Road Sign Management System of Teramo Province, Italy

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Road sign placement must be extremely accurate in order to provide the level of safety and inspection originally engineered into a section of road.
Maintaining sign configuration as originally intended by a traffic engineer is hard as signs are replaced, damaged, or stolen. This can cause risk for inadequate or improper signage.
The risk of liability from missing signs, incorrect signs or incorrectly placed signs can be significantly reduced by increasing the accuracy in maintaining road signs in good conditions.
Considering these matters, the Provincial Administration of Teramo, Italy, has implemented a Road Sign Management Systems (RSMS) as an important part of a larger integrated road management system. This activity is one of those included in the Pilot Project to increase Road Safety, developed by the Administration to access to the financial aids forecasted in the National Plan for Road Safety (NPRS), promoted by the Italian Ministry of Public Works.
The RSMS is strongly linked to another activity of the Pilot Project: the implementation of Road Cadastre, a set of geographic data files compliant with the TC287 CEN standard. Some effort has been placed on the GDF and LandXML modeling and representation of the information of our interest: this way we test the forward compatibility with the future road database.

The implementation of Teramo RSMS has been divided in the following steps:
- Survey of all the road sings installed on the provincial roads. The survey begun with a mobil mapping system (mms) vehicle and was set up at the same time of the road Cadastre. In this phase, the geographic coordinates (East and North) of all the signs and the kind of each one were recorded.
- Collection of the principal informations about the sings (location, construction year, producer name, provincial decree of apposition, state of maintenance, visibility, readability) with a paper surveying form;
- Photographic survey of every road sign by a digital camera;
- Data-base implementation to collect the information surveyed on the road;
- A GIS digital map. Simply selecting a sign on the map all the data are available.

The creation of this RSMS allows the analysis of every sign to check the conformity to the Italian Road Code and it is becoming the principal tool of the Administration to:
- know how many and which signs are installed on provincial roads;
- manage and schedule the works to replace, or remove or add road signs.
This paper deals with the implementation of Teramo RSMS.

1. Introduction

In recent years, the statistics on Italian accident data show that an high percentage of road accidents is due to misbehaviour or lack of attention of drivers and, in many cases, these behaviours are induced by wrong or unreadable or badly placed road signs.
The road signs must give all the information, remarks and warnings, by symbols that allow the road users to adjust their behaviour to different incoming situations. A bad understanding of the sign increases the reaction time of the user, especially in case of uncomfortable traffic condition, and unbelievable or unreadable road indications produce a lack of trust in the rules by users.
The most common problem on Italian roads is linked to the loss of effectiveness of signs during the time: there are a lot of old signs that must be replaced, unreadable, with detached or not more refracting film, with bended, rotated or crashed postsigns.
The Italian Road Code determines the rules and the competences to manufacture the signs, to draw up the road sign plan, to install and to manage the signs.
In detail the code says:

- every road administration must draw up a specific plan, in accordance with the administration of adjacent roads, to produce a harmonic, integrated and effective sign system, to guarantee safety and fluidity of pedestrian and vehicular circulation;

- every road administration must periodically verify the state of the system of signs. Particularly the effectiveness of guide signs related to the traffic flow and the needs of users must be checked.

So we can say that a road Administration has two competences: design, and maintenance of system of signs. The knowledge of installed signs on its roads is so important to:
– decide which signs must be added, removed, or modified during the design phase;
– manage the replacement of old signs, the removal or addition of other signs when new traffic conditions need it.

These actions can be easily managed by a computerized system and the Administration of Teramo Province is implementing a Road Sign Management System. This is a part of the Pilot Project to increase Road Safety, developed by the Administration to access to the financial aids forecasted in the National Plan for Road Safety (NPRS), promoted by the Italian Ministry of Public Works.

2. The Italian Plan for Road Safety

In 2000, the Italian Ministry of Public Works (now Ministry of Infrastructures and Transportation) issued the National Plan for Road Safety (NPRS), the first real attempt to face safety problems by the definition of an appropriate, strict, efficient policy to control all the main risk factors.
According to its definition, the NPRS is a system of guidelines and measures to promote and increase plans to improve road safety standards with special regard to infrastructure design, accident prevention and control activities, so to achieve an important EU goal: 50% reduction of deaths or injuries in road accidents.
The NPRS promoted the implementation of “Pilot Projects”, in order to plan safe mobility systems and to improve road infrastructure at test sites, proposed by road-owners and management bodies in partnership with local administrations.

