WHITE PAPER

MODERNIZING RAIL INFRASTRUCTURE WITH COTS TECHNOLOGY

Rail Control and Safety Technology

Profiting from the wave of modernization in the global rail industry

By Sedat Sezgün, Group Vice President Business Segment Rail

How system integrators can quickly develop cost-efficient and digitizable interlocking, level crossing and signaling solutions based on standardized commercial-off-the-shelf (COTS) technology.

Executive Summary

To remain capable of satisfying future transportation requirements in a competitive environment, the global rail industry is faced with the task of switching to digital technologies as quickly as possible. To reach this goal, the existing rail infrastructure needs to be brought up to speed first which results in a massive need for modernization of the technical infrastructure – with rail control technology playing a major role. This urge for quick modernization represents a huge challenge to the rail industry as it has to fight on several fronts at the same time: from tight budgets, over heavily diversified historically grown automation architectures and thousands of outdated rail track kilometres, up to a complex landscape of national norms and approval processes. The most cost- and time-efficient approach for the global rail industry to overcome the immense modernization backlog and to achieve its ambitious growth goals lies in using proven technology and components already available on the market. This whitepaper takes a look at the status and the challenges of rail infrastructure modernization in different parts of the world with a focus on rail control and safety technology. It then describes what technological trends are currently shaping the industry. Finally, the whitepaper outlines how system integrators can develop their own interlocking, level-crossing and signalling solutions with a significantly reduced time-to-market in order to profit of the increased demand for control solutions due to the wave of modernization currently happening in the global rail industry.

Sedat Sezgün
Group Vice President Business Segment Rail

Having graduated from Darmstadt University of Applied Sciences in 2006 with a degree in Electrical Engineering, Sedat Sezgün subsequently joined HIMA with responsibility for rail customers. He was appointed Head of Rail Segment in 2015.

E-mail: s.sezguen@hima.com

Table of Content

1. Digital transformation pushes rail industry for infrastructure

We currently live in an era of unprecedented transformation of mobility and transport. This is true for rail as well. There are several strong drivers jointly pushing the sector to new limits:

First, we see a continuous trend of urbanization and growing world population with mega cities asking for increased passenger transportation capacities. Digitization will have an important role to play here, considering the improvements in efficiency and environmental sustainability it can offer. According to the “Feasibility Study on the Roll-out of ETCS and Digital interlockings (DSTW)”[1], digital technologies could increase passenger and goods traffic capacity by up to 20 %. Rail could become the backbone of transport between and within cities, in coordination with other transport modes to provide the door-to-door services.

Second, the growing awareness for the consequences of climate change and increasing air pollution in urban centers lead to a greater demand of environmentally friendly means of transport that reduce congestion and air pollution. Rail transport has proven to be one of the most eco-friendly means of transport as it can use green energy, causes nearly no emissions, and resolves the problem of congestion in city centers. Furthermore, digital technologies have a lot of potential for energy efficiency gains in transportation, e.g. smart rail traffic management could reduce energy wasted through stop-and-go, especially for heavy freight trains.

And third, digitization has heavily transformed the perception of mobility and people’s expectations with regard to modern transportation (e.g. sharing economy). With digital services like mobile commuting apps, real-time information and digital user interfaces have become part of the everyday life. Railway passengers now ask for the same level of services for their end-to-end journey as they know it from other parts of life (Mobility as a service). On top of this, new players enter and disrupt the mobility market with platform-based business models.

Advantages

Increased passenger capacities

Most eco-friendly method of transport

Digitized processes (Mobility as a service)

Meeting today’s transport challenges while providing the seamless, user-centric services that people and businesses expect is not an easy task. Success will depend on the rail sector’s ability to adopt new mindsets as well as new technologies. Digital technologies are fundamentally changing trains, rail infrastructure and processes. Innovations like automated train operation (ATO), intelligent maintenance and networked logistics become a reality. In fact, rail transport is about to make a quantum leap which UNIFE, The Association of the European Rail Industry, describes as follows:

“From a rigid value chain linking suppliers, integrators and end-users, the sector is evolving towards dynamic networks with added-value, joining suppliers, integrators, technological platforms, mobility service provider, clients in permanent interaction.”[2]

The digital transformation of the rail industry comes with huge opportunities as well as with significant challenges. Let us first look at the opportunities. Digitization will allow the rail sector to improve its efficiency and competitiveness. By adopting digital technologies, the railway traffic will become even more climate-friendly, safer, more economical, and more comfortable. For example, traffic capacity and reliability can be increased through intelligent traffic management or automated train operation. Operational and energy costs can be reduced through smart maintenance and energy management concepts. Digital interlocking systems allow for a denser train sequence and thus optimum utilization of the existing infrastructure. The large-scale introduction of standardized digital interlockings will significantly reduce maintenance costs.[3]

Now, let us talk about the challenges. Rail digitization requires significant financial investment. Often, the resources for investing in new technology and modernization are lacking though. Furthermore, maintenance has been neglected for long due to shrinking budgets and limited number of qualified staff. This has led to systems operating past the end of their lifetime. The huge amount of outdated technology still in the field makes digitization a challenge. There are still many single-market proprietary solutions in use that make interoperability and consistent data exchange nearly impossible. With increased connectivity, rail infrastructure becomes also more exposed to cyberattacks so that any successful digitization strategy requires a sound security concept.

According to experts, technology is probably not the biggest challenge of rail digitization though: “The switch from electro-mechanical devices to electrical and then digital components or the implementation of automated systems will not be the most

difficult aspect. (…) Developing a new mindset is by far the more complicated challenge for rail operators and authorities, which will have to share data and consolidate business resources."[4] The rail industry must improve its competitiveness to compete with other modes of transport such as low-cost airlines or buses that are becoming serious alternatives to main-lines transport. The key to the necessary boost in productivity and efficiency lies in the consistent deployment of modern technologies. Therefore, we currently see a huge wave of infrastructure modernization taking place in the global rail industry. Countries such as China, India or Germany invest huge sums in new technology, e.g. replacing mechanical/electromechanical relay stations by electronic signal boxes in big style.

The massive modernization backlog in combination with rising cost pressure has increased the need for flexible, cost-effective automation and control solutions in the railway industry worldwide. Amongst these urgently needed technologies, signaling and control solutions are the "hidden champions of Rail 4.0"[5], the digital railways era. With the help of modern control and security technology they monitor and control rail transport through interlockings, signals and level-crossings or onboard train protection systems. In times of networked rail transport, state-of-the-art computer systems in digital signal boxes locate trains precisely and calculate in real-time who can drive on which track or section of the track. They control the speed as well as the braking and starting of trains accordingly. Furthermore, they enable decentralized control concepts. While traditional interlockings are location-bound and only responsible

[1]McKinsey & Company, Machbarkeitsstudie zum Rollout von ETCS/DSTW, 2018
[2]UNIFE, Position Paper on Digitalisation of Railways, Brussels 2016
[3]Deutsche Bahn, Broschüre Digitale Schiene Deutschland, Berlin 2018
[4]European Parliamentary Research Service, European Parliament Briefing, Digitalisation in railway transport – A lever to improve rail competitiveness, Brussels 2019
[5]Verband der Bahnindustrie in Deutschland (VDB), Politikbrief, Berlin, February 2016

for a very limited section of the route, digital control centers can control large parts of the system regardless of their location of the railway network. For example, a digital signal box can replace up to 15 old, mechanically operated signal boxes, thus reduce the costs for maintenance by up to 30 %.[6]

As digitization is putting constant pressure on the rail industry, the market is in urgent need of technology that is quickly deployable. At the same time, this technology must be interoperable (standard interfaces), globally available (certification), digitally enabled (programmable) and flexible (non-proprietary). The only technology fulfilling all these criteria is proven Commercial-off-the-Shelf (COTS) technology. For system integrators to develop modern interlocking, signalling, level-crossing and train protection systems on their own is time-consuming, expensive and needs a lot of special functional safety knowledge. By using proven certified SIL4 COTS technology, they can significantly reduce their time to market. And development speed can be decisive: Despite the rail industry being a somewhat closed market with high entry barriers, if existing players do not develop solutions suitable for the networked age soon, they risk to get left behind or lose market share to new players.

Standard technology is the future. A study by the International Railway Research Board (IRRB) and the International Union of Railways (IUR) indicates that standard technology will be key to success. The research identifies a "convergence towards a global rail system with a maximum degree of interoperability, as well as a global railway supply market. Many rail and transit networks around the world are under enormous pressure to bolster their infrastructures and enhance their services, while facing the realities of decreasing public investment to respond to steadily increasing demand.[7]

