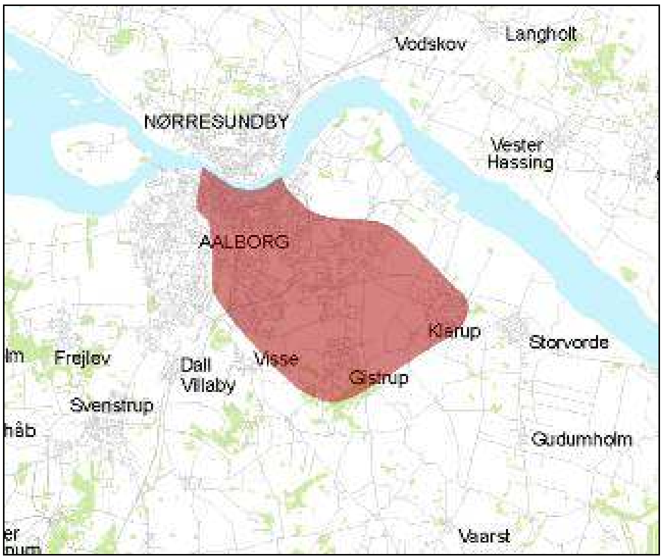

Figure 1: The Archimedes Corridor in Aalborg

2.3 Brighton & Hove

Brighton & Hove is an historic city, in the south-east of England, known internationally for its abundant Regency and Victorian architecture. It is also a seaside tourist destination, with over 11km of seafront attracting eight million visitors a year.

In addition, it is a leading European Conference destination; home to two leading universities, a major regional shopping centre, and home to some of the area's major employers. All of this, especially when set against the background of continuing economic growth, major developments across the city and a growing population, has led the city council to adopt a vision for the city as a place with a co-ordinated transport system that balances the needs of all users and minimises damage to the environment.

The sustainable transport strategy that will help deliver this vision has been developed within the framework of a Local Transport Plan, following national UK guidelines. The ARCHIMEDES measures also support the vision, which enables the city to propose innovative tools and approaches to increase the energy-efficiency and reduce the environmental impact of urban transport.

2.4 Donostia - San Sebastián

The city of Donostia -San Sebastian overlooks the sea and, with a bit more than 180,000 inhabitants, keeps a human scale. Some people consider the balanced combination of small mountains, manor buildings, and sea as the setting for one of the most beautiful cities in the world. We have a tradition in favouring pedestrians, cyclists and public transport.

For about twenty years, the city has been enforcing a strong integrated policy in favour of pedestrians, bicycles and public transport. Considering walking and cycling as modes of transport, has led to the building of a non-motorised transport network for promoting this type of mobility around the city.

Likewise, the city has extended its network of bus lanes. The city holds one of the higher bus-riding rates, with around 150 trips per person per year.

The CIVITAS project is being used as the perfect opportunity to expand Donostia -San Sebastian's Sustainable Urban Transport Strategy. With the package of CIVITAS measures Donostia-San Sebastian will:

- Increase the number of public transport users
- Decrease the number of cars entering in the city centre
- Increase the use of the bicycle as a normal mode of transport
- Maintain the high modal share of walking
- Reduce the number of fatal accidents and accidents with heavy injuries
- Reduce the use of fossil fuels in public transport.

2.5 Iasi

The City of Iasi is located in north-eastern Romania and is the second largest Romanian city, after Bucharest, with a population of 366,000 inhabitants. It is also the centre of a metropolitan area, which occupies a surface of 787.87 square kilometres, encompassing a total population of 398,000 inhabitants.

The city seeks to develop possibilities for habitation, recreation and relaxation for all citizens in the region, business opportunities and provide opportunities for more consistent investments.

The city has five universities with approximately 50,000 students, the second largest in Romania. The universities and their campuses are located in the central and semi-central area of the city. In the same area, there are also a large number of kindergartens, schools and high schools with approximately 10,000 pupils. This creates a large number of routes along the main corridor, served by the public transport service number “8” (Complex Tudor

Vladimirescu - Copou) with an approximate length of 10 km. The City of Iasi will implement its integrated measures in this area to be known as the “CIVITAS+Corridor”.

The city's objectives in CIVITAS - ARCHIMEDES are based on the existing plans related to transport, Local Agenda 21, approved in 2002, and the Sustainable Social-Economic Development Strategy for City of Iasi. The CIVITAS Plus objectives will be integrated in the Strategy for metropolitan development to be finalized in May 2009.

2.6 Monza

Monza is a city on the river Lambro, a tributary of the Po, in the Lombardy region of Italy, some 15km north-northeast of Milan. It is the third-largest city of Lombardy and the most important economic, industrial and administrative centre of the Brianza area, supporting a textile industry and a publishing trade. It is best known for its Grand Prix.

The City of Monza, with approximately 121,000 inhabitants, is located 15 km north of Milan, which is the centre of the Lombardia area. This area is one of the engines of the Italian economy; the number of companies is 58,500, i.e. a company for every 13 inhabitants.

Monza is affected by a huge amount of traffic that crosses the city to reach Milan and the highways nodes located between Monza and Milan. It is also an important node in the Railways network, crossed by routes connecting Milan with Como and Switzerland, Lecco and Sondrio, Bergamo and Brianza. "Regione Lombardia", which in the new devolution framework started in 1998, has full responsibility for establishing the Local Public Transportation System (trains, coaches and buses) and has created a new approach for urban rail routes using an approach similar to the German S-Line or Paris RER.

Monza has recently become the head of the new "Monza and Brianza" province, with approximately 750,000 inhabitants, so will gain the full range of administration functions by 2009. Plan-making responsibilities and an influence over peri-urban areas will require the city to develop new competencies.

In this context, the objective of the City of Monza in participating in CIVITAS as a Learning City is to set up an Urban Mobility System where the impact of private traffic can be reduced, creating a new mobility offer, where alternative modes become increasingly significant, leading to improvements to the urban environment and a reduction in energy consumption (and concurrent pollution).

2.7 Ústí nad Labem

Ústí nad Labem is situated in the north of the Czech Republic, about 20 km from the German border. Thanks to its location in the beautiful valley of the largest Czech river Labe (Elbe) and the surrounding Central Bohemian Massive, it is sometimes called 'the Gateway to Bohemia'. Ústí is an industrial, business and cultural centre of the Ústí region.

Ústí nad Labem is an important industrial centre of north-west Bohemia. The city’s population is 93,859, living in an area of 93.95km2. The city is also home to the Jan Evangelista Purkyně University with eight faculties and large student population. The city used to be a base for a large range of heavy industry, causing damage to the natural environment. This is now a major focus for improvement and care.

The Transport Master Plan, to be adopted in its first form in 2007, will be the basic transport document for the development of a new urban plan (2011), which must be developed by the

City subject to the provisions of the newly adopted Building Act. This will characterise the development of transport in the city for the next 15 years, and so the opportunity to integrate Sustainable Urban Transport Planning best practices into plan development during the project means an ideal match of timing between city policy frameworks and the ARCHIMEDES project.

The projects main objective is to propose transport organisation in the city, depending on the urban form, transport intensity, development of public transport, and the need for access. The process, running until 2011, will include improving the digital model of city transport that Ústí currently has at its disposal. The plan will have to deal with the fact (and mitigate against unwanted effects that could otherwise arise), that from 2010, the city will be fully connected to the D8 motorway, running from Prague to Dresden.

3. Background to the Deliverable

This deliverable summarises the research and preparatory activities conducted in relation to workpackage 8 of the CIVITAS ARCHIMEDES project - Transport Telematics.

3.1 Summary Description of the Tasks

Research and preparatory activities in respect of transport telematics applications have been conducted in three of the ARCHIMEDES cities, namely Aalborg, Donostia - San Sebastian and Monza, as part of tasks 11.8.1, 11.8.2, 11.8.3, 11.8.4, 11.8.5, 11.8.6 and 11.8.7. These tasks are introduced in the following sections.

The work and findings of these tasks are reported in detail in deliverables R70.1, R75.1, R78.1, R79.1, R80.1, R81.1 and R82.1. This deliverable draws together the content of the individual deliverables and presents the common issues and any conclusions that can be drawn at the workpackage level.

Task 11.8.1 Congestion Analysis - Aalborg

The objective of ARCHIMEDES measure 70 is to influence car drivers' choice of routes and travel time and thereby reduce congestion during rush-hours. This is driven by the fact that about 20% of the traffic in Aalborg occurs within each of the 2 hour morning and afternoon peak periods. Due to congestion within these periods energy consumption is particularly high.

Providing new and innovative information to all road users could influence their choice of route and travel time thereby reducing congestion during the rush-hours. Measurements of congestion during the day will enable actual information about travel time savings if journeys are re-scheduled away from the peak period. Reduced congestion in peak periods will provide better conditions for public transport which will be a more attractive transport mode. Another positive effect will be better energy consumption due to fewer and smaller queues.

The research element of this measure is contained within Task 11.8.1 and presents the possibilities, challenges and state of the art concerning collection of congestion data and dissemination of information.

Task 11.8.2 Park & Ride Guidance System - San Sebastian

Parking Guidance Systems (PGS) are designed to ease congestion resulting from vehicles travelling to a city's parking facilities by directing vehicles to the nearest available parking space and reducing congestion in city´s general traffic, at the same time as offering energy savings linked to journeys to the parking facilities and making the city more attractive to visitors.

PGS also helps control parking and traffic by directing drivers to available parking facilities throughout cities, universities, airports, shopping centers, etc. through the use of vehicle counting technology and space availability signage.

Within measure 75, task 11.8.2 covers the research conducted by the city of Donostia - San Sebastián into installing Variable Message Signs (VMS) informing car drivers about free parking places in Park & Ride areas in real time throughout the city; covering the warnings and recommendations issued, the data centralisation system and appropriate devices for its operation.

The Parking Guidance System is expected to benefit drivers and everyone in the city by:

- Directing drivers to available parking spaces.
- Reducing the amount of time drivers spend searching for an available parking space thus saving petrol, vehicle emissions and reducing vehicle wear and tear.
- Minimise potential stressful situations and reduce the risk of accidents.
- Optimisation of all public and private parking spaces by providing real-time space inventory to the public.
- Control parking occupancy by Facility, Level, Zone or Individual Parking Space.

Task 11.8.3 Park & Ride Guidance System - Monza

The scope of this task is similar to 11.8.2. In particular, within this research task the following actions have been accomplished in the particular context of Monza:

1. Meeting with the companies owning the most significant parking areas in the City, aimed at gaining their approval to implement the measure.
2. Analysis of the road network and related traffic flows according to data depicted in the General Urban Traffic Plan (GUTP) of the city.
3. Identification of the precise positions of the signs, both fixed and variable, indicating available parking spaces and parking areas inserted in the system.

Task 11.8.4 AVL/AVM System Interface Design and Implementation - Monza

The use of real time location information gathered by the automatic vehicle location / monitoring (AVL/AVM) system is fundamental to increasing the service level provided by the Urban Public Transport which is an objective of the ARCHIMEDES project in Monza.

As part of this task Project Automation (PA) in corporation with TPM (the former local public transport provider) has carried out a study to define the requirements for interfacing the AVL/AVM System already implemented by TPM with the other elements of the public transport / wider traffic management systems in Monza (particularly bus traveller Information and for public transport priority at traffic lights).

This task is strongly linked to the other ARCHIMEDES measures being implemented in Monza as part of workpackage 8, as it will provide information necessary to implement measures 79 (Improved Traveller Information), 81 (Urban Traffic Control Activities) and 82 (Public Transport Priority System).

Task 11.8.5 UTC System Technical Design - Monza

Urban Traffic Control systems have been developed to manage in a coordinated way intersections driven by traffic lights. One of the main advantages gained by the application of UTC systems is to make available the opportunity to vary green times, duration of cycle times, green waves depending on traffic conditions, day of the week, hour of the day and so on.

The aim of the ARCHIMEDES measure 81 is to design and implement an Urban Traffic Control (UTC) technological system that contributes to maximize the flow of traffic through the identified CIVITAS corridor in the city of Monza.

In this context Project Automation (PA), the technological partner of the Municipality of Monza, has carried out a study to apply the Roadmanager® UTC system in Monza within this task. The study includes actions to define the exact activities to be carried out to pursue the centralisation of the intersections selected.

Roadmanager® is designed to manage priority requests issued by the AVL/AVM systems in use on the public transport fleet in Monza and to optimize public transport priority within the context of the overall traffic.

Task 11.8.6 Public Transport Priority Management - Monza

ARCHIMEDES Measure 82 (Public Transport Priority System in Monza) is concerned with implementing a framework that allows for the traffic light plans of the intersections (managed by the UTC system) to change when the actual situation of the buses would benefit from more green time at these intersections (so long as the overall traffic status allows this).

Within task 11.8.6 a study has been undertaken by Project Automation, in agreement with Comune di Monza and with Nord-Est Trasporti (NET) which is the owner of the Public Transport fleet, to propose a conceptual framework to manage Public Transport Priority at the relevant intersections.

Task 11.8.7 Bus Traveller Information Study - Monza

In the context of encouraging sustainable mobility, the use of Public Transport in the City of Monza needs to be increased. In order to achieve this objective, within the ARCHIMEDES framework a clear decision has been made, which has the full support of the government of the Municipality, to implement technological measures to make Public Transport more attractive to citizens.

