
Spanish high speed trains. Energy efficiency in operation: driving designs based on simulation

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1 PURPOSE

The EU is committed to reducing its overall emissions to at least 20% below 1990 levels by 2020. Spain supports this target. In transport sector measures are focused on planning, infrastructure, modal change, renewal of vehicles and also programmes on efficient driving (ecodriving).

Some strategies can be applied in short term or even in real time. Given the infrastructure, and the vehicles in service, rail traffic operation may consider energy efficiency goal in addition to operational and commercial ones. One of these strategies is the design of efficient driving commands: no powering in slopes (coasting), speed regulation without braking.

Renfe eco-driving programmes are applied research projects focused on reduction of energy consumption on train operation. Making use of the time margin available in actual timetables, efficient drivings (ecodriving) are designed to reduce consumption, based on simulation models and tested specifically for high speed trains (HST) classes 102, 103 and 120, running on different high speed lines (HSL) in Spain: Madrid-Barcelona, Madrid-Cordoba-Sevilla and Madrid-Córdoba-Málaga. These projects started on 2008 and continue nowadays.

In these projects, new realistic and accurate simulation models have been developed and adjusted by means of specific driving tests, and have been applied to design the optimal eco-driving for each commercial service. Important savings can be obtained by means of efficient driving. 21% of average energy savings have been measured.

2 ORGANISATION

Several Renfe eco-driving projects named ElecRail, EfiTrans and AveDrive (*) are being developed in collaboration with academy and railway industry.

Renfe, as the leader of the projects, plans and organises the diurnal and nocturnal driving tests and provides authorisations, trains and drivers, and validates driving designs as well as the obtained results. In addition, Renfe provides statistical data of trip times and consumption.

Comillas University develops simulation models, designs the required tests, designs the eco-drivings, collaborates on driving tests execution and analyses measures obtained during these tests.

Traintic and the train suppliers collaborate on the execution of tests making possible on board acquisition of measures such as energy, consumption, speed, force, time, etc.

Eco-drivings are designed for the following cases:

HST class 102 in HSL Madrid-Barcelona (Madrid-Zaragoza section).

HST class 120 in HSL Madrid-Barcelona high speed line (Madrid - Plasencia de Jalón section)

HST class 103 in HSL Madrid-Barcelona.

HST class 102 in HSL Madrid-Málaga.

HST class 100 in HSL Madrid-Sevilla.

3 TASKS

These are the tasks related to the project:

- Development of simulation models of the train motion.
- Preliminary tests for the model adjustment and validation: nocturnal specific tests and commercial services to measure non-guided driving (before eco-driving design).

- Optimal design of ecodriving and evaluation of the expected energy saving from simulation results.
- Tests of ecodriving designs. Driving is guided according to the ecodriving design in commercial services and on board measures are recorded to compare them with non-guided driving measured in the same trip conditions (non-delayed trains).

Ecodriving projects have been designed for all the previously specified cases, and they have been tested in HSL Madrid-Barcelona with HST classes 102 and 120. For this purpose 19 tests have been performed with HST in commercial services and 12 specific test trips, from July to December 2010.

4 RESULTS AND IMPACT

The results and impact on the sustainability performance of rail is clear in this project due to the fact that the main goal is reduction of energy consumption in traffic operation. 21% of average energy savings have already been measured, and these strategies can be applied in short term, with very low effort.

5 MEASURED SUCCESS. ENERGY SAVINGS

The success of these ecodriving projects has already been measured with 2 different HST, classes 102 and 120, by means of on board measures of energy consumption and running time. Energy saving reach up to 70% in Guadalajara-Madrid section, and up to 42% in Calatayud-Zaragoza section, both of them in HSL Madrid-Barcelona (Figure 3). Average saving measured in this line is 21%.

The following tables resume measured average results:

	Time	Consumption (kWh)			
	Margin	Non-guided	Ecodriving	Difference	%
Madrid-Guadalajara	0:03:51	1350	1000	350	25,9
Guadalajara-Calatayud	0:03:59	2300	1900	400	17,4
Calatayud-Zaragoza	0:05:01	1350	900	450	33,3
TOTAL	0:12:51	5000	3800	1200	24,0

	Time	Consumption (kWh)			
	Margin	Non-guided	Ecodriving	Difference	%
Zaragoza-Calatayud	0:02:54	2005	1534	471	23,5
Calatayud-Guadalajara	0:01:34	2950	2875	75	2,5
Guadalajara-Madrid	0:12:02	850	350	500	58,8
TOTAL	0:16:30	5805	4759	1046	18,0

6 JUSTIFICATION

It has been demonstrated that ecodriving projects have an important impact on reduction of railway energy consumption and the results will be extended to the rest of the railway lines in the near future. These ecodriving projects are a very good example of collaboration among administration, railway industry and academy in the development of a successful applied research.

