Electronic Toll Collection & Traffic Management in Italy

An effective telecommunications system is a key to the successful implementation and operation of electronic toll collection and traffic flow management systems.

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With electronic toll collection and traffic management (ETTM) projects in operation or underway in Oklahoma, Texas, California, New York, Massachusetts and other states, the interest in the use of advanced technology in transportation continues to grow in the United States. A review of the ETTM effort of Autostrade S.P.A., Italy's largest toll road agency, as well as a discussion of future ETTM activities being planned by the Autostrade may be useful for the implementation of current, and the design of future, ETTM projects in this country.

Background

The Autostrade is a quasi-governmental agency that operates 3,000 kilometers of toll roadway. Figure 1 shows the extent of the Autostrade road network, along with other associated road systems. It is owned by stockholders, but its rates (tolls) are regulated by the government. One of many toll road agencies in Italy, the Autostrade also has controlling interest in other toll road agencies in the country.

The Autostrade has been using advanced technology for a variety of ETTM purposes. For more than 15 years, Autostrade engineers, computer scientists and telecommunications experts have worked in a telecommunications laboratory outside of Florence in an aggressive, Da Vinci-like style on developing a comprehensive incident management program. In addition, the Autostrade currently employs both stop and non-stop forms of electronic toll collection using a crediting/debiting method that would have been the envy of former Medici bankers. In fact, the Autostrade's understanding of political and institutional concerns, on the whole, would have impressed even Machiavelli. It is not surprising that this agency's work ethic and operational expertise have translated into successful implementation of advanced technology in order to increase safety and reduce traffic congestion.

Toll Collection

A traveler can pay a toll on the Autostrade in one of three ways:

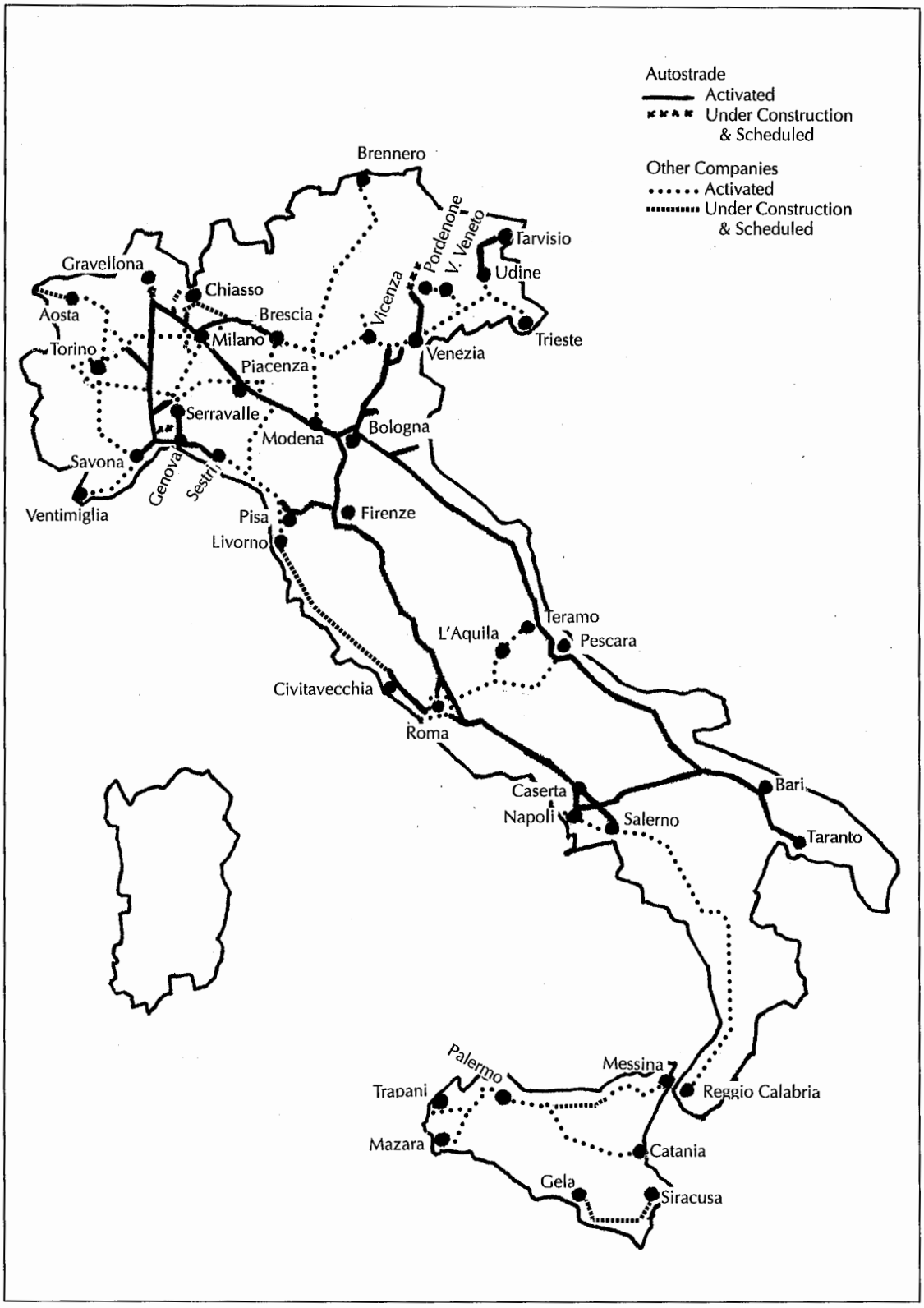

FIGURE 1. A map of the Autostrade network showing the vast coverage of toll roads in Italy.

