Integrated security systems for hazard prevention, management and control in the Italian high speed train line

F.Garzia, G.M.Veca
Department of Electrical Engineering
University of Rome "La Sapienza", Italy

Abstract

Due to the strategic importance of the line between Firenze and Bologna and owed to the presence of a so high number of galleries it has been necessary study and design an integrated security system capable of protecting the whole infrastructure from voluntary intrusions, for damaging, vandalism and sabotage and from not voluntary intrusions, due to animals, that would compromise the train circulation and passengers safety. It this paper we illustrate this security system which is capable of reducing a great variety of risks.

1 Introduction

The continuous development of technology has allowed the realization of a plenty of devices, sensors and other powerful instruments that give raise to advanced security systems which show all their strength when they are properly used for hazard prevention, management and control and they are properly integrated in a higher level system [1, 2].
In this paper we want discuss the capability of these integrated systems, their advanced functionalities, the integration modalities with high velocity telecommunication networks, and finally a case study, represented by the integrated security system that controls the Italian high speed train line, where trains can reach a velocity up to 300 km/h, referring in particular to the line between Firenze and Bologna, 80 km long, composed by a quasi-uninterrupted series of nine galleries whose length varies from 654 meters to 21.6 kilometres,

and a series of viaducts. This train line represents a unique engineering infrastructure from the national and the international point of view.
The authors have designed a proper security scheme that manages and controls the security of this high speed train line, using an advanced system that integrates antintrusion, access control, videosurveillance, and structural monitoring, ensuring a high security level to the circulation of trains.
The integrated security system allows to the central circulation managers, located in Firenze and Bologna, to check directly each zone of the series of galleries, stopping immediately the circulation of the trains if a dangerous event takes place.
The integrated system has been properly divided into security sub-systems so that each sub-system is capable of working even in the case of malfunctioning of the other systems.
The system is capable of performing a plenty of advanced functionalities that prevent dangerous situations for the circulation of the trains and for the passengers inside them.

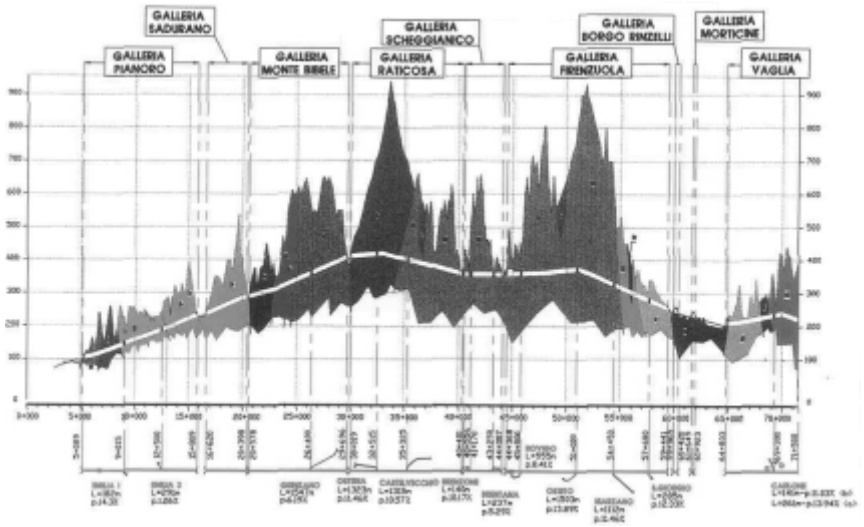


Figure 1: Scheme of the galleries between Firenze and Bologna

2 The integrated security system

Owed to the strategic importance of the line between Firenze and Bologna and owed to the presence of a so high number of galleries it has been necessary study and design an integrated security system capable of protecting the whole infrastructure from voluntary intrusions, for damaging, vandalism and sabotage and from not voluntary intrusions, due to animals, that would compromise the train operation and passengers safety.
The designed system allow the capillary control and the total visibility of the whole line, using advanced architectures and design solutions.

