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COMPETIVENESS OF THE EUROPEAN RAILWAY INDUSTRY AND THE PARTNERSHIP INDUSTRY-ACADEMIA: A MUST

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Abstract. *The Railway Industry can be separated between the Supply Industry offering products and the Operating Industry (Operators and Infrastructure Managers) maintaining the Railway System at nominal operating conditions and offering services for the transport of persons and goods. The Railway Manufacturing Industry is a world leader supplying more than 50% of the world production with a large part of the production located in Europe, but this position is being jeopardized by the entrance of new players, mainly from Asia. Concerning the Service dimension, Rail transport is also vital for the European economy. For the sustainable development of the European economy for the next years and decades, railway transport must play a key role with a drastic increase of the % of freight and passengers transported by that mode as it is stated in the European Commission's 2011Transport White Paper. To keep its world leading role as a manufacturing industry with a large number of jobs in Europe, the Rail Supply Industry must increase its competitiveness through innovation. To support the growth of the rail mode in Europe i.e. to meet the users' needs, operators and infrastructure managers must be able to provide high level of services i.e. reliable, affordable and sustainable, and being able to meet the demand for a massive increase in capacity, whilst providing increasingly seamless mobility keeping the very high level of safety of that mode. During the last decades, the Rail Sector has demonstrated its capacity to innovate. Suffice to mention the Very High Speed Trains, the Tilting Trains, the ERTMS signaling System, the catenary-free tramways, etc…However, in that Industrial Sector which is "project oriented", there are limitations preventing long-term R&D investment for different reasons: low operating margins, short series with high level of customization, long cycles (a rolling stock product can be operated for more than 50 years), conservatism favorable to proven technologies and leading to a slow penetration of innovation, cost pressure, etc… To take up the challenges that the European Rail Sector is facing, there is no other issue than a step-change investment in R&D to exploit all the potential of innovation taking place in Academia labs as well as the Research and Technology development in other sectors through adaptation of solutions to the railway needs. In that endeavor, Academia has an important role to play because Industry which is not the place where new ideas can emerge, be explored and be nurtured, does not have the resources to perform that task and all the necessary expertise. Thus, Partnership between Industry and Academia is a MUST.*

Key words: *Railway, Competitiveness, Academia, Research & Development (R&D)*

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1. INTRODUCTION

The Railway Transport Industry has two main components: the Manufacturing Industry offering solutions of transport and the Transport Industry offering services to passengers and freight operators and keeping the system at nominal operating conditions.

The European rail supply industry is one of the few industrial sectors in which Europe still leads at the world level. The global rail market is estimated at €136 billion (Europe accounts for more than €45billion) with a predicted annual growth of 2-2.5% for the next few years. The UNIFE (UNion des Industries Ferroviaires Européennes) member companies supply more than 50% of the worldwide production of rail equipment and services. Throughout Europe it is estimated that 400,000 people are directly and indirectly employed by the supply industry.

The supply industry has manufacturing and R&DI facilities throughout the EU and the sector is characterized by stability and robustness. During the last two decades, consolidation took place and a number of key actors are major players on the global market while keeping their position of national champions in their home territories.

Railway transport of persons and goods is vital for the European economy. To address the challenge of climate change and the need to reduce "addiction" to carbon, the rail transport represents one of the key solutions for a sustainable transport system. Modal shift is becoming a primary policy objective that will be achieved if rail is becoming the mode of choice for passengers and freight forwarders. Rail must be responsive to users' needs and infrastructure managers and operators must deliver high quality services. The operation of the railway system employs more than 1,350,000 people in Europe. Employment on urban railways is about of equal number. The business environment has changed. Railway operators who were acting as the National Operators in their home countries in the past are being challenged by local private operators but they are also becoming private operators in other countries exporting their expertise to Cities/Regions/ Countries and creating jobs.

However, the Rail Sector is at a turning point of its history. In this paper, we will review the challenges lying ahead and discuss how it is possible to meet them and why the Industry-Academia partnership is a MUST for the European Railway Industry to keep its world leading role.

2. THE SECTOR AT A TURNING POINT OF ITS HISTORY

The European leadership has been made possible by a significant investment in key high-technology products (not only high-speed trains, but also in urban transport, such as control, command and signaling, e.g. ERTMS, Driverless Metro). This leadership position is being challenged by a growing competition from overseas suppliers, in particular from Asia. Those suppliers, operating from a closed domestic market, have and continue to enjoy strong governmental support. The growing investment in Research & Innovation by foreign countries is a significant challenge to the EU stake holder's worldwide leadership.

The European rail industry cannot compete with foreign rivals on price only. Long-term competitive success depends on continuous introduction of completely mastered innovation in the products as well as the enhancement of the quality of the products.

Similarly, rail infrastructure and operators are faced with major challenges to make rail transport the most attractive mode of transport i.e. become the first choice of travelers

and freight operators. Rail currently has about 6% share of the passenger market and around 16% of the inland freight market, both dominated by road transport. The European Commission set up objectives for modal shift towards rail and the underlying growth of transport for the next decades. For example for 2050, it means an eightfold increase in freight moved by rail and a twelve fold increase in passenger travel. This is an opportunity but also a challenge for rail. How to respond to that demand?

