BRIEFING

European Parliament

Artificial intelligence in transport

Current and future developments, opportunities and challenges

SUMMARY

Artificial intelligence is changing the transport sector. From helping cars, trains, ships and aeroplanes to function autonomously, to making traffic flows smoother, it is already applied in numerous transport fields. Beyond making our lives easier, it can help to make all transport modes safer, cleaner, smarter and more efficient. Artificial intelligence-led autonomous transport could for instance help to reduce the human errors that are involved in many traffic accidents. However, with these opportunities come real challenges, including unintended consequences and misuse such as cyber-attacks and biased decisions about transport. There are also ramifications for employment, and ethical questions regarding liability for the decisions taken by artificial intelligence in the place of humans.

The EU is taking steps to adapt its regulatory framework to these developments, so that it supports innovation while at the same time ensuring respect for fundamental values and rights. The measures already taken include general strategies on artificial intelligence and rules that support the technologies enabling the application of artificial intelligence in transport. In addition, the EU provides financial support, in particular for research.

In this Briefing

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Author: Maria Niestadt with Ariane Debyser, Damiano Scordamaglia and Marketa Pape

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Introduction

Artificial intelligence (AI) is in the spotlight as one of the emerging fields transforming the transport sector. It is not a new term. Academics talked about artificial intelligence as early as the 1950s. Since then, AI has undergone a number of ups and downs, where optimistic expectations were followed by bitter disillusion. In recent years, AI has made a lot of progress, as machine learning techniques have been combined with technologies used for searching and analysing the large quantities of data (otherwise known as big data and data mining) produced by the development of the digital world. Other reasons for its successful growth include the development of communications networks and the internet of things,[1] as well as progress in transport devices. The future progress of AI in transport is expected to be even more spectacular, although there is no agreement on the timing and exact nature of these developments.

There is no commonly agreed definition of AI, neither at the technical nor the legal/policy level. However, a plurality of definitions can be found. An American scientist, Marvin Minsky has defined it as 'the science of making machines or systems do things that would require intelligence if done by men', by the European Commission Joint Research Centre as 'any machine or algorithm that is capable of observing its environment, learning, and based on the knowledge and experience gained, take intelligent actions or propose decisions', and again by the European Commission as 'systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals'.

AI does not refer to one technology but rather to a vast set of diverse approaches, methods and technologies, which to different degrees and in different ways show intelligent behaviour (such as logical reasoning, problem solving and learning) in various contexts. AI can be hardware based (for instance, in devices such as robots), or present in software (such as Google Maps). Some of the key AI technologies are described in recent EPRS briefings on 'How artificial intelligence works' and 'Understanding artificial intelligence'. These briefings group the key AI technologies into three sections: symbolic AI, data-driven AI and future technologies. Symbolic AI includes systems where a human creates a succession of logical rules, transcribed in algorithms, which machines can follow to decide how to act in a given situation. Data-driven AI is an AI that combines machine learning techniques with technologies used for searching and analysing large quantities of data. Future technologies include various developments where AI could display an even wider range of human capacities (such as creativity and intuition), or where AI outperforms humans.

AI is helping to make all transport modes safer, cleaner, smarter and more comfortable. AI can be applied in vehicles, infrastructure, for drivers or transport users, and to the way in which these interact to deliver a transport service. AI helps to detect market trends; identify risks; ease traffic congestion; reduce greenhouse gas and air pollutant emissions; design and manage transport; and analyse travel demand and pedestrian behaviour.

However, with the benefits of AI come real challenges. AI applications raise numerous ethical, social, economic and legal questions, such as who is liable for an accident; how to protect AI from cyber-attacks; or how to ensure data protection and transparency. AI also poses risks for citizens and consumers, as it can be used for surveillance purposes. AI can lead to biased decisions, restrict users' options, influence their opinions and manipulate their choices. Some analysts have raised concerns that AI could threaten jobs or render decision-making processes opaque.

EU action

The European Union faces the question as to how to adapt its regulatory framework to these developments, so that it supports innovation while at the same time ensuring respect for EU's values and fundamental rights. The first steps have already been taken. The European Commission (responding to a call from the 28 leaders of the EU Member States), adopted a strategy paper on 'Artificial intelligence for Europe', complemented by a coordinated action plan on AI in April 2018.

