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Meeting the challenges for future mobility

The European Energy Measurement System on board of trains

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1861 > 2011 > >
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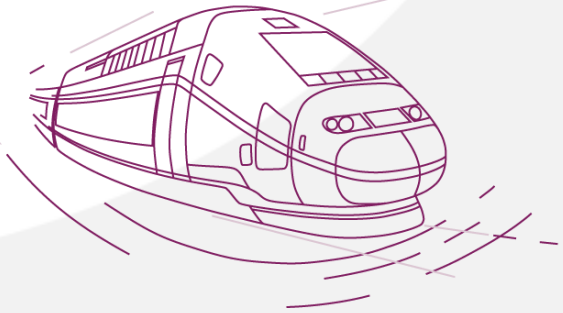

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Challenge A: A more and more energy efficient railway

Session A4 - Energy Efficiency

Chairperson: Henning SCHWARTZ

Further improving rails' green credentials / Keep increasing the relative carbon emission advantage.

Table of Content

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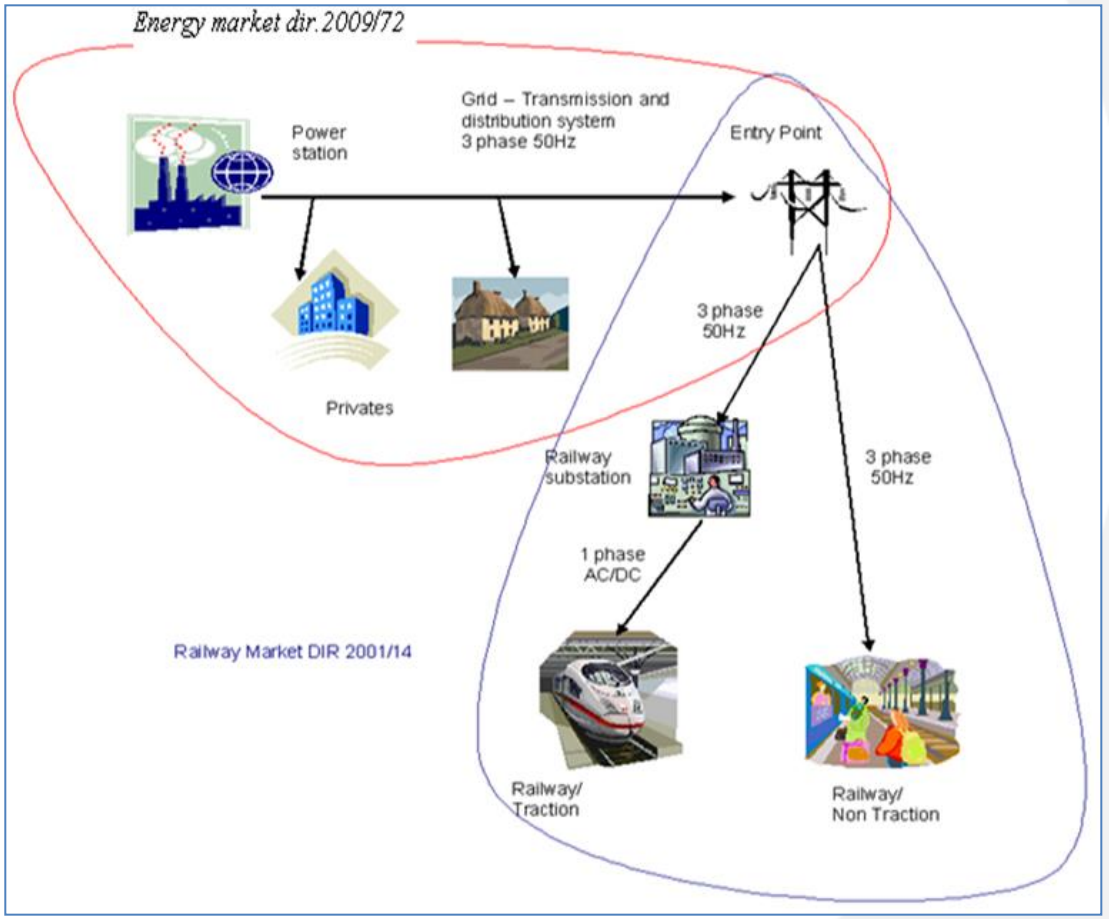
Energy Market

In the context of the electricity market, the Commission further distinguishes five different types of operations:

- **generation**, the production of electricity in power stations;
- **transmission**, its transport over high tension cables;
- **distribution**, the transport of the electricity over the low tension local cables;
- **supply**, the sales and delivery of the electricity to the customer;
- **trading**, the purchase and resale of electricity that is not necessarily directed to final consumers.