Within measure number 79 (“Improved Traveller Information in Monza”), an Advanced Traveller Information Service for Urban Public Transport is being set up to provide real time information at the most important bus stops of the city and at Porta Castello interchange node. The implementation of the measure has been made possible by the activation of measure number 78 ("Bus Management System in Monza" – see task 11.8.4).

Within task 11.8.7 a study has been undertaken by Comune of Monza, with the technological support of PA and the operational support of NET, to define the requirements of the kind of information to be provided to passengers at key interchanges and key bus stops in Monza.

4. Summary of Transport Telematics Research in ARCHIMEDES

The main theme of this deliverable is designing and researching different systems towards improving traffic flow, improving information to road users and passengers using public transport and reducing congestion in cities. Two of the studies in this deliverable cover designing and implementing Park & Ride Guidance Systems. In Monza, a Bus Management System has been implemented and has provided information necessary to implement Bus Traveller Information and a Public Transport Priority Management System based on an Urban Traffic Control (UTC) technological system to maximize traffic flow. In Aalborg a study of the next generation navigation systems has been performed.

4.1 Deliverable R70.1

Study of Next Generation Navigation Systems

Traffic has been increasing for many years and has caused an increase in transportation and rising congestion costs worldwide. EU has concluded that all cities have to face the many challenges with increased congestion and all its negative side effects and sees ITS regarding congestion monitoring and information as one of the solutions towards a better working road transport network in built-up areas.

In Denmark the development has been concurrent to the overall EU with road transportation increasing by 2.7 % per year from 1980 to 2007. In 2008 the Danish National Road Directorate calculated that the traffic volume will increase by a further 70 % until 2030.

Although the road network has in general been expanded, these expansions have usually not been sufficient to match the increasing traffic. Therefore road networks have become more and more congested over time. In many medium-sized and big cities it has resulted in traffic collapses. In some cities it is still only a rush hour problem whilst other cities have to deal with heavy congestion all day.

By 2030, areas which currently have moderate congestion problems will experience serious congestion problems and areas with congestion today will experience daily traffic collapses. Due to the fact that most road authorities will not have sufficient resources to increase the road capacity in line with traffic growth, other methods for calming the congestion challenges are necessary. One efficient tool is congestion monitoring and travel time information to road users.

With an advanced congestion monitoring system the road authorities can improve traffic flow by ongoing monitoring and optimisation for signalized intersections, both regarding single traffic signals and regarding chains or networks of adaptive signalized intersections. If data are variable or used in real time, Variable Message Signs (VMS) can also be used to optimize traffic flow by fitting the actual posted speed limit with current requirements concerning road safety and optimal traffic flow.

Providing information to road users concerning routes and travel time can also be a tool to reduce congestion. With reliable, and preferably real time, information about congestion on the driver's desired route, the driver can select another route or postpone / bring forward the trip. A provider of navigation systems for cars has estimated that available congestion information based on historical data can result in a faster route selection in more than 50 %

of the trips in congested areas. Furthermore, knowledge about congestion might lead to some of the road users to change to another transport, whilst others might postpone or bring forward their journeys. Both effects lead to reduced congestion in the peak hours.

Data Collection

There are two approaches for collecting congestion data: spot speed measurement and measurements based on floating car data (FCD).

<u>Spot Speed Measurement</u>

Systems for spot speed measurements record the speed behavior of all passing vehicles at a certain spot on the road network. The most common methods for spot speed measurements are:

- Loop detectors
- Video cameras
- Radar/Lidar
- Distance speed measurement.

The results from these types of measurements are highly precise on the spot, but do not measure the speed at other parts of the road section. Moreover, the equipment has to be installed, operated and especially maintained by the road authorities.

<u>FCD Measurements</u>

FCD measurements cover most of the road network in most periods of the day. In return, results based on FCD are associated with some uncertainties because it cannot be guaranteed that probe vehicles are collecting data at the time and place where any incident appears. However, the number of devices which can collect data is continually increasing. Also, information from only a few percent of the total vehicle fleet is sufficient to capture all serious incidents with a high probability.

The most common methods with different advantages and disadvantages are:

- GPS receivers
- GSM cell phones
- Cell phones with GPS receivers
- Car navigation units.

The overall conclusion is that floating car data result in more reliable and wide covering data than do traditional spot speed registrations. Moreover, it seems that the most efficient approach to reach enhanced congestion information will be from existing providers of navigation units - as expanded later. However, regardless of the selected approach, the handling of the data from the probe vehicles towards the server and further towards the road users and road authorities for use as congestion information is challenging and still has to be improved. Approaches for controlling these challenges are presented below.

Challenges Concerning Congestion Analysis

A case study computing the travel time in intersections to estimate the congestion level and find the rush hours on two major signalized four-way intersections in the centre of Aalborg has been completed. GPS data collected from probe vehicles in a recently finalized Intelligent Speed Adaption trial Pay As You Speed (PAYS) were the basis for this study.

The study is a new type, because it also focuses on time use associated with turns, while most former analyses on GPS data have been for road segments and on motorways or approach roads towards a city area. As the focus of the study is on travel time alone, a simple model for storing GPS data could be used.

To be able to use GPS data from vehicles moving on a road network the GPS data must be map-matched to the correct road segment, which can be quite a complex challenge. In this study, the GPS data have been map-matched by reusing and refining results of an existing map-matching algorithm.

One of the two intersections and the associated travel time matrix for crossing the intersection appear in Figure 1 and Figure 2 respectively. The 12 average times used for crossing the intersection depending on the direction are from 21 to 47 seconds. When looking in more detail at the data it appears that the highest time use is in the peak hours. In Figure 3 the time use for the traffic going north-south distributed over the day is shown. Similar results are found for the other studied intersection Hobrovej-Østre Alle. The trips have been grouped into quarter hours and the average of each group is calculated.

It is quite clear that the travel time even in non-rush hours varies substantially. The reason for this is the splitting of the day into 15 minute intervals. This split means that many trips have to be recorded for each quarter of an hour in order to gain a representative value. If there are only a few trips within each interval a single trip can cause the calculated travel time to fluctuate markedly.

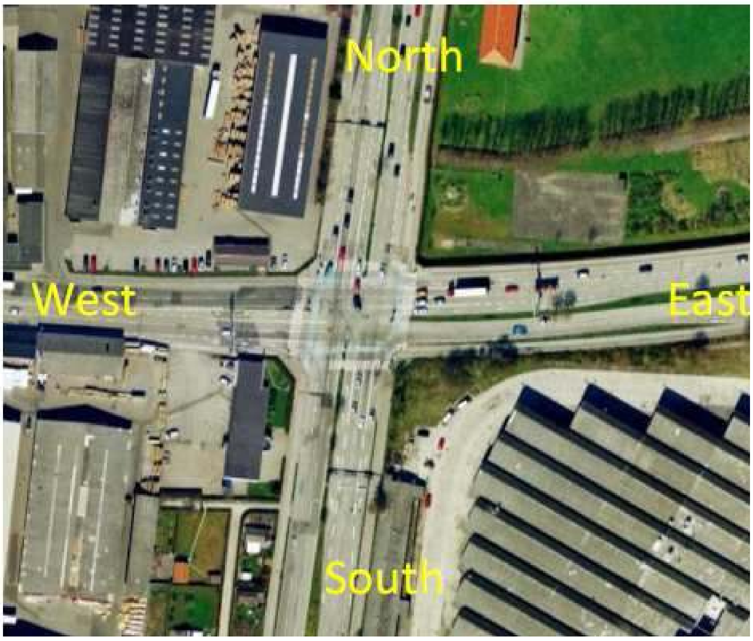

Figure 1. The selected intersection Sønderbro-Østre Alle (Google Earth).

	N	S	E	W
N	-	23	48	23
S	22	-	22	30
E	28	39	-	29
W	53	23	28	-

Monday-Friday

	N	S	E	W
N	-	23	38	17
S	18	-	21	23
E	20	20	-	23
W	24	22	22	-

Saturday-Sunday

	N	S	E	W
N	-	23	47	21
S	21	-	22	21
E	27	33	-	28
W	47	23	27	-

All days

Figure 2. Travel-time matrices for weekdays for the Sønderbro-Østre Alle intersection, weekends and all days. All values in seconds.

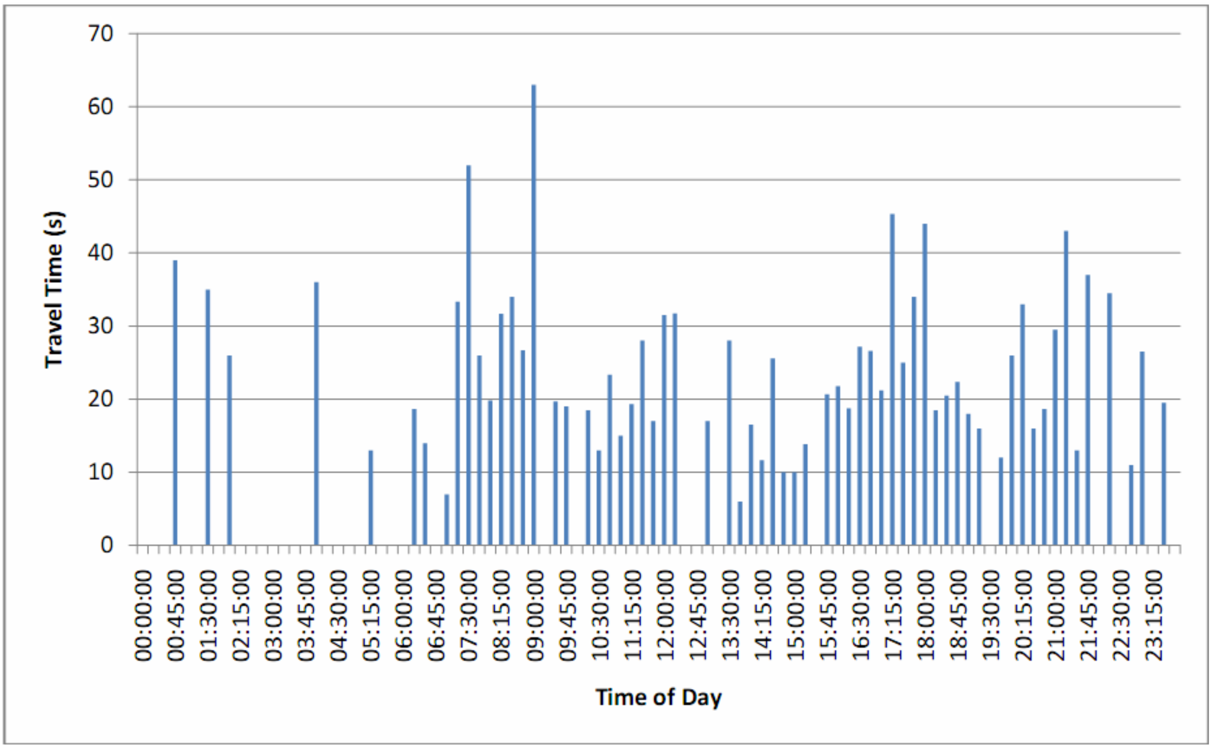

Figure 3. Travel time distributed on the day (north-south) on the Sønderbro-Østre Alle intersection.

The results show that the algorithm can be used to find the rush-hours at the intersections. However, the algorithm requires a fairly large number of trips if the travel time in intersections is to be reported in quarter hour intervals. Such a fine accuracy is needed to be able to determine when the rush-hour actually starts and ends.

Feedback to the Drivers

Information about the transportation time and congestion level on a road network can be based on three types of data: static, variable and dynamic speed and congestion data.

Static Data

With static speed data it is assumed that the transportation time for a certain route is constant regardless of the time of the day, any incidents, and general congestion level. Static data are normally based on the posted speed limit, with an allowance deducted based on a fixed proportion of the speed to take any red lights, curves and other road users in to consideration. This approach neither reflects congestion during rush hours nor the general trend towards more vehicles on the road network.

On the Internet a number of companies and public bodies provides travel time and route information. The information consists in most cases of route descriptions and one or several maps showing the desired trip. Also several companies have provided navigation units which can estimate the fastest or shortest route between two positions. Until recently these services have in common that all calculations were based on static data.

Variable Congestion Data

In recent years it has become clear that congestion information and travel time estimations based on fixed velocities have serious limitations. In the peak hours such systems often overestimate the travel velocity markedly. Consequently, reliable travel time estimations have only been available outside the peak hours and have hence virtually been unnecessary in many cases. Furthermore, the difference between estimations and real travel speed has also increased over time due to increased traffic on the road network. However, also signalized intersections and the road design can affect the real speed significant.

Variable congestion data represents a substantial improvement. It means that variation over time due to rush hours, winter/summer etc. is taken into account when estimating the travel time and congestion level. In this type of data, only historical data are included. Any isolated incident causing extra congestion is not included in the estimations. This data type can be named as 'variable congestion data'. If sufficient probe cars provide data it can cover a road network and estimate the travel time at all times of the day precisely if no unexpected incidents appear.

A number of trials and systems have been developed in the recent years; amongst these is a pilot trial by The Danish Road Directorate estimating reliable travel time and congestion levels on mainly the arterial motorways and the development of a tool by the International traffic consultant company COWI together with the courier company 3x34 to estimate travel time and congestion levels on all central national roads. In the first part of 2009 TomTom went on the market with next generation navigation units, a so-called intelligent navigation system (TomTom 2009).