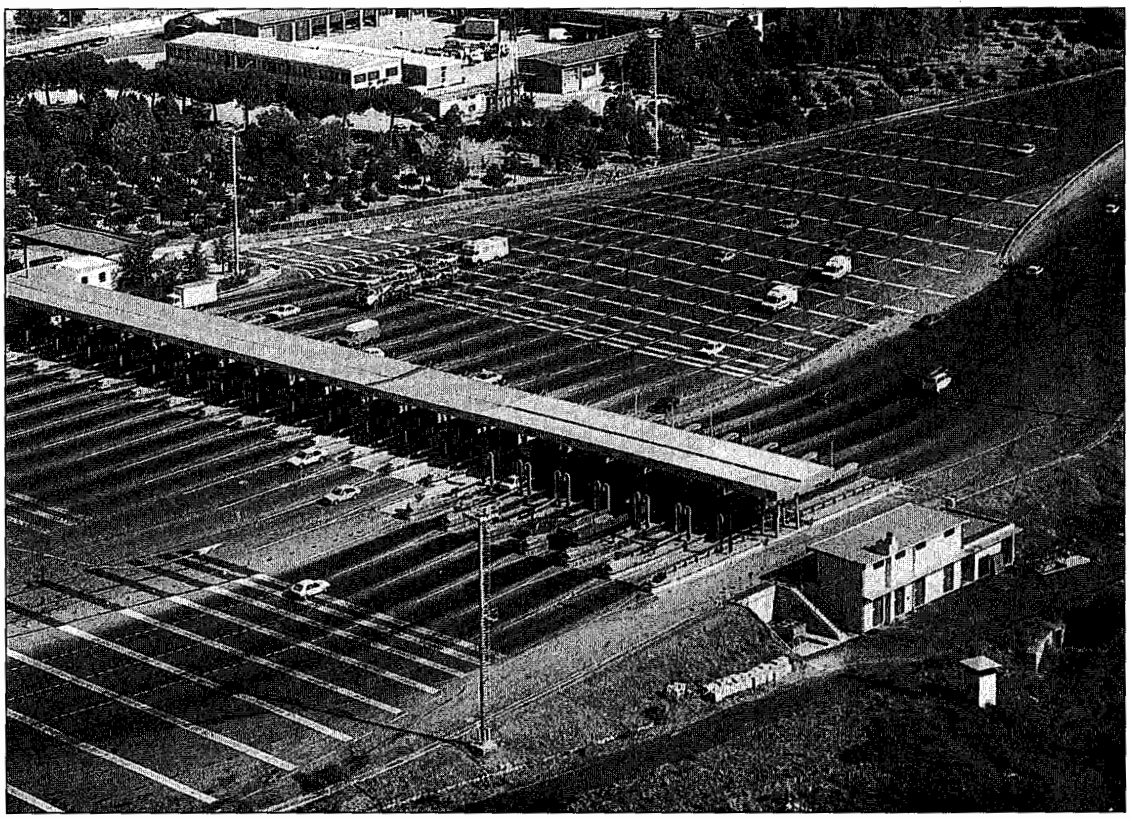

FIGURE 2. A view of a large Autostrade toll plaza.

- *Contante* (with cash);
- With a ViaCard; or,
- With a Telepass.

The ViaCard and Telepass are both used as part of the Autostrade effort to automate toll collection. At present, 35 percent of the tolls on the roads are collected using the ViaCard and Telepass. Along certain corridors, toll plazas accommodate all three methods of collection (see Figure 2).

ViaCards. The Autostrade has used the ViaCard since 1982. The ViaCard is a magnetic plastic card that is used in a stop form of electronic toll collection. Motorists enter clearly marked ViaCard toll gates and stop to insert their ViaCards and toll tickets (where necessary) into the ViaCard computer. The collection system accommodates two types of ViaCard: current account and deduction ViaCards.

With the current account ViaCard, the computer debits the toll fare directly from an account that has been set up with the Autostrade or a participating bank. Motorists maintain about 800,000 active current accounts.

Travelers can purchase deduction ViaCards in denominations of 50,000 to 90,000 *lire* (about $40 to $75) at local tobacconist shops, restaurants and service areas on the highway, as well as at special Autostrade offices. The deduction ViaCard is also inserted into a computer that reduces the value of the deduction card after each toll payment. Approximately three million deduction ViaCards are sold each year.