Third-party Access

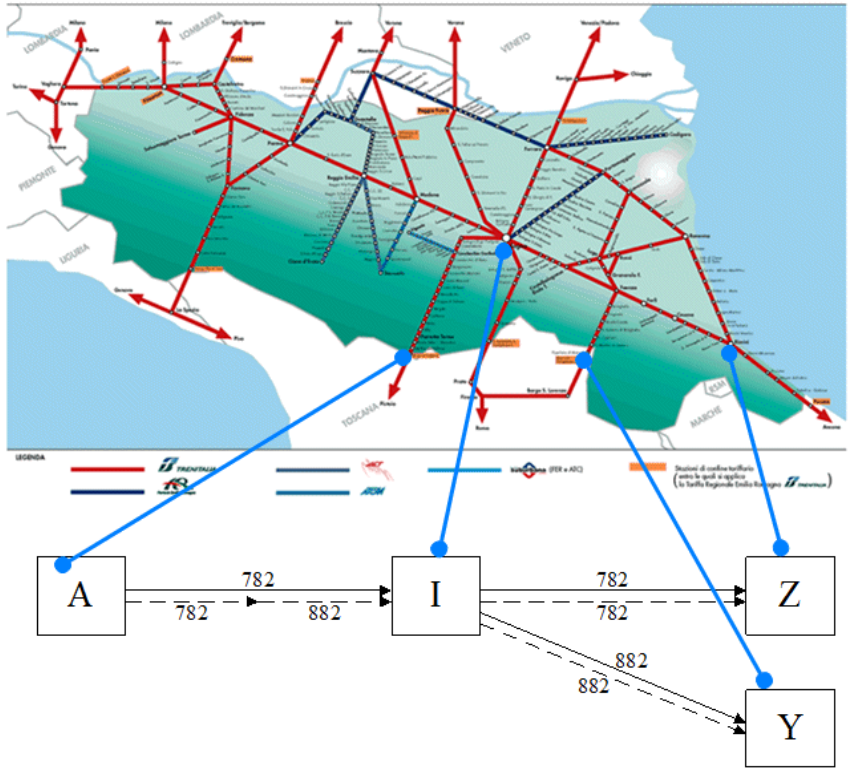
The Concept of Third-party Access

The third-party access right ('TPA') in the energy market context is the idea that in certain circumstances economically independent undertakings operating in the energy sector should have a legally enforceable right to access and use various energy network facilities owned by other companies.

The **Internal Energy Market Directives** envisage the third-party access right as a crucial element of organization of access to the energy infrastructure system in Europe and as the main instrument for opening the Internal Energy Market to competition.

Institutional and regulatory framework

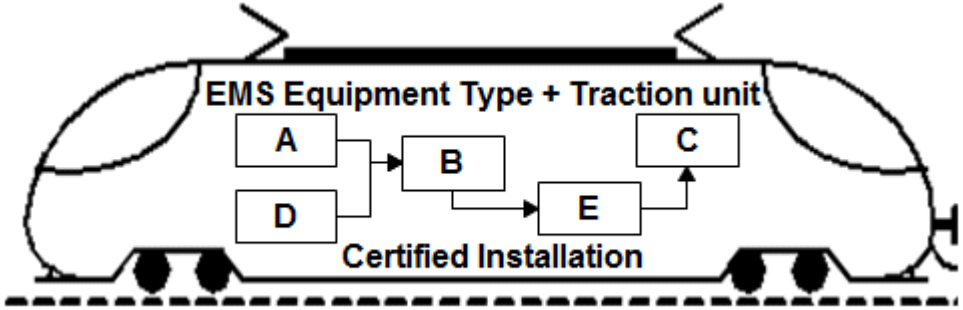
Third-party Access



Country Boundary and Tariff Boundary Concept

Consumption Point

The train it is a moving object and it's not a fixed building. The Energy Measurement System is the first mobile energy meter in the history of human being.



The **Consumption Point** (CP) is an identified Traction Unit (TU) equipped by certified EMS devices using a certified installation procedure.

The number of CP are defined by the consist architecture (e.g. Multi-voltage systems, n° of traction units etc).

CP Key Points

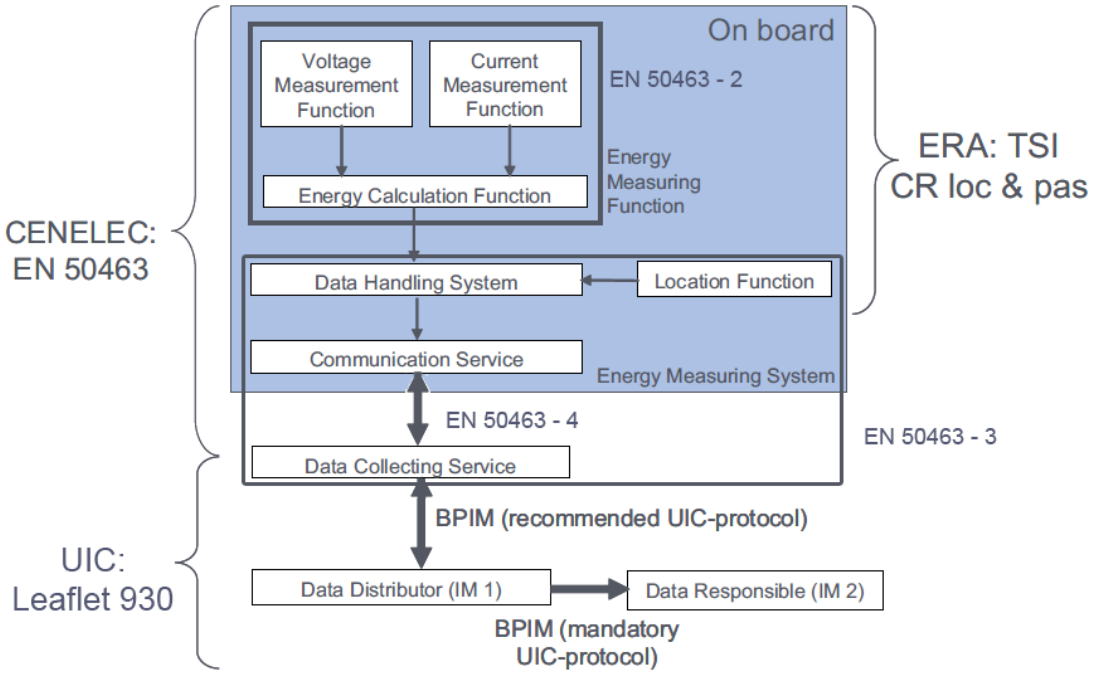
from the Traction Unit point of view:

- The CP is fully autonomous, no need of ground balises like RFID or sideway references;
- Consumption data are associated to Geographical Position and Synchronous Time Stamp;
- The Consumption Data for billing purpose are secured;
- The Consumption Data for Energy Management and Saving purpose could be access protected;
- Near Real Time Snapshoot Capability of Consumption Data.

