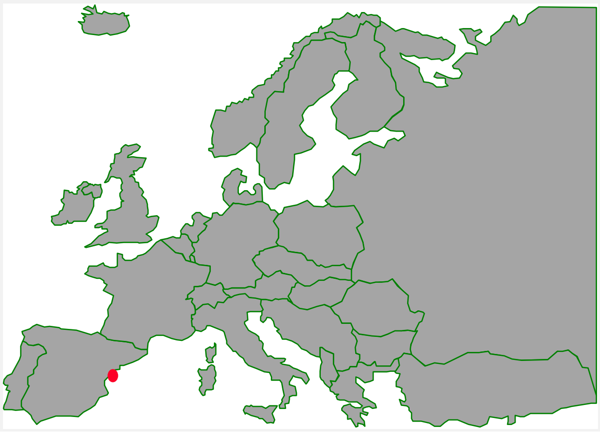
DEMONSTRATION SITE:	VALENCIA/SPAIN 
NAME OF THE DEMONSTRATION PROJECT (CASE STUDY):	AUSIAS PUBLIC TRANSPORT: BUS PRIORITY AT CROSSINGS, DYNAMIC SCHEDULING, INTEGRATED FLEET MAINTENANCE
DURATION OF THE PROJECT:	01.01.1996 – 31.12.1998
NAME OF THE TAP PROJECT:	AUSIAS ADVANCED TRANSPORT TELEMATICS IN URBAN SITES WITH INTEGRATION AND STANDARDISATION

URBAN PROFILE

Valencia is the third largest city of Spain, the capital of the Province and the Autonomous Region of Valencia, located in the Mediterranean Arch. Valencia has about 1.421.000 inhabitants in the metropolitan area and an average of 3 million trips/day. Due to its history, Valencia is today a major tourist centre. It is also one of the Spain's most important industrial centres, with a dynamic commerce and industry.

A recent study revealed the fact that in Valencia almost 66% of the families own at least one car. In the area of public transport, 44% of the people use it for their travels around the city. The most used public transport mode is the bus (80% in the urban area and 60% in the metropolitan area) while trams and metro serve the remaining passengers.

ABSTRACT

For the demonstration of a number of applications in the AUSIAS project (Dynamic Plan Generation, Information Exchange between Traffic Control Centres, Dynamic Scheduling and Bus Priority), a wide area of the city (12 km^2), representative of the traffic and transport problems of the overall city, has been selected.

One key element of the transport policy of the city of Valencia has been to promote Advanced Transport Telematics (ATT) to improve traffic management and reduce congestion and negative environmental impacts of traffic on the urban area .

The AUSIAS project demonstrated how the integration of different telematics sub-systems within a common architecture could lead to considerable improvements of the urban transport situation at the test site.

With an overall cost of 2.418.675 ECU, the applications areas covered by the AUSIAS project were Traffic management, Public transport management and Dynamic information to users. In

each application area, specific solutions have been implemented and demonstrated. In all the cases, exchange of information and co-ordinated operation among the different systems has been achieved. The applications demonstrated in the AUSIAS project rely on three principles : integration, standardisation and introduction of new technologies.

In Valencia the quality of bus services could be improved by stabilising and gradually reducing bus journey times. The following Public transport management subsystems demonstrated and validated in the area of public transport are described in detail in this study: Bus priority System, Dynamic scheduling of public transport, including real-time rescheduling and Predictive Bus Maintenance.

An integrated approach to public transport priority for buses running behind schedule (timing of buses detected at traffic lights) and dynamic creation of schedules has been shown to be effective in moving towards these aims. On average, the improvement in journey time for the integrated (manual) bus priority reduced the journey time by 30%. In terms of fuel consumption, the average reduction was 1750 Euro/line. In terms of emissions, these total to an average reduction of CO-emissions of 7 kg, and a reduction of Nox of 14 kg per year per line. The net indirect socio-ecomonic benefits are calculated on average at 10.800 Euro/line/year.

After being demonstrated in AUSIAS, the Public Transport Priority System for example can be applied in any other European City when the proper basic infrastructure is installed.

