



Railway geolocation and communication-management platforms

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ABSTRACT

The article gives a technical and functional description of the onboard tracking and communications-management platforms, as well as their associated control centres, supplied by GMV for the whole fleet of railway locomotives and motor cars of the Spanish railway operator RENFE.

KEYWORDS: transport, heavy goods vehicle, telematic services, framework, categories, analysis

1. Introduction

This article gives a technical and functional description of the onboard tracking and communications-management platforms, as well as their associated control centres, supplied by GMV for the whole fleet of railway locomotives and trains of the Spanish railway operator RENFE.

The described platforms are being set up in the 1700-strong fleet of trains and locomotives currently run by RENFE, shared out among its three business units: Freight and Logistics, High-Speed/Long-Haul, Local/Medium-haul.

Although the system is essentially a fleet-management system, it also has a series of additional items to perfect it for use as a railway platform.

2. Need for setting up a system of this type

The main reasons why a railway operator might be prompted to purchase a system of this type are summed up below:

- Need of keeping a permanent track of the whole fleet of trains. Conventional railway tracking systems based on track circuits are not very precise. Furthermore it is not economically viable to set up tracking balises in a railway network covering a large geographical area,
- Need of establishing permanent voice and data communication between the control centre and the engine driver onboard the train. Data communication arrangements, in particular, can provide engine drivers with onboard mobile office facilities,
- Need of giving information to passengers onboard the train and waiting in stations,
- Need of establishing public-address communications from the control centre to onboard passengers,
- Need of monitoring the various train operation parameters remotely and in real time,
- Need of monitoring the various onboard devices and sensors remotely and in real time,
- Need of working up recorded information for statistical purposes,

All these needs, habitual in any railway operation, have to be covered by a system available to the railway transport

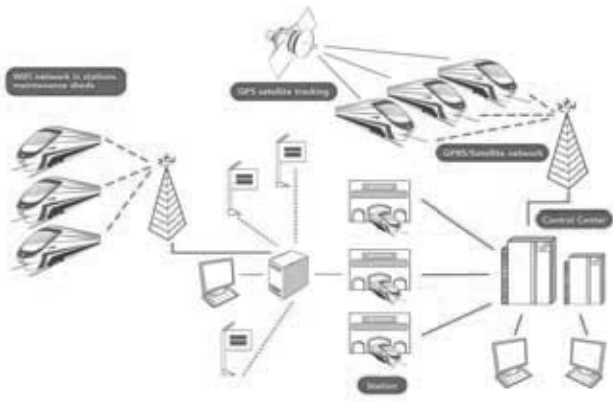


Fig.1. General System Architecture

operator. This system must be independent of the railway infrastructure manager according to European Commission Directive 91/440 and the provisions laid down and developed in later directives.

The system described herein covers all the above mentioned needs.

3. Technical description of the system

The system set up in the Spanish operator comprises a set of onboard platforms kept in permanent contact with the control centres of each of RENFE's business units.

The information received in the control centres makes it possible to feed station information panels with arrival times and other information.

The general architecture of a system of this type is shown in the diagram on fig.1:

Each system component is described in the following sections.

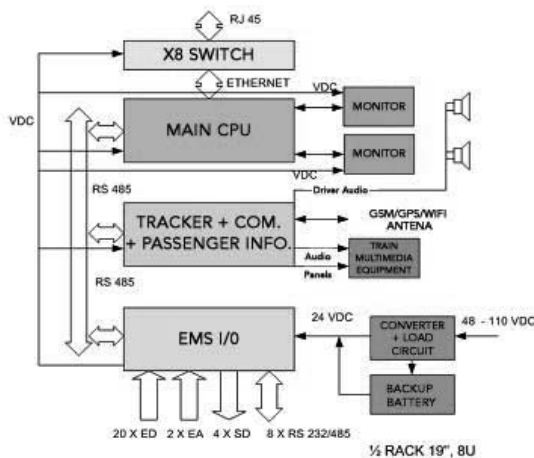


Fig.2. Main components of the onboard platform

3.1. Communications Infrastructure

An onboard fleet management system is fitted in each of the rolling-stock vehicles (locomotive or motor car) with all the necessary software and control electronics for carrying out the tasks related to the onboard monitoring, regulation and control of communications (voice and data).