Telepass. The Telepass, a plastic "smart" card, contains a microchip and is used in non-stop electronic toll collection. The Telepass payment system is similar in set-up to the current account ViaCard. Telepass users may pass through designated Telepass toll gates at up to 30 km/hour (see Figure 3). Speed is limited at that rate for safety purposes only; the system can function with vehicles passing by at speeds up to 130 km/hour. Vehicles are also requested to maintain a safe distance of 20 meters from each other in the lane.

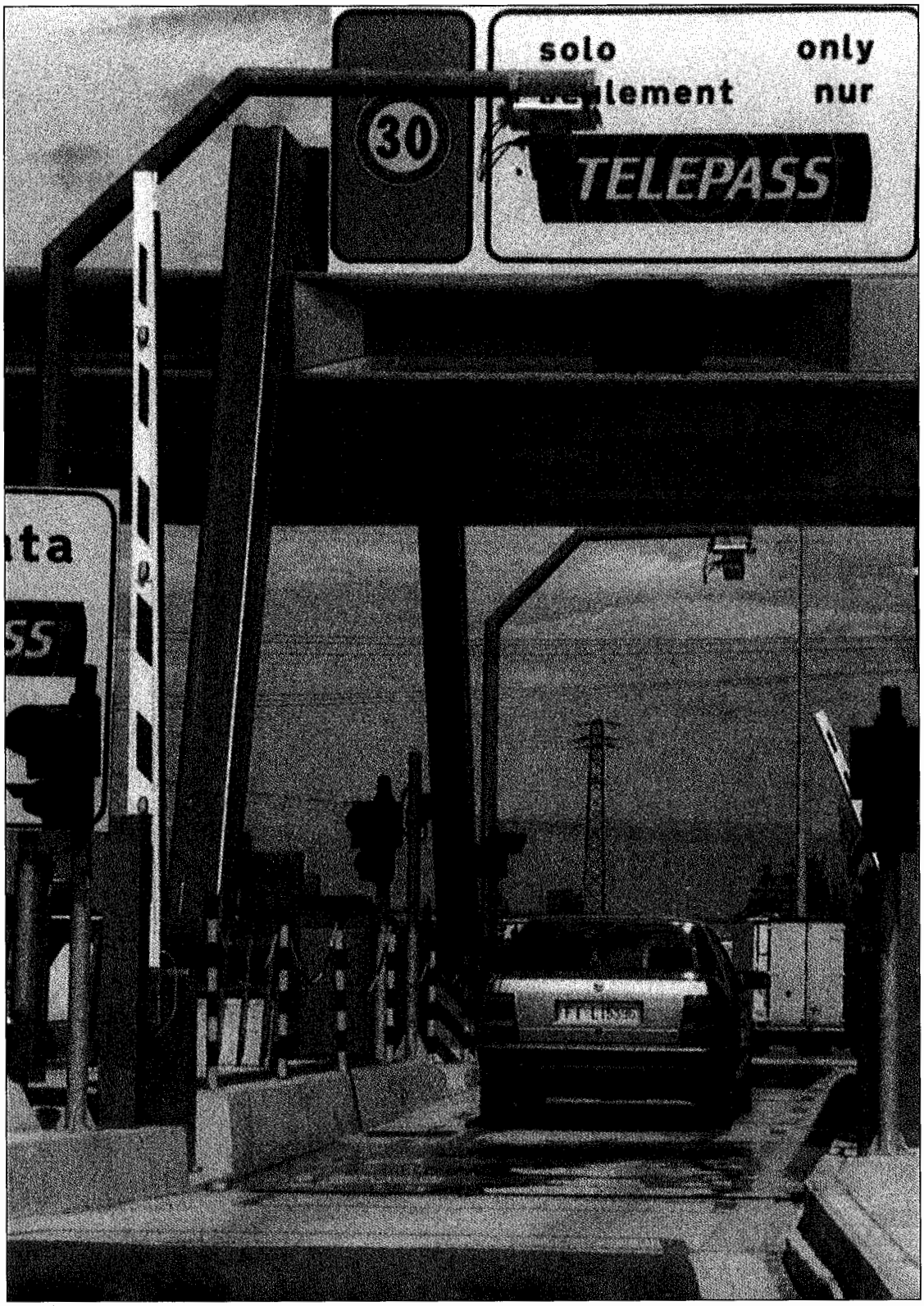

FIGURE 3. A view of a Telepass toll collection lane.

