NEW APPROACHES FOR INTEGRATED MOBILITY MANAGEMENT IN CONGESTED CITIES

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ABSTRACT

The congestion that many cities suffer usually has a great negative impact on socio-economic and environmental conditions. In general it is difficult to associate to specificy the cause of the congestion, because it depends on several factors. Therefore, it becomes necessary to put in practice measures and technologies that minimize the impact of these factors, but in a coordinated and integrated way to guarantee optimization of the mobility conditions in the city.

A new approach entails the definition of an organizational and technological frame that establishes the guidelines for the mobility management. In an organizational level the measures and its scopes are established, so that, the technological tools that are applied help in the practice to develop a model of efficient and sustainable mobility in the city.

The purpose of this paper is to present tools of implementation of management solutions for urban mobility that successfully integrate advanced traffic light control, traffic engineering, computer vision, communications, information platforms, management of public transport, management and regulation parking lots, detection and management of violations and promoting the use of electric vehicles.

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1. MOBILITY IN CONGESTED CITIES

The existing problems that limit mobility in current cities arise from several factors. It is necessary to bear these in mind to find suitable solutions to minimize the negative impact caused by the appearance or combination of some of them.

Below lists some of these factors:

- The number of vehicles is growing. This involves a high level of congestion and pollution in the cities
- Occupation needs of public roadway, for activities like works, moving, etc., reduce the capacity of the roadway at certain times.
- Vehicles parked or stopped in inappropriate places cause difficulties t to the rest of the vehicles.
- The incidents or breakdowns that happen sporadically cause congestion and *traffic jams* on certain city roadways.
- The holding of local events or holidays may require closure of some city streets, with the consequent traffic disruption.
- Some vehicles do not respect the road signs and the existing rules, causing traffic problems.
- In specific periods (vacations, public holidays, etc.) serious traffic problems happen in cities exits or accesses.

These factors are often well-known, and cause problems that are necessary to foresee and detect in real time to minimize their impact. For that reason it is important to rely on suitable planning and organization, with *a* number of tools and systems that, operated in a centralized, coordinated and integrated way, should reduce the socioeconomic and environmental impacts of these problems.

It is necessary to introduce measures to improve circulation, reduce the number of vehicles in circulation and encourage the use of less polluting vehicles, alternative means of transportation and public transport.

2. MOBILITY MANAGEMENT CENTER

The Mobility Management Center for a city is an essential element in intelligent and integrated traffic management, since it is the place where, using traffic information compiled by the different systems implemented in the city, the decisions are taken for the improvement of the city´s global mobility.

The Management Center tries to be the link between all the agents involved in the city mobility management: pedestrians, cyclists, private vehicles, collective transport, City police, media, etc. From it traffic management is done in an integrated way with the aim to optimize the general conditions of the circulation for all the thoroughfare users.