The AUSIAS example shows that considerable positive impacts on the overall urban transport situation can be achieved through Integrated Traffic Control and efficient Public Transport Management. It is likely that if Public Transport Management efforts will continue in future and are integrated into the overall strategy to better control (and reduce the volume of) private cars, then the city will be able to reach to a sustainable increase of the number of Public Transport Passengers. Only the integration of all the sub-systems within AUSIAS will lead to an increased use of Public Transport, quicker journeys into and out of the city, less pollution and a better use of the city's infrastructure.

BACKGROUND AND OBJECTIVES

In recent years, the following advanced Transport Telematics systems and technologies in different application domains have been installed and financed with over 15 Mecu. of investments from the Spanish Administration : an advanced Traffic Control Centre, 800 centralised intersections, 450 CCTV cameras, 50 VMS panels, 480 Public Transport buses, 50 Public Transport lines.

The key objective of the AUSIAS project was to apply Advanced Transport Telematics to reduce congestion, improve traffic management and the overall quality of life in the city. Valencia had already implemented Advanced Transport Telematics in different applications domains as growth of road traffic led to the search for ways to use existing transport infrastructure more effectively.

The applications demonstrated in the AUSIAS project rely on three principles:

Integration: AUSIAS demonstrated the benefits for users and operators of integrating the different Control and Information Systems that usually co-exist in a European city.

Standardisation: By interconnecting or enhancing the different ATT applications in Valencia, AUSIAS followed the increasing demand for harmonisation and standardisation.

New technologies: By taking the opportunity to further adapt and demonstrate new technologies.

The areas covered by these strategic principles were:

- Traffic management: Integration and validation, in the current Urban Traffic System, of

- a subsystem for Dynamic Plan Generation
- a subsystem for Traffic Information Exchange between the Urban Traffic Control Centre and the Inter-Urban Traffic Control Centre
- a subsystem for Parking Management
- a Qualitative Simulator to detect and prevent congestion situations

- Public Transport: Integration, demonstration and validation of three subsystems:
  - Bus Priority at crossings
  - Dynamic Fleet Scheduling, to update the service schedule in order to cope with incidents that may affect it
  - Integrated Fleet Maintenance, covering preventative, predictive and corrective maintenance.
- Dynamic information to users. An information system for drivers, passengers of public transport, and others, with demonstrations of VMS, interactive kiosks, etc.

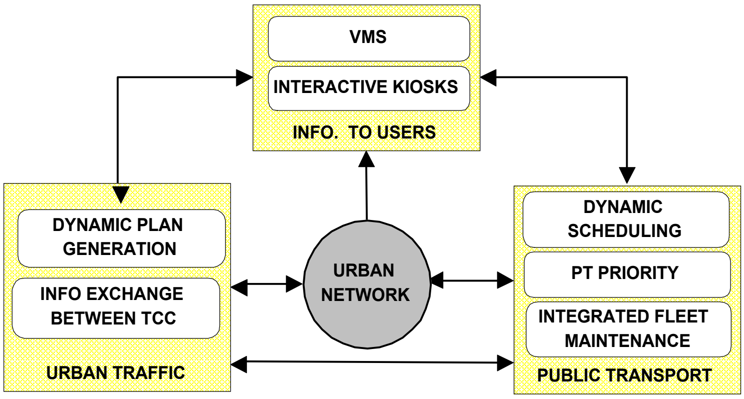


Figure1: AUSIAS Architecture

Only the subsystems demonstrated and validated in the area of public transport will be described in further detail:

Integration in AUSIAS is mainly understood as integration of information. Information obtained from data collected through basic infrastructures, for traffic or public transport management, can be transformed, combined, managed and directed by the appropriate channels to the citizens to facilitate their trips. Technical users and authorities, in order to support strategies such as public transport promotion, intermodality, etc., can use this information also.

PRESENT STAGE OF IMPLEMENTATION

The applications demonstrated in AUSIAS project are currently in full operation in the city of Valencia.

As regards the **Bus Priority System**, the validation of the demonstrators took place between 11/97 and 12/98. In the validation phase, three different test cases took place, each in different traffic conditions. For each test 15 buses were equipped with transmitter beacons.