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EfiTrans: Renfe Operadora, Traintic, U.P.Comillas

AveDrive: Renfe Operadora, U.P.Comillas

FIGURES

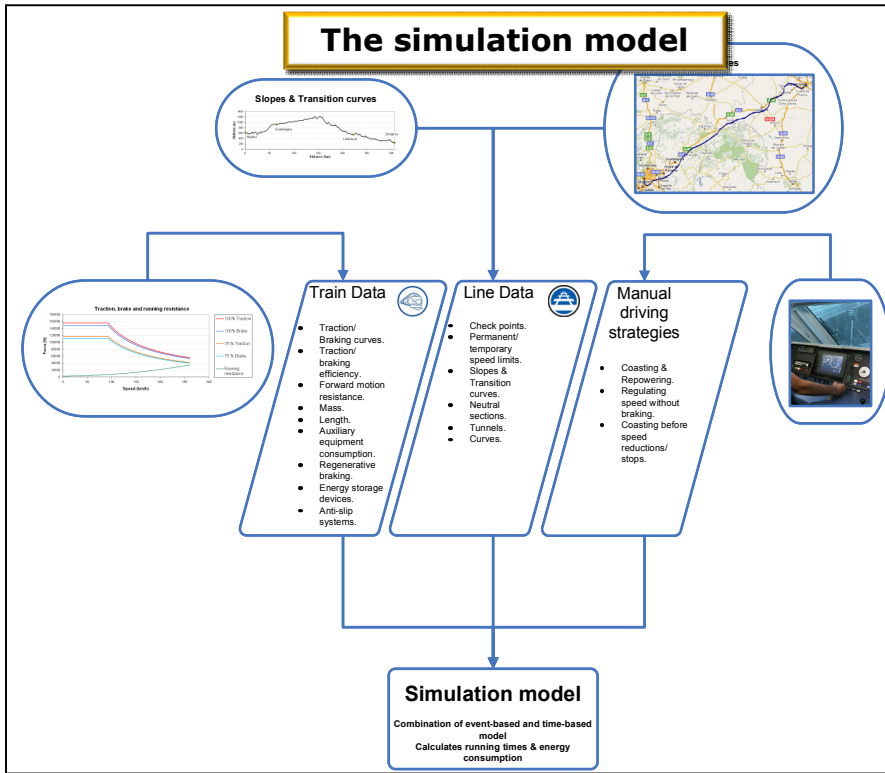


Figure 1: Simulation model

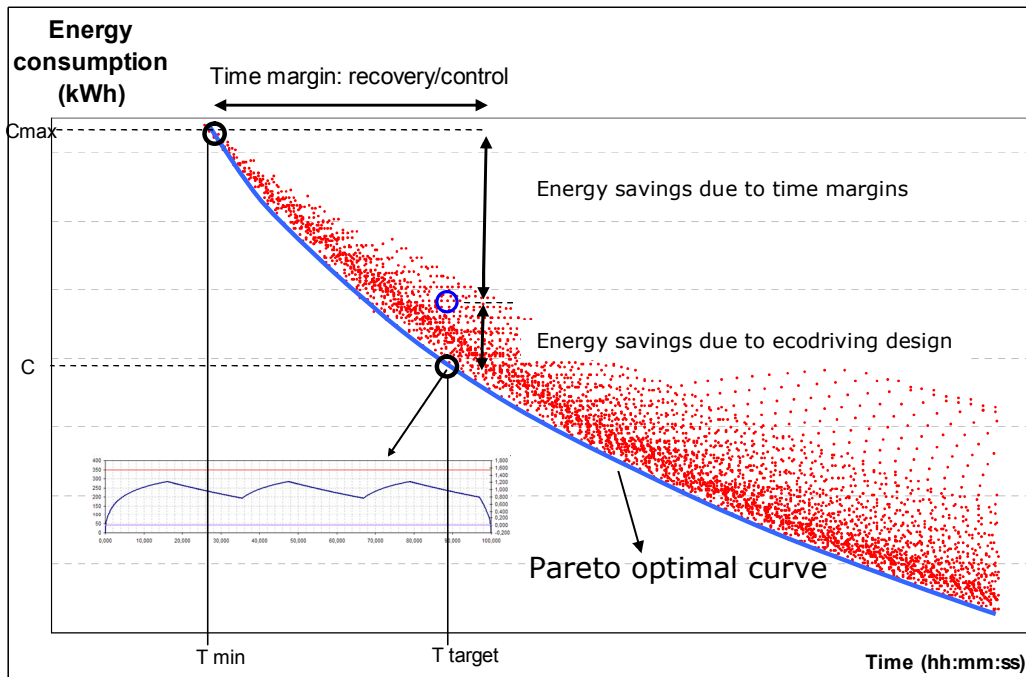


Figure 2: Time margin vs. ecodriving

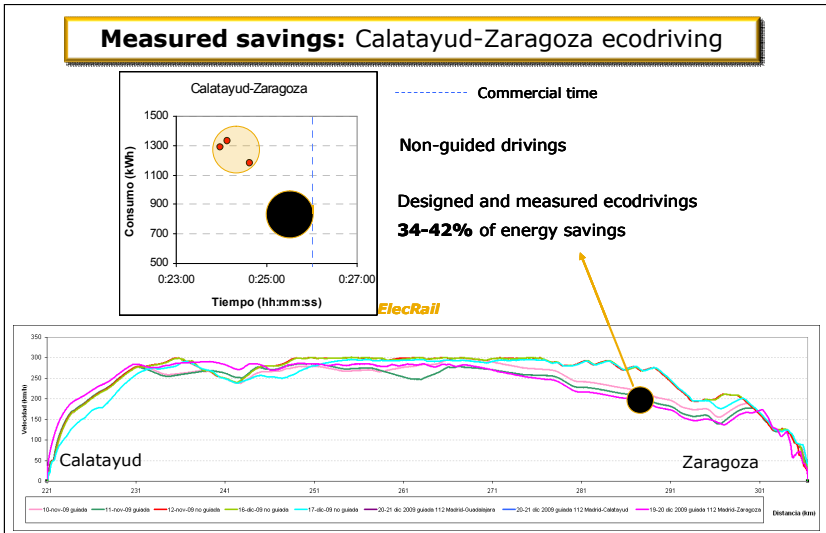


Figure 3: Driving tests. Measures comparing ecodriving and non guided drivings