Dynamic Congestion Data

Even though dynamic navigation systems still are under development, feedback concerning congestion and other incidents to the road users has been carried out for several years. It can be given in a number of ways. Feedback can be given to road users via TMC as voice message via the car radio, it can be given as voice message via a navigation unit, or it can be given direct via the navigation unit in the form of a changed route proposal and/or changed estimated travel time. Also road authorities can provide congestion information. It is in most cases done by VMS which show e.g. a reduced speed limit or a proposed detour to pass round any congested area. Besides these real time information approaches information about regular congestion situations can be circulated via newspapers, radio spots and the Internet. Radio spots and the Internet can also be used in real time but is not necessary to be as precise and language independent as is TMC.

4.2 Deliverable R75.1

Study of Park & Ride Parking Guidance System in Donostia - San Sebastián
The municipality of Donostia - San Sebastián has seen the need to reform, improve and complete the existing information system for Park & Ride parking places with the objective of informing users about Park & Ride parking places in the city and its level of occupation, so they can decide where to go at a stage when they have enough time to decide.

To date, the only signposting available in the City about parking places has been limited to signposting of underground parking. Drivers are guided to their car park locations by static signposting, as shown by following Figure 4. In addition, and always in relation to inner city areas, more information is offered to drivers informing them not only of underground parking locations but also the general situation (full or free parking) through the use of green and red lights, as shown in Figure 4.

Figure 4. Left: Static signposting guiding to Parking Easo. Right: Signpost with lighting used to indicate status of parking situation.

Description of the Parking Guidance System
It was clear that a new Parking Guidance System was needed to improve the current parking signposting system, to give more information regarding the number of vehicles entering the city and to provide consistent information.

In this sense, two types of signposting were considered:

- Variable message signs (VMS), Warnings and Recommendations, to be installed at city entrances and singular points
- Parking availability information signposting, to be installed at parking searching routes.

<u>Variable Message Signs</u>
Information signposts need to be compact with information grouped in the same panel. In these panels, the city's parking status information is shown, grouped by zones or individually. Warnings/recommendations or any other type of information that system centralises would also be displayed.

VMS Panels need to be capable of transmitting at least the following set of information:

- Occupancy status of city's Park & Ride carparks, individually or grouped by zones, according to the following table of underground carparks to centralise.

Nº	PARKING	ROT	TYPE	ZONE	TITULARITY
1	ARCCO AMARA	214	ROT	AMARA	MUNICIPAL
2	PIO XII	339	MIX	AMARA	MUNICIPAL
3	ILLUMBE	500	ROT	ANTIGUO	MUNICIPAL
4	ZUATZU	500	ROT	AMARA	MUNICIPAL
5	ANTIGUO BERRI	489	ROT	ANTIGUO	PRIVADO
6	BOULEVARD	386	MIX	CENTRO	MUNICIPAL
7	BUEN PASTOR	384	MIX	CENTRO	MUNICIPAL
8	CERVANTES	607	ROT	CENTRO	MUNICIPAL
9	OKENDO	767	ROT	CENTRO	MUNICIPAL
10	EASO	146	MIX	CENTRO	MUNICIPAL
11	SAN MARTIN	300	MIX	CENTRO	MUNICIPAL
12	ATOTXA	210	ROT	EGIA	MUNICIPAL
13	KURSAAL	304	MIX	GROS	MUNICIPAL
14	CATALUÑA	477	ROT	GROS	MUNICIPAL
15	TXOFRE	465	ROT	GROS	MUNICIPAL

- Warnings, recommendations or any information that may be interesting to improve the overall traffic flow of the city.

By default, VMS panels will provide information on about the occupancy status of Park & Ride car parks, grouped as follows:

- “Centro” zone: Okendo, Boulevard, Cervantes, San Martín
- “Centro - Amara” zone: buen Pastor, Easo
- “Gros” zone: (Katalunia, Txofre, Kursaal, Atotxa)
- “Amara Nuevo” zone: (Pío XII, Arcco Amara)

Depending on the occupancy status of each zone, information will be given out in different colours to inform the driver, at a glance, the occupancy status of the zones. The system will enable the display of different information in each of the panels. Figure 5 shows the proposed drawings for this type of signpost. Figure 6 shows a VMS panel installed at the city entrance in the Amara zone.

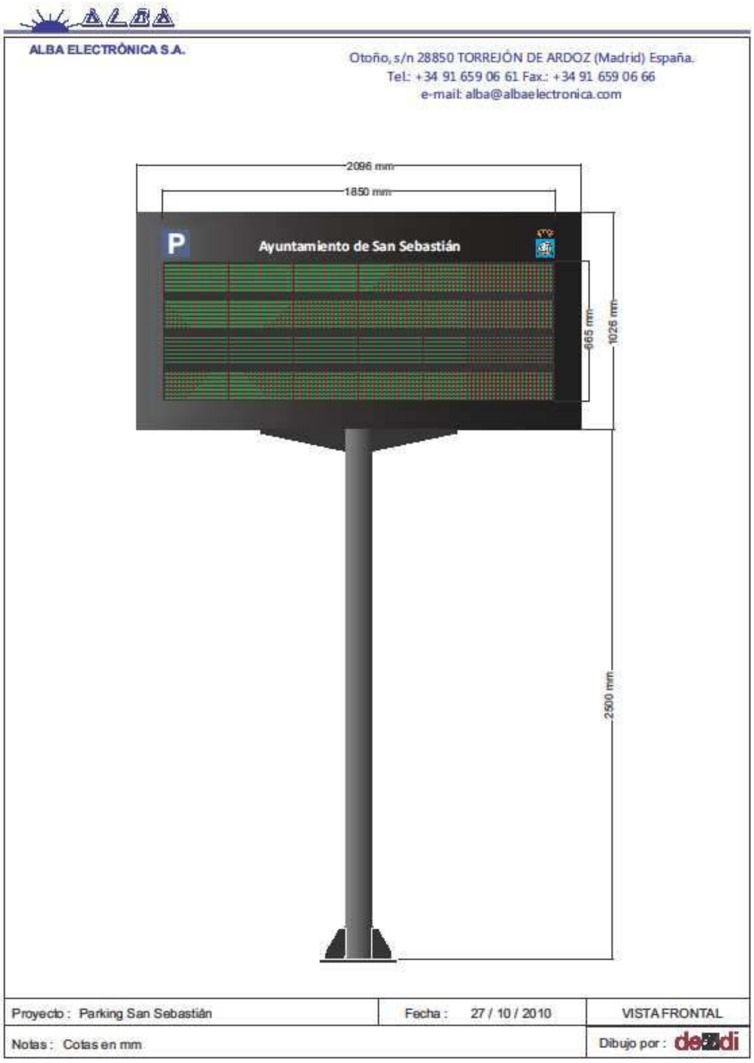

Figure 5. Rendered image of a VMS panel with overall dimensions.

Figure 6. VMS Panel at city entrance in Amara zone.

Parking Availability Information signposts

Information panels need to be compact with information grouped in a single panel or composed by modules. On these panels information will be displayed about the available places in each parking facility, or its current status: Available, Full, Maintenance work in progress. Depending on each location, information on available parking places will be complemented with fixed information panels.

Panels will be capable of transmitting at least the following information:

- The quantity of free parking places
- Parking status (according to occupancy percentage)
- Free
- Full
- Maintenance work in progress.

Depending on the occupancy status of each parking facility, information will be displayed in different colours to inform the driver, at a glance, the occupancy level status. Figure 7 shows a proposed drawing for this type of signposts. Figure 8 shows some of the installed signposts with information panels showing to underground parking locations.

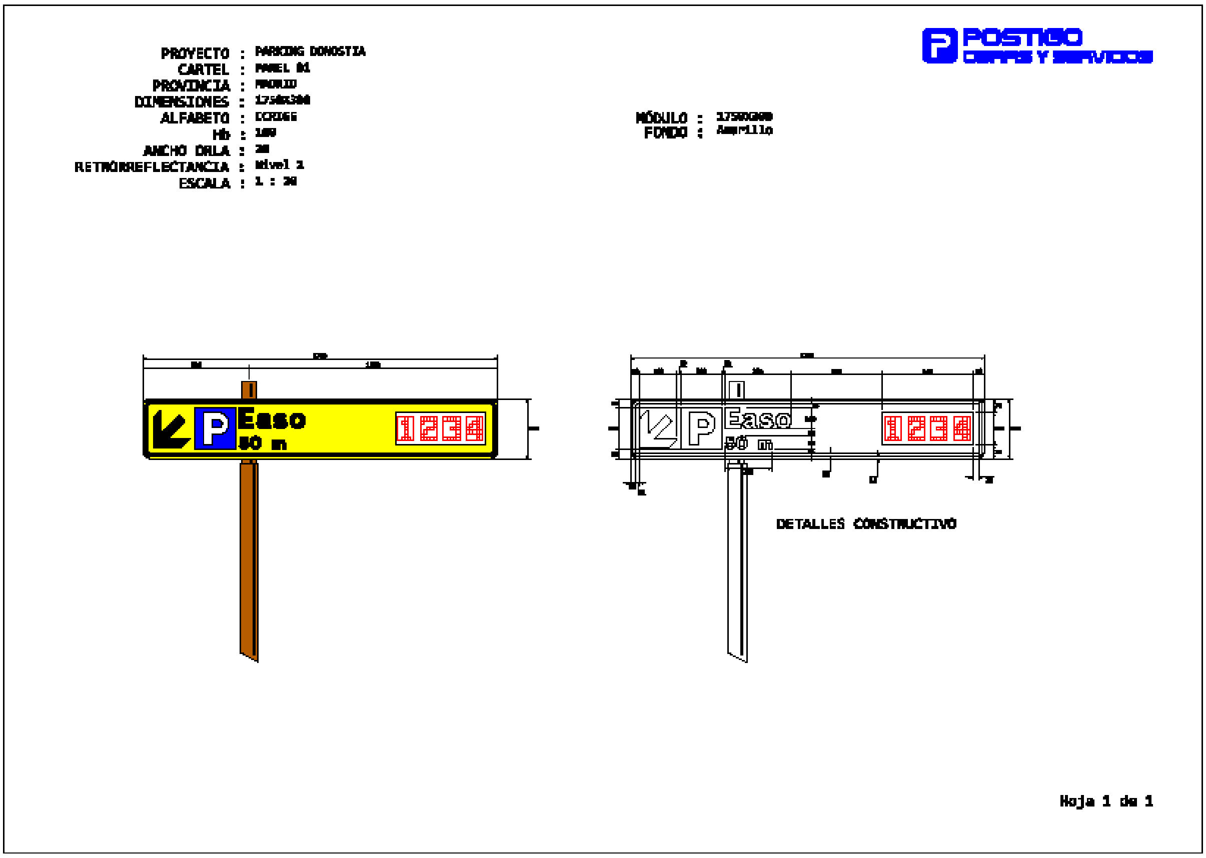

Figure 7. Information signposting with a single parking panel.

Figure 8. Information panels showing underground parking locations.

Data Centralization System and Operation Device
A data centralisation system will enable data process and warnings/recommendations to be broadcasted from the traffic control centre towards the panels located throughout the city.

The system is totally customisable and programmable, so that it will be possible to:

- Modify expected parking groupings
- Emit different warnings/recommendations in each of the VMS panels
- Store Park & Ride parking bay occupations historically
- Store Warnings/Recommendations historically
- Schedule events to display in VMS panels
- Emit operating alarms
- Record operating alarms
- Expand the number of Park & Ride areas operated within the system.

The data centralisation system will automatically capture the occupation status information of each Park & Ride car parks from the data obtained by the operating device, and it will transfer this information to the control centre.

4.3 Deliverable R78.1

Bus Management System in Monza: Interface with AVL/AVM System
Since November 1st 2007, the Urban Public Transport Service in Monza has been defining the tender requirements for various system upgrades in preparation for the ARCHIMEDES project. One such set of requirements concerns the technical requirement for the interface between the AVL/AVM system, which will be used to monitor the service accomplished by public transport fleet, and the other elements of the public transport and wider traffic management systems in Monza.

The use of real time location information gathered by the AVL/AVM system is fundamental to increasing the service level provided by the Urban Public Transport which is an objective of the ARCHIMEDES project. Therefore measure 78, which covers the AVL/AVM system, is heavily interlinked to the other measures, as it will provide information necessary to implement the following measures:

- The capability to show through Variable Message Signs (VMS) installed at several important bus stops in the city the expected schedule for each monitored TPM bus (measure no. 79);
- The capability to announce the arrival of a bus at an intersection managed by an Urban Traffic Control (UTC) system for the coordinated control of traffic light controlled intersections (measure no. 81). The announcement also needs to include information about the status of the bus (i.e. on-time, delayed or ahead of schedule) so that the appropriate level of priority can be assigned to each bus as it approaches the intersection (measure no. 82).

AVL/AVM systems have been designed to ensure complete control of the bus fleet.

The AVL function allows monitoring of the position and other relevant information relating to the status of each bus at given time intervals (typically every 30 sec). In order to do this, every bus is equipped with an on-board unit ("OBU"), consisting of an industrial PC with an internal GPS module to monitor and relay the position of the bus and the facility to communicate with other diagnostic devices on the bus such as the odometer, door controller (to know door opening times) etc to help monitor the status of the bus.

The AVM function maps the location information to the timetable assigned to the buses moving on their routes. This allows the system to know the following basic information:

- If the bus is on-time, delayed, or in advance: this information may influence taking specific actions to improve bus behaviour: as an example, if the bus is running in advance with respect to its timetable, the driver takes into account of this; in addition, in such circumstances it is not necessary to require priority for the bus at traffic light intersections where the option of bus priority exists;
- Forecasts of bus arrival times at bus stops: such forecasts can be shown on the intelligent bus-stops ("info-bus"), as expected in Monza through measure no. 79;
- Forecasts of bus arrival times at intersections: if the intersection is properly equipped, if the bus is delayed and if the overall traffic conditions allow it, a priority action on the traffic lights phasing can be issued to prioritise the passage of the bus, as expected in Monza through measure no. 82.

