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The State of the EU's Rail Infrastructure

Investment priorities for more connected and resilient networks

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Executive summary

Europe's railway infrastructure is at a **critical moment**. After decades of underinvestment, the network is expected to deliver greater reliability and capacity, while also becoming more resilient to natural disasters and external threats, including sabotage.

This report assesses the **current state of rail infrastructure** across EU member states and sets out **how the EU should prioritise future investments** to strengthen connectivity and resilience across the rail network. It is based on data from the EU Agency's *Registers of Infrastructure* (RINF), Eurostat, and OpenStreetMap, covering EU-27 countries as well as Switzerland, Ukraine, and Moldova for selected indicators.

Key findings

Overall, our analysis finds that despite the strategic importance of rail and **annual investments of €40 billion across the EU**, the rail system remains fragmented. Large portions of national networks also fall short of meeting the requirements set out in the EU's core infrastructure policy, the *Trans-European Transport Network* (TEN-T). At the same time, strong performance on specific indicators in some member states demonstrates that faster progress is achievable.

The most notable results include:

- **Fewer than 20% of TEN-T corridors are equipped with the *European Train Control System* (ETCS)**, which is essential to allow trains to run across borders and to increase safety, capacity and reliability.
- **The average speed of rail lines often remains low,** with eight member states achieving a maximum speed of only 80 km/h on the majority of their lines, far below the goal of 160 km/h for the TEN-T.
- **Just over half of the European network is electrified**, although electrified lines are more reliable and curb pollution and noise from trains.

These gaps undermine rail's capacity to offer fast, reliable and clean transport and to remain resilient in the face of disruptions. A targeted approach to investment is therefore essential.

Policy Recommendations

This report identifies six priority areas for investment that can unlock a more

reliable, connected, and competitive EU rail system. They are summarised in the infographic below.

With the European Commission preparing new proposals to support rail investments, a strategic and focused approach is critical:

- **The upcoming *Connecting Europe through high-speed rail* plan should prioritise the removal of interoperability and capacity barriers**, particularly the slow rollout of the *European Train Control System* (ETCS). The next EU budget should earmark investments accordingly and increase co-funding rates to at least 60% under the *Connecting Europe Facility* budget.
- **Infrastructure upgrades should be prioritised over newly built megaprojects** to make an impact across most of the rail networks in the short- to mid-term.
- **Dual-use considerations should be integrated into rail infrastructure investments.** An increase in rail investments is expected due to the EU's new emphasis on military mobility, and these funds should be directed toward dual-use infrastructure that also benefits civilian rail services and helps address the challenges identified in this report.

1. Context and aim of the report

1.1 Rail plays an important role in zero emission mobility and its potential should be maximised

Rail carries 7% of EU passenger traffic but accounts for 0.4% of transport greenhouse gas emissions, making it an important part of the solution for decarbonising the transport system. It is also fundamental for the transport of goods across Europe.

Europe has one of the densest rail networks in the world, but its quality varies between countries. Instead of a unified pan-European network, the system remains a patchwork shaped by national rules and priorities.

To address this, the EU has revised the Trans-European Transport Network (TEN-T) regulation, setting minimum standards for speed and interoperability along the main European corridors. Future EU funds are expected to focus on supporting member states in TEN-T implementation. And the European Commission is working on a so-called Connecting Europe through high-speed plan to connect EU capitals and large cities.

Given the estimated €515 billion needed for the completion of the core network alone, prioritising investment will be essential. However, this is a complex task. Our analysis provides an EU-wide perspective on key infrastructure upgrades, alongside detailed country-specific insights. The aim is to learn from past mistakes and ensure investments target the most effective projects.

1.2 Rail infrastructure must become more resilient

Recent climate disasters and geopolitical developments have evidenced the need to update European infrastructure in order to improve crisis management and strengthen the continent's security. For this reason both the European Commission and the member states are aiming to adapt the railway network to a dual civilian and military use, especially within the TEN-T network. As a result, new infrastructure will need to include dual-use considerations in the planning phase.

The White Paper on EU defense sets out this vision. Four priority multimodal corridors have been selected, along with 500 projects within them for urgent upgrades. A Joint Communication on Military Mobility will follow later in the year. In addition, stress testing is being considered to protect railway operations from cyber attacks and minimise the damage of extreme weather events.

1.3 Change depends on strengthening strategic infrastructure investments in the next year

The TEN-T provides a framework for both high-speed and conventional rail connections between Europe's main urban nodes. The regulation sets deadlines for member states to complete key railway lines, with priorities divided into three phases:

- Core network by 2030
- Extended core network by 2040
- Comprehensive network by 2050.

Additional requirements for interoperability and competitiveness include:

- The European Rail Traffic Management System (ERTMS) must be implemented within the same time frames.
- By 2040 75% of passenger rail sections in the core and extended networks must allow speeds of up to 160 km/h
- Provisions for track gauge harmonisation and intermodality.

A large share of EU funding is needed to support these commitments but the exact amount remains unclear. The European Commission will propose a new EU Multiannual Financial Framework (MFF) by July 2025, which is expected to include a revised budget for investments in rail infrastructure. A business-as-usual approach could put these plans at risk. With funding levels uncertain, investments should be more targeted.

1.4 Stagnating rail spend requires targeted investments

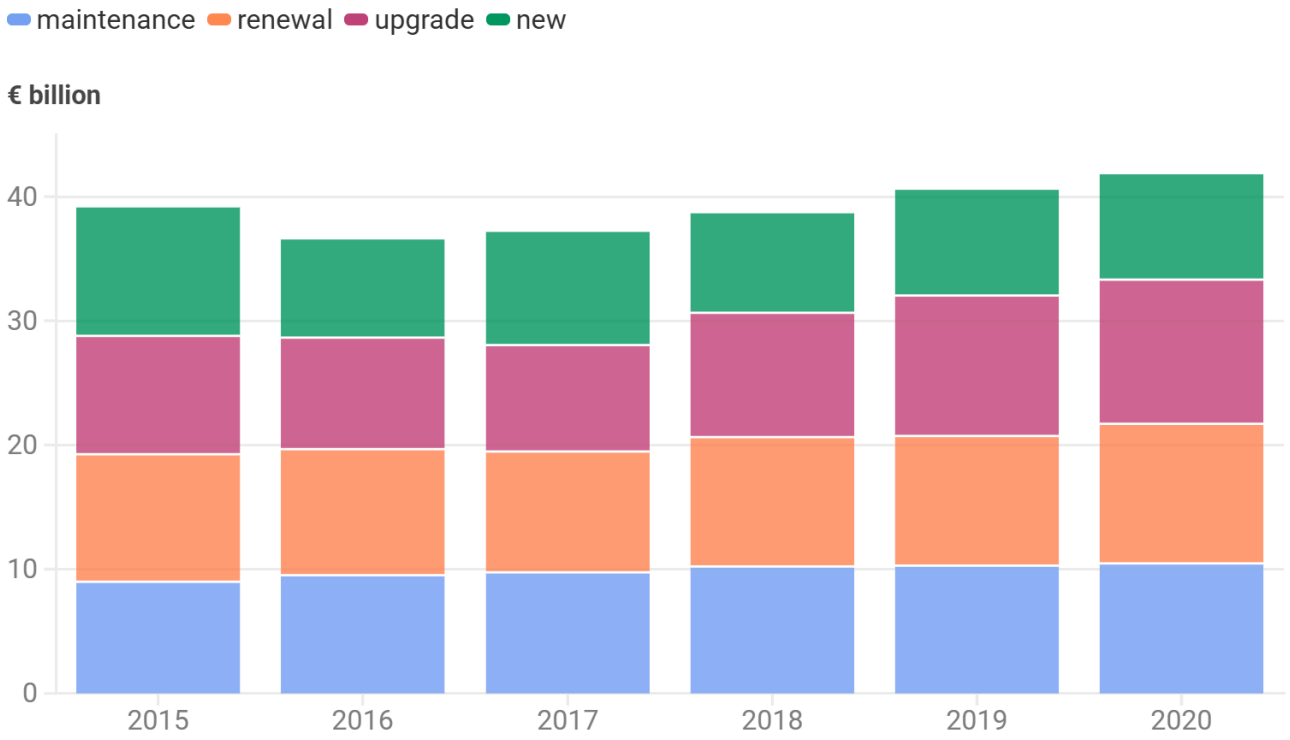
The Connecting Europe Facility (CEF) has been the main funding mechanism for the implementation of the TEN-T. However, it has been dominated by megaprojects due to the previous TEN-T configuration, which focused on 30 priority axes and projects instead of the current emphasis on complete corridors. Many of these large-scale projects, such as the Lyon-Turin or the Brenner base tunnels, have been delayed and over budget, continuing to consume CEF resources.

The new MFF presents an opportunity to support a broader range of projects, as some of the major projects near completion. However, the size of the upcoming funding pot remains uncertain.

Spending on rail infrastructure increased slightly from €39.1 billion in 2015 to €41.8 billion in 2020. When accounting for inflation, the real value stayed almost the same. Of this, 25% was allocated to maintenance, 27% to renewals, 28% to upgrades and 20% to new infrastructure investments. National budgets provided the majority of funding, while EU co-financing accounted for 8%. After 2020, EU funding through the CEF, Cohesion policy and the Recovery and Resilience Facility is likely to determine an increase in the share of EU funding over the total spending on rail. This EU funding remains crucial for cross-border sections and countries under the cohesion framework.

Rail spend remains largely unchanged

Total expenditure on rail infrastructure (EU-27)



Source: RMMS (2022)

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The European Commission estimates that completing the TEN-T core network by 2030 will cost an estimated €515 billion. For 2040 this figure would rise up to €850 billion. But the CEF is continuously oversubscribed, sometimes by 300%. Meanwhile, other transport sectors require major funding under the Clean Industrial Deal, making a significant rail funding increase unlikely in the next MFF.