To achieve those objectives, besides behavioral changes and securing physical means with which to attract, manage and retain the anticipated future new volumes of demand and still remain safe, there is no doubt that in addition to policy measures, innovation will be a major driver behind the growth of the railway sector. Railway manufacturing industry, operators and infrastructure managers must come with solutions to meet the users' needs, ensuring high level of services i.e. reliable, affordable, sustainable, and being able to meet the demand for a massive increase in capacity, whilst providing increasingly seamless mobility and keeping safety at the present level.

So two main challenges lie ahead: keep the competitiveness of the Railway Manufacturing Industry and respond to the increasing demand for transport of persons and goods in Europe. With no compromise on safety while increasing its green credentials, the railway sector must embrace new technologies. There is a need for a step-change in railway research, similar to what the automotive industry has demonstrated in response to the challenge to internal combustion engine.

The specificity of the railway business must address a number of barriers to innovation such as low margins, long product renewal cycles, small product runs, lack of standardized products and rail's complex system interfaces.

3. Is Railway Industry Innovative?

Yes it is! Here are a few examples, taken from ALSTOM, demonstrating that the Railway Industry is innovative.

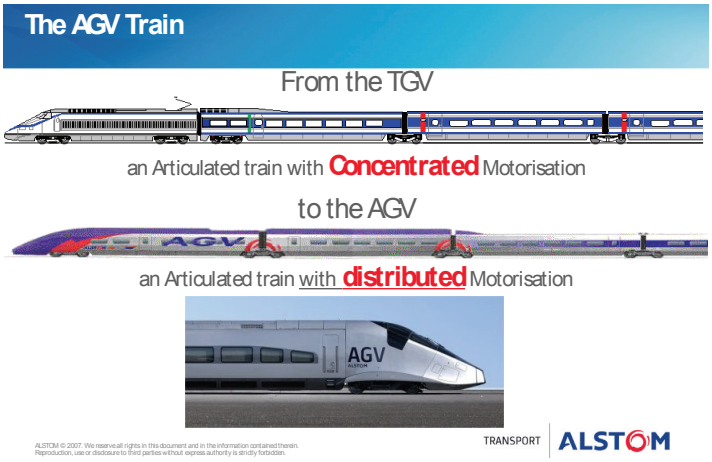

Fig. 1 AGV, an articulated Very High Speed (350km/h) train with distributed motorization incorporating innovation (Permanent Magnet Motors)

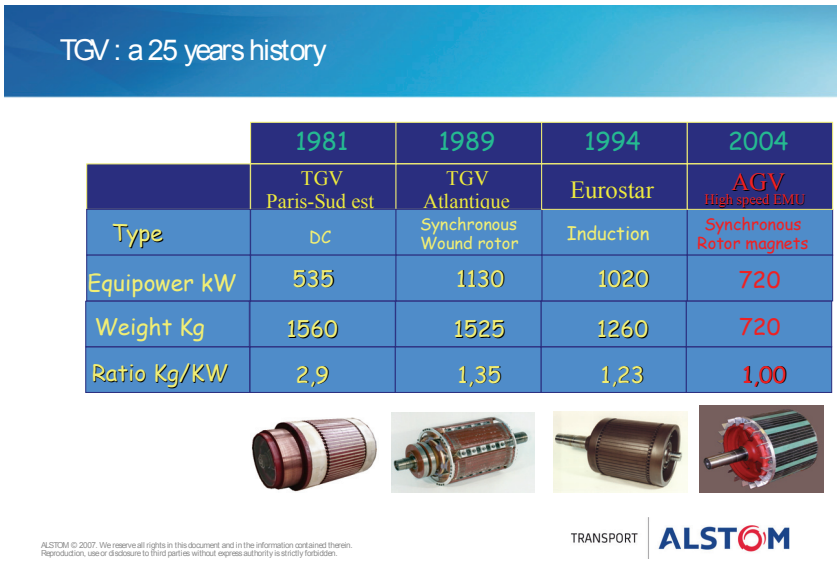

Fig. 2 25 years of innovation in Traction Motors. High Power Permanent Magnets Motors for traction is a genuine innovation