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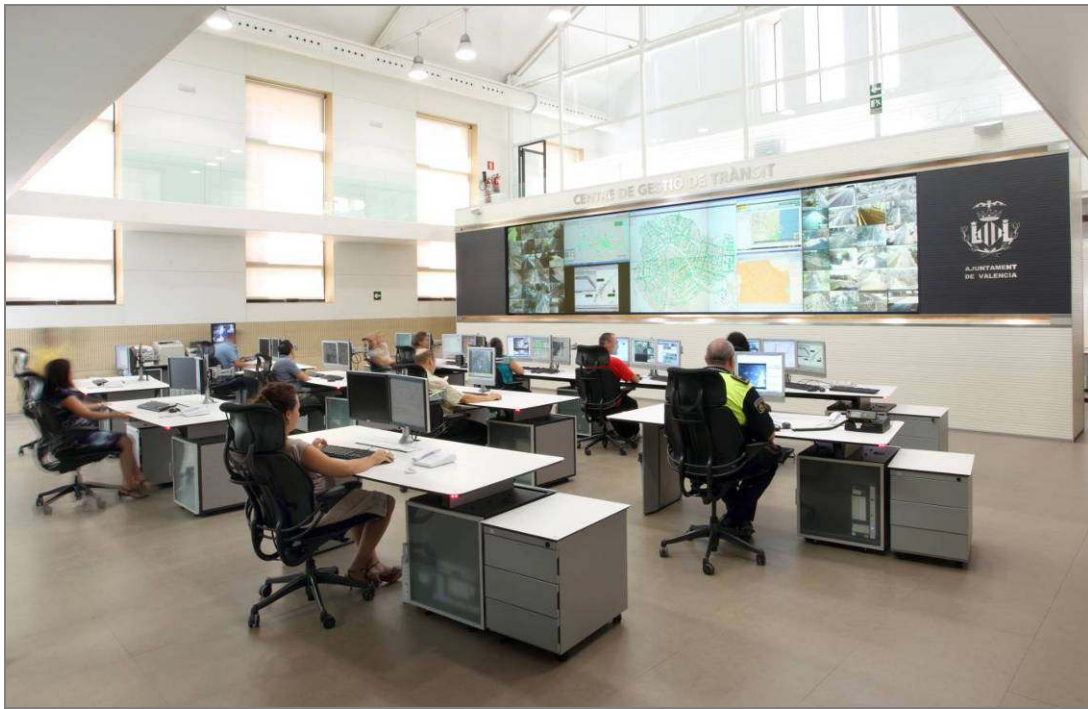
Figure 1 – Valencia Mobility Management Center

2.1. On real time Information

To do a suitable management, is necessary to have useful and reliable information in real time. This information has to be related to the mobility in the city, in the Mobility Management Center.
This information is collected from:

- Data Collection Systems related to traffic. Systems are implemented at strategic points on city routes that are in charge of gathering important information for mobility management. Some of them are:

  o Traffic Detectors Systems. They are used to determine the traffic state of the road network. They are installed at key points of the different streets and measure the circulation intensity, that is; the number of vehicles that pass through the keys points, the occupation time and the mean speed of circulation.

  o Closed Circuit Television System. Through cameras installed in strategic points, is possible to detect any incident or problem related to the traffic, thus take the convenient measures to solve it adequately

  o Environmental Data collection Systems. The installation of an environmental sensors network. That measures concentration data of the different pollutant gases, provides a pollution map of the area, and subsequently allow traffic management to be based on the existing levels of pollution in different parts of the city

  o Video detection Systems Video detection systems analyze the images obtained cameras which are installed in the city. Identify alarms related to traffic circulation, and capture traffic data

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o   Plate recognition System. These systems, through the vehicles plate reading, calculates route times in different segments/distances of the city and establish origin-destination matrices

- External Systems. Further systems have important information for mobility management, but they do not belong specifically the monitored subsystems from the Mobility Management Center. Some of these systems are

  o   Parking Management Systems. The integration of these systems in the Control Center would allow information of free space in every car park, so that this information could appear to users with the aim to reduce the time of searching for free parking spaces.

  o   Meteorological information system. Independent meteorological data; is an important contribution of Mobility Management Center

- External Control Centers. This includes Control Centers that have information related to city mobility. Some of them are:

  o   Inter-city Traffic Control Center. The exchange of information with this Control Center allows having information related to the traffic state of access routes to the city. This allows planning the operation of the traffic system in the internal routes/roads of the city.

  o   Urban tunnels Control Center. The coordination with the urban tunnels Control Center allows having useful information about the state tunnel systems

  o   Municipal Company of Transportation Control Center (bus, tram, etc.). The integration of the Traffic Management System with the Systems of the public transportation provides establishing priority to public transport under different criteria, improving the quantity of their services

- City police. The main task of city police as far as in traffic is concerned, is the adoption of specific measures, traffic control, resolution of localized problems, enforcement of the orders and communication with the traffic agents to coordinate the different actions that can be made by both

It is very important to highlight the importance of having a high capacity of communications network, redundant and extendable, which allows the information flow between the equipment installed in the street and in the Control Center.

