ITALIAN POSITION ON ELECTRONIC TOLL COLLECTION INTEROPERABILITY: A PRAGMATIC APPROACH

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SUMMARY

The paper describes the Italian contribution to the project for the creation of an interoperable Electronic Toll Collection (ETC) service across Europe, presenting a practical approach that, while meeting the requirements of the regulatory framework, represents a solution that minimizes the impact on existing systems and put the basis for the migration from single-functionality (ETC) towards global mobility management.

INTRODUCTION

On April 23rd, 2003 the European Commission issued a proposal for a Directive on interoperability of Electronic Toll Collection (ETC). The Directive mainly addresses the technical issues related to the development of a pan-European interoperability service: it states that DSRC microwave 5.8 GHz, Gps (Galileo) and Gsm (Gprs) are the technologies on which an interoperable ETC service should be based.

In defining the timing for the implementation of the service, the approach followed by the EU basically proposes two steps:

- a short term objective, where the harmonization of all existing DSRC 5.8 GHz systems should be achieved by means of a multistandard On Board Unit (Obu), which should progressively become interoperable with satellite-based systems;
- a long term goal, where all DSRC systems should migrate to a satellite platform.

While the text of the Directive is undergoing its approval process with the European Council and European Parliament, where the Member States might require amendments, particularly on the compulsory migration of national systems to the satellite technology and on the dates of this shift, the scope of this paper is to present the Italian experience and the ongoing projects to pursue the Directive objectives.

EUROPEAN ETC MARKET

ETC was introduced in Italy in 1990 with Telepass, the system fully developed by Autostrade, based on DSRC 5.8 GHz technology. Telepass is a public standard, available from the UNI (Italian National Standardization Agency) Norms 10607. In more than ten years, the system passed through a continuous process of technical and commercial improvements, as shown in figure 1. As of today, approx 3.5 million OBUs circulate in Italy, accounting for over 800 million transits per year. Automation of toll collection in Italy reached over 60%, Telepass alone representing 43% (figure 2). Interoperability and interconnection among the 24 Italian concessionaires operating the Italian 6,400 km motorway network are managed by means of a Memorandum of Understanding describing all the technical, legal, fiscal, financial and operational issues required by ETC interoperability.