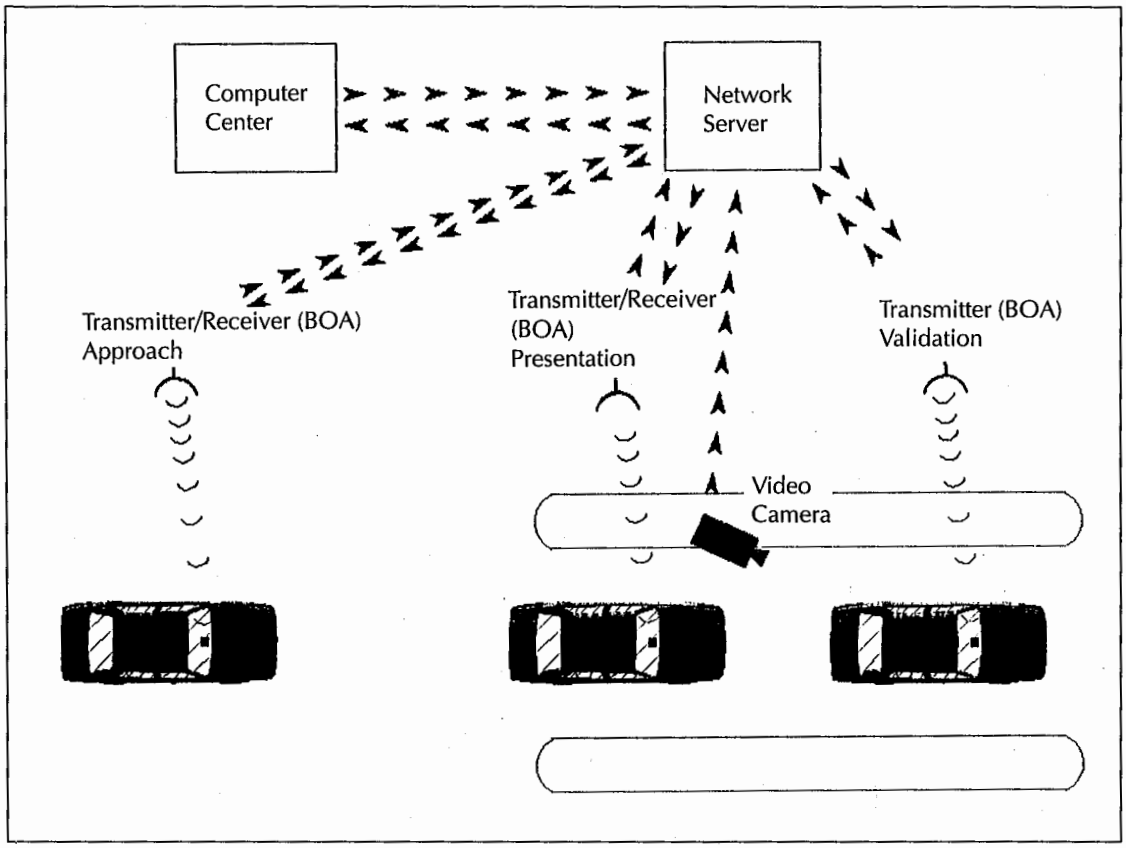

FIGURE 4. A schematic of the Telepass telecommunications system.

Before entering the approximately 500-meter-long Telepass lane, the motorist inserts the Telepass into a two-way communication device (about the size of a cigarette pack) that is mounted on the top center of the windshield. As the vehicle passes, the system reads and writes data on the Telepass via a series of overhead radio frequency (RF) units (see Figure 4). These units (BOA) operate at frequencies from 5,785 to 5,815 gigahertz.

If the system fails to verify the Telepass, perhaps because of an insufficient credit account balance, it transmits audio and visual signals to the vehicle via the mounted communication device while the motorist still has time to switch from the Telepass lane to a manual toll gate. If the motorist ignores the alarm and uses the Telepass lane, a video camera captures an image of the vehicle's license plate. Its registration number is placed on the Autostrade's *lista nera* (blacklist) and further administrative action is taken.

All toll payment transactions are stored on the Telepass via the radio frequency unit and are transferred to a central computer via a network server in order to facilitate the preparation of a monthly debit statement that is provided to each user. The user reviews the statement to verify that such trips were made and possibly utilizes the statement for business record keeping and reimbursement.

The Autostrade began using the Telepass system in 1990 along a 750-kilometer corridor between Milan, Rome and Naples. On this corridor, Telepass toll gates stand at both entry and exit points because toll charges are based on distance as well as vehicle classification. Treadles count axles and infrared devices measure the vehicle's frontal height in order to classify a vehicle. Similar "read/write" systems are being examined for use in the metropolitan areas of Boston and New York City.

