TRAFFIC, SPEED AND SAFETY ON HIGHWAYS

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Abstract: There are different types of vehicles running on Highways, so travelling it's often very dangerous, especially when there is a lot of traffic. The manoeuvrability is extremely limited because of the high traffic flow and therefore physical and psycological comforts afforded to the drivers are extremely poor. Travel speed limits may cause in the drivers a great desire of freedom and this can induce them to effect risky manoeuvres. Sometime these risky manoeuvres can bring to fatal accidents.
Our research tries to identify the necessary means for a safer driving.

1.Introduction.
Nowadays highways may be very dangerous. In these last years vehicles technological progress created a very huge difference between road infrastructures and vehicles. It is often impossible to adequate road infrastructures to vehicles. Engineers are called to give their opinion about new systems capable to increase road safety level for drivers. This research has developped a traffic signals system for directing drivers' actions during highway travel.

2. Territorial Information System.
In these last years Territorial Information Systems developped and improved very much, these systems can archive, analyse and manage all the information connected to territorial data.
The technological component of the Territorial Information System (TIS) is constituted by all the information data, known as GIS (Geographical Information Systems).
The TIS can be applied also to road traffic management.

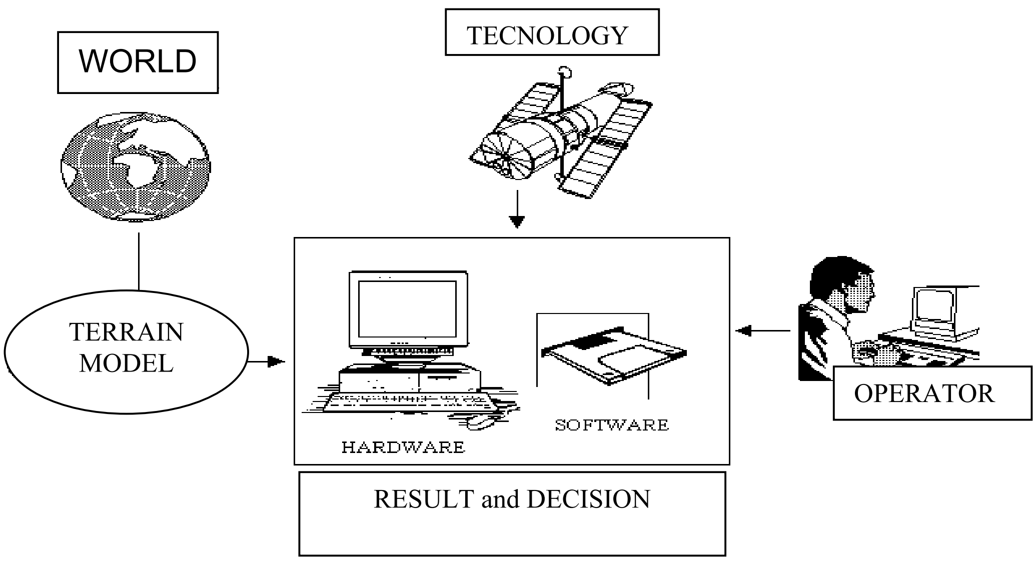

Fig. 1 - General Structure of a Territorial Information System.

Territorial Information System can be defined an entire group of computers, software, geographical data and personnel who has the task to collect, to memorize, to up-date, to analyse and to represent georeferenced information (information referred to geographical data) (Fig.1).
GIS allows working with both mapping and alphanumeric information through a logic scheme allowing system interrogation.
Three fundamental elements are necessary for a correct organization of the system:

- territory knowledge,
- mathematical models related to the topics to be faced,
- an information system (hardware and software) capable to manage, to elaborate and to cross among them a series of referenced information.

In this study, GIS application to road system is dedicated to the conditioning caused by overtaking on highway.

3. Overtaking on highway.

The speed adopted by a driver when there is no restriction is called "desired speed" . When there is much traffic on the highway, vehicle speed is sujected to the other vehicles. If the driver wants to travel at his desired speed, he has to effect a series of overtakings.