Both documents give examples of how AI is changing transport in the EU. In the strategy paper, the Commission proposed to boost public and private investment in AI (including increasing research funding for AI in Europe by €20 billion by the end of 2020); to prepare for socio-economic changes brought about by AI; and to ensure an appropriate ethical and legal framework. In December 2018, the Commission also published draft AI ethics guidelines and is in the process of assessing whether the national and EU safety and liability frameworks are fit for purpose.

The European Parliament touched upon the general issues related to artificial intelligence in its February 2017 resolution on civil law rules on robotics. The Parliament considered that it is necessary to update the legal framework related to robotics and AI and complement it by guiding ethical principles. It emphasised the principle of transparency by saying that 'it should always be possible to supply the rationale behind any decision taken with the aid of AI that can have a substantive impact on one or more persons' lives'. The Parliament also called for the creation of a European Agency for Robotics and AI and asked the Commission to submit a proposal for a legislative instrument on legal questions related to the development and use of robotics and AI.

Furthermore, in February 2019, the Parliament adopted an own-initiative resolution on 'a comprehensive European industrial policy on artificial intelligence and robotics', which has a specific chapter on transport. In this chapter, the Parliament calls inter alia for an increase in research and investment in AI, and notes that autonomous vehicles[2] pose risks to data privacy and liability.

Besides general strategies, the EU has dealt with several challenges related to the use of AI. For instance, it has taken steps to protect vehicles against cyber-attacks. In its 2016 Directive, the EU asked Member States to ensure that transport operators providing essential services take appropriate measures to manage the risks posed to the security of network and information systems, as well as to prevent and minimise the impact of incidents. In addition, EU data protection rules, updated in 2016, set some of the highest standards of data protection in the world.

In general, the EU has placed greater focus on the application of AI in road transport. This is the case with the Commission strategy 'On the road to automated mobility: An EU strategy for mobility of the future' for instance, which explains how the EU intends to further apply AI technologies in automated vehicles. However, in its recent own-initiative resolution on autonomous driving in European transport, the European Parliament provided a number of recommendations for all modes of transport.

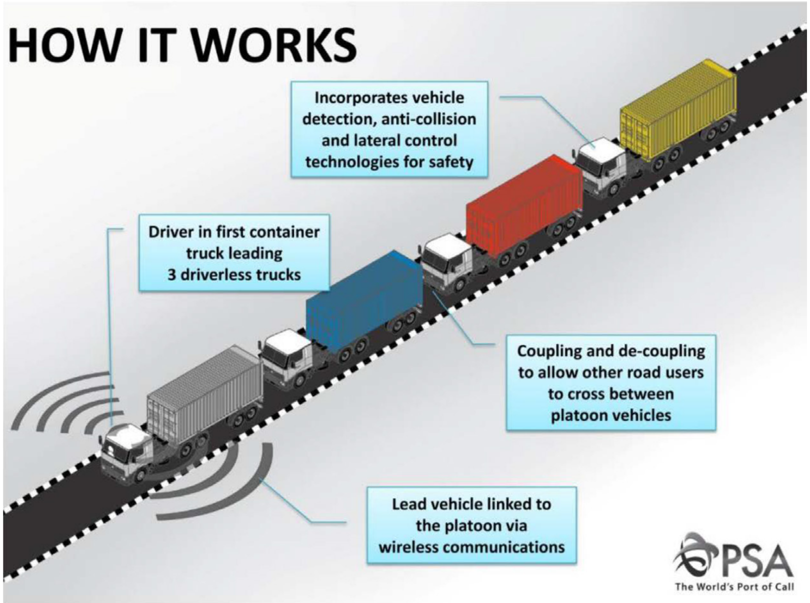
The EU is also adopting rules to support technologies that enable the application of AI in transport. These include rules for harmonised digital reporting for ships, meant to simplify information exchange procedures between the ship and the port community, and the rules on electronic freight transport information, seeking to digitalise cross-border transport operations.

In addition, the EU supports projects financially that explore the applications of AI in all transport modes, in particular under the EU's research and innovation programme, Horizon 2020. For 2014-2020, the Commission allocated, for example, a total budget of around €300 million from Horizon 2020 to support research and innovation on automated vehicles. Similar support is envisaged in the new multiannual financial framework proposal for 2021-2027 under negotiation, in particular in the digital Europe programme.

