Harnessing innovation
to improve performance and safety

TECHNOLOGY RFI has introduced a variety of tools over the past two decades to improve the condition and capability of the national rail network, but these need to be integrated and managed effectively in order to maximise the benefits they offer.

Photo: Alstom Transport

The introduction of ACC electronic interlockings and the SCC traffic management system has facilitated the opening of new integrated control centres such as this one at Bologna Centrale.

According to recent data from the International Union of Railways, the Italian railway network is one of the safest in Europe. This is no surprise. Technical innovation has always been a priority for Rete Ferroviaria Italiana, and the safety of our infrastructure has been guaranteed by the consistent development of both lineside and onboard safety systems, as well as enhanced operating standards.

This strategic approach has many goals. RFI is constantly seeking to make best use of its assets, and manage services efficiently to ensure a lean, flexible and market-oriented network. We have been taking steps to increase infrastructure capacity and improve performance by harnessing technology and by targeting bottlenecks, particularly in the major metropolitan areas where the demand for train services is very high.

New technologies enable us to control maintenance costs, using RAMS parameters to feed into the design of equipment and the selection of suppliers. Monitoring systems and mobile detectors keep track of the infrastructure, allowing RFI to adopt condition-based maintenance and optimise our life-cycle costs when setting investment priorities.

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In recent years, a wide range of innovative technologies have become available on the market, but when considering which ones to implement we felt it was important to highlight the need for systems integration, as well as functional modularity, interchangeability, and diagnostics to facilitate easy maintenance. With this in mind, RFI has been promoting the standardisation of the software and hardware interfaces between various products, before selecting the appropriate technologies to increase system reliability and availability.

We have developed a range of design and configuration tools to ensure that any new systems are correctly implemented, and ensured that RFI staff are trained to use and maintain them effectively. This has been done in collaboration with some of Italy's leading universities, including the Politecnico di Milano, Scuola Superiore Sant'Anna di Pisa, Università Degli Studi di Napoli Federico II, Università Di Roma La Sapienza and Università Degli Studi Di Salerno.

Table I lists some of the main innovations that have been introduced by RFI over the past two decades, or are currently under development. They can be categorised under three main areas: to improve safety, to improve the performance of the network, and to increase efficiency. In addition to these new technologies, we have been making a significant investment to replace obsolete systems, such as the introduction of electronic interlockings instead of electromechanical relays, and the widespread use of LED signals in place of conventional filament lamps.

Signalling and train control

The FS Group has been widely recognised as a pioneer in the use of the European Rail Traffic Management System on high speed lines, having agreed as early as 2001 to implement ETCS Level 2 for operation at up to 300 km/h on the emerging *Alta Velocità/Alta Capacità* routes. Revenue

service began with a limited shuttle service on the Roma – Napoli line in January 2006, leading to full operation by the end of that year. ETCS has since been extended to the Torino – Milano, Milano – Bologna and Bologna – Firenze sections. We believe that ETCS Level 2 is now a proven traffic control system that offers the highest levels of safety, thanks to the continuous radio communication between the trains and control centre.

Of course, one of the key objectives behind ERTMS was to facilitate interoperability between different national networks across the EU. The technology has continued to develop over the past decade, and we are now studying the possibility of a technical upgrade of the Roma – Napoli line to the latest standards, as part of our continuous performance improvement programme (p53).

On conventional lines, RFI has adopted a simpler form of automatic train protection, known as SCMT (*Sistema Controllo Marcia Treno*), which is designed for use at up to 250 km/h. Using a similar 1023 bit data message to ETCS Level 1, this is an intermittent overlay to the existing lineside signalling, where encoders and balises along the track pass information to the trains via an onboard antenna. As well as repeating the signal aspects in the cab, SCMT provides information about the line speed and gradient, including any speed restrictions in the following section. An onboard unit calculates a target speed and braking curve, intervening with an automatic braking command if the actual train speed exceeds the calculated curve.

On around 4900 km of secondary lines where the traffic density is not sufficient to justify the use of SCMT, we have installed a driver support system known as SSC (*Sistema di Supporto alla Condotta*). This uses a microwave transmission technology with transponders, and is limited to a maximum of 150 km/h. SSC also monitors the train speed in relation to the permitted line speed and signal status, and intervenes with a braking command if the train speed is too high.

Track occupancy on most routes is monitored using axle-counters rather than track circuits, but performance of the network can be interrupted if there is a fault with the system or the entry and exit counts do not agree. In order to ensure better performance, we have therefore fitted several main lines with a multi-section axle-counter block system.

