COMMUNICATIONS FOR PUBLIC TRANSPORT IN THE CITY OF BARCELONA
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1. **Introduction**

The cosmopolitan city of Barcelona has history, one of the more active ports in the Mediterranean, beaches gained from the sea, a valuable monumental heritage, as well as an intense cultural, commercial and creative life.

In the last years, city’s population has increased considerably, coming to have currently more than 5 million inhabitants. Barcelona is the second most populated city in Spain and, together with London, Madrid or Paris, one of the most populated of the European Union.

This growth has made the sustainable urban mobility plans a crucial need for the city development. In fact, there are studies which point out that Barcelona public transport moves around one million people a day, and more and more people choose these systems as real and efficient alternative to the private transport.

This growing massive use of the public transport makes the transport companies demand new communication systems that support their operations and, therefore, improve the services offered to the citizens.

2. **The public transport in the city of Barcelona**

The public transport means in Barcelona are managed by various operators, being the main ones: TMB – **Transports Metropolitans de Barcelona** y FGC – **Ferrocarriles de la Generalitat de Cataluña**. On the one hand, TMB manages **underground** and **bus** networks. On the other hand, FGC offers two underground lines and several **suburban lines** that give easy and convenient access to different metropolitan areas of the city.

These three transport networks are briefly described below.

Barcelona underground network is composed by 11 lines, which run almost entirely underground. It is the largest network in Spain after Madrid and, since December 2009, has become the first Spanish metropolitan railway network that has fully automated lines, like Line 9.
The bus network that serves the entire city has more than 100 operating lines, along which around 1200 vehicles operate. In the near future, when the new lines that are being incorporated to this network are fully operational, users will be able to get from one end to the other of the Catalan capital in a maximum time of 40 minutes, which will save considerable time.

Finally, the suburban network is a fundamental part of the public transport system for long journeys, since they run mainly around the province of Barcelona, linking the towns around the capital.

A good urban mobility plan makes essential to have a wide range of transport means to meet the needs of the different user profiles.

3. Communication needs in the transport environment

As we have seen, public transport includes several services, such as buses, subways, trams or trains. Although these systems may seem totally different, they all have common general objectives:

- Drastic reduction of journey time
- Easing of traffic congestion in the city
- Increased comfort on the trip
- Cost savings for the user
- Pollution reduction
- Etc.

For the achievement of these objectives, transport systems require the support of communications systems that link the onboard equipment with wayside applications (communications “Train-Ground”), and that take charge of functions such as the ones described below:

- Send and receive instructions regarding the driving.
- Send the vehicle position data to the Control Center, so from there, they can be located and displayed and their personal and material resources can be managed in an efficient way.
- Monitor the status of onboard equipment and manage the alarms raised from the Control Center.
- Transmission of events related with the signaling systems.
- Broadcast messages for passengers to inform about schedules and upcoming stops.
Summarized, the indispensable requirement is that all the people involved in the operation are in continuous contact for different purposes. In these mobility environments, a radio technology is needed to achieve it.

TETRA technology has emerged itself as communication standard for transportation environment thanks to the benefits and advantages it presents. Some of them are mentioned below:

A single TETRA communications network can serve all the different communication needs within the public transport ensuring the service quality of each application.

It works in low frequency bands, which translates into savings of radio equipment and civil works (shelters, towers, connections, etc.).

It has innate functionalities very useful to the transport: Group calls, Broadcast, Emergency, Ambience listening, fleet and groups management, priorities management, dynamic group allocation, direct mode operation, etc.

TELTRONIC, radio equipment manufacturer since almost 40 years ago, provides complete solutions for transport environment based on this technology. These are composed of infrastructure, fixed network, onboard part and communications control centers. In addition to the advantages provided by the technology itself, the TELTRONIC solution adds features like:

- **Redundancy**: Users of transport environments require 100% availability since, apart from ensuring uninterrupted service, they must guarantee passengers safety. Thus, redundancy is a key requirement for communication systems, which should not present any vulnerable point (“No single point of failure”). TELTRONIC TETRA solution can be redundant in all its elements (onboard radio equipment, modules, infrastructure connections, redundant radio coverage, etc.), providing continuous service to the users.

- **Scalability**: The areas covered by public transport networks grow as the size of the city. Similarly, the number of necessary vehicles and resources also grows if the mobility needs of citizens do so. Therefore, it’s necessary a communication system...
as the TELTRONIC one, which is easily scalable and allows simple and efficient updates and upgrades.

- **Integration and Project Management**: Transportation systems projects always require a high level of engineering and integration. Although the communication solution is based on standard elements, the success can only be guaranteed if special attention is paid to the specific aspects of each (integration of onboard equipment with different vehicle models, interfaces with fleet management applications, interaction with railway signaling applications, etc...). The control TELTRONIC has over its own technology, as well as the ability of its engineering and projects department, makes possible to offer, along with the equipment, a unique and reliable integration service that guarantees the project success.

The following sections explain how TELTRONIC has collaborate on projects for expansion and modernization of buses, underground and suburban networks in Barcelona, always providing complete solutions and contributing to the improvement of services provided.

### 4. TMB Buses

One of the essential services in a public transport system is the **continuous information to the user**, so the arrival time of the vehicle is always known, whether it has been any incident on the journey, etc. To achieve this, the Control Center must know the location of all the vehicles in real time.

Thus, TELTRONIC solution is composed of:

- Base stations that provide coverage to all the areas where bus lines run.
- 1100 onboard radio terminals in the buses, integrated with the driver equipment. This equipment provides voice and data communication and facilitates the connection between the on-board part and the Control Center.
- **GPS global positioning system** to locate the vehicles.
The positioning data of each vehicle is sent to the Control Center through the TELTRONIC intelligent application SDM (Synchronous Data Manager).

