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Towards an integrated technology management across the rail supply chain extended to society: Building the case study on high-speed trains

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Towards an integrated technology management across the rail supply chain extended to society: building the case study on high speed trains [1]

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Abstract:

The railway industry is pushing for market uptake of research for better and competitive products and services as resulted from the workshop of the European Railway Advisory Council held this year 2010 [2]. What seems less considered by the industry concerns is however the new paradigm resulting from the financial crisis from 2008 and, as important, the increasing exposure to social movements (this last one the focus of my research). In support, the present paper proposes to develop a scientific based methodology driven from technology assessment (TA) that manages research results within society. In a first instance such exercise should be limited to a specific technology in railways as it can be the High Speed (HS) train and the technologies it embeds. The high-speed trains integrate the most advanced technologies in the sector and represent billions of Euros of public investment, greater than for conventional lines. The expected impacts are to integrate the technology effort of all parties extended to society from early stage of design to latter market entry. This increases the rail industry competitiveness, enhances innovative technologies, and improves predictability of future social conditions while decrease risks of market failure.

Key words: high-speed trains, technology management, technology assessment
JEL codes: M16; R42

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[1] The present paper was prepared for the course "Project III", with the supervision of Prof. António Moniz, reporting on the author speaking notes at the Winter School on Technology Assessment, 6-7 December 2010, as part of the Doctoral Programme on Technology Assessment at FCT-UNL.

[2] ERRAC Evaluation WG WP06 Workshop 18 March 2010 in Brussels http://www.errac.org/spip.php?article25: At this workshop ERRAC WG06 stated that "Over the past years, a great number of rail research projects have been funded by the European Commission, representing billions of Euros of investment. Yet the question remains as to how much of this research has actually been useful or relevant. It is clear that otherwise valuable research results are sometimes lost (forgotten) and some work is repetitive or redundant. To the Euros invested in European collaborative research one should add other billion that industry invest per year on its own and other more on regional and national funding in developing national and local projects".

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1. Introduction to the problem

Just after the spotlight given to railways by the European Commission Transport White Paper (COM(2001)370final) the European rail industry – economic stakeholder designing, producing and supplying rail systems and sub-systems, from track to rolling stock - faces today a new paradigm driven from financial restrictions and the emergent new societal pressures, as from environmental communities, consumers associations, opinion makers etc.

With its origins in metal-works engineering, ruled by public management and underinvested, it's now a flourishing new industry clustering a series of new engineering competences and embracing novel and complex relations between manufacturers and customer, manufacturers and component-supplier, and the manufacturers and academia, and most recently manufacturers and society.

Europe's White Paper on Transport - "Transport White Paper: European Transport Policy – Time to decide (Sep. 2001)" (COM/2002) - gave a new spotlight to rail, placing it as backbone of Europe's transport system. It called for further investments in rail performance capable of meeting Europe's targets of sustainable development and knowledge-based society and fully interoperable and modular European railway system. ERRAC's Vision 2020 represents the sector's reply to the White Paper set of objectives[3]. It set the agenda and road-maps to foster collaborative research in the technology areas rail stakeholders considered relevant to expand the scale of viable, affordable, competitive and reliable railway system, leaving out however social aspect impacting new technologies acceptability.

Also, the resulted restructuring on rail industry organization contributed to the entrance of new players, new private train operations, component suppliers with the increase in outsourcing, bringing with it a quite broad range of new technologies.

[3] "Investments in collaborative research on interoperability and 'modular' production became the base for a truly borderless European rail network, the growth of the European rail market, and the future prosperity of the European rail manufacturing industry (…). "Eliminating duplication of research and limited serial production will also reduce manufacturing costs and help return the industry to a healthy level of profitability", ERRAC European Rail Research Advisory Council, Strategic Rail Research Agenda 2020, May 2007, p.1-34.

Those new stakeholders arise from various other sectors, as from automation, aeronautics, telecommunications, robotics, etc. Railway engineers were faced with all series of different new emergent expertise.

