*Ministry of Infrastructure and Transport*

*DEPARTMENT OF TRANSPORT, NAVIGATION, GENERAL AFFAIRS AND HUMAN RESOURCES*

***Directorate-General for Transport and Railway Infrastructure***

# National implementation plan of ERTMS

referred to in Section 7.4.4 of the Annex to Commission Regulation (EU) 2016/919
on the technical specification for interoperability for “Control-Command and Signalling” subsystems
(TSI CCS)

# 4 Infrastructure operated by Rete Ferroviaria Italiana S.p.A. (Italian Railway Network) (RFI)

Rete Ferroviaria Italiana S.p.A., hereinafter RFI, has been in cooperation with other Member States of the European Union and ERA *(European Union Agency for Railways)* for several years for the development and implementation of the ERTMS system.

On the basis of completed and taking into consideration that stability of the relevant technical specifications has been achieved, RFI considers that the system is mature and holds the necessary potentials for its implementation apart from the HS (High Speed) network, progressively on the lines of the conventional network (beginning with the TEN-T Core Network), as well as in the high density rail transport in urban nodes and on the regional lines with low traffic. Therefore, RFI proposed an ERTMS development plan for its network [Ref. 6].

## 4.1 Lines in operation with ETCS

Currently 750 km of HS/HC (High Speed/High Capacity, 300 km/h) lines are in operation, equipped with the ETCS L2 system without lineside signals and without national protection system on the following sections:

| HS/HC section | SST ETCS supplier | Level ETCS | SRS version |
|---|---|---|---|
| Rome - Naples<br>(Roma Prenestina - Napoli Afragola) | Alstom | L2 | 2.3.0d |
| Florence – Bologna<br>(Firenze Castello - Bologna HS) | Alstom | L2 | 2.3.0d |
| Bologna - Milan<br>(Bologna HS - Milano Melegnano) | ASTS | L2 | 2.3.0d |
| Milan - Turin<br>(Milano Rho - Torino Settimo Torinese) | ASTS | L2 | 2.3.0d |
| Treviglio - Brescia | ASTS | L2 | 2.3.0d |

The currently ongoing migration of the “Florence-Rome Direttissima (direct line)” section to ERTMS will ensure technological uniformity along the entire Turin-Milan-Rome-Naples HS/HC axis, thus improving the performance of North-South connections of the country by speeding up services and increasing the reliability of the system.

## 4.2 Criteria of migration to ERTMS

### 4.2.1 Specification levels and versions

Considering the investments carried out in the past for the implementation of SCMT and GSM-R, an important step has already been taken on the network operated by RFI for the migration towards ERTMS.

The existing Class B SCMT signalling was designed and implemented to increase the automatic protection of train movements while being as “transparent” as possible with pre-existing legal provisions and regulations by integrating with the Codified Current Automatic Block System (BACC), and it can be superimposed on any pre-existing station and block facilities. In addition, it was built with interoperable components such as Encoder and Eurobalise with a view to being superimposed with the ETCS system during migration.

Taking into account the various ETCS specifications laid down in the technical specifications for interoperability (TSI) currently in force, we wish to point out that:

- *“Baseline 3 - Maintenance Release 1"* introduces important new functions compared to Baseline 2, including:
    - more potentially available “International Train Categories”;
    - management of non-protected Level Crossings

    - standardisation of the train model (braking curves);
    - standardisation of Driver Machine Interface;
    - "Limited Supervision" operating mode;
    - optimised management of radio infill;
    - "Permitted Braking Distance";
- *"Baseline 3 - Release 2"* involves, in addition to a few corrections of errors, the management of GPRS communication (Internet Protocol, IP) and the management of on-line encryption keys. The principle of its creation is to ensure, in addition to *"backward compatibility*" of an on-board Baseline 3 - Release 2 with all recognised trackside Baselines, the *"forward compatibility*" of an on-board Baseline 3 - Maintenance Release 1 with a trackside Baseline 3 - Release 2.

It is therefore appropriate to use Baseline 3 for conventional lines because it allows to exploit the functionalities necessary for the management of interoperable freight traffic *(train categories* complete) for the management of specifications occurring in conventional lines (e.g. the function dedicated to the protection of Level Crossings) and for high-density urban nodes (optimised management of braking curves and using GPRS for track-train radio communication); while Baseline 2 is adequate for High Speed lines where there is a greater uniformity of train categories.

Therefore, the general criteria that inspire ERTMS migration strategy and the selection of Baselines and Levels to be implemented in the network is the following:

- High Speed Lines → ETCS Baseline 2 (BL2) - Level 2, not superimposed on national systems
  The reference baseline is Baseline 2.
- Conventional Lines → ETCS Baseline 3 (BL3) - Level 1/2 (depending on the type of present signalling), superimposed on the national signalling system for a transitional period:
    - *Conventional lines with Codified Current Automatic Block System (BACC):* ETCS Baseline 3 - Level 2.
    - *Conventional lines with Axle Counter Block:* ETCS Baseline 3 - Level 2 is preferred as it offers a higher level of performance and security, but it is also possible to choose Level 1 with radio infill in particular cases or when it is particularly advantageous economically (e.g. in the absence of Computerised Multi-Station Interlocking).
    - *Urban nodes:* ETCS Baseline 3 (Release 2) - Level 2 with virtual block (train integrity function available on board).
    - *Border crossing lines to Switzerland* (if there is Swiss signalling): ETCS Baseline 3 - Level 1 with Euroloop.

In order to facilitate a gradual and sustainable upgrading of trains running on conventional lines to ERTMS BL3, the current SCMT will also be kept on the trackside for a transitional period enabling traffic for both the existing rolling stock equipped with Baseline 2 (not compatible with Baseline 3 on the trackside) and the one without ETCS. However, with the aim to fully exploit the main benefits offered by ETSC Baseline 3 and to reduce the management impact of potential disturbances induced in the traffic to trains upgraded to BL3, a progressive phase-out of SCMT will follow on the conventional network from 2026.

### 4.2.2 Elements of economic assessment

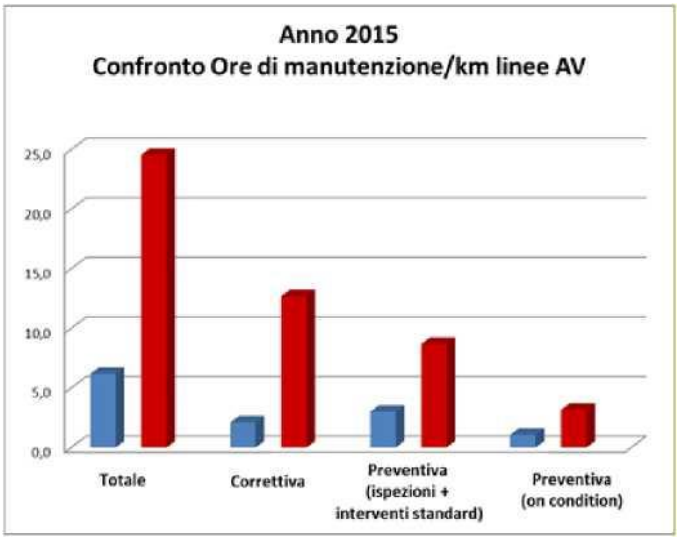
The technical-economic evaluation carried out by RFI [based on the data collected in its own *Inrete2000* database used for maintenance activities, study ordered from Ernst & Young (E&Y) by the European Commission in 2015 regarding the RALP and NSM corridors, as well as the cost/benefit analyses carried out by the Bocconi University of Milan in the frame of the ERSAT project for the application of satellite technology (Ref. 5)] points out that the introduction of ERTMS on the conventional network enables a reduction of signal maintenance costs compared to the national system and determines a positive business case at the level of the entire railway system. The more the migration to trackside ETCS is accompanied by a phase-out plan of the pre-existing class B system, the greater the effect. In addition, a

phase-out programme of the national signalling system is necessary to limit the extra maintenance costs of two overlapping signalling systems. This should be appropriately gradual in time to allow the progressive conversion of on-board signalling systems.