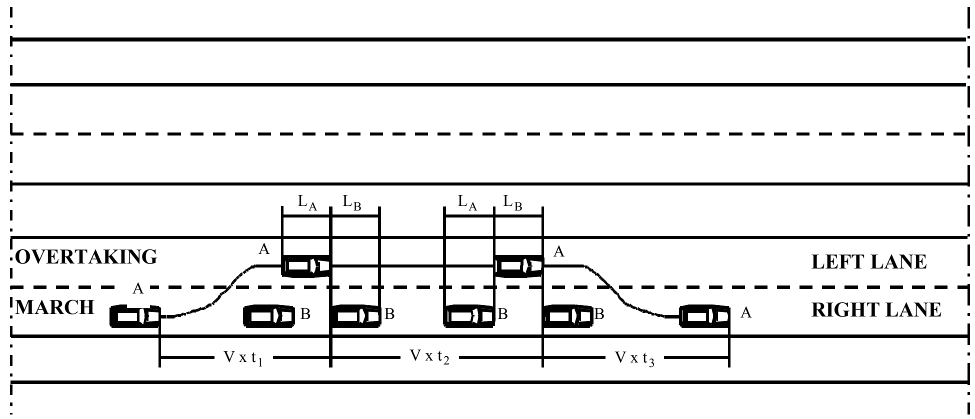

Fig. 2 - Scheme of highway overtaking.

The driver's desire to effect overtaking is subjected to local vehicular conditions.
The vocation to overtake can be defined as the difference between the driver desired speed and the speed of the former vehicle.
Highways surveys evidenced that when vehicular traffic is high, fast vehicles move into the overtaking lane. It was also noticed that when vehicular density is over 10 vehic./km on running lane, fast vehicle driver must effect, in a very short time interval, several overtaking maneuvers - in and out the lane. These conditions can create in the fast vehicle driver a phycologic element of stress defense, so he can decide to avoid exits and ri-entries in the normal running lane, going on the overtaking lane and staying on this lane for all the time requested to overtake all the slow vehicles he finds.
Fast vehicle running on normal lane often cannot overtake because the overtaking lane is already occupied by other fast vehicles, therefore it's obliged to run slowly and to stay in the slow lane, waiting until the necessary space is available on its left so to effect overtaking. This uncomfortable condition is supposed to increase in strict relation with the waiting time necessary to overtake and therefore may bring the driver of fast vehicle to accept high risk to get the possibility to enter the overtaking lane, also if all the necessary conditions for a safe overtaking do not exist.
A software was created to check what measured, thinking of a vehicular traffic volume constantly increasing.
Vehicular volume is divided into:

- fast vehicles (running at a speed between 80 and 120 km/h);
- slow vehicles (running at 80 km/h).

Speed diversification of fast vehicles allows a simulation of overtaking dynamic very adherent to reality; three main situations may occur:

- **overtaking**: fast vehicles speed: 120 Km/h, which has to be maintained for all the time necessary to overtake and anyway as long as running in the overtaking lane;
- **normal running**: fast vehicles speed 100: Km/h, which has to be maintained during running on the right lane till the exigency of overtaking a slow vehicle arises;
- **waiting condition**: fast vehicle speed: 80 Km/h which has to be maintained for a time interval which is function of the available space on the right lane in order to overtake a slow vehicle.

It was possible to simulate the interactions among different vehicles through these diversifications of the "speedy" flow, and to determine the variation of waiting time when vehicular traffic changes. The Flow Chart of the elaborated methodology is reported in Fig.3.

