BRIEFING

European Parliament

Digitalisation in railway transport

A lever to improve rail competitiveness

SUMMARY

Since the 1990s, digitalisation has been advancing at speed across all industrial sectors, public entities and society at large; and railways are no exception. Digital technologies already govern rail customers' expectations, ticket reservation and purchasing habits, operators' information and payments systems, but experts believe these technologies have much more to offer the sector.

Digitalisation is key to industry competitiveness and has therefore become an EU priority. The EU has been forging a cross-policy approach and programmes to ensure a solid policy framework, finance research and infrastructure, develop standards and connectivity, and use data effectively. This should enable rail actors to capture digitalisation's potential, improve their efficiency and serve their customers better. The European Parliament has been contributing to this policy.

Rail companies have already implemented a vast array of new services and applications using digital technologies, be it for providing more information and leisure services on board, improving the monitoring of their assets or automating more operations. The changes introduced by digitalisation in rail transport are perceived by many stakeholders as an opportunity – owing to the benefits it can offer – but also as a challenge. Indeed, it will require a change of mindsets and business models. Rail digitalisation will also require financial investment and a strategy to tackle cyber threats. Addressing these challenges will allow digitalisation to improve the efficiency and competitiveness of the railway sector.

In this Briefing

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Background

Digitalisation began in the 1990s, in the first instance affecting industries based on the provision of information, such as encyclopaedia or business directory publishers. Subsequently, it touched network industries, for instance in the energy, postal and transport sectors, and continued to develop at a previously unforeseen pace: it now concerns all business areas and society at large. Digitalisation encompasses the processes by which digital technologies and information are used by business sectors and public administrations to modify their organisational models, improve their performance and create new value. According to the World Economic Forum, by 2025 the combined value of digitalisation to industry and society could exceed US$100 trillion. For companies, digitalisation requires a customer-driven business strategy and major organisational change.

On the basis of research carried out in key sectors of the German and European economies, strategy consultancy Roland Berger has identified four levers of digital transformation for an industry:

- digital data, which, once collected and analysed, provide for better predictions and decisions;
- automation systems, which increase speed, and reduce error rates and operating costs;
- connectivity, which synchronises supply chains and shortens innovation cycles; and
- digital customer access, which enables companies to offer customers transparency and new services.

Key enabling technologies

Digitalisation has been expanding thanks to the emergence and development of key technologies.

- Since the 1990s, the main driver of digitalisation has been the development of the **internet**. The 2018 Global Digital reports reveal that more than 4 billion people around the world use the internet – representing approximately 53 % of the world population – and more than 3 billion people use social media to share information. Overall, mobile devices (smartphones or tablets) generate approximately 60 % of the volume of the Internet traffic.
- The **internet of things** (IoT) began life roughly in 2009, when physical devices such as sensors and actuators connected to the internet and computing systems outnumbered the world population. The IoT is a system of interrelated computing devices, mechanical or digital machines, objects or people, having the ability to exchange data over a network, using intelligent interfaces. The IoT has developed rapidly, with, in early 2018, an estimated 127 new devices connected to it every second. It is expected that by 2020, up to 50 billion devices will be connected to the internet. According to the McKinsey Global Institute, the IoT will have the greatest economic impact of all disruptive digital technologies, ahead of mobile internet, cloud computing or advanced robotics. A European Commission study considers that, by 2020, the market value of IoT will exceed €1 trillion.
- **Cloud computing** is a model to deliver or obtain information and communication technology (ICT) services over a network, available at any moment and facilitating data processing. The services provided can include servers, software, operating systems, storage and applications. Cloud computing enables customers to pay for only the services they use in accordance with their needs, and to avoid massive investments in their own IT infrastructure.
- **Big data analytics**: big data are large amounts of data produced by a broad range of sources such as machines, sensors, satellites and GPS signals. They cover many areas such as energy, transport and healthcare. Improved processing and analytics of big data enable industry to offer innovative products and services, and increase productivity and efficiency, including in more traditional sectors such as transport.
- The combined interaction of all these technologies have led to the creation of the concepts '**Industry 4.0**' and '**industrial internet of things** (IIoT)'. These refer to automated production based on real-time data exchange, likely to reduce operational costs, improve performance and broaden the range of products and services offered.

