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High-speed railway and the digital future

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Abstract

This paper deals addresses the current state of High-Speed Railway with respect to signalling and train control technology and how digitization will play a significant role. The analysis includes proposal in the medium term for improvements from current situation.

Different aspects of the current High-Speed Railway are described, including their success factors, the requirements of the railway operators and the technology currently used. It also describes the current portfolio of products offered by Siemens for the signalling of High-Speed Railways.

Finally this paper describes a potential future for High-Speed Railway and how digitalization will play a key factor in its transformation. As an example of the systems that benefit from digitalization, ETCS Level 3 system is briefly described.

Keywords: high-speed railway, digitalization, ETCS, future, smart data

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1. Introduction

Digitalization is one of the key factors to ensure an increasing use of railway, especially High-Speed Railway and to achieve three important mobility objectives: efficiency, reliability and sustainability.

The High-Speed Railway has evolved from the initial projects. The evolution of the technology during the last years has produced several techniques and applications that can be used by High-Speed Railway. Although, due to the High-Speed Railway safety requirements, every technological step in railway technology has been taken with great care. It is time to evaluate the current state of the railway and define the functionality required for the medium term.

The paper describes these applications and the development of railway signalling technologies, linked with the digital era. One of them is ETCS Level 3, where Siemens have been working in the last years, and where wireless communication will make part of track infrastructure unnecessary. This will improve the availability and maintenance of infrastructures, facilitating greater occupation of the railways and total safety.

2. State of the High-Speed Railway today

This chapter describe the success factors of the High-Speed Railway, the current requirementsof the different stakeholders and the Siemens signalling products related with High-Speed Railway.

2.1 Success factors

Today High-Speed Railway is worldwide perceived as a transportation system which is:

- Safe
- Comfortable
- Reliable
- Green
- Fast
- Efficient

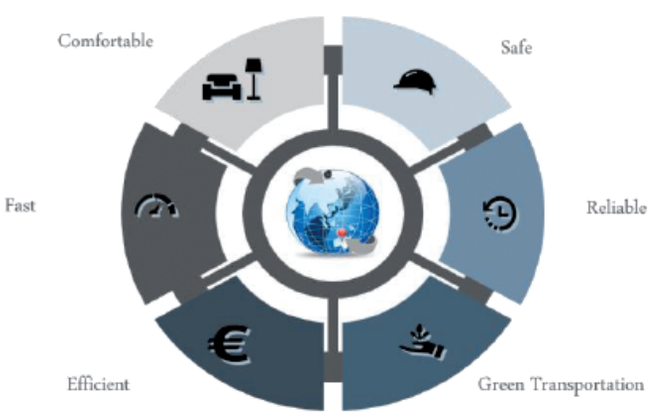

Figure 1: Success factors

Safety is one of the main aspects of a High-Speed Railway. The number of fatalities experienced on High-Speed Railways is much lower than in other transport systems. Signalling systems used for the control of High-Speed Railways meet the highest safety standards, ensuring that the likelihood of a wrong side failure is very low.

Comfortability is provided by modern rolling stock and its associated services on board. Another important element that contributes to comfortability is the reduced time that the passenger needs to be at the station before the departure of the train. This is really an advantage when compared with other transport systems as aviation. Another positive factor is that main train

stations are located in the centre of the cities, which facilitates access by public transport, as well the reduced time necessary to reach the main stations.

The reliability of the system ensures that train departure and arrival times are consistently met. Punctuality rates are the best among current transportation systems.

High-Speed Trains are usually powered with electricity. This reduces the CO^2 emissions during operation and in its complete lifecycle. That is why it can be considered as a **"Green transport"** system (although electric power can be generated by several means and some of them emit CO^2 into the atmosphere).

Finally High-Speed Railway is the **fastest** ground transportation system. Due to this, and the characteristics described above, it is perceived as an **efficient** transportation system.

2.2 Requirements from operators

From a High-Speed Railway operator s point of view the main requirements for this type of railway are similar to other railways, transportation systems or industrial businesses. Requirements as Availability, Ease of Maintenance, Efficiency and Low Lifecycle Costs (LCC) can be applicable to different areas. Even so, achieving those requirements requires a clear definition of the targets and their associated costs.