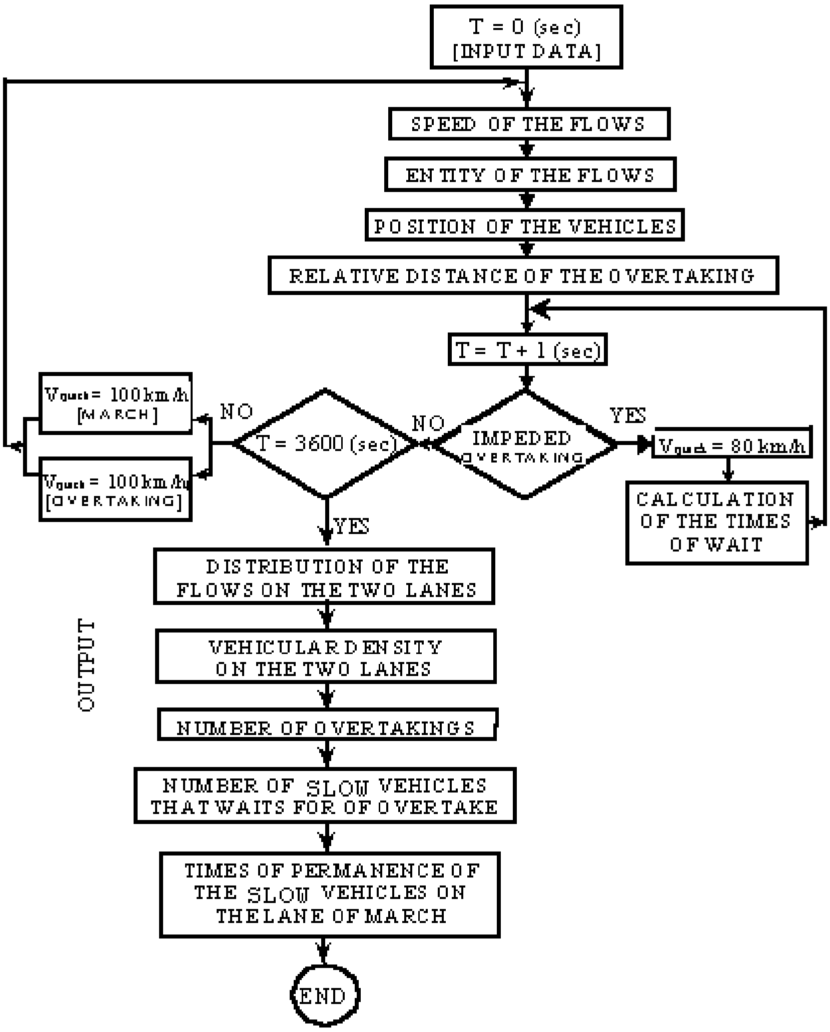

Fig. 3 - Flow chart of the elaborated methodology.

The main results of the above described elaborations are synthetically represented in a series of graphs. (Fig. 4 and Fig.5)

The graph of Fig.5 shows how the distribution of vehicles along the two lanes varies according to flow variations. It can be noticed that, up to a flow of about 2200-2400 vehic./h, the overtaking lane has a lower number of vehicles than the running lane; but over 2400 vehic/h, there is a contrary tendency: the overtaking lane is much more occupied than the running lane.

This disomogeneous distribution of the flows on the two lanes is due to the fact that the limit condition is reached and so the time interval needed by fast vehicle for two consecutive overtakings is minor to the time limit, indicated in 8 seconds.

The conseguence of this scenery, fast vehicle doesn't re-enter into the normal lane but continue its running on the overtaking lane, causes a strong over-traffic.

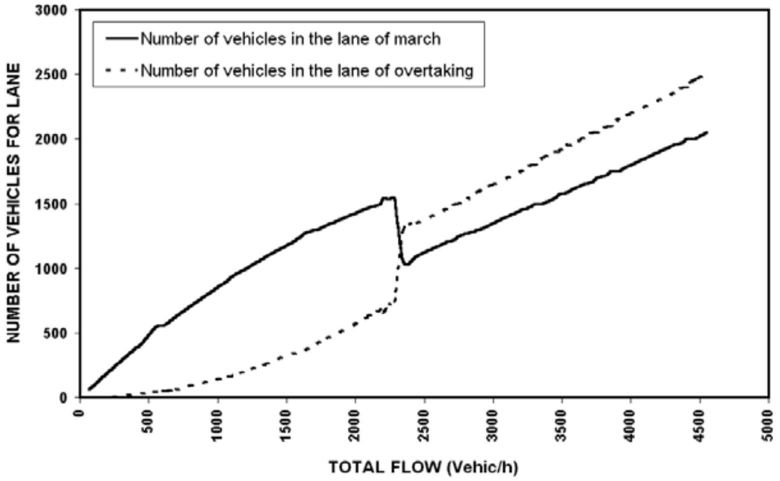

Fig. 4 - Distribution of vehicular flow in the two highway lanes.