Digitalisation has not touched all industrial sectors, Member States and regions equally. According to European Commission data for 2017, transport had a modest index of digital intensity,[1] lower than 15 %. In the 19th century, when railways were first set up and developed, they were a major actor in the industrial revolution and one of the most innovative sectors of the world economy. With the subsequent development of automotive and air transport, railways relinquished their leading position in technological and technical innovation. When digitalisation developed across industrial and economic sectors, rail transport embraced it unevenly and thus, according to stakeholders, digitalisation is still at an early stage in rail transport.

Today, numerous experts consider digitalisation as a necessary step in the development of rail transport to maturity. As it can improve manufacturing, operations and maintenance, rail companies and infrastructure managers view digitalisation as a lever to improve their efficiency and management, lower their operating costs, and enhance their competitiveness with other transport modes. Rail companies and their suppliers have launched investments, start-up incubators and research to develop new digital solutions to run their businesses. It is more than likely that digitalisation will further offer new opportunities to rail transport actors, for instance in asset management, operations or the role of users, and contribute to the emergence of new players in the rail market. Digitalisation is a new element of competitiveness for companies in all sectors and an important condition for economies to perform well. This is why it has become one of the EU's main priorities.

EU policies and programmes impacting rail digitalisation

Since the mid-1990s, the EU has been working to set up a more integrated European digital economy and to provide the necessary safeguards. Rather than putting forward legislation or programmes dealing exclusively with rail digitalisation, it has adopted broader cross-policy initiatives and projects that can contribute to this process in rail transport. In 2010, the European Commission presented the digital agenda as one of the seven pillars of the Europe 2020 strategy. Aiming at exploiting information and communication technologies (ICT) more effectively to create growth, it underlined their potential to contribute to more efficient and sustainable intelligent transport systems. In 2010, the EU provided one of the first measures of digitalisation applied to transport. The co-legislators adopted a framework to deploy innovative technologies, known as intelligent transport systems (ITS), in road transport as well as in its interfaces with other transport modes, and identified priorities such as EU-wide multimodal travel information.

The digital single market is one of the Juncker Commission's 10 priorities and is aimed at securing access to online activities for businesses and individuals while respecting fair competition, consumer and personal data protection. The digital single market strategy for Europe, adopted in May 2015, is based on three pillars: improving customer access to digital goods and services, creating a level-playing field for digital networks and services, and maximising the growth potential of the digital economy. To benefit fully from the potential of big data, cloud computing and the IoT, the strategy proposes to remove technical and legislative barriers. The

Shift2Rail: innovation for railways

In 2014, the EU established a public-private joint undertaking, Shift2Rail, to provide a platform coordinating and developing research and innovation activities to be integrated into advanced rail solutions. Funded by Horizon 2020, it aims to promote rail competitiveness and to pursue specific benefits such as cutting the life-cycle cost of railways by 50 %, doubling its capacity and increasing its punctuality by 50 %. Although Shift2Rail does not identify digitalisation as an objective *per se*, it carries out activities linked to it in some of its five innovation programmes (IP). For instance, the first programme (IP1) is designed to reinforce the digitalisation of train subsystems and equipment (traction, brakes, and doors). IP2 is geared towards maintaining the European rail traffic management system (ERTMS) as a solution for signalling and control systems across the world. IP4 introduces innovations in digital services for passengers (ticketing, trip tracker, etc.) and IP5 focuses on new digital features enhancing the punctuality of rail freight.

mid-term review of the digital single market identified data as one of the top priorities and, in September 2017, the EU proposed a new regulation on a framework for the free flow of non-personal data, adopted in November 2018. The regulation promotes free circulation of these data across EU and IT systems and establishes the principle of data availability for competent authorities.

On more technical aspects, to improve the interoperability of digital technologies and to foster innovation, the European Commission published a communication on ICT standardisation priorities in April 2016. It considered that digital technologies were already a key element of rail transport and that the latter could benefit from the proposed ICT standardisation. The same month, to reinforce the industrial and innovation aspects of the digital market strategy, the Commission adopted a communication 'Digitising European industry – Reaping the full benefits of a digital single market', its main objective being to ensure that industry, across sectors and territories, fully benefits from digital innovation. This communication mentions the transport sector very briefly, limiting itself to automated driving. It also highlights the importance of deploying and taking up high performance internet networks in all economic sectors and in particular in transport. In relation to this topic, the European Commission introduced a new strategy on connectivity in a September 2016 communication 'Connectivity for a competitive digital single market – Towards a European gigabit society'. Referring to transport, the strategy sets a gigabit connectivity[2] objective for 2025 for all main transport hubs, to facilitate the use of intermodal transport, based on innovative applications. Additionally, it proposes to support the coordinated development of the fifth generation of mobile telecommunication technology (5G) networks and sets the objective of covering all major terrestrial transport paths (railways, motorways and roads) and urban areas with 5G.