Most recently societal stakeholders are emerging as from environmental groups or communities of people impacted by high-speed trains, opinion-makers, etc, which have been so far external to product development.

The rail sector is yet behind from other transport modes in technological advancements reflecting what seams to be lack in good practices in the technology management and forecasts.

The aim of the research to be conducted during my PhD in Technology Assessment applied to the railways is at proving that the rail industry misses an integrated technology management capable of overcoming present market conditions such as closed culture, tight specifications, low volumes, difficult business environment with concentration of players, tight certification process and most recently emergent society.

2. The technology gap

The liberalization of the European rail market (Transport White Paper 2001) and co-modality[4] (Transport White Paper Mid-term Review 2006) placed railways under technology pressure from its direct competition between themselves and with other transportation modes, as from road and regional airlines. The actual economic crisis added to it cost efficiency, demanding for affordable rail vehicles and infrastructure.

Such unveils rail's technology development gap. It took almost 200 years to occur the first technology breakthrough since the first seam engine train and the high-speed

[4] "Co-modality" was introduced by the Mid-term review of the Transport White Paper, as the efficient use of different modes of transport on their own and in combination where that is more appropriated (Mid-Term Review Transport White Paper 2006, p.4).

train in the 70's in Japan and latter the Maglev train in the 1980 decade [5] in Germany. The technology has been developed in a logic of engineering centric.

In the automotive industry for instance, the technology evolution from the Ford T model from 1917 to the Tesla Roadster[6] from 2006 was greater and faster, no more than 70 years. In road the technology developments have been costumer centric.

It is however with the aeronautics that the technology gap from railways has greater meaning. Operating within similar market conditions as rail, the airspace industry suppliers of aircrafts achieved greater technology development. From the first plain human powered to the new Airbus A380[7] with autonomy to fly from New York to Hong Kong for example at a cruising speed of 900 km/h, with a maximum capacity of about 800 seats, it only took 100 years. In aeronautics the technology development has been costumer centric in road with a great emphasis on service optimization as introduced by the low cost airlines.

[5] Looking back, only with the introduction of the high-speed train (HS) in the 70' and latter maglev in the 80'[5] that happened the technology breakthrough from the steel and heavy vehicles, running at low speed with high levels of energy consumption. Introduced by Alstom in 2007, the new generation of HS trains, the AGV, was intended as the successor to France's TGV high-speed train. The name AGV stands for *automotrice à grande vitesse*, or high-speed self-propelled carriage. Instead of having separate power cars at either end of the train, as current TGVs do, the AGV have distributed traction with motors under the floors of the passenger carriages. It's a novelty in relation to many regular-speed multiple-unit trains and also high-speed trains such as the Siemens Velaro and Japan's Shinkansen trains. The space saved through not having a power car will enable the AGV to provide more seats. AGV can also assume configurations from seven to fourteen carriages, with a total of 250–650 seats, depending on internal layout and number of carriages. The commercial service speed is 360 km/h. It weighs less, reducing its power consumption, and it consumes 30% less energy than previous TGV designs. It's a fully interoperable vehicle, as it also incorporates the latest ERTMS signaling standards and so will be able to run on all European lines when equipped with the new technology. It has an innovative design creating more space for passengers and enhances the AGV's performance. As a result, the new design can carry up to 900 passengers at a speed 360km/h, which is 40km/h faster than the double-decker TGV trains that today carry 400 fewer passengers on the main French high-speed line between Paris and Lyon. A latter technology Maglev (derived from magnetic levitation) was pioneer in using electromagnetic force rather than an engine to propel with speed records of 430 Km/h (average HS train is 200 km/h), going from 0 to 300 km/h in just two minutes. The highest recorded speed of a Maglev train is 581 km/h (361 mph), achieved in Japan in 2003, 6 km/h faster than the conventional AGV speed record.

[6] Tesla Roadster is fundamentally different in almost all conceivable ways from any other road vehicle. Its an electric car powered with a battery lithium-ion variety found in the typical laptop PC, with recovering energy from the breaking system with few moving parts to repair or maintain, since it has no internal combustion engine.