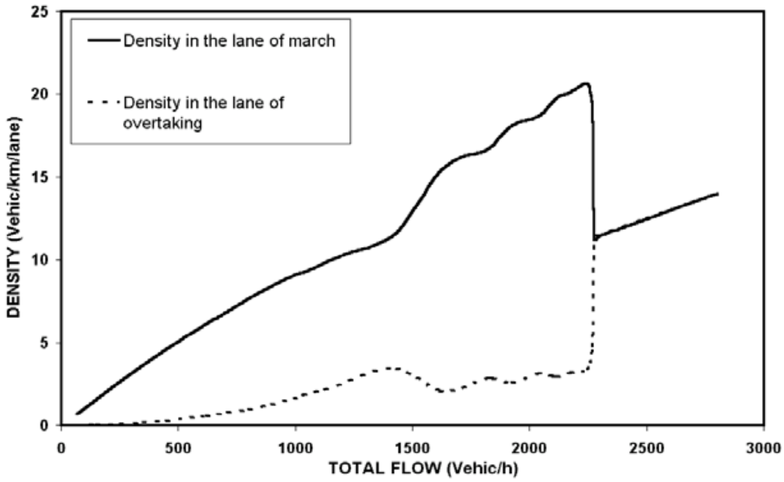

Fig. 5 - Variation of vehicular density on the two highway lanes.

The variations of traffic density due to the variations of traffic flow are reported in the chart n.5. Also in this case it's possible to reach some interesting results:

- vehicular flow $\leq$ 2200 vehic/h: the running lane is much more "crowded" than the overtaking lane;
- vehicluar flow $\geq$ 2200, when fast vehicles don't re-enter into the running lane after overtaking: the "division" of the two flows takes place, creating the condition of "parallel running" on the two lanes.
- the vehicular density of the two lanes, when over 2200 vehic/h, becomes almost the same because, according to what abovesaid, at a speed variation between the two flows, corresponds a proportional variation of vehicular inter-distance (the two lanes have iso-safety characteristc).

Particularly, our studies are addressed towards the simulation of the following conditions:

- casual arrival of vehicles;
- anomalous behaviour of some users;
- heavy vehicles presence.

We think, however, that the results obtained are good enough to constitute the basis for the elaboration of a Territorial Information System suitable to manage traffic road and, contemporaneously, predisposed "to self-reset" in function of the real vehicluar traffic.

Some researchers studied traffic movement on highways and the results of some surveys are shown in the fig. n.6. This figure shows the perfect relation with the silumation carried out through software.

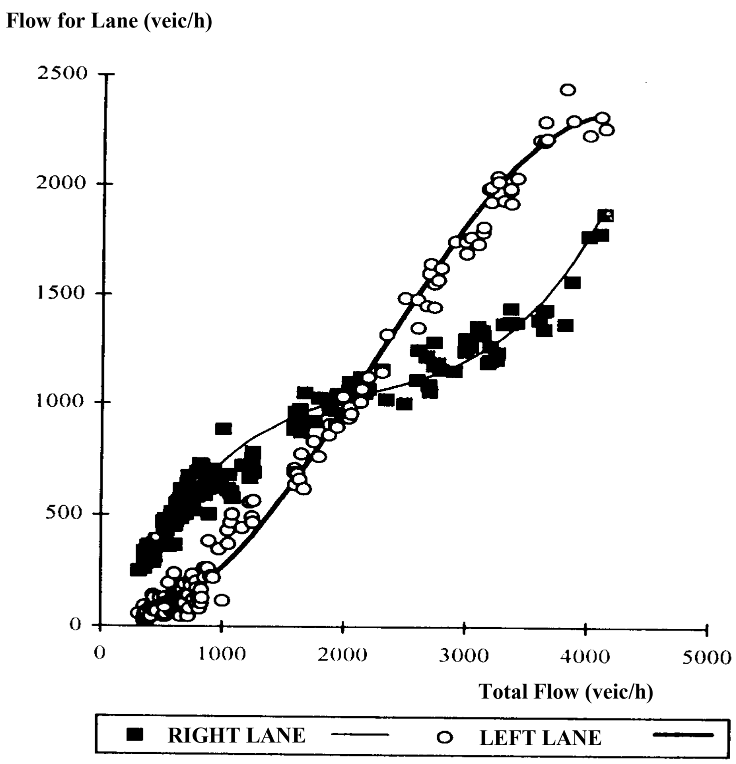

Fig. 6 - Result of a traffic remark on the highway A3 Salerno-Reggio Calabria

4. Highway Traffic Management System Elaboration.

The effected simulations evidenced that, when the vehicular flow changes, overtaking influences the safety of road circulation.It is possible to individuate a "limit" flow value in correspondence of which the drivers of fast vehicles think that it's more convenient not to re-enter after overtaking, creating in this way the "division" of the two flows.
As soon as the vehicular density gets the limit value, which would cause the separation of the two flows, the "invitiation" to dispose on parallel lines and avoid overtaking, should be signaled to drivers, by means of a series of variable message signs.