European rail traffic management system (ERTMS): the backbone of digital trains

In the EU, there are roughly 30 national rail signalling systems, a situation that can cause technical or operational issues at borders. To overcome this shortcoming, the EU decided to develop, adopt and deploy a single control, command, signalling and communication standard, the ERTMS, establishing an interoperable rail framework across EU territory. Installed both trackside and on-board, it is composed of a European train control system (ETCS), ensuring that a train does not exceed a safe speed and distance from other trains, and a global system for mobile communications on railways (GSM-R), the radio communication standard for rail operations. 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 signalling system on-board, reducing costs and driver training expenditure. Lastly, it helps to enhance rail competitiveness and promote the EU supplier industry, as the system is also in use on other continents.

Originally planned for 2020 on the six corridors with the highest freight traffic, the ERTMS deployment plan was revised in 2017 with more realistic deadlines: aligned with the trans-European transport network (TEN-T) and the requirements for a European rail network for competitive freight, the ERTMS should equip 50 % of nine core freight corridors by 2023 and the remainder by 2030. The European Union Agency for Railways, the authority for ERTMS implementation and standards, and the European coordinator for the ERTMS, Karl Vinck, observed recently that deployment of this system was too slow. The EU coordinator noted that the biggest problem was the slow migration from legacy signalling to the ERTMS.

* Headway is the minimum distance or time between commercial service vehicles.

In 2015 the European Commission set up an expert group, the digital transport and logistic forum (DTLF), with a view to improving interoperability in freight transport across modes and sectors. Composed of experts from Member States, public entities and organisations, who share expertise and coordinate recommendations with regard to transport digitalisation, it provided input for the 2018 legislative proposal on electronic freight transport information and for the establishment of digital corridor information systems, which are designed to facilitate data sharing between supply chain stakeholders. The proposal is aimed at encouraging the use and acceptance of e-freight information by state authorities and business operators in all transport modes, including rail, and to propose interoperable IT solutions to exchange this information. Digitalisation would lead to a

reduction in the use of paper documents, make the transport of goods more reliable and, according to the Commission, generate savings in administrative costs.

To provide a comprehensive response to the challenges of digitalisation, in June 2018, the Commission adopted a proposal for the 2021-2027 Digital Europe programme, currently being debated by the EU co-legislators in the broader framework of the EU's long-term budget, the multiannual financial framework (MFF) proposal for 2021 to 2027. The new programme is a funding instrument that would focus on strengthening the EU's capacities in key sectors: high-performance computing, artificial intelligence, cybersecurity and digital skills. It includes a transport component, built into the objective of deploying digital capacities across the economy and society.

Transport Commissioner Violeta Bulc has highlighted the importance of digitalisation in rail transport. In May 2016, debating her vision for investment in transport, she named digitalisation as one of six content drivers for efficient transport in the EU. At the single European rail area convention in June 2017, she put digitalisation at the forefront of future rail development, and underlined the links it could create between travel modes and business opportunities, for instance thanks to e-freight.

EU institutions' positions

European Parliament position

The European Parliament has taken a stance on digitalisation in transport and rail in various resolutions. In January 2016, in its resolution 'Towards a digital single market act', it mentioned the need to support the digitalisation of industry in all sectors and called on the Commission to develop a digital transformation plan. In its resolution on logistics in the EU and multimodal transport in the new TEN-T corridors, adopted in December 2016, Parliament called on the Commission to support a digital framework for multimodal transport with a view to facilitating simplified, paperless, seamless, transparent, secured and trusted information flow between businesses, customers and authorities. It also insisted on the need for the Commission to ensure the integration, accessibility and protection of data underpinning logistics and freight transport.

In a resolution of June 2017 on digitising European industry, the European Parliament indicated that it considered digitalisation to be a precondition for retaining the transport industry's competitiveness and increasing its efficiency. Commenting on the 2016 Commission communication 'Digitising European industry – Reaping the full benefits of a digital single market', Parliament regretted that concerning transport its focus was limited to connected and automated driving, and therefore called on the Commission to consider digitalisation across all transport modes and throughout the value chain, from manufacturers to passengers and freight. Parliament underlined increasing disparities between Member States, regions and companies in transport competitiveness and digitalisation, and called on the Commission to support further digitalisation in this sector to improve its safety, quality and sustainability. Parliament indicated that digitalisation would improve free-accessibility for customers, including older people and people with disabilities, and provide them with more user-friendly services. It would also reduce transport costs and red tape, improve the efficiency of infrastructure, for instance through the use of the ERTMS, and foster the emergence of new actors. Parliament called for investment in broadband for major transport hubs and pathways and underlined the value of open data, big data and analytics to reap the full benefits of digitalisation in the transport sector. In relation to that, it pointed out the importance of legal certainty and of an EU approach to cybersecurity.

