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Digitizing Europe's railways: A call to action

The future of train traffic is digital. To accelerate the digitization of Europe's railways—and thus secure the future of its railroad industry—stakeholders must change the way the industry operates.

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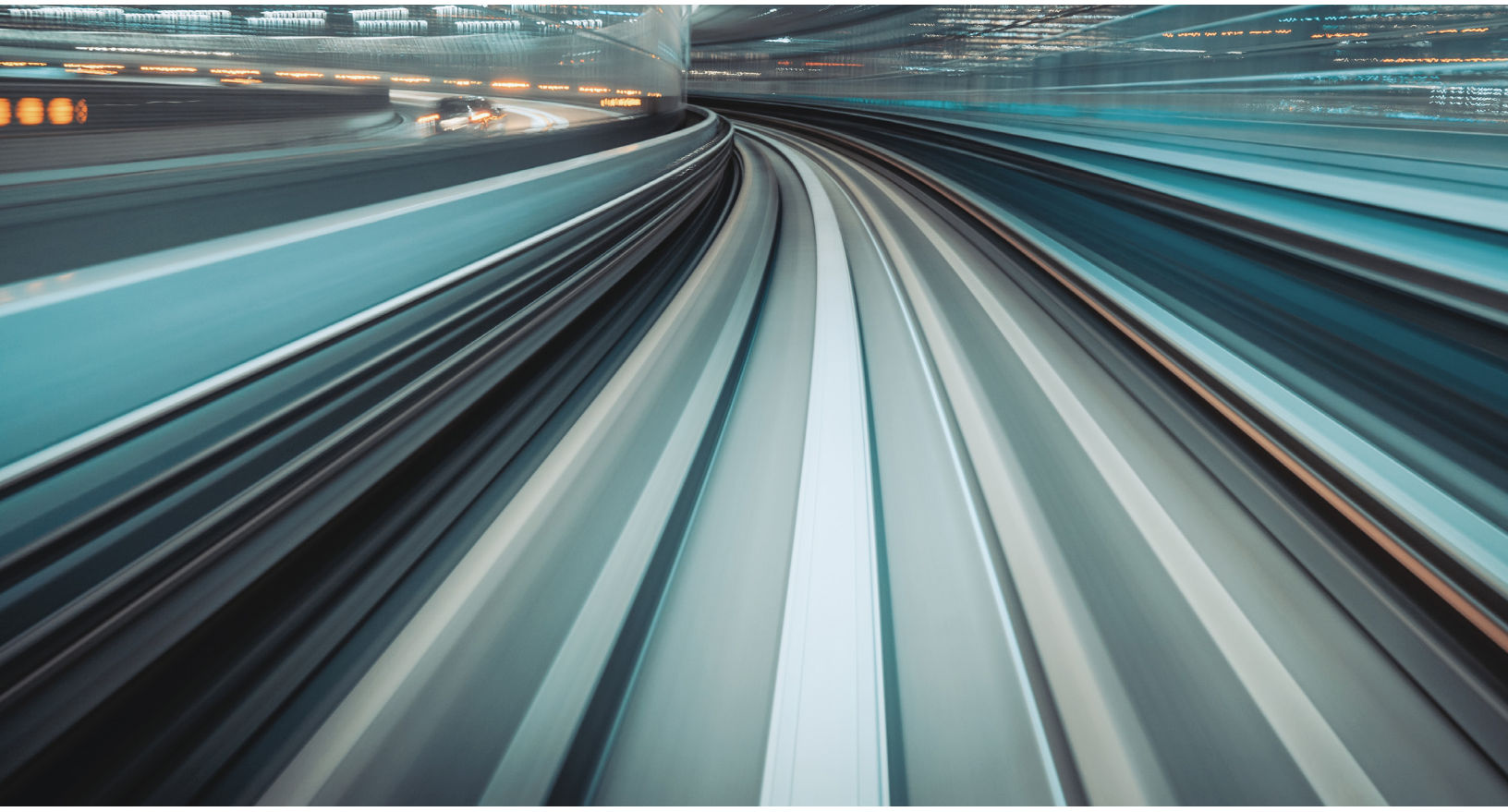

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The train is a symbol of industrial development and national pride for many European countries, and the importance of railways shows no sign of waning. Passenger kilometers have grown by more than 10 percent in the past five years, and rail has been winning passengers from air travel on major intercity routes. Around 7 percent of passenger traffic in Europe runs on the railways, compared with less than 1 percent in the Americas. The European Green Deal, along with national regulations, pushes railway travel even further. In addition, the French government's cancellation of short-haul flights on Air France as a prerequisite to funding the airline during the COVID-19 crisis will likely result in additional passengers turning to the railways.