The use of the AVL/AVM system involves three basic processes:

- The first process is typically carried out off-line and related to a set of activities that need to be carried out well before the actual bus service becomes active. This is part of the service specification and concerns the configuration of the system, including the route of every line, timetable details, set-up procedures (all that happens before the bus can start with the service);
- The second process is strictly carried out on-line and concerns the use of the system during the execution of the service; as buses perform the assigned runs, the system gathers all the positions of the buses at predefined time intervals (AVL), enriches such information with the predefined schedules to achieve monitoring capabilities (AVM);

- The final process contains completion procedures. These are conducted after the last run is performed each day, and on entering the depot the OBU downloads all relevant information concerning the services performed (e.g. diagnostic information) to the central AVL/AVM computer.

4.4 Deliverable R79.1

Study of Bus Traveller Information in Monza
At the beginning of 2011 responsibility for the contract for PT bus service, previously managed by the Province of Milan passed into the hands of Province of Monza. Within this framework, the Province of Monza, before starting the management of the contract, has decided to revise the network of PT services, taking into account problems and suggestions collated during the last three years.

The aim of this revision is to implement PT service in the urban area of Monza, connecting important transport nodes and interchanges to less well served areas, optimising costs and resources and improving timetables in order to offer best service frequencies.

The choice of the bus stops has been shared with PT companies and with the Province of Monza and Brianza with the aim of installing thirty electronic bus shelters, ten of which will be located on one of the two CIVITAS corridors which have been identified at the beginning of ARCHIMEDES project, and more specifically on the corridor mainly dedicated to Public Transport routes, which end at Porta Castello interchange node, located at the bottom of the orange line close to the central Railway Station of Monza.

Prerequisite of AVL/AVM System
Before merging with NET, TPM had already installed on its fleet an automatic vehicle location / monitoring (AVL/AVM) system, but that system would need to have been heavily upgraded to fulfil the ARCHIMEDES requirements.

The new management of the service, exploiting experience of ATM, decided to extend on the fleet inherited by TPM an existing AVL/AVM system, already active on ATM fleet operating in Milan; the extensions required have been accomplished with success in a short time, due to the internal design of this new AVL/AVM system. Since July 2010, each vehicle of NET fleet has been equipped with an On-Board Unit (OBU) consisting of an Industrial PC with specific devices and sensors:

- A GPS device to determine the vehicle position, coded with Lat-Long coordinate system (WGS 84);
- A GPRS communication system to send the information to a Control Centre;
- As drivers begin their shift, they identify themselves to the system, typing their personal code on a dedicated keyboard.

Data concerning vehicle positions are produced at a given frequency (sampling interval) and sent to the Control Centre at another given frequency (transmission interval). Once records are received by the Control Centre they are stored in a database table, for subsequent use. In the ARCHIMEDES context, the immediate use provides information which will be used for Measure 79 (InfoBus) and for Measure 82 (Priority to intersections on the corridor identified). In addition, data are available for every type of statistical analysis.

The above described data have been used to install and provide real time information at thirty electronic bus shelters since the beginning of 2011.

Technological framework to implement the measure
The technological framework needed to provide end-user information concerning the actual arrival time of buses relies on the software system used also for Measure no. 78 (Bus localization system). This system has been extended through two new modules presented as pink boxes in Figure 9.

In more detail, localization data collected by the buses of the Public Transport Fleet are now available as Real Time data, as they are received by the Central system, through the specific software module “DB Real Time Updater Server”.

Such data are transferred to another software module running in the Central System (“Electronic Display Server”) which is aimed at preparing data for every Electronic Display board installed across the city, depicted in Figure 9 by the black symbol with yellow characters.

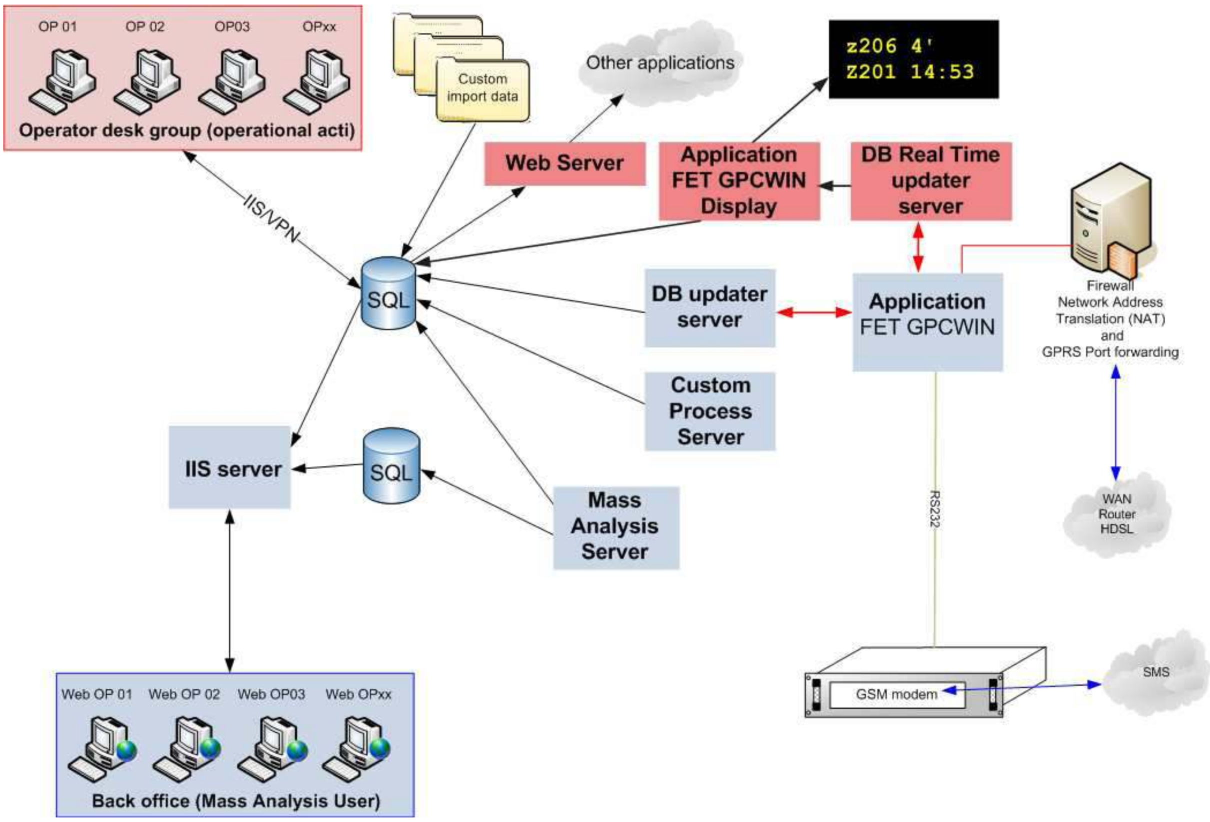

Figure 9. Architecture of the system.

An example of the electronic displays that will be installed at relevant bus stops is shown in Figure 10. The display can be both connected to a power supply line and fed by solar power. The displays consist of three lines; each of them can show up to 20 characters with proportional font or 16 characters with a fixed font. The communication with the displays is accomplished through GPRS lines; the same front-end used for the GPRS communication with the On Board Units (OBU) installed on the buses of the fleet is used also for GPRS connection with the displays.

For each bus line the following information will be displayed:

- Below 5 minutes to arrival, the number of minutes;
- Above 5 minutes to arrival, the expected time of arrival in hour and minute format (e.g. 15:35);
- If the expected arrival is far away in time (e.g. 2 hours or more), the value is not shown and a courtesy message is presented, if configured.

Figure 10. AESYS electronic display.

At the Porta Castello node a vertical interactive totem produced by Samsung will be installed; its functions allow a strong interactivity with users, thanks to touch screen function and built-in speakers. The precise location within the Porta Castello node is under definition with Rete Ferroviaria Italiana (Owner of the Italian Rail Network). Through the interactive totem, the following functions will be made available:

- Map of the Urban Public Transport Network, to allow travellers not knowing the city of Monza to understand the Public Transport Service;
- Travel Planner application, involving the Urban Network of the city of Monza;
- Real time situation at Milan airports;
- Weather forecasts.

Other functions will be evaluated, such as daily news to be acquired by journalistic specialised providers, events planned in Monza or in the Province and so on.

4.5 Deliverable R80.1

Study of Park & Ride Guidance System in Monza

There is no Parking Guidance System in Monza (hereafter: “InfoPark Monza”) at the moment. Contacts were established in 2007 with the companies owning the most significant parking areas in the City to promote such a system, gaining a substantial approval.

In addition, TPM has been delegated by the Municipality to manage all services related to public parking areas in the City as well as to become the reference partner of the Municipality to set up technological systems for Mobility Management, within the framework if ITS (Intelligent Transportation Systems), supporting it in the execution of public tenders.

In the meantime, after the elections in June 2009, Monza officially became the capital of the new Province of Monza and Brianza and its administrative offices started their activity. This new role will increase the mobility attraction, both for existing institutions (Hospital, University) and local government offices (Province, Police). As a consequence, in order to be ready to accept an increased number of vehicles used to reach the new services, it is very important that the most important parking areas are clearly identified with the real time availability of parking places.

In addition, as well known all over the world, every September Monza hosts the Formula 1 Grand Prix, and more than 100.000 people approach the city; InfoPark will be very useful also for this purpose. The panels carrying information concerning the occupation rate of car parks will be enriched with messages to be used also for general information about traffic which will be very useful not only during Formula 1 Grand Prix, but also for daily commuters.

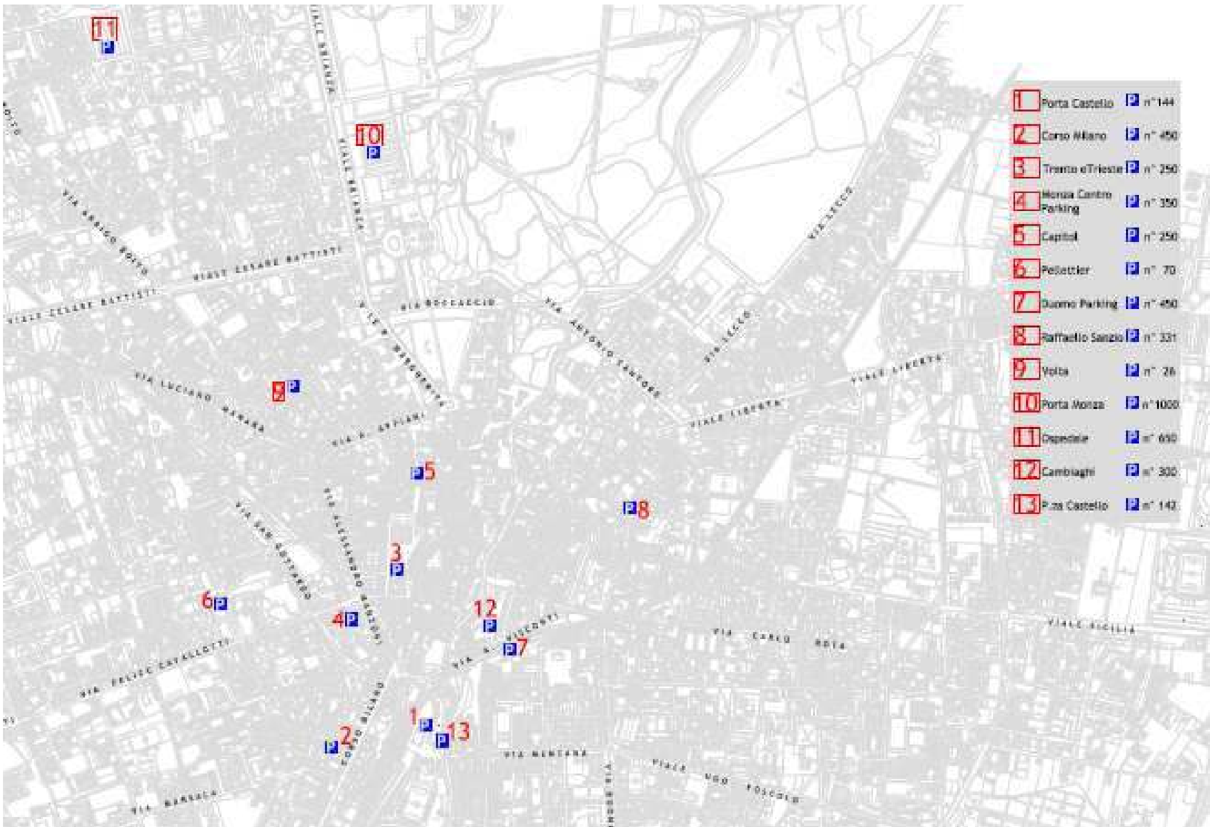

Figure 11. Location of the parking areas in Monza.

Most of the parking areas in Monza are located close to the Historical Centre, as shown in Figure 11. As known, drivers are attracted to reach the city centre, but parking areas are not always equally used, so the result is traffic congestion due to cars driving round looking for available parking places.

