

# Methodological and software tools for public local transport planning in the Lombardy Region

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**Abstract:** In line with EU regulations, the Italian Government has started the reform of public transport, transferring competencies from central Government to Regions for railway networks and from Regions to Local Administrations for bus services. The Local Administrations are therefore called to redesign the bus urban and inter-urban services. The targets are not only to increase the effectiveness and efficiency of public transportation, but also to improve all the quality issues related to mobility and to promote the environmental sustainability. This paper is focused on the methodological and software tools developed by Poliedra – Politecnico di Milano to support the Lombardy Region in defining a common framework where Local Administrations can operate and achieve their targets. The software tools are supported by a quantitative methodology. A set of meaningful indicators is defined, some of which are related to environmental and quality issues of public transport services, such as the vehicles kind and age, their emission levels in atmosphere, their suitability for disabled people, the total number of carried passengers, the accessibility to public facilities, the fitting of territorial mobility demand, the introduction of innovation services (e.g. services on demand) in low demand areas, which can be used to measure and to compare the different local situations. The whole software tools constitute the Regional Information System for Local Public Transport Services (MISTRAL). MISTRAL, that will be shared with Local Administrations, can help to monitor the transportation services contracts and to guarantee the respect of their quality standards, to evaluate the transport system through indicators and procedures and to provide support to decision processes in transport planning by methodologies based on multi-criteria analysis.

**Keywords:** decision support system; information system; transport planning

## 1. INTRODUCTION

The paper aims to illustrate the methodological and software tools developed by Poliedra – Politecnico di Milano as consultant of the Lombardy Region to support the Regional Administration in implementing a monitoring system of public local transport. All the software tools as a whole constitute the Regional Information System for Public Local Transport Services (MISTRAL).

MISTRAL development took more than 3 years, in order to collect all the transport and territorial data from different Region departments and to completely understand the new configuration due to the public local transport reform for the information flows between the Region, the Local Administrations and the transport companies. Poliedra workgroup was composed of a scientific co-ordinator, Prof. Eliot Laniado, and 2/3 full-time researchers each year. During all the

development time, this workgroup was supported by the Regional staff, which interacted with Poliedra step by step.

The Region is now going to share MISTRAL with the local authorities both to provide a common framework for all the involved subjects and to have the system periodically fed by updated data. In spite of its long and complex development phase, MISTRAL was projected as an easy system, which can be used and queried even by not advanced users. Furthermore, its flexibility and modularity makes easy and low-cost the system maintenance operations, which can be done directly by the Regional staff whenever needed.

## 2. BACKGROUND: THE REFORM OF PUBLIC LOCAL TRANSPORT IN LOMBARDY

According to the Regulations set by the European Union (Directive 1831/1991), in Italy the reform

of public transport started in 1997 with the National Acts (l. 59/1997 and D.Lgs. 422/1997), which transferred the competencies related to railway networks and to bus services from central Government to Regions and to Local Administrations. One of the main point of the reform was the transition from a concession-based system in public transport, without no potential time limits and where everything was settled by the central authorities, to a competitive tendering system, where the Regions and the Local Administrations set up tenders for each part of their transport networks and stipulate services contracts with train and bus companies. Consequently, the local authorities had to take upon themselves some new tasks with regard to transport planning, such as redesigning the networks, classifying the lines, co-ordinating the bus services with railways, introducing some innovative transport services in low demand areas, monitoring the services contracts.

The Lombardy Region accomplished this reform with the Regional Acts 13/1995 and 22/1998, aiming to improve not only the effectiveness and the efficiency of public transportation, but also all the quality issues related to mobility and to environmental sustainability. In this context the Lombardy Region started thinking of the implementation of a monitoring system for public local transport and commissioned Poliedra – Politecnico di Milano to develop it.