replacement of up to 15 mechanically operated boxes by one digital signal box

reduction of maintenance costs by up to 30 %

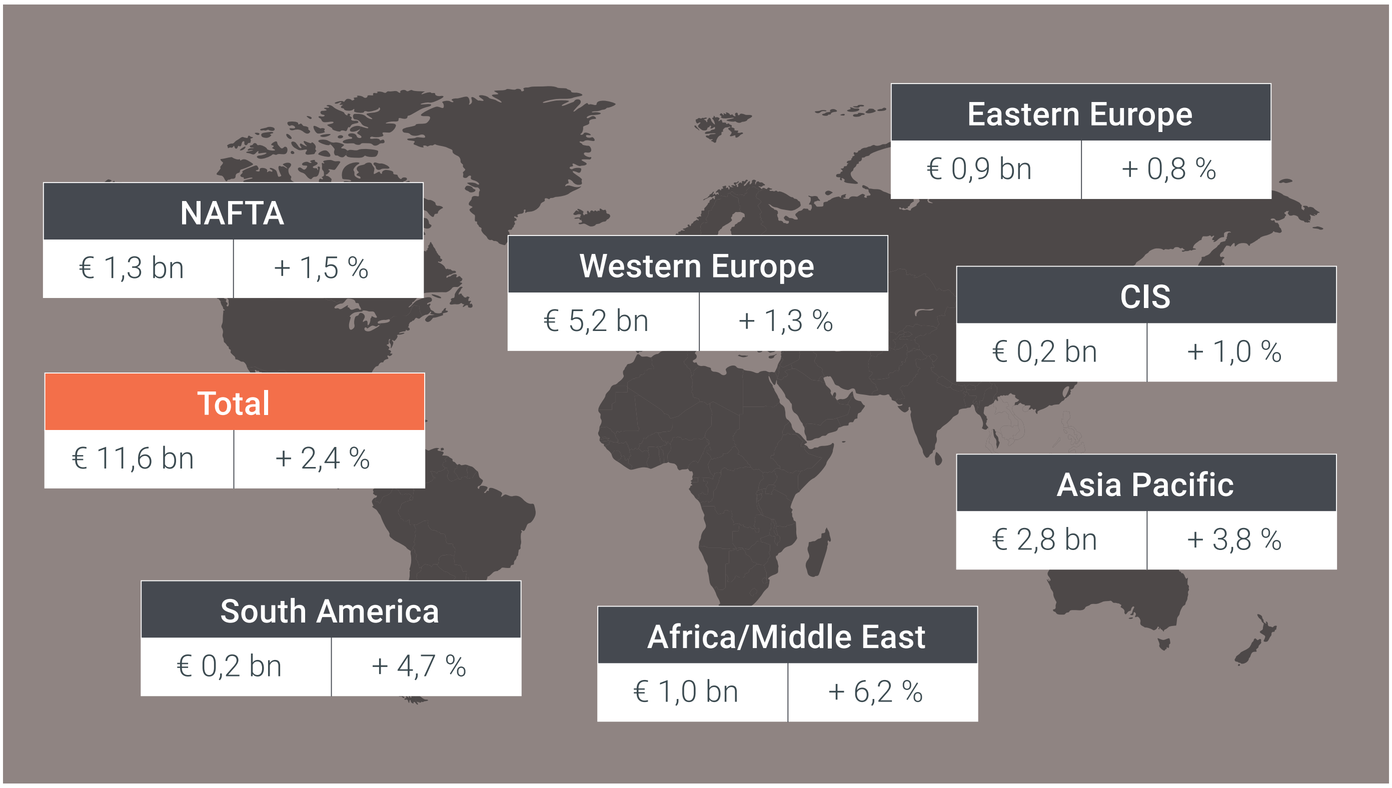
[6]Verband der Bahnindustrie in Deutschland (VDB), Politikbrief, Berlin, February 2016
[7]WSP, Global Rail and Transit Trends for 2018, www.wsp.com/en-CN/news/2018/global-trends-2018, January 2018, accessed May 27, 2020

2. Snapshot of rail modernization initiatives around the globe

This rising need for new rail control technology is mirrored by the positive market development in recent years as well as in the forecasts. According to the UNIFE Global Rail study[8] conducted by Roland Berger, the rail supply market saw constant growth in recent years driven by considerable investments in services, infrastructure, and rail control. According to the study, especially Western Europe and Asia Pacific have contributed to this positive development of the market. The study forecasted an annual growth rate of 2.7 % from 2018 until 2023, ultimately reaching an expected annual volume of approximately EUR 192 bn. The authors of the study identified mature rail markets as a key driver as in these markets, operators consistently invest in upkeep and extension of their infrastructure and rolling stock bases, including upgrades and modernizations of signaling systems. In addition, emerging rail markets, such as Africa/Middle East or Latin America are forecasted to contribute to market growth through continued development of their infrastructure and rail systems.

A recent McKinsey study[9] had similar findings. According to this study, global rail infrastructure technology – not entailing tracks, tunnels, or other low-tech infrastructure components – accounted for approx. a EUR 36 bn market annually at the time of the study in 2018. The train control and signaling industry was identified to be the largest segment of the market at EUR 17 bn p.a. and was expected to steadily grow by ~ 2.5 % p.a. in real terms until 2025. According to the McKinsey report, market growth in this sector stems from selected regions that cyclically undergo dedicated rail infrastructure development or upgrade programs. Until 2025, the authors of the study predict a shift of market growth from new development activities (mainly in China and Middle East) towards advanced signaling technology upgrade programs (particularly ETCS in Europe and PTC in North America). In addition, the study forecasts renewal and maintenance business to be a strong growth segment (3 – 4 % real growth until 2025) along installed base growth, particularly in China and Middle East, as well as shorter renewal cycle times driven by higher share of software components.

Figure 1: Expected growth rates (CAGR) for rail control systems from 2018 to 2023.



Source: Roland Berger.

[8]Roland Berger (for UNIFE), World Rail Market Study (7th edition) - forecast 2018 to 2023, Hamburg 2017
[9]McKinsey & Company, Arnt-Philipp Hein and Anselm Ott, Signals set for growth – how OEMs can be successful in a digitized rail infrastructure, September 2018

The numbers are telling us that rail infrastructure modernization currently taking place across various markets clearly has a positive impact on the control and rail safety markets. Now, let us look at the current state of rail infrastructure and how major modernization initiatives unfold in different parts of the world.

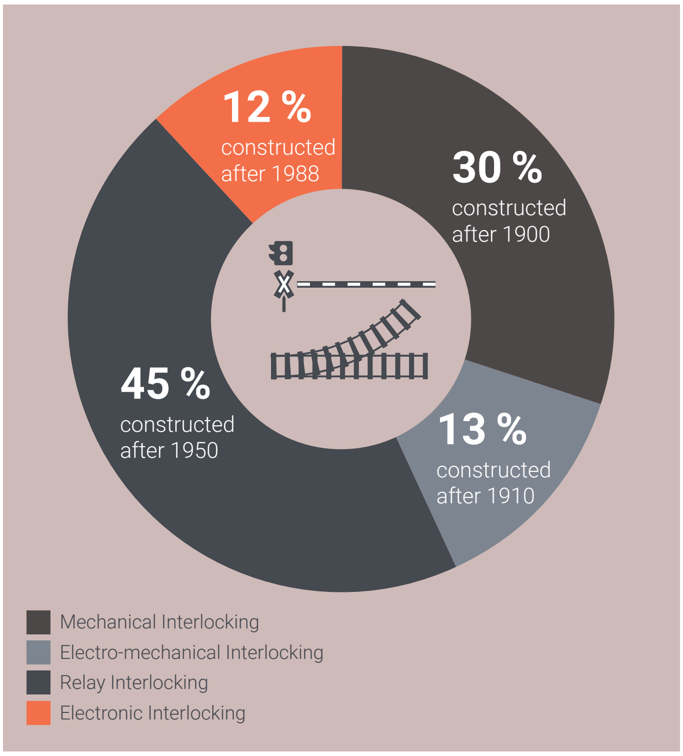
2.1 DACH

As an exporting nation and a high-tech and transit country, Germany relies on smoothly functioning passenger and freight transport. With a length of around 33,400 kilometres in operation in 2019, the German rail network is the largest in the EU.[10] Deutsche Bahn, the German railway company, carries more than 5.5 million customers every day in the passenger transport segment, and ships via rail about 596,000 tons of freight.[11] The train traffic is controlled by nationwide around 2,800 signal boxes according to DB Netz, the infrastructure company of Deutsche Bahn. Large parts of the rail control technology in Germany is outdated though (see figure 3).

The control technology in the German rail network has grown historically over time and therefore still shows large numbers of mechanical, electro-mechanical or relay-based signal boxes (see figure 4). Because many of them are proprietary solutions for specific applications (about 60 %), there are currently around 100 different types of signal box designs in use in Germany.[12] And each of these has its own proprietary technology, which makes it difficult and expensive to provide spare parts, servicing and maintenance and the updates which may well be required. Also, they are very difficult or even impossible to control remotely, requiring high local staffing levels. All of this represents a major challenge for digitization and interoperability.

Deutsche Bahn has accepted the challenge and started to heavily invest in infrastructure digitization and modernization, e.g. replacing obsolete interlocking technology with electronic devices. The introduction of Europe's first digital interlocking (digitales Stellwerk – DSTW) in March 2018 marks a milestone for the future of rail control and safety systems. It is a clear indicator that intelligent communication networks and their associated standardized and modularized technology are setting the trend for the coming years in safety and control applications. The digital interlocking does not transmit computer-based commands via conventional electrical switchgear using cable

Figure 3: Outdated rail technology hinders standardization and digitization in Germany.



Source: VDB.

Figure 4: Different interlocking types in the German rail network in numbers, 2017.

Type	Quantity	Share of Total Stock	Control Share in the Network*
Mechanical Interlocking	718	26 %	15 %
Electro-mechanical Interlocking	311	11%	7 %
Relay/Push button Interlocking	1.274	46 %	43 %
Electronic Interlocking	385	15 %	32 %
Other	54	2 %	3 %
Total No. of Interlocking Systems	2.742	100 %	100 %

Source: DB Netz.