The Pilot Projects are tools selected by the Ministry to validate the NPRS guidelines, according to a very strict selection process, since it was expected that such a huge program could be of a wide interest at national level. So, the Pilot Projects' concept was, on one hand, to develop some tests on the most dangerous sites to implement holistic designs to increase the overall safety level and, on the other hand, to partially contribute by fundings to the implementation of packages of solutions, whose costs administrations wouldn't be able to afford in short times. Total budget for fundings was 11,878,508 Euros for 60 projects.

The most appropriate procedure to start Pilot Projects process was supposed to be a competition among all the bodies that at different level, and according to different tasks, participate to roads management, addressing the call to municipalities, provincial and regional administrations, school and health authorities, practitioners, public transportation operators, pressure groups, private services companies and so on. About 200 design proposals have been presented at the call for competition deadline, in spite of the Ministry's decision to finance only the 60 best proposals.
The protocol for the competition was very strict, since participants had to present an in-depth study on the state of the art of the mobility and of the safety standards of the site worth to be re-designed, reporting data and information on the local economy and social structure, on the road system and the related mobility pattern, statistics on accidents (from 1991 to 1999, when available), as well as an analysis of the risk main causes.

The protocol asked the participants to outline, among various practical information, the proposals objectives at short, mid and long terms, to describe the design contents also by drawings and maps (if necessary), to indicate how results would be monitored, to highlight how partnership among the involved bodies would work, to add a Gantt-chart describing the design and the building phases and eventually a detailed list of costs.
Interventions to be dealt with in the proposals could envisage all the main fields that contribute to make roads safe environments: improvements on road links and intersections design (not only in terms of crossings safety standards, but also in terms of appropriate lighting systems, paving management, system of signs, etc.) vulnerable users safeguards, alignment readability and perception, enforcement, educational and training programs, telematics monitoring, on-board safety devices, first aid and emergency services, awareness and so on.

In December 2001, the Ministry released the list of the 60 awarded Pilot Projects. Teramo Province was located at 30th place of the list.

3. Teramo Province Pilot Project

The Pilot Project, implemented by the Department of Roads of Teramo Provincial Administration, was born with the cooperation of other Administrations working on road safety, in the same area: the Local Office of the Government, that coordinates several Police Forces and the Consortium of Val Vibrata, a consortium among the municipalities of Val Vibrata, an area of Teramo Province. The scientific coordination has been entrusted to the Department of Hydraulic, Transportation and Roads of University of Rome "La Sapienza". The title of the Pilot Project is: *Safety Audit – increase of road Safety in Val Vibrata* (CERA, DI MASCIO and VALENTE 2003).

The activities of the Pilot Project are shown in figure 1. They are:

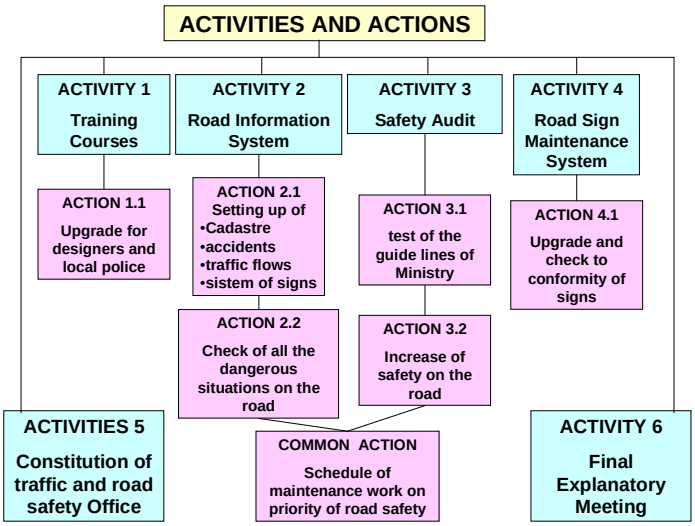

Fig. 1: Actions and activities of Teramo Province Pilot Project

1. Upgrading Training courses for designers and local Police;
2. Development of the Road Information System of Teramo Province by:
   - setting up the following data-bases:
     - geometric and functional characteristics of road network (road cadastre);
     - road accidents;
     - traffic flows;
     - system of signs.
   - Implementation of routines to make queries to the data-bases. The aim of this step is the study of all the dangerous situations on the road, to give a tool to the Administration for scheduling the maintenance interventions on the priority of road safety.
3. Testing procedure of guide lines on Safety Audit and Safety Review drawn up by the Italian Ministry of Public Works. In Italy these procedure are in testing phase yet, and the Ministry asked to include this action in the Pilot Projects, when possible.
4. Implementation of the Road Signs Maintenance System.
5. Constitution of *Traffic and Road Safety Office*.
6. Final explanatory meeting.

4. The Road Information System of Teramo Province

The Italian Road Code urges the road Administrations to implement and upgrade cartography and cadastre, according to a recent law (D.M. 1/06/2001:Institution and upgrading of road cadastre). The cadastre is a part of a largest data-base: the Road Information System. This is the tool for collecting, processing and representing data regarding different roads, coming from different sources (police, municipalities, territorial agencies) and that can be used by the administration with different aims (maintenance, safety analysis, etc.).
All the data collected by every Administration will be gathered in the National Road Data-base, that will be formed at the Ministry of Infrastructure and Transportation.
The National Road Data-base is composed of the following sections:

a. List of the roads, identified by the classification settled by the road code;
b. Traffic data
c. Accident data

d. Practicability for working machines
e. Pollution data

The Italian Road Administrations are starting the implementation of the system and Teramo Province has tested the construction of the cadastre and the Road Information System in the Pilot Project. Cadastre, traffic, accident and system of signs data-bases have been developed as activities of this project (figure 2). The other data-bases (pavement, bridge and tunnel, work yards, economic, pollution data) will be implemented after the end of the Pilot Project as activities of the new Traffic and Road Safety Office.

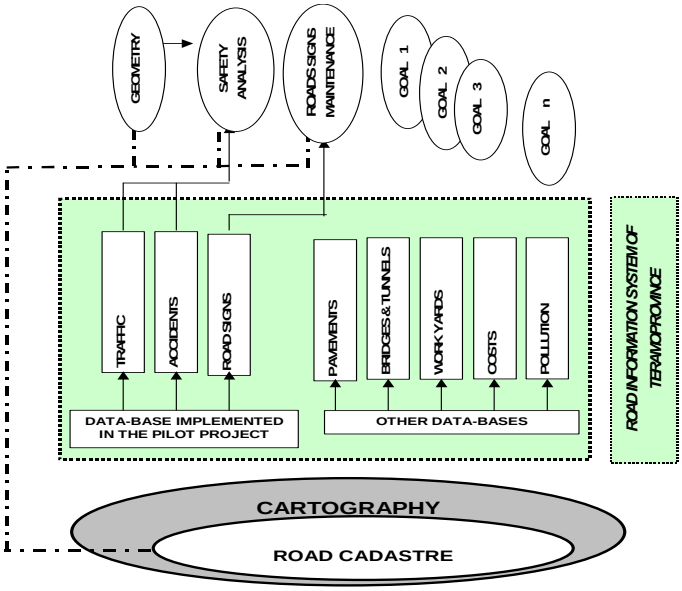

Fig. 2: Road Information System of Teramo Province

4.1 The Italian "Road Cadastre" project

The Italian road surveyors and GIS makers are nowadays paying a great attention to the so-called "Road Cadastre". It is a set of basic digital road maps, which in a few years will be applied to the whole Italian road network. The "Road Cadastre" introduces the GDF (Geographic Data Files, version 3.0, 1995) European standard in the representation of the road network and the road related informations. In this way, it represents a challenge to the GIS and RTTT (Road Transport and Traffic Telematics) applications makers, because of the induced standardization process. It represents also a challenge to surveyors, because very productive and accurate techniques are required to meet his completeness, up-to-dateness and accuracy requirements.