2.2. Actors involved in the operation system

As mentioned above, it is important to have a trained and experienced team to manage the mobility of the city, which is able to take advantage of technological tools that the system makes available, so as to create an organizational framework and appropriate technology for integrated and efficient mobility.

The persons involved in the operation of the system, in the Mobility Management Center, are:

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- Officers responsible for the service.
- Mobility Management Room Supervisor
- Mobility Management Room Coordinators
- Traffic Operators
- Traffic engineers
- City Police
- Others

2.3. Equipment and tools of traffic performance

Once the necessary information to manage the traffic in the city road network is ready, it is necessary to have the suitable tools to implement the measures agreed for traffic regulation and for the information of the users of the route. These tools are:

- Traffic Regulators. These regulate the traffic by changing the colors of the traffic lights.
- Information panels. The panels show traffic information in real time to users about the route state, recommended itineraries, incidents and the available parking spaces in the city.
- Informative Web pages. The Mobility Management System must be capable of spreading useful information for users about city traffic by the web.
- Media. The media, in collaboration with the Traffic Management Room, allows spreading the mobility information to the users of the road network

3. INTEGRAL SOLUTIONS FOR THE MANAGEMENT OF THE URBAN MOBILITY.

Integral solutions for the management of urban mobility in congested cities include technological tools integrated to the Management System such as:
- Traffic operation and regulation
- Information systems to road users
- Integrated Management of priority to public transport
- Advanced tools of traffic engineering
- Analysis and exploitation of Traffic Information
- Promoting the efficient use of the vehicle

These tools work on platforms based on client server architectures that are connected to field devices by a powerful communications network.

Below are described some of these tools:

3.1. Traffic operation and regulation

These tools are integrated to the Mobility Management System, and facilitate Traffic operation and regulation to the operators of the system, providing to them utilities that optimize their work and allow a better management of the traffic control equipments.

Complete programming of the traffic regulator tool

This tool facilitates the data introduction in the programming of the traffic regulator from the Mobility Management Center. The tools shows color boards depending on the groups

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existing of traffic lights, and generate documentation related to the programming of the equipment
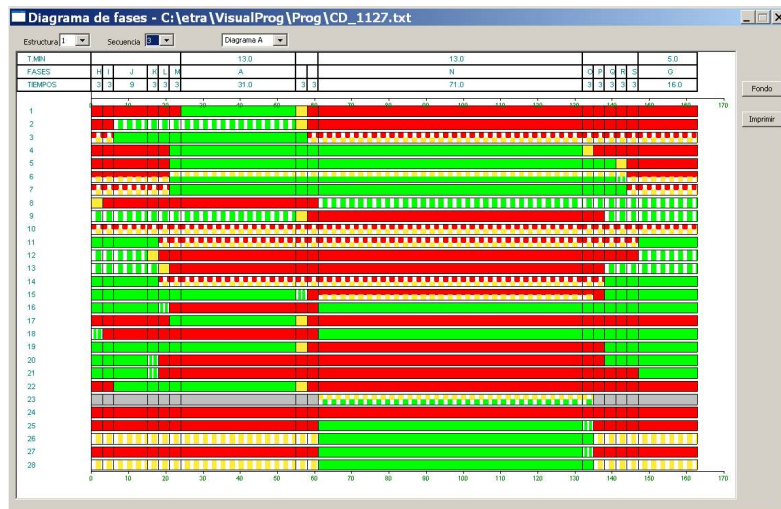

Figure 2 – Regulator Phase Diagram

Verification tool for the traffic controllers programming

This tool allows review of programming of the equipments in the street and its comparison with the system databases, with the aim to visualize the differences between the different programming and to update them if it is necessary.