### 3. ARCHITECTURE OF THE INFORMATION SYSTEM

#### 3.1 The objectives

MISTRAL (Monitoring Information on Local Transportation System) is an information system designed to support the Region and the Local Administrations in their transport planning activities. The Region competencies are related to the railway network, while the bus services are now arranged by the Provinces and the main Municipalities.

MISTRAL objectives are the following:

- monitoring the services contracts that the regional and the local authorities set up respectively with train and bus companies, helping the Administrations to guarantee the contracts quality standards;
- evaluating the transport system through some indicators related to the effectiveness and the efficiency of services and also to the quality issues;
- supporting the decision making processes by using the multicriteria analysis.

#### 3.2 The structure and the technical features

MISTRAL is constituted by two different parts: monitoring and assessment of public local transport, through an indicators system and the decision support applications for planning the transport services.

MISTRAL collects together in a single database all data on public transport under the competence of the Lombardy Region; it is also able to query this database to compute some meaningful transport indicators at different levels of detail and aggregation. The information from the database and the indicators can then be used to facilitate decisional processes, using a methodology based upon the multicriteria analysis techniques. Figure 1 illustrates the structure of the information system.

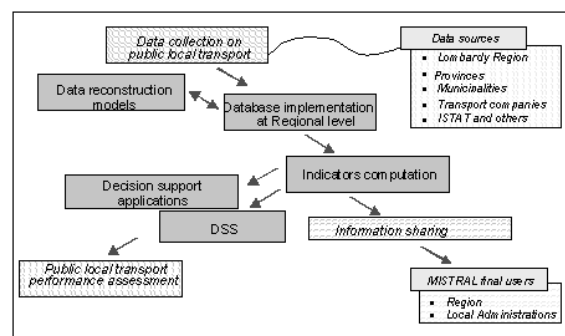


Figure 1. MISTRAL structure

MISTRAL is implemented with a Microsoft Access database, although some special interfaces are managed by Microsoft Visual Basic codes. Part of its database can also be geographically represented by ESRI GIS ArcView.

All the software tools are flexible and modular and have an user-friendly interface. This means that any advanced user will be able to easily modify or to develop new forms or modules in the future; furthermore, the system can be used even by not advanced users.

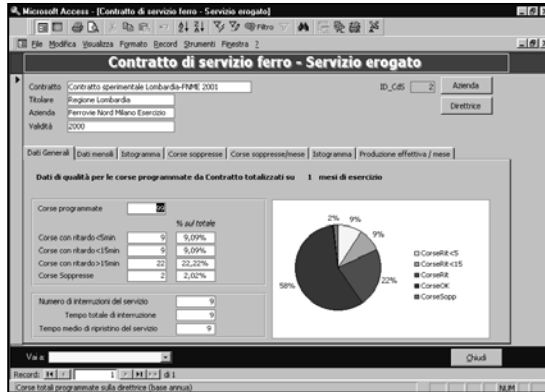
The next paragraphs illustrate MISTRAL main components: the database, the indicators system and the decision support applications.

#### 3.3 The database

The database was created to ensure consistency among all databases at the Regional level and to increase the quality level of information with regard to the transportation field. It includes demand and supply data, economic data, territorial and demographic information and data on services quality, with special care to the environmental sustainability of the mobility system. The quality issues deal particularly with reliability, punctuality, comfort and safety of the transport services, with the technical standard for the vehicles, with the availability of information

for the passengers.

All the information is available in proper forms, like the one shown by Figure 2, that can be accessed by the users following one of these two paths: the 'elementary units' path and the 'thematic ambit' path.



**Figure 2.** An example of MISTRAL form: railway services features at the services contracts level.

An elementary unit is individuated as something connected to the transport system or to geographic areas, for which some meaningful data are available. The first path includes some families of elementary units, such as the railway networks, the bus services and the territorial issues (Region, Provinces, Urban areas, Municipalities). Examples of units can be a bus line, a transport company, a railway station or a single Municipality.