In particular, the performed analysis pointed out the following aspects:

- Being in operation on the RFI network, both on HS lines with ETCS L2 without light signals and on an HS line with light signals and protected with the national SCMT+BACC system, the ordinary maintenance (OM) costs of the two traffic protection systems were compared.

  The results showed that in the calculation of total maintenance hours on the examined sections, corrective maintenance had a smaller share for ETCS (approximately 30 %) compared to SCMT+BACC (approximately 50 %). The reasons for this also include that less components are required by the ETCS system for the protection of train traffic. Furthermore, results showed that in terms of maintenance hours normalised to km, the total hours of ETCS maintenance were 1/4 of the hours required by SCMT+BACC.




***2015***

***Comparison of maintenance hours/km in HS lines***

*Total* *Corrective* *Preventive (inspections + standard interventions)* *Preventive (on condition)*

Taking an average cost of 100 EUR/hour for maintenance (including personnel costs, spare parts, reconfiguration and costs related to disruptions caused by malfunctions), RFI estimated that the average costs per km per year for Class A and B systems are the following:

| ERTMS L2 - Class A | SCMT - Class B |
|---|---|
| 600 EUR / km per year | 2 400 EUR / km per year |

- Extraordinary maintenance (EM) on existing signalling is part of an already started investment programme, parallel and preparatory to the ERTMS programme. This programme also involves the renewal of equipment in electronic and central posts which are essential elements for the low cost implementation of ETCS L2 or L3.

- The factors determining the management costs of the two systems were also examined:

  - <u>Double management of the modifications</u>

    The maintenance interventions carried out only on one of the two systems (even though they are

completely decoupled in terms of their functions) have a disturbing and financial effect on the maintenance, management and reconfiguration costs of the other system as well. This either because they use some common HW components (beacons, encoders and GSM-R) or because every necessary modification to the units or the station or line layout or equipment (ACEI or ACC) which are common reference points for the two separate systems, later requires a double reconfiguration, non-regression testing and re-certification and commissioning for both security systems.

Furthermore, SCMT and ERTMS Level 2/3 have different architectural concepts.

ERTMS L2/3 maximises the concentration of both line and station information under the control of a Radio Block Centre Database while SCMT distributes its equipment and the related information in the area. This implies that a local modification for SCMT only requires local re-certification while for ERTMS Level 2 or Level 3 it requires a complete re-certification of the Radio Block Centre Database.

Therefore, the different architecture determines the costs of Planning, Testing, Validation, Certification and Commissioning of the two types of modifications on the individual distributed unit of SCMT and on the Radio Block Centre of ERTMS at the central post. Due to direct and indirect costs, there is even a tenfold difference between them, to the disadvantage of ETCS. Estimating with one intervention per year for 200 km for specific application modifications (reconfiguration) for one of the two systems or for one station equipment, the average costs of planning, testing, validation, evaluation by NoBo, trial runs, certification and commissioning in the ETCS system (also when caused by the modification of another system), can be estimated with a conservative approach as an average of 70 000 EUR, thus 350 EUR/km per year.

- Management of slowdowns
  In addition to the 3 relevant warning signs, the management of slowdowns imposed in SCMT requires the beginning and the end of the slowdown, the use of at least 6 beacons per track. These are first programmed by personnel dedicated to this task and later handled by specialised teams, then removed always in a closed line mode. On the other hand, ERTMS level 2/3 uses a centralised method via radio for the setup and removal of slowdowns which has no costs. Considering the setup of five slowdowns per year on average in a 200 km section, the average internal costs in total for setting up and removing SCMT slowdowns can be estimated as 4 000 EUR per slowdown including labour costs, setup and material costs, thus 100 EUR/km per year.

As a conclusion, the projection of these ordinary, extraordinary maintenance and management cost estimates in relation to the implementation capacity of ETCS on the network and the possibility of temporary coexistence of the two systems is a key element for defining the criterion of progressive phase-out of the SCMT national system.

## 4.3 ERTMS activities in the HS network in the implementation phase

### 4.3.1 Florence-Rome Direct Line (“Direttissima”, DD)

The technological adjustment plan of the “DD” line according to HS/HC standards aims to establish the conditions for:

- the qualitative and quantitative improvement of services through increasing the performance levels allowed by the system and increasing the overall efficiency of the asset in traffic;
- the improvement of traffic management in the entire Milan-Rome HS route both in normal operation and failure situations through advanced traffic management functions concentrated in a single Central Post in Bologna.

In order to achieve these objectives, the signalling system will be adjusted to the ETCS L2 BL 2.3.0d standards.
The implementation will be carried out in 3 phases:

- Phase 1: Rovezzano - Arezzo Nord (54 km) - Commissioning: 30 June 2019

- Phase 2: Arezzo Nord - Orte Nord (125 km) - Commissioning: 29 November 2019
- Phase 3: Orte Nord - Settebagni (58 km) - Commissioning: 31 December 2019

and simultaneously with the activation of each phase, the actual Class B system (SCMT) will be eliminated, thus it can only be used by trains equipped with SSB ETCS.

| Line | Description of Activity | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|
| Florence-Rome direct line | Application of ETCS, GSM-R, ACCM, SCCM, RTB, new power supply system of the facilities. Phase-out of SCMT. | L2 | BL2 | Contract awarded to ASTS - final design phase | December 2019 |

The choice of using ETCS Level 2 system without the SCMT system on the Florence-Rome "DD" line as well is consistent with the system already in operation on other HS lines and allows to exploit the advantages associated with the uniform management of the entire Milan-Rome section as the System enables centralisation in a single central post in Bologna which also maximises the use of its functions (for example, the flexibility in case of malfunction or traffic, capacity or speed disruption), while reducing the ownership costs of ERTMS as well.

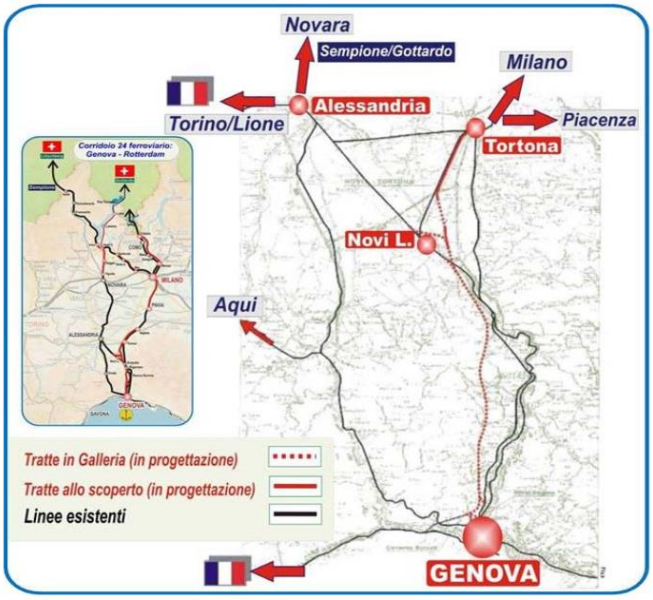
### 4.3.2 Milan-Genoa HS/HC line "Third Giovi Tunnel"

The project envisages the construction 53 km of new line (in addition to interconnections) of which 37 km will be in tunnel, connecting Tortona and Genoa (North side: Tortona junction and Novi Ligure plain - South side: Fegino junction and Voltri interconnection) which will be equipped with ERTMS L2 BL2. 6 construction phases are planned: Construction phases 1, 2 and 3 are already financed and are in the implementation phase. Works are planned to be completed in December 2021. The Third Giovi Tunnel is a line which forms part of the Rhine-Alpine "core" Corridor for freight and passenger traffic with a maximum speed of 250 km/h. The project was scaled to adequately address the needs of freight transport.