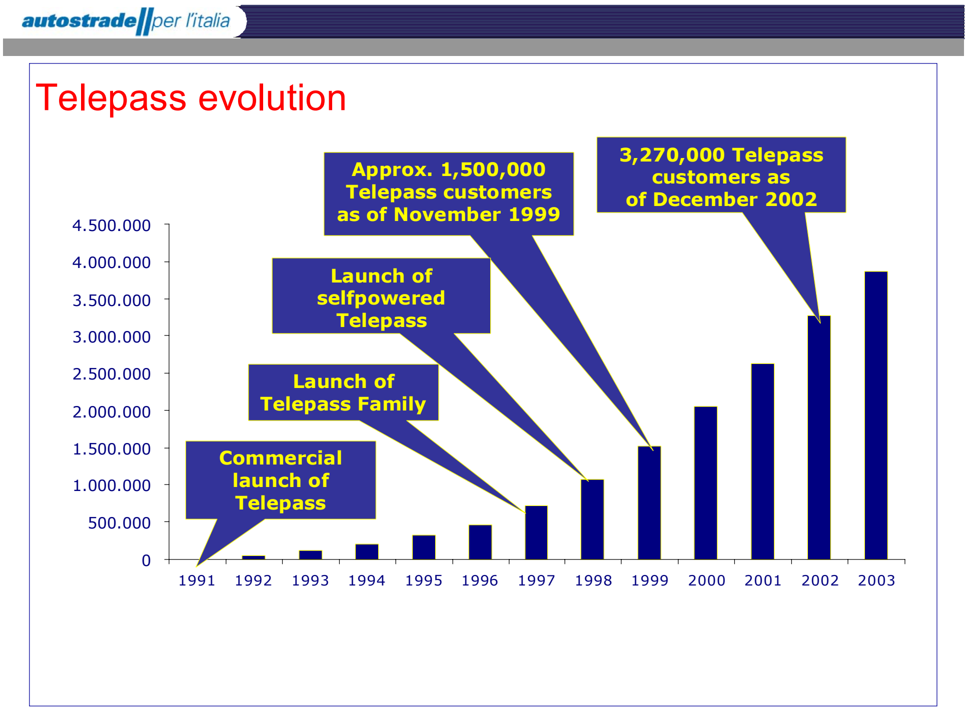

Figure 1: Telepass growth and evolution

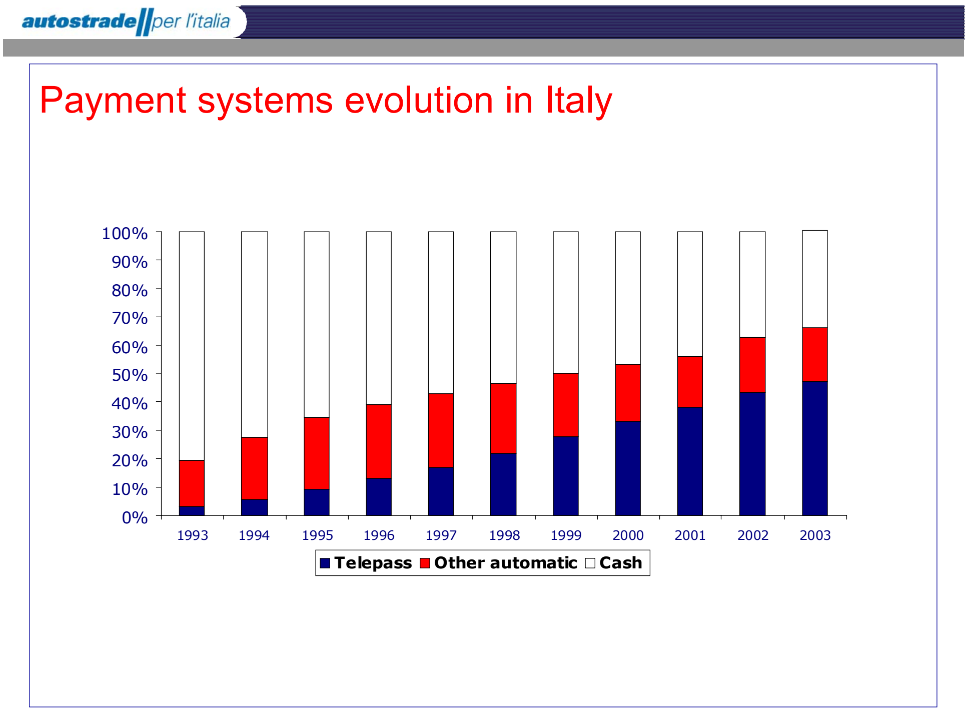

Figure 2: Payment systems in Italy

In Europe most of the ETC systems are based on the same DSRC 5.8 GHz technology, but with different applications. Besides Telepass, the other systems are based on the so-called CEN TC 278 specifications, which led to the development of two different systems not fully compatible each other. As of today in Europe over 6,5 million OBUs circulate, more than 50% being Telepass customers.

The most effective and – most of all – efficient way to make all these systems interoperable is the development of a single "multi-standard" OBU. This way, three main results are achieved:

– Expensive and highly complex impacts on road infrastructures are avoided;

- Since the multistandard OBU is linked to the driver, the solution is symmetric, regardless on the origin or destination country;
- The incremental cost of this solution (a few Euro, on top of an overall cost of 20-25 Euro of the monostandard OBU) is charged only to those customers willing to benefit of ETC throughout Europe. By the way, it is predictable that in a few years manufacturing costs of mono- and multi-standard OBUs will be aligned.

It is in this context that Autostrade started the development of a bistandard OBU, with the aim of solving the technical hurdles for the realization of ETC interoperability with Italian neighbour Countries. Further on, Autostrade decided to develop an OBU that, by integrating localization features (e.g. based on satellite technology) allow the provision of value added service for the drivers. Figure 3 shows the steps of this approach, described in the following section.