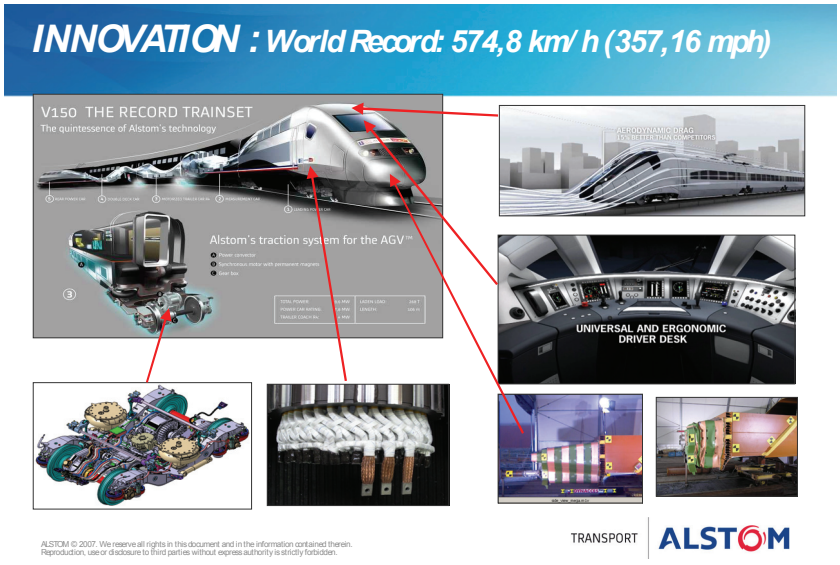

Fig. 3 A series of innovation made possible the World Record 574,8 km/h

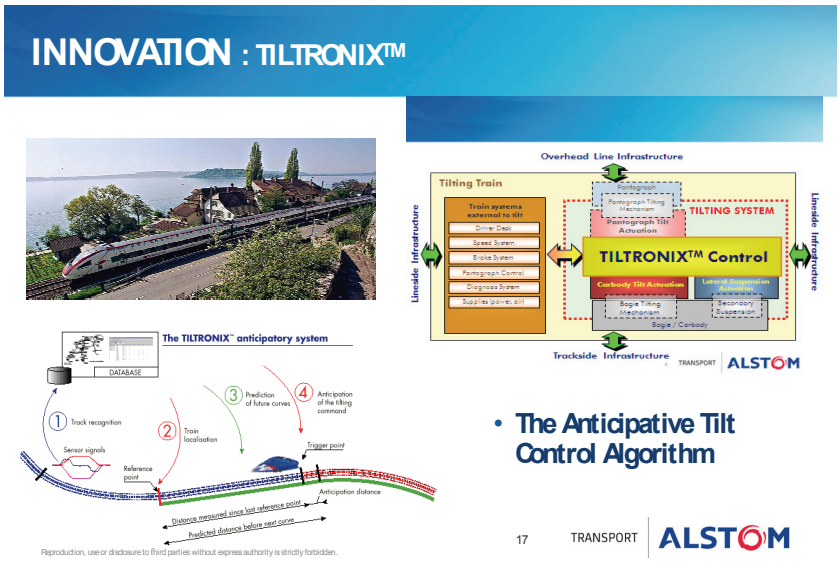

Fig. 4 Tilting Train (Pendolino). The introduction of that technology was a major breakthrough allowing increase of speeds on conventional lines

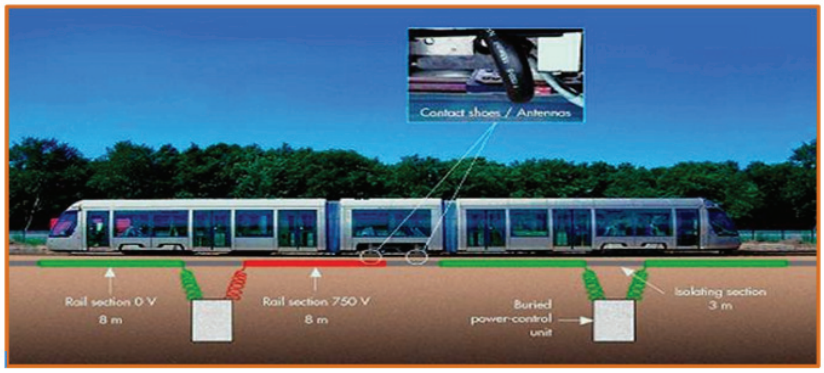

Fig. 5 The APS (Aesthetic Power Supply) catenary free power system for Tramways for a complete insertion in cities. The powered section under the tramway is shifted as the tramset is moving.