Parallel to this project, the old "comprehensive" Tortona - Genoa line (via Mignanego) will be equipped with ERTMS by 2020 as laid down in the new ERTMS European Deployment Plan (EDP) [Ref. 3].

Equipping the two lines with ERTMS will ensure that today's commercial needs will be satisfied.

*Small figure: Railway corridor 24 Genoa-Rotterdam*



***Sections in tunnel (planned)***

***Open sections (planned)***

***Existing lines***

| Line | Description of Activity | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|
| Third Giovi Tunnel | Milan-Genoa new HS/HC line: Third Giovi Tunnel | L2 | BL2 | Under construction | 2021 |

The line will allow to significantly increase transport supply by improving the railway connections between the Genoa port system and the Northern part of the country as well as with Central and Northern Europe (Rotterdam, Antwerp).

## 4.4 ERTMS Activities on the Corridors of the Core Network (first phase by 2020) [in line with Regulation (EU) 2017/6]

### 4.4.1 Rhine-Alpine Corridor (RALP)

| Line | Description Activity | Interlocking | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|---|
| Milano Smistamento (Milan Marshalling Yard) and Milano Centrale - Chiasso | ETCS fitting superimposed on SCMT | ACCM and conventional | L2 (+SCMT) | BL3 | Under construction. Contract signed on 23 December 2015. Final design approved, work commencement in December 2016. | December 2018 |
| Domodossola-Novara (via Borgomanero) (comprehensive) | ETCS fitting superimposed on SCMT | Conventional | L1 + radio Infill (Multi-station RIU) (+SCMT) | BL3 | Under construction. Contract signed on 19 November 2014. Final design approved, work commencement in December 2015. | June 2018 (*) |
| Ranzo-Luino (comprehensive) | ETCS fitting superimposed on Eurozub and EuroSignum. | Conventional. Swiss traffic signals and regulation | L1 Limited Supervision + euroloop | BL3 | Under construction. RFI-SBB cooperation contract signed. For 6 months from June 2017, the line will be closed due to infrastructural works /gauge adjustment /replacement of equipment. | To be confirmed for civil engineering works in progress: December 2017 (**) |
| Iselle-Domodossola | ETCS fitting superimposed on Eurozub and EuroSignum. | Conventional. Swiss traffic signals and regulation | L1 Limited Supervision + euroloop | BL3 | Under construction. RFI-SBB cooperation contract signed. Contract signed on 20 November 2015. Final design approved, work commencement in May 2016. | December 2017 (***) |
| Milan Rogoredo - Tortona - Genova (via Mignanego) (partly comprehensive) | ETCS fitting superimposed on SCMT. | ACCM under construction (with internalisation) | L2 (+SCMT) | BL3 | Design phase started (tendering launched in 2017). | December 2020 |

(*) The commissioning of the "Domodossola-Novara" line is currently in 6 months delay compared to the planning reported in Regulation (EU) 2017/6 due to technical difficulties encountered in the planning phase for the modification of existing systems, as this line is the first one in Italy to apply Level 1 and Multi-station radio infill, and because of two pending certificated BL3 boards to be able to activate the line which will only be available in the first months of 2018.

(**) The "Ranzo-Luino" line will be closed for infrastructural works and gauge adjustment / replacement of equipment and represents complex issues related to the dual RFI-SBB management. However, this is a comprehensive line which is not included in Regulation (EU) 2017/6.

(***) The "Iselle-Domodossola" line has a plan in line with Regulation (EU) 2017/6 but it represents complex issues related to the dual RFI-SBB management and in particular the still pending data to be received about the 44 EuroZub/EuroSignum package from the Swiss side and the board to run the tests.

### 4.4.2 Mediterranean Corridor (MED)

| Line | Description Activity | Interlocking | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|---|
| Pilot Line Milano Lambrate - Treviglio | ETCS L2 fitting superimposed on SCMT | Conventional / ACCM | L2 (+SCMT) | BL3 | Project completed | Authorisation request for commissioning at the end of 2015. Pilot project, no commissioning |
| Novara - Venice | ETCS fitting superimposed on SCMT. | ACCM under construction (Turin-Padua project) + modifications to conventional facilities and ACC | L2 (+SCMT) | BL3 | Design phase started (tendering launched in 2017). | December 2020 |
| Vicenza - Trieste/Villa Opicina | ETCS fitting superimposed on SCMT. | Conventional + modifications to ACC and ACCM facilities | L1 + Radio Infill /L2 (+SCMT) | BL3 | Design phase started (tendering launched in 2017). | December 2020 |

### 4.4.3 Scandinavian - Mediterranean Corridor (SCANMED)

| Line | Description Activity | Interlocking | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|---|
| Brenner - Verona | ETCS fitting superimposed on SCMT. | ACCM under construction (with internalisation and DTP project) + modifications to conventional facilities and ACC | L2 (+SCMT) | BL3 | Design phase started (tendering launched in 2017). | December 2020 |

## 4.5 Details of the implementation plan of ERTMS in the RFI network

### 4.5.1 ERTMS in the Conventional network

With regard to the conventional network, both central (*Core*) and general *(Comprehensive),* lines, ERTMS fitting is planned incrementally, according to the following programme:

- By 2020, approximately 1 250 km of lines will be equipped, mainly in the central network;
- By 2026, approximately 4 000 km of lines will be equipped, mainly in the central network;

- By 2030, the entire central network of approximately 6 000 km will be equipped as per Regulation (EU) 1315/2013 and Regulation (EU) 2017/6.

With regard to the cost of works, the estimate for cumulative costs is shown in the table (until 2020, until 2026, until 2030):

| Investments | 2020 | 2026 | 2030 |
|---|---|---|---|
| | 270 M EUR (*) | 730 M EUR | 1 100 M EUR |

(*) of which 204 M EUR is currently available by the Programme Contract.

Given that the reference version for ERTMS equipment in the conventional network is "Baseline 3" (BL3) [see section 4.2.1], the following table shows the programme with the line details (section and km), indicates the Corridor it belongs to, the type of equipment (level) and the expected date of commissioning:

| No | WORKS | Km line | Km tracks | Core or non-core lines | ERTMS equipment | Commissioning |
|---|---|---|---|---|---|---|
| 1 | Iselle - Domodossola | 20 | 40 | RALP | L1 LS + Euroloop | December 2017 |
| 2 | Ranzo - Luino | 14 | 14 | Non-core | L1 LS + Euroloop | December 2017 |
| 3 | Domodossola - Borgomanero - Novara | 88 | 91 | Non-core | L1 + radio Infill (+SCMT) | June 2018 |
| 4 | Chiasso - Milano | 65 | 130 | RALP | L2 (+SCMT) | December 2018 |
| 5 | Novara - Milan | 60 | 120 | MED | L2 (+SCMT) | 2020 |
| 6 | Milan - Verona | 180 | 360 | MED | L2 (+SCMT) | 2020 |
| 7 | Brenner - Verona | 246 | 492 | SCANMED | L2 (+SCMT) | 2020 |
| 8 | Verona - Padua - Venice | 175 | 350 | MED | L2 (+SCMT) | 2020 |
| 9 | Vicenza - Treviso - Portogruaro | 102 | 152 | Non-core | L1 + radio Infill (+SCMT) | 2020 |
| 10 | Portogruaro - Cervignano - Villa Opicina/Trieste CM | 119 | 238 | MED | L2 (+SCMT) | 2020 |
| 11 | Milan - Tortona | 80 | 160 | RALP | L2 (+SCMT) | 2020 |
| 12 | Tortona - Genoa (via Mignanego) | 60 | 120 | Non-core | L2 (+SCMT) | 2020 |
| 13 | Domodossola - Gallarate - Milan | 112 | 224 | RALP | L2 (+SCMT) | By 2026 |
| 14 | Arona - Novara - Alessandria - Arquata | 134 | 230 | RALP | To be evaluated | By 2026 |
| 15 | Novara - Torino O. | 103 | 206 | MED | L2 (+SCMT) | By 2026 |
| 16 | Verona - Bologna | 133 | 266 | SCANMED | L2 (+SCMT) | By 2026 |
| 17 | Bologna - Florence - Pisa - Livorno/La Spezia; | 180 | 360 | SCANMED | To be evaluated | By 2026 |
| 18 | Pisa - Civitavecchia - Rome | 328 | 656 | Non-core | To be evaluated | By 2026 |
| 19 | Rome - Naples (via Cassino) | 224 | 448 | Non-core | To be evaluated | By 2026 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | Rome - Pomezia | 20 | 40 | SCANMED | L2 (+SCMT) | By 2026 |
| 21 | Luino - Laveno - Sesto Calende - Oleggio | 51 | 51 | RALP | To be evaluated | By 2026 |
| 22 | Laveno - Gallarate | 31 | 31 | Non-core | To be evaluated | By 2026 |
| 23 | Portogruaro - Venice (via the "Bivi" line) | 61 | 122 | MED | To be evaluated | By 2026 |
| 24 | Rome - Florence LL | 310 | 620 | SCANMED | To be evaluated | By 2026 |
| 25 | Venice - Padua - Bologna | 162 | 324 | MED | L2 (+SCMT) | By 2026 |
| 26 | Bologna - Ancona | 220 | 440 | SCANMED | L2 (+SCMT) | By 2026 |
| 27 | Ancona - Foggia | 320 | 640 | Non-core | L2 (+SCMT) | By 2026 |
| 28 | Foggia - Bari | 110 | 220 | SCANMED | L2 (+SCMT) | By 2026 |
| 29 | Naples - Villa San Giovanni | 460 | 920 | SCANMED | To be evaluated | By 2026 |
| *30* | *Modane - Turin* | *90* | *180* | *MED* | *To be evaluated* | *By 2030* |
| *31* | *Milan - Bologna* | *200* | *400* | *core* | *L2* | *By 2030* |
| *32* | *Castel Bolognese/Faenza - Ravenna* | *74* | *74* | *MED* | *To be evaluated* | *By 2030* |
| *33* | *Pomezia - Naples (via Formia)* | *213* | *426* | *SCANMED* | *L2* | *By 2030* |
| *34* | *Bari - Taranto* | *104* | *208* | *SCANMED* | *To be evaluated* | *By 2030* |
| *35* | *Messina - Catania - Augusta* | *150* | *203* | *SCANMED* | *To be evaluated* | *By 2030* |
| *36* | *Palermo - Catania* | *181* | *239* | *SCANMED* | *To be evaluated* | *By 2030* |
| *37* | *Genoa - Ventimiglia* | *138* | *245* | *core* | *To be evaluated* | *By 2030* |
| *38* | *Genoa - La Spezia* | *87* | *174* | *core* | *To be evaluated* | *By 2030* |
| *39* | *Alessandria - Ovada - Genoa* | *85* | *85* | *RALP* | *To be evaluated* | *By 2030* |
| *40* | *Tarvisio - Udine - Cervignano* | *114* | *203* | *BAC* | *To be evaluated* | *By 2030* |
| | **Total** | **5 604** | **10 502** | | | |

### 4.5.2 ERTMS in the HS/HC network

With regard to the HS/HC network, ERTMS will be installed *stand-alone* in the new lines, while in the existing Florence-Rome "DD" section instead of the Class B system, according to the following schedule:

| No | WORKS | Core or non-core lines | ERTMS equipment | Commissioning |
|---|---|---|---|---|
| 1 | New Milan - Verona HS/HC line: Treviglio - Brescia section | MED | L2 stand alone | 2016 |
| 2 | Turin-Milan-Naples HS/HC network: Bologna Centrale - Bivio Venezia (Venice Junction) section | MED | L2 stand alone | 2018 |

| | | | | |
|---|---|---|---|---|
| 3 | Turin-Milan-Naples HS/HC network: Firenze CM - Settebagni section(*) | SCANMED | L2<br>(with simultaneous phase-out of SCMT) | 2019 |
| 4 | Third Giovi Tunnel HS/HC line | RALP | L2 stand alone | 2021 |
| 5 | Milan-Verona HS/HC line:<br>Brescia Ovest (West) - Brescia Est (East) - Verona section | MED | L2 stand alone | 2023 |
| 6 | Verona - Padua HS/HC line:<br>Verona - Vicenza section and Vicenza crossing | MED | L2 stand alone | By 2026 |
| 7 | Brenner Base Tunnel (BBT): Stand-alone fitting of a new line | *SCANMED* | L2 stand alone | By 2026 |
| 8 | Upgrading of access lines to Brenner: Fortezza-Ponte Gardena fitting | *SCANMED* | L2 stand alone | By 2026 |
| *9* | *Milan - Verona HS/HC line: Shunt of Brescia* | *MED* | To be evaluated | *By 2030* |
| *10* | *Naples — Bari HS/HC route* | *SCANMED* | To be evaluated | *By 2030* |
| *11* | *Turin-Milan-Naples HS/HC network: Florence HS bypass* | *SCANMED* | L2 | *By 2030* |
| *12* | *Turin - Lione*<br>*(phase 1: Stand-alone fitting of a new line)* | *MED* | To be evaluated | *By 2030* |

(*) ETCS stand-alone equipment (with SCMT removal). Electric traction remains as 3 kV DC.
Simultaneous fitting of non-HS rolling stock in traffic here with ETCS.

### 4.5.3 HD ERTMS in urban nodes

The demand for high capacity of rail transport (especially commuting) in the urban nodes will be met by the use of the ERTMS/ETCS Level 2 system with on-board train integrity function (as in Level 3) which is appropriately optimised for the specific rolling stock in order to maximise high density functionalities.

In addition, the future improvements of Baseline 3 include the development of an interface with ATO *(Automatic Train Operation)* function which will provide further traffic optimisations.

In the nodes, a type of RBC (so-called “Node RBC”) will be used, by which high capacity trains will be managed. These will be channelled into appropriately identified and specialised “streams” with sections of reduced length of appropriately 350 m in the line and station (EMI-routes).

The ETCS trackside subsystem will be set up superimposed on SCMT or simultaneously with the planned technological migration.

For “HD ERTMS” traffic management, the secure rear end function for specialised rolling stock will be introduced. This involves the RBC verification of the “position report” sent by the train with a special secure rear end qualifier after checking the connection between the on-board subsystem of the front engine and that of the rear engine in Sleeping mode.