Despite the strength of European rail, the industry is partly built on antiquated legacy systems that are becoming more difficult—in some cases, nearly impossible—to maintain. Some large European railways have multiple different interlocking types, some more than a century old, and tons of obsolete trackside technology that they can no longer maintain due to a lack of the requisite knowledge or spare parts.

Automated interlocking, train dispatching, and incident handling offer the significant benefits of capacity, efficiency, safety, and sustainability to rail passengers, operators, regulators, and manufacturers.

The landmark European Rail Traffic Management System (ERTMS) legislation passed in 2000 has led to some improvements in technology, but progress to date has been slow and fraught with setbacks.[1] Part of the reason is that effective digitization requires a "big push" transformation rather than a step-by-step approach. Also, a regulatory environment that is ill equipped for the logic of digital platforms hampers migration to new digital systems.

To overcome these difficulties, and to modernize European train control and traffic management, industry leaders need to acknowledge that digital technologies completely change the rules. We have identified five major shifts that are necessary to accelerate rail digitization, starting with a fundamental shift in the way the industry operates, including new modes of collaboration among network operators, regulatory authorities, and original-equipment manufacturers (OEMs). The challenge is significant, but success is vital to securing the future of the industry—and the European rail network more broadly—for decades to come.

The future of train traffic is digital

The importance of the railway industry to Europe is clear. Many world-class train-control and traffic-management OEMs (including Alstom, Bombardier, Hitachi Rail STS, Siemens, and Thales) are either European or have the largest share of their global footprint in Europe. Overall, about 60 percent of the world's train-control and traffic-management market is European. These OEMs lead the world in signaling innovations such as moving-block technology, which allows trains to run in the sequence of brake distance, increasing capacity by more than 20 percent on many lines, and in fully autonomous operations, which further increase capacity and safety. Together with the railroads, European OEMs have already developed and put these systems into commercial operation, though on a small scale.

Replacing legacy technology with an advanced train-control and signaling system—such as ERTMS level 2 and above, which uses wireless communications to supervise train movement—is a core element of the digitization of train control and traffic management. Whereas today's systems might have 100 to more than 1,000 mechanical and electrical signal boxes, those will be replaced with

[1] ERTMS, which has been under development since the 1980s, is a system of joint standards for the management and interoperation of signaling and is now ready for widespread rollout. For details about ERTMS levels and operation modes, see "Rail: ERTMS—Levels and Modes," Mobility and Transport, European Commission, April 11, 2020, ec.europa.eu.

new, digital interlocking and control centers, only a few of which are required to control even the largest rail systems. Within the next ten years, these digital advancements will also allow operators to withdraw most of their trackside equipment, and autonomous train operations will be based on a digital rail infrastructure.

Studies have shown that large-scale digitization of this sort would provide the following substantial gains for passengers, operators, regulators, and OEMs[2]:

— *Additional capacity.* Increases in railway demand have pushed many systems to their capacity limits; digitization could increase capacity by more than 20 percent on many network lines without additional tracks being built.

— *Less-expensive, more-efficient services.* Network operators will benefit from much more efficient operations and maintenance. They will also benefit from lower equipment costs because, potentially, more than 90 percent of signal boxes can be replaced by a few control centers. In addition, the lower costs may result in reduced track access charges, from which the train operators will profit. As soon as digital train control and traffic management are introduced, the rail system's availability, reliability, and punctuality will increase.

— *Enhanced technological leadership.* Automation and the harmonization of standards required by digitization offer European OEMs—and the rail industry more generally—an opportunity for substantial product innovation and the chance to conquer new markets.

— *Increased environmental sustainability.* Digitization enables smoother operations, which will be a key to the rail industry's contributions toward meeting overall transportation CO_2 emission targets by 2030 and beyond.