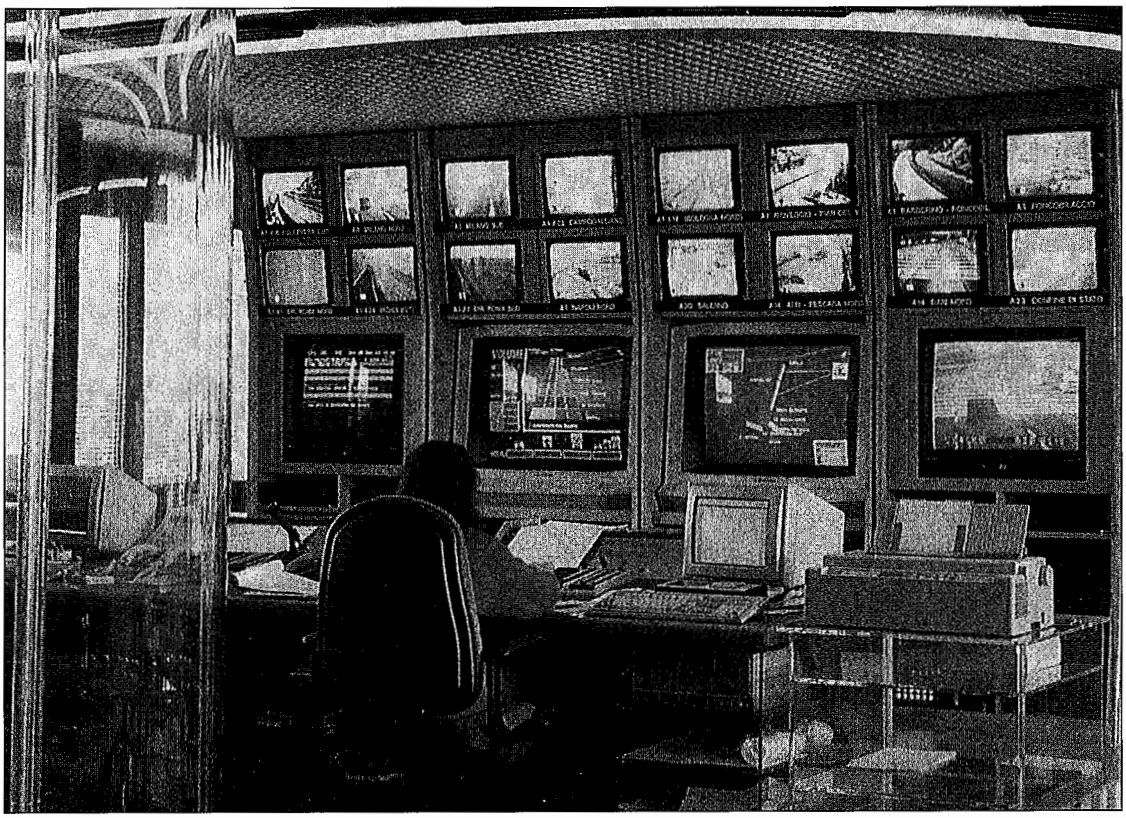

FIGURE 5. Autostrade staff in a traffic control center.

The Autostrade has used the Telepass since 1992 on about 60 kilometers of highway in the Milan-Laghi area where the distance is fixed between tolls and the fares vary only by vehicle classification. A toll gate is required only at a single point. A similar "read only," RF-based toll collection system has been employed by the Oklahoma and Texas turnpike authorities over the last several years.

At present, there are over 80,000 Telepass users and Autostrade officials expect this number to increase as the result of expanding Telepass service. Telepass users tend to be former current account ViaCard users. Autostrade pays about $40 for each two-way communication box and presently provides them to motorists free of charge.

Lessons Learned. As the use of electronic toll collection continues in Oklahoma and Texas, and as systems are developed in California, Florida, New York, Massachusetts and other states, interest will grow in this country in applying advanced technology to collect tolls. Perhaps some of the following lessons learned by the Autostrade will help federal and state highway officials:

Electronic toll collection can reduce delays at toll gates substantially. Autostrade officials estimate that typical transaction times are: 30 to 60 seconds for cash; 20 to 40 seconds for the ViaCard; and, two to three seconds for the Telepass. Time savings increase significantly when waiting times in queues during peak traffic periods are considered. (The time of a transaction includes the time the vehicle takes to travel through the toll gate.)

The fact that a stop toll system (ViaCard) was in place facilitated the implementation of a non-stop system (Telepass). Because the typical Telepass user is a former ViaCard user, issues of billing and accounting, privacy and customer acceptance already had been addressed.

Designing and implementing the ViaCard system addressed many of the issues, dilemmas