On 14 March 2018, in its resolution on the next (post-2020) MFF, the European Parliament stressed that an updated and more effective Connecting Europe Facility (CEF), should cover all transport modes, including rail infrastructure, and called for investment to promote 5G deployment and gigabit connectivity. It also underlined that the CEF should continue to support digital infrastructure and high-speed broadband networks.

Council and European Council positions

In September 2017, a digital summit in Tallinn debated the future role of digitalisation in enterprises, society and the public sector. The conclusions of the summit referred to mobility needs, and the importance of the EU having a world-class digital infrastructure and a common approach to cybersecurity by 2025. The European Council meeting on 19 October 2018 endorsed these conclusions. On 5 December 2017, the Council of the European Union adopted its conclusions on the digitalisation of transport. It stressed the importance of digitalisation to help create 'user-friendly, inclusive, affordable, seamless and demand-driven transport services' and called on the Commission, in cooperation with the stakeholders, to develop a comprehensive and multimodal digitalisation strategy. It asked for the continuation of the work of the DTLF, in particular for the acceptance of e-documents. So as to integrate railways more effectively into transport chains and to support rail freight, it encouraged rail actors to share pertinent data within the logistics chain and insisted on data protection. Lastly, the Council argued in favour of further deployment of ERTMS, underlining its benefits for safety, interoperability, efficiency and quality.

Main EU funding instruments for transport and rail digitalisation

Setting aside national funding, under the current MFF, the biggest source of financial support for digitalisation is provided by the research and innovation programme Horizon 2020, with roughly €13 billion out of a total envelope of €80 billion in current prices.* Its main components contributing to digitalisation are the Excellent science section and its future and emerging technologies objective. The Leadership in enabling and industrial technologies section focuses on research and ICTs with an industrial dimension. Lastly, the Smart, green and integrated transport objective under the Societal challenges section promotes activities related to connectivity and digitalisation. The proposal for a renewed framework programme for research and innovation for the 2021-2027 period (Horizon Europe) is currently under legislative scrutiny and would allocate a total budget of €100 billion in current prices. It would develop the technologies to be used by the proposed Digital Europe programme and link up with it operationally.

The Connecting Europe Facility (CEF) is another key EU funding instrument for transport, energy and telecommunications infrastructures. Out of €30 billion, the transport budget of €24.1 billion (of which €11.3 billion comes from the Cohesion Fund) focuses mainly on improving cross-border connections and completing missing links. The CEF also promotes rail interoperability, energy efficiency and security and funds ERTMS. The €1 billion CEF Telecom envelope focuses mainly on digital services infrastructure and broadband networks. The proposal for a new post-2020 CEF puts forward a global budget of €42.3 billion in current prices, of which €30.6 would be devoted to transport and €3 billion to digitalisation and telecoms. Its aim is to improve the integration of the transport, energy and digital sectors. In the latter area, it supports the digital infrastructure development and digitalisation of industry, including transport, by providing for instance for 5G coverage on important transport axes.

In addition, the European Regional Development Fund (ERDF) invests in broadband networks and the proposal for a Digital Europe programme has a financial envelope of roughly €9.2 billion in current prices. Lastly, the proposal for the InvestEU programme provides financing opportunities for innovative transport-related technologies, digital infrastructure and technologies such as cybersecurity and network protection infrastructure. It would build on the current European Fund for Strategic Investments (EFSI), a financial instrument offering loans to finance the digital transformation of the mobility industry and whose duration and capacity has been extended to €500 billion by the end of 2020.

* Current prices do not make adjustments for inflation, whereas constant prices do.