[10]DB Netze Themendienst, Vom Stellhebel zum Mausklick: Wie die Bahn in ihrem Schienennetz täglich 40.000 Züge steuert, Frankfurt a.M., January 2019
[11]WSP, Global Rail and Transit Trends for 2018, www.wsp.com/en-CN/news/2018/global-trends-2018, January 2018, accessed May 27, 2020
[12]McKinsey & Company, Machbarkeitsstudie zum Rollout von ETCS/DSTW, 2018

bundles to points, signal boxes and level crossings anymore. Instead, communication with train route equipment is digital, using bus systems. With this technology, distance, i.e. the potential distance between the central signal box and the track-side equipment, is no longer of importance. In 2019, Deutsche Bahn started a pilot in which digital interlockings were set up at four different locations throughout Germany.[13]

The second important milestone is "digital rail" (Digitale Schiene) – the biggest capital expenditure program in the history of Deutsche Bahn. In January 2020, Germany's federal government and Deutsche Bahn (DB) have signed an agreement for the record sum of EUR 86 bn Euro for the maintenance and modernization of the existing rail network in Germany, including the renewal of the tracks, train stations, signal boxes and energy supply systems. With this program, officially called LuFV III and spanning from 2020 to 2029, DB and German government plan to tackle the investment backlog and fundamentally modernize the infrastructure. One main goal is to implement the EULYNX standard including the open safe protocol RaSTA on a broad scale. The programme will also ensure that approximately 2,000 km of track and 2,000 switches are renewed each year, and a total of 2,000 additional railway bridges will be renewed within the next decade. This significant investment is urgently needed as today, only a fraction of Germany's entire rail network had been converted to European Train Control System (ETCS) standard. The roll-out of ETCS and digital interlockings will enable Deutsche Bahn to benefit from the advantages of digitization[14]: Switching to ETCS Level 2 in combination with digital interlockings is the basis for making the rail network up to 20 % more productive in the future. With ETCS Level 3, this can be increased by up to as much as 35 %.[15]

Switzerland

With "SmartRail 4.0"[16], the Swiss railway SBB has also launched a major digitization and modernization program. Switzerland has understood the benefits of rail infrastructure modernization early on and has become a driver for standardization in Europe.[17] And with good reason: Many Swiss railway systems such as interlockings, control technology, radio data transmission and software systems are approaching their "end of life" and must be replaced in the next few years. On top of this, Swiss rail network has mixed traffic and is one of the busiest in Europe. The SmartRail 4.0 program bundles various modernization and automation projects that aim to make the Swiss rail network fit for the future. The plan is to modernize the railway system with technologies that are largely available today and already used in other industries (COTS), in order to increase the robustness of future offerings, increase capacity on the existing infrastructure, further improve safety and ensure the stabilization of system costs. Like the German program, SmartRail 4.0 also builds on ETCS with the difference that SBB plans to completely convert their command and control technology to ETCS/ERTMS (European Rail Traffic Management System). This includes replacing the approx. 500 decentralized interlockings of today by one central system and working towards automated rail traffic management. With these modernizations, SBB hopes to reduce trackside assets by up to 70 % and to increase traffic capacity by up to 20 % after the complete rollout.[18] The rollout phase of the ambitious project starts in 2020, completion is scheduled for 2040.

Austria

In Austria, the transport plan 2025+ formulates goals and strategies for a comprehensive transport policy up to the year 2025.[19] It is a comprehensive overall concept with concrete implementation steps for the railway infrastructure in Austria. The target rail network 2025+ is implemented by ÖBB infrastructure, the infrastructure company of Austrian railway operator ÖBB, in several stages. According to the plan, the Austrian government is investing more than two billion euros a year in the expansion and modernization of the rail network and stations – more than ever before and twice as much than the investment in roads. The upgrade of the rail infrastructure to the state of the art and the further development of safety performance is ensured by implementing the following measures (selection): Train control systems ETCS Level 2 on the new lines Vienna—St. Pölten, Kufstein—Brenner including Brenner base tunnel, Semmering base tunnel, and Koralmbahn. On the rest of the Trans European Transport Network (TEN-T) and on selected other routes replacing intermittent train control (punktuelle Zugbeeinflussung) through ETCS. On the ÖBB network, based on the forecasts, the realization of the target network enables an increase of train kilometers by over 30 %.

[13]Service and Funding Agreement - Infrastructure Status and Development Report 2018, Deutsche Bahn AG, April 2019.
[14]https://www.spiegel.de/wirtschaft/unternehmen/bahn-86-milliarden-euro-fuer-erhalt-des-schienennetzes-a-1279067.html
[15]https://www.deutschebahn.com/de/presse/suche_Medienpakete/medienpaket_digitale_schiene_deutschland-1177310 ebenso https://www.verkehrsrundschau.de/nachrichten/bahn-baut-erstes-digitales-stellwerk-auf-hauptverkehrsstrecke-2413903.html
[16]More information can be found here www.smartrail40.ch
[17]SBB, Wichtigste Fragen und Antworten zu Smartrail 4.0 und dem Ergebnis der Konzeptphase (2017-2019), April 2020
[18]European Railway Agency 2017 23 OP/Arcadis, Feasibility study reference system ERTMS final report – Digitalisation of CCS (Control Command and Signalling) and migration to ERTMS, Amersfoort (NL) 2018
[19]ÖBB Infrastruktur AG, Zielnetz 2025+ Ergebnisbericht, Wien 2011

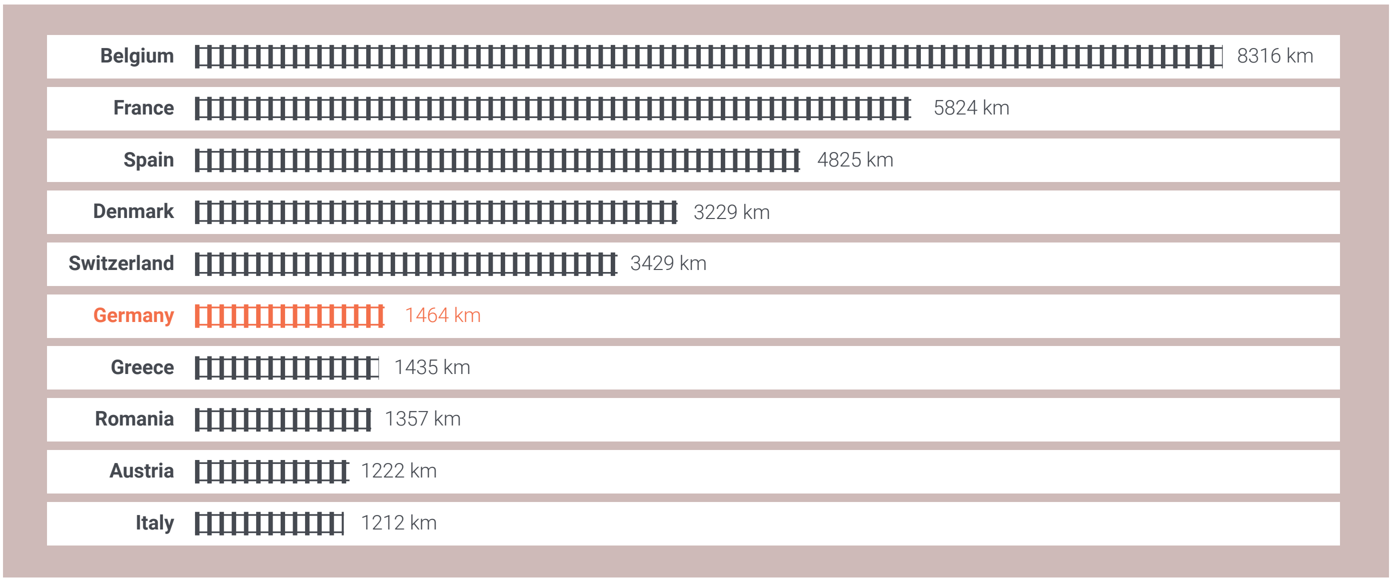
2.2. Rest of Europe

Europe has a developed rail network that has grown over time – with all the benefits and flaws that come with it. Transport activity across Europe is high and set to continue growing – estimates suggest that passenger transport will increase by 42 % by 2050, and freight transport by 60 %. This is good news for passengers and trade but puts pressure on the transport network.[20] Since the global economic crisis back in 2009, the EU has been suffering from low levels of investment in transport infrastructure – including rail. This has held back modernization of the EU's transport system.[21] Outdated and country-specific rail control technology – currently there are about 30 different signaling systems in operation – has made cross-European rail traffic cost-intensive and overcomplicated up till now. A train on cross-border routes needs either to be equipped with all different required systems, or train engines must be exchanged at the border to enable the train to drive on in the neighboring country. Operational and maintenance costs continue to be high due to the lack of Europe-wide standardization.

The market opening, increased competition and accessibility of the rail market as well as technological standardization and a single signaling system have been identified as key enablers to create a single rail market in Europe.[22] Therefore, the EU decided to develop, adopt and deploy a single control, command, signaling and communication standard, the ERTMS, establishing an interoperable rail framework across EU territory. Installed both trackside and on-board, it is composed of the ETCS, ensuring that a train does not exceed a safe speed and distance from other trains, and the global radio communication standard for rail operations (GSM-R). ETCS is also accepted outside Europe as a viable future standard by many countries. The benefits of the ERTMS are manifold. In addition to interoperability, the ERTMS increases train safety, speed (up to 500 km/h), capacity on lines – as it reduces the minimum headway between trains –, and punctuality. It allows rail companies to install just one signaling system on-board, reducing costs and driver training expenditure.[23]

ETCS serves as the reference standard and is currently implemented in two so-called levels: Level 1 (Limited Supervision) and Level 2 (Continuous Supervision). Based on the EU Regulation 2017/6, the EU intends to equip defined major cross-European train corridors with ETCS (Level 1 or Level 2) as soon as possible. Originally planned for 2020 on the six corridors with the highest freight traffic, the ERTMS deployment plan was revised in 2017: aligned with the Trans European Transport Network (TEN-T) and the requirements for a European rail network for competitive freight, the plan now is that ERTMS should equip 50 % of nine core freight corridors by 2023 and the remainder by 2030. But even this goal seems to be ambitious considering the slow overall migration from legacy signaling to the ERTMS in Europe to date.[24] There are positive exceptions to this though: Countries like France, Belgium or Denmark are leading the way when it comes to ETCS implementation and rail control technology modernization (see figure 5).[25]

Figure 5: Top ten countries in regards of lengths of rail network equipped with ERTMS in 2015.



Source: Unife.