5. Architecture of the information system for the dynamic management of road serviceability.

The Information System for the Dynamic Management of road serviceability should allow (Fig. 7):

- to start a procedure to collect information about the number of (N_v) all the present vehicles on a given road section (**NV**);
- to manage the knowing process of the average speed (S_a) of the vehicular platoons (**ASP**);
- to deduce the vehicular flows present on the road sections;
- to compare the real flow with the reference limit value and, consequently, to start a management procedure of variable message signs (**VMS**);
- to control the working conditions and the eventual failures of the peripheral units (Variable message signs, Speed detector, Registration stations of the vehicles in and out the road infrastructure).

The designed Information System for the Dynamic Management of road serviceability is a system "physically" distributed and constitued by:

- *n* remote site corresponding to *n* "Toll stations Environment" existing on the studied infrastructure (TE);
- a central site, physically corresponding to a Management Structure of the studied highway (MS).

The central site manages all the information coming fron the different Toll unit Environments; those are elaborated and translated into VMS, These messages are resent to the Toll stations Environment (TE) for the transmission to the peripheral units.

The proposed scheme foresees the sub-division of the road net in two section types:

a) extreme road sections;

b) intermediate road sections.

- The *extreme sections* are the sections which limits are physically determined by the "entry" to the highway and by the first "exit"; they take a denomination composed by the official name of the highway (or the name of the main road section) followed by the lane direction and by the names of the sites "at the limits".
- The *intermediate sections* are the sections which limits are determined by two consecutive "exits"; Their denomination is composed by the official name of the highway (or the name of the main road sections) followed by the land direction and by the names of the sites "at the limits".

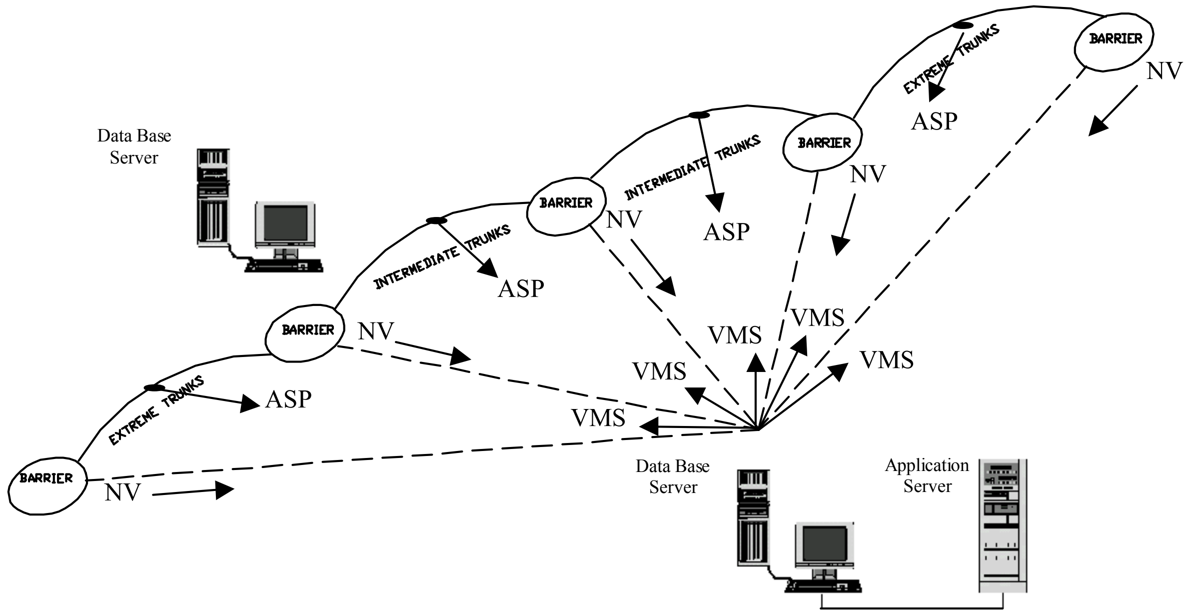

Fig. 7 - Architecture of the Information System for the dynamic management of road serviceability.