The Energy Measurement System (EMS)

Key Point of EMS

EMS is an on board equipment that shall first conforms to railway regulations and standardizations and then to comply with metrological requirements.



Structure of Energy Measurement System (EMS) standard

EN 50463-1

Scope, general architecture, document structure, normative references, general requirements

EN 50463-2

The measurement chain from the sensors/transducersv attached to the voltage and current coming from the headlines up to the metering unit and relative interfaces are specified

EN 50463-3

Input/output handling and memory management unit. The input/output interfaces and their use are specified.The energy data samples are stored in the memory together with the other data necessary for the billing and saving purposes.

EN 50463

EN 50463-4

Specification of the on-board communication subsystem, ground station requirements limited to right data transfer from train to ground, communication protocols, application profiles

EN 50463-5

Specification of the test procedures to be used for assessing the conformance and the interoperability of the implementation under test

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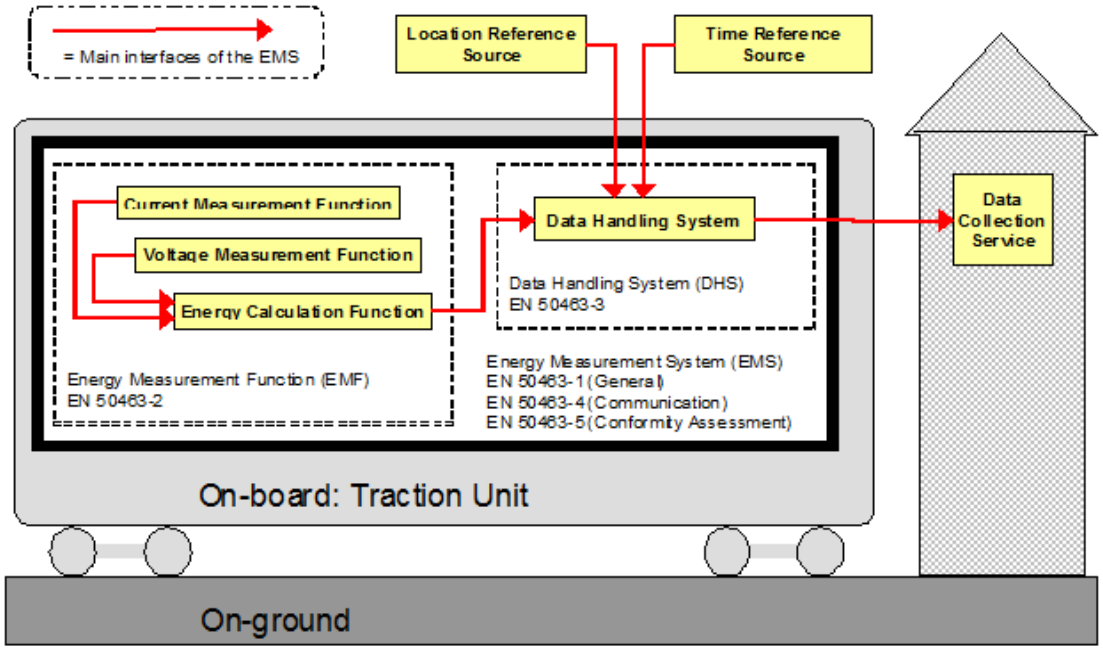
The Energy Measurement System (EMS)