Artificial intelligence in road transport

Road transport is one of the sectors where AI has most successfully been applied, opening up entirely new levels of cooperation between various road users. Worldwide, automotive manufacturers, technology firms and research groups are exploring AI technologies to develop automated vehicles for use in commercial as well as personal transportation. Such vehicles are based on a variety of sensors (such as GPS, cameras, radar), in combination with actuators (devices which transform an input signal into motion), control units and software. Some of these technologies only take over certain driving functions (like parking), others are intended to completely replace the human driver. AI technologies that take over certain driving functions are already widely available on the EU market, while fully automated vehicles are being tested (including to deliver parcels) in a limited number of driving situations and areas. In general, it is more complex to test automated vehicles in urban areas, as there are lot of different actors, complicated road systems and infrastructure (intersections, road signs etc.), where the vehicle needs to predict much more (often unpredictable) signs of movement.

Illustration of truck platooning



Source: Autonomous vehicles and their impact on road transportation, 2018.

AI also makes truck platooning possible – the coupling of several heavy goods vehicles (HGV) within minimal distance of each other, allowing them to automatically and simultaneously accelerate or brake. While the lead HGV is driven by a human driver, drivers in those following may only be present in case complex traffic situations (such as roundabouts) or unexpected incidents arise, rather than actively driving. In the future, it is expected that the responsibilities of the drivers of following HGVs will reduce progressively, until ultimately they are no longer necessary. Although HGV manufacturers are already testing truck platooning in several EU countries, further tests are still needed on multi-brand truck platooning in more complex traffic situations, to verify safety requirements are met.

In addition, AI algorithms are used extensively in sharing economy platforms that offer road transport services. For example short-distance ridesharing platform Uber uses AI techniques in all aspects of its services, from matching riders and drivers to route optimisation.

AI technologies are also applied in road traffic management, helping to analyse the traffic pattern, volume and other factors. These can in turn provide drivers with information on the fastest route, to relieve any traffic congestion that may have formed. AI technologies also help to keep the traffic flowing via traffic signals and traffic lights that rotate in real time to meet on-the-ground traffic flow demands.

Opportunities and challenges

AI brings great benefits to road transport but also poses serious challenges, especially in mixed use environments. AI has the potential to make traffic more efficient, ease traffic congestion, free driver's time, make parking easier, and encourage car- and ridesharing. As AI helps to keep road traffic flowing, it can also reduce fuel consumption caused by vehicles idling when stationary and improve air quality and urban planning. However, lower transport costs and freeing the driver from driving tasks could also lead to more people choosing a car as a transport mode (instead of public transport), and subsequently increase congestion and air pollution.

In addition, cybersecurity and data privacy are also of particular importance in the development of AI in automated vehicles. Namely, AI-based automated vehicles require access to a lot of data that is often sensitive or protected. If third parties manage to access automated vehicle data without control, the safety of the vehicle, its occupants and other road users is endangered.

Systems based on AI used in autonomous transportation could significantly improve road safety, since human error (such as speeding, distraction and drink-driving) is involved in more than 90 % of accidents on EU roads; in which more than 25 000 people lost their lives in 2017. However, AI also creates new risky situations, as accidents with automated vehicles have demonstrated. In an interim period, when vehicles are increasingly automated but not yet completely autonomous, drivers might be distracted and pay less attention to the road. When a situation arises where the human needs to intervene, a distracted driver can be slow to react. It is simply difficult for humans to maintain effective visual attention during a longer period of automated driving. At present, therefore, more progress is needed to ensure that fully automated vehicles can safely interact with other road users, perform well under all weather and road conditions, correctly recognise obstacles and understand the environment.

AI also raises various ethical issues. When faced with life-versus-life situations, the question as to how an AI algorithm in a fully automated vehicle should decide how the vehicle reacts divides opinion. In 2016, a Mercedes-Benz executive said: 'If you know you can save at least one person, at least save that one. Save the one in the car'. The respondents to a survey published in Science the same year, on the other hand, wanted others to drive vehicles that would sacrifice their passengers for the greater good, whilst simultaneously preferring to drive vehicles that protect their passengers (especially family members) at all costs themselves. Where only one passenger would be killed to save 10 pedestrians, most respondents preferred the vehicle to save the pedestrians. Use of AI also raises the question as to who should make such a decision. Should AI algorithms automate ethical decision-making independently, or should all vehicles have the same ethical settings, or could people who buy a fully automated vehicle could determine such settings themselves?