Apart from those requirements, there are other requirements specific to the Railway business. They are: Standardization (interoperability) and Improved transport capacity. Although standardization is also claimed by most industrial business, one of the key aspects linked with standardization is Interoperability. This aspect is closely related with ground transportation.

Interoperability (as the one provided by the ERTMS/ETCS signalling system) is a key element to provide operators the possibility to operate High-Speed trains across borders with the same signalling system and, eventually, with similar if not the same rules. Interoperability saves efforts and time in terms of definition of operational rules, equipment investment, time, Interoperability also contributes to improve the overall safety of the railway, as all equipment behave exactly in the same way in despite of the country they operate, reducing operational procedures that are sometimes more prone to human errors.

Another important requirement for the High-Speed Railway is the increase of the transport capacity and, associated to it, the improvement in headway. We can have very fast trains but, if we cannot adapt the operation to customer demands, this will not be enough. Improving transport capacity allows the High-Speed Railway operator to have more trains per hour, increasing the number of passengers per hour. This is one aspect that is becoming more relevant as the population increases, especially in the main cities where the number of passengers increases. Systems that can best contribute to increasing transport capacity are modern signalling systems such as ETCS level 2.

2.3 Signalling Solutions

Modern High-Speed lines use ERTMS/ETCS as the preferred signalling system. And in most projects ETCS Level 2 is the solution chosen. ETCS Level 2 system reduces the amount of equipment to be installed on the track and provides a better headway capacity than other systems used in previous decades. Siemens TrainGuard system provides a complete ETCS Level 2 solution for ETCS Level 2 applications.

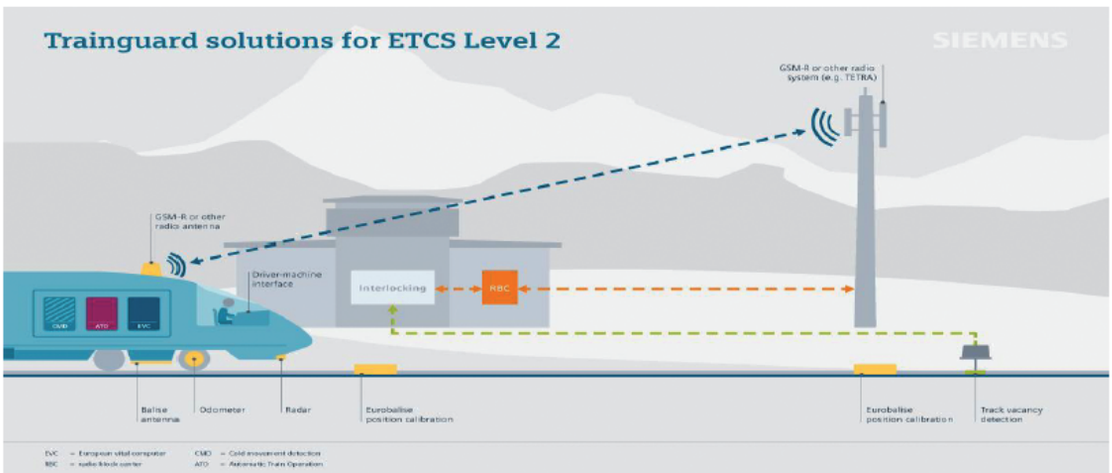

Figure 2: ETCS Level 2

3. High-Speed Railway needs

In the future High-Speed Railway will probably have the following needs:

Better Availability: Even if current High-Speed Railway shows high availability figures, once the infrastructure is used at its limit (i.e. more passenger and freight traffic), availability will become even more important. Use of redundant and distributed systems is the basis for ensuring and increasing availability. The use of cloud computing and virtualization allows having redundant systems and immediate fault recovery in case of disasters.