GDF is an European standard (upon studies of the Comité Européen de Normalisation – Technical Committee 287), that is used to describe and transfer road networks and road related data. It is much more than a generic GIS standard and an exchange format, because GDF gives rules how to capture the data, how the features, attributes and relations have been defined. A GDF map has no scale, but contains accuracy. The scale depends on the application where it is used.

A GDF database will never be used as such. The first thing that a user will do, is to transform it into their system. This could be a GIS, or any other application: the GDF standard is application independent.

GDF uses a three level structure in the world representation :

1. Level-0: Topology. This is a common GIS topology description. Everything is described by Nodes, Edges and Faces.

2. Level-1: Features. Level 1 is the most used level of GDF. It contains simple features like “Road Elements”, “Road Junctions”, “Traffic Areas”. Features have attributes (i.e. road width, number of lanes). Features can also have relations (i.e. “Forbidden turn from Road Element #1 to Road Element #2” or “Road Element #1 has priority over Road Element #2”).
3. Level-2: Complex Features. At this level the simple features are aggregated to a higher level of generalization. For instance a “Road Intersection” is a group of “Road Elements” and “Road Junctions” at the Level-1, while at the Level-2 it is just a Point Feature. Level-2 is mostly used when a simplified description of the road network is sufficient.

The Italian “Road Cadastre” Specifications are a GDF implementation. These contains:

- Level-1 features definition. The only defined features are: “Road Junction” (simple point feature) , “Road Element” (simple line feature), “Enclosed Traffic Area” (simple area feature). There exist a huge number of segmented attributes definitions.
- Accuracy requirements. Accuracy is defined for the point coordinates needed for the Level-0 representation. Plane coordinates must have 1-metre accuracy in the global frame. Accuracy is also defined for some segmented attributes: the road width must have 1-decimetre accuracy and the slope data must have 1% accuracy.
- Survey guidelines for the identification of features and road axis measurements process. Briefly, 1. the axis topography must be obtained by a least-squares process from a “seed” of measured points and 2. the junction features, which represent the start- and end-point of road elements, must be obtained by a road axis functional intersection.
- No Relationships definition exist.

Thus, the “Road Cadastre” aims to be a only a basic Level-1 GDF digital road map. His Level-0 representation meets the accuracy standards of the Italian national technical cartography.

In this way, it is open to a wide range of applications, because each application may define his requirements, relationships and data structure extensions. Furthermore, accuracy requirements are adequate for a wide range of application fields. Finally, all the road applications will be virtually compatible because of the standardization process.

4.2 The “Road Cadastre” of the Teramo Province experimental road network

An intermediate product of the pilot project described in this paper is a “Road Cadastre” compliant database depicting the interested road network, which is intended as the kernel of the information system described above.

The experimental cadastre is generated upon mobile mapping measurements. A mobile mapping system is substantially a van-mounted trajectographic subsystem with high performances, whose positional solutions are synchronized with the data collected from the so-called “mapping sensors”, such as digital cameras, laser scanners and so on. The data obtained from the *mms* are subsequently post-processed in order to obtain an ordered set of point coordinates records - the so-called “point seed” - provided with the curvimetric distance along the road axis and a set of “segmented attribute” values georeferenced in the curvimetric frame which geometrically and functionally describes the given road. The process of the GDF road network definition starts with the identification of the “Road Junctions”, as intersection points of road axis. Subsequently, the “point seed” is clustered obtaining a set of “Road Elements”, each starting and ending at a “Road Junction” and, finally, the segmented attributes curvimetric references are reported to each “Road Element”. In the figures 3 and 4 we can see the interface of the photogrammetric process, specifically developed for this project, and a snapshot of the final result imported into the Intergraph GDF Viewer wich assures the GDF 3.0 compliance.