[20]European Commission, Transport in the European Union - Current Trends and Issues, Brussels, March 2019
[21, 22]European Commission, Transport in the European Union, March 2019
[23]European Parliamentary Research Service, European Parliament Briefing, Digitalisation in railway transport - A lever to improve rail competitiveness, Brussels 2019
[24]European Railway Agency 2017 23 OP/Arcadis, Feasibility study reference system ERTMS final report – Digitalisation of CCS (Control Command and Signalling) and migration to ERTMS, Amersfoort (NL) 2018
[25]Verband der Bahnindustrie in Deutschland (VDB), Politikbrief, Berlin, February 2016

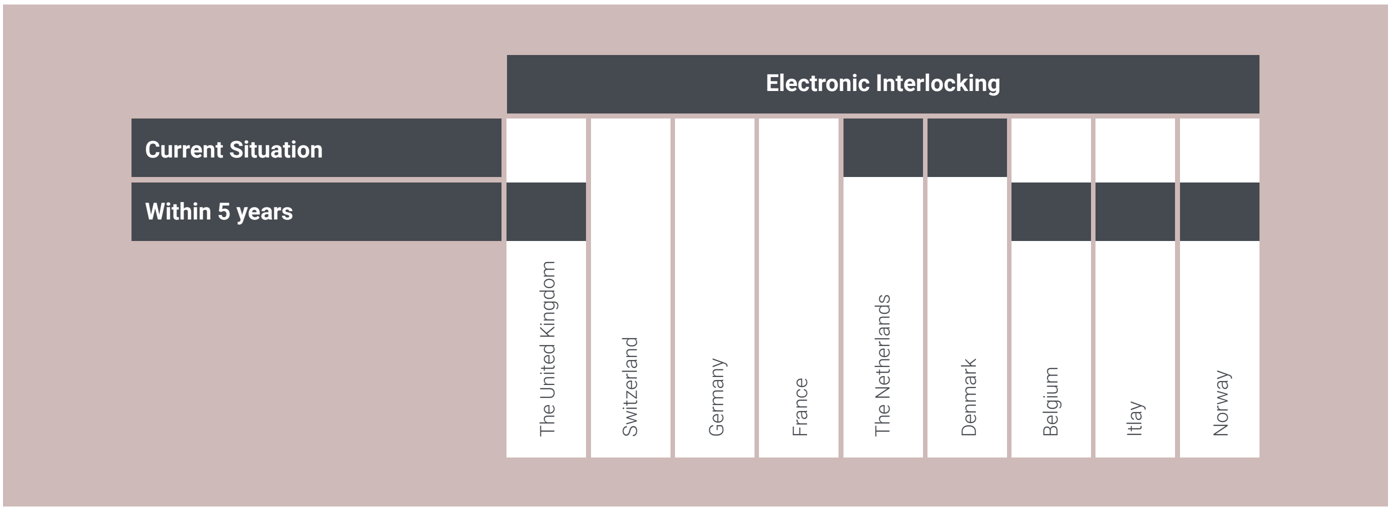
Although the time schedule for ETCS implementation has been pushed back due to the complexity of the topic, there are a lot of rail control modernization initiatives currently going on across Europe. And as ETCS Level 2 requires electronic or digital interlockings, we see modernization and replacement of outdated rail control technology taking place across the whole continent to reach the ambitious ETCS deployment rate goals (see figure 6).

Figure 6: Outlook on remaining ETCS deployment in Europe (line length in km by country).

	ETCS deployed km of total line length by country line lenth in km, 2017		Target year full ETCS deployment Estimated	Annual development km per year
Germany	-250	38,828	~2040	~1,750
France	-2,750	28,765	~2040	~1,190
Poland	-300	18,510	~2050	~570
Italy	-650	17,041	~2050	~520
UK	-200	16,209	~2044	~625
Belgium	-500	3,607	~2030	~260
Denmark	-0	2,552	~2023	~510

Source: McKinsey.

Figure 7: Overview of the rollout of electronic interlocking, 2018



Source: ERA/Arcadis.

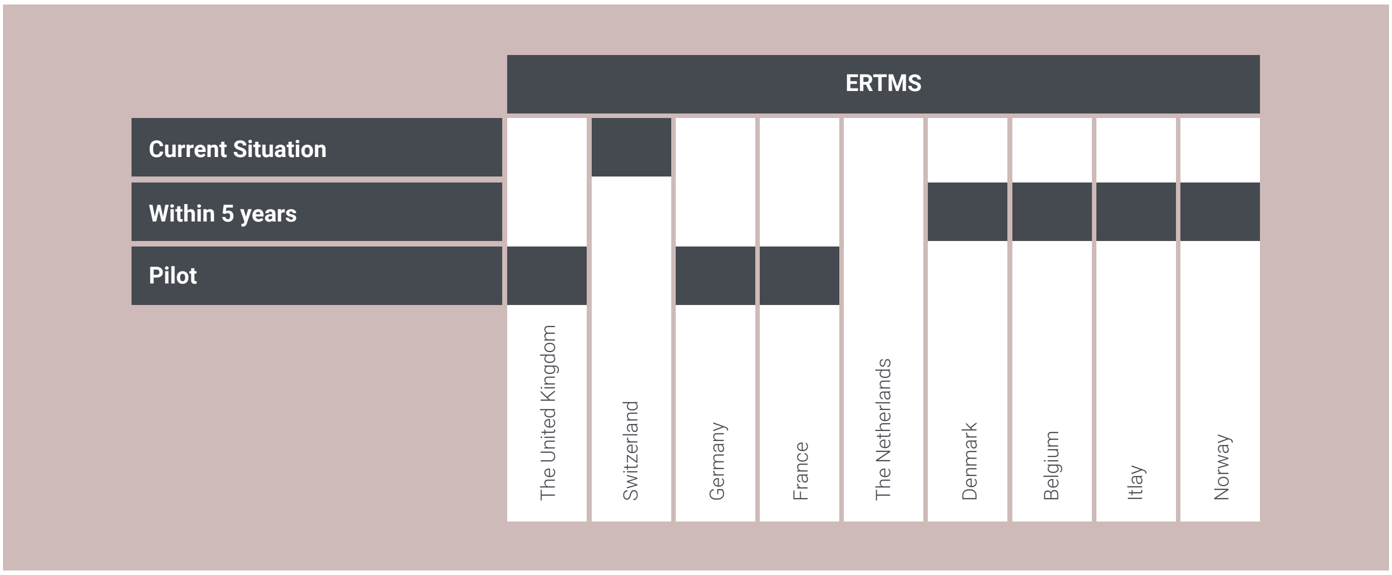
A recent study[26] from the European Railway Agency (ERA) identified digitization programs in all nine surveyed European countries (see figure 7). All these country plans have in common that significant parts of the train and rail control technology has reached the end of their technical or economic lifespan. Therefore, all surveyed infrastructure managers are implementing, have plans to implement, or consider implementation of digital-based command and control systems, often including the implementation of ERTMS.[27] In all the countries surveyed in this study relay interlocking is still commonplace. In several countries even mechanical interlocking is still in use. All of these must be replaced by electronic systems – no matter how long their theoretical technical lifespan is.[28]

[26–28] European Railway Agency 2017 23 OP/Arcadis, Feasibility study reference system ERTMS final, Amersfoort (NL) 2018

Deployment of ERTMS today represents a patchwork in systems and planning. Although European countries have agreed to deploy ERTMS on their network, this does not mean that ETCS trackside will be rolled out on the entire national network of each individual country. Hence, there are different approaches and paces in ERTMS deployment (see figure 8). Only a few countries will or already have rolled out ECTS trackside (Level 1 LS, Level 1, Level 2 or a combination) on their entire network (Luxembourg, Belgium, Denmark, Norway and Switzerland). All other European countries plan to only convert parts of their network to ERTMS and keep their legacy Class B system – a principle also known as dual signaling.[29]

While the ETCS implementation remains challenging, it bears huge potential for growth. With more than 65,000 additional kilometers in line length to deploy under the ETCS regime across Europe until 2030, one can derive a cumulative market potential of ~EUR 30-40 bn for advanced signaling technology. On an annual basis, the ETCS program hence contributes around 4 % real growth p.a. to the European train control and signaling market.[30] Several cross-country initiatives launched in recent years such as Shift2Rail[31], EULYNX[32] or the 4th EU Railway Package help working towards the goal of a European single EU railway market, network and signaling system.

Figure 8: Overview of the rollout of ERTMS, 2018.



Source: ERA/Arcadis.

2.3. APAC

The APAC region – including the two rail giants China and India – is a dynamic rail market. There are a few specific challenges in rail modernization to be overcome here though. One is trade protectionism. This can either be in form of rail projects being financed by loans from a country and a group of countries, resulting in the projects "preference" to employ suppliers from the country or group, or in form of company consortiums that are formed to bid for the projects, resulting in only member companies or affiliates reap the benefits. Another hurdle to rail modernization is that many countries in the region, apart from countries like China and India, are lacking a regional or national regulatory body or rail operators with enough experience to shape the common rail practices. For the most part, these countries therefore rely on control technology from the major proprietary rail signalling companies in combination with supervision and validation from a rail consultant and assessed by an external regulatory body like TUV. There are of course exceptions to this rule, one being Australia for example with the Rail Industry Safety and Standards Board (RISSB) and experienced rail operators. Lastly, the shortage of independent rail signaling companies or engineers in some APAC countries leads to a significant dependence on the proprietary rail signaling companies.

Fueled by economic growth and rapid urbanization, the investment in the rail and transit sector in the region remains high. Rail infrastructure in APAC is currently under-going modernization of the main lines through upgrading badly maintained tracks, double tracking (addition of another track in parallel) and rail network extension. Also, urban mass transit systems are expanded, e.g. the light rail traffic line 3 in Kuala Lumpur, Malaysia – a 40 km mostly underground circle line. Similarly, in Thailand, Bangkok's transit system is being extended with new lines and a new monorail network to improve connectivity and address traffic congestion. In Hong Kong and Singapore, investment will continue to be available for network extensions and system upgrades to their aging mass transit networks.[33] Despite a slight

[29, 30]European Railway Agency 2017 23 OP/Arcadis, Feasibility study reference system ERTMS final, Amersfoort (NL) 2018
[31]https://shift2rail.org/
[32]https://www.eulynx.eu/

slowdown, the high-speed rail market is still strong in APAC, with several projects under construction or in planning, e.g. in Thailand, Singapore, and Malaysia. China will continue to be a key player in the high-speed rail (HSR) market, seeking opportunities to support regional nations to develop such networks as part of the "One Belt One Road"[34] initiative.[35]

Investments in the rail industry in 2020

$ 6.6 bn Thailand
$ 114.3 bn China
$ 10 bn Australia

Apart from China and India that both take up a special role, Thailand, Indonesia, and Australia are taking the lead in rail modernization in the APAC region.

