The technical uptake of E-Highway concept in Italy

Prof. Ing. Renato Mazzoncini

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Scope of ERS

The objectives of COP 21 and COP 23 as regards freight transport provide for the transfer to railway, as a more environmentally friendly mode of transport, by 30% of the volume by 2030 and 50% by 2050.

Hardly these are achievable objectives because the capacity of the railway networks of the main European countries are already saturated with the actual only 12% of goods transported.

In addition, the constant growth of passengers, about 3-5% per annum, recommends dedicating capacity to passenger transport.

The final objective for the transport sector for the Roadmap 2050 remains the decarbonisation and to date the only technology available to decarbonize the road freight transport are the ERS.
Work stages

Of course, the e-Highway also has a sense of European corridors and a mechanism is needed to support the development of the network during the period in which traffic will be limited in the absence of equipped trucks

Step 1: Choice of the best technology with laboratory tests, in particular for electrical dimensioning and mechanical interaction of catenary/pantograph
Step 2: Pilot and field test installation with the first trucks
Step 3: Extensive corridor development
Step 4: Development of different truck models (or retrofit to pantograph)
This area is therefore exposed to polluting emissions with a level among the highest in Europe.
The italian pilot – A35 Brebemi

First phase: PILOT STUDY
Electrification with maximum extension useful to set up the system, in the central section of the A35, to test the ERS.

Second phase: Electrification of the entire A35 Brebemi
A single European laboratory between Sweden, Germany and Italy

It is absolutely necessary to choose the best technology before starting an extensive realisation of ERS and it is obviously necessary to make it interoperable at least at European level. 

PoliMi participates in the European Standardisation Platform (CENELEC TC9X WG27).

We think it is useful to consider all the pilots realized and/or in the design phase as part of a single European field test available to all the research centers to speed up the tests and maximize the usefulness.

In this perspective, we believe it is important that the Italian pilot is not a copy of Swedish and German pilots but allows to carry out different and complementary tests. By way of example we consider it very important to test fleets that move in platooning.
The prospect of platooning

It should be considered that trucks manufacturers are investing in the technology of platooning that can lead to very close distances between trucks, up to 10/20 Mt.

Will the ERS infrastructure be dimensioned for service in platooning? If yes, as we think, must ensure that the pilot has a power supply that can support this level of service.

In this case it will be possible to carry out dynamic tests of the pantograph/catenary interaction in the specific case of platooning never tested on a ERS.

The data supplied by Siemens indicate a maximum power absorbed by a truck in motion with batteries charging up to 400KW, which potentially leads to absorption at the km of many MW. It is certainly necessary to make simulations in the laboratory to simulate this situation and to define the correct dimensioning of the electrical substations and of the contact line.
The design and sizing of the supply system (number and location of the substations, cross section of the catenary wire, etc…) is correlated with the line voltage and the expected traffic.
Voltage drop calculation and evaluation of the best system for operation & maintenance

Unilateral power supply

Bilateral power supply
Example of study on the application of VSC (Voltage Source Converter) in AC/DC substations for supply system improvement

Use of Voltage Source Converter for DC voltage regulation, regenerative braking and power quality improvement
Mechanical simulation of pantograph-catenary interaction

Simulation program certified according to EN50318

- Definition and verification of different possible solution for e-Highway catenary design
- Possibility to account for multiple pantographs’ operation
HIL testing principle: simulating the behaviour of a dynamic process, where

- a part of the process (the “hardware”) is represented by a physical prototype
- the rest of the process/system is represented virtually using a mathematical model

Aim of HIL pantograph testing: replace line tests (at least partially) in the pantograph homologation process.

Advantages

- (vs line tests) HIL laboratory tests can be performed at much lower costs and in a more reliable and controlled environment
- (vs pure simulation) the pantograph still undergoes a physical test, avoiding the implications of model uncertainties
HIL hybrid simulation of pantograph-catenary interaction

Real-time catenary model
HIL hybrid simulation of pantograph-catenary interaction
Validation of closed-loop HILS against experimental data

ATR95 pantograph – C270 catenary ($T_{cw}=20$ kN), $V=300$ km/h

Contact force (approx. 4 spans)
Current collection test rig

• The test rig enables the testing of full-scale contact strips under realistic conditions:
  ▪ speed up to 210km/h
  ▪ electrical current intensity up to
    • 1100 A in dc (extendable up to 1400 A)
    • 500 A in ac 16 2/3 Hz
    • 350 A in ac 50 Hz.
• Main activities:
  • Accredited acceptance tests for collector strips (RFI 65C)
  • Test for SNCF train Regiolis
  • Test for EU COSTRIM Project (DB, SNCF)
Current collection test rig

Ventilation apparatus

TOP VIEW
- Contact wire
- Air Flow
- Contact strip
- Relative Speed
- Stagger

FRONT VIEW
- Rotating disk
- Static Vertical Force
- Stagger
Numerical and laboratory analyses limitations

With numerical tools it is possible to account for an «unlimited» number of pantographs interacting with the catenary at the same time, both from an electrical and mechanical point of view. But, numerical tools need experimental validation.

On the other hand lab test-rigs only allows to test single pantograph/components.

The availability of a suitable test section to reproduce the real conditions in platooning is of fundamental importance for the development and enhancement of ERS concept.
Platooning related issues: electrical aspects

- Power supply: sizing of the supply system (size, number and location of the substations, cross section of the contact wires, etc...)
- Possible electrical interaction between the vehicles
- Current collection policies and supervision (traction only, recharging)
- Identification of unauthorised collection/operation
Platooning related issues: mechanical aspects

- Multiple pantographs' operation with very small and recurrant spacing: possibility to have even more than one pantograph (up to 3?) per span
- Influence of the leading pantographs on current collection of the trailing ones (running on perturbed catenary)
- Possible resonance phenomena, depending on catenary characteristics, speed and spacing
- (Aerodynamic disturbances on the trailing pantographs)
Diagnostic

Another theme that must be addressed with the ERS is the diagnostics, in particular for the correct interaction pantograph/catenary.

The experience that comes from the rail sector tells us that it is not uncommon to break the contact rope as a result of abnormal wear of the pantograph itself or the contact strips, or even mechanical defects of the pantograph itself. The diagnostics of a ERS is even more critical for the potentially huge number of different trucks and pantographs. The railway technique has developed portals and camera systems able to monitor the integrity and correct maintenance of the pantograph. As well as vehicle-mounted systems can monitor the consumption of the contact line.
Diagnostic: from road side
Diagnostic: from vehicle side

Optical systems

http://www.mermecgroup.com/

Instrumented pantographs

Contact force measurement

Panhead accelerations
THANK YOU FOR THE ATTENTION

Renato Mazzoncini