The second path groups the same forms into different ambits, grouped as follows:

- transport demand (mobility level and kind, number of sold tickets, number of carried passengers, ...);
- transport supply (number of buses/trains, number of seats, bus/train kilometres,...);
- services production (economic data, staff information, quality indicators, ...);
- territorial shape (demographic data, indicators related to the territorial services, such as schools, hospitals, commerce, etc);
- historical data.

### 3.4 The indicators

The performance indicators are computed at different detail levels, to fulfil the needs of any potential user of the information system (the Region, the Provinces, the Municipalities).

For example, the quality indicators for the bus services are computed at two levels: the services contract and the single line. In fact, it's more significant monitoring the reliability and the crowding of the bus services at contract level for

the Regional authorities rather than for the local ones, who perhaps would be more interested in disposing of the same information in a more detailed way, for each line of their network.

In general, the detail level can be referred to different spaces (the territorial extensions), times or service kinds. Figure 3 illustrates all the possible detail levels for a quality indicator (e.g. the reliability). The reliability can be computed referring to a contract, a line, a traffic area (for railway service); to a year or a month; to the bus or the railway services.



**Figure 3.** Detail levels for the indicators: the reliability.

All the indicators can be used by the regional and the local authorities to check and to redesign the transport networks, considering issues such as the integration between different modes, the classification of the network lines related to their efficiency and effectiveness, the accessibility to each Municipalities and so on. Furthermore, they are useful to help the authorities to accomplish their planning activities, that are pointed out in their Triennial Services Programmes.

Some indicators are particularly related to the environmental and the quality issues of public transport services, such as the vehicles kind and age, the vehicles emission levels in atmosphere, their suitability for disabled people, the total number of carried passengers, the accessibility to public facilities, the fitting of territorial mobility demand. All these indicators can be used to measure and to compare the different local situations with respect to the quality issues of the mobility.

The indicators can be accessed through the following keys:

- effectiveness (indicators related to demand and supply, frequency and speed, capillary);
- efficiency (transport and economic indicators);
- service quality (indicators referred to reliability, crowding, vehicles kind);
- historical key (effectiveness, efficiency and quality indicators trends).

Table 1 shows the indicators list for the service quality key, with the available aggregation levels.

**Table 1.** MISTRAL indicators for the services quality key.

QUALITY KEYS	INDICATORS	AGGREGATION LEVELS
reliability	% of suppressed buses	Region
	% of buses with delay	Provinces
	% of suppressed vehicles*kilometers	Urban networks Traffic areas Services Contracts
crowding	No. of buses/trains with crowding index (rate between the max passengers load and the number of seats) greater than 120%	Region Provinces
	No. of passengers travelling on buses/trains with crowding index (rate between the max passengers load and the number of seats) greater than 120%	Urban networks Traffic areas Services Contracts
vehicles kind	average and max age	Region Provinces Urban networks Services Contracts (only bus)
	% of more than 10-year-old vehicles	
	% of Euro3/4 vehicles	
	% of electric or hybrid vehicles	
	% of air conditioned vehicles	
	% of suitable vehicles for disabled people	
% of vehicles with localisation devices		

### 3.5 The decision support applications

The decision support applications can help the Administrations to plan their transport services and to manage conflicts between all the subjects involved in transport decision processes. These tools can be divided into the following parts:

- a series of thematic applications, which are completely integrated in MISTRAL, even if they can also work as stand-alone applications;
- the decision support system (DSS), that can import data and indicators from MISTRAL, letting the user modify the information as needed to define the alternatives before he starts the decisional process.

All the thematic applications are supported by a quantitative methodology. They all read MISTRAL database and eventually have their own database in addition. They are finalised to give help to the local authorities in their transport planning activities, e.g. finding out any existing overlap between railway and bus networks, individuating the low demand areas, where the mobility demand can be better arranged by

innovative services, like services on demand, classifying the bus lines with regard to their effectiveness and efficiency.

The following Table 2 contains a list of MISTRAL thematic applications and specifies their objectives.