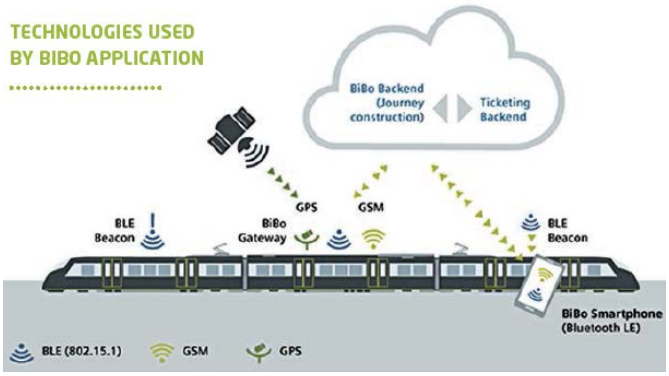
The internet of trains

Rail digitalisation offers a wide range of short- and medium-term potential services and applications. New solutions such as passenger and freight information services, video surveillance, smart infrastructure, monitoring of assets, signalling systems, and automated train control systems have the common objective of improving the efficiency of operations and serving the customer more effectively.

A broader range of services for customers

In recent years, thanks to digitalisation, rail companies have widened the range of services they can offer their passengers considerably, notably through: more informative websites, mobile applications providing reservation, ticketing, timetables and real-time information, onward journey planning, and an on-board combination of information and leisure services (often referred to as infotainment). Digitalisation of reservation and ticketing has many benefits. On the one hand, passengers get an easier access to their travel details, which can be electronically stored on their smartphones or tablets. On the other, the cost of providing tickets is significantly lowered for operators since they do not have to produce individual disposable tickets for each journey. Moreover, rail operators can use stored travel data to assess travel patterns and then modify existing services or plan new ones.

Figure 1 – The 'Be in/be out' scheme



Source: JustGo Ticketing.

At the end of 2014, the Swiss company Südostbahn (SOB) introduced an innovative JustGo ticketing scheme (see Figure 1). Once its application is installed, the program automatically registers passengers when boarding and disembarking the train. Travellers do not have to decide on a route or buy tickets in advance as they are charged when disembarking, thanks to data sent by the background system to their smartphone. In this example, digitalisation speeds up boarding, simplifies travel and tariff-setting, and reduces infrastructure costs in stations. Many rail operators have launched internet multimedia portals accessible on board. Austrian national railways (Österreichische Bundesbahnen, ÖBB) offer infotainment on their Railjet trains. It includes not only information on travel, real-time connections, and live maps with an indication of the train's speed but also the possibility to access to recent editions of regional, national and international publications, magazines, a platform of classical music and a selection of TV programmes. The Italian national operator Trenitalia and the German national operator Deutsche Bundesbahn (DB) offer similar services respectively on the *Frecce* services and on the ICE trains. In 2017, the French national company Société nationale des chemins de fer (SNCF) added new digital services on numerous high-speed trains. In addition to the usual travel services, it provides meals at the passenger's seat, e-concierge services and an automatic modification of tickets in case of early arrival at the station, detected through geolocalisation. Aside from providing real-time traffic data and train timetables, the Spanish Adif mobile application offers information on stations and shopping areas and the possibility to subscribe to train alerts.

To benefit from these services on board trains, connectivity is of key importance. In order to address some possible challenges in this respect, such as a weak internet signal or the absence thereof, innovative technologies have been applied. A frequency-selective coating, consisting of a transparent layer of metals or metal oxides vaporised by a laser onto window panes, has been developed. It makes mobile radio reception up to 500 times better than with conventional glazing and was launched in Germany in December 2018 for use on the new Rhine-Ruhr express line.

Connectivity develops in stations too. Italian state-owned holding company Ferrovie dello Stato Italiane (FS) has progressively deployed free high-capacity Wi-Fi internet in major Italian stations and their shopping areas. The connection can provide information on services, events, trips and geolocalised content.

Owing to changing needs, the concept of mobility has undergone an evolution in the last two decades, the focus shifting from low-emission and sustainable mobility to smart mobility and mobility on demand. The development of ICT solutions based on electronic platforms and applications has resulted in 'mobility as a service' (MAAS). MAAS incorporates multimodality, including in urban areas. In addition to booking and ticketing services, it can monitor online traffic, road works, accidents and takes into account travellers' preferences in terms of costs, time or carbon footprint. Following this logic, the SNCF has set up a collaborative platform to enable customers to rent a private car, make use of a carpooling service, or arrange taxi hire with driver services to get to a station, airport or home. German rail operator DB has meanwhile launched the DB navigator application also offering a broad range of services linked to MAAS. In addition to ticket booking, it integrates a door-to-door route planner with GPS tracking, pedestrian navigation and metro, tram and bus connections. DB has also set up a specific application for bicycle rental in 50 stations across Germany.