Figure 3 – Verification controller programming

Tool to facilitate the traffic operation

This tool provides useful functionalities for traffic management, doing, among others, the following actions:

- Actions on the devices
- Order Management deferred in time.
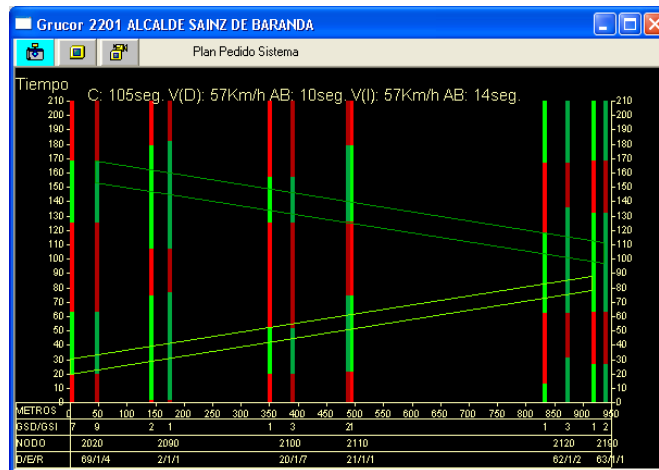- Visualization of green waves in the user´s interface.

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Figure 4 – Representation of a green wave

Also, this tool allows the application of traffic control strategies depending on the needs in each moment:

- o Strategies control by time selected.
- o Traffic control strategies
- o Combined control mode
- o Dynamic Generation
- o Adaptative
- o Micro regulation

Expert operator Tool

This tool allows automated actions on the system, emulating the operators´ actions from defined rules about the variables that describe the traffic state and the state of the system. The tool acts as an operator with high traffic knowledge and with a computer information processing capacity.
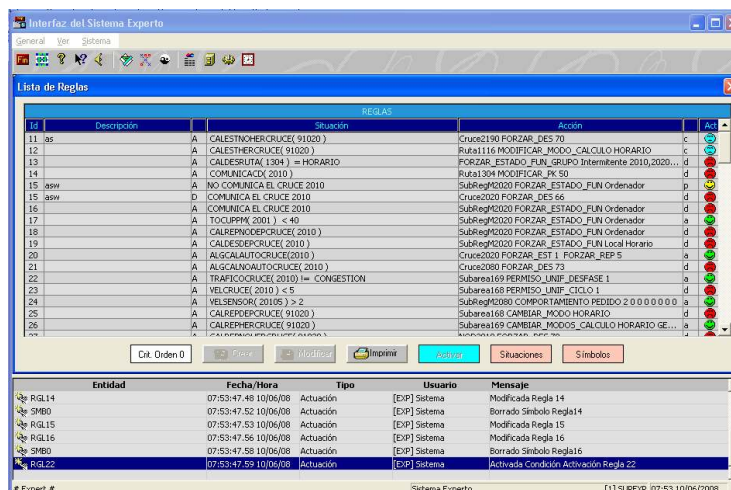

Figure 5 – User interface of the expert operator

Tool for the strategic Mobility Management

The strategic mobility management tool allows high-level mobility management. It integrates the high-level information generated by the Urban Traffic Control System and the Information Management System. It is prepared to integrate the generated information

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by other systems as public transportation, inter-city traffic and periurban, etc. It is able to implement strategies of mobility management under different criteria:

- By calendar
- By schedule
- In planned events
- As an automated response to traffic situations identified by pattern recognition
- In response to incidents

Figure 6 – User Interface of the Strategic Control System

3.2. Information Systems to the Citizen

These are systems that, from the traffic information and mobility gathered by the system in real time, manage and spread this information through different means (variable message panels, parking panels, web pages, etc.), in order that road users have useful information to choose their optimal routes.

System of management and advanced diffusion of the mobility information

This tool allows the acquisition of information from multiple sources by means of specific protocols, SDKs or web services. In addition, it incorporates mechanisms to verify the information reliability and integrity in this way, it avoids the spreading of wrong information. Once validated, it spreads the information through web services, thus any system can use it.