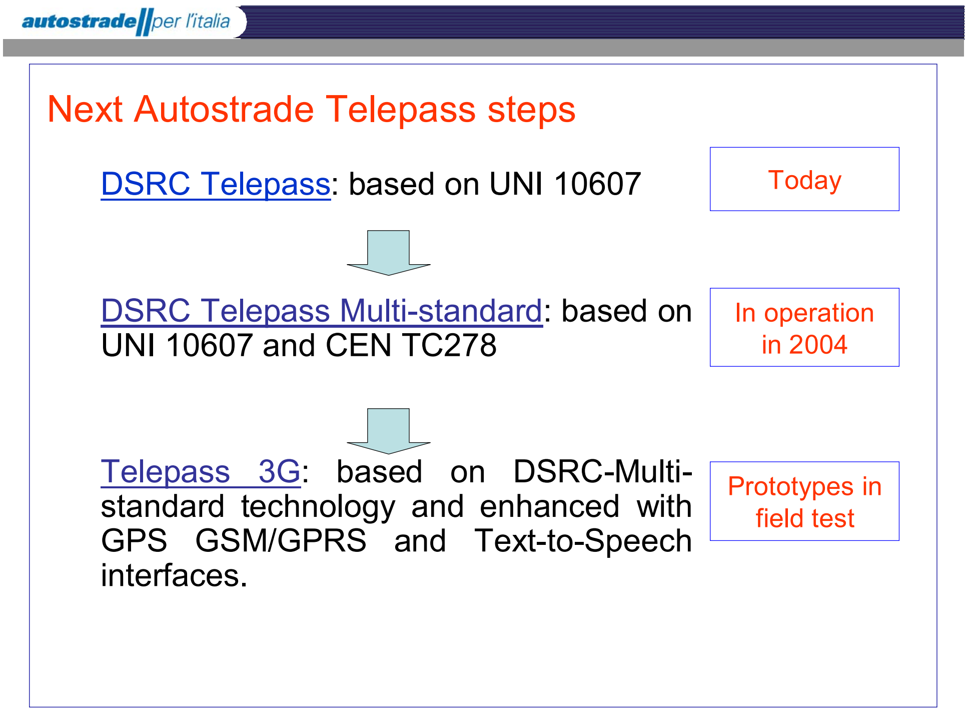

Figure 3

TELEPASS DSRC MULTISTANDARD

The Telepass bistandard project aims at realising an OBU capable to work both in motorway lanes compliant to the Telepass system and to the CEN TC 278 prenorms as well. The OBU is capable to work separately with the two standards thanks to the characteristic of being able to detect the type of standard used by the Road Side Equipment. This can happen after a sort of “wake up signal” that the RSE sends before the OBU respond in a coherent way for the standard communicated. This feature will allow the OBU to be used in different countries’ lanes depending on the local standard. This way of working is similar to the one used for the mobile phones where a three standard chip can detect the signal coming from 3 different communication systems, choosing the correct one to reply (figure 4).