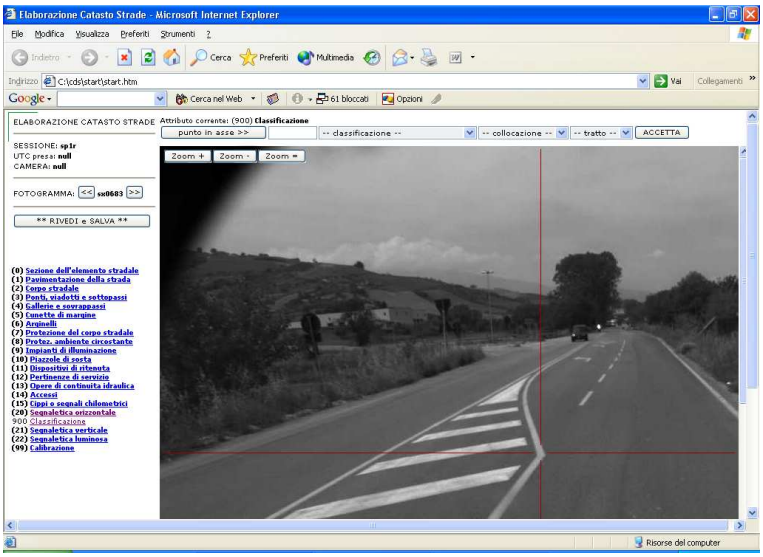

Fig.3: The main interface of the MMS photo observation process

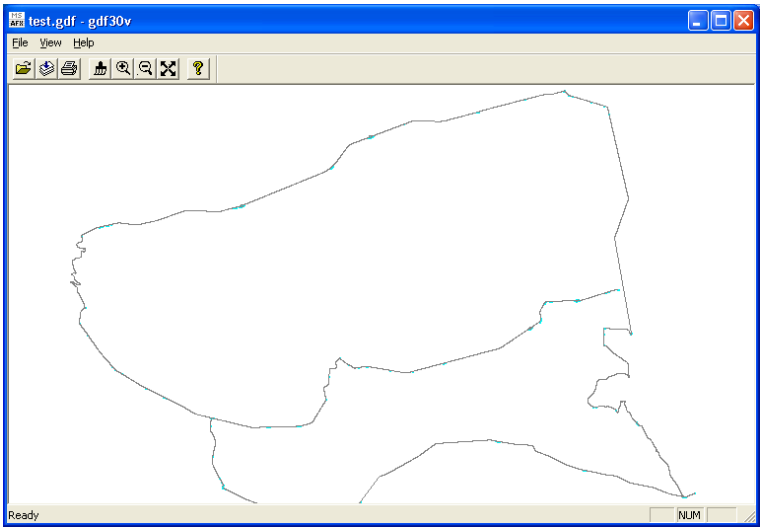

Fig.4: The experimental road network databse opened by the Integraph GDF viewer

To include the road sign domain, the set of the themes, entities and attributes of the Italian "Road Cadastre" specifications is expanded as described in § 5.2, so mantaining the GDF standard compliance of the whole database. The *mms* accuracies, certified by the Trieste University, are compliant with the ADAS (Advanced Driver Assistance Systems) requirements, as specified in the Nextmap project of the European ITS Research Organisation

5. The Road Sign Management System of Teramo Province

The computerized road sign data-base allows:

- the re-organization, homogenization and registration of all the paper documents in the Office;
- the carrying out of research on all the signs installed on the roads;
- the knowledge of the condition of the system of signs installed on a road or on a intersection or on a route;

- the verification of the conformity to Italian Road Code;
- the management and scheduling of the all the maintenance works;
- the layout of all information.

5.1 The Data-base Implementation

The development of data-base follows two phases:

1st phase: START

The quickest tool actually available to create a data-base is the automatic continuous survey by means of the *mobile mapping system* (*mms*). In the Pilot Project of Teramo Province this phase has been performed at the same time of the survey for the road cadastre. The coordinates and the kinds of all the signs (pavements markings, roads signs and traffic lights) on the road network has been recorded. So all the signs are geo-referred.

2nd phase: DATABASE UPDATING

The *mms* could be used to upgrade the data-base of signs. Alternatively, especially when the survey is limited to few data, the following procedure can be used:

1. manual survey of technical characteristics and the conditions of the signs with a survey paper form.
   According to Italian law, every sign must have written on the back:
   - the name of manufacturer and supplier of the sign
   - the year of manufacture
   - the owner of the road
   - the reference of the decree of apposition (for regulatory signs only).