**Table 2.** MISTRAL thematic applications.

NAME	OBJECTIVES
SCHOOLS	Appraisal of the demand student part
LOW DEMAND AREAS	Individuation of the low demand areas
RAILWAY AND BUS OVERLAPPING	Analysis of the overlapping level between the railway and the bus services
TARIFFS	New tariff systems assessment
OD MATRIX	Reconstruction of ISTAT Origin-Destination matrix
RELATIONS	Relations classification
BUS LINES	Bus lines classification
COST CONTROL DATA	Analysis of the Cost Control data for bus services

Most of these applications can help the local authorities to draw up their Triennial Services Programmes. These Programmes, which must be updated every three years, include the transport planning activities stated by the local authorities. The network redesign represents the core of each Programme; for this reason it's very important that each authority would be able to analyse its network and to individuate its critical points.

For example, the RAILWAY AND BUS OVERLAPPING application can be used to individuate in an automatic way the railway and bus services overlapping, within the systematic mobility, for a Province or a railway track. The software allows to classify the lines on the basis of the overlapping level with the railways. The methodological steps are the following:

1. individuation of the bus lines partially overlapped (bus lines which arrange at least two Municipalities lying on the same railway track);
2. comparison between bus routes and railway tracks, using a set of proper indicators, such as the rate between the number of Municipalities with at least a railway station and the total number of Municipalities arranged by the bus line, or the average number of bus stops for each Municipality.

Another example of a thematic application is BUS LINES, which aim is to classify the bus lines through the analysis of 3 different indicators: the number of passengers for each bus, the rate between tickets proceeds and operating costs, the number of travels per hour. Each indicator is then compared with a threshold,

which can be user-defined or automatically computed on the basis of the average value of the Province. This leads to a bus lines classification which includes six different classes:

1. effective and efficient lines;
2. effective but not efficient lines;
3. uncertain effectiveness but efficient lines;
4. uncertain effectiveness and not efficient lines;
5. not effective but efficient lines;
6. neither effective nor efficient lines.

The sixth class lines are obviously the worst and need to be heavily restructured or redesigned.

The next paragraph illustrates in a more detailed way an example of the utilisation of a thematic application (LOW DEMAND AREAS – Low demand areas individuation software).

The DSS is useful to compare and to assess different territorial situations referred to the same time, e.g. comparison between Provinces or transport companies, or the same area related to different years. The user can build an evaluation matrix, whose rows represent the alternatives and whose columns are the indicators, by saving data and information from MISTRAL database and indicators system. The evaluation matrix can eventually be modified. Lastly the software allows to apply the multicriteria analysis techniques to sort the alternatives. This entails the use of utility functions and the choice of a set of weights, which allow to calculate the weighted sums and then to define the alternatives ranking.

### 3.6 An example of MISTRAL thematic application: LOW DEMAND AREAS

The aim of the LOW DEMAND AREAS thematic application is the individuation of low demand areas, finalised to the introduction of innovative transport services, which can better answer to the citizens needs rather than the traditional ones. A low demand area could be a territorial extension with a low or scattered urbanisation level or with a low population density, where a traditional kind of public transport system, with fixed routes and schedules, could be less effective and efficient than a more flexible kind of service.

The application allows to check if each Municipality satisfies a set of criteria, with respect of some user-defined thresholds. The user can modify the thresholds values to simulate different scenarios; he can then visualise these areas in a proper ArcView project, which is linked to the Access application. Furthermore, the software provides for additional information about each Municipality included in these areas, such as the mobility index, the presence of isolated groups of houses, the comparison

between the systematic mobility demand and the interurban transport services, and so on; this information can help to understand the reasons of each area weakness.