The onboard equipment is kept in permanent contact through a real-time communications network (HSDPA/UMTS/GPRS modems and a satellite communicator as a back-up), with its respective control centre. All the information required by the control centre will be transmitted through this channel, of limited bandwidth, in real time.

The bulkier information not required in real time (multimedia files, onboard device monitoring data, configuration files, etc) will be sent over the secondary broadband network (WiFi), which will be accessible in the vicinity of stations and maintenance sheds.

3.2. Onboard fleet management equipment

Fig.2. shows the onboard equipment making up the railway fleet management platform.

The equipment shown in fig. 2. includes the following components:

- Onboard computer for the railway fleet management system, with the following main items,
 - › Tracking and communications equipment, including: a GPS receiver, a set of up to 3 HSDPA/UMTS/GPRS modems for real-time communications management and a WiFi receiver for broadband communications in the vicinity of stations and maintenance sheds,
 - › Equipment for managing interfaces with external equipment already fitted onboard: train central unit, passenger counting systems, juridical recorder unit, etc,



- › Equipment for managing the man-machine interface with the driver in both cabs, using a touch-screen TFT monitor and a windows-enabled application,
- › A railway-range power source with backup batteries,
- Cab components (to be fitted in each one of the two cabs of the locomotive or motor car) including:
 - › Driver's desk, normally a 10.4-inch TFT" touch-screen, used as a messaging service between the driver and the control centre, for onboard display of automatic regulation messages and for receiving information on alarms and events furnished by the train's central unit,
 - › Microphone and loudspeaker for voice communications between the driver and the control centre and between the driver and onboard passengers,
- Connection with the onboard Passenger Information System, to display announcements on trainborne monitors and information panels, plus acoustic information (piped music, next-stop and other announcements) through the train's public-address system,
- Connection with the train's TCN (Train Communication Network) bus to access various rolling-stock information in real time: malfunctioning alarms and announcements, door opening detection, odometers, etc,
- Connection with other onboard systems, such as: passenger counting systems, juridical recording units, energy consumption measuring systems (watt hour meters), train diagnostic devices, CCTV systems, etc,
- (Optional) Inmarsat or Iridium type satellite communicator used to guarantee communications in 100% of sites and 100% of the time, even with no cell-phone signal. Devices of this type are highly useful in railway networks covering a large geographical area and with many routes, such as RENFE's freight and logistics business unit,
- (Optional) TETRA (terrestrial trunked radio) for voice and data communication between the vehicle and control centre. TETRA networks are frequently used on tram and underground lines,
- (Optional) Track-mounted balise reader for precise tracking of passing trains. Repositioning balises are commonly used on tram and underground lines,
- (Optional) Connection with the onboard fare collection equipment. Fare collection equipment is common on trams and light rail transit systems,

All the onboard equipment has passed the relevant railway type approval tests and has been certified under the following standards:

- UNE-EN 50155 on electronic equipment used on railway rolling stock,
- UNE-EN 50121-3-2 on the electronic compatibility of rolling stock equipment,
- UNE-EN 61373 on shock and vibration tests.

Type approval guarantees that the platform is fit for service onboard any train formation in all aspects (mechanic, electrical and electromagnetic) ensuring that it works correctly in conjunction with the other onboard systems.

3.3. Control centre equipment

Each of RENFE's business units has a Madrid control centre while the local commuting trains unit (Cercanías) has several centres spread throughout the different regions in which this unit operates.

From the control centres the operators can monitor the whole fleet of trains, communicate with it and regulate its operation.