Management and advanced System for the traffic information diffusion

This tool allows spreading information of the traffic state on real time, using intensity data and occupation times gathered by the Mobility Management System, and calculating the service levels (fluid*, dense,* congested). This information can appear in urban panels or web pages.

Likewise, this tool allows display of travel touring times in itineraries using advanced algorithms on the traffic information.
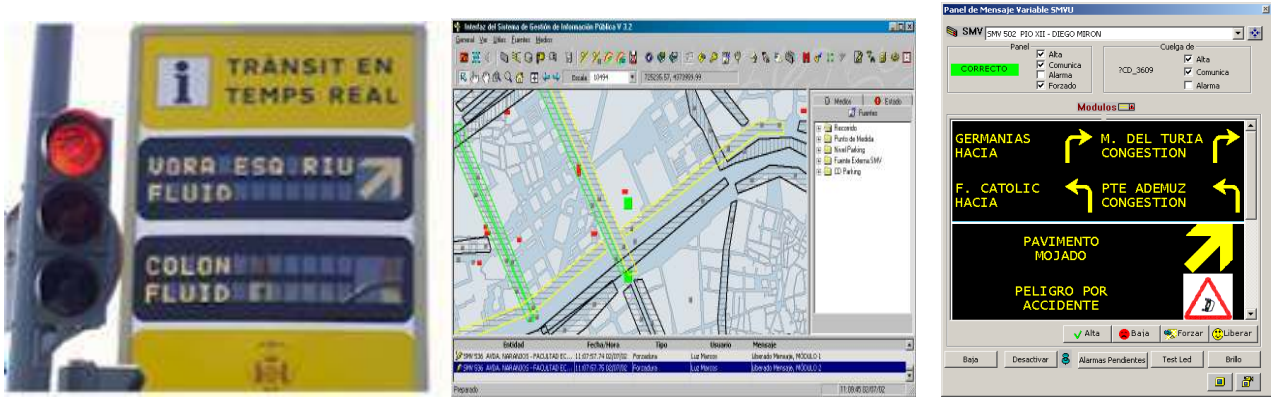
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Figure 7 – Information Public Diffusion

Information management System of Parking spaces

A parking information system gives information about the occupation of public urban parking. It receives, numbers of available spaces in the different city car parks and reports available spaces and the capacity level (FREE, HALF-FULL, FULL). This information is available for Web display.

Figure 8 – Parking spaces information

3.3. Integrated Management of priority to public transport

Tool for priority management to the collective transport

This tool allows monitoring and managing the priority that the traffic system offers to the vehicles of public transportation (buses, tramway, etc.), through the integration of the *Help Aid System* (SAE) of the service of public transport with the System of Management of Mobility.

The SAE knows and continually transmits to the system delay of every bus. Depending on the delay for the selected bus, and its distance to the end of the line, the system calculates the priority that should be awarded and sends this information to the traffic light controllers
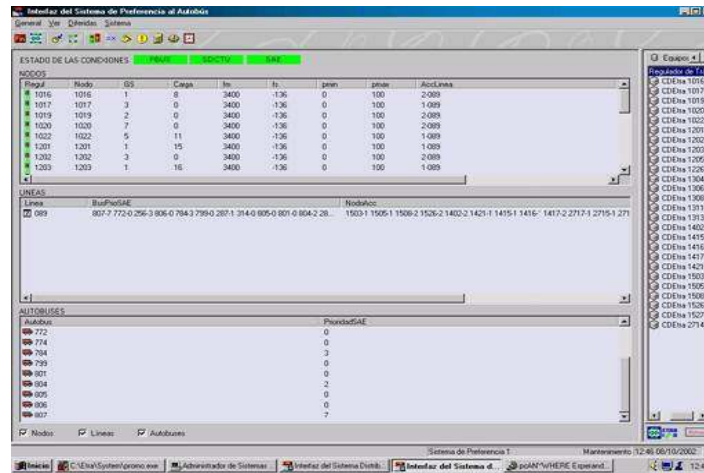
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Figure 9 –Public transportation Priority Monitoring

3.4. Advanced Tools of Traffic Engineering

This set of tools allows to the Traffic Engineers to have useful information to do planning and calculation studies about traffic plans in the different city intersections.