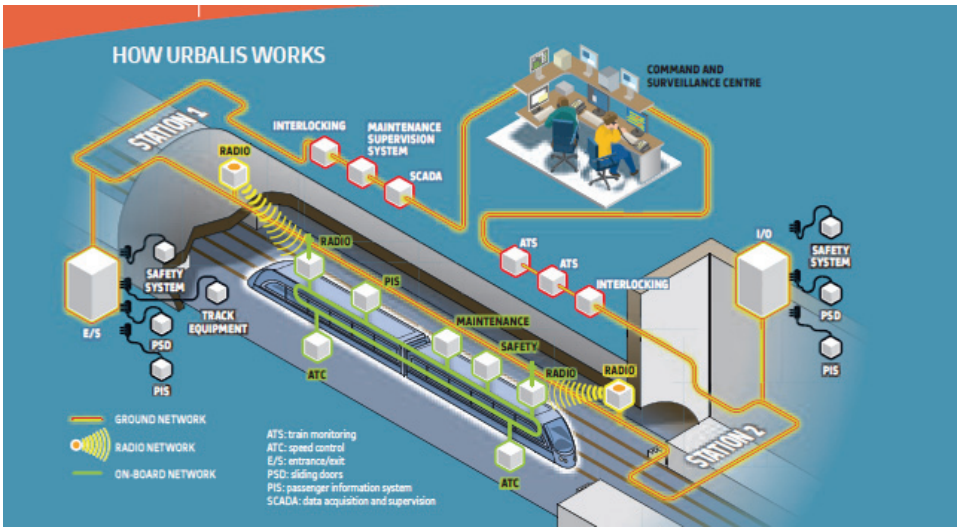

Fig. 6 The URBALISTM CBTC (Communication Based Train Control) for Driverless Metro Operation

4. What are the Limitations for R&D Long-Term Investment

There are limitations to investment in long-term R&D in the Railway Sector.

The Railway Industry is "project oriented" and characterized by the putting in service of a small series of vehicles, designed to meet the inherent constraints of unique infrastructure, electrification or control-command systems i.e. answering the specific needs of customers. In addition, the customers request "proven technologies" with warranty over several decades.

The supply industry tries to compensate the market fragmentation by the development of "platform solutions" for rolling stock and the adoption of highly standardized architectures for control command.

Because most orders are short series specific for a customer i.e. high level of product customization, this leads to low operational margins that do not allow to invest into speculative technology-oriented research.

Rail products are characterized by very long renewal cycles. A rolling stock can be operated well beyond 50 years. This does not help to introduce innovative technologies.

Another feature of the sector is the strong and complex interaction between all the components of rail system i.e. infrastructure, control-command, electrification, vehicles. Thus, it is difficult to introduce innovative technologies that can really impact the efficiency and the competitiveness of the whole system.

Lack of standardized products prevent also the introduction of innovative technologies. Other sectors (e.g. aeronautics, automotive) are driven by suppliers' offers, whereas the railway sector is mainly driven by customer/operator demands.

5. WHY IS PARTNERSHIP WITH R&D CENTERS A MUST?

The spectrum of expertise that a railway Manufacturing Company has to encompass is wide. It covers (not exhaustive) core business topics such as Material Science (for car-body-shell and bogies construction, wheel-track interaction and wear), Traction Motors, Power Electronics (for Traction Drives), to enabling "technologies/subjects" such as aerodynamics, noise & vibrations, electromagnetic compatibility through the New Technology of Information and Communication for Signaling and Passenger Information and Rolling Stock Maintenance to Industrial Design (Aesthetics) to Human Machine Interaction (Driver Cab; Traffic Management Center) to qualitative and quantitative understanding of the passenger comfort.

Considering the very wide range of expertise that a Railway Integrator must master and/or have a sufficient level of knowledge, it is easy to understand that the industry cannot invest in terms of R&D activities into all the fields as some of them are not in its core business and some fields are pushed by other sector businesses and moving very fast. Furthermore, the Manufacturer job is not to carry out research but to deliver high quality products while keeping ahead of competition for which innovation is one component but not the only one. However, it is important that the Industry be aware of new ideas popping up in laboratories, in start-up companies, in Small ad Medium Enterprises and being developed up to the level of prototype or as a product in other sectors. Scouting for new ideas, innovations within Academia as well as within public and private applied research centers is important for the Industry.

Thus, Relation/Partnership with Academia is a MUST!

To be kept updated on research activities within Academia and other R&D Centers in the domains of interest, tools are available nowadays through Internet, proceedings of Conferences. Usually, the problem is not a lack of information but too much information that leads to poor efficiency to collect the relevant ones. In the domains of the core business, one additional solution is to become a member of the Industry Liaison Program offered by a University or an Academia Group so that all of their information on Research activities and results are accessible, giving also first access to patents and licenses. This is a first level of partnership.

For the domains that are within the Core Business of an Integrator, R&D Projects are carried out by the Integrator. Those Projects are not "Engineering Projects" for which no research activities are needed. Referring to the European Union definitions, two types of Research activities are carried out by the Railway Industry: Industrial Research corresponding to TRL (Technology Readiness Level) 1 to 4 and Experimental Development corresponding to TRL 5 to 7.

Most R&D Projects span over the two activities. For Industrial Research, more basic expertise is needed and Academia Laboratories are frequently partners in the Projects. There is less participation from Academia laboratories in the Experimental Development.

Industrial sectors are more or less secretive and conservative. This is particularly true in the Railway Transport sector. The specificity of the business is such that most R&D activities have an 3-5 years time objective in terms of products or market uptake. It is a not exploratory research but it can rather be classified as competitive research. Consequently, there is a tendency to carry out such projects totally internally.