- Thailand: Railway transportation is key for freight and passenger transportation to its neighbouring countries. Modernization is necessary to cope with the anticipated demand from China's "Belt and Road" initiative, in particular the high-speed rail between Myanmar, Laos and Vietnam. The double track and high-speed train projects currently in planning or construction are part of a significant modernization initiative of the State Railway of Thailand (SRT) that includes plans to tender rail schemes in 2020 worth more than $6.6 bn.[36]
- Indonesia: There are several modernization programs going on to improve passenger and goods mobility to increase economic growth. A recent modernization project with HIMA involvement represents a good example of this. In this project, the state-owned Indonesian rail supplier PT Len Industri tasked HIMA to upgrade the safety technology at 25 railway stations in Indonesia worth EUR 1.74 m.[37]
- Australia: Australia has been continuously modernizing its freight lines over the years. A major modernization project currently going on is the "Inland Rail Freight Corridor" which is part of the Australia New Zeeland Infrastructure Pipeline initiative (ANZIP). The circa $10 bn Inland Rail project entails the creation of a 1,700 kilometres Melbourne to Brisbane freight rail line along Australia's east coast including approximately 1,200 kilometres of major upgrades and enhancements, and 500 kilometres of new track.[38] Furthermore, the Australian government's "Smart Cities Plan" envisages the construction of new multibillion dollar metro rail systems in Australia's two largest cities Sydney and Melbourne – both forecasted to double in size by 2050. Additionally, existing passenger rail networks are being extended, made safer through level crossing removals and grade separations, and undergoing capacity upgrades by employing latest signalling technologies, such as Communication Based Train Control (CBTC) and ETCS.

China

China is in a different league – in terms of financial invest, scale and modernization speed. China's Ministry of Transport has announced that a CNY 800 billion (USD 114.3 billion) investment is expected to be provided for railway projects in 2020.[39] The country has been investing heavily in high-speed and metro projects over the past decade. China's rail network is expected to reach the mark of 150,000 km in 2020. The current network includes over 30,000 km of high-speed line and serves 75 % of cities with a population of 500,000 or more. China plans to further extend the network to 200,000 km over the coming decade, of which over 45,000 km will be high-speed lines.[40]

According to the Thirteenth Five-Year Plan, by 2020 China will increase its urban rail network by 3000 km and will have 13 cities with over 200 km of operational track. A further six cities will have over 400 km of operational lines. Nanjing, Shenzhen and Chengdu are expected to join Beijing and Shanghai with 500 km of operational metro in 2020, with Chongqing and Wuhan not far behind. The recent approval of additional phases has ushered in a new wave of metro construction. As an example of the scale: The city of Guangzhou alone approved the construction of 10 new metro lines under phase 3 of the city's Urban Rail Transit Construction Plan (2017 – 2023) and adding 258.1 km to the network at an estimated cost of USD 31.28 bn.[41]

China's high-speed network is not only the world's largest; it also remains the most ambitious with more lines and connections consistently added. The country continues its bold expansion plans with over 11,000 km of lines currently under construction and a further 15 projects expected to be commissioned by the end of 2020. The results have come at a high cost, with China investing an average of USD 100 bn per year in high-speed rail.[42] According to the International Union of Railways (UIC), China had a 31,043 km high-speed network as of October 2019. UIC predicts that by 2030 – 2035 China's high-speed lines could exceed 80,000 km.[43] Two recent high-speed modernization projects include the 794 km long Shanghe - Hangzhou Expressway (Cost: USD 13.6 bn) and the 618 km long Yinxi High-Speed Railway (Cost: USD 11.6 bn) – both expected to be completed in 2020.[44]

China also heavily invests in new technology and automation. The 190 km automated Beijing—Zhangjiakou high-speed line with 10 stations is being built in preparation for the 2022 Winter Olympic Games and will offer 350 km/h operation, reducing the travel time between the cities from three hours to just 50 minutes. China is also intensifying research on maglev technology.

[33, 35] WSP, Global Rail and Transit Trends for 2018, www.wsp.com/en-CN/news/2018/global-trends-2018, January 2018, accessed May 27, 2020
[34] https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative
[36] http://www.globalconstructionreview.com/news/thailand-fast-track-66bn-rail-projects-2020/
[37] https://www.railwaygazette.com/technology/hima-signs-indonesia-signalling-technology-contract/45022.article
[38] https://infrastructurepipeline.org/project/inland-rail-freight-corridor/
[39] https://www.railwaypro.com/wp/china-announces-its-2020-railway-investment-plan/
[40 – 42] https://irjpro.com/blog/article/china-ramps-up-metro-and-high-speed-construction
[43] https://irjpro.com/blog/article/china-ramps-up-metro-and-high-speed-construction
[44] https://irjpro.com/blog/article/20-projects-for-2020

After having built the world's first commercial maglev system – the 30 km stretch between Shanghai city center and Pudong Airport – back in 2002 (still the world's fastest commercial train system, operating at up to 431 km/h), China is now working to develop even faster maglev technology. In May 2019, the China Railway Rolling Stock Corporation (CRRC) unveiled a prototype maglev train that is claimed to travel commercially at up to 600 km/h. A working prototype is expected to be completed 2020 ahead of the start of tests in 2021.[45]

India

India, the second giant in Asian rail business, operates with roughly 67,000 km the fourth largest rail network in the world. The Indian Railways route length network is spread over 1,23,236 km, with 13,452 passenger trains and 9,141 freight trains from 7,349 stations plying 23 million travellers and 3 million tonnes (MT) of freight daily. Increasing urbanization and rising incomes (both urban and rural) are driving growth in the passenger segment. Investment in rail infrastructure is expected to increase in the coming years and to reach a level of Rs 50 lakh crore (USD 715.41 bn) by 2030.[46]

There are a couple of specific challenges for rail infrastructure modernization in India, besides the sheer size of the network. One is that a lot of the rail control technology has come of age. Furthermore, the protective market is only opening slowly for privately-owned competitors and suppliers from abroad. On top of this, often local approvals are required in addition to international standards and compliance to these is mandatory. The Indian government is increasing funding for railway modernization though and is undertaking several initiatives to upgrade its aging railway infrastructure and enhance its quality of service. The Indian government announced an outlay of Rs 1610 bn (USD 22.4 bn) for Indian Railways (IR) for the 2020 – 21 financial year. Over the next financial year, IR plans to construct 500 km of new lines, carry out gauge conversion work on 600 route-km, and track-doubling on 2,650 km. IR will also renew 4,000 route-km of track and electrify 6,000 km.[47]

Indian Railways is also working on the upgrade of its entire rail network with modern signals and anti-train collision system. The upgrade includes systems such as automatic train protection, long term evolution based mobile train radio communication, remote diagnostic and predictive maintenance, electronic interlocking, and centralized traffic control or train management. The new signaling system comes at a cost of Rs 77,912 cr. and envisages improving safety, line capacity as well as to run trains at a higher speed. With newer technologies being utilized, the Indian cabinet cleared the plan to upgrade the IR network to higher speeds such as the Mumbai—Delhi and Delhi—Howrah route to 160 km/h which is targeted to be completed in the next four years. The ambitious 508 km Mumbai—Ahmedabad high-speed train is also under construction now.[48] Four works of total 640 route kilometres have been sanctioned as pilot projects for the new signaling system.[49] A recent Government report presented early 2020 shows that IR has made significant progress in signaling modernization on the entire network.[50]

2.4. North America

The North American rail freight transport is mostly privately-owned, and the influence of the state is low – which in some cases is hindering a more intensive development of the rail segment. In North America, freight transport is way more important than passenger transport. While the rail share in passenger transport is below 1 %, over one third of the freight transport performance takes place on railways. With large transport distances, integrated and large structure clearances plus very high reliable axle loads, higher quantity effects can be achieved than for example in Europe. On the other hand, trans-regional passenger rail transport remains substantially below its economic possibilities, also considering the attractiveness of air transport for very long journey distances.[51]

The U.S. rail network is one of the largest in the world, but lines are single track for the most part and only have a very low degree of electrification. The technology level of infrastructure, in some cases, is significantly lower than in Western Europe and typically leads to long sections that only allow comparatively low speeds. Large train lengths and high train weights provide sufficient operational capacity under these circumstances. This means track system technology must be, above all, durable and reliable. Therefore, the technology in use often is more material-intensive ("heavier") than in other market regions, more expensive to procure and often refurbished and reused after the first operating cycle.[52]

Because of several safety issues in the past, the Positive Train Control (PTC) system has been introduced in the U.S. and made mandatory for trains carrying passengers or dangerous goods. PTC is advanced control technology designed to automatically stop a train before certain types of accidents related to human error occur. The rollout of this new technology is still undergoing, but phase 1 focusing on Class 1 railroads is nearly completed.