EU funds are not the most prominent part of most member states' rail budgets but are crucial for countries under the cohesion policy and cross-border projects. With limited resources, the Commission must balance European priorities with national network needs, prioritising projects that offer the best value for money. In addition, the EU's Preparedness Union Strategy establishes that dual-use considerations will have to be included in all of its infrastructure investments.

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2. Our Methodology

Our analysis used multiple data sources to assess key infrastructure characteristics.

- ERTMS deployment data was sourced from the Register of Infrastructure (RINF), managed by the EU Agency for Railways. We calculated the total length of ETCS-equipped track and compared it to Eurostat's overall track length data.
- Track electrification, traffic volumes and capacity utilisation - measured by dividing train kilometers traveled by total network length - were also sourced from Eurostat. Data on track gauge, double-track sections and on dedicated high-speed lines were all obtained from Eurostat.
- Speed limits were assessed using OpenStreetMap, filtering for actual rail lines and removing duplicates. Track lengths were then calculated based on geographic coordinates, and speeds over 250 km/h were crosschecked with Eurostat. No external validation was available for lower-speeds data.

Our analysis focused on EU-27 countries, though we included countries like Switzerland, Ukraine and Moldova for specific metrics such as capacity and track gauge changes, as well as their relevance for military mobility. Some countries lacked data due to incomplete or unavailable datasets at the time of analysis. It is also important to note that two countries in the EU do not have railway systems.

The focus is mostly on passenger rail. We selected six criteria for their relevance to rail interoperability and competitiveness across Europe, as well as their connection to European funding. Further information on why these indicators were selected can be found in the annex, along with national case studies for each specific indicator. While maintenance spending is critical, it primarily relies on national budgets. Other criteria, such as the condition of rolling stock, could not be analysed here and shall be addressed in future research.

3. Rail investment priorities

Main priorities

3.1. Accelerate ERTMS deployment for high quality, efficient infrastructure

ERTMS is an essential signalling and speed system for rail quality, safety and interoperability. Its benefits include:

- Allowing higher speeds when substituting national legacy systems that impose limits of 200 km/h on lines designed for higher speeds;
- Increases track capacity by reducing train separation distance;
- Lowering signalling maintenance costs while enhancing safety;
- Supports seamless cross-border rail by eliminating the need for multiple signalling systems.
- Facilitates the integration of freight and passenger services on shared lines, especially when combined with digital enablers.

ERTMS consists of the European Train Control System (ETCS), which supports interoperability, speed and safety. It also relies on railway mobile radios like the currently deployed Global System for Mobile communications for Railways (GSM-R) for operational communication and the upcoming Future Radio Mobile Communication System (FRMCS). ETCS is designed to work seamlessly with both systems to ensure continued functionality and interoperability during the transition to FRMCS. The third component is Automatic Train Operation (ATO), a digital layer that automates certain driving tasks and enhances the performance of ETCS-equipped trains.

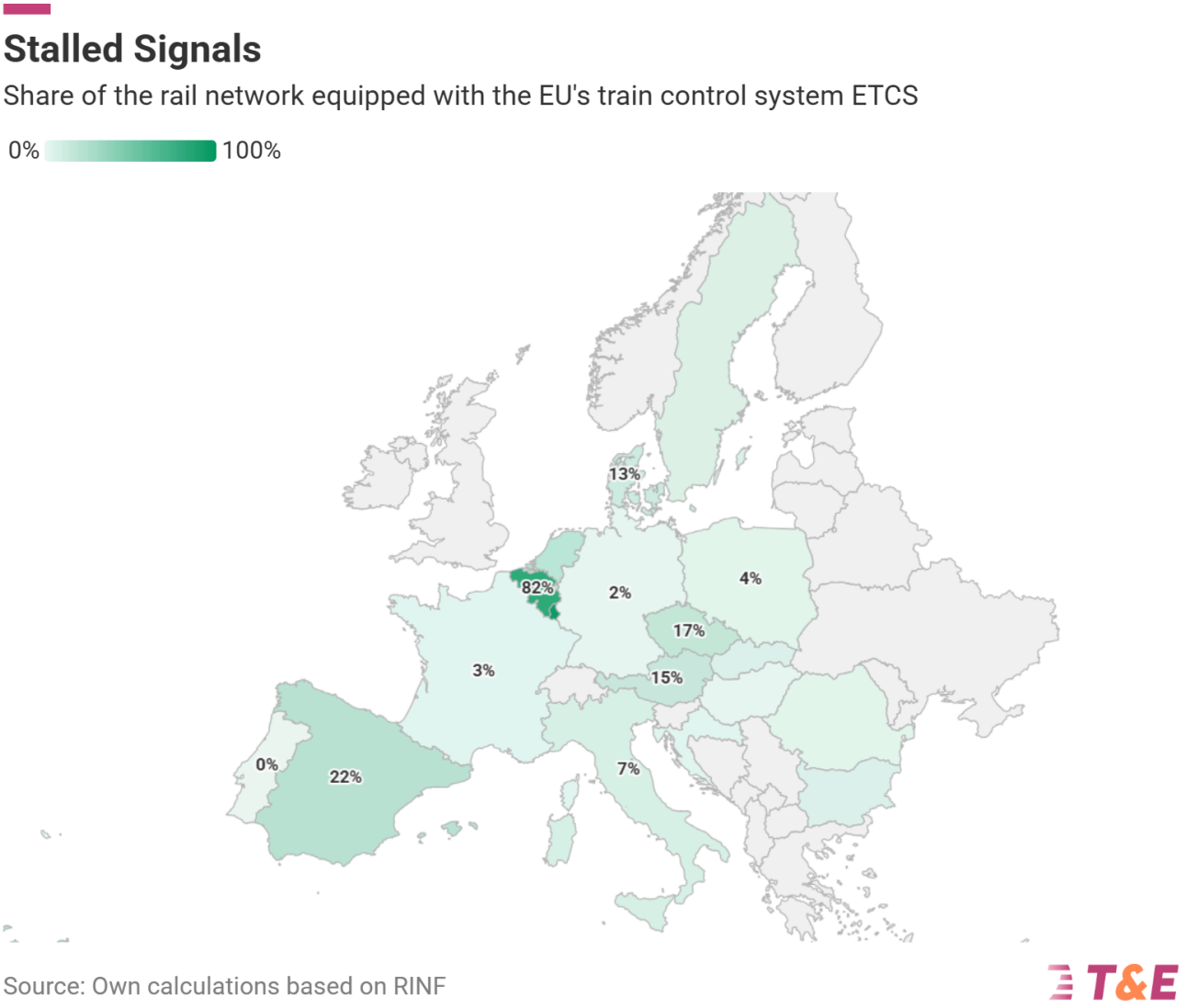
Despite long-term EU goals for full deployment, progress remains slow. The TEN-T regulation requires ERTMS deployment across the core network by 2030, with national legacy systems phased out by 2040. Although GSM-R reached 61% of the core network in 2023, only 15% had ETCS installed. In the case of on-board ETCS, high installation and retrofitting costs are further hindering progress. The lack of a single ETCS variant and the frequent updates of the system force locomotives to undergo additional and costly adjustments at the workshop.

Yet these obstacles should not overshadow the strategic importance of ERTMS for modernising the EU transport system. A wide deployment, including beyond the Core Network and aligned with national implementation plans, can deliver significant improvements in capacity, punctuality, and cross-border performance. When supported by complementary measures such as Digital Automatic Coupling, longer and faster trains, and harmonised operations, ERTMS can become a cornerstone of a resilient, low-carbon, and high-efficiency European rail system. Failing to invest now would risk locking in fragmentation and inefficiency for another generation.

A) General EU overview of ERTMS deployment

ERTMS deployment has been uneven across member states. Belgium has exceeded the Commission's deployment plan, aiming to fully decommission its legacy system in the conventional network by the end of 2025, benefiting from increased capacity and reduced costs. While deployment on the infrastructure side is expected to meet the deadline, a two year extension is expected for rolling stock.

In contrast, Portugal's National Implementation Plan lacked sufficient detail to comply with the EU deployment plan. Its legacy signalling system, the EBICAB version commonly known as Convel, is no longer manufactured, restricting cross-border services and complicating the renewal of rolling stock. While a solution to allow ETCS compatibility is being developed, such as the Specific Transmission Model, full ERTMS deployment across TEN-T would prevent such issues.



Out of the countries from which the data was available, only Belgium and Luxembourg are close to completing all of their networks with ETCS. And many still have a share below 10%. This is

especially problematic in countries like France, Germany and Poland, as they are key nodes in the TEN-T network.

B) Policy recommendations

With member states slow to act, the EU should strengthen its support for ERTMS.

- **Increase CEF support:** Co-funding rates under the CEF should rise to at least 60%;
- **Include coverage of urban nodes:** ERTMS should be implemented along entire lines, including urban nodes near central stations, which are often left out for financial reasons. This would avoid system changes and maximise interoperability;
- **Raise State Aid limits:** The revised State Aid Guidelines should allow up to 100% coverage of eligible costs. This would enable wealthier countries to accelerate deployment, indirectly benefiting smaller member states by improving cross-border connectivity, without harming the level playing field.
- **Enhance EU management:** The European Commission should reinforce its internal resources for ERTMS coordination and collaborate with member states to appoint national ERTMS coordinators. The EU Agency for Railways (ERA) should receive more resources, supported by industry participation, similar to how the European Union Aviation Safety Agency (EASA) is partly funded by fees and charges for services provided to the aviation industry;
- **Harmonise, standardise and address cost drivers:** Harmonising technical requirements and simplifying authorisation processes will lead to a more cost-effective implementation. Although ERTMS was conceived as a unified European system, there are various national specificities and variants that were introduced to address local or national specificities but undermine the goal of interoperability. The EU and the rail sector should agree on a standardised version to be deployed for at least 10 years to end the current fragmentation of different baselines and national "ERTMS grammars" that actually make things more complicated.