Other projects needing more basic expertise are carried out in partnership with Academia. There are several advantages to that scheme:

- Complement the expertise of industry engineers (a company has the best engineers but. there are smart and knowledgeable people outside!);
- Open the perspective of industry engineers through a genuine interaction with scientists more knowledgeable in basic spects;
- Permit more basic research work that does not appear as necessary from an engineer perspective but that can bring a deeper knowledge that helps later to understand some issues that may pop at a certain point during the course of the project;
- Give an opportunity to both sides to understand each other (different culture, different way of working), thus building up a confidence relation for the future.
- Give Academia information on future needs of Industry in terms of Research so that University R&D is more tuned to Industry needs.

  As a synthesis, this a reciprocal benefit for Industry and Academia to interact.

It is good for researchers to get out of their labs and for engineers to interact with researchers who are not tight by too much economic pressure.

6. Examples of Partnership Projects with Academia

ALSTOM Transport has a large portfolio of Contracts and Research Projects with Academic Laboratory.

A contract has a different objective. For example, there is problem appearing on a product after certain time of operational service. Understanding the root cause, means the physical/chemical/etc… phenomenon behind the problem must be identified and hopefully understood. Expertise from Academia is a must.

There are different kinds of Cooperative Research Project.

- The Industry has identified a domain in which it has to beef up its expertise. The Industry is funding a PhD student who is going to work part time in the Academia Lab as well as at the Industrial Site on a subject decided by Industry but needing an important Research work so that it can lead to the defense of a PhD dissertation. In some countries, e.g. France, the Industry is partly funded for the student salary. This is a national policy to enhance relationship between Industry and Academia. Most of the time, after getting his PhD, the young doctor is recruited by the Industry.
- The Industry decides to initiate a 3-5 year Research Project for which the expertise/ knowledge of an Academic Lab is necessary because it does not exist within the Industry. The two partners engaged into a collaborative work sharing their resources. Such a Project is organized, as all Projects within the Industry i.e. with Gate Reviews with potential NoGo at the end of a phase if the results are indicating that the development will not lead to a market uptake within a reasonable time scale.
- To boost Partnership between Industry and Academia, several Countries have established Research Programs with annual Calls for Proposals. For example, in France the Agence Nationale de la Recherche (ANR) has set up Thematic Programs, one criteria of acceptance of a proposal being that it is a joint proposal between Industry, Academia and at least one SME (Small and Medium Enterprise) if the leader is a Large Group. An accepted Proposal is funded : 25-30% Grant for a Large Group, 50% for a SME and 100% of the marginal cost of the Academic Partner.

The European Projects (funded at 50% by the European Commission) represent another kind of Cooperative Projects between the Industry (Large Groups, SMEs), Applied Research Centers and at Academic Groups. However, in EU Projects, the large number of partners does not facilitate an "intimate" relationship between an Academic Group and one of the Industry partner.

Here are some Projects carried out in partnership between ALSTOM Transport, other Industrial Companies and University Groups.

The driver of the ULTIMAT (UtiLisaTion Innovante des nouveaux MATériaux dans la construction ferroviaire) Project is the Energy Efficiency of the Mass-Transit Transport system. Metallic materials are used for carbodyshell construction. New lighter materials have emerged and are being used by other transport industries e.g. aeronautic, automotive. The objective of the ULTIMAT Project was to reduce the mass by 20%, the number of parts by 20% and the final cost by 30% while achieving the same performances in terms of resistance and reliability than a metal carbodyshell. The monitoring of the health status of such a structure was also a key issue. The Project was a joint effort between ALSTOM (Leader), Arcelor-Mittal, EADS/Sogerma Services (manufacturing composite parts), a railway supplier of thermoplastics parts and several universities (Université de Valenciennes; Ecole des Mines de Douai and the Université de Technologie Compiègne). Those university groups with a large expertise on composite materials based on years of research brought their knowledge to select the right materials, to test samples, to derive numerical models, etc… This Project that ended with the construction of a carbodyshell was successful in term of research but also in term of partnership between Industries and Academia groups.

Traction Drives are one of the core sub-systems of a Railway Integrator. ALSTOM manufactures Traction Drives i.e. Motors and Power Electronics equipment. The Power Electronics components installed on trains are using IGBT (Insulated-Gate Bipolar Transistor) that are Power Semiconductors devices made of silicon materials characterized by high efficiency and fast switching and able to control large amounts of power, for example to drive motors. They have limitations in terms of acceptable maximum temperature. Other materials are being looked at such SiC (Silicon Carbide), GaN Gallium Nitride) but also Diamond for the future. In partnership with Academia Groups that are leading the Project, Industrial companies and Semiconductor SMEs are working at exploring the potential of the Diamond material. The scientific work is on mastering the growing process of diamond monocristal doped with bore ions.

The STEEM (Tramway System for Maximum Energy Efficiency) is another project carried between ALSTOM Transport, RATP (the mass-transit operator in Paris) and IFSTAR (French Research Institute on Surface Transport). The objective was to develop an Energy Storage System using Supercaps supervised by an Energy Management System to operate a Tramway between stations without using a power line. The technology was successfully tested on Line T3 in Paris in commercial service i.e. with passengers onboard.