[45]https://irjpro.com/blog/article/china-ramps-up-metro-and-high-speed-construction
[46]https://www.ibef.org/industry/indian-railways.aspx
[47]https://www.railjournal.com/financial/india-announces-us-22-4bn-2020-21-rail-budget/
[48]http://news.railanalysis.com/modernization-of-signal-smodernization-of-signalling-system-in-railways-with-tcasystem-in-railways/
[49]https://www.financialexpress.com/infrastructure/railways/world-class-signalling-indian-railways-undertakes-one-of-the-most-ambitious-modernisation-projects/1807305/
[50]http://news.railanalysis.com/modernization-of-signalling-system-on-indian-railways/
[51]SCI Verkehr, WORLDWIDE MARKET FOR RAILWAY INDUSTRIES, Market Volumes for OEM Business and After-Sales Service as well as Prospects for Market Developments of Infrastructure and Rolling Stock, Hamburg 2018
[52]SCI Verkehr, WORLDWIDE MARKET FOR RAILWAY INDUSTRIES, Hamburg 2018

According to The Federal Railroad Administration's (FRA) progress report, as of January 2020, PTC is in operation on the majority (98.5 %) of Class I PTC route-miles network-wide. PTC was mandated in 2008 to prevent certain rail accidents such as the collision of two trains on the same track. The law affects nearly 58,000 route miles of freight and passenger rail lines and as of March 31, 2020, PTC systems were in revenue service demonstration or in operation on 56,541 of these route miles.[53] The goal still is to have PTC fully operable by the end of 2020. The Association of American Railroads considers PTC technology to be "the necessary foundation for tomorrow's advances in automated train operations".[54] While investment in rail infrastructure remains relatively low in the U.S., the PTC program has led to a market uptake for rail technology in North America due to retrofitting of existing safety technology and increasing demand for wagons and diesel locomotives.[55]

In Canada, the Canadian federal government remains committed to infrastructure spending, with up to USD 3.4 bn to be allocated through the Public Transit Infrastructure Fund (PTIF). Additional funding for rail infrastructure modernization is expected to come from The Canadian Infrastructure Bank and The National Trade Corridor Fund (NTCF). VIA Rail, Canada's national intercity passenger rail provider, will invest as much as USD 3 bn to build a dedicated new corridor between Toronto, Ottawa and Montreal, which is expected to boost ridership by as many as 7 million passengers. The Ministry of Transportation Ontario (MTO) is seeking to move forward with an environmental assessment of a potential high-speed rail (HSR) line between Toronto and Windsor, Ontario at a total cost of USD 20.9 bn.[56]

2.5. Middle East and Africa

The state of rail infrastructure is diverse in the Middle East and Africa region, depending on the age of installation. The rail infrastructure in the Gulf countries is relatively young for example with metro line quipped with CBTC and main lines with ETCS L2 specified control technology. In Egypt and Iran relay based signalling systems are still dominant on the main lines but are coming up for upgrade to electronic interlocking. Most modernization projects here rely on proprietary solutions with SIL4 certification that comply with EN standards. Metros are upgraded at a faster pace and call for the latest technology. In Turkey, COTS philosophy is well accepted and there is a national modernization program for signalization system ongoing. In the Sub-Sahara region and the remainder of Africa, digitization is planned, but the lack of funding is delaying implementation.

Major challenges in rail technology modernization in Middle East and Africa are the relatively low overall level of safety awareness and the fact that many projects are internationally funded. COTS is still not accepted in all countries despite being the basis for future digital technologies such as ATP and ATO. Furthermore, there are unstable political circumstances in many countries and some economies heavily depend on oil prices (and the infrastructure spending with it). Not all countries have regulatory bodies, but generally, the EN standards are used as base standards. Although there is no overarching cross-country standardization happening, there are some regional initiatives working towards higher interoperability such as GCC RAIL in the Gulf countries.

Despite significant downscaling of capital projects investment in the Middle East due to falling oil prices, the region is adjusting, and new rail infrastructure projects are emerging, particularly in passenger rail systems in major regional cities with their emerging middle-class e.g. metro schemes in Riyadh, Doha and Dubai. Countries like Egypt, Iran and Turkey are taking the lead in terms of rail infrastructure modernization in the region. This is partly due to the relatively old railway network as well as due to various initiatives for signalling upgrades on main lines and metros. There are also several new metro lines planned in the region. South Africa's rail and transit sectors face major challenges, including rail's declining share of the public transport market. Market conditions are currently turbulent, but the National Development Plan entails major investments in urban transit through to 2030. Recent years of heavy investment in rolling stock have left South African rail systems short on capital for infrastructure investment, thus no new rail projects are foreseeable for several years ahead.[57]

Modernization Challenges

Low level of safety awareness

COTS not widely accepted

Unstable political circumstances

Lack of regulation and standardization

[53]https://www.masstransitmag.com/rail/railroad-signals-ptc-control-systems-and-products/article/21138532/fra-releases-q1-2020-ptc-progress-report-as-end-of-year-deadline-looms
[54]https://www.aar.org/campaigns/ptc/
[55]SCI Verkehr, WORLDWIDE MARKET FOR RAILWAY INDUSTRIES, Hamburg 2018
[56, 57]WSP, Global Rail and Transit Trends for 2018, www.wsp.com/en-CN/news/2018/global-trends-2018, January 2018, accessed May 27, 2020

3. Tech trends shaping the rail control market

With digitization on the horizon, innovation cycles get shorter and technology develops in an unseen pace in the history of railway industry. Traditional technology concepts and restrictive markets are disrupted. There are many tech trends currently shaping the rail control market, from connectivity, over IoT and big data up to artificial intelligence and secure communications. But there are three tech trends that stand out: Standardization and interoperability, automation and automatic train operation and digitization as an overarching scheme.

3.1. Standardization and interoperability

Today, the control and signaling market is highly fragmented and dominated by proprietary technology, tailor-made by a specific OEM for a single national rail network. Characterised by an insufficient product standardization, cross-border traffic often is complicated and cost-intensive as trains need to be equipped with several systems and staff must be trained accordingly. The small (country-specific) product series also lead to high maintenance and spare parts costs as rail operators are dependent on the original system manufacturer (vendor lock-in). The monopolistic rail tech market has high accessibility barriers and low competition – both driving up prices and hindering innovation.

As connectivity and interoperability are key preconditions for continuous data exchange and advanced traffic management control, the global signaling, interlocking and control market is opening, and more and more rail companies and governments are striving for international standardization and interoperability. This also leads to higher competition as new players can enter the market more easily. The signaling industry is increasingly shaped by software solutions and real-time data transmission between train control centres and the trains themselves. To be able to create such an "internet of trains" – a combination of trackside and onboard control technology continuously communicating with each other – broadband must be implemented everywhere based on GSM-R or ERTMS standards. This on the other hand means, all technology in use needs standard interfaces so flawless communication is possible at all.

Therefore, we currently see an increased use of industrial COTS technology certified according to international standards worldwide as it features open interfaces and programming, is modular and can be easily sourced and modified. This change is driven by many reasons, e.g. a lot of legacy technology approaching its end of life or is not fulfilling future safety (APO) or efficiency needs (remote control). From a survey[58] conducted in the name of the European Railway Agency (ERA) amongst global infrastructure managers we know that by modernizing rail control technology, they aim to reduce their (maintenance) costs, e.g. by implementing predictive maintenance schemes, introducing central control centres, improving energy efficiency, or reducing number of required maintenance staff. By implementing digital control technology, infrastructure managers also seek to increase track capacity and to reduce the number of or completely replace old, costly, obsolete analog systems. In the ERA study, the surveyed infrastructure managers identified vendor lock-in and tailor-made control technology with different interfaces as major challenges they currently face and expressed the hope to resolve this situation by using standard technology.

Standardization of communication interfaces could spark huge developments in rail technology and automation. By creating consistent communication, organizations could connect rail networks across entire nations, or even internationally. But consolidating different communication protocols presents challenges. Therefore, experts agree that controllers should be designed in a way that they fulfil the requirements for standardizing communication and ensuring continuous safety. "Due to the rise of digitization in the rail sector, solutions based on COTS systems and open safety technology will form the key foundation for digital platforms in the future", says Reinhold Hundt, Rail Industry Expert at German consulting company Astran.[59]

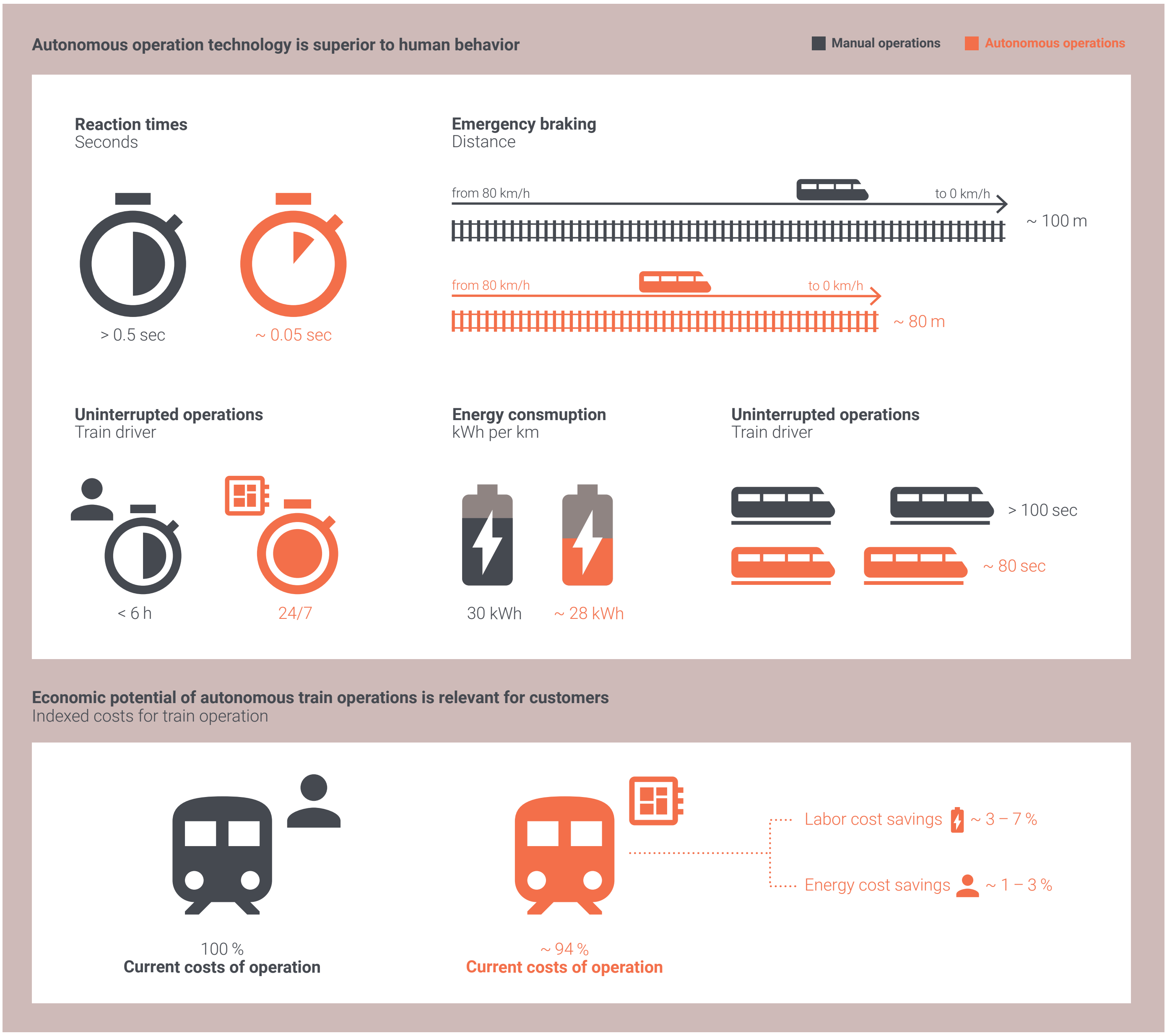
[58]European Railway Agency 2017 23 OP/Arcadis, Feasibility study reference system ERTMS final report – Digitalisation of CCS (Control Command and Signalling) and migration to ERTMS, Amersfoort (NL) 2018
[59]HIMA Smart Safety Hub, The two faces of digitization – part 1, February 2019, https://smartsafety-hub.hima.com/en/the-two-faces-of-digitization-part-1/?cn-reloaded=1, accessed June 5, 2020