[7] This double-deck, wide-body, four-engine airliner manufactured by the European corporation Airbus, a subsidiary of EADS, is the largest passenger airliner in the world. The A380 made its maiden flight on 27 April 2005 from Toulouse, France, and made its first commercial flight on 25 October 2007 from Singapore to Sydney with Singapore Airlines. The A380's upper deck extends along the entire length of the fuselage, and its width is equivalent to that of a widebody aircraft. This allows for an A380-800's cabin with 478.1 m^2 of floor space, 49% more floor space than the next-largest airliner, the Boeing 747-400 with 320.8 m^2, and provides seating for 525 people in a typical three-class configuration or up to 853 people in all-economy class configurations. The postponed freighter version, the A380-800F, is offered as one of the largest freight aircraft, with a payload capacity exceeded only by the Antonov An-225. The A380-800 has a design range of 15,200 km, sufficient to fly from New York to Hong Kong for example, and a cruising speed of 900 km/h at cruising altitude.

3. The case study: The highs-speed trains in Europe

From MODTRAIN film http://www.modtrain.com/video.html [showed during the presentation] one can see that the origins for rail technology gap relay on the fragmentation of the sector duplication technology developments, ruled by national specification. They have justified the latest developments on interoperability of train sets and reduce costs by modularization of train subsystems.

But MODTRAIN film however kept out of the references the external constraints arising from society. High-Speed train vehicles in Europe are this way a significant expression of such reality. It has the latest technology onboard, operating in a defined European regulatory framework with the set of Technology Specifications for Interoperability (TSIs)[8], which meets the objectives of interoperability and modularity, while societal trends appear left out of product development processes.

Despite the small dimension of the high speed market, with some 1.650 high-speed train vehicles and tilting trains in operation worldwide (UNIFE market study 2009), its notorious the high cost of each vehicle from the complexity of the technology system, requiring significant public investments.

According to UNIFE market study (2009), the average 100 trains sold per year represent a business volume of €1.4 billion. From the 20 high-speed trains manufacturers world-wide the majority are based in Europe, such as Alstom (France), Bombardier (from Canada but with a strong presence in Germany and supplying to many countries in Europe), Siemens (Germany), Talgo (Spain), Ansaldo (Italy). Outside Europe are Hitachi (Japan) as most recently CNR and CHR (China). About 13 countries have high-speed train lines, operated by less than 10 private companies.

The most recent technological advancements in high-speed trains are the result from the past decades of European and national stimulus. Those advancements are mainly

[8] TSI for high-speed has been revised and came in force 2008. Originally decided EU in May 2002 TSIs for Directive 96/48/EC for high-speed lines and high-speed trains and came in force December 2002. The TSIs for high-speed railways apply to new construction, rebuild and upgrading of the high-speed network and high-speed trains (maximum speed above 200 km/h). Source: http://www.transportstyrelsen.se/en/Railway/Approval/TSI/TSIs-for-high-speed-railways/

in wheeled trains, which have pushed the speed limits past 400 km/h, tilting train-sets, aerodynamic designs (to reduce drag, lift, and noise), air brakes, regenerative braking, stronger engines, dynamic weight shifting, energy efficiency and weight reduction.

The latest generation of high speed trains as the AGV (Automotrice a Grand Vitesse) supplied by Alstom and the ICE-350E by Siemens integrates findings from research projects as the European Drivers Desk[9] (EUDD) and MODTRAIN[10], as well as from eco-procurement projects as RAVEL, REPID and PROSPER[11]. However such integration lacks a structured technology management methodology capable of bridging all the parties involved - from component suppliers, industry, operator companies – extended to societal actors.

My research work will aim to prove that and came up with a technology management methodology driven from technology assessment.

4. Research questions and propositions

From what was referred arise two primary research questions which folds into sub-research questions:

RQ1. How the incumbent industry is falling short in extending technology development processes to new emergent stakeholders as society?