Tool for interactive generation of traffic plans

This tool allows the capture, visualization, documentation, analysis, modification and generation of traffic plans in an interactive and graphical way and on the road network map. This is done by the creation of work configurations for nodes groups or the full network, on that is possible to generate traffic plans associated with the created configuration or to import traffic plans from the Mobility Management System databases.

Using these configurations it is possible to analyze and modify the created and loaded traffic plans, or create itineraries graphically to visualize and modify the associated green wave.

Once traffic plans have been simulated on the city map, they can join to the databases of the traffic system.
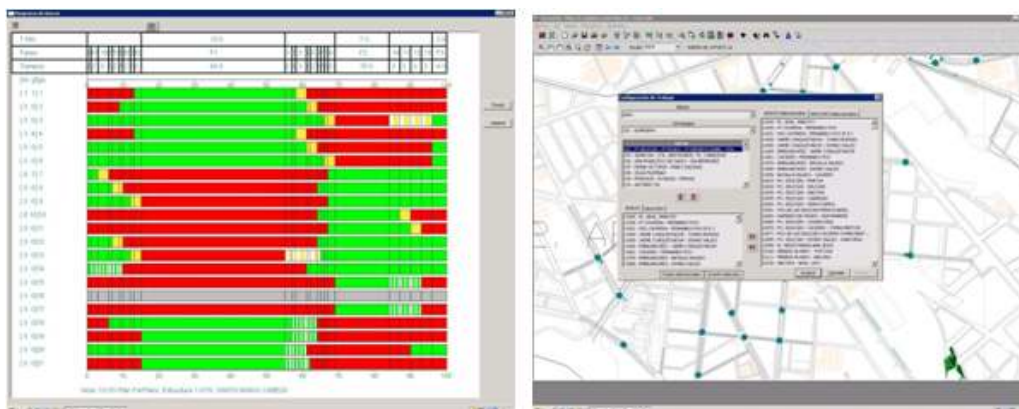

Figure 10 – Tool for the creation of traffic plans

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Traffic Performance Analysis

Traffic performance is analyzed from information extracted by the floating vehicle technique and using vehicles provided with data capture equipment (EMA - Mobile Acquisition Equipment).

Mobile Equipment Acquisition captures data collection of all movements made by the vehicle. This provides information on real traffic situations, and provides information representative of real routes in the city.
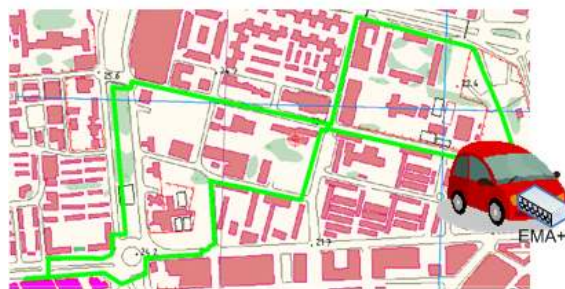

Figure 11 – Floating car route

3.5.   Tools of Analysis of Traffic

This type of tools allows, from the traffic information collected by the system, and the creation of reports and statistics that could be useful for mobility planning in the city