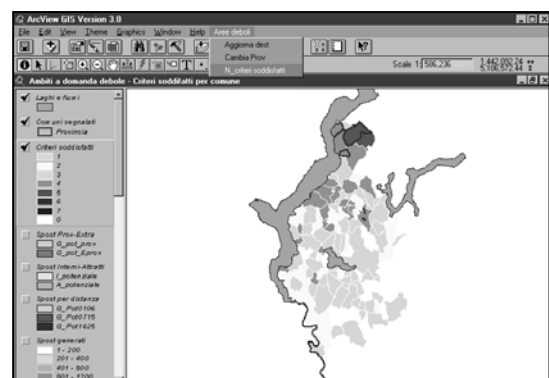
This analysis can then help the Local Administrations to individuate the critical points of their network, with respect to the existing transport supply and to the different mobility needs within their territory; it can constitute the initial step of the network redesign process.

The application is based upon the following methodology. First of all, a set of indicators is used to analyse the Municipalities:

- the low demand level (number of inhabitants and number of originated travels);
- the scattered population (rate of inhabitants who lives in isolated sites outside the town centre);
- the territorial criticality (average elevation, rate of inhabitants who are more than 65-years-old, difference between the number of inhabitants in 1998 and in 1991).

Secondly, a threshold for each one of these indicators is settled; a Municipality can then be defined as a low demand area if all the low demand level indicators and at least one of the other indicators respect the thresholds. The thresholds can be user-defined or individuated by each Provincial authority. Different low demand areas scenarios can be generated by choosing different sets of thresholds values; moreover, the user can choose which number of criteria he wants a Municipality to satisfy to generate a scenario.

As shown in Figure 4, the classification results can then be visualised by the ArcView project.



**Figure 4.** Visualisation of the low demand areas.

The definition of the low demand areas is made by grouping together the Municipalities that respect a certain number of criteria and the neighbouring Municipalities or the Municipalities

which respect at least three criteria.

The application can also show a series of territorial and transport services data related to the Municipalities; it allows to store other information too. A synthetic form for each area is then available, which illustrates the area dimension and features.

#### **4. THE DEFINITION OF A COMMON FRAMEWORK FOR THE LOCAL AUTHORITIES**

One of the Region aim is to define a common framework for the transport planning where local authorities can operate. That's the reason why the Lombardy is now planning to share MISTRAL with Local Administrations, providing them with information on public transport and with tools such as indicators and applications. All the procedures and tools integrated within MISTRAL can really constitute a general quantitative methodology to support the transport planning activities and the networks redesign.

MISTRAL decision support applications allow to assess different alternatives referring to different criteria, even in conflict situations, and to structure the decision making context providing a logic framework of the decisional process, helping the decision makers to deal with uncertainty and to manage the conflict.

The multicriteria analysis techniques can guarantee the problems evaluation from different points of view, the critical analysis of the problem, the procedures transparency and the repeatability step by step, that is the possibility to go through the procedure, eventually modifying some of its parameters.

#### **5. CONCLUSIONS**

MISTRAL was developed by Poliedra – Politecnico di Milano by commission of the Lombardy Region. The system now constitutes the Monitoring Information on Local Transportation System of the Region. MISTRAL main purpose is to help the Region and the Local Administrations to manage all the new tasks related to transport planning activities that the reform of public local transport assigned to them.

MISTRAL allows to monitor and to assess the public local transport through a consistent database and an indicators system and offers a set of decision support applications for planning the transport services. The transport indicators are related not only to the effectiveness and the efficiency but also to all the quality issues of the

local transport. All the software tools are supported by a quantitative methodology; the decision support system is based upon the multicriteria analysis techniques.

The software will be shared with the Local Administrations: this can contribute to create a common framework where the regional and local authorities can operate, redesigning and evaluating their networks, monitoring the transport services contracts, trying to achieve effectiveness, efficiency and quality higher levels and to guarantee a more sustainable mobility system.

MISTRAL is implemented with a Microsoft Access database and uses an Access-Visual Basic interface. Its main features are to be a flexible and modular system, open to any development in the future, to have user-friendly interface, easy to use, and to be able to support decisions both at regional and local levels.

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