RQ1. Proposition - The high-speed train industry, formed by the collective of stakeholders taking part in the development of the vehicles, address new societal

[9] EUDD European Divers Desk project website http://www.euddplus.eu/

[10] MODTRAIN, Innovative Modular Vehicle Concepts for an integrated European Railway System http://www.modtrain.com/. Its the pioneer collaborative research project of a modular train, where for the first time European railway systems manufacturers, subsytems suppliers, railway operators and professional associations and research centers have came together to develop modular interfaces for intercity trains and long distance. The main outputs of MODTRAIN are related to standardisation: i) operational requirements specifications form operators; ii) train architecture and functional requirerment specifications to be used by OEMs; iii) standardized fucntional interface specifications between the main subsystems of the train; iv) standardisation of certain components as the water pump, driver's cab, vertical damper for the secondary suspension, interoperable door system. The project was divided into MODBOGIE (running gear); MODCONTRO (train control architecture); MODPOWER (onboard power systems), MODLINK (man to machine and train to train interfaces).

[11] Eco-procurement research projects RAVEL, REPID and PROSPER http://www.railway-procurement.org/

demands mainly outside their value chain (meaning little involvement of emerging societal networks in their R&D projects). It reflects a predominance of technological initiators[12] aiming at promotion & control[13] their technologies. Those industries practice a single loop learning[14] as they have little pressures internal and external to the sector[15]. This proposition requires the analysis of the strategic management of technology development process (or R&D projects).

In doing so from technology assessment literature review constructive technology assessment perspective appears to offer the analytical tools, being mapping societal embedding in the innovation journey (Deute, Rip, Jelsma 1997), multi-level dynamics analysis (Geels 2002) and multi-level alignments analysis (Rip & Propp 2008).

The following sub-questions are inherent:

SRQ1. What evidences of societal embedding practices are found in the industry technology development process?

SRQ1. Proposition – High-speed trains innovation journeys follow established practices. If technology management extended to society is addressed it is to be found there. This requires understanding the technology, their actors, organizational technology surveillance structure and technological patterns.

Analytical method used here is as proposed in Deuten, Rip and Jelsma (1997) referred as innovation journey.

SRQ2. What has been the evolution in time?

SRQ2. Proposition – Innovation journey have not been the same over time. From mapping the technology transitions and multi-level alignments one can understand the how societal demands have been addressed and might evolve in the future.

[12] Paradian (2012) referees to technology initiators and technology selectors.

[13] Here I refer to Deuten, Rip and Jeslma (1997) promotion and control vs mutual-learning and orchestration.

[14] Here I refer to Deuten, Rip and Jeslma (1997) learning process (single loop vs double loop).

[15] Here I refer to Deuten, Rip and Jeslma (1997) learning pressures (high vs low).

The analytical method suggested is multilevel dynamics found in Geels (2002), multi-level alignments analysis and socio-technological scenarios found in Robinson & Propp (2008).

SRQ3. Who in the R&D process has propensity to address society in the technology development process?

SRQ3. Proposition – High-speed trains are complex nested technology systems. For example manufacturers (i.e system integrators) as Alstom and Siemens have the overall knowhow necessary to make the various technology components interface in ways that makes the vehicles run, but lack specific knowledge on each individual sub-system. Many actors are this way involved in the vehicle R&D and each one of them has different approaches to societal embedding.

The survey method was here applied to determine not only who, but also at what stage society is embedded in the technology development of the trains.

RQ2. Why there is potential for improvement?

RQ2 Proposition – ERRAC most likely is overlooking wider society demand. As this is a new a trend, it lacks this way the necessary instruments to address their demands in their research projects. This proposition requires an analysis on ERRRAC governance structure if reflecting what was said before.

SRQ2.1. How that can be done? (laying the foundations for an experiment)

SRQ2 Proposition – The necessary instruments are found in Constructive Technology Assessment (CTA). CTA Socio-Technology Scenarios allow for the integration of the new emerging societal demands in the product creation, by addressing resulting dilemmas in the heterogeneity of interests and values through orchestration and mutual learning. Here justifies review Te Kulve and Rip (2008) suggested steps in the application of CTA.