Therefore the HD ERTMS system will be implemented superimposed on SCMT (ETCS Level 2 configuration with Level 3 functions according to the TSI CCS 2016) on approximately 150 km of tracks to be equipped until 2026 in a few lines of the main urban nodes, beginning with Florence, Rome and Milan:

| Site | Description of Activity | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|
| **Florence**<br>Firenze Rifredi - Firenze Statuto - Firenze Campo di Marte - PM Rovezzano (LL and DD);<br>Firenze SMN - Firenze Statuto;<br>Firenze SMN - Firenze Campo di Marte;<br>Firenze SMN - Firenze Castello | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | For 2018/2021 phases |
| **Rome**<br>Roma Tiburtina - Roma Ostiense - Cesano; Ciampino - Roma Termini | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | For 2018/2021 phases |
| **Milan**<br>Milano Porta Garibaldi - Milano Greco Pirelli; Bivio Mirabello - Milano Lambrate | Application of ETCS L2 with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | For 2018/2021 phases |
| **Turin** | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | For 2018/2021 phases |
| **Venice** | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | For 2018/2021 phases |
| **Bologna** | Application of ETCS L2 with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | 2026 |
| **Naples** | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | 2026 |
| **Bari** | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | 2026 |
| **Genoa** | Application of ETCS with GPRS and ATO for high density | L2/L3 (train integrity with fixed block) | New version of BL3 | Specifications of Functional Requirements issued, testing started, procedure to ANSF started | 2026 |

## 4.6 “Regional” ERTMS for regional lines

By «Regional» lines we refer to secondary lines with medium/low traffic with no need for trains to

follow each other closely, normally with single track, not electrified or electrified at 3 kV, with «multi-station» operational regulations and automatic traffic supervision.

The Regional ERTMS system aims to reduce the operating costs of these lines in order to make them more sustainable economically and competitive compared to road transport through:

- the removal of: all light signals, train detection systems (both in lines and stations) and the control pedals for opening/closing level crossings; the national traffic protection system; the Eurobalise beacons with train localisation functions (through the "virtual beacons" function provided by satellite technology);

- the introduction of: an integrated trackside system which, in the fullest configuration, performs the tasks of Route Management by means of station equipment and block systems according to the logic of Computerised Multi-Station Interlocking with peripheral posts which cannot be attended; a GSM-R or public radio system for on-board - trackside subsystem communication; train spacing functions by means of RBC ERTMS L3; radio control of yard devices (e.g. switches, level crossings, etc.); the function of Supervision and Automation of train movements (SCC); satellite technology for railway signalling applications ("virtual beacons"); worksite security protection by radio with the use of tablet/smartphone devices.

In the future, the functions of optimised Traffic Management and on-board ATO can be introduced with the objective of providing on-board indication of the recommended speed in the first phase (also for reducing energy consumption) and allowing *driverless* traffic in the second phase.
Regional ERTMS may not have all described functions or these can be included at later stages.

RFI has taken a path for achieving the objectives of this system through risk analysis, specification of requirements and field testing with regard to satellite applications.

Activities for a Regional ERTMS system has already started in the following lines of RFI:

| Line | Description of Activity | Interlocking | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|---|
| Avezzano-Roccasecca (first 3 stations) | Application of ETCS L3 integrated with Computerised Multi-Station Interlocking and Supervision system on single track line (ACCM+SCC+ETCS L3 without backup system).<br>Application of ETCS in public radio system.<br>Removal of light signals, level crossing pedals and train detection systems in the line and station. | ACCM (to be introduced) | L3 | BL3 | Risk analysis and system specification in progress | 2020 (Field testing starts in 2017) |
| Sangone - Pinerolo | Application of ETCS L2/L3 integrated with Computerised Multi-Station Interlocking and Supervision system on single track line.<br>Introduction of satellite technology and ATO. | ACCM (to be introduced) | L2/L3 | BL3 | Risk analysis and system specification in progress | 2020 (Field testing starts in 2017) |

In addition, RFI is performing support activity for the implementation of ETCS and GSM-R in the networks of other operators such as "La Ferroviaria Italiana" (LFI) in the Stia-Arezzo-Sinalunga line and "Strutture Trasporto Alto Adige" (STA) in the Merano-Malles line (see sections 5.1 and 5.2).

## 4.7 GSM-R

### 4.7.1 GSM-R network in operation

GSM-R is the mobile radio communication standard adopted by the railway sector at a European level in order to ensure traffic control and operation according to the principles of interoperability. The GSM-R system operates in a UIC frequency band which is harmonised at a European level, being in the range of 876-880 MHz (uplink) and 921-925 MHz (downlink).

By virtue of the *"Individual licence for the installation and operation of a telecommunication network (by ETSI GSM-R technology) exclusively dedicated to the control and operation of railway traffic*" issued by the Ministry of Communications in December 2002 for Rete Ferroviaria Italiana S.p.A., RFI has established a GSM-R network infrastructure with proprietary radio access in approximately 11 200 km of railway lines. In order to facilitate communication in lines without GSM-R radio coverage, RFI has signed national "2G" roaming agreements with mobile operators Tim and Vodafone. In addition, RFI's GSM-R network is directly connected to the networks of Wind and Telecom Italia operators which provides national and international transit services towards other mobile/landline operators.

The functional and system requirements of GSM-R, including the ones relevant for interoperability, are included in the UIC EIRENE technical specifications, its versions currently in force being:

- EIRENE FRS (Functional Requirements Specification) vers. 8.0.0
- EIRENE SRS (System Requirements Specification) vers. 16.0.0.


*Figure title: Italy's Railway Infrastructure – GSM-R system coverage*
*Legend: Railway network covered by GSM-R system*
*High Speed / High Capacity network covered by GSM-R system*
*Railway network not covered by GSM-R system*

RFI's GSM-R network is directly connected to the GSM-R networks of neighbouring countries (France, Switzerland and Austria) which enable the transit of GSM-R communications towards other non-neighbouring countries through an agreement signed by all GSM-R operators of the European network. The GSM-R international roaming is extended to Germany and the Netherlands as well.

### 4.7.2 Technological development plan of the GSM-R network and telecommunication systems

Since *GSM-R Industry Group* (which includes the providers of technologies used in the RFI network) has undertaken to ensure the support of GSM-R technology until 2030, the remaining lifespan of GSM-R is still considerable. Efficiency maintenance of the system by implementing a technology development plan for RFI's GSM-R network, is therefore carried out according to the following criteria:

- Scheduled and targeted phase-out management of HW and SW technology platforms, the bases of individual GSM-R subsystems.
- Increasing the efficiency of network architecture (reduction of management and maintenance costs) through the reduction of network elements and their optimisation (dimensioning/configuration).
- Implementation of *"disaster recovery*" architectures, with increasing the overall availability of the GSM-R service, introducing geographical redundancy methods in the MSC Core Network subsystem, in the BSC/TRAU Radio Access subsystem and in Management Systems with a view to ensure the continuity of phone service (voice, ETCS data, emergency calls) and network supervision in the case of catastrophic events (losing a NSS site, losing a network management centre, etc.).
- Protection of investments, by the adoption of modern, state-of-the-art technologies (Flexi BSC/TRAU, Flexi BTS, NSS R4).