   All these information must be surveyed and recorded.
   In addition, it is important to have information on visibility, readability and conditions of maintenance for every sign, according to the standard of Italian Road Code.
2. photographic survey of the signs with a geo-referred digital camera;
3. input of gathered data and photos on computer.

5.2 Data Organization

The database of our interest is composed by:

- a road network description based upon the set of Road Cadastre's entities, compliant with the GDF 3.0 theme "Road and Ferries"
- a road sign description based upon a set entities included in the GDF 3.0 theme "Road Furniture".

Briefly, the data organization for a representation of Level-1 (GDF 8.9) is:

Catalogue of Entities:

Theme: "Road and Ferries"**.** Entities (from the Road Cadastre)

- Road Element
- Road Junction
- Road Traffic area

Theme: "Road Furniture" (GDF 8.9.2). Entities**:**

- Signpost (GDF 5.9.2)
- Road Sign (GDF 5.9.3)
- Traffic light (GDF 5.9.4)

Catalogue of Relations

- "Road Related Object" related to "Road Element" – This relation, described in GDF 7.2.25 is intended to establish an association between the "Road Element"

entity from the “Road and Ferries” theme and the “Signpost” entity from the “Road Furniture” theme
- “Signpost” related to “Traffic Sign” – This relation is intended to establish an association with a “Signpost” and the set of installed “Traffic Signs”.
- “Traffic Sign in + Direction” of “Road Element” (GDF 7.2.31)
- “Traffic Sign in – Direction” of “Road Element” (GDF 7.2.32)
- “Traffic Light in + Direction” of “Road Element” (GDF 7.2.33)
- “Traffic Light in – Direction” of “Road Element” (GDF 7.2.33)

Catalogue of Attributes

Entity: Road Element
- “Pavement marking” – This segmented attribute, associated with a tipology code (continuous line, double line, dashed line, pedestrian crossing and so on) and a maintenance code (good … poor) is intended to describe the marking painted on the road surface and the maintenance condition

Entity: Signpost
- “Signpost information” – This is a composed attribute: curvimetric distance, direction, offset from centerline, link to imagery

Entity: Road Sign
- Direction (GDF 6.10.1)
- Traffic Sign Information (GDF 6.10.3) – This is a Composed Attribute: Traffic Sign Class (GDF 6.10.4) , Symbol on Traffic Sign (GDF 6.10.2), Textual Content of a Traffic Sign (GDF 6.10.3), Value on Traffic Sign (GDF 6.10.6), Manifacturer, Year of installation, Ordinance of installation

Entity: Traffic Light
- Direction (GDF 6.10.1)
- Traffic Light Information, composed attribute: Classification, Manifacturer, Year of installation

5.3 The software for road sign management

We have already said that four data-bases have been implemented during the Pilot Project of Teramo: cadastre, traffic, accident and road sign.
It is clear that these data-bases are useful to the Administration if there is an interface among them, so that the duplication of upgrading function are avoided and all the application are uniform. In addition some data should be processed by other software and many users. For these reasons the data-base of Teramo Province is managed by subroutines for input and output of data.
As we already said, the data-base of road sign is linked to cadastre so we have immediately the coordinates of the signposts.
The data-base of Teramo Province is divided in three principal sections:

1. Pavement markings
2. Road Signs
   - warning signs
   - regulatory signs
   - guide signs
3. Traffic lights
   - Variable message panels
   - Traffic lights
   - Others

The software is composed by the following subroutines:

UPDATING SUBROUTINE (with restricted access) : it allows
- maintenance and updating of data with accuracy requirements (as the coordinates of the centerline of the road). The access to these subroutines is restricted to the company that manage the software;

- maintenance and update of data without accuracy requirements that can be often variable during the time (as conditions of road signs). The access to these subroutines is restricted to Administration technicians.

QUERING SUBROUTINE: all the technicians of the Administration can make queries on the database. Two kinds of queries are possible:

- *maintenance queries*: i.e. queries on the physical condition of the signs; for example, how many and which signs must be changed until a defined date;
- *design queries:* i.e. queries on the location of the different kinds of signs for different roads. This subroutine allows to see the signs and the traffic light phases on the screen.