In case an accident arises, liability is another challenge that needs to be addressed. A clear boundary of liability must be defined for the different levels of automation, so that it is possible to identify who is actually responsible for the accident. This might require changes in legislation, traffic rules and insurance policies. The current rules are based on the assumption that when the vehicle is used on the road, there is a human driver on board, whereas automation technology is intended to partially or fully replace the driver, thus shifting the responsibility.

Regarding employment, it is anticipated that AI will contribute to the creation of new jobs, the disappearance of others and the modification of most. AI can make workers' lives easier, by helping workers in the car manufacturing industry for instance with repetitive, difficult and dangerous tasks. AI can also help to manage large amounts of data and help to plan, design and control road transport networks, for example. AI can also enable more people (for instance persons with disabilities) to participate in the labour market, or help to cut labour costs (as an example, long driving hours and stopping for a break will no longer be a concern with fully automated fleets). At the same time, some jobs, such as bus, taxi and truck drivers, might no longer be needed in a further future, where fully autonomous vehicles are available. These drivers will need reskilling to find a different job.

The answers that public and private stakeholders provide on these issues, will also determine public acceptance and the consequent market penetration of AI technologies in road transport. A recent Eurobarometer survey on autonomous systems showed that respondents are more comfortable with autonomous vehicles transporting goods than travelling in such a vehicle themselves. The study also indicated that younger respondents and respondents with a higher level of education felt more comfortable about autonomous vehicles.

Artificial intelligence in aviation

AI is not new to the aviation industry which, according to a 2018 International Air Transport Association (IATA) report, has already been using it in various parts of the business and across the value chain for decades. However, we are now entering a new era in which AI capabilities are reaching heights that will have a major impact on how aviation business is conducted.

The use of AI in air traffic operations is very much in its infancy. Progress in automation and computing power, utilising technologies associated with machine learning and data analytics models, are being used to improve the management of increasing air traffic volumes. The IATA report points out that the development of unmanned aircraft systems (UAS) and UAS traffic management systems, using enhanced computing capabilities, will create new opportunities for improving existing traffic management systems, separation standards and airspace planning design.

What is known as advanced business intelligence can substantially modify the way airlines run their business in marketing and sales, distribution, pricing, and fleet management. A high potential application of machine learning is the translation of historical and real-time insights about customers' behaviour into real-time tactical changes (adjusting the website content presented to the customer). Other uses include social media sentiment analytics, which implies predicting customers' needs based on their social media behaviour.

Another area where AI can make a difference, whether in terms of processes or speed, is ground handling. Some examples of high potential use cases include safety checks, aircraft movement operations (pushback and towing), aircraft turnaround operations (fuelling, catering, loading and unloading, de-icing and anti-icing), and ground transportation on the ramp (passengers, baggage, cargo and mail).

AI can also facilitate a shift towards seamless airport security, as it is able to digest large amounts of data both in historical and real-time and to detect anomalies (see example below).

Examples of EU research projects

The SESAR joint undertaking has supported a number of research projects in relation to AI and air traffic management (ATM), covering issues such as the predictability of traffic at different phases of flight, the improvement of passenger flows at airports, and greater automation of the system.

It has supported the INTUIT (Interactive toolset for understanding trade-offs in ATM performance) project for instance that explored the potential of machine learning and visual analytics. The work of INTUIT was structured in the form of case studies. One focused on identifying sources of en-route flight inefficiencies, with a machine learning model trained to assess performance for a certain airspace area. This assessment was not based on globally calculated performance indicators but on interrelationships identified through machine learning techniques. This led to the detection of unknown patterns, not previously taken into account when establishing key performance indicators. The second case study focused on modelling airline route choices to predict traffic, when no flight plan is available, in order to know which route the airline will choose. Improving predictability can help Europe's network manager to make a more stable plan for European airspace, with fewer short-term adaptations, allowing for greater cost-effectiveness.