Other improvements and efficiency maintenance of telecommunication systems (TLCs) for serving train traffic (included in PIR) are also planned.

| Project | Brief Description | Timescales |
|---|---|---|
| Development of the GSM-R network - BSC upgrade | The work involves the upgrade of BSC equipment from legacy technology to RAN Flex technology, bringing the number of BSC from 24 to 10 and that of TRAU equipment from 117 to 10. | Project in the implementation phase.<br>Expected completion: Q1 2018 |
| Development of the GSM-R network - MSC upgrade | The work involves the upgrade of MSC equipment of the core network from Release 99 technology to R4 technology. It envisages the implementation of redundant architectures to address disaster recovery requirements and the reduction of the number of network elements from the actual 7 switching centres to a scheme with 2 switching nodes and 2 MGWs. | Final design in the construction phase.<br>Expected completion: by 2017.<br><br>Implementation from 2018. |
| Development of the GSM-R network - BTS upgrade | In the event of projects with the extension of GSM-R radio coverage to new railway sections and/or to sections not covered by GSM-R, BTS *(Base Transceiver Station)* devices will have to be equipped with RANFLEX - Flexi BTS technology integrated to the new Flexi BSC of the RFI network. | New plans involving the implementation of GSM-R radio coverage or the renovation of existing facilities are carried out in line with the GSM-R network upgrade plan. |
| Development of the SDH data transmission network | In the case of renovation and/or technological upgrading projects, when it is necessary to intervene in RFI's SDH data transmission network, obsolete devices will have to be replaced by new ones that are in possession of all HW and SW features that are necessary to ensure their complete integration into RFI's existing SDH network and in the SDH management system of RFI's NOC. | New plans are carried out in line with the technological data transmission network upgrade plan. |

| Project | Brief Description | Timescales |
|---|---|---|
| Upgrade of the GSM-R network - extension of RFI's GSM-R radio network to railway lines in the competence of the Regions | Planning/implementation of a GSM-R radio network infrastructure by the Infrastructure Operators of railways in the competence of the Regions which is suitable to support the ERTMS/ETCS signalling system.<br>Planning requires the construction of a radio access infrastructure of single BTSs *(Base Transceiver Station)* connected to RFI's GSM-R network and the related data transmission network.<br>The specific requirements of each Infrastructure Operator are to be analysed separately for each case. | Active projects:<br>LFI:<br>- Arezzo-Stia<br>- Arezzo-Sinalunga<br>Commissioning for pre-operation: 2018<br>STA:<br>- Merano-Malles<br>Commissioning for pre-operation: 2019<br>Other projects may need to be realised in the near future according to the needs communicated by the concerned Infrastructure Operators. |
| Technological upgrade of TLC systems of the Rome - Florence "DD" section | Within the project, works are planned on the telecommunication equipment of the section, including: technological and device upgrading of GSM-R devices to adjust them to HS/HC standards and a related upgrading to create redundancy in radio coverage; installation of new fibre-optic backbones and technological and device upgrade of the SDH transmission system serving GSM-R; adjustment of management and maintenance systems; installation of a new, selective long-line telephone system, at the Central Post and in Peripheral Posts. | 1 195 days from awarding the contract |
| Technological upgrade of TLC systems with the aim of implementing the ERTMS system in interoperable corridors: Novara-Padua, Verona-Brenner, Vicenza-Villa Opicina, Padua-Venice, Milan-Genoa | Within the project, works are planned on the telecommunication equipment of the interoperable sections with a view to adjust and upgrade TLC systems (fibre-optic cable networks, transmission systems, GSM-R radio subsystems) to adjust the actual level of network performance to the necessary level for ERTMS/ETCS L2 and L1 applications (depending on the system provided for each section). Necessary adjustments to central systems and management and supervision adjustments are also considered. | Characterisation reports / Final design: by 2017 |
| Technological upgrade of TLC systems with the aim of implementing the ERTMS system in the nodes of Milan, Florence, Rome | Within the project, works are planned on the telecommunication equipment serving rail nodes with a view to adjust and upgrade TLC systems (fibre-optic cable networks, transmission systems, GSM-R radio subsystems) to adjust the actual level of network performance to the necessary level for HD ERTMS applications Necessary adjustments to central systems and management and supervision adjustments are also considered. | Characterisation reports / Final design: by 2017 |
| Technological upgrade of TLC systems of the Rome - Naples HS/HC section | Within the project, renovation works and technological upgrade of telecommunication devices serving the Rome - Naples HS/HC line are planned (fibre-optic cable networks, transmission systems, LD subsystem, trackside-train subsystem, GSM-R radio networks, management and supervision systems). | Characterisation reports / Final design: by 2017 |
| Centralised registration system (SCR) | Implementation of a centralised system which is integrated with GSM-R switching centres to register verbal communications between traffic controllers (DM and DCO) and train personnel / maintenance agents.<br>Upgrading of the system to develop new functions and performances. | Commissioning by 2017<br>Planning of upgrades: 2017 |
| Technological upgrade of management systems of RFI's data transmission network. | Renovation of the TNMS system on a virtual platform for the management and supervision of RFI's SDH network and the related DCN transport. | 2018 |

| Project | Brief Description | Timescales |
|---|---|---|
| Management System of RFI's fibre-optic cable network | Advanced Technology Management System of RFI's fibre-optic cable network:<br>Phase 1 - Pilot Project - System modelling and testing<br>Phase 2 - Implementation in the entire fibre-optic cable network | 2019 |

During the year 2017, the functional verification activities will be completed by the Notified Body for the certification of GPH/OPH type GSM-R terminals, according to EIRENE specifications and national RFI requirements. The objective of this work is that the Technical Management of RFI issues the Authorisation for Use for terminals on the GSM-R network.

### 4.7.3 Testing of Satellite System and public telecommunication for ERTMS

Considering that the operation of the "GALILEO" European system has been launched recently, the introduction of the satellite positioning system for railway signalling will be done in the subsequent steps.

The *"3InSat Project",* financed by the European Space Agency (ESA), was completed at the end of 2015 in the Cagliari-Olbia section in Sardinia, in order to define a satellite train positioning system which is compliant with SIL4 CENELEC and also to use public radio carrier waves other than GSM-R for trackside-train communication of signalling data.

This project was in preparation for the subsequent *"ERSAT"* project in the Cagliari- Decimomannu line co-financed by GSA (European Global Navigation Satellite Systems Agency) which uses the results of 3InSat to achieve the final objective, namely certification and commissioning of the ERTMS system with satellite train positioning and public TLCs.

This project has been realised with a 2020 time horizon on an approximately 50 km long double track section between Cagliari and San Gavino stations. This is the first pilot site in Europe which is equipped with the ERTMS/ETCS system and the function of integrated satellite train positioning and TLC (GSM-3G, Tetra, Satellite) based on IP protocol.

The test site uses an Aln 668 - 3114 train equipped with an ERTMS platform which integrates satellite train positioning and public TLCs for track-train communication while the Radio Block Centre (RBC) and other devices will be installed on trackside which are necessary for the operation of the full configuration required by the ERTMS standard in an operating scenario.

The objectives of the experiment are the following:

1. to reduce investment costs (CAPEX) and maintenance costs (OPEX) by the simplification of technological infrastructure;
2. to ensure a standard level of European railway security (SIL4);
3. to increase transport network security and capacity;
4. to modernise the signalling system at the lowest costs to ensure its sustainability;
5. to ensure fleet interoperability;
6. to minimise the impact on the actual regulation for PdC and DCO;
7. to operate with satellite application integrated in ETCS L2.

| Site | Description of Activity | Partner | ETCS level | Baseline | Status | Commissioning |
|---|---|---|---|---|---|---|
| Cagliari - S. Gavino | ERSAT - ETCS project with satellite application for train positioning e data transmission. | Financed by: GSA.<br>Signalling provider and coordinator: ASTS.<br>Key partners: Bocconi University, RADIOLABS (University), CEIT, DLR, DB, ASSTRA, Trenitalia, Italcertifer (via ASTS) | L2 | BL3+ | Test in progress | End of Test April 2017<br>Commissioning: 2020 |

The operating principle of the ERTMS/ETCS system is based on the positioning of the train through the Eurobalise subsystem which consists of beacons installed along the railway track. In the new proposed solution, Eurobalises are replaced by the *"Virtual Balise Group*". To overcome the problem that satellite signal is not available in tunnels longer than 2 km, current beacons can be used in the future as well.