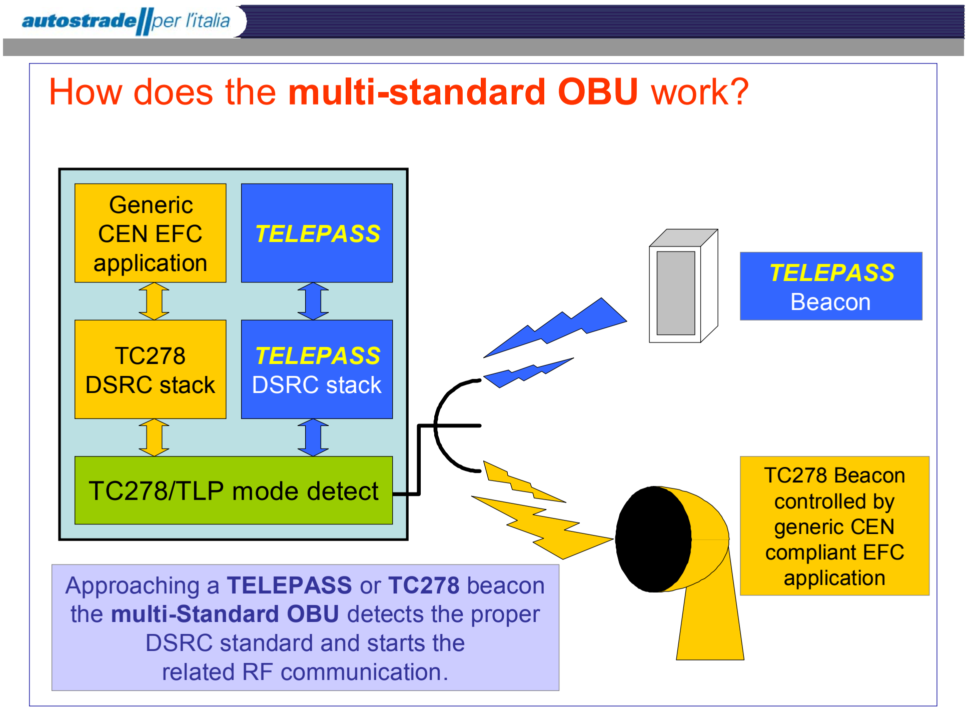

Figure 4:architecture of the multistandard OBU

In particular the project purposes are:

1. the development of 1 kit of components for an OBU devoted to the electronic toll collection and a set of services. This OBU will be compliant both to the Telepass standard (UNI-10607 and ETSI ES 200 674-1) and to the CEN TC 278 prenorms.
2. the engineering of the low-end OBU, the realisation of prototypes and the pre-series production, using as far as possible the same box already developed for the existing OBU's.

Structure of the system

The OBU is the on board unit allowing the radio-frequency dialogue with the Road Side Equipment by the antenna and the TX/RX module.
Besides, it is equipped with a micro-processor capable to execute commands given by the Road Side Equipment. The possibility to access multiple services is due to the terminal multi-purpose functionality, being only a slave for what the master is asking it to do. In other words, the intelligence of one specific application (i.e. the dynamic toll collection) is, for the main part, located in the Road Side Equipment that, via a pre-defined set of commands, requires to the OBU to execute what is necessary to complete the transaction.

Functionality

The functions of the OBU can be summarised as the followings:

- To allow the functionality without smart card, using the factory pre-set data;
- To ensure the independence of the applications configured;
- To represent an interface to be used by the RSE to access to data both in reading and writing;
- To manage the communication towards the RSE by a micro-wave radio link;
- To interact with the driver using an optical-acoustic interface, directly driven by the RSE;
- To allow the change of the battery without losing the configuration;
- To detect the type of standard used by the RSE that awakes it and to respond in a coherent way with that standard;

Components

The project aims at realising a modular chip set gathering the following base blocks of functions:

- DSRC function (Dedicated Short Range Communication) Telepass, i.e. standard UNI-10607 and ETSI ES 200 674-1;
- DSRC function based upon the CEN TC 278 prenorms and ETSI 300 674;
- RF, CAN, sync and not sync Serial Lines, GSM, A/D, general purpose I/O, USB interfaces;
- Vocal synthesis, noise and echo gate;
- CPU, memories, bus and timer block;
- Power supply block.

and capable to allow the new programming of the code by means of the adoption of a flash memory.

To build the OBU only a few more components are required: (figure 5):