Reduced Maintenance: Maintenance costs are an important factor in Life Cycle Costs. The use of Smart Data based systems, which can provide predictive maintenance, will reduce maintenance costs and also increase availability. Reducing the amount of equipment also leads to a better maintainability: less probability of faulty elements and less requirements for spares and maintenance personnel.

Increased Efficiency: The usage of Automatic Train Operation and/or Driving Advisory Systems for optimal driving profiles helps to reduce the carbon footprint. The use of cloud computing maximizes the efficiency of investment.

New technology: Digitalization is becoming a must in many businesses. And this also applies to High-Speed Railway. Use of wireless technology, improved Security, Smart Data strategies and implementation of new signalling systems such as ETCS level 3 for High-Speed Railway, will open the door to a digital future.

4. The Future of High-Speed Railway

4.1 Retrospective

Spain has had the High-Speed Railway since 1992. If we look at the progress of technology over the last 25 years, we can provide examples of technology that did not exist at that time, but are essential today:

- Internet (in 1992 it was very primitive)
- MP3 players such as IPod
- GSM (in 1992 it was just started)

- GPS
- DVD
- Social Networks
- WiFi
- Use of Solar Power for end consumers

Some of them (e.g. Ipod, DVD), are now even becoming old technology. They were very successful and disruptive inventions but technological progress and digitalization has been so rapid that in less than 20 years they became obsolete.

However the progress of High-Speed Railway has not been so fast. It is true that there have been several major steps, but High-Speed Railway has several limitations to a rapid progress of technology. One of this limitations is Safety. The High-Speed Railway has to be Safe since any type of incident / malfunctioning can lead to an accident with hundreds of deaths / injuries. This is why the technology adopted by the High-Speed Railway has to be very mature and Proven-By-Use.

4.2 Where we go?

However passengers, operators and maintainers are demanding from High-Speed Railway that provides better performances and services. Requirements such as faster trains, higher train frequencies, improved connectivity, use of open systems... demand from High-Speed Railway technology to move faster. Of course we cannot expect High-Speed Railway to progress at the same pace as IT technology but we can expect broader use of current technology based on the digitalization process. This will include:

- Advanced Centralized Control: including SCADA and concentrate all High-Speed Railway techniques (signalling operation, maintenance, rolling stock,) in one place with the same management systems.
- Smart data and Cloud Computing: This will provide, among other benefits, comprehensive maintenance management. It will also reduce the obsolescence hardware costs and CAPEX and OPEX costs related to computing hardware. The use of open standards will also be beneficial to this step. This technology is also linked to Smart Access technology that will reduce access time to High-Speed Trains and increase Security.
- Virtual reality: that will be applied for maintenance and training purposes. Other existing technologies will be used on High-Speed Railway such as 3D printing to supply spares just in time. The use of Drones and Robots would be beneficial for maintenance and security activities.
- Intelligent Systems: that will be applied to High-Speed Railway to increase frequency of trains through dynamic distancing, conflict detection and resolution and the use of intelligent surveillance to automatically solve any type of situation during the operation of the High-Speed Railway.

4.3 Siemens proposal and the basis for the Digital Future

In all the systems described above there is a common topic: Digitalization. The use of digital technology will radically change the shape of our High-Speed Railways.

Siemens is focused on Digitalization trend in all its activities and businesses: from industry to transportation.

Siemens proposal for the digital future of High-Speed Railways is focused on:

Safety and Security: Future High-Speed Railway systems will become more complex in terms of functionality and interfaces. This will require continuing to ensure the safety of the system as some elements such as signalling require being safety critical. But on top of that, Security is increasingly important, especially in all technological areas (IT Security). Special measures will be required to ensure that High-Speed Railway Security is not violated, as a Security failure may cause a failure in Safety. IT Security implementation will be required for most IT related systems on a future High-Speed Railway.

A sustainable and green system: Reducing carbon footprint can be achieved through the use of advanced Automatic Train Operation (ATO) and Driving Advisory Systems, which are capable of providing optimized driving strategies depending on the demand. This includes from Ecodriving when the requirements in transport capacity are medium-low to the maximization of the transport capacity (with greater energy consumption) when the transport capacity requirements are higher. In addition to this, conflict detection and resolution strategies will optimize the use of tracks and trains avoiding unproductive waiting times.