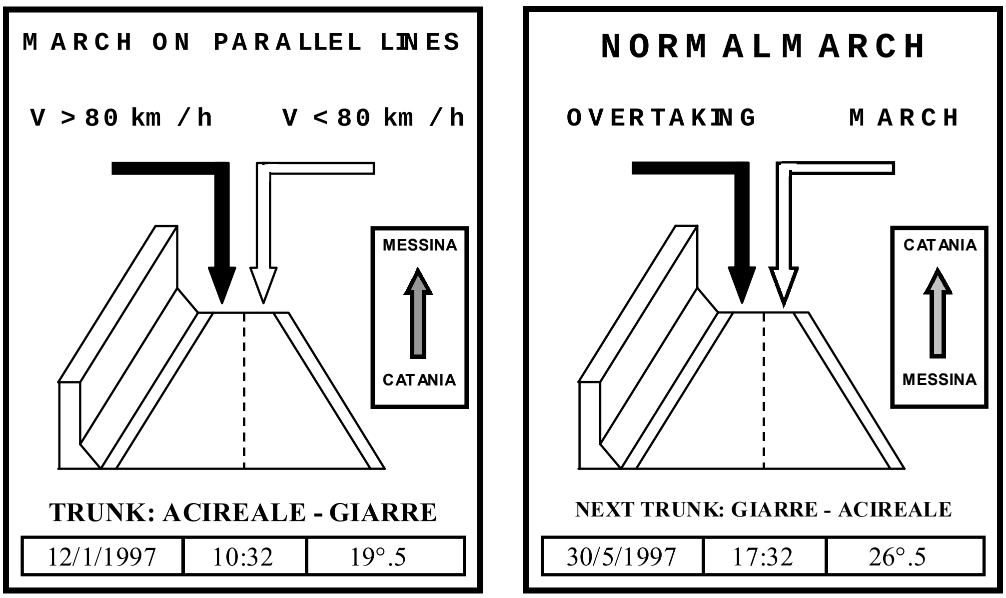

Fig. 8 - Example of Variable Message Sign.

The NV process (Number of vehicles) manages the collection of the number of all vehicles on the various road sections.
The ASP process (Average Speed of the vehicle Platoons), manages the data collection coming from the speed deterctors placed on the highway.
The VMS process (Variable Message Signs) has the function to interface the variable message signs for information diffusion (Fig. 8).
All the information concerning vehicular flows, collected through the elaborations on the various TE (Tall stations Environment) host, are gathered on the MS (Management Structure) system. The types of messages which must be dynamically suggested to the attention of highway users, are mainly two:

- the invitation to take place on parallel lines (sent when vehicular flow is over the permissible value, obtained with the aid of a "self-setting" procedure);
- the indication to run according the "normal" modalities, using the right lane to overtake.

The elaboration process of the Variable Message Signs works on MS host and manages a data base which has a "net level" visibility .
There are three strategic positions for what concerns VMS placement:

1) *Entry*: The VMS is placed at the entrance of a station or of an interchange and has to be well visible from outside in order to allow the correct and dynamic "disposition" of the highway users on the lanes;
2) *Itinere*: The VMS is placed on the highway section, at least 500 mt. before the following section, so to allow the safe disposition on a different configuration.
3) *Section entry*: The VMS is placed at the beginning of a section (near the exit). At this point the highway user should have already taken the suggested configuration, according to the messages received from VMS.

A suitable software was prepared to analyse the abovesaid concepts, the main graphical interfaces of this software are reported here following.
The upper part of the video shows a "flag menu", whose options allow the control operations of the "matter" under examination, by the System Operator.
In the central part of the screen can be visualized the graphic of the investigated area, in order to give to the operator a schematic and synthetic representation of the mobility situation of the various sections and a panoramic view of the state of activity and functionability of the peripherals (VMS, speed detectors, vehicles counter devices) (Fig.9).