EMS functional blocks



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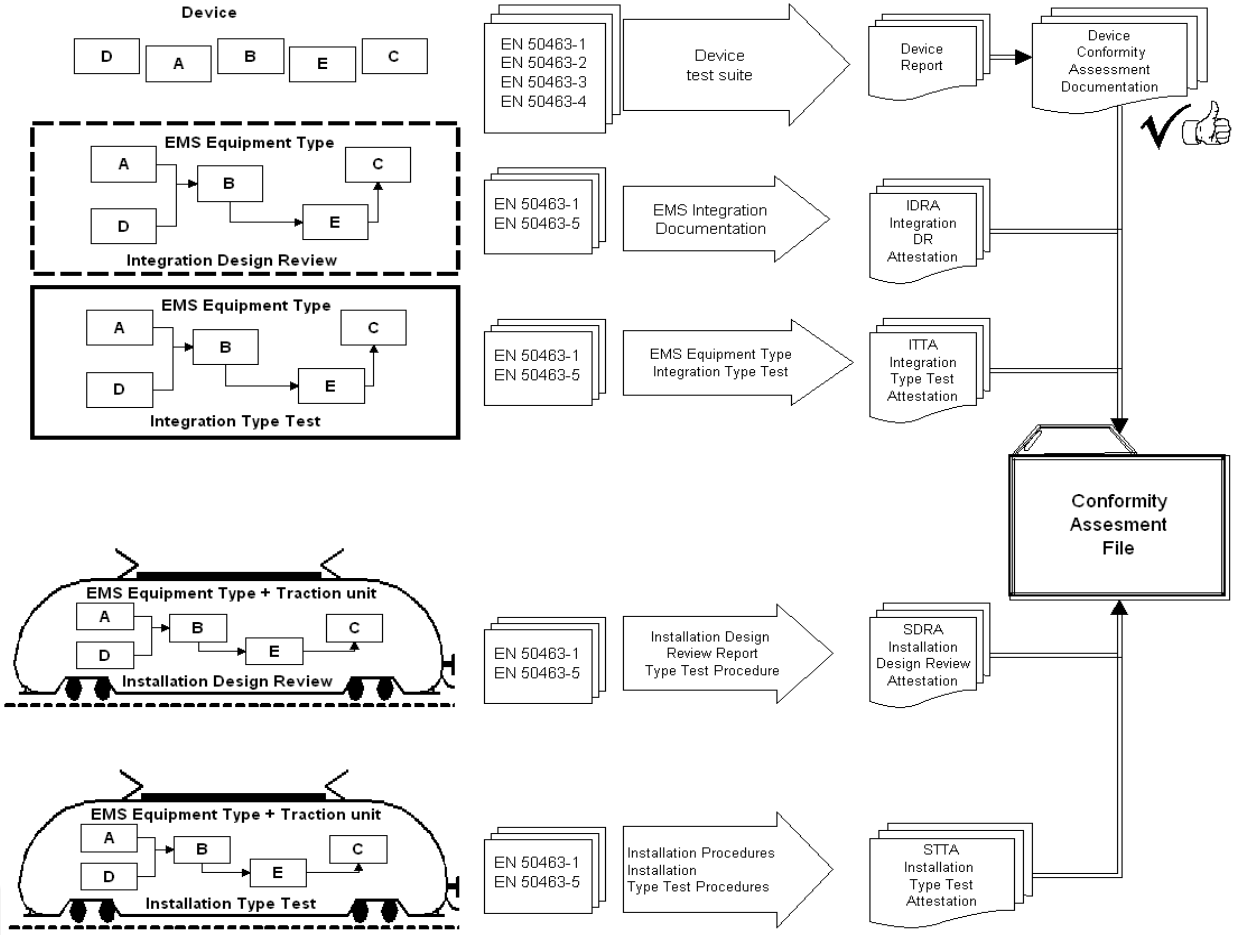
The Energy Measurement System (EMS)

From EMS to CP



Installation on existing vehicles

ETR500 Frecciarossa

This method was applied as trial test to an existing consist: the multi-voltage (25kV AC and 3kV DC) ETR500 Frecciarossa. The ETR500 is normally composed by two E404 series locomotives and 11 coaches.

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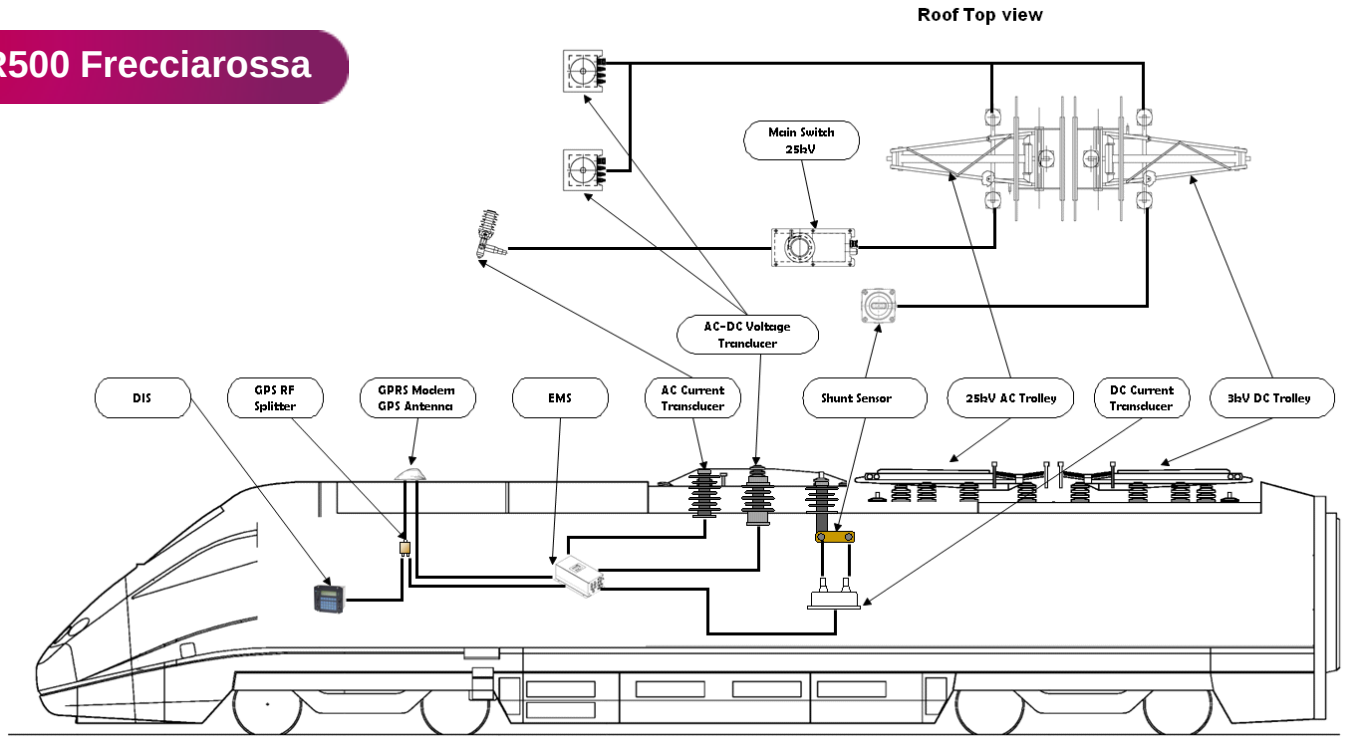
Installation on existing vehicles

ETR500 Frecciarossa



On each Loco E404 some of the existing sensors and transducers, as they are able to fulfill the EMS requirements, where used “as is”.