In this paper we illustrate only the general features and philosophy, without getting into details, to avoid of compromising the intrinsic security due to the divulgation of significant informations.
The security system show anyway unique features from the potentialities, functionalities, availabilities and for geographical extension, that makes it unique from the international point of view, since it represent a unique system extended for 80 kilometres into galleries.
The whole system is divided into two subsystems that are totally autonomous from the operative point of view, but that are linked by the communications point of view. The first system, that has already been designed from the constructive point of view, takes care of the protection of the so called peripheral places, that are particular building where the device used for train signalling, for telecommunications and train circulation, are located. The second system, that has just been designed from the preliminary point of view, takes exclusively care of the protection of the galleries and it represents the system that we illustrate in this paper, since it has directly been design by the authors.
To guarantee a high reliability of the security system it has been necessary to divide it into a series of subsystems that are totally autonomous and that are able of controlling and ensuring the security of the single galleries (the longer ones) or of group of galleries (the shorter ones).

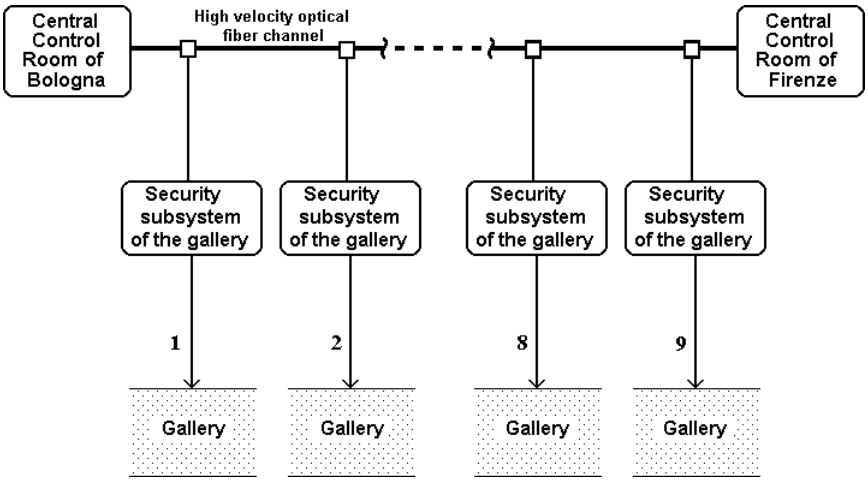
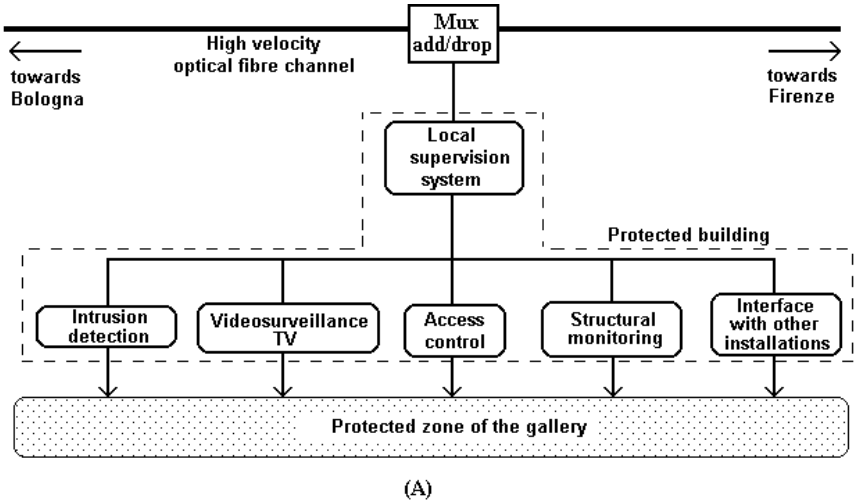