Improved Traveller experience: By using Smart Data to provide immediate information to all High-Speed Railway stakeholders (operators, maintenance personnel,..) and especially to the passenger in such a way that travelling in a High-Speed Train is an easy and pleasant experience.

Intelligent investment: This will be achieved through the use of current technologies and tools. As an example the use of Cloud Storage and Cloud Computing, so that investment costs related to hardware assets can be reduced. This would also offer the possibility of having distributed computing that offers better availability and the possibility of centralizing, in a single application, all management of High-Speed Railway. Extensive use of wireless technologies will also help to reduce installation and maintenance costs. As an additional intelligent investment initiative, it can be included the ETCS Level 3 application, as described below.

4.4 ETCS Level 3

ETCS Level 3 is the future of signalling systems. It combines most of the advantages of existing signalling systems with few drawbacks.

The main advantages of this system are:

- Based on existing ETCS Level 2 system
- Interoperability (it is an ETCS Level and will become interoperable)
- Very low requirements for track detection systems (low CAPEX and OPEX)
- Based on radio communications
- The usage of Moving Block/Virtual Block technology notably improves the performance of Level 2 as it can potentially provide the best possible headway improving transportation capacity

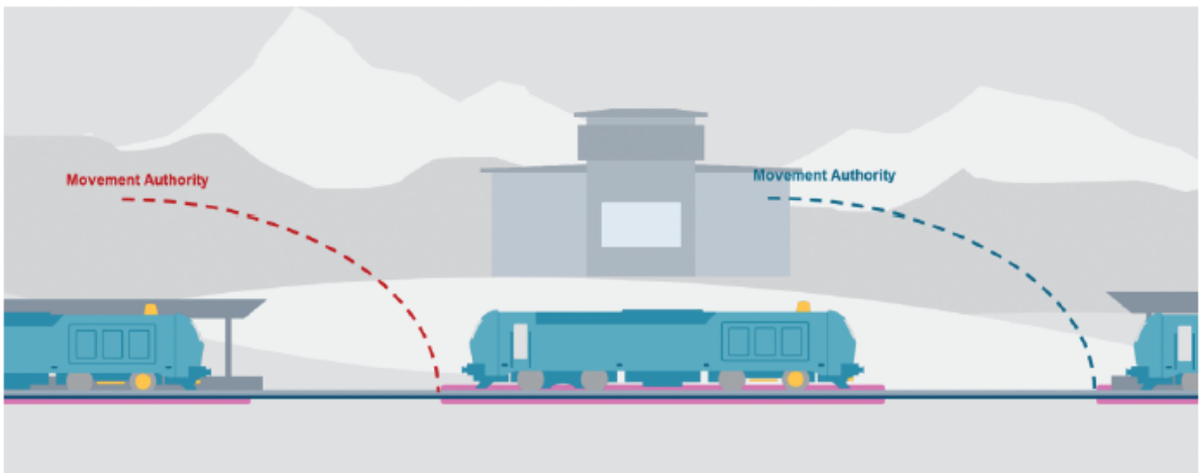

Figure 3: Moving Block Principle

Due to the requirements of High-Speed Railways, now and in the future, ETCS Level 3 may be the optimal signalling solution since it reduces the CAPEX and OPEX linked to these projects, providing flexibility in terms of transport capacity. Interoperability also ensures competition and long Life Cycles.

5. Conclusions

Implementation of new technologies in High-Speed Railways takes more time than in other sectors. One of the main reasons is the need to have Proven-In-Use systems and include requirements for Safety Critical systems. However digitalization is a trend that is also reaching the railway and is expected to accelerate railway digitalization during the next few years.

High-Speed Railways will use Digitalization to improve CAPEX and OPEX, to have better travel experience, to increase the availability figures and reduce carbon footprint. The use of Smart Data, Cloud Computing and new interoperable systems such as ETCS level 3 will be the artefacts for this digital future.