- Antenna
- Buzzer
- Multi coloured led
- Passive components
- Plastic box

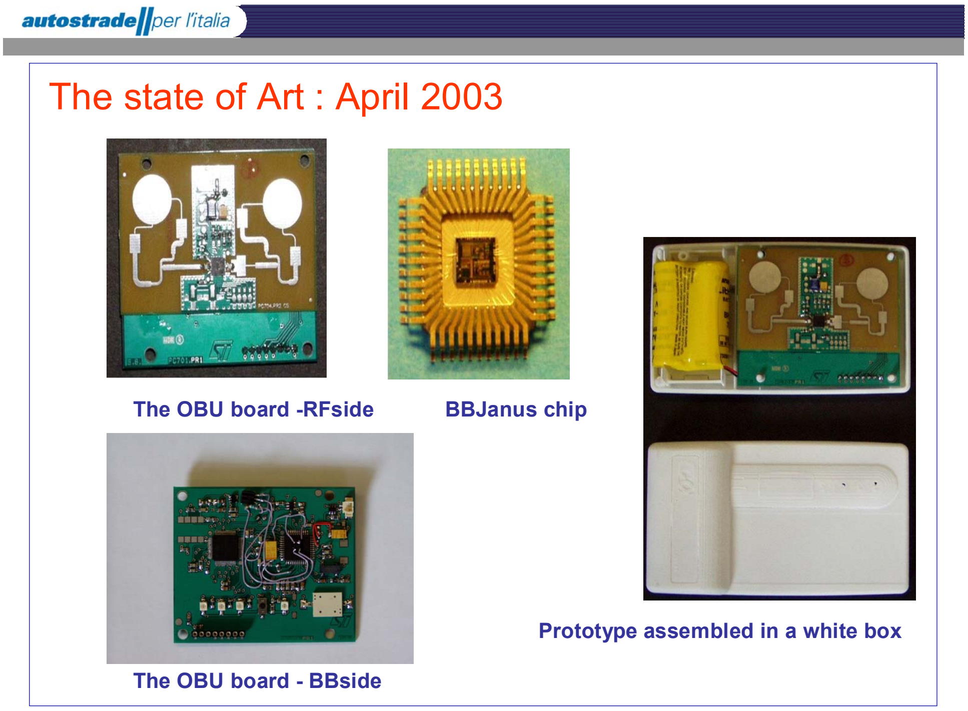

Figure 5: the multi-standard DSRC OBU

As a first, concrete example of technical interoperability between Countries using Telepass (Italy) and TC 278 (Austria), starting next year Autostrade will provide interested drivers with its bi-standard OBU for vehicles travelling between the two countries.

In fact, after the successful bid for the planning, financing, installing and operating of the entire Austrian 2,000 km motorway network, Autostrade founded the subsidiary Europpass Lkw-Mautsystem GmbH. The implementation of the "Truck toll system in Austria" project started in July 1st, 2002 and operation will start in 2004.

On top of the functionalities above described, the OBU will be enhanced with several features required by the Austrian systems:

- possibility for the driver to check the correct status of the OBU before beginning the travel;
- possibility for the driver to directly modify the class of the vehicle;

- possibility to store on the OBU the plate number of the vehicle;
- possibility to manage all the tolling and enforcement procedures required by the operator.

Autostrade is appointed second supplier of OBUs in Austria; in addition, Autostrade will provide bi-standard OBUs for technical interoperability between Italy and Austria.

TELEPASS 3G

There is a common vision about the development of Intelligent Transport Systems that On Board Units and Road Side Equipments have reached a different upgrade and implementation scale, so that only vehicles can be defined as intelligent at the present state of art. This means that one of the next actions shall likely be a hard work to improve the old infrastructure or install new infrastructures in order to guarantee an acceptable level of reliability, to face mobility related problems. This is expected to slowly change the perspective of the transport operators because new equipments (RSE and OBU) will have to respond not only to needs related to dynamic payment of services (mainly ETC), but also to dynamic needs of new services for the users. Therefore, all the efforts will have to be dedicated towards open-minded applications in order to fulfil the growing demand for mobility, taking into account the most suitable solutions allowing wide scale European interoperability.

Of course, every sector of the transport system (land, air, waterborne) will have to give its contribution and gain the best solution in order to create a true intermodal and interoperable scenario.

As for road traffic, different situations can contribute to create congestion problems or difficult traffic management; such as:

- oversized and overloaded vehicles, hazardous goods vehicles have an urgent need to be controlled in a dynamic way allowing operators to keep an on-line track of what is happening along a network to guarantee on one side the correct and punctual delivery and on the other side the minimum impact for the normal traffic.
- emergency vehicles or company patrol cars need to be addressed with the maximum respect of time and space constraints;
- transport operators in general are waiting for an urgent help from the latest technology to keep track of their vehicles and goods;
- everyone need precise, concise, useful and time saving information regarding the area crossed.

The intelligent vehicle will likely include a unique bus able to manage a number of different applications for the provision of multimedia services to the driver. Technology is going towards a very open, distributed architecture by means of the latest products and it is not difficult to imagine a scheme in which the vehicle has a real time multimedia dynamic interface, able e.g. to inform the driver, connect to internet, entertain passengers by means of radio/TV, DVD or any other electronic equipment. The acronym **I-SEE** (Information, Service Easiness and Entertainment) seems to be a good definition of the on board intelligence of the future.