Dynamic Scheduling: The off-line scheduling system has been tested on the 10 lines of the network, whereas the on-line scheduling has been demonstrated and validated on 5 lines. On-line scheduling required that the buses were equipped with the Operating Aid System (OAS) hardware (see: Technical Profile).

Predictive Bus Maintenance: The full demonstration of this application involved 10 buses that were monitored during their daily operation.

Financing and Resources used

The overall cost of the AUSIAS project was 2.418.675 ECU

The EU Commission contribution was 1.199.135 ECU

Other sources were from Sponsoring Partners and the contributions of the Project Partners

TECHNICAL PROFILE OF PROJECT

Bus Priority System

This system maintains and enhances the operation of the public transport buses, acting over the crossing controlled by traffic lights. The objective is to improve the level of bus services and to provide a reliable interval of buses. The Bus Priority System applied in AUSIAS allows communication with the urban traffic control system to give traffic light priorities to the buses that are delayed in time. The system provides traffic light priorities along the paths followed by delayed buses, trying to recover lost time as quickly as possible

The system co-ordinates the Public Transport Operating Aid System (OAS) with the Urban Traffic Control System (UTC). The OAS updates priority requests of buses based on pre-defined parameters (especially delays) and sends priority messages to the UTC.

Beacons (a sender on the bus and a receiver at a certain distance from the crossing) detect a bus that is arriving at a crossing with traffic lights. A serial port connects the receiver beacon with the traffic controller that controls the respective intersection.

The OAS controls the position of the buses and sends this information as well as the priorities requested by each bus to the UTC. The UTC sends the loads of the traffic by traffic light group. The controller then checks the traffic-light group which the bus is allocated to and determines the action to be performed.

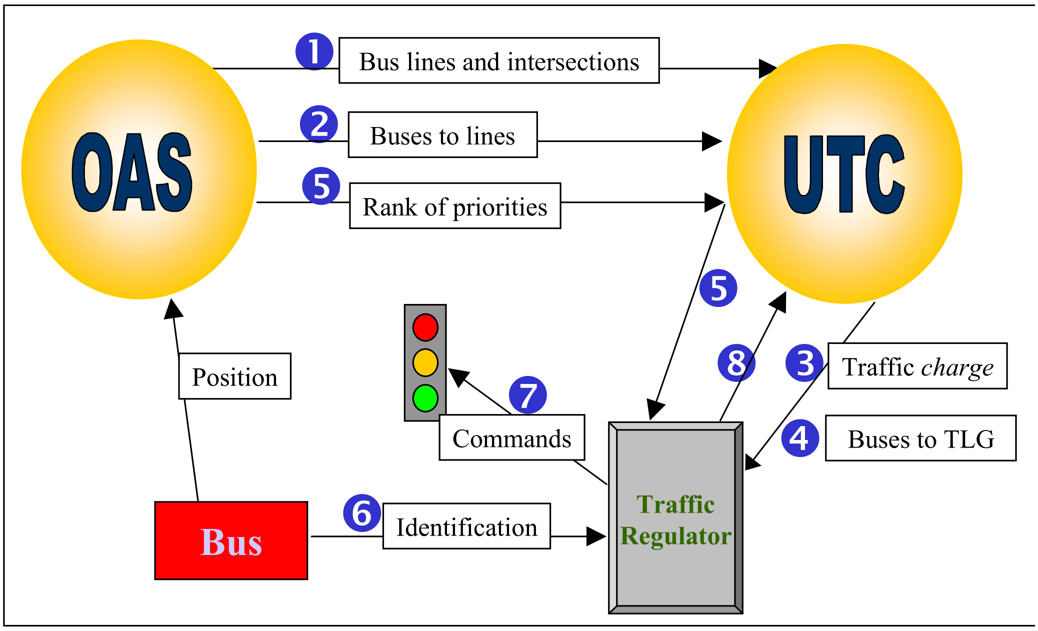


Figure 2: Functional description of Bus Priority System

The physical element used for this activity is a communication system developed by ETRA, which continually sends information to the control permitting and assuring communication between the control centre and the drivers.