Others where replaced with improved ones pin-to-pin compatible.

All wiring had been verified in order to fulfill the EN 50463.

Installation on existing vehicles

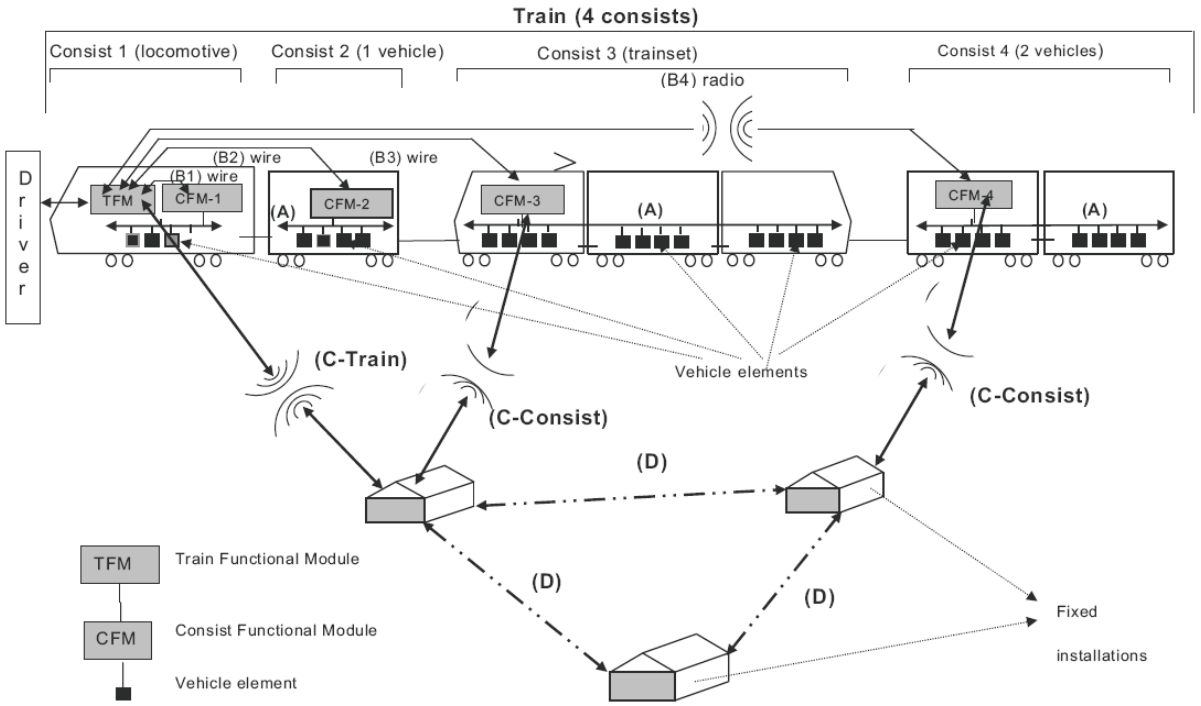
ETR500 Frecciarossa

Voltage and Current Sensors

3KV cabling assembly

On board to Ground Communication

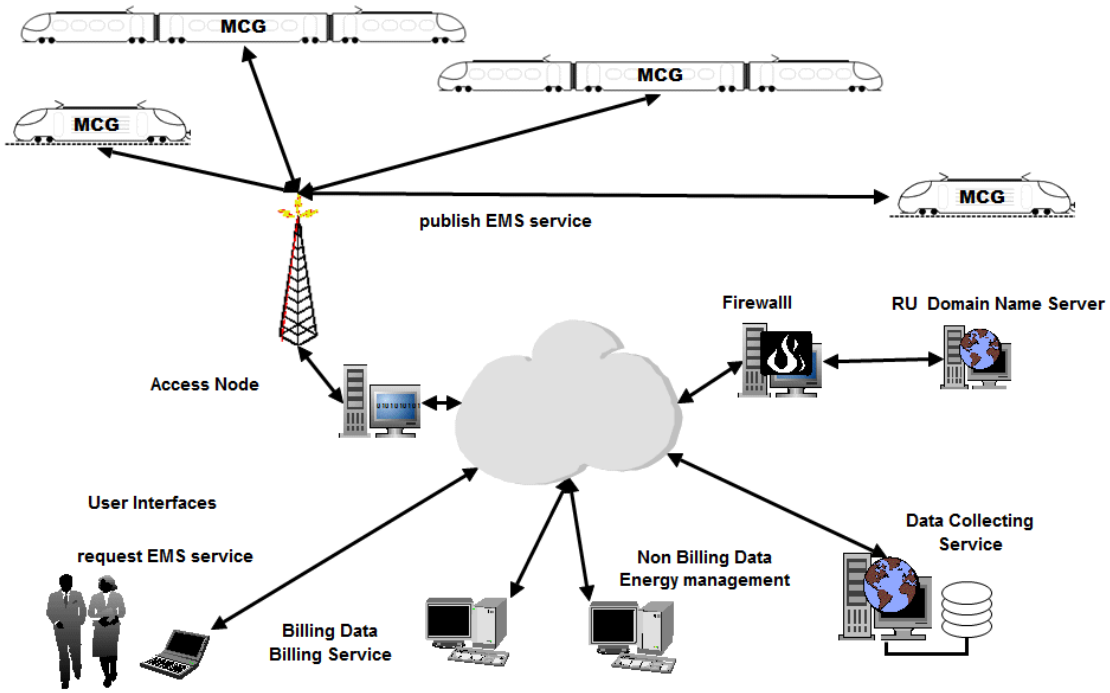
Reference Architecture



The Cross-Border services either in terms of Country boundary or Tariff Boundary drive to an Open and Standardized Communication Infrastructure.