Another project, COPTRA, focused on trajectory prediction closer to take-off or during the flight, in particular when an aircraft enters into a particular area of airspace, in order to support improved route demand-capacity balancing.

Other research projects involving AI were geared towards the management of passenger flow at airports or the improvement of some airport operations. Indeed, use of AI and big data is becoming increasingly important for airports and is used to better analyse market demand, improve security control and customise passengers' experience. In the BigData4ATM project, partners looked at how different passenger-centric geo-located data could be analysed and combined with more traditional data to identify patterns in passenger behaviour, door-to-door travel times, and choices of travel mode. With smart devices and interconnected services, researchers have access to large-scale, detailed longitudinal (dynamic) data that allows them to test hypotheses about passenger behaviour. Another application interesting airports, and more specifically air traffic controllers, is the development of automated speech recognition models. The MALORCA (Machine Learning of Speech Recognition Models for Controller Assistance) project developed a solution that adapts the speech recognition tools for use at other airports, and automatically learns local speech patterns and controller models from radar and speech data recordings. These are then automatically encoded into the recognition software.

Further potential areas of AI research and development could embrace automation for better air traffic management and to ensure a high degree of air-ground integration, as well as allowing for certain tasks to be alleviated, enabling pilots and air traffic controllers to focus on safety critical tasks. However, as aviation is a safety and security critical industry, the introduction of AI driven technologies will have to meet and be subject to high safety and security requirements. To widen the use of AI in aviation, several issues need to be addressed, for instance the protection of personal data linked to the use of automated aircraft.

Artificial intelligence in railway transport

When they were set up and developed in the 19th century, railways were one of the most innovative sectors of the economy and a major actor of the industrial revolution. With the subsequent rapid growth of road and air transport, rail lost its leading position in innovation. Since the 1990s, the emergence and development of the internet, the internet of things and big data have provided the rail sector with an opportunity to embark upon a new phase of technological innovation. Indeed, the vast quantity of data generated by these digital technologies can be a useful instrument, enabling rail companies to modify their organisational structure, improve their performance and create new added value. To reap the full benefits of digitalisation, railways can rely on AI.

AI can improve manufacturing, operations and maintenance for rail operators and infrastructure managers. It can consequently be perceived as a lever to improve management, lower costs and enhance competitiveness with respect to direct competitors or to other transport modes.

Intelligent train automation

One of the most telling examples of uses of AI in rail technology is its contribution to the automation of train operation (ATO). ATO transfers responsibility for managing operations from the driver to the train control system, with varying degrees of autonomy. The International Electrotechnical Commission has established four standard grades of train automation: the third grade corresponds to driverless operations (with crew members present on board) and the fourth to autonomous and unattended train operations.

European rail traffic management system

In the EU, the first key step towards the introduction of ATO and AI solutions in rail transport is the deployment of the European rail traffic management system (ERTMS), which provides trains with a driver assistance system. The ERTMS aims to harmonise EU rail transport systems by deploying a single control, command, signalling and communication standard. It is composed of a European train control system, which enables beacons installed on the track to retrieve information and convey driving instructions to the vehicle, and a standard system for mobile radio communications on railways. In addition to ensuring technical compatibility between national rail systems, the ERTMS combined with ATO can reduce rail operators' costs and energy consumption, and increase rail speed (up to 500 km/h), punctuality, safety and line capacity.

In ATO, developments have been conspicuous in densely populated urban areas, with driverless metros and light rail transit (urban or regional services). In 2018, roughly 1 000 km of the automated metro lines in operation served 41 cities in 19 countries worldwide and forecasts indicate that by 2025 there will be over 2 300 km of automated lines.

Shift2Rail, the research and innovation joint undertaking set up by the EU under the Horizon 2020 initiative, is developing and validating a standard ATO for all rail segments (mainline/high speed, urban/suburban, regional and freight lines).