The new technology of Urban signalling system is called CBTC (Comunication Based Train Control). It is based on high-rate communications between the trains and the wayside. This communication system must be robust, adaptative, providing high rates while using minimum radioelectric ressources. The environment of mass transit is complex as trains are operated mostly in tunnels and other confined zones. The MOCAMIMODYN (MOdeling of DYNnamic MIMO ChAnnels) Project studied the potential of new technology such as MIMO (Multiple Input Multiple Output) as a promising technology. More

specifically, as performances depends on the characteristics of the propagation channel (the tunnel), it is necessary to take into account the dynamics characteristics and the variability of the propagation channel.

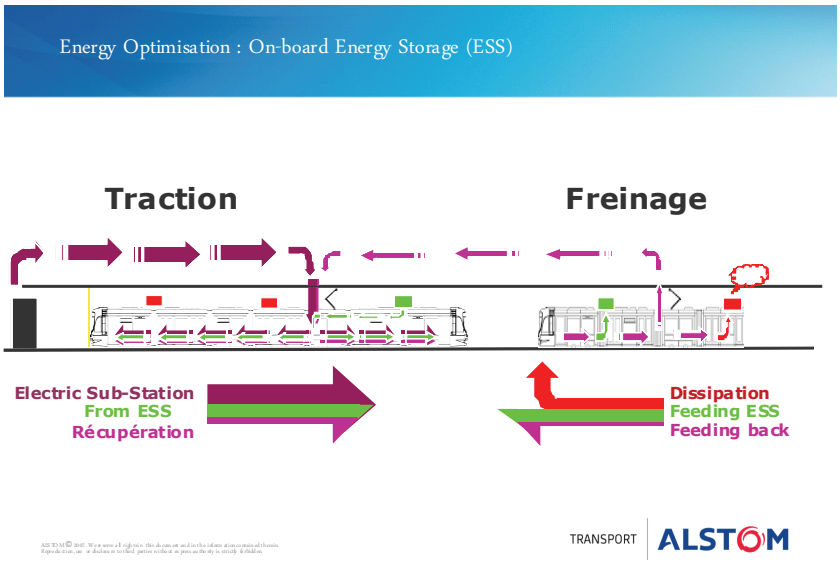

Fig. 7 With an Energy Storage System onboard a Tramway, part of the Braking Energy can be recovered, stored and reused for Traction

The partners were ALSOM Transport, IFFSTAR, Xlim SIC (University of Poitiers) and Telecom Bretagne (Engineering School in Information and Communication S&T).

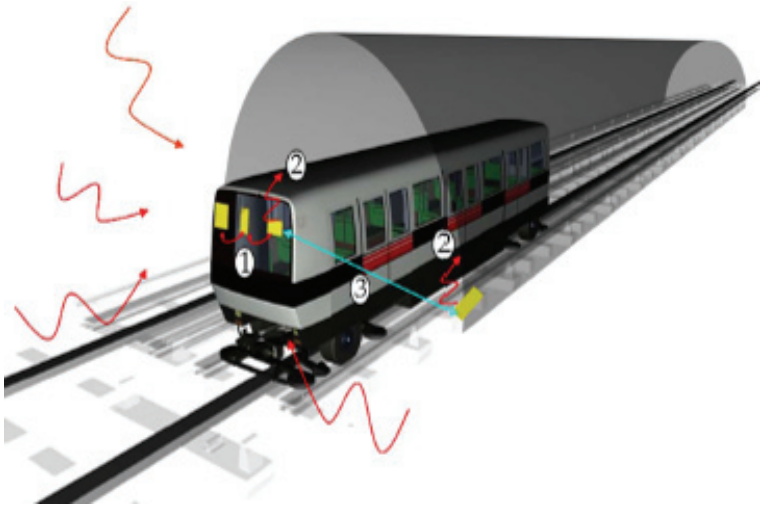

Fig. 8 Schematic illustration of radio-propagation in a tunnel in presence of moving trains

Projects are also carried at the European level through funding by the European Commission (Frame Work Program). Here are examples stressing cooperation between Academia and Industry.

Several Projects funded by the European Commission are tackling the issue of certification of trains. Certification against EN standards together with the relevant technical annexes of the High Speed TSI (Technical Specifications for Interoperability) extend train delivery times for months. Therefore, certification adds to the cost of the product. Furthermore, the physical tests that are performed do not capture all operating conditions. Thus there is a risk of failure or unsafe approximation in such tests. In addition, uncontrolled environmental and other boundary test conditions can influence results. The costs and duration of tests performed in such conditions are also often increased by the need to do these tests several times so as to explore as much as possible all the range of environmental and boundary conditions and secure the results.

Three years ago, 3 Projects were submitted accepted by the European Commission (7^{th} Frame Work Program) and clustered into the TRIOTRAIN "holding", an acronym for "Total Regulatory acceptance for InterOperable TRAIN". The three Projects (DYNOTRAIN, PANTOTRAIN and AEROTRAIN) were dealing with key railway interoperability issues. The objectives were to propose an innovative methodology that will allow multi-system network and route approval in Europe to become a faster, cheaper and better process for all involved stakeholders.