On board to Ground Communication

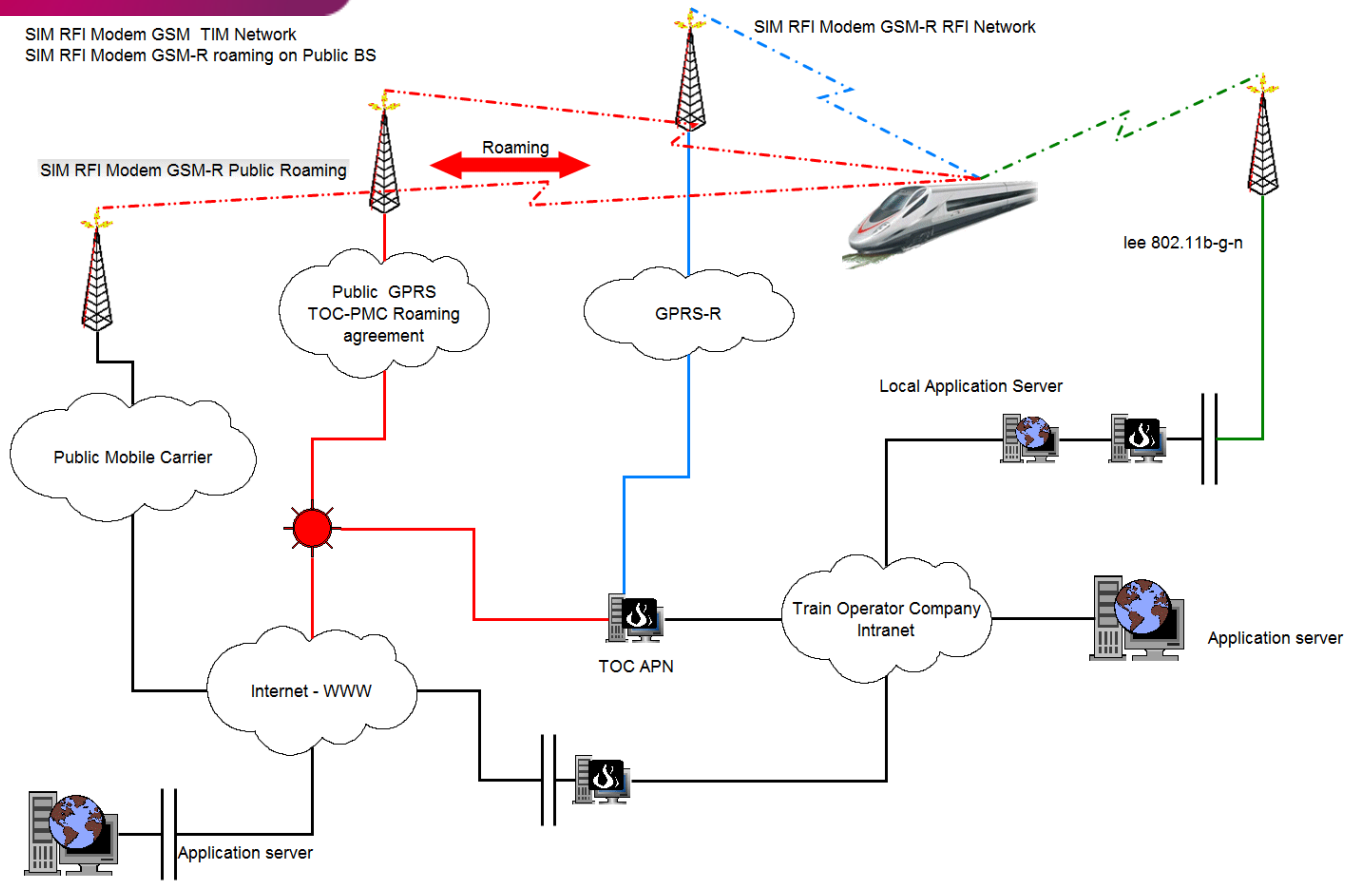
Communication Scenario



The train could be connected to the ground section with a Mobile Communication Gateway capable to switch between a pool of wireless connections “on the fly” according to the bandwidth requirement of the “service”.

On board to Ground Communication

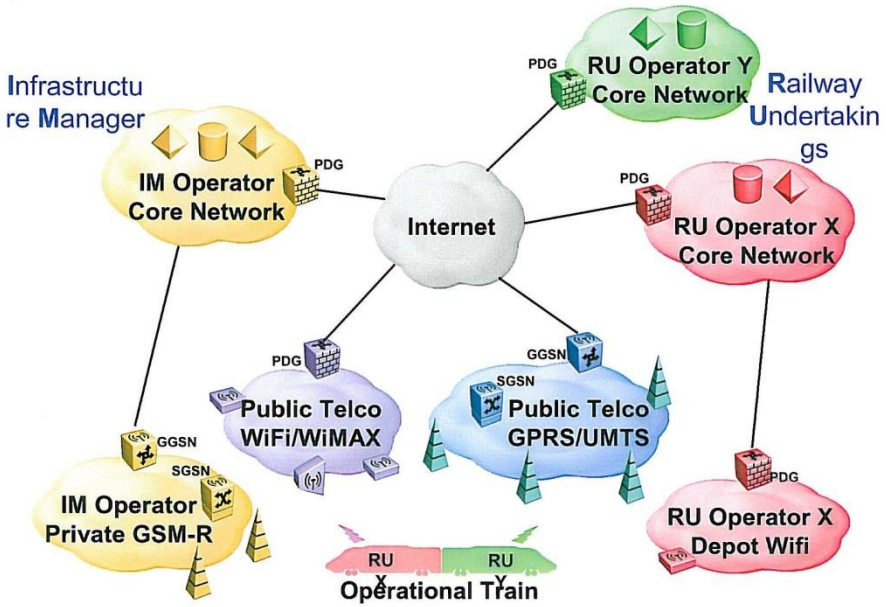
Communication Scenario



On board to Ground Communication

Communication Scenario

Functional addressing is one of the key point managed by the IEC TC9 WG46 - Onboard multimedia systems for railways.