Some outputs of the software are shown in the following figures to better explain the data-base.
It is possible to choose a single road of the network (Theme "Road and Ferry") on the menu or on the map on the screen (for example "*strada provinciale n.259 – provincial road n.259*" in fig. 5).

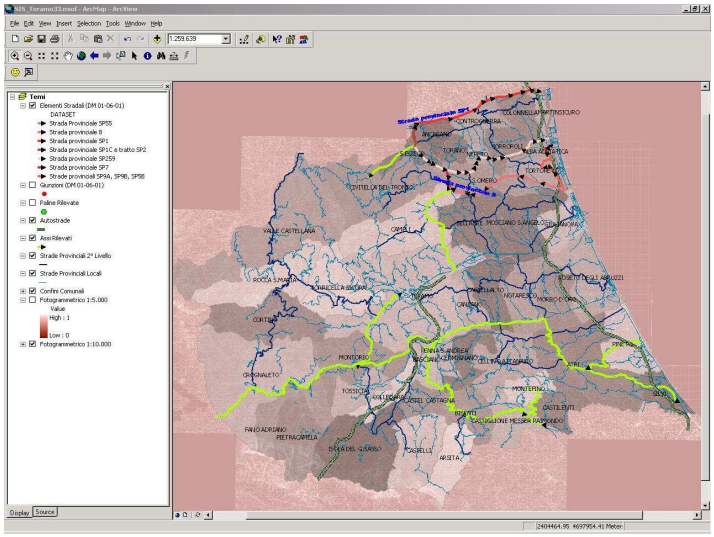

Fig.5: The road network of Teramo Province

The surveyed signposts are shown with a green dot on the map (fig.6) and selecting one of these by the mouse you can have all the information about it.
The length of the selected road element, the progressive of the signpost in the road element, the progressive in the whole road are shown. The geometric characteristics of the road close to the signpost are shown in a pop-up window *"Geometry"* (Catalogue of Relations): longitudinal slope, vertical radius, horizontal radius, cross slope.
Another window with two menus is available for the signpost (fig.7): *"General Data"* where the direction and the side of the road where the signpost is installed, the material, the type and the co-ordinate of the signpost are listed (fig.7), and *"Conditions"* where the condition, the name of the installer and the date of installation are recorded. Three menus are available for every sign on the same signpost (fig.8): *"General Data", "Refracting film"* and "*Maintenance*".
Symbol, identifier code, orientation, type of sign, dimensional class and decree of apposition (for regulatory signs) are in "*General data*". The condition of the refracting film, the refracting class, the expiry date and the installation date are listed in *"Refracting film"*. The past maintenance works are listed in "*Maintenance*".
Queries on all the items in the menus can be made.