Rail operators can also use digital services to ensure safety and on-board security, using remote on-board and on the ground cameras. Lastly, digitalisation allows infrastructure managers and operators to check the movement of trains and their speed, know the number of passengers and even adjust the lighting or air conditioning to changing external conditions.

Fixed assets and rolling-stock monitoring and management

Digitalisation 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 reduce the fleet reserves they always have to keep in case of defaults, and increases their effectiveness and reliability. Infrastructure managers too will be able to optimise the exploitation of big data obtained for the nowcasting and forecasting of infrastructure conditions and reduce their maintenance costs.

To illustrate some applications of these new services, German rail operator DB has recently opened its first digital interlocking system, which transmits commands via network technology and authorises trains to cross points or not depending on traffic. Experts think that this technology can be used on major lines with heavy traffic but also in rural areas, increasing rail capacity and punctuality. Spanish Red Nacional de los Ferrocarriles Españoles (RENFE), and the cross-Channel operator, Eurostar, use digital predictive maintenance. This has allowed RENFE to improve availability of rolling stock and punctuality considerably and thus secure 60 % of the Madrid-Barcelona market. Eurostar has meanwhile ordered 17 new trains equipped with predictive maintenance technology to minimise defects and delays under the Channel.

Rail operators can also use digital technology for operational purposes such as providing a warning in cases of abnormal vibrations or shocks. Britain's main infrastructure manager Network Rail has recently been using a drone to survey a trespassing hotspot and to check evidence of potential illegal trespassing and damage to the infrastructure, increasing the safety across its network. The images digitally captured by the drone are recorded directly and transferred to relevant authorities.

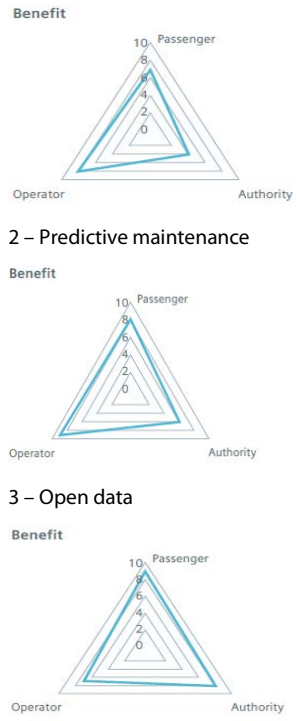
In the freight sector, the Xrail alliance, which brings together six European rail partners, has developed ICT and digitised solutions to provide information before, during and after transport, such as precise location of rolling stock or load monitoring. Aiming to enhance the competitiveness of wagonload traffic in Europe, it also includes alerts on delays. French SNCF has made a partnership with a maritime freight technology company to create 'digital freight trains'. The technology offers real-time information on the location of wagons and temperature of containers.

Automated train operation

Automated train operation (ATO) transfers responsibility for managing operations from the driver to the train control system. The International Electrotechnical Commission has established four

standard grades of automation; with the highest one, trains are fully automated. In rail transport, the development of autonomous systems has been conspicuous above all in driverless metros and light rail transit (urban or regional trains). In 2018, there were almost 1 000 km of automated metro lines in operation serving 41 cities around the world with forecasts of over 2 300 km by 2025.

Figure 2 – Benefits of rail digitalisation



Source: The Data opportunity, Siemens, 2016.

According to experts, the combination of two technologies, the European Transport Control System (ETCS, part of the ERTMS) and ATO, looks promising. ERTMS manages train signalling, 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 optimised speed, shortening headways and, consequently, improving line capacity. ATO could also save energy consumption and raise punctuality and safety. The Swiss federal railway company (SBB) has developed and tested an automated driver assistance system on the Bern-Olten high-speed line. Using a programme designed to avoid unnecessary stops and reduce energy consumption, it calculates the optimum speed for the train and transmits it to the driver.

Other rail operators have started carrying out activities relating to ATO. In June 2016, DB stated that it was increasing its focus on driverless operations, which could become a reality between 2021 and 2023, with the first pilot tests already taking place. The company was at that time launching discussions with staff and unions on the impact of this potential transition and on the evolution of the role of the train driver. In January 2018, the SNCF, the Railenium Institute of Technological Research and a group of technological and industrial companies set up two consortia to develop two driverless train prototypes. The first consortium has the task of designing an automated freight train; the second is to produce an automated express regional train. In March 2018, the rail company Govia Thameslink Railway along with Britain's Network Rail applied ATO with ETCS for the first time on the mainline railway during a passenger service to London St Pancras.