Dynamic Scheduling

This system updates the schedule in reaction to incidents that may affect it. This application provides Public Transport Operators with a tool for scheduling and timetabling tasks off-line, and for dynamic scheduling tasks on-line. The on-line dynamic fleet scheduling monitors the buses in each line and enables the operator to re-schedule the fleet when unexpected incidents are detected.

AUSIAS Dynamic Scheduling is composed of the following sub-systems. The off-line scheduling which is put into practice at the beginning of each day and the on-line scheduling that takes these schedules and adjusts them in real-time to take account of incidents happening on the network.

The *Off-line Scheduling* realises three sequential processes: timetabling, vehicle scheduling and crew scheduling. The process of scheduling is realised through a user-friendly Windows interface: "drag and drop" and "explorer" type navigation. This interface is contained in three main windows: navigation, process information and database information. These windows have external specialised editors/viewers.

It is an open application from which the scheduler can obtain different results by changing parameters and choose the best attending cost criteria, service criteria etc.

The On-line Scheduling system consists of the following main subsystems:

The Incident Management system uses information about the buses' delays, the planned timetables and the driver duties. It provides the human controller with: future consequences of each delay incident for the driver, end of duty times that can be affected by each delay, the relationship between different incidents and the estimation of the severity of an incident by a cost function based on the incident consequences. With this information, the worst problems, their possible relation with other problems and their future evolution can be determined.

The Incident Pattern Matching system is a tool to detect and solve automatically the most common problems that a controller may face (problems that can occur each day and for which the solution is always the same). The steps for accomplishing this are the following: identification of the repetitive problem and of its solution, formalisation of the problem by its definition in an incident pattern database, automatic detection and solving of the problem by means of automatic testing, using the defined incidents patterns.

This module is directly connected to the Operating Aid System of the Public Transport Company (OAS). Although the Dynamic Scheduling system is designed to be independent from the OAS, some interactions are needed. The systems require information concerning the position of the buses in order to send control actions to them. The communication between the two systems is automatic but also can go through the human operator.

The system runs on a PC under WindowsNT and Windows 95.

Predictive Bus Maintenance

The remote bus maintenance system in AUSIAS is a prototype (software and hardware) for the automatic Integral Maintenance Management of Public Transport vehicles, in order to optimise their operation. This system monitors in real-time in terms of motor, electrical system, electromechanical systems, etc. The level and safety of Public Transport services can be improved by detecting the anomalies in the bus engine so as to avoid breakdown.

The integrated fleet maintenance system can be divided into two main subsystems: the maintenance Control System that is in charge of bus engine monitoring and the Diagnosis System that is in charge of bus engine diagnosis.

The Maintenance Control System is an element inside the integrated fleet maintenance of the Public Transport Company. It is divided in three subsystems: the Acquisition Module, the Process Control Centre and the User interface of the Maintenance System. It uses information from the OAS and from the Diagnosis System.

The Diagnosis System receives the deviations in the parameters used to monitor the vehicle. It informs about the severity level and suggests corrective actions to be taken.

The on-board module receives the status of the sensors placed on the bus. When the value of one or more of these sensors reaches a determined value, an alarm is generated for the corresponding sensor. After detection of an alarm, the alarm notification and the current status of the sensor are sent to the Maintenance Control System via OAS.

The Maintenance Control Centre sends the whole package of information (alarm notification, sensor status, bus identifier, data, time etc.) to the Diagnosis Expert System, which gives a prediction of the future actions to be taken for maintenance. The Maintenance Control System can probe the status of the sensors from the on-board module at any time.

The applications of the Control Centre can run on a PC under WindowsNT and Windows 95. A standard communication infrastructure is necessary at the Public Transport Company.

RESULTS AND IMPACTS

The user acceptance of the systems has been very high and the integration of the systems into day-to-day operations has been relatively smooth.

The bus priority system, integrated with an urban traffic management and control system, as applied in AUSIAS, has proven to improve the quality of Public Transport services and reduce fuel costs and emissions. The punctuality and level of services is one of the most important criteria in evaluating the efficiency of the service offered by any Public Transport Company. The evaluation results of the Bus priority System in AUSIAS showed that considerable improvements could be made in the journey time of the bus and the reduction of the bus network delays.