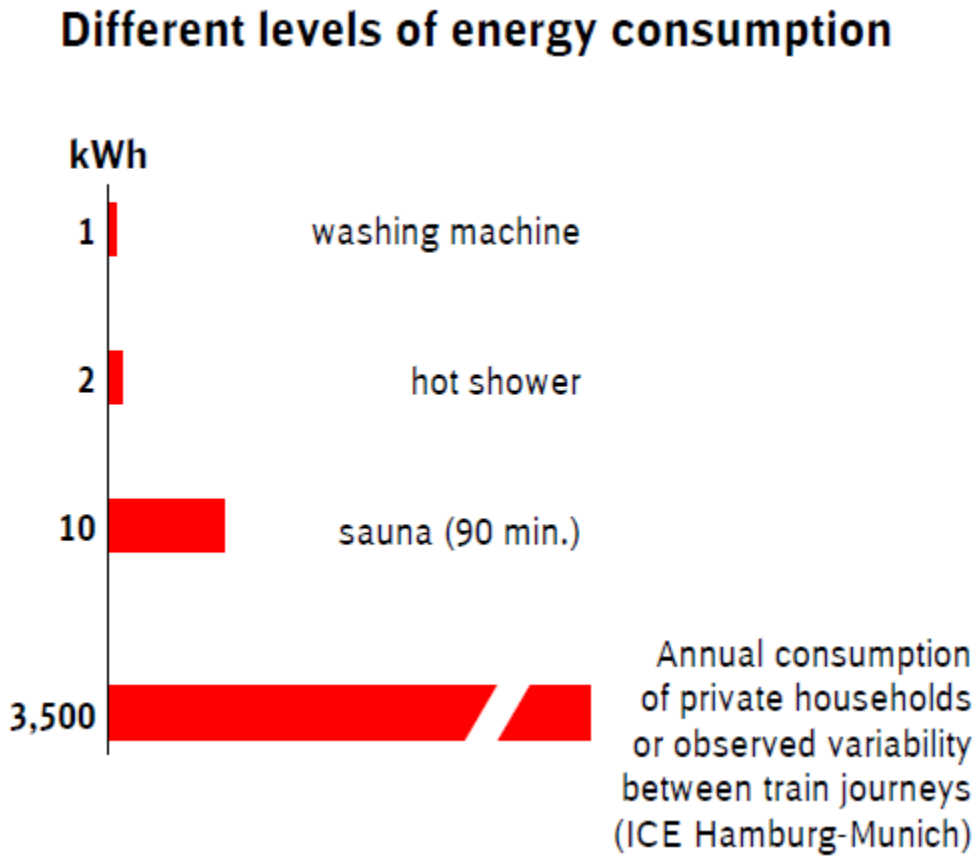


Shared Mobile Communication Gateway (MCG): the MCG acts as a proxy, representing the train functional structure to the ground network.

Dedicated MCG: the MCG acts as an IP sub domain device allowing each function/services to be reachable through its functional address.

Energy Saving Strategies

Energy Consumption



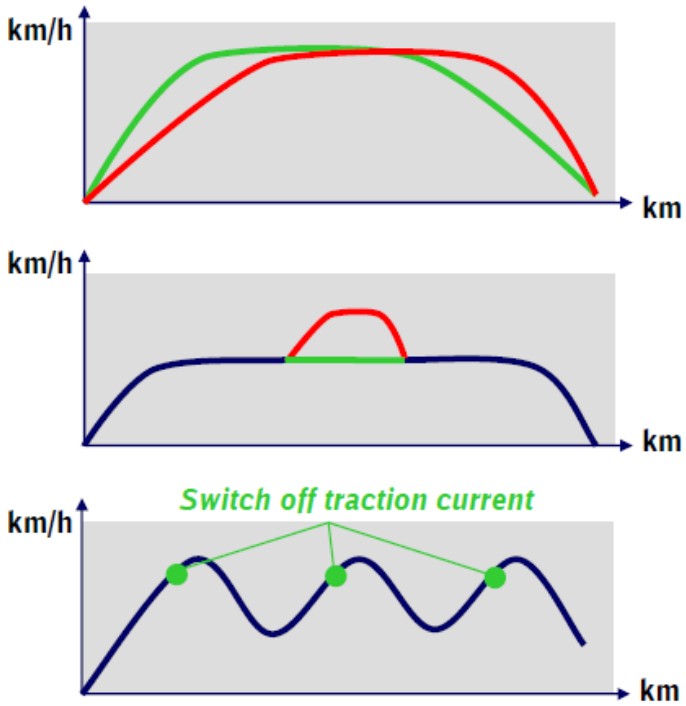
Source:
Deutsche Bahn 2007, Energy-efficent driving programme [9]

Energy Saving Strategies

Energy Consumption

Source:
Deutsche Bahn 2007, Energy-efficent driving programme [9]

Timetable recovery margins are the basis of energy-efficient driving patterns



Let it roll:

Once a train has reached maximum speed, it can coast for long sections without significantly losing speed.