New solutions based on open data

Digitalisation facilitates the collection, processing and analysis of transport data. Experts believe that maximisation of data use should stimulate experimentation and generate huge benefits for rail transport actors and customers, by means of what is referred to as co-creation.

Owing to the need to exchange data for common rail projects, in 2013, the International Union of Railways (UIC) and rail infrastructure managers and operators launched a project to define and develop a common standardised data format, called RailTopoModel. The first model to standardise the representation of rail infrastructure was released in 2016. According to the project's initiators, it will cut duplications and costs, bring streamlined and reusable development and integrated IT systems, and improve data quality. Another development in the exploitation of open data has been taking place in Sweden, where the Association of Swedish Train Operating Companies (ASTOC) is part of an open traffic platform called Trafiklab. Developers can use it to share data and application programming interfaces (API), which provide information on Swedish public transport and enable passengers to make optimal decisions.

A number of rail companies have set up open data platforms to collaborate on common issues and give start-ups the possibility to bring their input. This is for instance the case of SNCF and DB. Since

November 2015, UIC members have had access to a worldwide digital platform, to share good practice, connect with the digital community and with start-ups, and study and propose digital solutions. At the end of 2015, the association representing the European rail supply industry (UNIFE) also set up a digitalisation platform to promote rail industry expertise in this area.

Stakeholders' views

In March 2016, the Community of European Railway and Infrastructure Companies (CER), the International Rail Transport Committee (CIT), together with the association of European Rail Infrastructure Managers (EIM) and the UIC, published a joint Roadmap for Digital Railways. The roadmap presented digitalisation as a top priority for the sector, and the key to rail competitiveness. It underlined the political dimension of digitalisation and the contribution the EU institutions could make to the setting up of an EU digital single market.

The signatories to the roadmap highlighted the importance of connectivity to operate trains and provide passengers and staff with dependable information on train schedules, tickets and travel planners. To avoid or mitigate interference, they called on the European Union Agency for Railways (ERA) and the EU institutions to meet the specific rail requirements on connectivity such as those for the ERTMS radio communication standard, GSM-R. Signatories advocated for the development of door-to-door solutions designed for passengers while not forgetting freight customers' needs. They also insisted on the fact that the new technologies meet the highest requirements in terms of safety, security, availability and adaptability to the old railway set-up. Lastly, they expressed their view that rail transport was ready to rise to the challenge of the IoT, seen as a massive opportunity to improve services and safety and optimise energy consumption and costs.

UNIFE presented its priorities and objectives with respect to rail digitalisation in a position paper published in September 2016. It listed disruptive trends that rail transport should master, including the importance of the customer interface when it came to making travel or the transport of goods easier, the impact that automation will have on infrastructure capacity, the challenge posed by automated vehicles, and the fact that the digitalisation of tickets and payments is becoming the norm. Lastly, UNIFE underlined the competition that could derive from new private transport entrants using digital and mobile technology and proposing new services.

Identifying priorities, UNIFE highlighted the need to improve information exchange for the benefit of end-users (passengers, but also forwarders, shippers and ticket vendors) using standardised messaging. With respect to rail security, it suggested focusing more on cyber-attacks, developing exchange networks for experts and stepping up cooperation, for instance with the EU Agency for Network and Information Security (ENISA). UNIFE insisted on the need to make better use of existing rail infrastructure and expressed its two main objectives in this regard: increased availability of funds to deploy the ERTMS, and the implementation of predictive maintenance. UNIFE called for a new sector agreement on data access, sharing and use to enable rail transport to achieve greater efficiency. Agreeing with the European Commission on the importance of digitalisation to generate growth and efficient transport networks and logistics, UNIFE invited the Commission to establish an overarching platform on digitalisation to gather all stakeholders and existing dialogue structures, along the lines of the platform of rail infrastructure managers (PRIME), created in 2013.

In November 2017, the CER, the EIM, the European Rail Freight Association (ERFA), the International Union of Wagon Keepers (UIP), the International Association of Public Transport (UITP) and UNIFE signed a joint declaration on the digitalisation of railways. They underlined the key role of digitalisation in rail transport to adapt to customer expectations on safety, security, capacity, punctuality, and information availability. The signatories welcomed the recent open data initiatives and called for strong political and financial support from the European Commission to sustain the digitalisation process. In the framework of commitments under the next MFF, they insisted on dedicated CEF funding, in particular to continue the rolling-out of ERTMS. Lastly, the signatories called for an increase in funding instruments for rail research, innovation and deployment in a

'Shift2Rail 2.0' programme, with digitalisation at his heart, in the framework of the proposed Horizon Europe programme.