The infrastructure of each control centre comprises two servers in hot stand-by cluster configuration. The first of the clusters carries out the real time management of the fleet. The second, called non-real-time server, runs the historic operation database, gives a statistical analysis of this data and deals with queries thereon.

3.4. Passenger information systems equipment

The passenger information systems supplied by the fleet management system are composed of:

- Onboard the train: Information panels, monitors and onboard passenger address systems. The onboard fleet management system described above connects up with the train's passenger information system and gives information on:
 - › Next stations,
 - › Terminal destination,
 - › Correspondence with other lines,
 - › Information messages of other types,
- At stops and stations: Indicator panels, giving information on:
 - › Estimated times of arrival,
 - › Correspondence with other lines,
 - › Information messages of other types,
- By WEB: Portal with real-time information on:
 - › Public information:
 - › Lines,
 - › Stations,
 - › Running times,
 - › Fares,
 - › Train positions on map and line,
 - › Estimated times of arrival,
 - › Private information:
 - › Occupancy,
 - › Punctuality,
 - › Service incidents,

- By SMS: Sending information on:
 - › Lines passing through a station,
 - › Scheduled running times of each line in a stop,
 - › Next train and estimated waiting time.

4. Functional description of the system

The system being set up in RENFE provides functions of great value for running a railway, not only for the control centre operators but also for the train drivers and passengers using the railway transport network.

4.1. System functions for control centre operators

From the control-centre point of view the most important functions furnished by the railway fleet management system are the following:

- Permanent fleet tracking and monitoring with sub-meter accuracy and refresh cycle of a few seconds,
- Redundant system of voice and data communications with the trains. Each piece of onboard equipment uses up to three 3.5G modems working with SIM cards of different cell phone operators, WiFi cards and, optionally, satellite communicators,
- Two-way messaging service between the control centre and train drivers,
- Management of voice communications between the control centre and drivers,
- Management of public address messages between the control centre and passengers onboard any train,
- Regulation functions by timetable and frequency: control of late-running and early-running trains,
- On-line management of regulation actions and online services,
- Monitoring of warnings and alarms received from the trains,
- Generation of contents for the passenger information system in stations: estimated waiting times, messaging, etc,
- Running-time synchronization for the whole system.

The next figure shows the views offered by the application at the control centre's operator workstation. All the information on the position and state of the trains can be mapped in GIS format against the corresponding zone and also displayed on a synoptic chart showing the train's position on the line or corridor it is running through.

The operator workstation application gives specific views in relation to messaging, monitoring of onboard devices, reception of warnings and alarms, programming of planned services, time-distance graphs, etc.

4.2. Functions of the onboard system

The onboard system is in permanent communication with the control centre and also offers a set of functions onboard the train itself:

- Permanent positional information obtained by a GPS receiver, odometer connection and, optionally, reading of the track-mounted repositioning balises,
- Autonomous onboard regulation. Onboard configuration of the running times of the assigned services and information on the train's own position keep drivers informed of late- and early-running trains,
- Reception of regulation orders from the control centre,
- Two-way messaging service between the control centre and the driver,
- Reception of voice communications between control centre and driver,
- Reception of public address messages from the control centre and passing them on to onboard passengers,
- Mobile office functions for the drivers, enabling them to check documents (route map, technical manuals, etc) loaded on the onboard terminal and also to access all the company's intranet documentation. One of the ultimate goals of the system is the elimination of all hardcopy documents onboard the train,
- Monitoring of onboard signals and devices, some of which are described later,
- Control of information panels, monitors and onboard passenger information system and generation of information for the same.

The figure 4 shows the man-machine interface provided by the fleet management application for the driver.



Fig.3. Display of diverse railway lines in GIS format and synoptic chart in the control centre

From this application the driver gains access to all the aforementioned functions.

4.3. Integration with existing onboard systems

One of RENFE's main remits in carrying out these projects was the centralization of a great variety of systems with different functions previously installed onboard the trains.