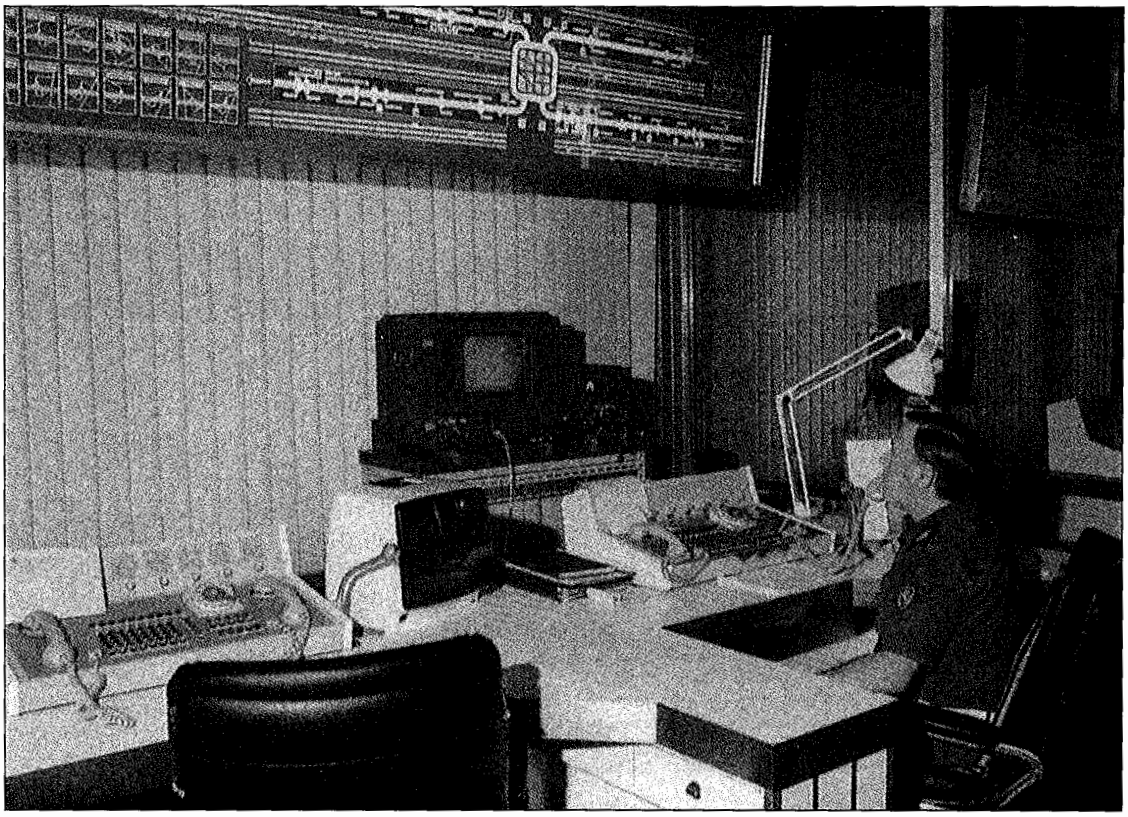

FIGURE 6. The police communicates directly with Autostrade staff at a traffic control center.

and institutional controversies regarding automatic vehicle identification. Consequently, when advanced technology became available to develop a non-stop toll collection system, the primary problem remaining was only one of technical communication between the vehicle and the central computer.

The cost of a Telepass lane, including pavement markings and equipment, is about $100,000; a ViaCard lane costs about $67,000.

In the early stages of ViaCard research and development, Autostrade officials worked with labor unions to ensure that toll collectors would remain productively employed. Some former toll collectors became ViaCard/Telepass sales personnel, while others were trained to assume comparable and, in some cases, higher positions.

Incident Management

Prior to commencing operations, Italian toll road agencies are required by law to establish a radio communication link with national police authorities and to create a written agreement for towing and related services with the ACI, Italy's national automobile association.

Because of the level and nature of traffic along Italy's more than 5,000-kilometer tollway system, responding to traffic incidents efficiently and with the utmost concern for safety has been considered essential by the Italian government. The toll roads in Italy at present accommodate some 50 billion vehicle kilometers per year, about 20 percent of which are for commercial vehicles. Despite a steady increase in usage, accident levels along the Autostrade have reached an all time low that, according to some officials, is attributed in part to a conscious effort to improve incident management activities on a continuing basis.

Fault-Tolerant Information System. An integral part of the Autostrade's current incident management program is the *sistema informativo* — its information system. This system consists

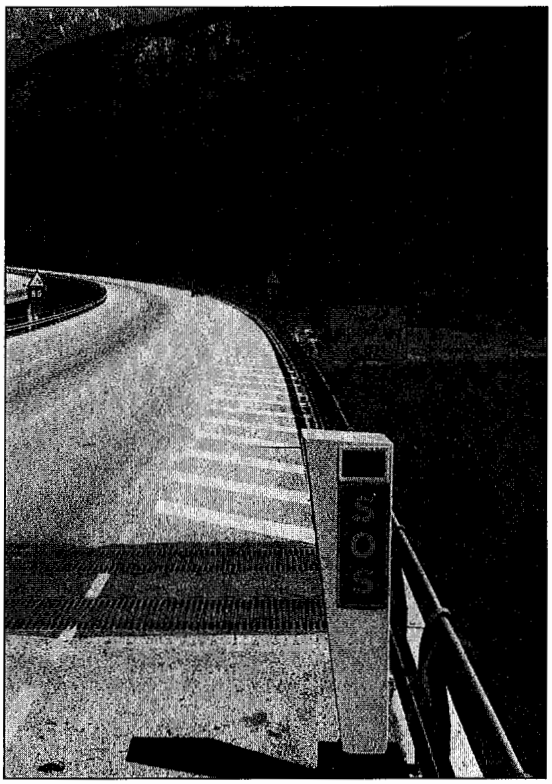

FIGURE 7. An SOS callbox.

of a central host computer to which are connected nine fault-tolerant mini-computers. These computers have secondary power sources in the event of a power outage. Each mini-computer is located in the nine Autostrade traffic control centers and is operated by Autostrade staff (see Figure 5). These control centers were established the late 1970s. Also located in each control center are police staff that communicate directly with the Autostrade staff and other police patrolling the Autostrade (see Figure 6).