3.2. Automation and automatic train operation

The expectations of automation and automatic train operation (ATO) in terms of rail capacity, efficiency and performance increase are high. The increased use of artificial intelligence and automation in train operations has the potential to hugely transform the global rail industry as we know it today. It holds many opportunities to improve the quality of services and safety. ATO is expected to contribute to enhance network capacity, increase punctuality, save energy, lead to financial savings and raise safety. Due to these safety improvements, operating cost reductions, and capacity enhancements, fully autonomous rail operations are expected to become wide-spread in future.[60]

Autonomous train operations have the potential to significantly improve the cost efficiency of train operations as both control officers and train drivers could be substituted by autonomous technology. In the long run, this could amount to annual savings in operations costs of up to EUR 7.5 bn based on the ~ 150,000 train drivers alone currently employed in Europe.[61] In addition, autonomous driving technology will increase network capacities as autonomous trains can run in shorter intervals resulting in up to 25 % higher capacity on existing tracks, according to McKinsey. With limited space and significant costs associated with the expansion of rail infrastructure such capacity improvements can

Figure 9: Autonomous operation systems interact more efficiently with existing safety and control technology than human drivers ever could.



Source: McKinsey.

[60, 61] Arnt-Philipp Hein, Anselm Ott, McKinsey & Company, Signals set for growth – how OEMs can be successful in a digitized rail infrastructure, September 2018

help to tackle the challenges of an ever-increasing urban population. Successful examples include the fully autonomous Paris metro line 1, which has already realized a capacity improvement of ~ 20 %. Success here triggered the retrofit of the city's Line 4 making it fully autonomous as well.

To enable the safe implementation of ATO, the large-scale rollout of ERTMS level 3 ready electronic or digital interlockings are required. Rolling stock on the other hand has to turn into cyberphysical systems by equipping them with onboard intelligence as well as GPS tracking. The required continuous data exchange also asks for maximum level of security. ATO relies on high safety levels – automated train protection (APO) requires SIL4 on rolling stock – and therefore is a key driver for control technology growth in developed rail markets in the years to come. Experts therefore recommend the implementation of proven SIL4 certified COTS technology wherever possible to meet ATO requirements in future without having to modernize the control technology again.

ATO transfers responsibility for managing operations from the driver to the train control system. The International Electrotechnical Commission (IEC) has established four standard grades of automation (IEC 62290-1); with the highest one, trains are fully automated without any operating staff on board. For now, ATO has mainly be implemented successfully in the area of public transport such as driverless metro lines, light rail transit (LTR), people movers and automated guided transit (AGT).[62] In the over 30 years since the launch of the first automated metro lines, the growth rate for driverless metro has doubled in each decade – an exponential growth that is bound to quadruple in the coming decade. As of the beginning of 2018 there are almost 1,000 km of automated metro in operation, in 62 lines that together serve 41 cities in 19 countries. Current forecasts, based on projects approved for implementation, indicate that by 2025 there will be over 2,300 km of fully automated metro lines in operation.[63]

Closed loop systems are easier to be automated than long-distance trains on interconnected main lines. According to experts, the combination of two technologies, the European Transport Control System (ETCS, part of the ERTMS) and ATO, are considered to form a promising ATO solution for mainline services. ERTMS manages train signaling, speed control and automatic brakes while the ETCS enables beacons installed on the track to retrieve information and convey driving instructions to the vehicle, ensuring its safety. ATO, meanwhile, controls the train's driving and braking systems. This combined solution enables trains to travel at an optimized speed, shortening headways and, consequently, improving line capacity.[64]

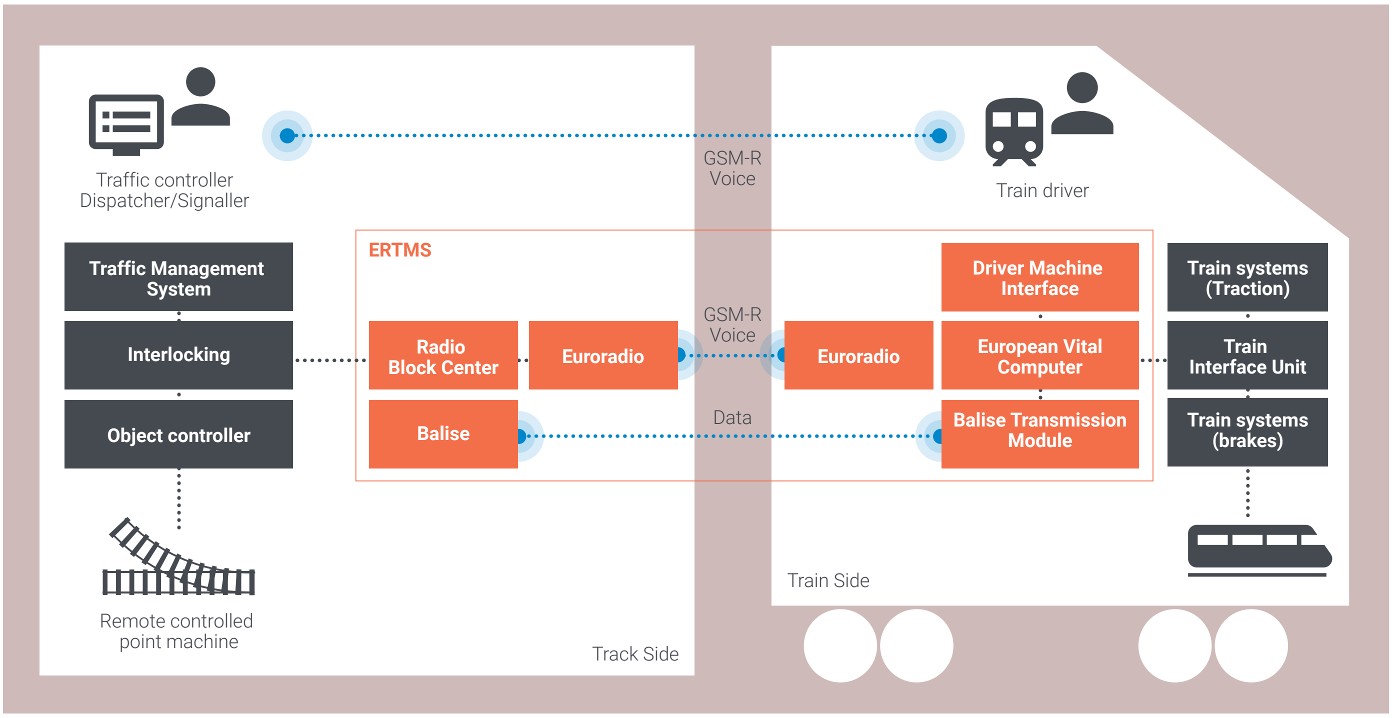
[62] Jana Pieriegud, Digital Transformation Railways, Warsaw 2018
[63, 64] Arnt-Philipp Hein, Anselm Ott, McKinsey & Company, Signals set for growth – how OEMs can be successful in a digitized rail infrastructure, September 2018

3.3. Digitization

Digitization is making its way into the global rail industry at a fast pace. Some of the main trends that accelerated digital transformation in the railway sector in recent years are Internet of Things (IoT), Cloud Computing, Big Data Analytics (BDA) and Automation. Rail digitization offers a wide range of short- and medium-term potential services and applications. New solutions such as passenger and freight information services, smart infrastructure, monitoring of assets, signaling systems, and automated train control systems, just to name a few, have the common objective of improving the efficiency of operations and serving the customer more effectively.[65] Digitization allows train manufacturers to offer new services such as remote monitoring, real-time diagnostics of rolling stock and preventive maintenance. Sensors placed on critical train or infrastructure components can send data that, once collected and processed, are able to detect imminent defects or breakdowns. This for instance allows train operators to increase effectiveness and reliability of their fleet. Infrastructure managers will be able to optimize the exploitation of big data obtained for the nowcasting and forecasting of infrastructure conditions and reduce their maintenance costs. Furthermore, mobile applications, e-ticketing, digital train control, signaling and traffic management, digital platforms for predictive maintenance are important digital applications in the rail sector.