This application, based on the TETRA data service SDS (Short Data Service), is responsible for requesting its position to every onboard terminal to, subsequently, manage this information and transmit it to the different modules in the Control Center. It is characterized by providing minimum refresh times, avoiding network congestion.

Thus, based on the position data received, the Control Center is able to perform all the functions related to the fleet management:

- Inform passengers in real time about the status of the routes, arrival times at destinations, incidents, etc.
- Display on the map the current location of the fleet vehicles and monitor the status of all of them.
- Calculate the deviation between the theoretical schedule and the actual one, so that the operator can perform different regulatory actions to maintain the scheduled services: introduce or remove resources on the lines, send instructions to the driver to speed up or slow down, etc.

Thanks to the combination of the on-board location systems and SDM system designed to send bulk data, it is possible to obtain the position of the entire TMB buses fleet in 20-30 seconds.

As an example, we show the traffic processed on typical bus line, where 100,000 SDS/day are sent on average.

![Number of daily data](image)

This shows that a good infrastructure sizing and an optimized use of the radio resources allows that all the voice and short data services can be handled simultaneously, guaranteeing the performance and quality of service of both the voice application and the location service.
5. Underground Line 9

Line 9 project is one of the most ambitious projects carried out by the Government of Catalunya. When the line is completed, it will cover a length of 47 kilometers and will join 52 stations, serving strategic points like the airport, the Zona Franca, the Trade Fair or the Port of Barcelona expansion.

The main innovation of the line is that it has automatic train operation, therefore, having data capacity and, thus, being able to manage the commands sent to and from the Control Center, which will remotely manage the trains operations, is an essential prerequisite for the selected communication system. Furthermore, voice services must always be present to allow communication with the train driver, in case the train is changed to operate manually.

For this project, the telecommunications infrastructure is composed of several base stations to ensure full coverage along the line (tunnels and passenger stations). In addition, trains have advances onboard terminals specially designed for railway regulatory compliance (EN50155).

On the whole, the solution envisages a number of main functions:

- Manage voice communications between trains and the Control Center, in case they are changed to operate manually.
- Remote Control of Rolling Stock: Control the rolling stock through communication between the onboard equipment and the other subsystems of the train, sending alarms to the Control Center in the event of a fault.
- Interact with the Passenger Information Systems (PIS) in order to keep passengers informed continuously about train schedules, station information, arrival times, incidences and even advertising.
- Provide redundant communications support for the signaling system CBTC (Communications Based Train Control).

In conjunction with the client, a protocol based on the short data TETRA service was defined and implemented. The protocol consists of 75 remote control commands for onboard elements and 35 alarms from the train which are processed from the central application. This protocol will enable the vehicle manual management and control in case of failure of the signaling system.
Some examples of remote controls are “Train switch on/off”, “Train identity (number and type of train)”, “Fire extinguishers activation”, “Query status of different onboard systems”, “Driving mode change”, etc.

Similarly, examples of alarms are “Emergency alarm activated”, “Emergency breaking applied”, “Intercom failure alarm”, “Manual driving console opened”, etc.

- **Integration with the Rail Control Center applications.** A module designed by TELTRONIC specifically for this project, allows transparently interconnecting TETRA NEBULA infrastructure with the different applications of the control center, so that each message, command, call can be redirected to the application responsible for its processing in each case.

Line 9 project, in which latest technologies Spanish companies are involved, will improve transportation in Barcelona, as it will provide underground service to neighborhoods that currently lack it, connecting the population from the five towns it goes through. Furthermore, it will connect strategic points, logistic centers, equipment zones and services zones, like the Airport, the Fira, the Diagonal campus, Güell Park and Camp Nou.

Some figures show that the innovative project of Line 9, when it is completely finished, will have about 165 million passengers per year in 2020.

6. **Line Barcelona – Vallés, FGC**

Of the 52 stations that are along the underground line 9, 22 are Interchanges and connect with other systems of collective, among them, FGC suburban trains.

The two main commuter lines of this operator are Llobregat-Anoia and Barcelona-Vallés. The latter has migrated its analogue trunking old communication system to a TETRA digital communication system, in line with the rest of public transport systems in Barcelona.
The part of the infrastructure for this project is based on TELTRONIC NEBULA system and consists of several base stations controlled by a central node. The main elements in NEBULA are redundant to offer the high availability required in this environment.

Over 140 onboard terminals have been installed, which manage voice and data between the train and the TELTRONIC Control Center, located in the town of Rubí.

Finally, portable equipment for the personnel and dispatch terminals have been supplied to complete the solution and equip all the operating personnel.

7. Conclusions

In big cities like Barcelona, it is essential to have a good public transportation system that facilitates the citizens mobility, which involves: regular networks of different type that flow through the entire city, connections between the lines of all these means, continuous service, good frequency and constant information to passengers on schedules, destinations or last minute changes affecting their journeys. To achieve this, the operators have gradually migrated from analogue systems to digital TETRA systems.

In a general way, Barcelona has benefited from all the advantages provided by the TELTRONIC solution. Through voice and data communications and the combination of the GPS positioning system and the SDM application, Catalan operators can currently:

- Have continuous communication with all staff.
- Offer real time information to passengers.
- Manage in a more efficient way their human and material resources.
- Have communication groups based on the work performed or location.

All these services and communications have managed to improve both the operators management and the service offered to citizens; technology moves forward by leaps and bounds, as the needs of society.

With these projects, manufacturers and companies seek a common goal: improving people life quality, while collaborating with economic growth of cities, social cohesion and environmental protection.