Detection & Verification. A major function of each control center is to assist in identifying incidents and in determining the location and nature of each incident. With the use of closed-circuit television equipment and video cameras, the Autostrade staff has been monitoring traffic flows at key locations for the last five years. Selected video cameras can be controlled from the traffic control center to pan, zoom and focus on the incident location. Depending on the nature of the incident, the Autostrade staff in turn communicates the necessary information to the police or to a service vehicle.

Other sources employed by Autostrade staff to detect and verify incidents include information from motorists with in-vehicle telephone, roadway maintenance crews and SOS callboxes. These callboxes were introduced in the early 1970s and are located every 1.8 kilometers along the roadside (see Figure 7). Motorists using the callbox can request directly either a service vehicle or an emergency vehicle, including police, fire or ambulance services.

Traveler Information. Another major function of the control center is to provide motorists with information regarding traffic conditions ahead. Variable message signs controlled by Autostrade staff are located at major toll plazas and along the roadway (see Figure 8). Information is provided continuously alerting drivers to incidents ahead and the need to reduce speed due to perhaps an accident, maintenance work, inclement weather or poor visibility. Operating speeds are monitored and estimated by the control center with the use of special video cameras and image processing software.

In selected locations along the roadway where fog is a common problem, a fog detection system is employed to measure visibility. This information is also transmitted via computer to the control center and, if necessary, is displayed on variable message signs. In addition, the control center is provided weather information on a continuous basis via satellite and a remote weather control system with the cooperation of the Italian Air Force.

Individuals can also obtain traveler information from a local radio station (103.3 FM) or the national "Televideo" television channel. Interested individuals can also telephone the national traffic center in Rome or the local Autostrade office and obtain recorded information regarding traffic conditions. Motorists may also acquire traveler information at locations called *Punto Blu* (the Blue Point) — an information center located at each service area on the roadway (see Figure 9).

Training. In order to prepare Autostrade staff to handle the day-to-day duties and responsibilities in the traffic control centers, the

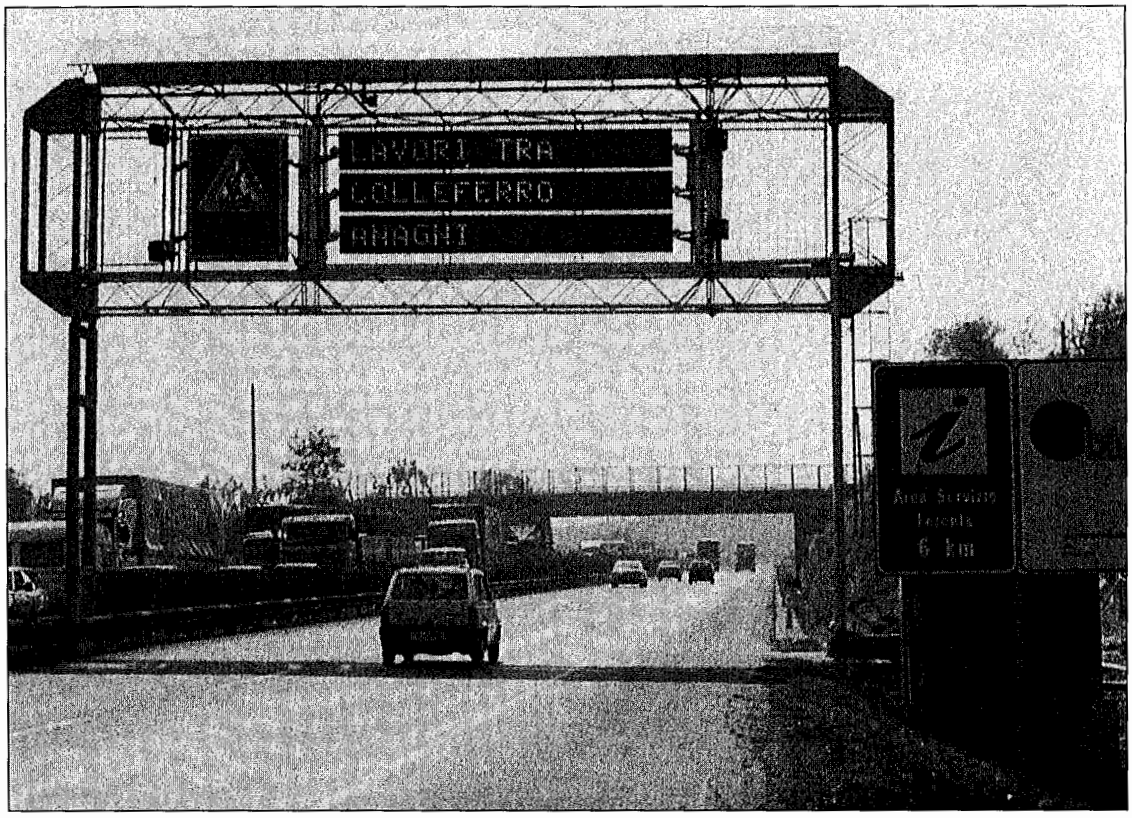

FIGURE 8. A variable message sign indicating that maintenance work is being carried out along a stretch of roadway.