3.2. Increasing line speeds to 160 km/h to make rail time-competitive

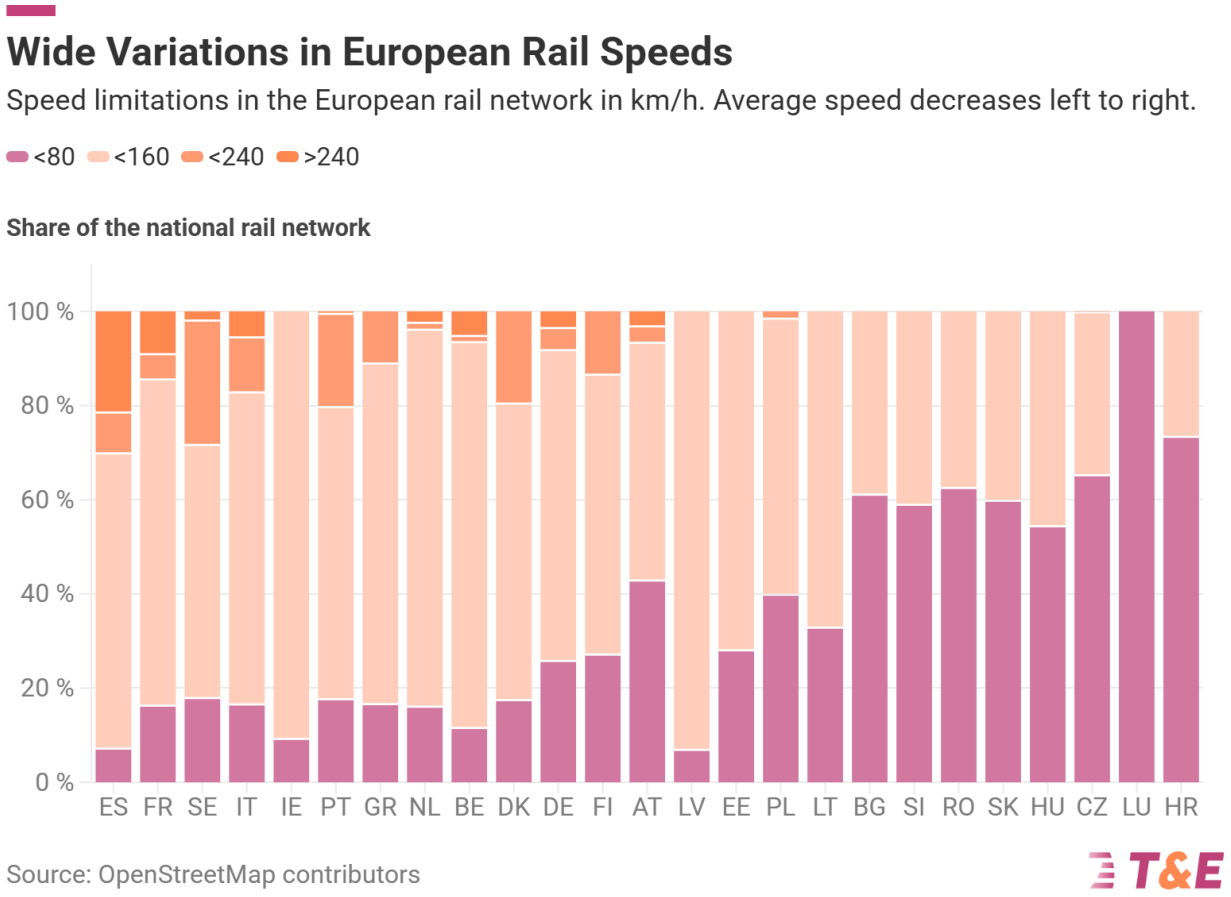
Rail's benefits are maximised when it carries large numbers of passengers. However, its competitiveness against other modes of transport is hindered by slow speed, particularly on the conventional network. Member states have generally prioritised increasing rail speeds between their main urban centres, neglecting other routes. In many cases, even major cities experience sluggish connections, such as Bucharest to Cluj-Napoca or Zagreb to Split. Meanwhile, intensive motorway construction, supported by EU funds, has accelerated conventional rail's decline, as road transport became faster and drained resources from rail.

The TEN-T regulation is now reversing this trend. It requires all lines in the core and extended core TEN-T network to support speeds of at least 160 km/h, which offers high transformative potential for countries in Central and Eastern Europe.

By setting this TEN-T requirement, many lines primarily included for freight or military mobility can also enhance conventional passenger rail. This will go some way to making it competitive with road transport. It is expected to increase passenger numbers, allow higher frequencies, improve service to citizens and enhance energy-efficiency. In many European countries, this will also mean faster connections on key routes where such speeds were previously rare. It also supports cohesion policy by ensuring competitive rail access in less populated regions.

According to a recent European Commission study, increasing speeds to 160 km/h in the TEN-T network would make rail faster than flying on 35 routes, reducing CO_2 emissions by 25% on all of them. However this study did not account for possible rebound effects, which may require measures like CO_2 ceilings or flight caps at airports to achieve those emission reductions. The report also highlighted that only 3% of the routes analysed allowed speeds above 150 km/h, while 30% were below 60 km/h. Outside the TEN-T, the situation is even worse.

A) General EU overview of line speeds



Track-side limitations create disparities in train speeds across Europe. Over one fifth of the Spanish network supports speeds above 240 km/h, whilst most of the Croatian network is limited to under 80 km/h.

Several factors influence line speeds, including challenging terrain, as seen in Austria's large percentage of low speed lines. In very small countries like Luxembourg, high speeds offer little advantage, but they will benefit considerably by speed improvements in neighbouring countries. However, stark differences remain between Western and Eastern Europe, largely due to financial constraints preventing proper maintenance and upgrades on their networks.

B) Policy recommendations

The TEN-T regulation has created opportunities for widespread upgrades on conventional lines.

- **Ensure rolling stock readiness:** To fully benefit from increasing line speeds, operators will need rolling stock capable of reaching these speeds. Financing options are available through organisations like Eurofima. The revised state aid guidelines for rail will also provide easier support for rolling stock investment.
- **Maintain high average speeds:** Prioritise maintenance to avoid temporary speed restrictions that undermine speed limit increases. Investments should focus on eliminating these bottlenecks promptly.
- **Coordinate with freight and military mobility priorities**: When working on structures that need to be modified to allow higher speeds, those that act as the main barriers to rail motorways and military mobility should be taken into account.

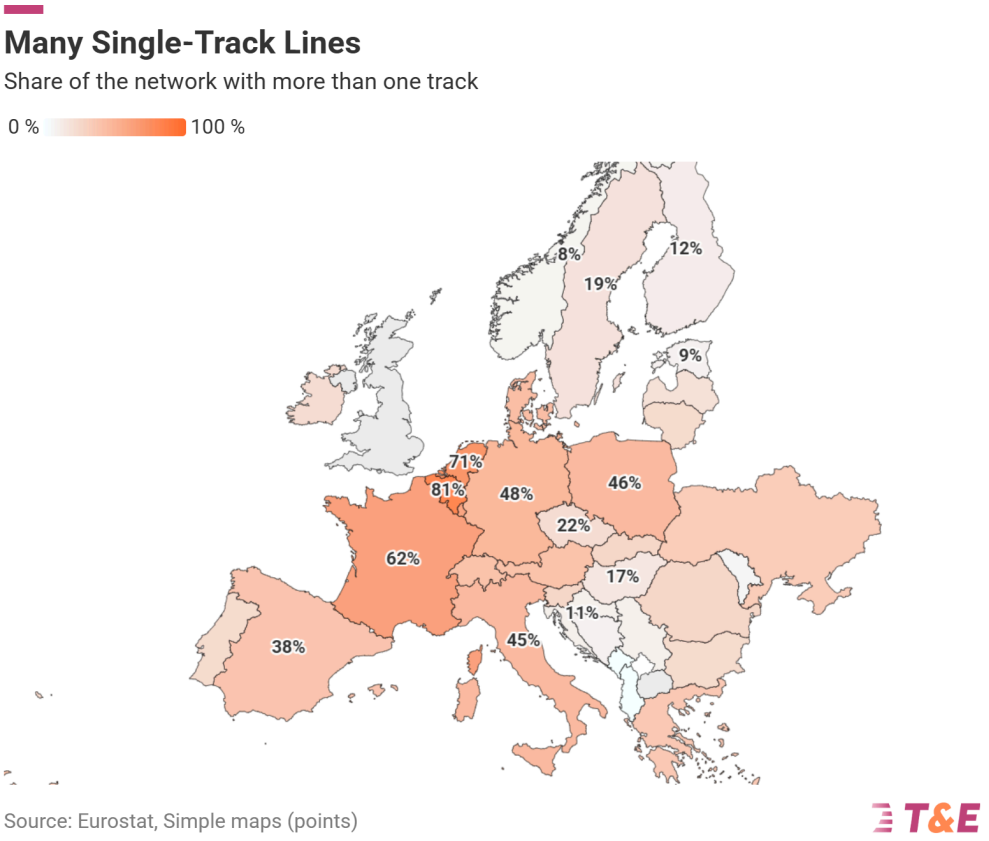
3.3. Add capacity through new tracks where needed

Some parts of the rail network are close to maximum capacity. According to the Commission's impact assessment of the infrastructure capacity regulation, 2934km of tracks were congested in 2020, which is the equivalent of 1.46% of the network. While this is not a high proportion, a small number of bottlenecks can affect large parts of the network, limiting frequencies, causing delays and impeding new connections. Building new lines or tracks can help, but is expensive. In many cases, the constraints are caused by stations rather than the lines themselves as referenced by the IRG-Rail report on congestion.