Rail operators have also launched activities relating to ATO and AI. In 2018, the Railenium Institute of Technological Research, the national company *Société nationale des chemins de fer* (SNCF), and a group of technological and industrial companies, set up two consortia to develop two driverless train prototypes: the first consortium is tasked with designing an autonomous freight train, and the second an autonomous express regional passenger train. For the latter, it will be necessary to integrate sensors, cameras and radars to produce the 'train's eyes', i.e. the instruments enabling it to detect signalling and obstacles on the rail tracks. The project also comprises other AI developments. One consists in transferring the sensory and intellectual capacities of train drivers to an automated driving module, ready to react to possible hazards. The second aims to design a module, which understands and integrates passengers' conduct on railway platforms and allows for automatic train door closure without danger. SNCF wants to deploy semi-autonomous trains by 2023 and fully autonomous trains by 2025.

The German national operator, *Deutsche Bundesbahn* (DB), has also started activities relating to ATO and AI. In 2016, the company 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. At that time, DB was launching discussions with staff and unions on the impact of this potential change and on the evolution of the role of the train driver.

ATO and AI technologies are also used to improve the performance and competitiveness of rail freight. Shift2rail is carrying out activities related to ATO to optimise resource utilisation. As intermodal transport of containers is expected to grow, projects are underway to better synchronise container train movements on the network, improve real-time information and data exchange. ATO was successfully tested in 2018 on the dedicated freight Betuwe route, connecting the port of Rotterdam to Germany.

Operational intelligence

For rail operators and infrastructure managers, the capacity to be aware of potential failures before they happen, to avoid any interruption of the service they provide, is very valuable. Today, AI can use the power of data provided by sensors placed on critical trains or infrastructures components, to extract information at the right time and recommend actions for maintenance. The benefits are manifold, such as 'nowcasting' and forecasting infrastructure or rolling stock conditions, faster and less comprehensive repair, reduction of maintenance costs and better customer satisfaction. Train operators can also reduce the fleet reserves they have to keep in case of breakdowns and AI helps them to increase their reliability and effectiveness.

To illustrate some AI applications, the French operator SNCF has started to apply predictive maintenance to pantographs, which can become fragile due to the wear effect. With time, the company says it will be able to forecast 80 % of incidents on catenaries, which supply electrical power to the trains. According to SNCF, predictive maintenance also allowed incidents involving train switches to be reduced by 30 %, and this technology has been applied to many train systems and subsystems. SurferLab, a rail industry joint research and development laboratory set up with the support of the EU Regional Development Fund, focuses, among other things, on preventive maintenance and AI learning. One of its AI ongoing projects is developing the possibility for a train to transmit its 'health diagnostic' to a fleet supervisor, who will be able to organise maintenance remotely, using voice recognition software.

Asset intelligence

Infrastructure managers, rail operators and engineering companies can rely on AI not only to predict systems failures but also to assess the long-term performance of rail assets and put forward areas for improvement in product design. Data produced by rail infrastructure and critical train subsystems help equipment manufacturers to build a digital representation of physical entities or systems, known as 'digital twins', a technology already applied in aerospace industry. AI helps create a railway clone, integrating IT, operational and engineering technologies to assess the overall condition of the systems through their entire life-cycle (degradation of assets, failure, customer behaviour), including information on possible design and manufacturing enhancements. These improvements represent a competitive advantage for equipment manufacturers and rail operators.

Laing O'Rourke, an international engineering company, uses AI and asset digital twins to schedule maintenance work, enabling the company to reduce scheduling activities to just 19 seconds, with a forward-planning of 23 days, instead of planning three hours and one day ahead, when these activities are carried out by a human being. The AI technology also allows for more balanced train usage and fewer service cancellations. Modelling a digital twin also proves useful for infrastructure managers. For example, *Rete Ferroviaria Italiana* (RFI), the Italian rail infrastructure manager, is developing a digital model of its network, integrating it with geolocation information, to be able to provide its customers with a unique and detailed technical description of rail infrastructure.

Future challenges

To reap the benefits AI presents, rail industry and operators must tackle sector specific challenges as well as common challenges shared with other transport or economic sectors. Specific challenges firstly concern geolocation. To be fully autonomous, intelligent trains must be equipped with sensors and have AI calculation capacities. Unlike metros, trains run in an open environment and can encounter unexpected obstacles such as animals, a person crossing the tracks, or fallen trees. To operate safely in an open network, autonomous trains must have train positioning technology with a detail level of 50-70 cm at their disposal, instead of the current 1-5 metres. The Geofer research project, launched in 2016 by the SNCF and the French Space Agency CNES, aims among other things to experiment with a more precise geolocation of trains using Galileo, the EU global satellite navigation system. Moreover, as previously noted, automated trains need optical sensors and cameras to detect obstacles on tracks. According to experts, train automation will need an incremental renovation of existing infrastructure. Intelligent trains will also have to integrate external technologies, developed in particular for the automotive industry.