With the implementation of the InfoPark system, people reaching Monza by private car will be correctly directed to available parking areas, minimising time spent looking for them and consequently reducing traffic congestion and pollution.

The aim of this measure is to design and implement a real time parking guidance system that will inform drivers about the occupancy rates of the most relevant parking in the city of Monza.

Identification of Parking Areas
The first task accomplished is the identification of the parking areas to be considered by the system. There is a distinction among the parking areas in that some are owned by private companies and others are public areas currently assigned by the Municipality to TPM Company, which is a private company 100% owned by the Municipality of Monza.

Meetings were therefore arranged with the companies owning the most significant parking areas in the City, aimed at gaining the approval to implement the measure. An agreement between parking owners and Comune of Monza about the location of the signs and about reciprocal obligations concerning the implementation of the measure has been substantially reached.

Study of the Road Network and Related Traffic Flows
A study has been conducted on data collected in the draft of the General Urban Traffic Plan, which is going to be adopted by the City government, analysing traffic flows within peak hours on the major ring- and radial routes in Monza.

Identification of position for signs
Once the parking areas to be included in the system had been identified and road network and traffic flows had been analysed, experts from the Municipality proposed the location of the signs, both static and dynamic, as depicted in Figure 12 and Figure 13.

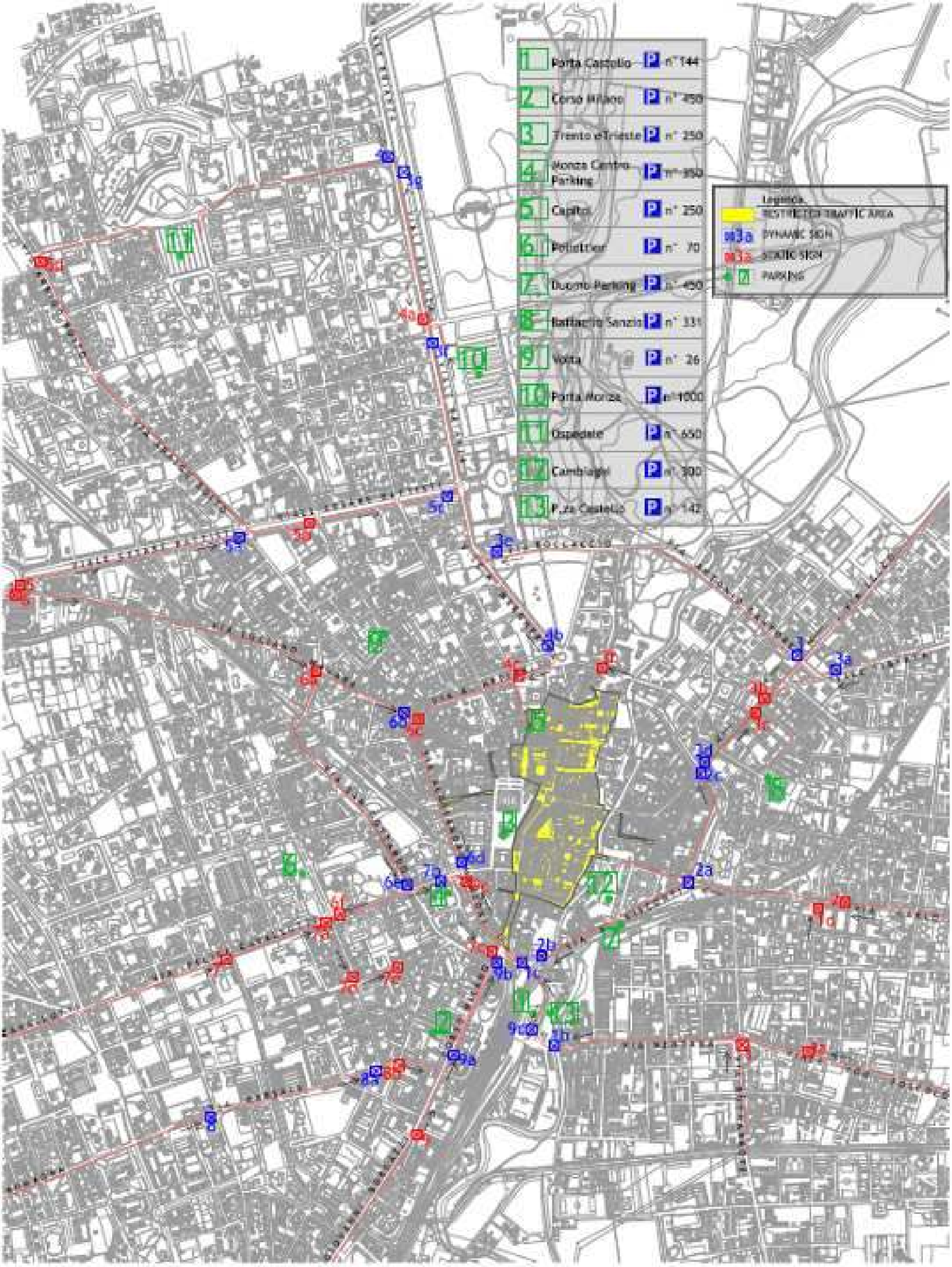

Figure 12. Monza general plan: identification of position for signs.

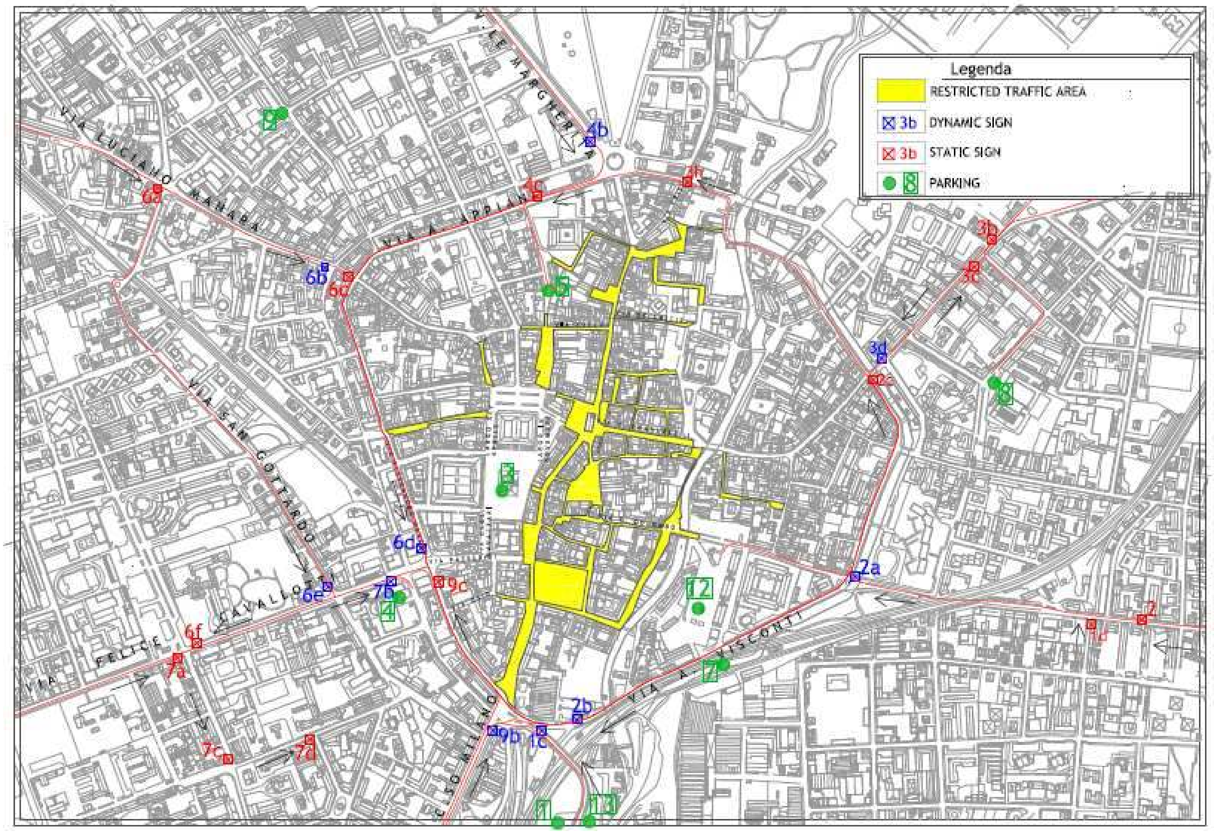

Figure 13. Monza historical centre: identification of position for signs.

Nine principal routes approaching the historical centre have been identified. It has been decided to direct traffic flows towards the nearest parking area along the route, in order to distribute flows in a homogeneous way in the city and to avoid traffic congestion in the historical centre.

The first signs along each route are static indications since they indicate parking areas near the historical centre, without giving the number of available places which could change before reaching the area. Dynamic indications have been located in proximity of important crossroads, in order to direct drivers to the chosen parking area, giving in that moment the information about available places.

It has been decided to equally distribute the number of dynamic signs between the different parking areas in order to consequently obtain an equal distribution of traffic flows in the city.

InfoPark Monza is constituted of the following functional interrelated components:

- *Data Collection component*: this is aimed at gathering data concerning the availability of free places in the car parks included in the system.
- *Data Management component*: all data collected are kept in databases (relational or object oriented) for their processing; in addition, a specific software application must be provided to manage the system;
- *Data Communication component*: this is aimed at ensuring the communication between the Control Centre, the car parks which generate data and the VMS spread across the city;
- *Data Processing component*: information collected are checked before their use;

- *Data Presentation component*: data concerning the status of the car parks and the number of free places will be communicated through Variable Message Signs (VMS) spread across the city and through a specific Web Server that can be accessed by standard PCs as well as mobile devices (e.g. simple mobile phones, Smart phones,…).

InfoPark Monza is designed to be encapsulated in a wider ITS system that will encompass all the technological systems concerning Mobility management in the city; some of them are already installed (e.g. video surveillance), others will become available within the ARCHIMEDES project lifetime, whilst others are expected in the future.

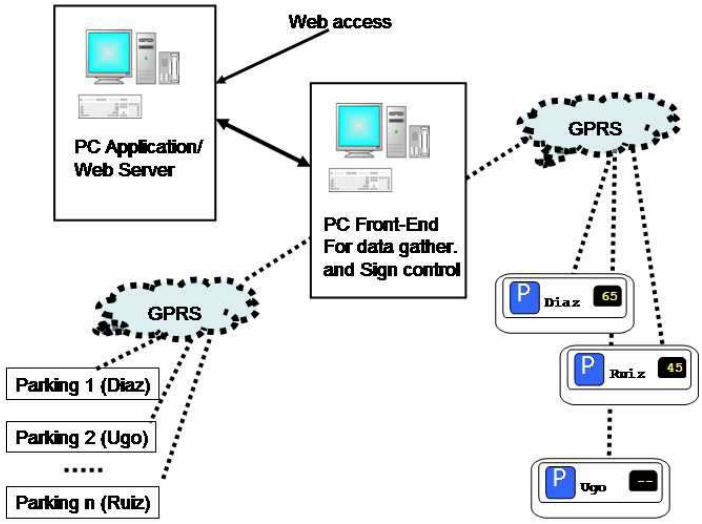

Figure 14. InfoPark Monza as a part of a wider technological system concerning Mobility management in the city.

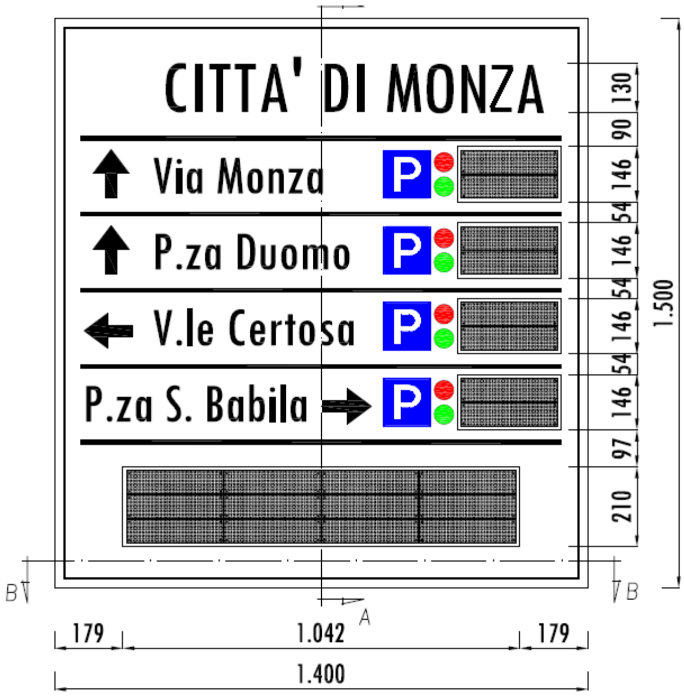

Figure 15. Example of VMS to be installed.

4.6 Deliverable R81.1

Study of UTC System Technical Design in Monza
The aim was to design and implement an Urban Traffic Control (UTC) technological system that contributes to maximize the flow of traffic through the identified CIVITAS corridor in the city of Monza.

The CIVITAS corridor for private vehicles is depicted with the dark line in Figure 16. This corridor has been selected since it is the main route to bypass the Centre of the City on the North of the city. The corridor consists of eight intersections divided into two coordination groups.

Figure 16 also presents a second corridor mainly dedicated to Public Transport (depicted by the orange line). This second corridor is affected by many Public Transport routes, which end at the Porta Castello interchange node, located at the bottom of the orange line close to the central Railway Station of Monza, and is used in measure 82.