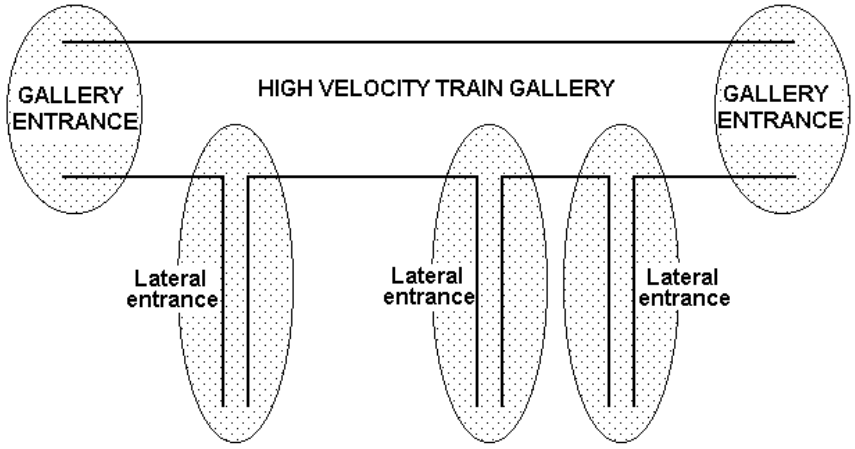
Figure 2: Scheme of the gallery security integrated system

The security subsystems takes care of controlling the intrusion detection, the access control, the videosurveillance and they are capable of interfacing with the other installations such the structural monitoring anti-fire and so on. These installations are controlled by proper security central boxes that are autonomous from the functionality and power supply point of view and they are able of working even in the absence of functionality of the hierarchical superior system.
Every installation is controlled by a local supervision system that manages the single centrals and takes care of the communications with the central control rooms, situated in Firenze and Bologna, using high velocity optical fibre

channels able of carrying data flows whose velocity is greater than hundreds of Mb/s.
A proper devices, named add/drop multiplexer, pointed out as Mux add/drop in the figure, inserts the low velocity data flow coming from the single security subsystems into the high velocity optical fibre data flow and viceversa.
All the subsystems use a proper emergency communication channel to communicate in a reduced way in the case of malfunctioning of the optical fibre channel, even if this event does not verify easily due to the high reliability of this main channel and of the whole security system.



(A)



(B)

Figure 3: Scheme of the gallery security system. (A) Scheme of the components of the subsystems. (B) Protected zones

Each subsystem represents a totally autonomous unit from every point of view. The supervision system and all the security central boxes are located in proper protected building from the physical and from the electronics point of view (the electronics protections is ensured by the security central boxes themselves).
The videosurveillance installation takes all the pictures coming from the cameras placed in the galleries. The cameras are sensible to the infrared radiation (IR) and they are equipped with proper IR light so that they can clearly see even in the dark, that is a typical condition inside a gallery.
The images coming from the cameras are recorded by proper digital recorders that are located in a different protected place with respect to the security central boxes, to increase the security level of the whole system in the case of damaging intrusion, preserving the sequence of images related to a terroristic attack.
Digital recorder have been used since they are characterized by a high reliability and by a casual access capability. Further it is necessary to remember that in a few year the tradition videocassette recorder will be no more produced.
In normal condition the images are recorded using the so called time lapse modality, that is a single frame at fixed time interval, to avoid of wasting memory with not significant images. When of element of the security give and alarm condition the images are recorded in real time to avoid of losing significant details.
The images coming from the cameras are not only locally recorded, but also digitalized, compressed and transmitted to the central control room of Firenze and Bologna, using the high velocity optical fibre channel, where they are recorder once more with a different modality, to increase the reliability of the whole system.
The image management policy aims at reducing the number of image sent to the central control rooms, to reduce the number of communication channel and consequently the realization cost of the optical fibre channel. In an alarm situation the central system automatically gives a higher number of channels to the alarmed subsystem to allow the central vision of the whole images coming from the cameras of the alarmed gallery, since any dangerous event must be promptly evaluated and managed from the circulation Manager to decide to stop the high speed train traffic, guarantying a high safety standard to the passengers.
In the case of interruption of the communication channel, that does not allow the vision of the images in the central control rooms, the images cam be transmitted in a second time, since they are recorded into each local subsystems.
All the operation that are executed at the gallery level are strongly interconnected. In fact, the entrance authorization to the personnel given by the access control installation generates the following sequence of operation:
1) communication to the intrusion detection installation that deactivates temporarily the protection;
2) recording of the face of the entering person by means of the videosurveillance installation;
3) storing of the operation inside the local supervision system to constitute a historical archive;
4) transmission of these information to the central control room.
An alarm signalling made by the intrusion detection system or by the access control system generates the visualization of the nearest camera on the monitor