The system

Autostrade has been studying a new concept On Board Equipment for three years with the cooperation of the Italian/French industry ST-Microelectronics. This OBE, named provisionally Telepass® 3G project, has the aim to help realising an integrated system based upon (Figure 6):

- satellite technology to determine the position of vehicles,
- GSM/GPRS technologies capable to provide a channel to exchange text, audio and video files,
- DSRC 5.8 GHz (following the specification of both the Italian standard UNI-10607 and also the CEN TC278's)
- Intranet/Internet technologies for the information management via the Traffic Information Centre (TIC) of the involved transport operators.

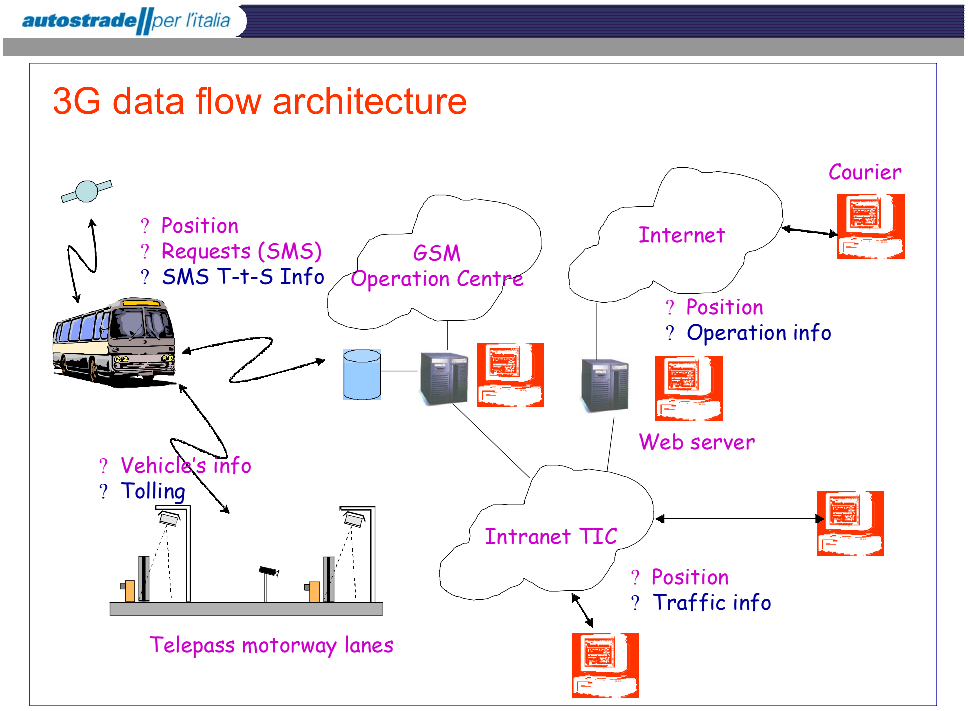

Figure 6: System architecture

Objectives

One of the main features of the system is to detect the position of vehicles along the supervision area (mainly motorway network, but with no limitation of expansion towards a wider road network) in order to use this information and take profit of added value services.

In general, we could have the following application fields:

- Control of hazardous material vehicles and oversized/overloaded vehicles, monitored through their trip along the supervision area, with tracking and communication of all the parameters used for a good quality check (i.e. over limit speed);
- Control of the Operator's patrol cars or corporate and operation vehicles;
- Support for the TIC's and first aid vehicles during emergency phases, with particular attention to winter operations (snow and ice treatment through the localisation of operational vehicles) and bad weather conditions in general;
- Better response for May-Day operations following emergency calls through the localisation of operational corporate vehicles and mechanic/medical vehicles.;
- Information management referred to traffic conditions or service operations;
- Other services:

Fleet management localisation: for example a Courier can receive the current position of its Fleet via Internet access to the Autostrade Operation Centre WEB server;
Control, management and data exchange with Fleets: the Operation Centre can send traffic information to the Fleet;
The Courier can send messages via Internet to one or more of its vehicles and they will be transformed in SMS messages by the Autostrade Operation Centre and sent to whom they may concern with a text-to-speech module.

- Services to motorway users:
    - ♦ Fees payment facility, by means of an integrated DSRC module capable to communicate with the Road Side Equipments for the electronic toll collection;

- Assistance to drivers, following SOS calls (made by some function keys placed on the Telepass 3G Obu), or automatically after an accident with direct allocation of calls to competent bodies;
- Traffic information related to the stretches the vehicle is going to ride on.