— *The chance to futureproof the industry.* Only a digitally transformed railway system will be able to compete in the transport industry of the future; operators cannot hope to beat smart mobility platforms with 1920s signaling systems, 1940s level crossings, or 1960s interlocking systems.

Europe's slow pace of digitization threatens its preeminent position

Luxembourg and Switzerland have migrated their train-control and traffic-management systems to ERTMS levels 1 and 2. Spain has introduced ERTMS level 2 on many lines—yet the pace of overall progress across Europe has been slow. The process of migrating the Danish and Swiss rail systems has been fraught with setbacks, including multiyear delays as a result of underestimations of the project's complexity, and, so far, progress in rolling out ERTMS in large markets such as France, Germany, and Italy has been very limited.

The deployment and telecontrol of digital interlockings and the rollout of digital user interfaces have also been slow. Some central rail-network operations, such as France's Commande Centralisée de Réseau and Germany's Digitaler Bedienplatz, do have a plan to update a portion of their interlockings, but the time horizons are long: they expect to be finished in 2033 and 2035, respectively.

This slow migration puts a speed limit on the R&D efforts of European OEMs and leaves room for other players to enter the market with a more aggressive strategy backed up by huge investments. China's government, for example, has pushed hard to export railway technology, and the Chinese rolling-stock industry dominates many segments—more than 50 percent of global high-speed trains, for

[2] *Machbarkeitsstudie zum Rollout von ETCS/DSTW: Zusammenfassung der Ergebnisse (Feasibility study on ETCS rollout in Germany),* a joint report from the German Ministry of Transport and McKinsey, December 2018, bmvi.de; *ERTMS business case on the 9 core network corridors: Second release,* a joint report from the European Commission, Ineco, and EY, June 2019, op.europa.eu.

example, are now produced in China. The export share of China's CRRC has doubled in recent years, including via contracts in mature markets such as Germany, and it is now by far the largest rolling-stock manufacturer in the world. Exports of signaling technology have lagged behind, but China is investing significantly and is likely to compete in Europe too before long.

All stakeholders need a clearly defined ambition and a new mode of collaboration

To be able to digitize its rail industry rapidly, Europe needs to make five major shifts. The first four relate mainly to network operators, regulatory authorities, and OEMs, and the last one will require substantial cross-industry collaboration.

1. Network operators need to establish a centralized technology function

There is currently no unified central approach in signaling and traffic management. Most network operators are organized into powerful regional units that control their own budgets and set their own development priorities. Digital technology is often viewed and managed as if it were simply one asset class among many, and it tends to become a lower priority when there are budget constraints.

Digital technologies need a management model different from that used for other hardware-intensive asset classes because digital development cycles tend to be shorter, extensive compatibility requirements create the need for greater standardization, and new subscription models—where operators pay a flat fee for hardware, maintenance, and updates—change procurement strategies.

Network operators therefore will need to develop new management and governance models and skills, with responsibility for all new technological developments consolidated under a new board-level position. This new role would include full responsibility for rolling out digital rail infrastructure, including ERTMS, as well as automatic rail-operations modules for movement protection and obstacle detection.

A key advantage of this approach is that the new position can be a central technology touchpoint for regulatory authorities and OEMs and therefore the linchpin of a new collaboration and sourcing approach between network operators and technology companies.

2. Governments need to adapt regulatory frameworks

Even when the technological and organizational path to digitizing train-control and traffic-management systems is clear, regulatory issues can slow down the implementation of new systems. For example, upgrading the signaling technology requires operators in some countries to upgrade additional elements of a network section to today's standards, which drives up costs significantly and may necessitate new public-permitting processes. In addition, the logic of today's approval process is often project based or route based, which means that approval is required for each piece of new technology for each individual situation, making upgrades time-consuming and expensive. A product-based approach to approval would allow for a solution to be specified, centrally approved, and then deployed across the network.

New approaches to testing and new concepts of security will also be necessary as the industry moves to more algorithmic, software-based solutions to support traffic management. Regulators might be able to learn valuable security-management lessons from other industries. For example, nuclear power plants' safety concepts are based on probabilistic approaches to evaluating relevant risks in terms of impact and likelihood. This type of concept is used in the reliability, availability, maintainability, and safety (RAMS) framework, which the railway industry already uses.