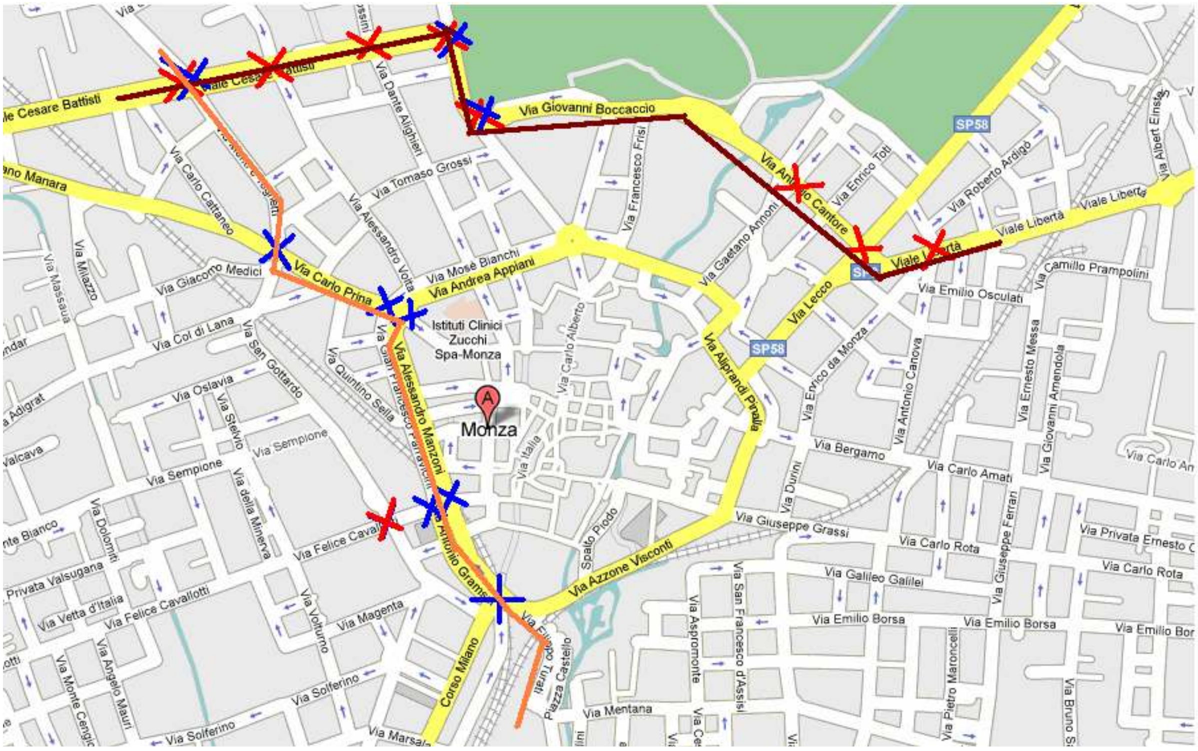

Figure 16. The CIVITIAS corridor in Monza.

The intersections to be centralised to the UTC system are identified by red and blue crosses. Blue crosses will implement the approach provided by Roadmanager® UTC system to manage Public Transport priority requests faced in depth in Measure no. 82 and related deliverables.

During December 2008, an intervention plan was agreed among the traffic experts of the Municipality of Monza and technicians of Project Automation. The plan started with a deep analysis of the equipment installed in the eight intersections of the first corridor, which showed that it was not possible to centralise the Traffic Light Controllers. Therefore, the Municipality decided upon an equipment upgrade to the most updated version of the Hydra model. The upgrading was carried out during July and August 2009, so the eight intersections involved in the first corridor could be centralised by the end of October 2009.

As part of the second step of the agreed plan, Project Automation asked the Municipality of Monza for a Hydra Traffic Light Controller in order to test in the laboratory software protocol used to exchange information among the UTC system and the controller. The controller was made available at Project Automation premises in January 2009 and specific tests were carried out to test the protocol. The objective of this session was to ensure a correct communication as well as the correct behaviour of Hydra. The test session concluded that the compatibility of the laboratory software protocol was good.

Figure 17 presents the architectural scheme for exchanging information between a controller and a UTC system.

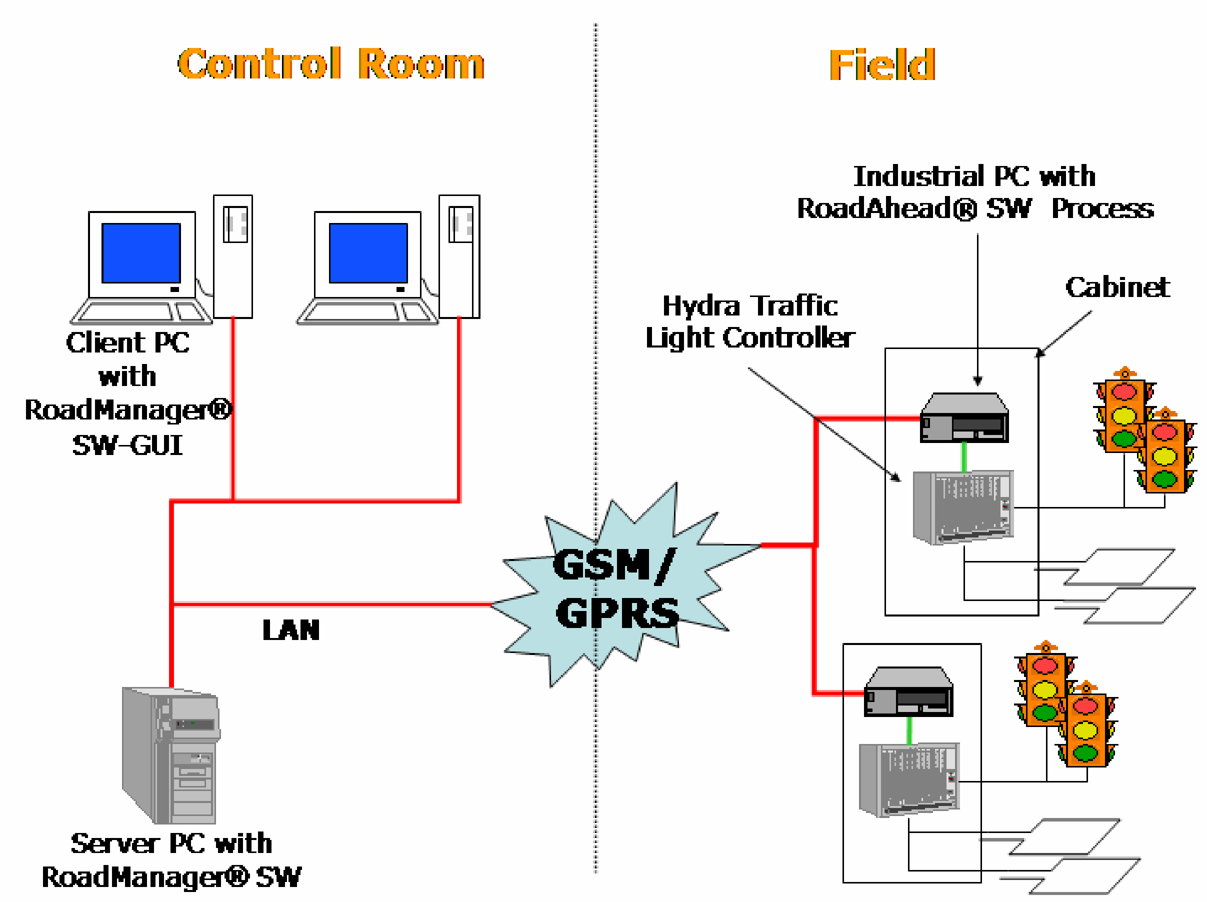

Figure 17. UTC reference architecture.

In order to perform the adjustment of the traffic lights controller to make them suitable for a centralised UTC, the experts of Project Automation have performed an audit of the existing equipment. The audit identified the need for a few technological solutions that have been evaluated. Finally, it has been decided to build a small aluminium board that will be installed within the cabinets to house the controllers.

At the time of dissemination the equipment to be installed in the technological cabinet had been ordered and was expected available in September 2009. The mounting of the equipment was expected to be carried out by the end of October 2009.

Once the Industrial PC installation has been completed and the link with the TLC established, the current traffic light plan operational on the TLC will also be configured within the RoadAhead® system, which will then take over the control of the TLCs. The local controllers will continue performing all the necessary safety controls (intergreens, minimum times, amber times etc.).

Setup of the equipment at Central level (server PC, client PCs) and installation of the RoadManager UTC application licensed by Project Automation was expected to take place by the end of year 2009.

In order to establish a communication between the control centre of the UTC system and the peripheral controllers by the intersections a wireless technology has been selected. This technology has a modest management cost, without any particular civil work and it is very flexible and allows to transmit/receive data using GMS/GPRS technology. The industrial PC will have a router able to house a SIM capable of data communication and configured to establish a protected connection with the network of the central control system.

A micro simulation model of the first corridor has been created. By September 2009, the model included four intersections in the corridor, whilst a fifth section was expected soon to be included. The model had already reached a good level of reliability. The simple model was also used to show the Municipality of Monza the benefits of micro simulation in allowing the validation of control strategies before deploying them.

The level of detail achievable with modern micro simulators is such that once a model has been created it can be used to test the result of the application of new policies without costly experiments on the road. In the future, the model of the CIVITAS corridor will therefore be used to validate all the traffic control plans to be developed for the UTC.

4.7 Deliverable R82.1

Study of Public Transport Priority Management in Monza
In the context of encouraging sustainable mobility, the use of Public Transport in the City of Monza needs to be increased. In order to achieve this objective, within the ARCHIMEDES framework a clear decision has been made, which has the full support of the government of the Municipality. This is based on the implementation of technological measures to make Public Transport more attractive to citizens.

Through measure no. 81 (“UTC System in Monza”), several intersections have been controlled by the Urban Traffic Control (UTC) System which implements the coordinated and centralised control of traffic lights.

Through measure no. 78 (“Bus Management System in Monza”), the buses of the Public Transport fleet are localised and monitored closely, i.e. it is known where each bus is with respect to its scheduled timetable.

This measure (no. 82, "Public Transport Priority System in Monza") is concerned with implementing a framework that allows for the traffic light plans of the intersections (managed by the UTC) to change when the actual situation of the buses would benefit from more green time at these intersections (so long as the overall traffic status allows this).

Within the main research task, the work has focused on a conceptual approach to increasing public transport use and implementation activities needed to achieve this. In particular, the following activities have been carried out:

- Detailed statistical analysis of the actual performances of the buses in critical segments of the corridor. This is required in order to gather quantitative data about delays and to characterise the situations found in the current regulatory framework. This is an important prerequisite to perform the measure;
- Definition of criteria to be applied to decide when a priority request should be issued to the UTC system;
- Management of the priority request and issuing to the UTC System;
- Fulfilment of the priority request within the UTC system.

It has to be highlighted that, except a single situation, where a bus lane enters one of the chosen intersections, the buses travel in the same traffic streams as private cars.

In Figure 18, the corridor for Public Transport is highlighted with an orange line and the intersections involved are shown as blue crosses.

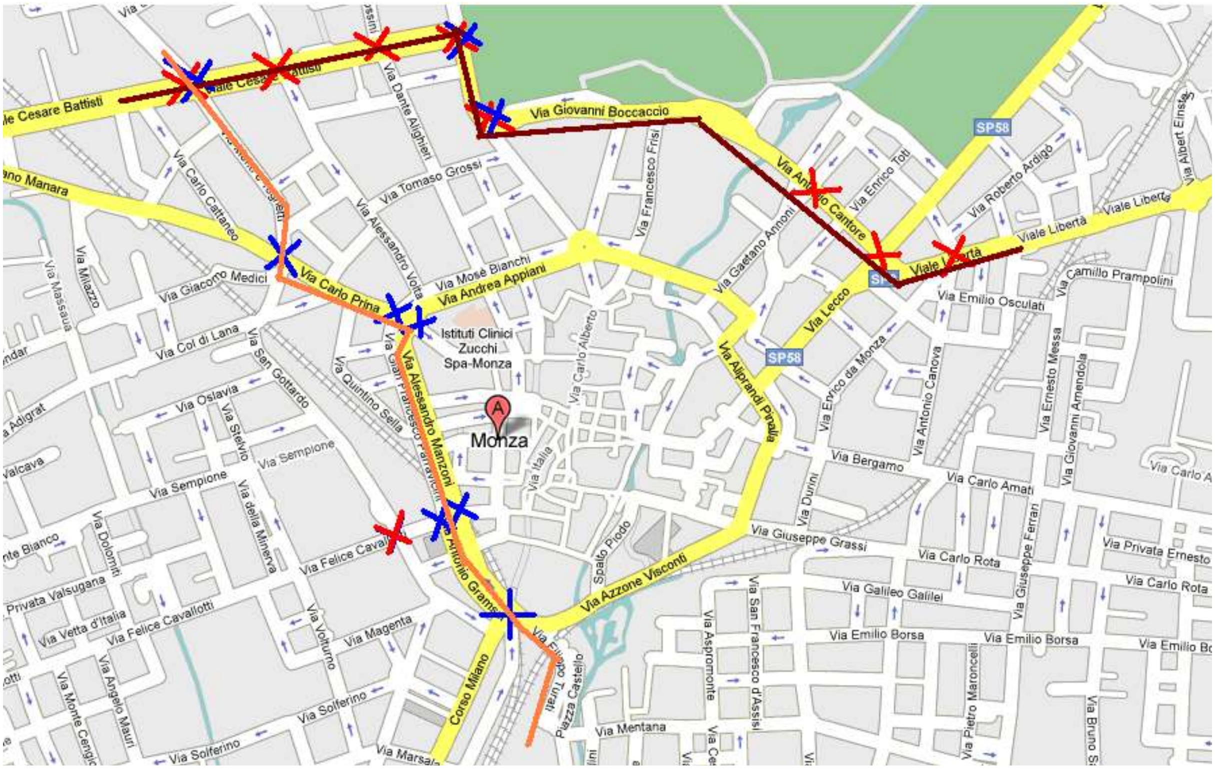

Figure 18. The public transport corridor is highlighted with an orange line.

