Wireless technology, more integration

**Dr Marion Berbineau** is the coordinator of a project aiming to increase the accessibility and productivity of railway systems. The application of cognitive radio technology enables the integration of numerous heterogeneous wireless networks already deployed along the tracks.

How did you become interested in wireless systems for railway applications?

Wireless communications are a key technology for the control and command of trains, particularly for driverless systems. I was recruited by the National Research Institute on Transport and Safety (INRETS) – now the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) – to work on the development of wireless systems for driverless trains. These have enormous potential for transforming railway systems in the future.

Could you explain what cognitive radio (CR) technologies are and why they are particularly suited to railway applications?

In the railway world, wireless communications have become key components for control and command, maintenance and monitoring, passenger information and internet access, among other things. Increasing communications needs have led to the multiplication of systems and antennae on board and along the tracks. The COgnitive Radio for Railway through Dynamic and Opportunistic spectrum Reuse (CORRIDOR) project introduces a new method capable of improving wireless systems. It relies on the CR concept – a new wireless communication type in which mobile terminals interact with their radio environment in order to automatically optimise the use of the available spectrum of frequencies. This solution is compatible with existing systems, satisfies the requirements of railways, and guarantees better quality, reliability and security of communications. It relies on the share of infrastructure and will, by design, drastically reduce the cost of deployment.

For what reasons is it key that applications such as Global System for Mobile Communications – Railway (GSM-R), CCTV and wireless internet are integrated in order to increase efficiency?

The integration of GSM-R, CCTV and passenger services in the same wireless system is very important because it avoids the need to deploy several systems as is currently done. It would be interesting to have a unique telecommunications infrastructure where we could allocate different wireless channels with varying capabilities and performances. We foresee that it could be possible to incorporate satellite infrastructures or to share the railway telecommunications infrastructure with other owners, such as public telephone operators, the fire brigade and the police.

Can you outline some of the methods you are using within the CORRIDOR project?

The project was divided into several work packages, three of which are related to the development of several key bricks: intelligent mobile terminals, intelligent infrastructure and management of quality of service and mobility. The methods used are the classic methods in research; by starting with state-of-the-art technology in a variety of domains, we found the most adaptive solutions to coping with the challenges associated with railways, such as functioning at high speeds and fighting against electromagnetic interferences. Measurements on an actual high-speed line were also conducted to acquire real signals.

What are the difficulties in integrating these CR technologies and putting them into practice on a large scale?

The fact that today’s trends for telecommunication operators centre around...
the development of long-term evolution (LTE) or LTE-advanced technologies means that it is not obvious to integrate CR technologies. The deployment of CR concepts will reduce the general cost of infrastructure deployment paid for by the state and its citizens, but it could perhaps also reduce the revenue of telecommunication operators.

CR concepts are orientated towards a more cooperative approach between telecommunication stakeholders and railway stakeholders and, while part of the technology is there, there is still a long way to go. Safety and security are a high priority for railways and although CR bricks are deployed in some Standards, they are not very well known. It is easier to guarantee safety and security on a unique system than for several cooperative systems.

Helping the railway world to understand and adopt CR concepts is also a problem due to lobbying. At present, the LTE industry is highly active and extremely powerful. China is already deploying a kind of Long Term Evolution for Railway (LTE-R), and for metro applications there are already projects with LTE for communications-based train control (CBTC). Many railway stakeholders are therefore pushing for this technology. Nevertheless, we must bear in mind that it was the same when Europe chose GSM-R; it is not deployed on every European high-speed line and is already considered an obsolete technology.

At present, there is no single wireless technology or standard that is universal enough to replace all of the others while simultaneously being able to support the multitude of railway needs. Integrating all of these heterogeneous wireless networks is therefore a key technical challenge for improving the global efficiency of the railway system and for overcoming the scarcity of spectrum problem.