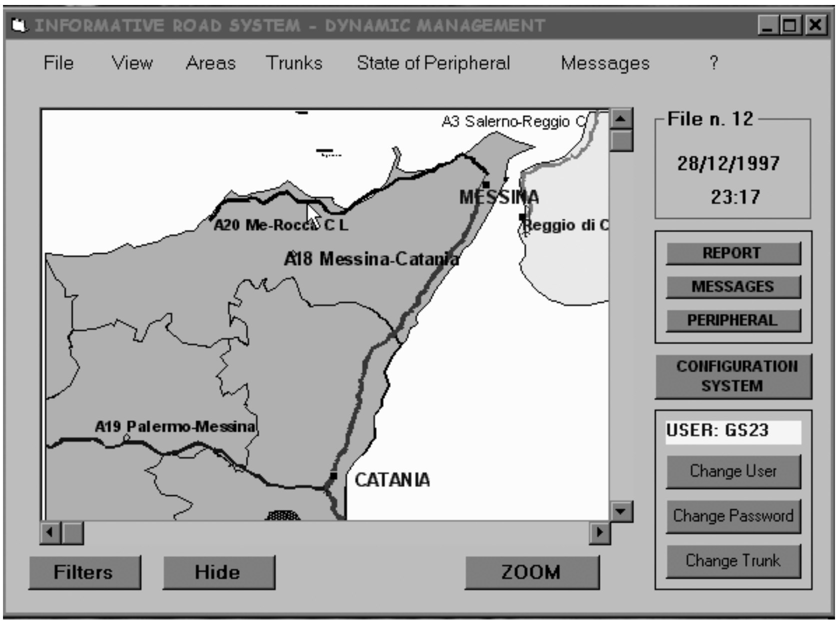

Fig. 9 - Graphic interface example: graphic representation of the investigated infrastructure, at large scale.

The data, represented with peculiar symbols, may be: static (highway sections, lanes, cartographic information, peripherals) and dynamic data (state of the peripherals, active messages and state of the Variable Message Signs).
Many functions can operate acting directly on the graphic representation put into visible form on the screen; for example, selecting the corresponding symbol, it's possible to visualize the state and the current message of a Sign (VMS).

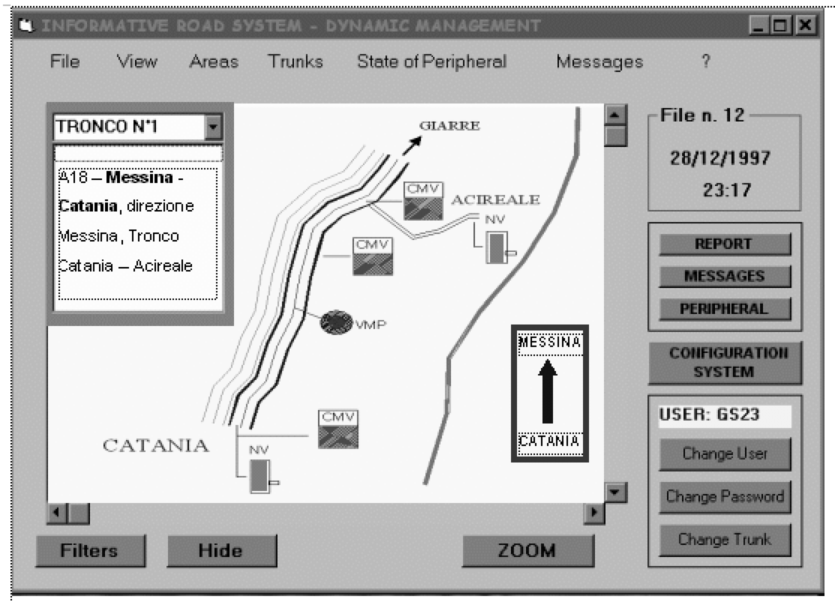

Fig. 10 - Detailed graphic representation concernig the Catania-Acireale Section (Highway A18 Messina-Catania, direction Messina). The locations of different peripherals are particularly evidenced.

A function of self-setting was introduced in the Information System, capable to allow the System to progressively improve its management procedures.
This self-setting function substantially corrects progressively the value of the reference limit flow: in practice, assuming initially a limit value of 2200 veich/h, through the peripherals system VMS and NV, it's possible to verify if the disposition of the vehicles on parallel lines has given real advantage with regard to the "fluency" of the flow.

6. Conclusions.

The conditionings and the restrictions caused by overtaking modality on highway may influence the psyco-physic state of the driver, and he could be able of anomalous behaviour.
Using road Variable Message Signs it's possible to help drivers when there is much traffic on highways. Travelling on parallel lines, when there is much traffic, is a very safe condition, specially because the risks connected to overtaking manoever decrease.

7. Bibliography.

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