Statistical Analysis

A detailed statistical analysis on the travel time of buses in selected stretches of the corridor has been delivered. For this purpose travel time data since September 13th 2010 up to the end of November 2010 has been collected. The choice of this starting date is due to this being the start of term for schools, which often causes significant demand on public transport and the road network.

One of the analysed intersections (Battisti-Boito-Monti Tognetti) is shown in Figure 19. The traffic light at this intersection is already operating within the UTC environment. Therefore the data collected through the AVL/AVM system has enabled data regarding the travel time of the buses to be gathered.

Data analysed concern the lines z206 and z266, which operate on the route identified by the blue line and the monitoring markers in Figure 19. These lines connect the hospital with the centre of the city through the CIVITAS PT corridor. In addition to the existing bus stops, some other relevant points (virtual stops) have been defined to monitor the buses in those positions.

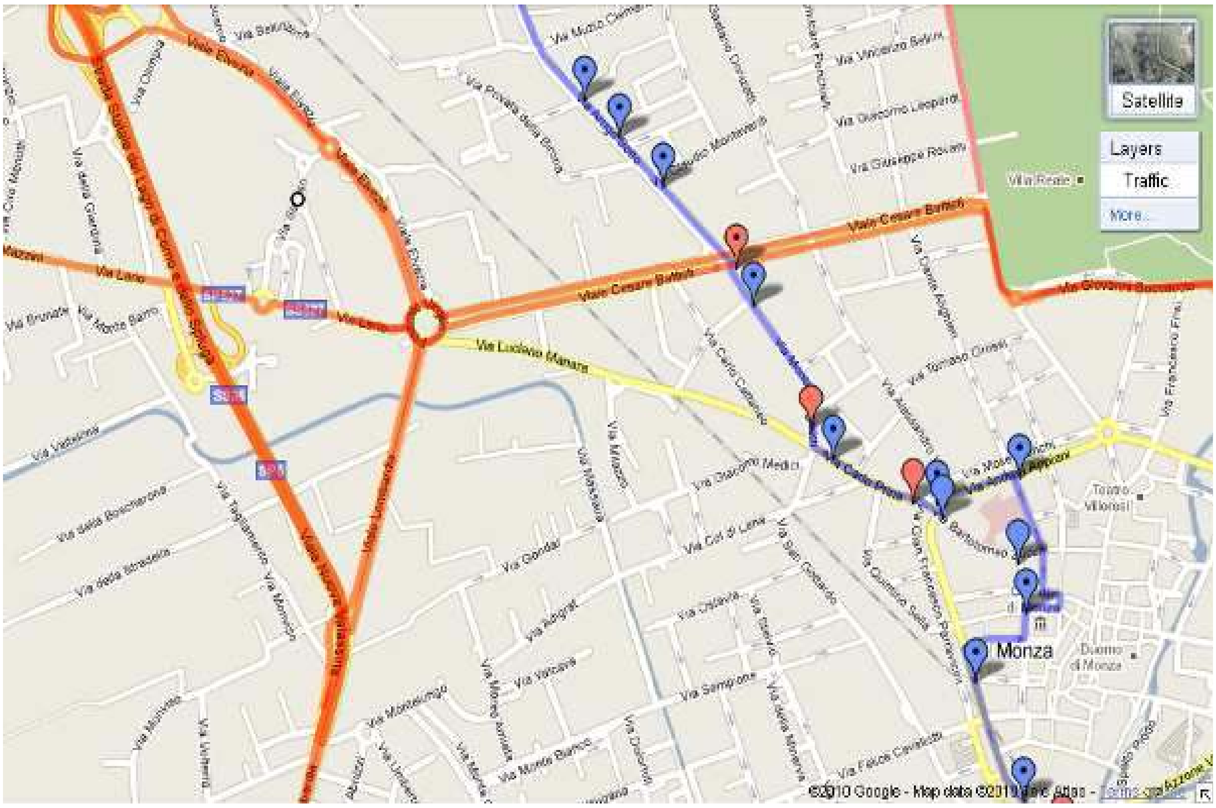

Figure 19. Markers which identify the bus stops (blue) and other monitoring points (red).

Travel times between pairs of bus stops were analyzed. This analysis has the following aims:

- It allows analysis of the expected arrival time at a given intersection; in this specific case the attention is paid to the intersection belonging to the corridor where it is possible to satisfy priority requests;
- It provides an estimation of the congestion of the link involved;
- It provides raw data to analyse the behaviour of the Public Transport lines in different traffic conditions (working day or week ends, peak and off-peak hours, etc).

After collection, pre-processing and cleaning of travel time data, it was analyzed which time slots where travel time of the buses of Public Transport is negatively affected by general traffic conditions. From this analysis, the following aspects emerged:

- Travel times have peaks entering Monza from 7am to 9am; it is well known that traffic demand is very high at this time;
- In the opposite direction, the morning peak is not so critical but the increase in travel time measured between 4pm and 6:30 pm is significant.

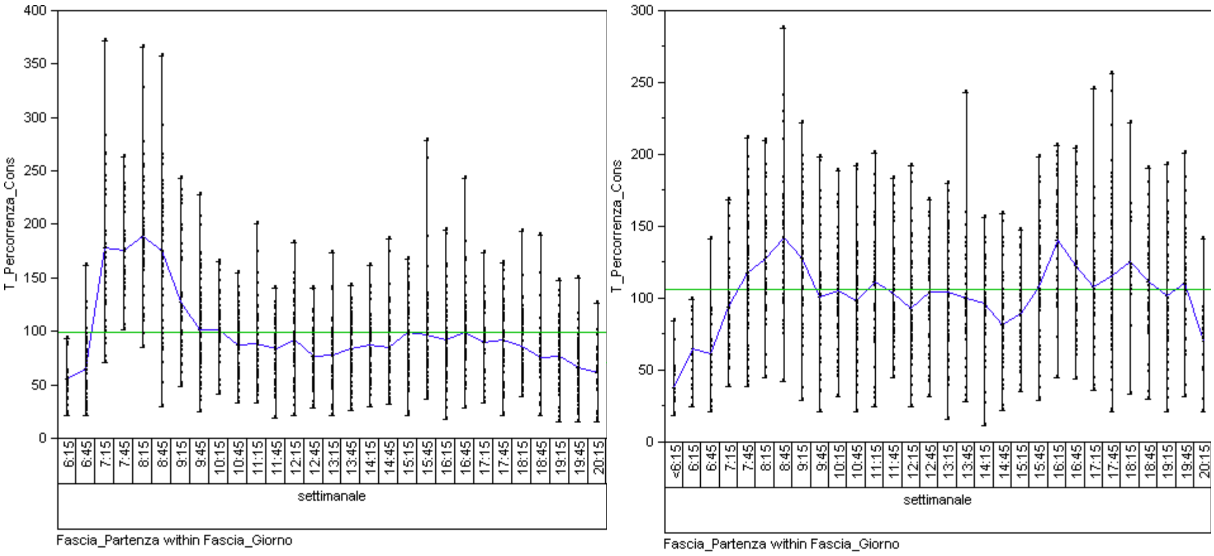

Figure 20. Travel times between Boito-Battisti and Battisti-Monti e Tognetti bus stops (and viceversa).

Distributions of travel times show a relatively high standard deviation. This is due to two different factors:

- A variance due to the traffic light cycle (if the bus approaches the intersection with the green light, the waiting time is low; but if the bus approaches the intersection with the red light it must wait about at most one minute);
- A variance due to the unpredictability of traffic.

Considering the intersection proposed, the Coefficient of Variation (Standard Deviation divided by Mean) takes comparable values for the three time slots; this holds also for the other intersections analysed and means that the slots were successfully determined.

A second analysis that has been carried out was aimed at searching for a correlation between travel times of subsequent stretches. The hypothesis to be assessed through data analysis is whether the travel time spent by a bus of the stretch A-B is correlated with the travel time spent on the subsequent stretch B-C.

This problem is interesting for the context in which priority requests can be issued since if travel time A-B predicts travel time B-C, it is possible to anticipate the issuing of eventual priority requests. The correlation analysis hasn’t provided significant results; the reason is the high variance already pointed out in the former analyses.

Criteria for Issuing a Priority Request to the UTC System
A policy concerning whether to issue a priority request or not is needed to be implemented in the system.

Four proposed criteria have been adopted and are presented in Table 1.

Criterion name	Color in Figure 21	Criterion description
Priority 300	Red	Priority request is issued if the expected delay is greater than 300 seconds.
Priority 180	Orange	Priority request is issued if the expected delay is greater than 180 seconds.
Priority St. Dev.	Blue	Priority request is issued if the expected delay is greater than the standard deviation of travel time for the stretch for that time slot.
Priority 0	Green	Priority request is issued if the expected delay is greater than 0.

Table 1. Criteria for issuing priority requests.

The number of buses for which a priority request is issued according to the four proposed criteria outlined above has been assessed. An example of the behaviour of the real offset compared with the expected delay computed in advance is presented in Figure 21, grouped by time slots. The different colours represent the single observations for which the request would be issued. The bus runs relating to the red point would issue a priority request.

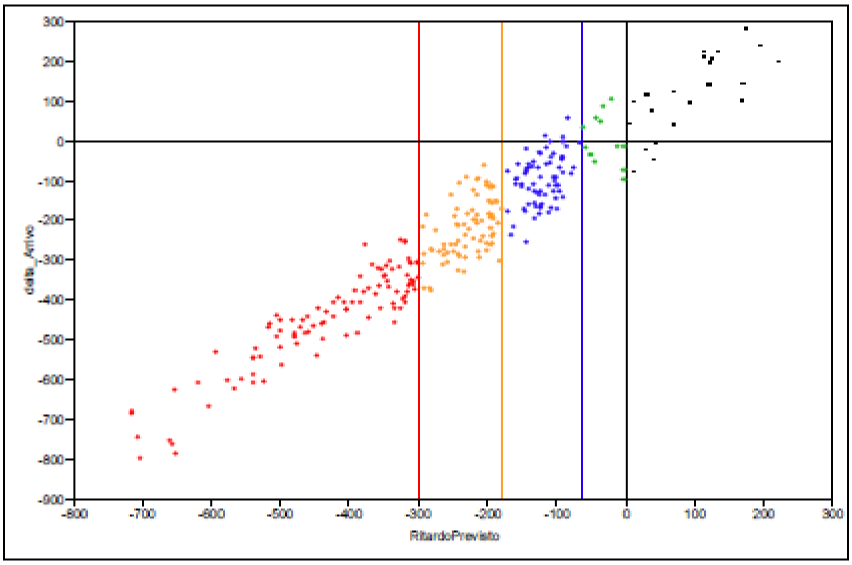

Figure 21. Priority requests in working days, morning peak hours, direction: Centre.

The final decision about which criterion will be adopted will be the responsibility of the Municipality; other criteria could be identified in the progress of the project based on other considerations. For example, an intermediate approach could be applied (Priority 180s) but if this worsens the flow of private cars too much a more restrictive scheme could be applied (Priority 300s).

Management of the Priority Request

As far as the realisation of these requests is concerned, other organisations need to be involved. These are shown in Figure 22.