Digital solutions like ERTMS or Digital Capacity Management and better governance among infrastructure managers can improve capacity on existing tracks. However, adding capacity through additional tracks should be justified, for instance, where fast intercity trains and slow local trains coexist, leading to timetable conflicts and delays.

A) General EU overview of rail capacity

One way to assess capacity is by examining the share of the network with more than one track. Core countries tend to have a much higher percentage of double tracks than peripheral ones, partly due to the need to accommodate more freight traffic.

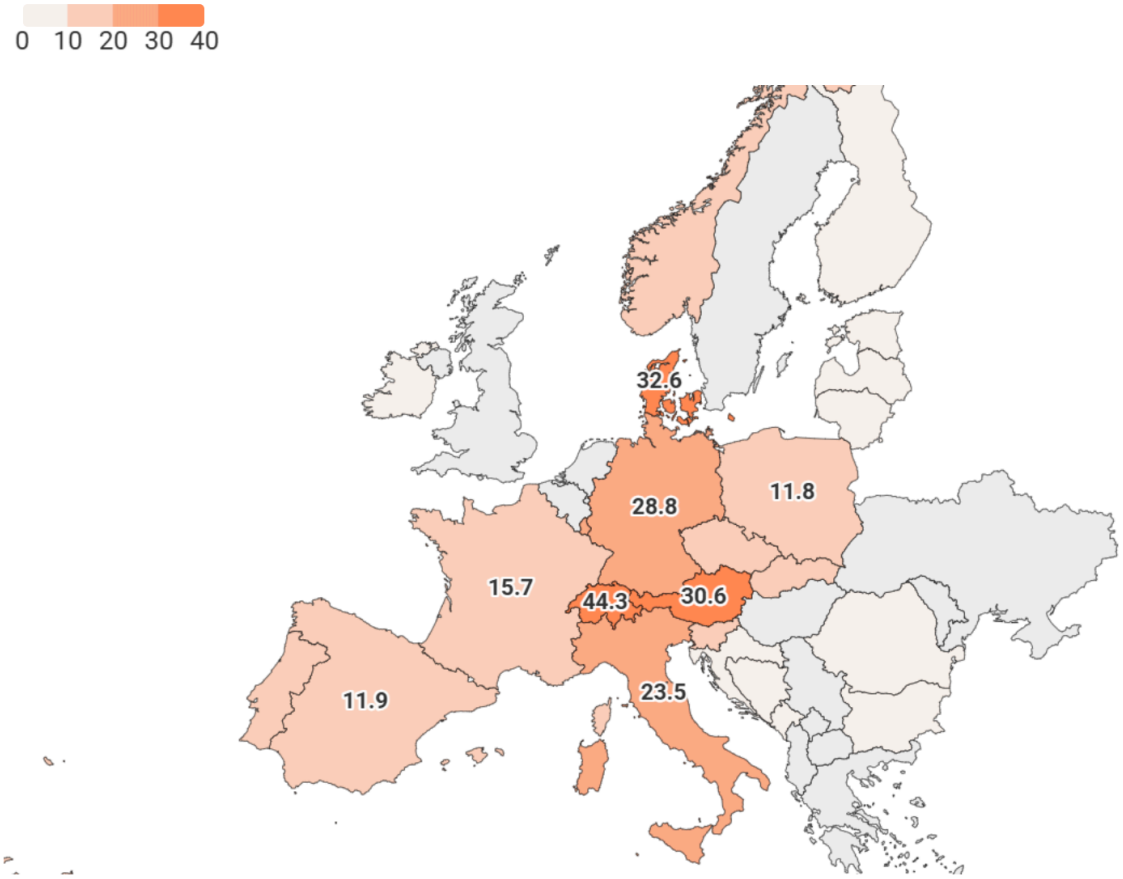


Population density also plays a key role, as seen in Belgium, Netherlands and Luxembourg, which have the highest share of multi-track. This trend is confirmed by countries like Sweden, Finland and Norway ranking lower despite their high GDP.

Looking at the growth of double tracked lines, Greece shows the largest increase. However, this does not necessarily indicate network improvement, for example, the closure of single-track lines raises the share of double tracked lines. Moreover, these figures do not reflect how much of the available capacity is actually in use. For a clearer picture, it is more relevant to analyse rail capacity usage.

Capacity Utilisation

average thousand train-km per track-km each year



Source: own calculation based on Eurostat

Train-km per track-km can indicate how efficiently a rail network is utilised. Our analysis shows that Switzerland leads this measure, with Denmark and Austria topping the EU ranking. These countries make the most of their capacity and are also among the leading countries in ETCS deployment.

In contrast, countries like Spain or Poland have a high proportion of double-track lines but low usage of their available capacity. For these countries the focus should be on increasing utilisation rather than expanding capacity. However, when planning new lines that see low current, but high expected future demand, partial or full double tracking remains a prudent investment to avoid higher costs in the future.

B) Policy recommendations

- **Prioritise station upgrades to resolve bottlenecks:** Station upgrades should take priority when they are the main cause of congestion. In Spain, for example, capacity issues are

mainly due to constraints in some railway stations. Rail's key advantage is the centrality of its stations, and any capacity expansion should maintain this.

- **Convert terminus stations into through stations where beneficial:** Where reasonable, converting terminus stations can improve network flow, but capacity gain must justify the cost. Malmö city tunnel enhanced commuter and long distance rail services for €1 billion, while Stuttgart 21, at €12 Billion, faces delays. Capacity gains in the latter are expected to be limited due to the closure of the existing surface station and design issues suggest future service demand may require a second underground station.
- **Build short connecting lines to ease congestion:** Small-scale solutions, like France's Massy barreau, can increase high speed line connectivity while improving commuter rail services at a low cost.
- **Optimise existing lines before expanding:** When a line has reached capacity, upgrading signalling systems and standardising speeds should be considered before adding new tracks or building an entirely new line. EU funding should focus on new tracks or lines that substantially improve freight and passenger services.
- **Maximise rail use in underutilised networks:** Countries with surplus capacity should implement country-specific policy measures to encourage greater use of the rail. These could include applying the polluter pays principle to their fiscal policies and the promotion of competition.

Secondary priorities

3.4. Boost electrification

There are several benefits to electrification. In addition to emission reductions, electric trains are more affordable over time compared to their diesel counterparts. Reliability can be approximately 40% higher for long-distance trains and 300% higher for suburban trains. They are also more energy-efficient and reduce journey times due to higher acceleration, which increases capacity. However, for the investment to be worthwhile, the lines considered for electrification need to have significant traffic. This is not only due to the initial capital investment for the catenary system, but also the higher maintenance costs. While capital expenditure (CAPEX) is higher, it reduces operational expenditures (OPEX) for trains. However, it increases OPEX for track maintenance. Consideration of these factors during the cost benefit analysis will determine whether electrification is the most appropriate option.

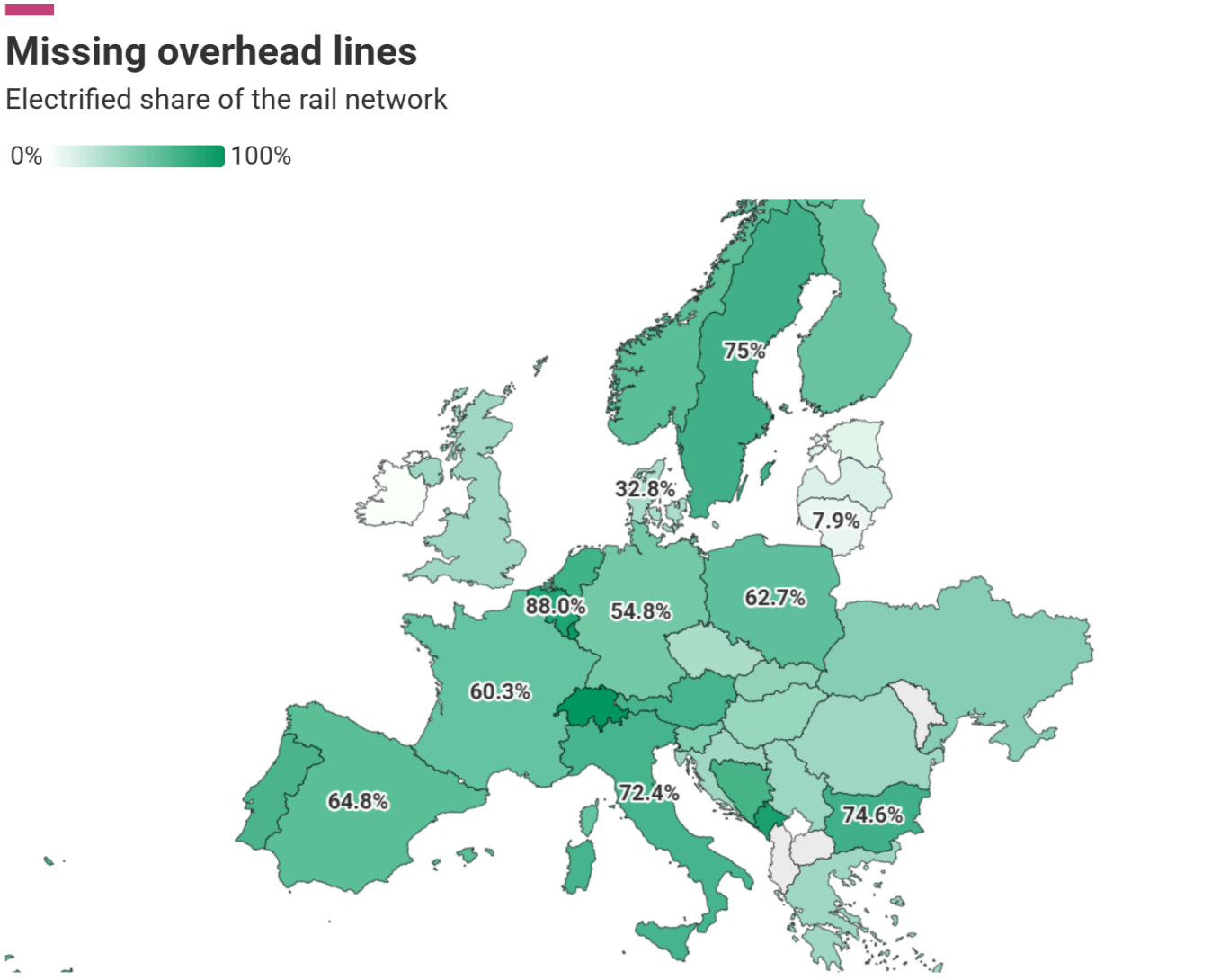
At present, 56% of Europe's railways are electrified. And electrified lines carry around 80% of rail traffic. This is one of the primary reasons rail is one of the most sustainable modes of transport.