5. Expected impact

It’s therefore proposed to construct an integrated management tool addressing, covering all the stages of product life cycle and company’s involved units. This functionality aims at integrating all the stakeholders involved. Contrary to most off-the-shelf products, the ordering of trains is a tailored process with intensive cooperation between operators, manufacturers and suppliers of subsystems and materials, where most of the technology developments result from collaborative research.

The integrated technology management approach extended to society aims to respond to the multiple motivations rail industries might have when performing technology assessment measurements as to:

a) identify and prioritize opportunities for improvement, which may lead to the reduction of significant cost and resources savings, and to better coordination and cooperation across the stakeholders and within firms.

b) make available the necessary information so that they can fulfill the limitations that are posed by legislation and various regulations and identify where the incentives are.

c) benchmark and compare alternative scenarios

e) identify and assimilate technology resulting from its collaborative research with customers, component suppliers and concerned interest groups and the society in general. This definitely works as a competitive advantage in the continuously growing of technology capability of the rail sector, making the sector and its products attractive.

6. Preliminary research structure (subject to future changes)

Chapter1. Technology Assessment

Chapter 1 is the theoretical chapter. It aims at determine the universe being studied and to look at the existing conceptualizations about the core topic on "managing technology in society". It’s where I will define the path to take when confronted with different currents of thoughts within Technology Assessment. This chapter is relevant to set the basis in which a technology management model will be build upon. For that reason is relevant that it sets a clear picture on technology assessment, its roots, evolution, application.

In this chapter scientific and academic literature and authors are of most relevance. For that purpose is relevant the bibliography of the PhD classes, such as Social Factors of Innovation (Factores Sociais de Inovação) and Economy and Management of Innovation (Economia e Gestão da Inovação), as well as History of Technology (História da technologia), Prospective and Foresigh Analisys (Métodos e Análise Prospectiva). It will be also used publications and articles extracted from B-ON database. For more references see the Bibliography.

Chapter 2. High-speed trains technology system

Chapter 2 focuses on the object of study, the Rail Sector in Europe, in which refers the high-speed train technological system. In a first stage, this chapter looks on how the rail industry is structure and how the rail market is organized; it’s past and present. Then, to better understand how new technologies are being introduced by the sector, this chapter narrows the field of study to the high-speed rolling stock (excluded is signaling, infrastructure and maintenance) and its manufacturing organization. It ends by looking on how technology management is held across the HS supply chain. From this exercise it should result a clear identification on the formal and informal R&D+I strategies and instruments used by system integrators and their component suppliers and R&D+I value for money. Such should open the way to the following chapter - defining an model of indicators applicable for the rail sector - by detecting the existing technology management gaps.

In this chapter information should arise from the rail industry. UNIFE, the European Rail Supply Industry, and UIC, the International Association for the Railways, have a series of publications on rail market outlook and have released a series of position papers on Transport Policy that are of use to understand how the rail market is structured today. Most recently with ERRAC, the European Rail Research Advisory Council, more information has been released on rail research and innovation. Despite no longer existent, ERRI, the European Rail Research Institute, have release some scientific papers on rail technologies, like noise vibration, energy efficiency, among others. Presentations at Conferences and Workshops, collected by the author during the last years, will also be considered.

Chapter 3. Extended technology management model for the high-speed train

Chapter 3 should result from the combination of the learnings from the two previous chapters. In this chapter is where it will be experimented the identified empirical technological indicators and scoring to the rail sector. To see what it works and doesn't. To arrive to a theoretical conceptualization of a model. For that purpose is relevant to involve at this point the Rail Research Advisory Council (ERRAC), specifically the companies (operators and industry) involved in Working Group 6 of ERRAC's Road-Map, mandated by the European Commission to assess the rail research projects and their market uptake.

Chapter 4. Conclusions

The contents of the this final chapter will depend on the previous ones.

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