BusinessEurope, an organisation representing business federations in 34 European countries, published its position paper on ICT and digital solutions for transport and logistics in November 2017. While highlighting the advantages of digitalisation in transport, as a way to increase its efficiency and interoperability, and decrease costs, BusinessEurope insisted on the need to remove the remaining barriers. With regard to rail transport, it mentioned the lack of investment in digital infrastructure and the underuse of smart data. On rail freight, it insisted on the numerous advantages of electronic consignment notes (e-CIMs), such as saving time and money and providing easier access to data. BusinessEurope made also some recommendations: it called for initiatives focusing on the digitalisation of train sub-systems and equipment, and on the production of data that could be used to measure trains' energy, maintenance and operation. BusinessEurope also supported new technologies to enhance the punctuality and productivity of rail freight.

In November 2017, the European Commission organised the digital transport days in Tallinn to discuss the topic with a range of public and private actors. In their declaration, stakeholders insisted on data access, sharing and re-use in the transport sector, action to counter cyber-attacks and a commitment to allocate sufficient EU funds to the development of transport digital initiatives. Lastly, the declaration stressed the need to invest in e-skills and life-long learning.

With regard to the new CEF proposal, in August 2018, the CER asked policymakers to increase the proposed CEF transport budget for 2021 to 2027 by at least €10 billion, in order to provide more robust support for rail digitalisation, and to earmark a specific budget for telematics applications and automation.

Future challenges

Experts and stakeholders perceive the changes brought by digitalisation as both an opportunity and a challenge for rail transport. Rural migration to urban areas and the continuous increase in world population are reinforcing the demand for rail services, where digitalisation could have an important role to play, in particular considering the improvements in efficiency and environmental sustainability it can offer. Rail could become the backbone of transport between and within cities, in coordination with other transport modes to provide the door-to-door services; something that is vital to remain competitive. Digitalisation is an opportunity for rail, owing to the numerous benefits it can provide: improved capacity, traffic management, reliability, energy efficiency, services and lower operating costs.

Rail digitalisation also represents a challenge. As underlined by some experts, the switch from electromechanical 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. As UNIFE notes, rail digitalisation modifies the business model, which must evolve from a rather rigid model towards a more dynamic network joining suppliers, technological platforms, mobility providers and customers. The second challenge regards financial investments in digital infrastructure, research and innovation, and digital skills. The current Horizon 2020 and the CEF, as well as the proposals for a Digital Europe programme, Horizon Europe and a new CEF represent, among others, tangible examples of EU support in this respect. Political support for implementing digital solutions in rail and a regulatory framework encouraging innovation are additional challenges, to which the EU has already provided some answers, in particular with its digital single market strategy and the proposal for a Digital Europe programme. Future regulatory issues remain, concerning for instance the liability of more autonomous railway systems and passenger safety, where a legal person is ultimately responsible in the event of an accident.

Another challenge rail digitalisation has to face relates to developing a comprehensive strategy to counteract cyber threats and secure rail assets. Indeed, according to an IBM study, cyber-attacks on

industrial automated control systems increased by more than 600 % between 2012 and 2014 and specialists consider rail networks to be potential cyber-attack targets. The challenge is both human and technical. The adoption of the Directive on Security of Network and Information Systems (NIS), which entered into force in August 2016, is aimed at reinforcing the level of cybersecurity across the EU. It specifies that rail operators and infrastructure managers are considered 'operators of essential services' and must take appropriate technical and organisational measures to manage the risks posed to the security of network and information systems and to prevent and minimise the impact of incidents.

Lastly, rail operators will have to monitor the impact that digitalisation will have on the expectations of passengers, staff and business partners, as well as what is on offer from competitors. If the rail sector is to achieve the objectives of a competitive and more resource-efficient transport system announced by the 2011 white paper on transport, it has to become increasingly efficient. Digitalisation can be a new and valuable ally in the pursuit of these objectives.

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ENDNOTES

1 The degree of digitalisation (digital intensity index, DII) is measured by the availability to a firm of a series of 12 different digital technologies.

2 Gigabit connectivity offers at least 1 gigabit per second (Gbps). Gbps are commonly used to measure data transfer speeds between hardware devices.

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