The push for further electrification will continue, with core TEN-T lines required to be electrified by 2030. Member states are making slow progress in the standardisation of voltage systems, which is another important element for interoperability. While a common signalling system is

vital, the need for rolling stock compatible with two or three different current systems increases cost considerably. A lack of suitable rolling stock remains one of the major barriers to cross-border rail services. However, full standardisation may not be cost-effective, so long-distance and cross-border lines should be the focus.

A) General EU overview of electrification

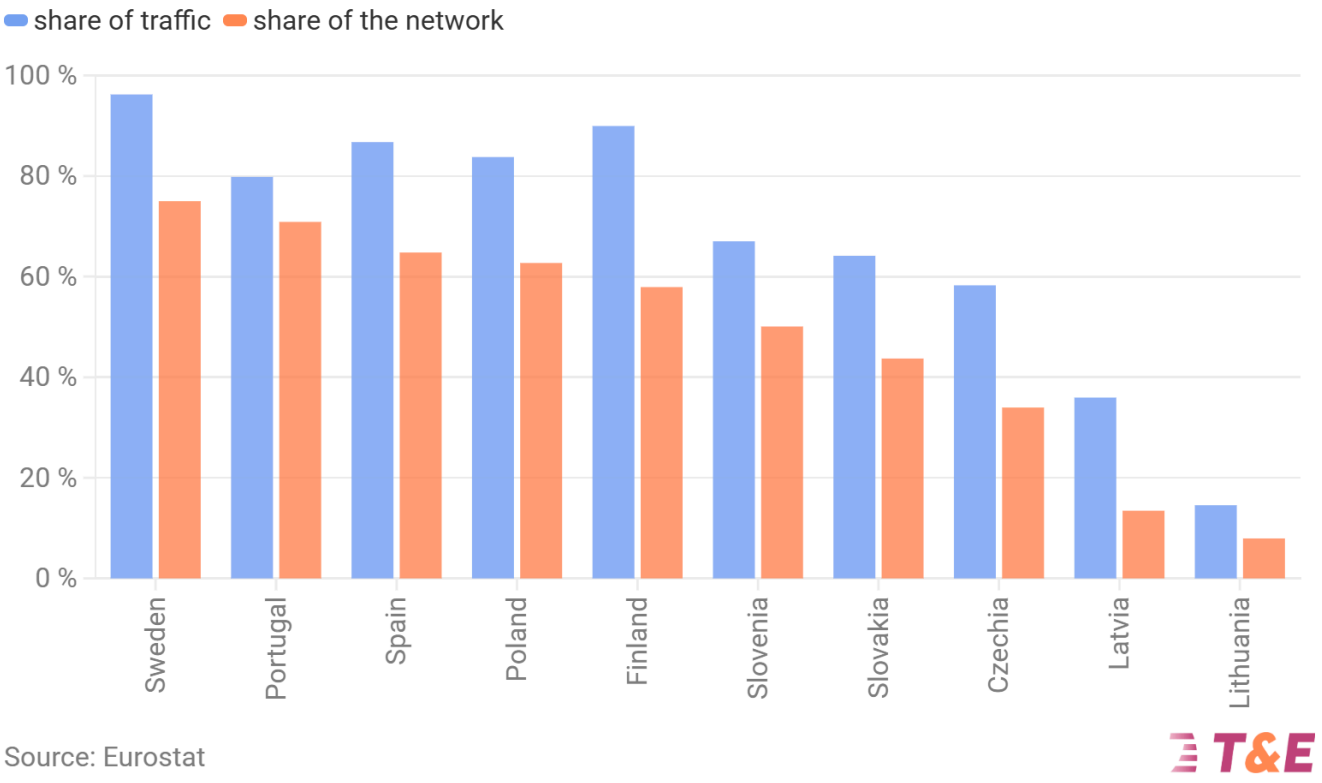
Many European countries are close to achieving full electrification, but a clear east-west divide remains, which is not as evident when examining network capacity. Since electrification is not essential, it can be lower in the priority list for member states with limited investment capacity, provided they invest in zero emission rolling stock such as battery electric trains for non-electrified lines.



There are some exceptions, however, such as Denmark with low electrification and Bulgaria with high electrification. Only 10 out of 27 EU countries have an electrification share above 60%.

The high impact of electrification

The electrified share of the annual rail km consistently exceed the electrified share of the rail network



Source: Eurostat

Electrified lines see higher usage, which is beneficial for efficiency and emissions reductions. Although the differences vary between countries, the share of traffic is higher in all cases.

B) Policy recommendations

- **Advance electrification for seamless rail travel:** Countries should aim to electrify most of their network to enable easy travel across Europe, but those with high electrification levels should focus on other investments.
- **Support energy storage solutions, such as battery-electric trains:** These alternatives should continue to be developed for lines where full electrification is not justified from a socioeconomic point of view.
- **Use 25 kV AC for new electrification where possible:** This system offers low energy consumption, fewer substations and higher capacity, which is why it is mandatory for high-speed rail. However, it also requires longer maintenance windows, which makes it less suitable for busy commuter networks. Member states should re-electrify key cross-border routes at 25 kV when there is considerable cross-border potential. A migratable catenary could be used for a smooth transition as in the Brussels-Luxembourg case.

- **Allow exceptions for commuter networks:** In cases where cross-border travel is unlikely and repurposing large rolling stock fleets would be costly, maintaining existing systems should be considered.

3.5. Track gauge conversion

The biggest physical barrier to cross-border rail is different track gauges, although this is a localised problem only affecting some peripheral member states. Solutions such as gauge changers and mixed gauge rails exist to mitigate the impact, but they are costly and better suited as temporary measures rather than long-term solutions. Nevertheless, a full conversion of all existing lines would be too expensive and inefficient, so member states should only prioritise the main corridors in the TEN-T.

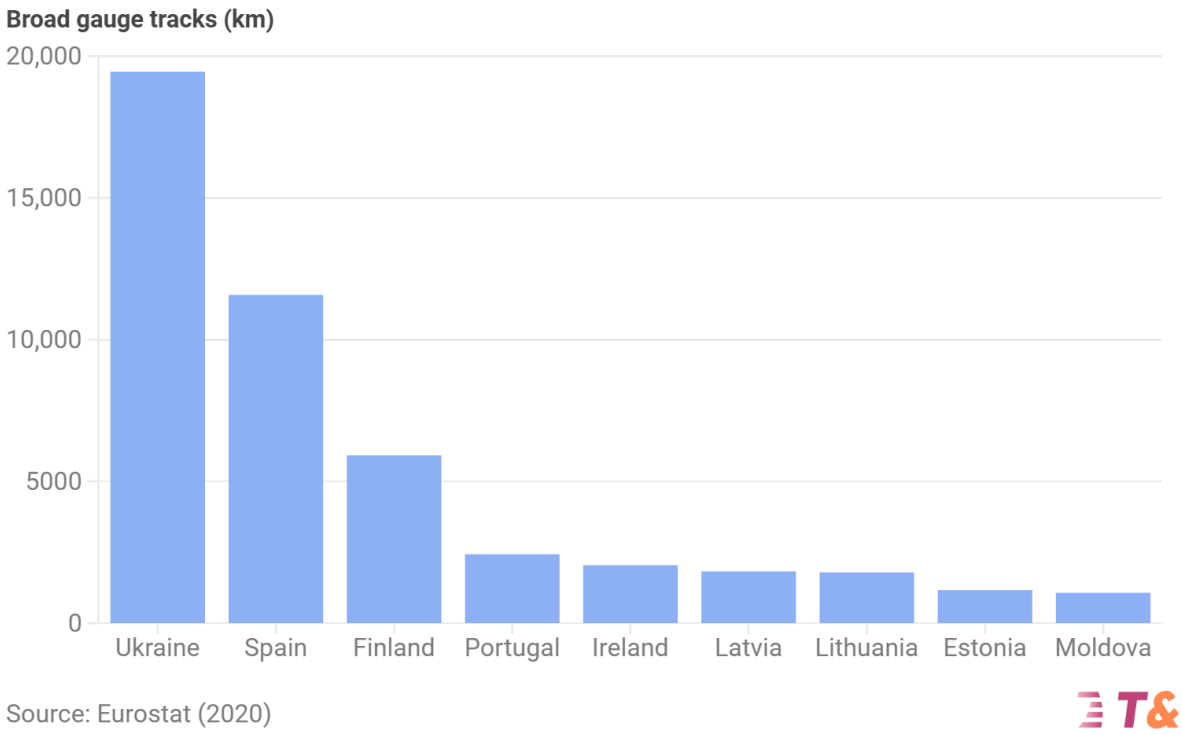
The EU should establish standard gauge as the primary track width in every country except Ireland if socioeconomic studies are favorable. In Finland, for instance, a conversion is unlikely to be positive due to geographical factors. However, for those member states where the transition is suitable, it must be phased and flexible to avoid disrupting operations in affected networks. Coordination between countries will be essential. For instance, Portugal cannot convert its network without clarity on Spain's approach.