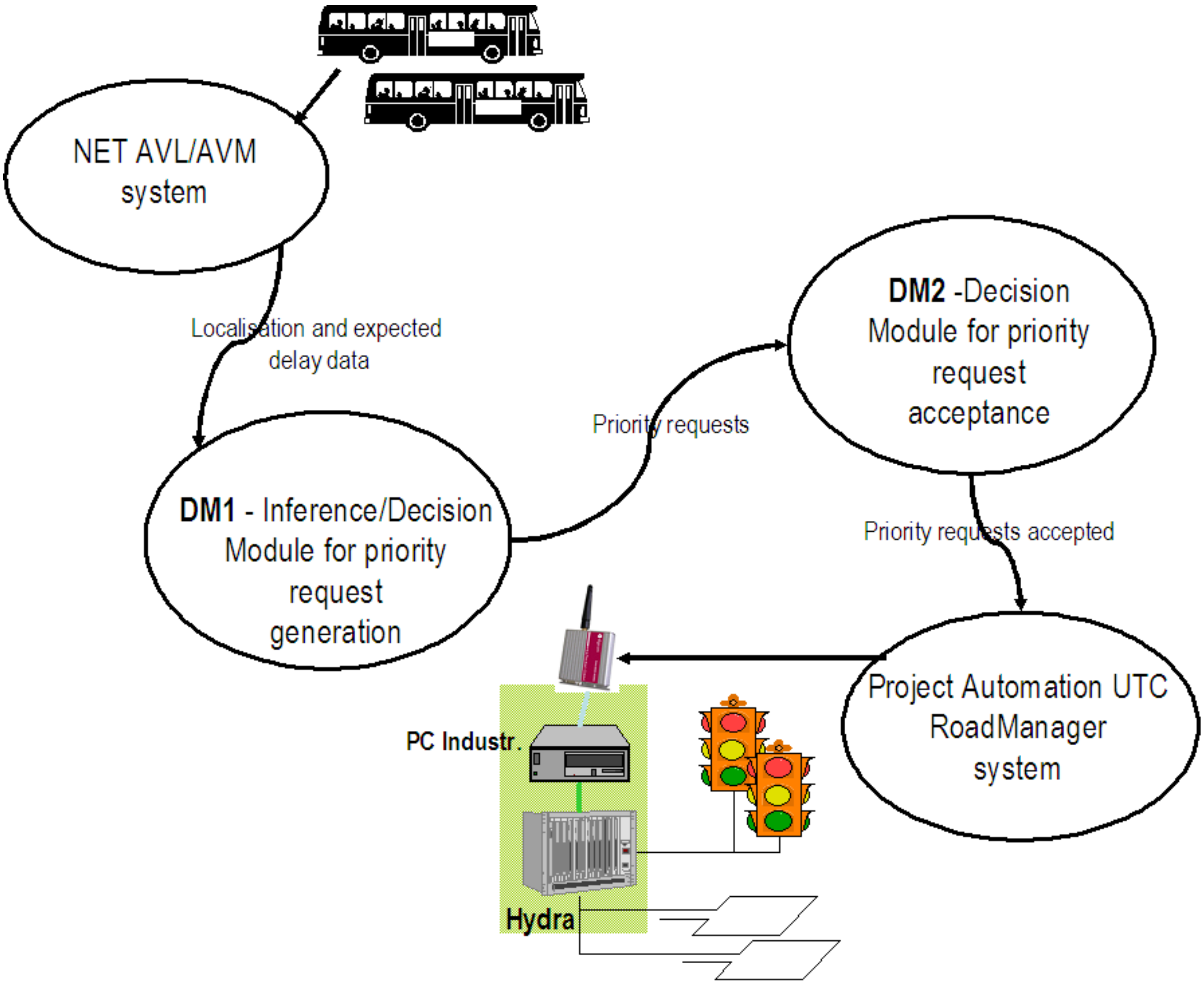

Figure 22. Functional flow for management of bus priority requests.

The functional flow involves four elements:

- The AVL/AVM system which generates localisation and monitoring data of the Public Transport fleet; starting form these data, it is possible to compute the "expected delay" feature;
- A first decision module (DM1), which is aimed at taking decisions on which priority requests generated by the actual behaviour of the Public Transport service are to be issued. This module will apply one of the decision schemes in Table 1 and is continuously updated since it accesses through appropriate Web-services to a dedicated Web Server made available by AVL/AVM system, in order to keep updated the "Expected Delay" feature which represents a degree of need of priority for a given run of a Public Transport bus.
- A second module DM2 which processes the priority requests issued and must decide which of them can be fulfilled. important objective of this decision module is to solve conflicts among different priority requests;
- The UTC system, namely the RoadManager Suite running in the city of Monza to manage the centralised traffic lights. The traffic light plans concerning the intersections belonging to the corridor for Public Transport priority management will be designed and coded to fulfil priority requests. The central component of the UTC system will forward to its peripheral software component managing the relevant intersection the proper information to serve the priority request to be delivered.

5. Conclusions and Recommendations

5.1 Main Research Outcomes

Aalborg, Donostia - San Sebastián and Monza have completed Transport Telematic research studies in a local context and now have a good picture of challenges and possibilities towards improving traffic flow and reducing congestion levels.

The results from the study of the travel time in intersections in Aalborg show that an algorithm can be used to describe the quality of flow and congestion levels during peak hours at the intersections. However, the algorithm requires a fairly large number of trips if the travel time in intersections is to be reported in quarter hour intervals. Such a fine accuracy is needed to be able to determine when the rush-hour actually starts and ends. Moreover, the method indicates which directions in the intersections suffer from the biggest delays - a useful tool to assess and improve the current signal schedule.

The literature review and studies in Aalborg recommended that data about congestion are built on Floating Car Data (FCD) to get sufficient coherent information. FCD should preferably be based on GPS data. Travel and congestion real time information is a very fast developing area and substantially changed recommendations might appear within short time from the time of the literature review.

The research conducted by the city of Donostia - San Sebastián into installing Variable Message Signs (VMS) informing car drivers about free parking places in Park & Ride areas in real time throughout the city has been used to define the system that will be implemented in Donostia - San Sebastián and reported further in ARCHIMEDES Deliverable T75.1. The Parking Guidance System is expected to benefit drivers and everyone in the city. In the city of Monza a similar study has been completed by PA and TPM. The Park & Ride Guidance System is designed to be encapsulated in a wider ITS system that will encompass all the technological systems concerning Mobility management in the city; some of them are already installed (e.g. video surveillance), others will become available within the ARCHIMEDES project lifetime, whilst others are expected in the future.

The city of Monza has elaborated a system used for Bus Traveller Information and Public Transport Priority Management by implementing and integrating an AVL/AVM system, a UTC System and a VMS system. The UTC system contributes to maximize the flow of traffic through the identified CIVITAS corridor in the city of Monza. The AVL/AVM system provides information necessary to show through Variable Message Signs (VMS) installed at several important bus stops in the city the expected schedule for each monitored TPM bus and to announce the arrival of a bus at an intersection managed by an Urban Traffic Control (UTC) system for the coordinated control of traffic light controlled intersections.

In the approach proposed, the AVL/AVM, UTC and VMS systems keep their own independency, which means that each of them has its own functionality, architecture, technology for sensors and devices.

Therefore a common conceptual model to define which information needs to flow between these systems to achieve interrelated functions is required. The specific functional and non-functional requirements for integration, as far as the AVL/AVM system is concerned, are:

- Requirement 1: the information should be available from the AVL/AVM system to the final ARCHIMEDES application (UTC, VMS) in “real-time”: i.e. the information must be available at the receiving application within a few seconds of when the position of a bus is gathered;
- Requirement 2: in order to provide the appropriate information as required by the final applications in the ARCHIMEDES project (UTC, VMS), the AVL/AVM system should be configured in relation to specific, selected sites relevant to the locations of the VMS displays and intersections where the UTC is active;
- Requirement 3: Data received from the bus by the AVL/AVM system should contain at least information of the line id, the direction of the line, the bus id, the site id, the time forecast and the status of the bus (On time / Delayed / Ahead of Schedule / Not Available). Should other information be available, it would be helpful to know it (in a format that matches the relevant fields in the other systems).
- Requirement 4: the protocol that is to be used by the AVL/AVM system to update the forecasts has to be specified. This is important for the final consumer application to know how it will get such information and keep it updated. (For example, forecasts may be automatically passed through on a regular basis, or forecast updates may only be notified through specific protocols and/or messages if there is a significant change from the previous situation).

At the time of dissemination, the research stage concerning the application of a UTC in Monza was not completed, as the entire chain of signals had yet to be proven effective; the demonstration tasks will start deploying the activities on all the intersections involved in the project once the entire chain is proven effective.

Regarding the Bus Traveller Information System, the effective collection of data related to the movement of the buses of the fleet across the city of Monza has been fully accomplished through the AVL/AVM System. Devices to be installed (electronic displays and interactive totems) have been selected by NET and the Comune of Monza and their functions will be tested during the demonstration activities.

5.2 Problems Identified

Not many technical problems have been identified in the completed research studies. With regards to the Park & Ride Guidance System in Donostia - San Sebastián there were difficulties determining the optimum location of the panels because their installation could affect the width of the pedestrian route available and /or would impair the visibility of existing signposts. This is due to the spatial constraints encountered in consolidated urban areas especially at major crossroads where there is little available space since it is occupied by traffic lights, traffic signposts lampposts, trees etc. An effort has been made to locate the panels after the crossroads, in central reservations, in gardens with low vegetation. Problems have also been experienced regarding the disruption of the automatic counting systems for unoccupied parking spaces due to blockage of the entry or exit lane at parking facilities without a manual over-ride system and staff available to log cars on exit. This has possibly been due to road closure or different city centre events. Therefore the operator must now manually report the occupation status of the parking facility when entry and exit lanes are blocked.

No functional issues have yet been identified in Monza. However, the merging of TPM and NET has underlined the importance of the system not being dependant on data from only supplier. It is therefore of high importance to be able to continue to operate an AVL/AVM system if the supplier changes or is replaced.

5.3 Mitigating Activities

Due to the fact that all measures have been research studies there are no mitigating activities to report in this deliverable.

5.4 Common Themes in Relation to Transport Telematics Studies

Workpackage 8 focuses on researching and designing different systems towards improving traffic flow, improving information to road users and passengers using public transport and reducing congestion in cities.

ITS can help to optimize traffic flow and congestion on existing road networks. Both the planning and the operating of systems based on ITS are dependent on an input of data, and preferably real time data. Real time data can be processed and used as a reliable real time service to road users. But they are also important to optimize the operation because they give a detailed knowledge on the flow on the road network. This information has another application as it can be used to develop forecasts that allow travellers to consider alternatives prior to their journeys.

Aalborg's study of the travel time in intersections points out that it is very important to have a sufficient amount of real time data. Data also needs to be of a certain quality and structure, and it is also important that data can be used for several purposes. There are many potential data sources, i.e. Bluetooth, GPS, Video, Loops etc. A wide range of technologies for controlling traffic flow exist on the market now and are in development for the future. This makes it difficult to formulate a universal plan for all cities to adopt.

Aalborg's study of the next generation navigation systems points out, that congestion data should be from Floating Car Data and preferably GPS data. Travel and congestion real time information is a very fast developing area, though, and therefore the situation could be vastly different within the next few years.

Using variable congestion data has become a more common way of informing road users about the actual traffic situation, i.e. through Variable Message Signs (VMS) that are being implemented as part of the Park & Ride Guidance Systems in Donostia - San Sebastián and Monza to inform road users about the parking situation at the major car parks in the city and thereby reduce congestion and improve traffic flow.

The merging of TPM and NET in the City of Monza has underlined the importance of a system not being dependant on data from only supplier. It is therefore of high importance that any system has open protocols and clear interfaces if the supplier of data changes or is replaced, which was the case for the AVL/AVM system in Monza.

The integration of different systems will help attain a maximum effect. In the City of Monza, the integration of the AVL/AVM Bus Management System, the UTC System and the VMS System has made it possible to make localization data collected by the buses of the Public Transport Fleet available as Real Time data and has also made it possible to setup a framework for the Public Transport Priority Management System.

Likewise in the City of Aalborg, it has been shown that the method in the study of travel times in intersections can be used for both measuring congestion levels and delays and indicating which directions in the intersections that suffer from the biggest delays - a useful tool to assess and improve the current signal schedule.

The studies indicate that it is important to consider the broader perspective and possibilities when introducing ITS systems. The value of data is multiplied if quality is ensured and different possible applications are considered. By processing the information there is a number of ways to use it to affect the traffic in cities, both for municipalities, road managers and transport operators.

5.5 Future Plans

As an outcome of the research study concerning collection of congestion data and dissemination of information the City of Aalborg has set up a congestion information scheme in partnership with the navigation unit provider TomTom. The congestion information scheme must show the congestion level on the major roads in Aalborg in half-hour intervals over the day and will be shown on maps available for road authorities and road users. Data collection to TomTom is ongoing and congestion information becomes increasingly reliable over time. The congestion information scheme will be disseminated in a separate deliverable.

The full implementation of the Park & Ride Guidance Systems in Donostia - San Sebastián and Monza will take place during the demonstration phase of these measures. This also includes reporting the occupations of the Park & Ride areas and recording the evolution of necessary maintenance tasks. Donostia - San Sebastián also have focus on checking the accuracy of information provided by the operator of parking areas affected by events which must be reported manually. Furthermore, Donostia - San Sebastián will be conducting an on-street survey throughout the city regarding user satisfaction levels after implementation of the system.

The full implementation of the Bus Traveller Information System in Monza will be carried out and its functions will be tested during the demonstration activities. NET has already started inspections on the locations of the 30 bus shelters to be installed according to the updated project work plan. The first bus shelters will be installed along the CIVITAS corridor and at the most important bus stops in the city by March 2011. In the same period the wide screen in Porta Castello will be installed.

The proposed technological framework is designed to host other functions that could be implemented in the future, such as:

- Software applications to provide information through SMS service;
- Software applications to provide information through a Web site;
- Installation on buses of screens to provide passengers on-trip information.

Another important possible extension is the management of data related to other Public Transport fleets; in the city of Monza other PT operators are active where the regulatory framework has been presented. For these purposes, the DB Real-time Updater server (see figure 9) should be fed by data originated by such fleets through specific software interfaces (e.g. Web services).

The proposed approach in the study of Public Transport Priority Management, both on the conceptual and technological side, is open to the management of other Public Transport fleets operating in Monza. In particular, referring to the functional flow, other AVL/AVM systems are used by other fleets: a software interface, based on Web service, could be the way to feed the Decision Module 1 with priority requests originated by other fleets. Following this approach, each fleet will refer to its AVL/AVM system; only relevant information will be gathered from it if priority actions could be helpful to increase the service level.

The number of traffic lights can be extended as well: the UTC system can manage without problems the eighty traffic light controllers operating in Monza.

The demonstration stage will be used to assess and consolidate the approach proposed in the study of Public Transport Priority Management.

Further deliverables will provide information about the implementation of the various systems and any common issues that arise.