The fleet management system thus sets up connection interfaces, inter alia, with the following devices already fitted on the trains:

- TCN Bus and the monitoring and diagnosis units, giving information and operational parameters on all the rolling-stock subsystems,
- Juridical recording units, acting as a "black box" to vet the operation of train and driver at each moment,
- Passenger counting systems,
- CCTV surveillance-video systems,
- Energy consumption measurement systems (watt hour meters),
- Information-panel and onboard-monitor control systems,
- Onboard public address systems.

The onboard fleet management system is connected up to all the above mentioned devices, implementing in each case the communication protocol furnished by the respective manufacturer. The onboard fleet management system thus centralizes all the relevant information on these devices and sends it pooled together to the control centres, allowing operators to access it conveniently from a single application: the fleet management control centre.

The interface with these devices does not only allow information and data to be obtained from them. In many cases

the connected devices can also be controlled by the onboard platform. This is the case of the passenger information systems (with information panels or public address system).

As well as pooling all the information from the fleet's onboard equipment, the fleet management control centre also incorporates interfaces with other corporate systems already existing in RENFE. Specifically, the fleet management server set up in the control centre incorporates an XML interface based on web services for interconnection with the following corporate systems of RENFE:

- SITRA: Track-circuit based train location system
- Service planning and allocation systems
- Corporate operation management systems: Ómnium and Copérnico.

4.4. Statistical working up of recorded information

The fleet management system culls a great amount of valuable information in real time; this information will be stored and classified for later use. The compiled information includes all the following:

- Precise line topology,
- Velocity profiles for all network sections,
- Cell signal coverage for all network sections,
- Hours of service at all stops on all lines: early and late running,
- Service regulation actions,
- Occupancy figures: passengers boarding and leaving the trains,
- Driving quality variables and technical alarms,
- Figures obtained from the onboard monitoring devices: energy consumption, information from the CCTV systems, etc.



Fig.4. Driver's fleet management terminal, fitted in both cabs of the train

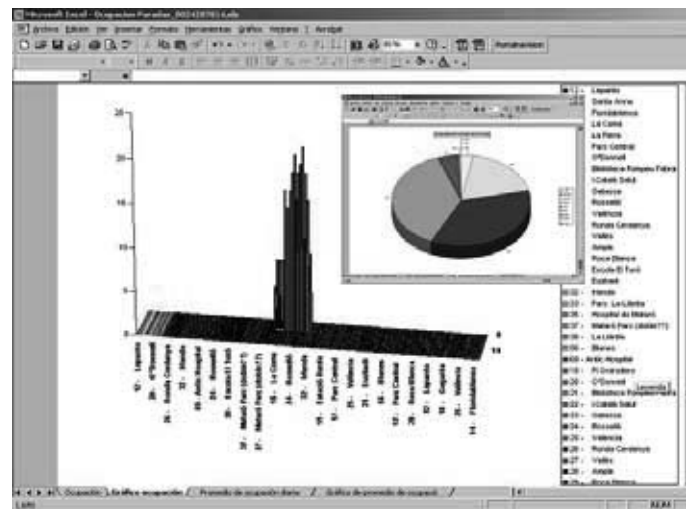


Fig.5. Examples of statistical analysis obtained from the fleet management control centre

By analyzing the above raw data, the system obtains a great amount of historical and statistical data that is invaluable for company management. On the strength of this information the system generates:

- Operation reports: times, incidents, alarms,...
- Driving quality reports,
- Occupancy reports,
- Service replanning data.

Some of this data also gives service-planning feedback, enabling results to be fine tuned to suit the desired profile.

5. Conclusions

Today's available technology makes it possible to set up fleet management systems that perfectly meet the needs of railway networks.

These systems provide important support for the transport company throughout all its business processes, including planning, real-time management, working up statistical data and service replanning.

One of the prime values of these systems is that they enable railway operators to manage their fleets in complete independence from infrastructure managers, obtaining their own information for tracking and communication purposes, for remote monitoring of onboard material and for giving information to passengers onboard the trains and waiting at stations.