A) General EU overview of track gauges

The majority of Europe uses standard gauge, with a width of 1435 mm, but some peripheral countries have a broader gauge. Ukraine, Finland, Latvia, Lithuania and Estonia use tracks of approximately 1520 mm due to historic ties to Russia. Ireland operates on a 1600 mm gauge, while Spain and Portugal use the Iberian gauge of 1688 mm. Many of these countries have begun converting parts of their network to standard gauge or are constructing new lines with it. However, the transition is expected to be complex and will require careful planning.

A lengthy conversion

Countries where broad gauge is dominant



Source: Eurostat (2020)

Overhauling thousands of kilometres of railway tracks is a complex task. In 2020, Ukraine alone had nearly 20,000 km of broad gauge railway. Such large-scale works will inevitably disrupt existing services, potentially weakening connections and pushing passengers towards more polluting transport modes. Careful management of the conversion process is therefore essential.

Under the TEN-T regulation, member states must submit a plan by 19 July 2026, including a socio-economic cost-benefit analysis assessing the viability of transitioning to standard gauge. This plan must be coordinated with neighbouring member states for cross-border sections and evaluate both positive and negative impacts on interoperability within and beyond the country making the transition.

B) Policy recommendations

- **Make the best use of available integration solutions:** Countries should take advantage of solutions like mixed gauge changers for track integration. However, these solutions should not be permanent due to their high maintenance costs and impact on train speeds. The Commission's tight deadlines make it difficult for many countries, especially those without experience in high-traffic line conversions, to make fully informed decisions.
- **Balance urgency with proper planning:** Countries where broad gauge is dominant and cost-benefit analyses are positive must immediately begin preparing their infrastructure

for future conversion. This can be done by using polyvalent sleepers for both new and upgraded lines, reducing migration costs and time.

- **Ensure all infrastructure elements are adaptable:** To guarantee smooth operations, all infrastructure components - such as sidings - must also be polyvalent. Flexibility is key to avoiding costly delays.
- **Provide member states with adequate time and support:** The Commission must show flexibility and allow sufficient time and resources for proper planning. A revision in 2030 would ensure that plans accurately reflect real-world conditions.

3.6. New high-speed lines

High-speed rail has been crucial to rail's competitiveness, attracting large numbers of passengers from more polluting cars and planes while increasing profitability for railway operators. For example, rail's modal share between Milan and Rome has gone from less than half in 2008 to 79% in 2023.

Europe has been a global leader in high-speed rail, with Spain and France having two of the five largest high-speed networks in the world. However, development has been highly uneven and costs have been significant - nearly €25 billion has been invested since 2000.

With limited future EU funding, high-speed rail investment should prioritise projects that offer the highest EU-added value while keeping costs in check. For T&E, this means focusing on new international links that enable fast, frequent connections between major urban areas or regions with strong socio-economic ties.

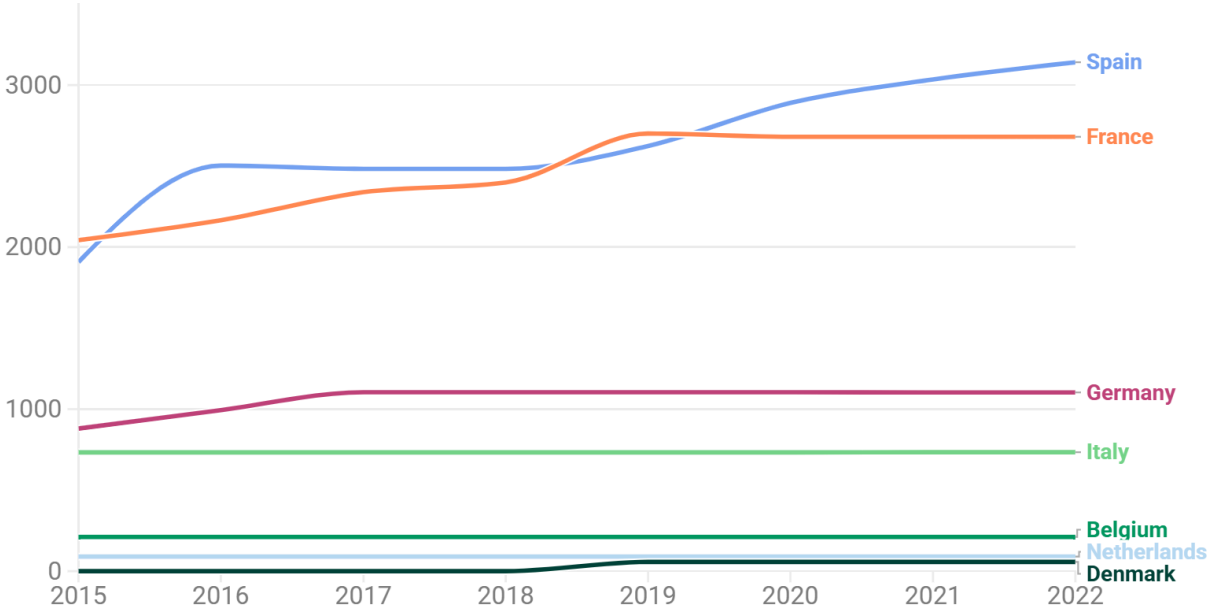
Previously, the EU prioritised big-budget cross border projects such as the Brenner Base Tunnel, Mont Cenis Tunnel, Fehmarn Belt Tunnel and Rail Baltica. While these projects could deliver EU wide benefits, their high costs have diverted funding from smaller projects, especially within conventional rail. This needs to change.

A) General EU overview of high-speed lines

High-speed networks have been designed in isolation. Despite Spain and France bordering each other and representing a large proportion of the EU's high speed network, connections between the two countries are limited and underutilised, even with existing cross-border infrastructure. This illustrates how poor planning and coordination can reduce the effectiveness of cross border high-speed infrastructure, especially when it's not well connected to the rest of the network.

A two country race

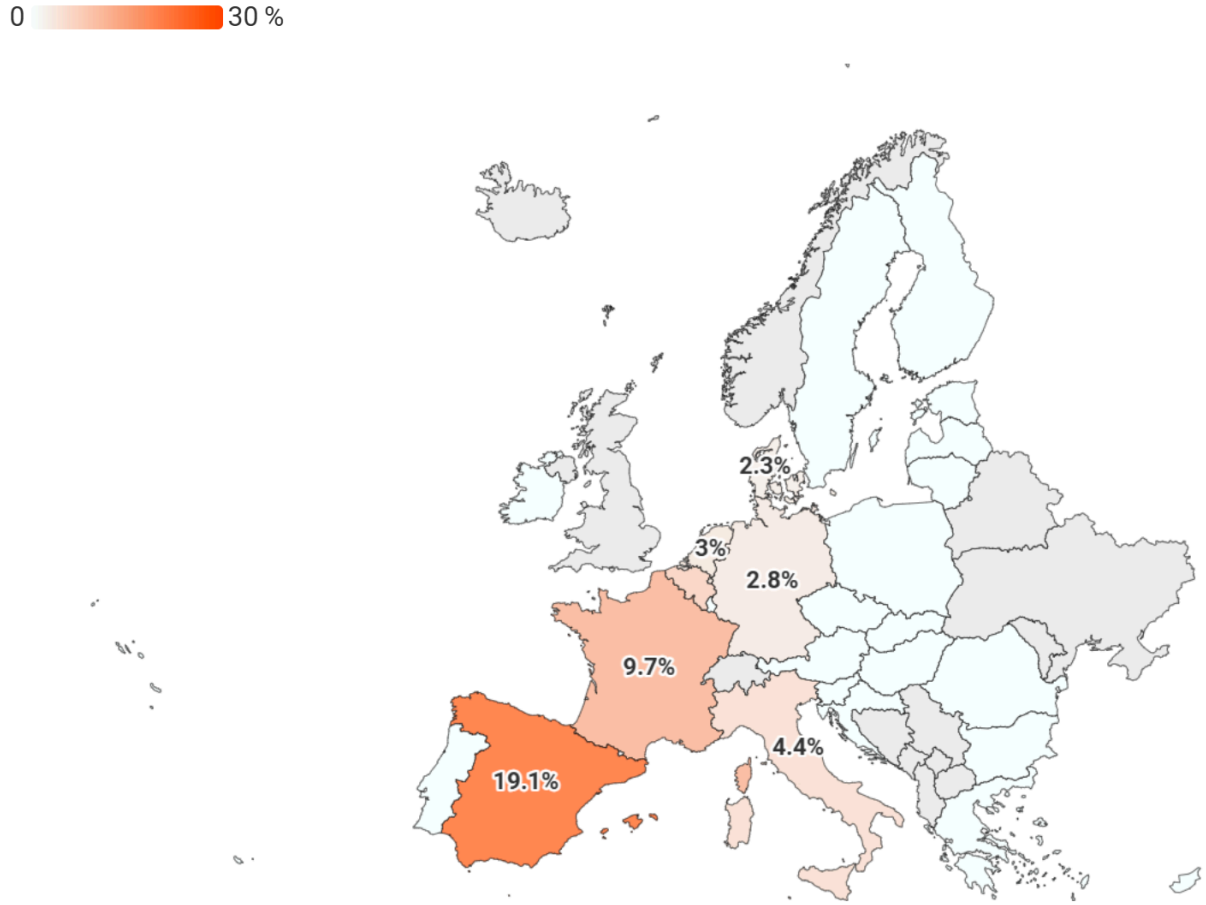
Dedicated high speed lines in EU countries (≥250 km/h)



Source: Eurostat (2023)

High-speed domination

Share of dedicated high-speed lines in total rail network length in EU countries by 2022



Source: Eurostat (2022)

While countries like Germany and Italy present a low percentage of dedicated high-speed lines, both have a large absolute number of high-speed services. Some countries, such as Sweden and Austria, have infrastructure that supports high-speed rail, but their rolling stock is not reaching those speeds yet. Denmark faces a similar situation, despite being counted as having dedicated high-speed lines in the Eurostat data, whereas Sweden and Austria are not. Central and Eastern Europe has yet to see high-speed rail. Poland and the Czech Republic are ready to build out their networks and the EU should provide support via Cohesion funding to assist with the development of these networks.