On average, the improvement in journey time for the integrated (manual) bus priority reduces the journey time by 30%. This improvement is a reduction of DELAY times (priority is given only when the bus is running behind schedule). On a per-line basis, the reduction percentage-wise has been likewise calculated at 30%. On a time-basis, this corresponds to a 15-min. reduction in the bus time per day for the lines surveyed in the assessment. In terms of fuel consumption, the average reduction is of 1750 Euro/line. In terms of emissions, these total to an average reduction of CO-emissions of 7 kg, and a reduction of Nox of 14 kg per year per line. The net indirect socio-ecomonic benefits are on average net 10.800 Euro/line/year.

As regards Dynamic Scheduling, the overall direct impacts on traffic management are neutral and rather focussed on internal objectives of the Public Transport operator such as improving the quality of services of the Public Transport System. With regard to the on-line system, although the verification tests have been carried out, there was insufficient data in the database in order to carry out a full socio-economical assessment of the application.

Very significant savings may arise in the increase of labour and fleet efficiency allowed by more efficient scheduling. A 1% efficiency improvement could easily save 100 000 EUR per year. This, however, has not been measured so far.

As far as the Fleet Maintenance System is concerned, the original test of the application has shown to the maintenance operators the functionality of the system, but only in a limited operational environment.

BARRIERS AND CONFLICTS

The main barrier encountered in planning the project was that there was no universally accepted method for assessing the quality of a timetable. For this reason the consortium developed a quality assessment method for considering whether the objectives that have been set out could be met.

TRANSFERABILITY

The general conclusion from the AUSIAS results is that it is necessary to integrate telematics applications in an open architecture. After being demonstrated in AUSIAS, the Public Transport Priority System for example can be applied in any other European City when the proper infrastructure is installed.

The results of the AUSIAS project will help to estimate the costs and benefits of an integrated approach. It will help to convince the authorities regarding the investments that need to be made, and to assess the socio-economical and environmental benefits that can be reached.

Public Transport and Traffic authorities have shown their interest in information kiosks and also on the applications of maintenance and dynamic scheduling.

Spanish cities like Vigo and Zaragoza, where the Operating Aid System is being installed, are now integrating the main parameters of the bus engine monitoring as a new feature.

Studies are being made with companies with interests in Public Transport within the UK for the implementation of the project in British cities, and also in Netherlands, especially the Bus Priority and Dynamic Scheduling systems. The Arnherm Nijmegen region is studying the possibility of applying the AUSIAS telematics applications. It is foreseen that the utilisation of demand management tools, parking management, traffic and parking information and Public Transport priority will offer solutions for the future development of the region.

LESSONS LEARNED

It is clear that no single sub-system can alone change the travelling habits of the public to obtain an increased use of Public Transport and improved mobility of citizens. AUSIAS has shown once more that all telematics subsystems need to be integrated in an open architecture. Significant modal shift can not be attained sustainably by telematics based efficiency improvements alone. It needs to be accompanied by a strategy, which promotes PT at the expense of the private car.

In order to guarantee the involvement of the users in the life cycle of the project, a User Representation Group (URG) was created within AUSIAS. This group is made up of representatives from the end-users and sponsoring partners including the Urban Traffic Authority, Inter-urban Traffic Authority, Public Transport Operators and Parking Operators. All of the URG members have been involved in the process of user needs identification, system requirements specification and functional specification phase, development of the demonstrator, validating the subsystem and evaluating the results of the project. This proved to be a very useful organisational arrangement.

Many of the advanced and interactive information systems used here are by their nature quite complex for the operator. It is essential that operators are involved and consulted right through the design and implementation process.

In future applications, Bus Priority needs to be tested with a configuration of the Urban Traffic System that gives flexibility to the phase times. The dynamic scheduling needs to demonstrate its capacity in a wider range of bus lines : for the verification of the results only 10 lines were used for the off-line system, 5 of them being used also for the verification of the on-line system. The Maintenance Subsystem still needs to demonstrate that it could perform preventive, corrective and predictive maintenance of any bus and under any circumstance.

ADDITIONAL INFORMATION

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