For the DYNOTRAIN Project (still going-on), the work is leading to improvement in cross-acceptance of track test, introduction of a certain level of Virtual Certification and the definition of the track loading limits related to network access.

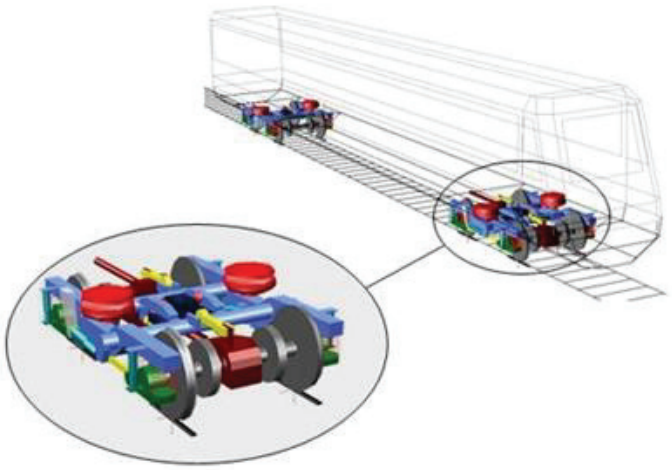

Fig. 9 The DYNOTRAIN Project deals with Railway Dynamics

In the AEROTRAIN Project (closed in June 2012), the following results were achieved :

- Propose harmonization of European and national standards to reduce costs and time of certification;
- Propose the replacement of existing cross-wind and slipstream tests with new alternatives without reducing safety;

- Introduction of virtual testing for head pressure pulse loads and corss-wind aerodynamlic loads;
- Closing of open points in the High Speed and Conventional Rail (limit values and new certification procedures).
- The PANTOTRAIN Project was dealing with the Pantograph-Catenary Interaction.

Two new Projects were initiated on other domains: ACOUTRAIN (Acoustics) and EUREMCO (ElectroMagnetic Compatibility).

These five R&D Projects are genuine examples of cooperation between Railway Stakeholders (Manufacturers, Suppliers, Railway Undertakings and Infrastructure Managers) and University Groups.

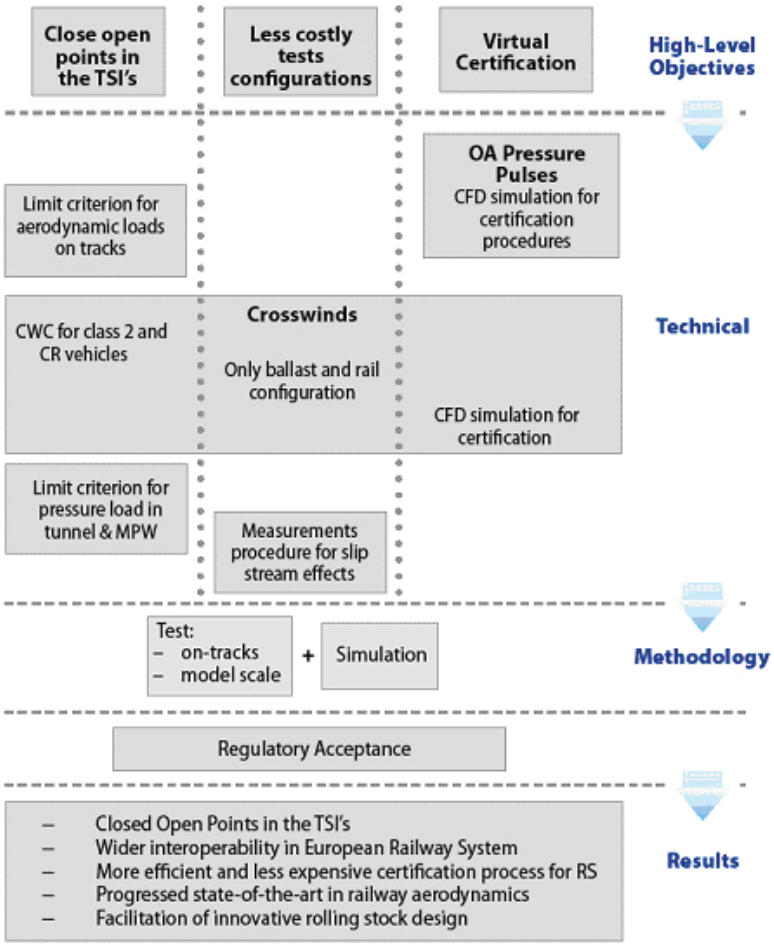

Fig. 10 AEROTRAIN: from high-level Objectives to Results

7. THE PROPOSED SHIFT2RAIL JTI

The respond to challenges lie ahead the Manufacturing Industry and the Service Industry has proposed an important Program within the Horizon 2020 (the Commission R&D Program for 2014-20) through a Public-Private Partnership (PPP), more specifically a JTI (Joint Technical Initiative).