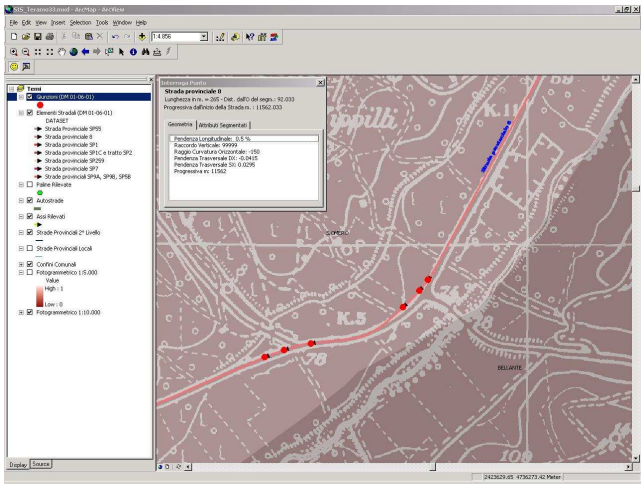

Fig.6: The geometric characteristics of the road close to the signpost

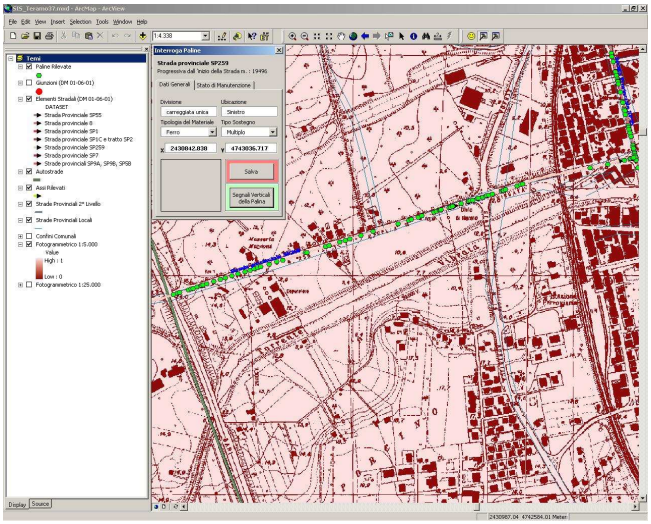

Fig.7: Data on the signpost

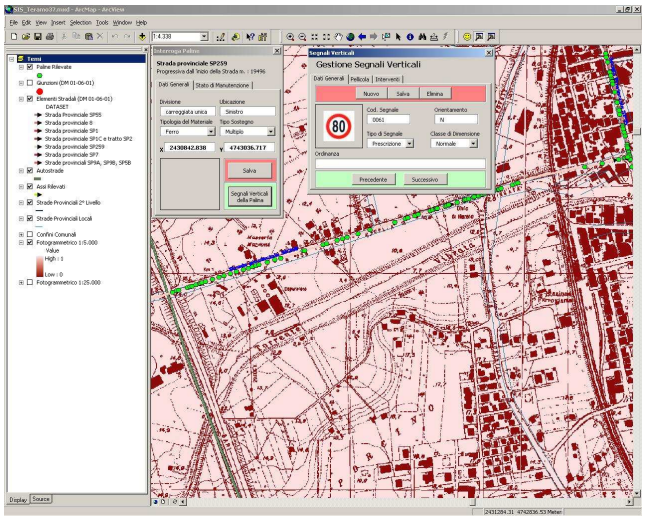

Fig.8: The data on the sign

6. Conclusion

The Provincial Administration of Teramo, Italy, has implemented a Road Sign Management Systems (RSMS) as an important part of a larger integrated road management system. It has been included in the Pilot Project to increase Road Safety, developed by the Administration to access to the financial aids forecasted in the National Plan for Road Safety (NPRS), promoted by the Italian Ministry of Public Works (now Ministry of Infrastructure and Transportation).
The system will help the Administration to manage all signs, pavement markings and traffic lights of its road network. This will be useful for plan, design and maintenance of the system of signs.
The RSMS is linked to the data-bases of cadastre, traffic, accidents and road signs implemented in the pilot project. All the signs are geo-referred. The data base of the signs is managed by a software composed by two kinds of subroutines: to upgrade the data and to make queries.
The system could be very useful for the Administration if the database will be updated constantly and if the other local Administrations (as municipalities) could consult it to have a homogeneous and integrated system of signs in the whole province.

REFERENCES

CERA L., DI MASCIO P., VALENTE A. (2003) "Il progetto pilota avviato dalla provincia di Teramo. innovazione e tecnologie contro gli incidenti", Onda verde n.83, maggio/giugno 2003.

COMITÉ EUROPÉEN DE NORMALISATION (1995), Technical Committee 287, Geographic Data Files, ver. 3.0

EUROPEAN COMMISSION (2001) WHITE PAPER EUROPEAN TRANSPORT POLICY FOR 2010: time to decide, 370, 12.9.2001

MANZONI G., MARTINOLLI S., PAGURUT R., PALERMO C., PURGA A., SLUGA T., (2003) Road survey by GIGI: status and results, Reports on Geodesy n. 2(65), pp. 159-164

MINISTERO DEI LAVORI PUBBLICI, Decreto Ministeriale 1/6/2001, Modalità di Istituzione e Aggiornamento del Catasto delle Strade, Supplemento Ordinario n. 6 alla Gazzetta Ufficiale n.5 del 7.1.02

NextMAP Project Paper Nr 2183, 2002

PANDAZIS J.C, NextMAP: Investigation the future of digital map databases, ERTICO