of the operator of the central control room, so that he's capable of evaluating the situation.
The cameras are also located at the entrance of the lateral tunnels, in the interior side, so that it is possible to follow the escaping sequence in the case of emergency evacuation of the train, that allows the passengers to reach the gallery exits, guaranteeing their safety.
Each gallery security subsystem is endowed by proper visualization monitor and of control console that allows the control and maintenance personnel of executing any kind of operation on it, by means of proper fixed procedures that depend of the access level of the operator. These consoles not only allows of executing the maintenance operations on the other security subsystem but they also allow of receiving and watching the images coming from each cameras of every gallery.
All the connections between the security central boxes of the subsystems and the elements located into the galleries, represented by the intrusion sensors, the access control readers and the cameras use proper optical fibre connection for two main reasons. The first reason is due to the long distance between the security central box and the sensor or cameras, that can reach a length of more than 10 km: in this case the reduced amplitude signals would experience a significant attenuation that could make them incomprehensible to the security central box. The second reason is due to the high electromagnetic interference (EMI) that is typical of the train environmental, both in the presence or in the absence of trains, which would induce disturbs on the transmission lines generating false alarms and probable damaging of the more sensible electrical components. In the optical fibre, on the contrary, the electrical signals are converted into light signals, that are immune to the EM disturbs. Furthermore they are capable of propagating inside the fibre with a reduced attenuation and reaching long distances where, once arrived at the final destination, they are back converted into electrical signals.
A lot of other procedures are implemented inside the system, but they can't be illustrated for secrecy reasons.

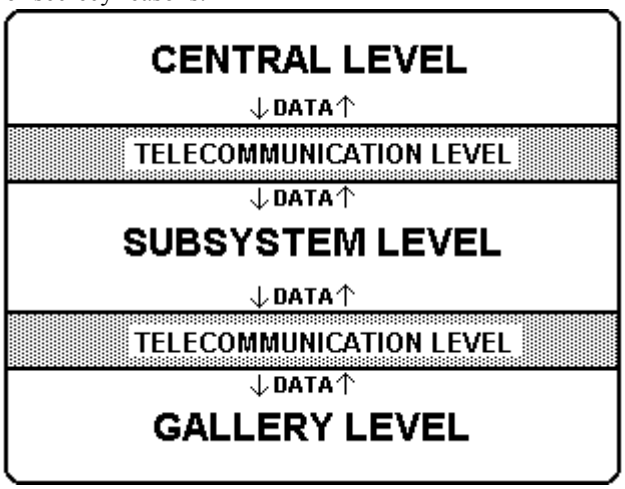


Figure 4: Scheme of the division of the system into security levels

The whole system can be divided into three levels: the central level, the subsystems level and the gallery level.
Every level represents a stand-alone unit, that is able of working independently from the functionality of the upper or lower level.
The communications between the different levels are made using proper telecommunication networks, whose features vary with each level, as it has been shown previously, using proper security protocols to guarantee the higher protection and functionality of the whole system.

3 Conclusion

It is evident that it has been necessary to use the typical multidisciplinary approach of the safety and security engineering to design this kind of complex and advanced system, since it is essential to match the risk analysis, the technologies, the normative and the community expectations to obtain concrete results that are optimised under every point of view.
In particular, the security system shown is strongly integrated both from the security that from the safety point of view.
It further integrates the human resources with the control and train traffic procedures and represents a unique system from the international point of view for technology, functionality and geographical extension.

References

[1] A.Focaracci, F.Garzia, M.Guarascio, P.Lunardi, F.E.Spagnolo, La sicurezza nelle gallerie dell'alta velocità ferroviaria della tratta Bologna-Firenze: sicurezza in fase di costruzione e protezione dell'infrastruttura in fase operativa, *Proc. of Sicurezza nei Sistemi Complessi*, Bari, 2001.
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