Web platform for traffic analysis

The platform provides a tool for the treatment, debugging and aggregation of traffic measurement data, in order to generate reports that may be useful at the level of planning. The tool allows the export of data to other standard formats: XML, CSV, XLS, PDF, TIFF.
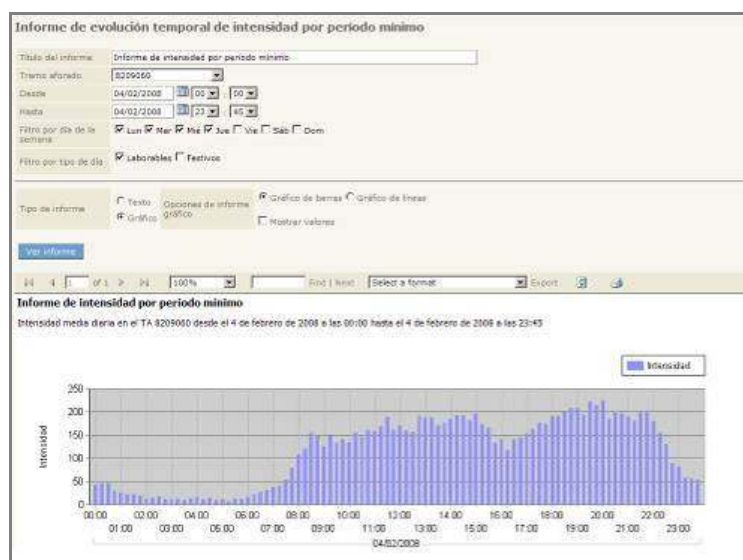

Figure 12 – Tool for the reports creation

Tool for statistical processing of traffic data system

This tool allows, through the continued acquisition of data traffic, the subsequent generation of graphical and tabular reports with statistical information stored in the database.
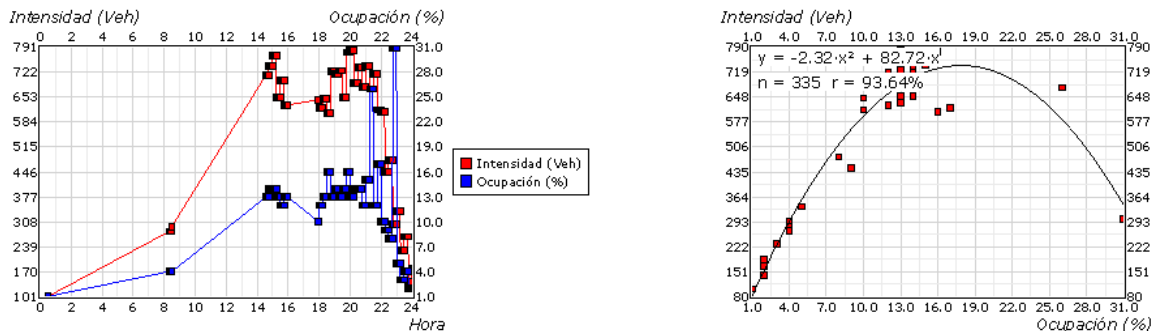

Figure 13 – Statistical data

Analysis Tool for the performance of the traffic system from the historical data using the whole functionality offered by the User's Interface

This tool functions off-line and allows, in the operator graphical interface, the reproduction of sequences relative to actions taken on the system by an operator, with the aim to analyze the applied measures and to extract useful conclusions in order to solve similar problems in the future.