Common challenges that railways will share with other sectors concern financing digital and AI research, innovation activities, and infrastructure as well as new digital skills. Setting out the responsibilities of manufacturers, operators and drivers depending on the level of automation is another important common challenge, to find appropriate answers to new legal issues concerning liability and ethics. Like any other industrial sector using automated control systems, railways will have a technical and human challenge to fight against cyber-threats and protect their assets. But, according to experts, the most complicated common challenge by far will be the development of a new mindset. Sharing data, evolving the rather rigid railways business model towards a more dynamic network that joins technological platforms, mobility providers and customers, is a difficult task. This might prove more difficult than switching from electrical to digital instruments and devices or implementing autonomous or automated systems.

Artificial intelligence in shipping, navigation and ports

Over the past twenty years, sea and inland waterway transport has undergone important developments. To name just a few of the trends that have shaped it, ship traffic has grown denser, which has raised the stakes of maritime safety and called for advances in maritime surveillance. The further increase of container traffic has called for adaptations to port terminals and better connections with their hinterland. Ever-growing vessel sizes have amplified the pressure that ships exert on ports and their cities. The raising awareness of environmental issues has brought the obligation to adapt to greener rules in the context of fierce international competition within the global maritime industry.

To this landscape, the technologies of digitalisation, the internet of things, big data and automation are a game-changer. Having penetrated various parts of the sector to a varied degree, the one feature common to these technologies is the generation of data. Building on that data, new tools, including AI, make it possible to analyse the information and gain insights which facilitate decision-making, in particular helping to improve safety, energy efficiency and optimise logistics. The several types of AI applications already used or tested only affirm the sector's focus on the coordinated introduction of such enabling technologies.

Maritime shipping and inland navigation

Maritime operations typically require swift adaptation to changing conditions and decisions taken based on many parameters. With the more advanced navigation systems, a growing amount of ship performance and navigation data is being generated. Data comes for example from radar, electronic navigation charts, auto-pilot systems and other related sensors. Special purpose vessels also need wave radars, oil spill detectors and high accuracy sensors. Automatic identification systems (AIS) transfer data such as the ship's identification number, position, course, speed and destination. Insights gained from analysing such data can be used to carry out technical operations and maintenance, make a ship more energy-efficient and help it to meet emission control standards, for instance. Detection of anomalies in marine operations can improve safety at sea and facilitate the management of accidents and environmental risks from shipping. Thanks to the combination of recorded ship movements and advanced image recognition, ships can be identified even if they turn their AIS transmitters off. Machine learning techniques can provide predictions of delays due to bad weather or traffic congestion, required maintenance, estimates of future demand and oil prices.

However, decisions that need to be taken to adjust the navigation system to the new situation are complex. While the gap from the current situation to fully autonomous ships is wide, research and pilot projects into autonomous navigation are ongoing. For instance, the EU-funded MUNIN project developed and tested the concept of an autonomous merchant ship, primarily guided by automated on-board decision systems but controlled by a remote operator on shore. The ship uses the autonomous operation only during deep-sea voyage, and not in congested waters or during its port approach. There is also potential for using autonomous ships in short-sea shipping and on inland waterways. Another EU-funded project, NOVIMAR, developed the concept known as 'vesseltrain'. In this waterborne version of 'truck platooning', a lead ship is followed by digitally connected individual ships, with a reduced crew or remotely controlled, cutting crew costs and emissions.

The industry is already investing in several types of AI usage. Ferry operator Stena Line, for instance, has introduced an AI-assisted vessel to help predict the most fuel-efficient way to operate a ship on a specific route. It considers a number of variables, such as currents, weather conditions, shallow water and speed through water, in various combinations, which would be impossible to do manually and should serve as a support for the captain's decisions. Stena is also running a pilot study involving AI-assisted ferry trips on the Gothenburg-Kiel route, and uses AI assistance in areas such as administration, finance, customer experience and customer care.