Avoid top speed:

Due to timetable recovery margins, trains often arrive on time without running at maximum speed.

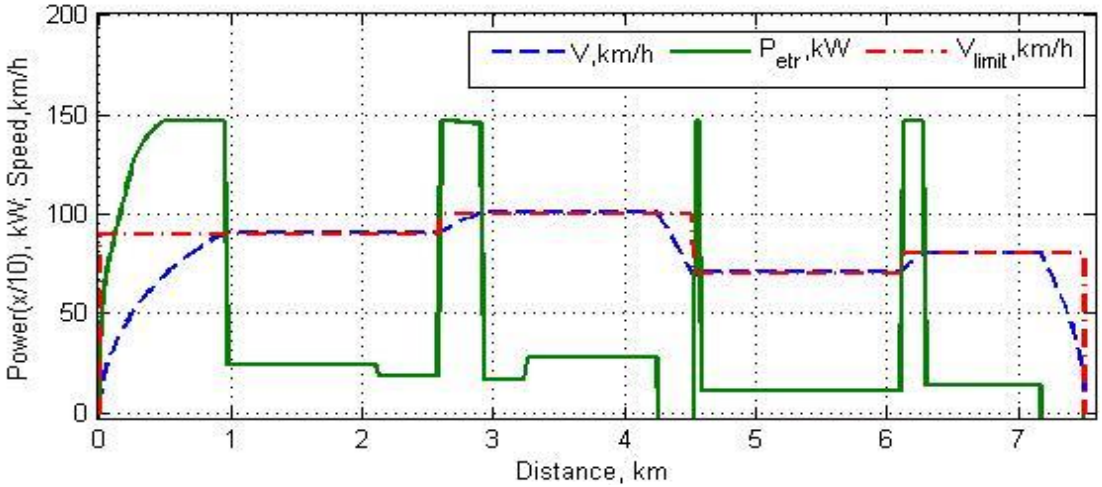
Use valleys and hills:

Switching off traction current before reaching the summit and coasting down hills reduces energy consumption.

Energy Saving Strategies

Source:
Energy Efficiency of a Railway Power Network with Simulation - . J. Hull, Dr C. Roberts and Dr S. Hillmansen - Centre for Railway Research and Education - University of Birmingham

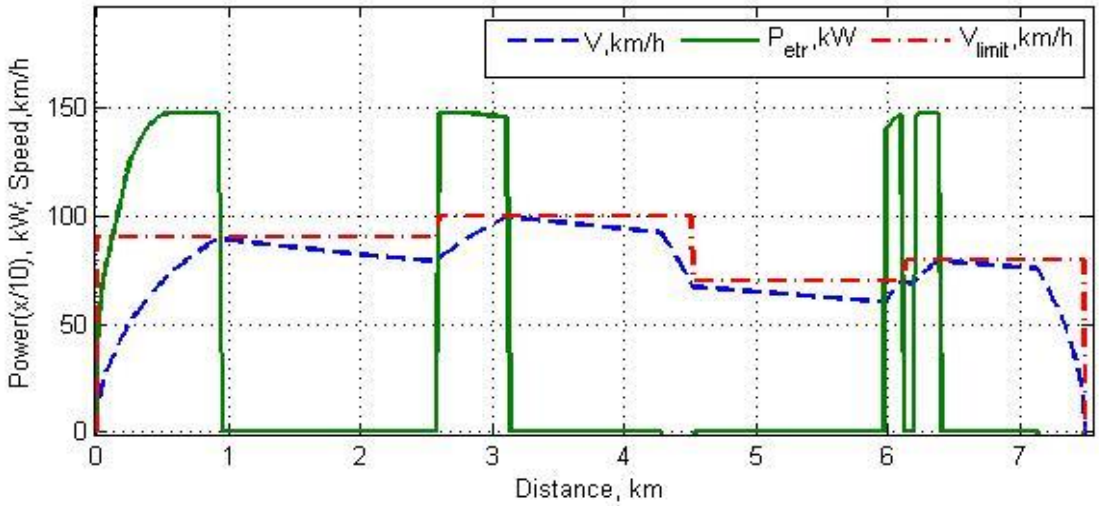
Energy Consumption



-> Train trajectory for fastest journey

6 min 2 sec

42.48 kWh



->Train trajectory for energy efficient solution

6 min 30 sec

36.13 kWh

Conclusion

Energy Consumption information could be used either in near real time condition to improve the driving patterns (efficient drive) according to the traffic condition or in attribution of energy consumption (energy cost forecast) and analysis on timetabling efficiencies.

Train driving technique can have a significant effect on the energy consumed for trains operating over the same route with the same stopping patterns. As example, the Timetable could be build for train trajectory optimization either for better reuse of regenerative energy or for adjustments in the timetable tailored for energy saving. Such approach can be considered at both the timetable design stage and dynamically according traffic and rolling stock condition. Area of improvement are also climate control and parking mode.

In all cases, the performance of the Energy Management System are affected by the Human Factor [9]. It is necessary inside the organization to increase awareness of the importance of energy saving, to convince all stakeholders to take part in the process, to motivate train drivers using incentive (e.g. energy saving competition) , institutionalizing a learning process with individual and focusing on a sustained process (e.g. energy consumption display).

Acknowledgement

The EN 50463 norm is based on the joint design and engineering effort of numerous colleagues. They have brought their expertise together to make it happen.

We want to present our credits to the whole Cenelec CLC TC9X WG11 team for the challenging and stimulating environment.

Finally, we like to express our sincere thanks to Mr. Carlo Fasoli, Convener of the WG11.

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Questions ?

Thanks for your kind attention

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