The initiative starts from what has been expressed above i.e. strong, market-driven, R&I capabilities, leading to innovative and far-reaching programs, are isntrumental to European industrial leadership and to answer the challenge of the future large increase of persons and goods mobility in Europe.

The SHIFT2RAIL JTI will tackle those challenges through a step-change in railway research and innovation and due to its collaborative nature, will allow to shorter time-to-market for key innovatiosn, positively contributing to both modal shift targets and the competitiveness of the European industry on the world market.

The SHIFT2RAIL initiative will bring together the stakeholders of Railway Research including Academia. This program will represent a real opportunity for Academia to participate to Industry R&D Projects.

8. CONCLUSIONS

To keep its world leader position, the European Railway manufacturing industry must invest into R&D to be able to offer products and systems that are affordable in terms of acquisition costs and also with a low Life Cycle Cost, of the highest quality and have even better than now, the constraints of a sustainable development.

The Rail Sector has an important role to play to respond as other transport sectors to the future demand for the transport of persons and goods.

To reach those objectives, a sizeable investment in R&D has to be made by the actors of the sector. The SHIFT2RAIL Project is the Industry answer to that challenge.

A transport system can be sustainable only if all aspects of sustainable development are taken into account. By setting high vehicle requirements with respect to safety and environmental efficiency for example, cars become more expensive and thus less affordable. A policy that would lead to low income households driving in unsafe and environmentally inefficient vehicles, would have negative consequences for social sustainability. A solution to this is to provide good alternatives through public transport, but this is not always possible and may be unaffordable for the authorities.

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KONKURENTNOST EVROPSKE ŽELEZNIČKE INDUSTRIJE I PARTNERSKIH INDUSTRIJA: ONO ŠTO SE MORA JE PARTNERSTVO SA UNIVERZITETOM

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Železnička industrija se može podeliti na industriju dobavljača nabavke koja nudi proizvode i operativnu industriju (operatori i upravljači infrastrukture) koja održava železnički sistem na nominalnim radnim uslovima i nudi usluge za transport lica i dobara. Industrija železničke proizvodnje je svetski lider u snabdevanju sa više od 50% svetske proizvodnje sa velikim delom proizvodnje lociranim u Evropi ali njen položaj sada ugružava ulazak novih igrača, uglavnom iz Azije. Što se tiče uslužnog domena, železnički transport je takođe vitalan za evropsku privredu. Radi održivog razvoja evropske ekonomije u narednim godinama i decenijama, železnički transport mora igrati vodeću ulogu sa drastičnim povećanjem procenta robe i putnika koji su na taj način prevoženi onako kako to navodi Bela knjiga Evropske komisije za transport iz 2011. Da bi zadržala svoju vodeću ulogu proizvodne industrije sa velikim brojem poslova u Evropi, železnička indutrija nabavke mora povećati svoju konkurentnost putem inovacija. Kako bi podržala rast železnice u Evropi, to jest, da bi zadovoljila potrebe korisnika, operatori i upravljači infrastrukture moraju biti sposobni da pruže visok nivo usluge, tj. onaj koji znači pouzdanost, realne mogućnosti i održivost, kao i što moraju biti u stanju da zadovolje potražnju za vrlo visokim stepenom sigurnosti tog načina transporta. Tokom prošle decenije, železnički sektor je ispoljio svoju sposobnost za inovacije. Dovoljno je da pomenemo veoma brze vozove, vozove sa naginjanjem, sistem za signalizaciju ERTMS, tramvaje bez trole, itd. Međutim, u tom industrijskom sektoru koji je "usmeren na projekat" postoje ograničenja koja sprečavaju dugotrajna ulaganja u istraživanje i razvoj iz brojnih razloga: zbog niskih operacionih margina, kratkih serija sa visokim nivoom prilagođavanja kupcu, dugim ciklusima (proizvodena vozna sredstva mogu se koristiti više od 50 godina), konzervativizmom koji ide u prilog dokazanim tehnologijama i koji znači veoma spor prodor inovacija, opterećenje troškovima, itd. Evropski železnički sektor, ako želi da odgovori na izazove sa kojima se suočava, mora da shvati da nema drugog puta sem stepenastog ulaganja u istraživanje i razvoj kako bi se iskoristio sav potencijal inovacija do kojih dolazi u univerzitetskim laboratorijama kao i u razvoju istraživanja i razvoja u drugim sektorima preko prilagođavanja njihovih rešenja za potrebe železnice. Univerzitet ima važnu ulogu u svemu tome jer industrija koja nije na mestu na kome se mogu razvijati nove ideje, gde se one istražuju i podhranjuju, nema resurse sa kojima bi ostvarila taj zadatak i svu drugu neophodnu ekspertizu. Otud je partnerstvo između industrije i univerziteta ONO ŠTO SE MORA USPOSTAVITI.

Ključne reči: *železnica, konkurentnost, univerzitet, istraživanje i razvoj*