Digital interlockings are a key technology enabler for rail digitization as it requires trackside and onboard control technology that is intelligent and communication-enabled. Modern control and safety systems such as ETCS make the infrastructure intelligent, e.g. by means of real-time location, data exchange and obstacle detection. Therefore, the large-scale replacement of outdated mechanical and relay-based interlockings by electronic devices worldwide can be considered as an important step towards digital rail infrastructure and ATO. In the "ERTMS Long Term Strategy" issued in 2016 railway companies and infrastructure managers defined ETCS Level 3 as one of four game changers (the other three being ATO, next generation communication systems and satellite positioning) needed to boost capacity, reduce maintenance cost, reduce energy consumption and further optimize traffic management.[66] With Level 3, ETCS will go beyond pure train protection functionality with the implementation of full radio-based train spacing. The route is no longer cleared in fixed track sections and fixed train detection devices are no longer required. Given sufficiently short positioning intervals, digital level 3 interlockings enable continuous line-clear authorization and train headways come close to the principle of operation with absolute braking distance spacing ("moving block"). The number of interlocking and cabling can be significantly reduced resulting in lower costs and minimized required maintenance effort.

Figure 10: Concept of ERTMS level 3 eliminates the need for trackside track-free detection, e.g. through axle counters or track circuits.



Source: ERA/Arcadis.

[65]European Parliamentary Research Service, European Parliament Briefing, Digitalisation in railway transport - A lever to improve rail competitiveness, Brussels 2019
[66]UNIFE, Position Paper on Digitalisation of Railways, Brussels 2016

4. How COTS technology enables system integrators to develop future-proof rail control solutions

4.1. Developing own solutions and new business models

System integrators have extensive application knowledge in the railway industry. However, they usually lack the technological platform to develop their own safety-related solutions. To develop this platform themselves takes years and is very cost intensive. To come up with a completely new interlocking or level crossing product from scratch, a system integrator would have to put significant effort into development and certification. If he relies on a COTS technology platform instead, the safety technology already comes with suitable certification. To benefit to the maximum when developing their own solutions, a suitable safety technology platform has to offer maximum programming flexibility, long-term availability and future viability, so that the products system integrators develop do not become obsolete after just a few years.

As part of the Smart Safety Platform, HIMA's SIL4 COTS safety controllers offer system integrators the opportunity to develop their own rail safety solutions and sometimes even completely new business models in a cost-effective and timely manner. The Smart Safety Platform combines functional safety with cybersecurity and end-to-end support along the entire value chain. System integrators can implement their own solutions based on open COTS controls regardless of the complexity and scope of the project and thereby opening up significant new business potential. Standardized, commercial off-the-shelf hardware enables system integrators to offer their customers more cost-effective solutions in comparison to solutions based on proprietary technology. The flexible COTS controllers can be used for a wide range of rail safety applications – from level crossings and signalling applications to interlockings and train protection systems. HIMA's standardized COTS safety controllers comply with the latest standards and regulations without the need for customization. Moreover, operators can implement these controllers around the world without any issues. Spare parts are available quickly and are easy to install.

4.2. Freedom of choice

In terms of technology, to date, system integrators have often been dependent on the suppliers of proprietary systems – making system changes, spare parts management, and maintenance quite costly for the railway operator. System integrators at their end struggled with the lack of flexibility and freedom in development. HIMA's open, COTS-based Smart Safety Platform puts an end to this vendor lock-in and creates new opportunities, for the rolling stock manufacturers to combine products from different suppliers, and for the system integrator to develop flexible and scalable safety solutions.

The Smart Safety Platform releases system integrators from technological dependency thanks to open communication interfaces. HIMA's COTS controllers can be used in any application and solution by any system integrator or OEM. In addition, each HIMA controller uses the same intuitive engineering tool (SILworX), which reduces the time and effort required for familiarization and training for the system integrator when developing its own solution.

4.3. Future-proof for digital era

Railway engineering systems have very long lifecycles, usually several decades. It is therefore crucial for railway operators that the technical solutions in use are available over a very long period. For system integrators this means that the solutions they offer must be future-proof and available for a long period of time. The challenge is that the software in particular must always be kept up-to-date for over 20 to 30 years. However, the hardware must also be able to be flexibly expanded and modernized. As a result of the rapid advancement in software over the past two decades, innovation cycles have become significantly shorter. If safety technology requires long-term availability, updates are necessary in short intervals. This is especially true when a rail network has to be made ready for digitization. With proprietary technology as it currently is in use, the effort to keep the solutions up to date is high due to the small product quantities produced. In addition, there is a risk for users that the product may no longer be available for the next application (obsolescence).

Whether it is interoperability, migrating central functions to the cloud, autonomous trains, or smart supply chains and maintenance models – digitization requires flexible safety solutions that are easily programmable, feature standard interfaces and are modular. Modern controllers must ensure that updates are simple and quick to perform. Additionally, it should be possible to map hardware functions using software. Backward compatibility would also be ideal to combine older systems with newer ones to ensure they are future proof. A modular design makes it possible for users to exchange certain functional modules or add completely new ones – even during operation.

With the HIMax and HIMatrix COTS controllers, system integrators and OEMs can be sure that project extensions can be easily implemented over decades and spare parts can be supplied quickly worldwide. They can also be used for easy retrofit, e.g. in applications where electronic interlocking is implemented in parallel to existing relay technology. The COTS controllers offer a flexible technology platform with the option to start small in a modernization project and scale up later. Furthermore, thanks to its many years of experience in the process industry, which also requires very long operating times, HIMA operates a sophisticated obsolescence management system. For this reason, HIMA guarantees customers in the railway industry spare parts and retrofits being available over a period of 30 years. Thanks to the standardization and widespread use of COTS systems, they give users planning security. This also applies to spare parts availability or software updates.

4.4. Accessing new markets

A central challenge in the railway industry is that the global market for safety and control technology is extremely diverse. In most cases, a veritable patchwork of heterogeneous technology from various decades emerges due to historically grown structures. In addition, railway infrastructure and standards differ from country to country. For example, there are many different international systems for operating regulations, train control, signalling or power supplies worldwide. System integrators therefore often face the problem that their solutions can only be used in their domestic markets and a few similarly structured markets, due to the high localization and approval hurdles in the individual markets.

With certified standardised COTS controllers, it is possible to adapt a solution relatively quickly once it has been developed in accordance with other market requirements, thereby opening up new sales markets worldwide for system integrators. HIMA's COTS controllers (HIMax and HIMatrix) are developed and certified in accordance with international standards. The Smart Safety Platform meets SIL4 requirements according to CENELEC and the COTS technology can be used worldwide.

4.5. Reduced time-to-market

Developing a COTS-based safety solution in-house is extremely complex and expensive for system integrators. The approval process for safety-related electronic systems in the railway industry can sometimes take several years. In some cases, system integrators also reach their limits in terms of safety and automation know-how. With the SIL4 COTS technology platform from HIMA, the time-to-market can be reduced by up to 60 % compared to in-house development. This is because the standardized hardware and operating system of HIMA's COTS controllers are already certified according to international rail standards and therefore, the approval process for solutions developed by system integrators is greatly accelerated. HIMax and HIMatrix are "proven technology" that has already proven its reliability worldwide in the demanding applications in the process industry. Every HIMA controller uses the same intuitive engineering tool (SILworX) based on standard programming languages. HIMA has decades of experience with safety solutions in safety-critical applications and provides system integrators with advice and support during the development process, which further accelerates the process, helps avoiding costly pitfalls and saves system integrators a lot of documentation work.

5. Global rail infrastructure modernization wave – what is in for system integrators?

The global railway industry is under enormous pressure to modernize, not least due to digitization. Outdated railway technology must be replaced and made fit for the requirements of the digital age within a short time. Automation, ATO and interoperability are on the rise. This pressure can only be countered by using open, standardized, and secure technologies. At the same time, the technologies must be as cost-efficient as possible since railway operators have only limited funds available for modernization measures.

Our snapshot of global rail infrastructure modernization initiatives showed that governments and rail operators around the globe have accepted the digitization challenge and understood the huge opportunities that lie in digital rail infrastructure. For these large-scale modernization initiatives, they are in urgent need for highly flexible, cost-effective, and future-proof interlocking, level-crossing, signaling and train protection solutions. To benefit of this massive wave of modernization and the market growth in control technology that goes with it, system integrators must develop these solutions quickly.

The times of vendor lock-in and expensive tailor-made control technology are gone. Digital rail infrastructure requires standard, easy to use technology with a high degree of interoperability. HIMA's COTS-based technology platform addresses all the major tech trends in the digital rail industry outlined in this paper and enables system integrators to develop their own cost-effective and future-proof interlocking, level crossing, signaling and train protection solutions for worldwide use. By using proven certified SIL4 COTS technology from HIMA when developing flexible, scalable rail control solutions, system integrators can reduce lifecycle costs by up to 30 % compared to traditional rail control technology and reduce time to market by up to 60 % compared to inhouse development. COTS technology enables system integrators to access new markets as well as to develop completely new business models.

The HIMA technology platform meets the highest safety and security standards in the global rail industry. Its modular design offers system integrators maximum flexibility in use and programming. In addition, the long-term availability of the developed COTS-based solutions is ensured by up to 30 years of spare parts and retrofit guarantee. Now is the time for system integrators to react, if they want to be the first to benefit of the current modernization wave in the global railway industry.

Do you wish to receive further information about HIMA rail control and safety technology?

Please write to us at: rail@hima.com

Would you like to learn more?
Please contact us:

HIMA Rail Segment Team
Phone: +49 6202 709-411
E-mail: rail@hima.com

Or visit us online:
http://www.hima.com/en/industries-solutions/rail

HIMA SMART SAFETY.

www.hima.com