Autostrade has established a training program in Rome. As part of this program, experienced Autostrade staff serve as instructors along with highway transportation expert consultants. Individuals enrolled in these training courses are required to work a designated number of hours in a control center under the supervision of a regular control staff member.

Summary, Conclusions & Future Directions

Autostrade officials expect significant increases in the use of ViaCard and Telepass over the next two years. In addition, officials plan to continue to enhance the incident management program with the use of further technological advancements.

Autostrade is collaborating with other transportation providers in Italy so that Telepass can be used on other toll roads in the country, as well as for air, rail, port and parking facilities. Autostrade officials also serve on several DRIVE projects. (DRIVE is the Intelligent Vehicle Highway Society research effort that is administered under the auspices of the European Commission.) Autostrade officials, together with toll road officials from other European countries, are exploring the possibility of establishing uniform functional and technical specifications for ETTM for all of Western Europe.

Autostrade staff are currently exploring the use of advanced computer-aided techniques to assist control center staff in making decisions in response to various types of incidents and accidents. Expert systems and other computerized methods and concepts are being considered.

Autostrade staff and Italian university researchers, in conjunction with engineers and computer scientists in Germany and France, are participating in the DRIVE-sponsored Gemini Project. This project's objective is to develop and test an integrated driver informa-

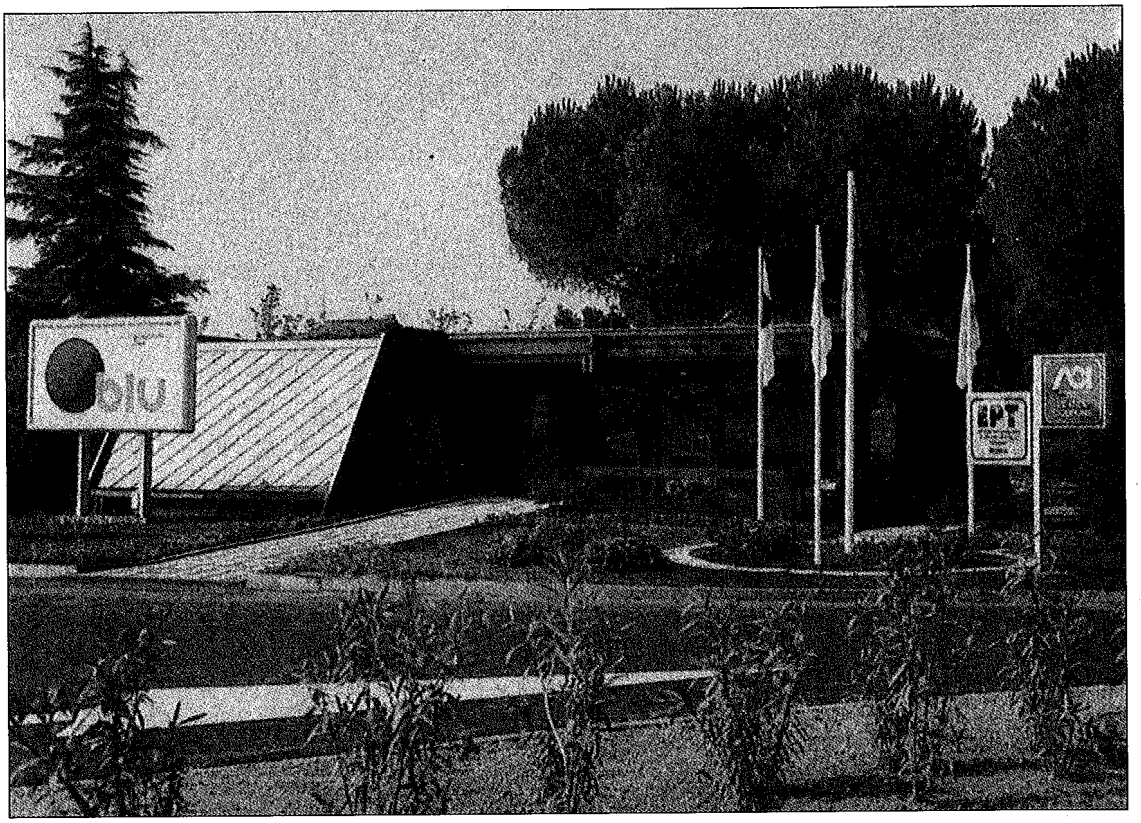

FIGURE 9. A *Punto Blu* information center.

tion system using radio data system traffic channel (RDS-TMC) and variable message sign (VMS) networks. Gemini's overall purpose is to contribute to the design of a pan-European driver information system that distributes non-contradictory and mutually confirming information that, in turn, leads to improvements in RDS-TMC and VMS standardization and protocols.

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