The introduction of satellite train positioning is also considered an effective means to increase traffic capacity of the network by the implementation of "mobile block" laid down by the ERTMS L3 standard.

### 4.8 Laboratory upgrading for Integration tests in Track-Train security

Section 6.5 of the TSI CCS 2016 sets forth that the on-board or trackside generic application of ETCS must be tested for system integration and technical compatibility. In addition, the basis for defining compatibility tests between trackside subsystem and on-board subsystem involves test run scenarios of the relevant ground subsystems.

UNISIG has recently distributed the Subset 111 and 112 documents with the aim of providing a guideline for the organisation, procedure and environment of interoperability tests (IOP tests) in the laboratory, in order to improve cooperation between suppliers, clients and NoBo ["compatibility" test used in TSI CCS and "interoperability/IOP" test used in UNISIG are to be understood as synonyms].

For the operation on its own ETCS lines, RFI provides an ETCS Laboratory where all ETCS trackside subsystems in operation and under certification are present for performing the above mentioned integration activity (compatibility testing).

RFI is also collecting of the logs obtained from more significant operating scenarios for the definition of integration tests. These, along with the schematic plan and the information included in the PIs, will be used to define test cases (trackside scenarios) and the expected result from the on-board subsystem. These will be made available to the suppliers of new generic applications of the on-board subsystem so that they can reconstruct compatibility scenarios in their own laboratories as well.

The future objective is to obtain ISO17025 accreditation and certification for the recognition of completed tests in *cross acceptance*.

### 4.9 ETCS track-train integrated diagnostics system

RFI is equipping itself with an integrated ERTMS diagnostic system (called "MISTRAL") which is independent from subsystem suppliers. This is able to decode and analyse the transmitted information through the acquisition of exchanged data on trackside and on-board communication lines (such as RBC-Interlocking, RBC-MSC).

In fact, the MISTRAL system enables the testing of ETCS/ERTMS logic and system configuration, it allows to analyse and objectively resolve any potential anomalies both from the Central control post of the section and from a remote connected post through the independent functional interpretation of legally recognised log files with the following advantages:

- help for assigning anomalies (ETCS or non-ETCS, on-board ETCS or trackside ETCS);
- a benefit for rail traffic by automatically identifying problems and resolving them faster.

| Project | Description of Activity | Status | Commissioning |
|---|---|---|---|
| MISTRAL | ETCS track-train integrated diagnostics system | Work awarded to ATI URMET-CWI. Under construction. | End of project: 2017 |

As mentioned in the previous section, the collection of logs is in progress as part of the project (telegrams exchanged between track and train) for some "sample operation scenarios" as an evidence for the behaviour of trackside subsystems in operation compared to the on-board subsystems in traffic. This information, along with the characteristics of the schematic plan of the line, will be made available to the

supplier of a new Generic on-board application so that it can stimulate the new on-board subsystem in a simulated environment and therefore minimise field integration tests.

### 4.10 Phase-out of the existing national signalling system (SCMT)

In order to fully exploit the potentials related to the implementation of the European ETCS signalling system on the conventional network, a progressive phase-out of the existing national system SCMT (Class B) is planned without any interruption.

The detailed plan ensures the coexistence of the two systems until 2026 for the sections which will be equipped with ERTMS until this date. However, in the sections where ERTMS will be installed after 2026, SCMT will be phase-out simultaneously where appropriate and justified.

Based on the planning of ERTMS works presented in the previous sections, phase-out is planned as follows:

| Sections | Km | Date of SCMT phase-out |
|---|---|---|
| Rome - Florence direct line:<br>"Rovezzano - Arezzo Nord" section | 54 | 30 June 2019 |
| Rome - Florence direct line:<br>"Arezzo Nord - Orte Nord" section | 125 | 29 November 2019 |
| Rome - Florence direct line:<br>"Orte Nord - Settebagni" section | 58 | 31 December 2019 |
| Domodossola - Borgomanero - Novara | 88 | 31 December 2026 |
| Chiasso - Milan - Tortona - Genoa | 205 | 31 December 2026 |
| Brenner - Verona | 246 | 31 December 2026 |
| Novara - Milan - Verona - Padova - Venice | 415 | 31 December 2026 |
| Vicenza - Treviso - Portogruaro - Trieste/Villa Opicina | 221 | 31 December 2026 |
| Florence node (only HD tracks) | | 31 December 2026 |
| Milan node (only HD tracks) | | 31 December 2026 |
| Rome node (only HD tracks) | | 31 December 2026 |
| Turin node (only HD tracks) | | 31 December 2026 |
| Venice node (only HD tracks) | | 31 December 2026 |

The time limit for SCMT phase-out in other sections of the conventional network will be indicated as soon as the 2020-2026 implementation schedule is available in more detail.

In order to enable Railway Undertakings and other railway network operators interconnected with RFI's network to finalise their programs, RFI will give confirmation that the national system is switched off at least 12 months before the actual "switch" for the sections equipped with ERTMS by 2026 (including the Rome-Florence direct line) and 24 months before, followed by a confirmation 12 months before, for the sections that will be equipped with ERTMS after 2026.

## 5. Railway networks of other Infrastructure Operators

Regulation (EU) 2016/919 lays down the rules for trackside implementation for the TEN-T network in section 7.4.1. of the Annex. Therefore, currently there are no obligations to implement ETCS in the non-TEN network of the Member States except in the case of a high-speed line or a railway infrastructure project receiving financial support from EU funds.

However, with a view to the modernisation of the networks of various infrastructure operators in order to pursue the objectives of transparency and the progressive implementation of ERTMS system in the entire network with a long-term national programme, we present the fitting programmes of those regional networks which have planned the switch to ERTMS, considering the consistency and economic viability of the railway system.

In addition, under a framework agreement signed on 20 January 2017 between RFI and ASSTRA (involving most regional infrastructure operators and railway undertakings which carry out transport services on these networks), RFI can be asked to evaluate and provide support to the operators involved in doing a cost-benefit analysis to identify the best solutions to adjust to their technology standards, starting with studying the type of equipment currently installed on the lines, considering where the installation of the ERTMS system is convenient instead of Class B (above Level 1).

This cost-benefit analysis will take (at least) the following comparison factors into account:

1. The adjustment of devices (according to Computerised Interlocking (ACC) or Computerised Multi-Station Interlocking (ACCM) logic) in order to make them compliant with RFI standards in terms of principle schemes, signal distances, etc. (even if it is the same in both solutions, the cost of ACMM in the case of a SCMT line is greater than that of an ERTMS line because the ACCM must also provide the controller unit of light signals).
2. The evaluation of the operation of Peripheral Posts (as these are normally small devices, the Peripheral Posts of ACMM are of PPM type; as a limit, PP-ACC may be used in the case of stations managing yards/depots).
3. The use of Encoder integrated in the ACCM devices located in the Peripheral Posts for SCMT solution.
4. The introduction of the GSM-R network where it is not present. At first, the SCMT solution does not require the introduction of the GSM-R network for voice radio communications, in line with the status of some secondary lines of RFI where the public network is used for track-train communication by roaming agreements (in this case, the on-board radio devices must support roaming function as indicated in Annex 1a of ANSF Decree 1/2016). For GSM-R, the following will be ensured (with reference to the agreements between RFI and LFI, for example):
    a. the installation of single BTSs connected and integrated to RFI's GSM-R network,
    b. the interconnection of the data transmission network of "operator X" with RFI's SDH data transmission network,
    c. operational management, technical assistance and maintenance service provided by RFI in return for an annual fee paid by Operator X.
5. The possibility of considering public GSM as the data network for ERTMS. At first, the use of the GSM-R network will be ensured for the ERTMS/ETCS solution with circuit data for RBC-EVC communication, although experiments are in progress with the use of the public system.
6. The presence of light signals (for the SCMT solution).
7. Encoders are necessary to drive Information Points (IP) switched to the signals (station and line) and with PA function (including cables for Encoder interface) (for the SCMT solution).
8. Encoders need to be integrated in the ACCM devices located in Peripheral Posts and for the management of Level Crossings (for the SCMT solution).
9. Fixed Information Points are necessary for the management of line speed, braking curves and linking recovery (for the SCMT solution).
10. The need for portable Ips and a tool for slowdown management (for the SCMT solution).
11. A device for INFILL codification and related conditioning of the unit is necessary (e.g. installation of inductive boxes) (for the SCMT solution).