With inland navigation also moving in the direction of more automation and autonomy, EU action on and financial support for the harmonisation of river information services is key for real-time exchange of electronic data. Furthermore, the European Commission has explored the potential for digitalisation in inland waterway transport, by defining the concept of a digital inland waterway area and mapping legal and commercial barriers to data sharing.

Ports

Large ports worldwide collect and process growing amounts of information at increasingly lower costs and see the potential of new technologies for port call optimisation. Many of them already use a combination of information technologies including internet, the internet of things, cloud-computing, geographic information systems and computer simulation technologies, to optimise port operations, enhance their production efficiency and improve relationships with customers. The analysed data opens up possibilities for forecasting and real-time planning, strengthening port operators' decision-making and supporting the port's economic growth. Furthermore, where several digital technologies are combined, processes in and between ports become more efficient.

Applying advanced digital technologies to the whole port environment is known as the 'intelligent' or 'smart' port concept. Such ports strive to provide a seamless supply chain, integrating both the supply and demand sides, to optimise allocation of relevant resources, services and supervision, as well as autonomous loading and unloading. Among the ports recognised as most advanced in becoming an intelligent port are Singapore, Rotterdam, Tianjin and Dubai.

AI is only one of the several key technologies used in an intelligent port. Its applications range from problem-solving and pattern recognition to machine learning. In port operation systems, it is used for instance in port equipment scheduling (to optimise the use of cranes and vehicles) and berth availability planning. In a number of ports in the United States, Asia and Europe, AI is used to run automated loading cranes and vehicles. AI makes decisions about which containers to unload first and how to stack them. It also helps with predictive maintenance of port equipment.

Having set up a port call optimisation platform, the port of Rotterdam applies AI to data to determine a ship's estimated time of arrival and departure, which helped reduce waiting times for vessels in the port by 20 %. Making the port and logistics supply more predictable, it also allows for more just-in-time operations and transparency regarding the available dock space. Using this information, ships can adjust their speed, while also improving their energy efficiency. Data collected during container port operations is stored and analysed as the basis for future AI-assisted tools, which are expected one day to manage the entire delivery cycle and further optimise terminal operations. These technological advances are understood as a part of a wider transformation of the supply chain.

Potential and challenges

For any AI use, the collection, quality, coherence and volumes of data available are paramount. Some data quality and quantity issues arise with ship performance and navigation data collected by sensors and data acquisition systems. Data may be erroneous, due to sensor faults or human intervention. Some errors can be wilful, caused by operators who wish to disguise illegal activity. For data to be used, it has to be secure and shared. Defined data ownership rules need to be put in place to clarify who the data belongs to and who can access it under which conditions. Furthermore, the rights of certain data must be ensured against monopoly. The first maritime big data sharing platform was launched in 2016, under strict access conditions. To improve data quality and availability, a group of industry players including several ports and shipping operators set up the International Taskforce on Port Call Optimisation to bring standards from the nautical and logistics sectors together. The taskforce wants to ensure that the nautical data on board vessels corresponds to the information from the port, as well as the information used in the logistics chains.

Application of AI in a port depends on the port's capacity to first introduce digital technologies to optimise the various individual processes, and this is the focus for most large container ports today. However, as the majority of the shipping world is slow to accept changes, it is expected that not all traditional ports will strive for higher levels of digitisation and some may not adopt it at all. Across the sector, therefore, partial automation is likely to coexist with central optimisation, as well as with traditional methods of navigation and port management.

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ENDNOTES

[1] According to recent EPRS research, internet of things 'refers to a global, distributed network (or networks) of physical objects that are capable of sensing or acting on their environment, and able to communicate with each other, other machines or computers'.

[2] According to recent research from EPRS, automated vehicles are motor vehicles 'which have technology available to assist the driver so that elements of the driving task can be transferred to a computer system'. Automated vehicles have different levels of driving automation, from level 0 (no automation) up to level 5 (full automation). A fully automated vehicle, capable of performing all driving functions without human intervention, is known as an 'autonomous vehicle' or 'self-driving vehicle'.

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eprs@ep.europa.eu (contact)

www.eprs.ep.parl.union.eu (intranet)

www.europarl.europa.eu/thinktank (internet)

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