This includes an automatic reconfiguration function which can keep the trains moving in the event that one or more intermediate counting heads should fail for any reason. The defective counter is automatically excluded, and the system is reconfigured to merge the two adjacent sections into one, by pairing up the working counters.

An 'auto-liberation' function allows for the release of contiguous axle-counter block sections that have remained showing 'occupied' as a result of interference or an incorrect count at the intermediate counting point. The sections are cleared totally automatically once the system has been able to compare the counts made at points before and after the affected sections.

Traffic management

Beginning at Roma Termini in 1999, RFI has been introducing electronic interlockings and operations control centres to manage many of its larger stations, replacing conventional signalboxes. These are known as ACC (*Apparato Centrale Computerizzato*). Safety is ensured by the use of a triple-redundant programmed logic processor, whilst bringing the management of a whole station area into a single control centre enhances performance, punctuality and response to any emergencies. As the traffic management process has continued to evolve, the system has been expanded to cover more than one station, leading to the so-called multi-station version, ACC-M. As well as monitoring an entire route from a single location, this brings a significant reduction in the hardware, with consequent saving in terms of maintenance.

Closely related to ACC is the introduction of our traffic management system, SCC (*Sistema di Comando e Controllo*), which has been rolled out across more than 97% of the network in the past two decades. From rural branch lines to busy urban nodes, SCC is used to monitor train operations, equipment status and maintenance diagnostics, as well as CCTV security monitoring and the provision of passenger information.

RFI's suite of technology

Train control and traffic management
ERTMS — including ETCS Level 2, GSM-R
SSC — Sistema Supporto alla Condotta (Driver Support System)
SCMT — Sistema Controllo Marcia Treno (Train Drive Control System)
Infrastructure systems
RTB hot axlebox detectors, multi-functional inpection portals, level crossing safety systems, obstacle detection
Traffic management
SCC — Sistema Comando e Controllo (Management & Control System)
Rolling stock systems
ETCS, SCMT and SSC on board equipment
Efficiency and development
ACC-Multistazione — Multi-station computer-based interlocking
Fixed and mobile diagnostics
High Density Traffic System

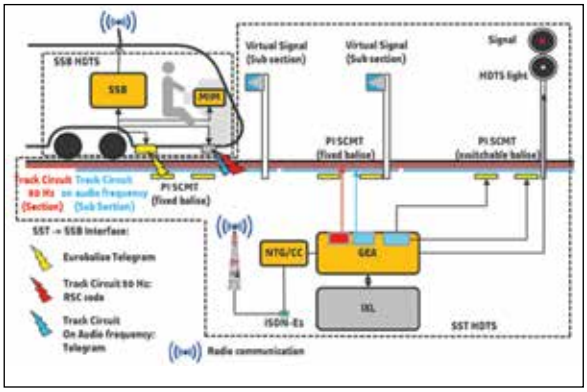

Fig 1. HDTS uses coded track circuits overlaid on the conventional signalling to shorten block sections and increase capacity on busy lines.

High-density overlay

In order to optimise the use of the network and accommodate more trains on the busiest lines without building additional infrastructure, RFI is now developing a new traffic control technology, known as the High Density Traffic System. This is a functional development of SCMT, but closely connected to ACC and SCC. By subdividing the signal blocks into smaller sections, down to a minimum of 300 m (Fig 1), it will be possible for trains to operate at closer headways under continuous supervision, potentially tripling the capacity of a given line.

As well as the discrete information provided by the SCMT balises at each of the lineside signals, the train receives continuous information about the occupancy of the subsections using

RFI is currently installing its first 'multifunction portals', which will inspect passing trains at speeds up to 300 km/h.

audio-frequency coded track circuits superimposed on the existing low-frequency detectors. The lineside signals are provided with an additional aspect, in order to indicate to the driver that the train may pass into an occupied block when operating under HDTS control, enabling the driver to run closer to the train in front. The permitted speed and remaining distance to the target point are displayed in the cab.

The system is currently being tested, and once it has been certified by the national safety authority ANSF it will be installed on the Roma – Fiumicino Airport line. It will also be rolled out in the Firenze area.

Monitoring systems

Among the developments intended to improve safety are a number of systems to monitor the condition and performance of passing trains.