12. The presence of RBC (for the ERTMS solution, above Level 1).
13. ERTMS signs are necessary (for the ERTMS solution).
14. The presence of RBC Operator Posts at the Central Post and at the potential Peripheral Posts (for the ERTMS solution, above Level 1).
15. The adjustment of fleet to the traffic protection system which is compatible with the system installed on the trackside (an STM module may be necessary for the management of interconnections with neighbouring lines).
16. The comparison of operating (slowdown management) and maintenance costs in the entire lifespan.

[Further evaluations with regard to security and performance aspects may be taken into account for the comparison.]

### 5.1 La Ferroviaria Italiana (Tuscany Region)

The infrastructure operated by *"La Ferroviaria Italiana S.p.A"* (LFI) in Tuscany Region consists of two single track lines with a maximum speed of 110 km/h in a total length of approximately 84 km (off-TEN network). The lines are electrified with 3 kV DC and they are separated with two neutral sections (one for each line) in the entrance/exit of Arezzo station. These are to separate the network powered by RFI from the one fed by LFI.

In line with the implementation plans presented below, the equipment of railway lines (trackside subsystem) and that of the vehicles (on-board subsystem) allowed to run on them must comply with the technological and operational requirements of the ETCS standard and comply with the interoperability requirements in accordance with SRS ERTMS / ETCS Baseline 3 Level 2 which relies on the GSM-R transmission channel, providing the transition to the Class B SCMT national system.

The lines with ETCS protection are operated in Centralised Traffic Control (CTC) by the Central Operative Controller (DCO). The lines with ETCS protection are equipped with ACEI I0/19 devices. In these lines, there are line level crossings of SBA (SB.SF.PD), BA (BC.SF.PD) and SOA (LA.SF.PD) UNIFER 11117 type.

LFI has signed an agreement with RFI for the development of functional and system requirement specifications for the application of the ERTMS/ETCS Level 2 System and the GSM-R Radio Network on a single track line and the presence of automatic line level crossings and country road crossings (closed with barrier and keys for the user).

| Line | Type of equipment | Baseline | Level | Status | Type of financing | Commissioning |
|---|---|---|---|---|---|---|
| Arezzo - Stia | ERTMS/ETCS | BL3 (3.4.0) | L2 | Tendering procedure | Funds of Tuscany Region | August 2020 |
| Arezzo - Sinalunga | ERTMS/ETCS | BL3 (3.4.0) | L2 | Tendering procedure | Funds of Tuscany Region | August 2020 |

This project also assumes intervention to RFI's ACEI device in Arezzo (interconnection station between RFI and LFI network) and the reconfiguration/installation of some IPs for the management of ETCS train departures from Arezzo.

### 5.2 Strutture Trasporto Alto Adige (Trentino Alto Adige Region)

*"Strutture Trasporto Alto Adige S.p.A*." (STA), the local company of the Autonomous Province of

Bolzano, exclusively operates the "Merano-Malles" railway line in Val Venosta, an approximately 60 km long single track line (off-TEN network). The electrification of the line with 25 kV will be completed in 2020 and the project involves the implementation of ERTMS/ETCS L2 signalling (with Baseline BL3R2) among additional works, enhanced with the "High Density" function developed by RFI.

Although the line is equipped with ACCM signalling and the ATP/MM in SIL4 train control system, this standardisation will allow more flexible management in the future. The HD function will allow to increase system capacity especially in case of traffic failure, and the simplification of trackside facilities along the line.

RFI will also provide its central GSM-R network in order to cover the Merano-Malles line.

STA also owns FLIRT type electric vehicles which are leased to the Railway Companies designated by the Autonomous Province of Bolzano. These are responsible for the Local Public Transport through service contracts. STA has submitted a retrofit proposal for its trains to CEF INEA (under evaluation) and purchases new rolling stock, all of them equipped with ERTMS.

| Line | Type of equipment | Baseline | Level | Status | Type of financing | Commissioning |
|---|---|---|---|---|---|---|
| Merano-Malles | ERTMS/ETCS | BL3 R2 (SRS 3.6.0) | L2 HD | Final Design | Funds of Bolzano Province (50 % mutual EIB) | June 2020 |

## 6. On-board ERTMS applications

Based on the programming of ETCS implementation on the lines discussed in the previous sections, the following considerations can be highlighted for fitting the vehicles with ETCS:

- in order to exploit the potential of the system in urban nodes, the vehicles designed for high density use should be equipped with Baseline 3 Release 2 (and its subsequent developments for the integration with ATO);
- for the vehicles of the HS fleet, a gradual migration plan towards Baseline 3 Release 2 will enable the online management of encryption key updating (among other things), also in anticipation for new HS sections that can be implemented with Baseline 3 in the future;
- vehicles in operation on the Rome-Florence direct line, without superimposition with the SCMT system, will have to be equipped with ETCS (for now Baseline 2 is sufficient but it is appropriate to evaluate the installation of Baseline 3 to exploit the introduced improvements, e.g. in high density context);
- for the rest of the fleet running on corridors or on the lines where ETCS will initially be superimposed on SCMT, the installation of ETCS (Baseline 3) enables to increase the level of protection [in line with Decree 4/2012 of ANSF (Ref. 4)] and performance where ETCS L2 is installed.

Naturally, with regard to High Speed Vehicles currently in operation, the rolling stock of NTV S.p.A. and Trenitalia S.p.A. is already equipped with ERTMS.

As far as Trenitalia railway company is concerned, the ERTMS implementation plan is coordinated with trackside implementation plans, in particular:

a) Equipping vehicles for being able to operate on the Florence-Rome direct line (DD) (with stand-alone ETCS): in addition to the already equipped HS vehicles, ERTMS will be equipped on vehicles to be able to perform IC services (day and night) and regional services in the DD line. In detail, the following vehicles will be equipped: 64 E464 locomotives and 23 Vivalto type coaches with driving cab for regional services, as well as 93 locomotives (40 of type 401, 30 of type 402B, 23 of type 403) and 87 coaches with driving cab (Z1 type) for IC services. The approval of the specific application and its serial implementation is expected consistently with the release time of the trackside infrastructure with ERTMS.

b) Equipping vehicles pertaining to nodes where ERTMS HD (High Density) function will be implemented:

- *Regional trains:* ERTMS implementation is expected for new High Capacity trains, new Medium Capacity trains, TAF trains, Jazz trains and as an extension for the rest of E464 locomotives and Vivalto driving cabs.
- *High Speed Trains:* ERTMS will have to be upgraded with HD function for ETR1000, ETR500, ETRV250, ETR600/610 and ETR485 trains to enter the nodes.
- *Trains for IC type passenger services:* implementation is expected for E414, ETR460/470 locomotives and complementary to the installation of the rest of 402B locomotives (in addition to the above mentioned 30).

For the above mentioned train types, the approval for the general application of the ERTMS HD system is expected to be obtained from the end of 2019, followed by the specific application and serial implementation.