Tool for the creation of Substitution Curves of traffic sensors

This tool is responsible for the generation and automatic update of the curves of the sensor data from the actual data from the sensors taken every day. The tool performs a statistical management of traffic data stored by a sensor, so you can detect shifts in the behavior of the detectors and prevent damage to them. The tool can replace the sensor data when its performance significantly deviated from its standard
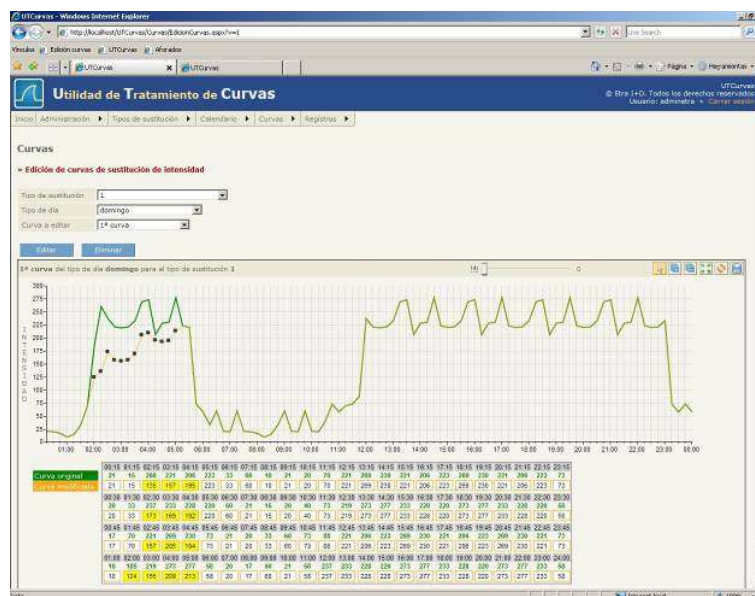

Figure 14 – Tool for the treatment curves

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3.6. Promoting the vehicle use in an efficient way

This group of tools, together with the information campaigns run by the authorities, allows promotion of efficient and intelligent use of the vehicle.

We start from the premise that travel decisions are often not based on efficiency or sustainability. Sometimes necessity forces the population in cities to make different tries (work, leisure, shopping, etc.), in a more or less efficient ways. From travel from going by foot, to by bicycle, to by public transportation, the electrical vehicle, the hybrid vehicle and the combustion engine vehicle, transporting one or more persons, we pass through different possible modes of transportation in a city. Competent authorities must promote modes tar are more efficient, emit fewer pollutants and are more sustainable.
These tools can help in some cases to reach these objectives.

Tool to control the exclusive use lanes for efficient vehicles

This tool, using data provided by license plate reading cameras installed in a lane reserved for a certain type of vehicles (electric vehicles, hybrids, etc.), controls access to special purpose lanes by unauthorized traffic. This tool allows promoting the use of efficient vehicles (electric, hybrid, etc.) in the cities.

Tool for accesses control of restricted areas

This tool provides facilities to control vehicle access to restricted areas within the city, often the center of it. This measure favors other more efficient means of travel than private vehicle, in congested areas of the city.

Tool for the control of lanes for high occupancy vehicles

This tool allows controlling the elements installed in high occupancy lanes to access cities and to manage the access of certain types of vehicles, based on efficiency criteria of travelers' transportation. This reduces the single-occupant vehicles, and helps vehicles with high occupancy.

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4. EXAMPLES

The city of Valencia is a good example of an Integral Solution for the Management of Urban Mobility. The integrated approach of the mobility in both the organizational and technological frames has been very important in the last years in order to develop a model of efficient and sustainable mobility in the city.

The use of a Management System that includes technological tools such as traffic operation and regulation tools, road user information tools or traffic engineering tools, used in a coordinated and integrated way to guarantee optimization of the mobility conditions in the city, has been decisive to reduce the congestion in the city.

5. CONCLUSION

Integral mobility management in a city needs the synergy of the technical and human resources. Both take part in the collection and analysis of the information in real time and when making decisions to improve the traffic flow. This may be system operation, or for strategic traffic planning in the city in the medium and long term.

Provision of the necessary human resources allows having a multidisciplinary team with the suitable knowledge and capacity to operate the system in an appropriate way. The analysis of the available information in the Mobility Management Center will allow to implement policies to improve the level of traffic and road safety, based on the real city needs, and the implantation of specific measures that help to obtain a more sustainable mobility, based on the intelligent and responsible use of the vehicle, the promotion of alternative fewer pollutants means of transportation (electrical vehicles, bicycles, etc) or the use of the public transport.

The functionality provided by the technological tools of the system is of great importance in these tasks, as it facilitates the implementation of the guidelines for mobility management and strategic criteria set by the managers of the system in a coordinated and integrated way to provide efficient management of mobility within the city.

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