Managing these changes will require a degree of internal reorganization by regulators. Like network operators, regulators will need to have an

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innovation-oriented central function that works closely with network operators and OEMs.

3. OEMs need to coalesce behind one or two technology platforms

Effective platform development requires significant up-front investment and is not suited to the current railway-innovation landscape, which is characterized by a mass of decentralized proprietary developments. In Germany, for example, there are more than 100 different subsystems of train control, and their interfaces are not standardized. These and other proprietary developments are connected only loosely via European associations and groups that contribute to norms, which leads to duplication and very long development cycles.

In other industries, we see players across the value chain combining their efforts and building joint ventures, joint development companies, or other forms of closer cooperation. In the automobile industry, for example, multiple premium-car OEMs organized HERE Technologies to combine their efforts related to autonomous vehicles. Similarly, Ford and Volkswagen formed an alliance to develop a platform for the electric vehicle that will eventually be an industry standard, open to all manufacturers. The telecommunications industry has long-established standards to enable cross-player operation, and advanced industry players offer platforms capable of integrating with various manufacturers' systems for predictive maintenance.

We believe there is room for one or two digital-technology platforms in European train control and traffic management. This will require, on the one hand, a closer collaboration of all players and, on the other hand, a reduction in the depth of specification and agreement on the outputs and interfaces of the modules instead of a prescription for the exact technical functionality.

4. Network operators, governments, and OEMs need to rethink financing

Europe has not yet developed financing structures that are adapted to the logic of digital platforms, which require a huge initial fixed-cost block and then more modest, incremental financing when new regions are connected.

This new model represents a fundamental paradigm shift in which technology costs change from capital expenditures into operating expenditures. This has far-reaching implications

for all major stakeholders in the railway industry: technology providers will see a shift from one-off, individual projects toward longer-term contracts, and current financing arrangements between national governments and network operators will require comprehensive updating. To finance this digital infrastructure, a consolidated funding program that is based on output will be preferable. Network operators, for example, could use a subscription-based model to pay for new train-control and traffic-management systems based on the capacity, availability, reliability, and punctuality of those systems.

5. The railway industry needs to pull together to define and strengthen a truly European ambition
We believe in the motivation and momentum that come from a joint ambition that is both challenging and concrete. Targets for rail digitization have not been especially ambitious at the European level. Standardized technology is a stated goal, for example, but multiple rules about traffic operation have been allowed to coexist, which means that slow movers are a drag on progress.

To this end, we suggest that relevant stakeholders—including operators and OEMs—jointly set an ambitious target of a single digital infrastructure for Europe by 2050. This target should be accompanied by a set of technological goals that include the following commitments:

— Every track and train is to be capable of delivering at least ERTMS level 3, which means that more than 250,000 kilometers of lines and more than 50,000 vehicles must be equipped with new train-control and signaling systems.

— Train operations are to achieve the highest possible grade of automation (GoA), level 4, which would enable an entire operation to exist without train drivers (and with appropriately equipped stations) on 100 percent of high-speed trains and 30 percent of local trains.

— Automated coupling and shunting are also to be implemented in rail freight in all major shunting stations and yards and for 100 percent of the rolling stock.

Formulating and ratifying these targets will not be easy, because only a fraction of the necessary financing is available. In addition, most stakeholders—such as network operators and OEMs—have insufficient capabilities in development, planning, and execution to proceed at a rapid pace. While development of the necessary capabilities is essential, these deficiencies can be partly offset by developing streamlined and simplified processes and by hiring people from industries that are more closely related to software.

Decisive action is needed

The European railway industry can indeed continue to push innovative technology forward. Digitization is fundamental to the ability of rail to grow into an economically viable and environmentally friendly mode of transportation, and we believe Europe is in a good starting position to achieve this growth and attain a successful digital transformation. The challenge is significant, the window of opportunity is narrow, and the entire industry, regardless of roles, must be willing to collaborate and change. The potential gains in cost efficiency and capacity, as well as the benefits of reduced CO_2 emissions, are large both within and outside Europe. To be successful, operators, governments, and OEMs need to act now.

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