Operation features

Localisation data acquired during the motorway trip, coming from the Telepass 3G OBU by means of a GPS/GSM module, are received by the Information Centre; information is here processed and elaborated in order to detect vehicles in the map. Processed information is then diffused towards peripheral centres located in the TIC, by means of the Internet/Intranet services in order to be displayed upon the local map (Figure 7).

Figure 7: Network scheme

Peripheral site operators have the possibility to directly communicate with the vehicles controlled, or they can taylor text format information messages for the drivers of vehicles under their control. These messages are automatically distributed via GSM network by means of Short Message Service in order to be displayed upon the Telepass 3G OBE and transformed to vocal synthesis.

The Operational Centre gathers information given by the Motorway Operator Traffic Information Centre, transform it into cartographic coordinates and, by means of GSM Short Message Service, broadcast the information related to particular stretches to those selected users only.

Telepass® OBE architecture

The system is made by the following base elements (Figure 8):

- Telepass 3G OBE;
- OBE-Operation Centre GSM communication system;
- Operational Information Centre;
- Peripheral sites for TIC operators
- Internet user sites for external operators

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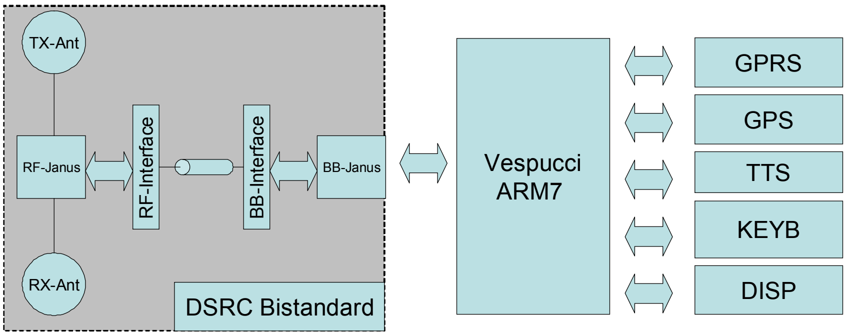
Internal Architecture



Telepass 3G : is based on DSRC technology and enhanced with GSM/GPRSGPS interface and with a Text-To-Speech module.

Figure 8: Obu scheme

The on board localisation system is based upon 24 satellite set NAVSTAR-GPS to determine their position. The signal coming from the various satellites is received via a small GPS antenna to be then processed by another module.
The GPS elaboration module defines the instant position of the vehicle based upon the received signals of 4 satellites and can be as an option connected to some external sensors (odometer and gyroscope) in order to automatically correct the position and to guarantee the necessary continuity in a bad reception environment (like urban areas where GPS satellites can be hidden by buildings). A gyroscope and an odometer allow determining the vehicle position also when the GPS signal is absent.

The OBU is equipped with a user interface with functional keys and real voice device in order to be used as a normal telephone for direct connection to the control centre and as a terminal showing information received by the centre.
The connection between the vehicle and Centre can be:

- continuous;
- regular intervals;
- depending on events;
- after a call by the Centre;

The message sent towards the Operation Centre can contain both localisation data and service data.

The communication system allows the bi-directional data exchange via the GSM digital cellular network. The Telepass® 3G OBU includes a GSM tx/rx for the communication with the Information Centre. The information exchange is made by means of the Short Message Service (SMS).

Internet User site for external operator

The Internet user site for external operator subscribing the service (controlling their own vehicles upon the motorway network) are connected to the system via Internet.

These sites allow operators to control the position of their fleet in order to ensure better management. Internet SMS are allowed via the Operation Centre to one's fleet.

In line with the European guidelines

Overall, the European guidelines on mobility take account of two key issues: interoperability and intermodality. The medium-long term future will be likely featured by devices gathering different technologies and standards inside, in order to respond to the service field of new applications and to geographical coverage for existing ones. When the Galileo satellites will be launched, it seems feasible that all the existing technologies will be used together to cover the needs: as a result, satellite and DSRC (in all the existing profiles) will finally coexist within the same equipment to become the M*obility* O*riented* Box to I*ncrease* the L*evel* of I*nteroperability*, T*echnology* and I*ntelligence* on Trans European Road Networks.

Figure 9: the Telepass 3g OBU