B) Policy recommendations

- **Prioritise high-speed links in Central and Eastern European key cross-border connections:** Western European countries like Spain and Italy have already benefited from EU funding for high-speed rail. Now, Central and Eastern European countries should have the same opportunity.

- **Focus EU funds on strategic TEN-T links:** While the TEN-T does not include the obligation to build high-speed lines, it is the basis for EU funding for cross-border links. Only projects in the core and extended core TEN-T networks should receive EU funding to maximise European connectivity.
- **Lower co-funding rates for national focused sections:** Sections on a long cross-border line between a capital and a mid-sized city will generally have a higher national interest than those between that mid-sized city and the border, where less traffic is expected. Co-funding rates should be adjusted in order to minimise the risk of member states deprioritising cross-border sections, except for countries under the Cohesion framework.
- **Reevaluate comprehensive network projects in the next TEN-T revision:** Some projects, like a second Paris-Lyon high-speed link, were planned for congestion scenarios that are no longer relevant. With ERTMS Level 2 increasing capacity, this project has been frozen. The Commission should avoid funding studies for outdated projects.

4. Conclusion and recommendations

4.1. A 'Connecting Europe through high-speed' plan that accelerates TEN-T

The EU is struggling to meet the targets of the TEN-T regulation. The upcoming *Connecting Europe through high speed rail initiative* must not become a distraction that diverts funding and focus away from lines identified as European priorities. Instead, if a masterplan is introduced, it should complement the TEN-T and aid its implementation to allow Europe to boost passenger rail and facilitate synergies with different modes through dual-use infrastructure.

Specifically, it should:

- **Address interoperability barriers** for each identified connection;
- **Propose solutions** with implementation timelines to improve access to interoperable rolling stock for these lines;
- **Moderate a process** between the EU and member state governments through so-called Implementing Acts to accelerate the completion of key corridors. This type of secondary EU legislation allows the European Commission to set concrete deadlines for cross-border missing links and should be used where appropriate.
- **Limit its scope** to the core and extended core of the TEN-T for a more efficient and targeted approach.

4.2. The next EU budget is the key moment

Rail must be a priority in the EU budget. The Multiannual Financial Framework (MFF) discussion must highlight rail's infrastructure needs. T&E's rail operators ranking showed how reliability issues are often due to substandard infrastructure. In some cases, reliability has deteriorated to the point of becoming a major national concern in their member states.

The MFF and especially the Connecting Europe Facility (CEF) must appreciate that:

- **EU funding won't fix everything**, but it can drive essential upgrades to cross-border connections and also main lines in Central and Eastern Europe.
- **Geopolitical shifts demand stronger European rail links to bring EU citizens closer together and move military goods.** Fragmented rules complicate the delivery of material needed to aid neighbouring countries and protect the Union from external threats. The next EU budget must take real steps toward a European Railway Single Area.
- **National priorities have dominated EU funding.** A shift in focus is needed to achieve true European integration.

4.3. Final recommendations

1	**Make ERTMS happen**: The EU should increase its financial support for ERTMS to better incentivise faster deployment by member states and promote a more standardised rollout.
2	**Make 160 km/h the new standard for conventional rail**: Member states should make rail competitive beyond the main urban nodes and high-speed rail projects by increasing line speeds.
3	**Increase capacity and add new tracks only where necessary:** New tracks should be added selectively, focusing on bottlenecks and areas with strong potential for increased or improved services.
4	**Electrify in a smart way:** All lines with sufficient service levels to offset higher maintenance costs should be electrified, with priority given to missing links.
5	**Plan for a track gauge conversion in a phased manner:** Rushing towards a unified gauge for Europe could put many rail lines, including cross-border ones, at risk.
6	**Targeted EU funding for select high-speed lines:** EU funding should focus on TEN-T lines, prioritising cross-border links, densely populated routes and Cohesion countries.

Methodological annex

1. Criteria

As highlighted in section 2 we selected 6 criteria that can be deemed relevant for rail's harmonisation and competitiveness. More detailed explanations for each of the criteria can be found below:

Selected criteria	Rationale
ERTMS	ERTMS is arguably the most important element for railway interoperability in Europe. International connections are generally underused and often have much lower emissions than alternative travel options. ERTMS will be one of the major elements to create or improve those services in the short term. The slow rollout also calls for a stronger push from the EU budget since member states are not prioritising its implementation.
Line speeds	Strong average speeds are fundamental for rail's competitiveness with other modes of transport and its ability to drive up demand. The reason for choosing to look at line speeds in general is to avoid the binary between high-speed and non-high-speed that does not properly convey the potential that increasing line speeds to 160 km/h can have in many countries. Its inclusion in the TEN-T regulation will favor significant upgrades in the conventional network and increase the funding opportunities for them.
Capacity increase through new infrastructure	While ERTMS can improve capacity, it is not always sufficient to resolve bottlenecks. For instance, old bridges may not allow heavy loads or the necessary elements for improved speeds and interoperability. In these cases new infrastructure is needed to reach the envisioned capacity. The objective then is to look at what is actually needed and avoid costly new infrastructure that is not tied to strong passenger or freight growth potential.
Electrification	The process of electrification has been the main driver of considerable and continued emission reductions from railways since 1990. Continuing this process is fundamental to reach climate objectives. It is also an important element of interoperability that can improve the harmonisation process. However, due to the arrival of zero-emission rolling stock capable of operating in non-electrified lines and the fact that more than half of the EU's lines are electrified means that electrification is not a priority for a majority of member states, which is why it's categorised as

	a lesser priority.
Track gauge conversion	Different track gauges are a big barrier to interoperability, requiring specific rolling stock that can adapt to the different gauges. A more interconnected Europe requires standard gauge becoming the most prominent gauge in every EU country. It is also a vital factor to ease market accessibility and foster competition. However, it's a process that mainly affects peripheral countries and does not bring massive operational benefits. A rushed conversion can actually create significant problems in the networks. For these reasons it's classified as a lesser priority.
New high-speed lines	There are important missing cross-border links between large EU cities that could help interconnect the various networks and boost rail travel considerably. But the limited amount of funding and the high cost of new cross border infrastructure requires caution. Prioritising large new infrastructure projects means very little will be left for necessary upgrades to the network.

2. Case studies

2.1 Germany

The Untapped ERTMS potential of Germany

Germany has the longest railway network in Europe and lies at the heart of the continent. Its failure to meet ERTMS targets could undermine the system's success at an EU level. If Germany were to face challenges similar to Portugal's, the consequences for the European network could be severe.

One of the manufacturers for its signalling system has already ceased and will end technical support by 2030. Most of the German railway network uses PZB, an intermittent signalling system from the 1930s. It is based on track side balises that allow speeds up to 160 km/h, and is comparable to ETCS Level 1. Less than 10 % of the network is equipped with LZB, a continuous monitoring system suitable for speeds above 160 km/h. It is comparable, but not interoperable with ETCS Level 2.

Currently, less than 1% of the German network has ETCS-compatible trackside equipment. Deutsche Bahn plans to equip the entire network with ETCS Level 2 in principle, but its latest migration strategy targets only 13% coverage by 2030. Many interlockings are not compatible with the ETCS requirements, posing another challenge. DB expects capacity increases of around 20% on upgraded tracks , but these gains depend on the removal of visual signals, which is planned for less than 5% of the network. Meanwhile, GSM-R coverage now extends to almost the entire rail network.

Just as ERTMS relies on multiple components to reach its full potential, the EU depends on Germany to unlock the system's benefits. Five of the nine corridors in the core network pass through the country. However the federal government has again failed to secure adequate funding while trying to finalise the 2025 budget. This poses a serious issue not only due to its central location in Europe but also because unlike many other member states, Germany cannot justify the rollout costs as being beyond its own financial capacity. For a reliable rollout of ERTMS in Germany it is crucial that DB's plans get adequate support from the new infrastructure fund that is planned by the Merz government. This is in line with a recent call led by German industry associations, companies and civil society organisations in favor of an increased commitment to rail transport in Europe.

2.2 Poland

The long path to high speed in Poland

Average rail speed in Poland has increased slowly, with a focus on road infrastructure delaying much-needed upgrades to its rail system. However, the country may now be ready for change

When construction of the Central Rail Line (CMK) began in 1971, it was intended to be the first high-speed line in Europe, designed for speeds up to 250 km/h. The line was meant to connect Warsaw with Poland's largest metropolitan region (Katowice-Kraków). Initially, only 120 km/h was achievable. This meant minimal improvements compared to the standard speed limit on many other Polish lines. A few years later train speeds increased to 140 km/h and eventually reached 160 km/h. With the introduction of Pendolino trains, speed rose up to the current 200 km/h. Yet, more than 40 years later, the line has not reached the high speed threshold of 250 km/h.