**Towards a flexible radio for railways**

**IN ORDER TO** operate safely and securely, modern railway operations rely on ever-increasing fluxes of information between staff workstations, central databases and the devices widely distributed both by the trackside and on board the train. As a means of improving levels of reliability and operational efficiency and to capture the countless operations that happen daily, railway operators throughout the world have embraced wireless technologies.

However, despite the benefits these systems bring, there is one major snag: many wireless communication devices operate within different frequency bands and have been deployed to address the specific needs of a particular railway function, without significant forethought to the way railways will need to operate in the future as increasingly more people require their services. As a result, the radio spectrum is becoming an increasingly scarce commodity.

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**Funded by France’s National Research Agency, the CORRIDOR project was established to investigate new methods of maximising the performance of wireless communications for high-speed railway operation. The findings have a significant bearing on the development of a competitive and resource-efficient railway system.**

In partnership with the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), France’s National Research Agency (ANR) has funded the development of the ‘Cognitive Radio for Railway through Dynamic and Opportunistic spectrum Reuse’ (CORRIDOR) project. Completed in July 2015, this 45-month project investigated potential ways of achieving the communication needs of European high-speed trains through integrating all of the heterogeneous wireless networks. Its key objectives were to design, develop and evaluate innovative telecommunication solutions for both vehicles and infrastructures, specifically focusing on three characteristic types of usage: control-command (that is, communication-based train control), CCTV for monitoring and maintenance activities, and on-board internet.
COGNITIVE RADIO TECHNOLOGIES

Coordinated by Dr Marion Berbineau, CORRIDOR was the first research project in Europe to contribute to the development of cognitive radio (CR) technologies for railway applications. CR is a system designed to use the strongest wireless channels (in terms of high signal and low interference levels) in its vicinity at any given time. It has the ability to automatically sense and determine its particular electromagnetic environment and autonomously adjust its operating parameters, such as throughputs and frequencies, and it can also mitigate interferences. Through repeatedly reconfiguring itself, CR maximises both the efficacy and efficiency of wireless communications and provides the level of service required to satisfy the needs of a range of stakeholders, including very high levels of robustness with low data rates or very high throughputs with high Quality of Service.

OUTCOMES OF CORRIDOR

The project findings will have a significant impact on the future of railway communications. As a cutting-edge technology, CR opens up a completely new way of thinking about wireless system deployments. It contributes to the development of a kind of autonomic radio system for railways that can also be resilient to technology evolution. In addition to being part of the ongoing 5G developments, CR provides solutions to many challenges, including the need for robust, agile, flexible and reconfigurable wireless systems.

Due to the compatibility of CR with existing systems – such as the Global System for Mobile Communications – Railway (GSM-R) and Long Term Evolution for Railway (LTE-R) deployment.

Ultimately, CR helps to pave the way for a more competitive and resource-efficient European transport system, driving connectedness and economic growth across the continent. With the publication of the CORRIDOR project findings, the hope is that CR for railways will become a reality in the not-too-distant future.

A COLLABORATIVE ENTERPRISE

The CORRIDOR project team has obtained many new results, not least through collaboration between several partners. In the researchers’ efforts to build an Intelligent Mobile Terminal – in this instance, a computerised device used on trains to communicate with a central dispatch office, distant applications or another train, among other things – the teams from IFSTTAR, the Institute of Electronics, Microelectronics and Nanotechnology (IEMN) and the University of Western Brittany (UBO) have developed several fundamental building blocks for CR that cope with high speed and interferences. These include six new blind spectrum-sensing algorithms, a new turbo receiver for interference cancellation (due to the Doppler effect) and new channel-estimation algorithms.

Thanks to the joint involvement of the National Society of French Railways (SNCF) and Thalès Communication la French multinational company and a worldwide leader in railway signalling and transport security, the researchers have successfully developed CR system specifications and highlighted their potential uses and possible services.

Notably, in cooperation with teams from Eurecom and Thalès Communications, the Networks, Security and Multimedia Department at Telecom Bretagne obtained results related to the possible cooperation rules between an Intelligent Infrastructure and an Intelligent Mobile Terminal, and found innovative solutions for managing mobility and Quality of Service.