Overheated axle bearings and dragging brakes are an ongoing problem, particularly for freight trains. A hot axlebox may lead to a bearing failure and consequent derailment, as with the tragic accident at Viareggio in June 2009. Overheated brake blocks can also cause mechanical failures, as well as potentially triggering a fire on the train.

Right: Both cabled and radio versions of RFI's Automatic Train Warning System use red LED indicators and audible warnings to inform staff working on the track of approaching trains.

RFI has therefore committed to equip the entire network with hot axlebox detectors, which are known as RTB (*Rilevamento Termico Boccole*). Thermal radiation emitted from the axleboxes and brakes is recorded at one or more measuring points along the line, and relayed to a control point in a nearby station. As soon as an over-temperature condition is detected, an alarm is sent to inform the traffic controllers.

We have recently awarded a contract for the development and implementation of 'multifunction portals', which will inspect passing trains at speeds up to 300 km/h (RG 8.13 p21). As well as a thermal assessment using infrared sensors to detect hot axleboxes and brakes, the portals will analyse the shape of the train and any load using 3D geometry scans, to ensure that it does not infringe the loading gauge.

We have so far ordered seven portals at a cost of around €7m. These will initially be deployed to protect the longer tunnels on the network. They will be linked to the signalling system so that a train can be halted immediately if a clearance infringement or high temperature is detected. To facilitate recovery and passenger assistance, the portals will be located in such a position that a defective train can be brought safely to a stand before it enters the tunnel.

In the longer term, RFI expects to deploy around 100 portals at key locations across the network, including border crossings as well as tunnel entrances on both the AV/AC and conventional networks. Including the development of the prototypes, the total cost of the programme is put at around €130m.

Meanwhile, regular monitoring of the infrastructure is undertaken using a fleet of mobile diagnostic trainsets. These enable RFI to monitor infrastructure assets continuously, providing timely and efficient information about their deterioration, and minimise the time taken for maintenance; this helps us to rationalise our resources.

Pride of the fleet is the Diamante high speed train (Diagnostics, & Maintenance Technology), powered by a pair of former ETR500 power cars. Able to survey our high speed line infrastructure at 300 km/h, the train is 100% Italian innovation, developed in-house by RFI and using a wide range of diagnostic systems from local manufacturers.

Obstacle detection

As well as monitoring the trains, we have introduced obstacle detection systems in selected areas where dangerous objects may fall onto the tracks as a consequence of accidents or landslides. These are typically installed near overbridges or at tunnel entrances. The systems can detect and flag up the presence of obstacles in a predefined 'supervised area', allowing trains to be brought to a halt if the line is blocked. The system is interlocked with the normal train detection equipment to prevent a false alert being triggered by a passing train.

Obstacle detection is also being used at level crossings, in the form of PAI-PL (*Protezione integrativa per i Passaggi a Livello*). After the barriers have closed, this scans the crossing area using radar to detect any obstacles before the signals are cleared for a train to pass. This technology was developed for the FS Group by GE Transportation about 15 years ago, and in 2011 RFI began work on a second-generation version which is intended to improve operational performance as well as reducing the waiting time for pedestrians and vehicles.

Protecting track workers

Another innovation now being introduced to protect staff working on the track is a new system known as ATWS (Automatic Train Warning System). This uses both audible and visual warnings to inform them of an oncoming train. The audible and visual warning systems are controlled by a central processor, which is in turn triggered by a train detection unit. At present this is a mechanical or electrical treadle attached to the track, but in the future ATWS will be connected to the signalling system.

Where staff are likely to be working on the track over a long period, as in large yards, or major civil engineering

projects, such as bridge renewals or tunnel upgrading works, the ATWS can be installed on a long-term basis with the equipment connected by cable. However, these can take a long time to complete, so a portable version using radio links has been developed for short-term applications.

All of these technical innovations are intended to improve the performance of the railway, using highly reliable assets and monitoring systems to minimise the economic impacts from any unavailability. To this end RFI has a comprehensive information system known as Meridium which monitors asset performance across the network, evaluates their reliability and enables us to optimise our maintenance policies.

Major investment projects underway at the current time include €700m to install ACC-M on the Torino – Padua line; this is due for completion by 2016. Another €170m is being spent on works to relieve bottlenecks in the Roma area, which will be completed in 2018, as will a €133m programme to extend SCC along the Adriatic coast. The installation of hot axlebox detectors will see €70m invested by 2016, with €14m to be spent by 2017 on the protection of track workers including a wider roll-out of ATWS.