The slow development of the CMK mirrors the broader situation across the network. By 2017 60% of the lines were still capped at 120 km/h. However, track conditions and reliability showed noticeable improvement, with tracks categorised as unsatisfactory reduced by 15% between 2010 and 2017. Additionally, the compatibility between the rolling stock and the infrastructure allows for good utilisation of maximum line speed.

Nevertheless, the delayed progress of the rail network contrasts with the rapid expansion of Poland's highways, which have benefited from substantial EU funding compared to rail. This has led to a shift towards motorised transport, despite the EU's commitment to promote rail. According to ACEA, between 2017 and 2021, Poland rose to second place in the EU in terms of vehicles per 1,000 inhabitants.

For years, Poland has had ambitious plans for a high-speed rail network with a new airport hub at its centre. However, these plans have yet to materialise, and the reliance on a new macro airport has drawn criticism. Meanwhile, investments for highways continue, deepening Poland's car dependency. Nevertheless, not all progress is reliant on megaprojects. Digitalisation will be key to upgrading Poland's rail network. By 2026, independent of the high speed rail plan, the CMK could reach its original goal of 250km/h, driven by the deployment of ERTMS. Nearly 50 years after its conception, the line might finally become Poland's first high-speed line.

2.3 Slovenia

Properly building for future capacity in Slovenia

When constructing new infrastructure, planners must decide whether to build for current demand or anticipate future growth. If traffic projections are low, efficiency dictates that platforms, viaducts and tunnels should be designed for a single track. However, opting for the cheaper option when demand is unknown can result in a bottleneck.

Slovenia's biggest infrastructure project, the new Koper-Divača line, exemplifies this challenge. The project connects the port city of Koper, the country's fifth largest, to the railway junction at Divača, where it links with the main line between Trieste and Ljubljana. Due to mountain terrain, the project requires extensive tunneling, making it costly but potentially transformative for freight transport and passenger rail. The new line will shorten the route between Koper and Divača from 45 km to 28 km and double passenger train speeds from 80 km/h to 160 km/h, cutting travel times by more than half.

While the primary objective is to enhance the competitiveness of Koper port and strengthen Slovenia's trade position, the project also improves passenger services as a secondary benefit. Freight projects often find it easier to secure funding due to the strong commercial and economic interests. In this case, the Connecting Europe Facility (CEF) and the European Investment Bank (EIB) have contributed substantial financial support. However, costs restricted the initial construction to a single track, leading to the project being widely referred to as "the second track of the Koper-Divača line".

With the new track and the renewal of the old one, daily capacity will increase from 90 to 212 trains. However, the new track's gentler gradient makes it more attractive so freight trains will use it in the Koper-Divača direction, while descending trains will use the old line. Although this is a good temporary solution, it limits the potential for both freight and passenger services, as passenger services need the new track to operate at 160km/h. . Recognising this, Slovenia has designed the three longest tunnels with expanded service tunnels that could later accommodate a second track. This approach would already provide 61% of the necessary alignment for the second track. However, outside the tunnels, new viaducts would still need to be built, making the expansion a costly undertaking.

Delaying the second track may save money initially but risks higher costs in the long term due the need to restart the administrative processes. Therefore, building single track only lines should only be considered when there is a high confidence that future traffic demand will be low.

Given the project's initial funding challenges, supporters such as the European Commission and the EIB should consider long term capacity needs when deciding which projects to back.

2.4 Bulgaria

High degree of electrification and low traffic in Bulgaria

Bulgaria is an exception in Eastern Europe, with 75% of its railway network electrified as of 2022 - far exceeding neighbouring countries like Romania and Greece, which remain below 40%. It has the highest share of electrified lines in the eastern half of the continent. Yet the benefits are undermined by low service levels.

Bulgaria and Romania developed their electrification programmes in parallel during the 1960s, but Bulgaria reached a higher share of electrification. However, both countries stagnated after 1990 and their networks soon fell into crisis. Decades of underinvestment led to a network that became unreliable and uncompetitive with road transport. Average speeds were low, rolling stock aged, and delays became frequent. Revenues collapsed, leaving BDZ, the state railway operator, unable to cover the high maintenance costs, and technically insolvent. European funds and World Bank support provided temporary relief, but came with conditions, including the closure of inefficient lines and staff reductions. This highlights that electrification alone is not a guarantee for success - rail investment must be comprehensive.

Bulgaria's high electrification level was coherent with a heavily used and expanding railway network. However, failure to address maintenance issues and the rapid deterioration of the system turned this advantage into a burden, as electrified lines have higher maintenance costs. This remains one of the many obstacles to the overdue renewal of the network, which is progressing very slowly, mostly along TEN-T corridors benefiting from EU funding.

Despite these challenges, Trans-European corridors offer a path forward. These lines, connecting Bulgaria's major cities are being upgraded to 160 km/h. Combined with modern rolling stock, this will make rail more competitive with road transport.

Assuming passenger numbers recover, a modernised and electrified network will become financially sustainable, allowing Bulgaria to fully capitalise on the advantages of near-total electrification.

Sacrificing speed and capacity for standard gauge in Spain

Increasing the implementation of the standard gauge across Europe is a key EU goal. But it must be done without compromising infrastructure potential - especially in costly cases of expensive brand new construction.

The Pajares Base Tunnels, Europe's seventh- longest rail tunnels, were built to overcome the great Cantabrian mountain range which had isolated the region of Asturias from the rest of the Iberian Peninsula. The tunnels were intended to replace the steep and winding conventional line, slashing trip times by over an hour and improving freight transport travel through a gentler gradient. Designed for speeds of up to 275 km/h, they had the potential to allow true high-speed rail to finally reach Asturias.

However, the need to accommodate both freight and passenger traffic meant that the line couldn't be completely changed to the standard gauge used in the majority of the spanish high-speed network, as freight trains would need to use the conventional network in Asturias to reach the major industries and ports of the region. With Renfe owning rolling stock able to run at high-speed on conventional lines, iberian gauge would not have been an impediment for its arrival, as those trains could simply go from the standard line to the iberian line through a gauge-changing facility.

In the neighbouring region of Galicia, for instance, new high-speed trains travel from Madrid to Ourense through standard gauge and continue to Coruña or Vigo at 300 km/h through iberian gauge. Thanks to this manoeuvre, competitive travel times have been achieved and Galicia's freight connections with Portugal have not suffered. But political pressure in Asturias led to this option being rejected in favour of a complex operation to partially implement standard gauge through the tunnel in order to provide the image that 'high speed rails' had reached the region.

The conceived solution consisted of building one track with iberian gauge and another with mixed gauge, so that high-speed trains could traverse it under the standard gauge track while freight trains would be able to use both tracks. However, the standard gauge would eventually end before any major population, forcing trains to still use a gauge changer in order to proceed into the asturian cities through the iberian gauge. Therefore, there wouldn't be any operability benefits of extending the standard gauge through the tunnels. On the contrary, mixed gauge track is capped at 160 km/h, meaning that high-speed trains going through it would not be able to reach the design speeds, unlike on the iberian gauge track. It would be more advisable therefore for the high speed trains to change gauge before entering the tunnels, so that they could use the iberian gauge at close to 300 km/h. On top of all this, the maintenance costs are expected to increase.

Having a European standard gauge is an objective that would benefit the Single European Railway Area, both in terms of technical harmonisation and market opening. It should be a key lever for interoperability, eliminating the need for specific gauge-changing trains and facilities. This would reduce costs and ensure that new entrants are not denied access to a region for not having compatible rolling stock with the different gauge. But this should not be done at the expense of the efficiency, capacity and speed of the line.

2.6 France

The great French wall

The success of the TEN-T network depends on every country committing to the agreed timelines. Yet, member states are moving at very different speeds.

When France neared completion of its main high-speed lines, it paused further projects to focus on conventional rail. While this seemed sensible after decades of prioritising high-speed rail, cross-border projects were the most affected.

Years later, France decided to relaunch its plans. However, the only new high-speed line under construction is Bordeaux-Toulouse, showing that national priorities still dominate rail policy.

High-speed is not just about swiftly connecting cities in a profitable manner. It can also free up capacity on conventional lines for freight and commuter services, or even act as an investment in climate resilience.

The Montpellier-Béziers-Perpignan high speed project illustrates this well. A new fast line would free enough capacity in the existing route to introduce a high-frequency commuter service between Montpellier and Sète every 15 minutes. It would also remove a freight bottleneck from the Iberian Peninsula and make international connections faster and more competitive. Currently, the Perpignan - Spain section is underutilised due to the lack of high-speed infrastructure between Perpignan and the rest of France, with only 4 all-year passenger trains per day in each direction. Above all, climate change makes the Perpignan-Narbonne section increasingly vulnerable, as it crosses low lying lagoons and is not fit for the future.

These factors should make this project a priority, yet France's current timeline delays completion until 2044, limiting capacity for two more decades. The same applies to other missing links between the Iberian peninsula and France. The Bordeaux-Spain high-speed line follows a similar timeline, and no works are underway to connect Bedous to Canfranc.

France has continued to work on the Mont Cenis tunnel, but its access line lags significantly behind the Italian section.

Planning is now progressing on all these connections, but the previous pause means that they will remain behind schedule, weakening both the core TEN-T network and Europe's rail system as a whole. While deprioritising high-speed lines may make sense for a country with an extensive network, key cross-border links should not be the first to suffer.

3. Definitions:

Megaprojects: T&E defines megaprojects on the basis of the report of the European Court of Auditors