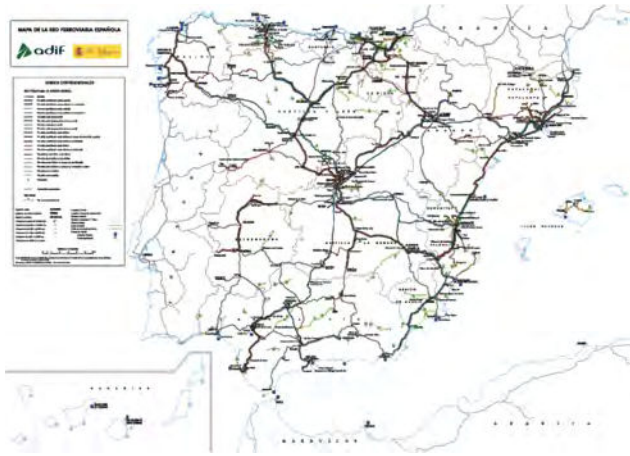
Asociación Caminos

Evaluation of Public Works in Spain

Railways
2023



the defunct FEVE since January 1, 2013. In the second category are the regional railway networks, whose lines belong to a single autonomous community. The third category includes urban metro and tram lines. Finally, the fourth category corresponds to private lines. In 1992, with the inauguration of the Madrid-Seville high-speed line, the exploitation of a new line began which had different technical characteristics from those previously built, reaching speeds higher than 250 km/h. and it was built with the international width (1,435 mm) and electrified at 25 KV in AC. With this new line, a network of independent conventional lines developed. As the high- speed network evolved, the equipment and features of the high- performance network improved. Currently, its design and construction is done in accordance with the Technical Specifications for Interoperability (ETIs), with design speeds of 350 km/h and it´s equipped with ERTMS/ETCS signaling systems.

Since 2019, high-speed train passenger transport has been liberalized, removing the monopoly held by the public operator RENFE. In 2023, three railway companies started to operate, competing with four brands (two of them public -RENFE and AVLO-). The market liberalization, summed up with the extension of new high- speed lines and the progressive recovery of rail traffic has significantly increased passenger traffic.

Methodology as an international reference model

✓ Open Methodology

It compares:
- ✓ Spain to other countries
- ✓ Periodical evaluation

Official databases:
- ✓ International databases
- ✓ Publicly accessible databases
- ✓ Reference databases

confidentially. To facilitate the assessment, the analysis has been grouped into eight sets of common characteristics for all sectors, referred to as "Criteria."

The Spanish railway network is complex, in which three different track gauges coexist, with a total railway network length of 15,652 km. The main historical gauge of Spain, called Iberian gauge (metric 1,668 mm), has its origin in the 19th century and has a total track length of 11,211 km. In areas with orographic difficulties (the Cantabrian coastline and the Catalan and Valencian coasts) metric gauge lines were deployed, with a total track length of 1,193 km.
Since the inauguration of the first high-speed line (in 1992), the most widespread gauge in the world was introduced, called UIC or international gauge (1,435 mm), with a length of 3,030 km. From then on, most high-speed lines were built with the international gauge; although some lines were built with the Iberian gauge, but with multipurpose sleepers (with the capacity to change to international gauge in the future), and others with mixed tracks (with a third rail). Currently, Spain has one of the best high-speed networks in service in the world, with a track length of 3,487 km in 2020.

The Spanish Railway Network is subdivided into four railway categories. The first corresponds to the General Interest Railway Network (RFIG). This network is created with the lines and sections managed by ADIF in its two public entities called ADIF and ADIF Alta Velocity businesses. This network is the most extensive and the one that supports the most traffic and includes

The methodology designed by the Asociación Caminos carries out an objective evaluation, it analyzes quantitative indicators of countries with a similar economic and social environment. As well, it carries out a qualitative evaluation, based on the opinions of a selected group of experts. The qualitative evaluation is developed through a comparative study with other countries (Spain, Germany, France, United Kingdom and Italy, USA, Chile, Mexico, Morocco, Egypt, Japan, China, India and Taiwan), obtained from publicly accessible databases available in important multilateral organizations (EUROSTAT, OECD, World Bank, UN, World Economic Forum, International Transport Forum, UIC, etc.). The **qualitative evaluation** pertains exclusively to Spain and is based on responses obtained from a selected group of experts in the sector. The responses obtained have been processed anonymously and

CAPACITY	PERFORMANCE	FINANCING	ADAPTABILITY TO FUTURE AND SUSTAINABILITY
OPERATION AND MAINTENANCE	SAFETY	RESILIENCE	ENGINEERING AND INNOVATION

• Evaluation of Railways

Indicators:
Experts:

Rating		
Spain	5.8	E
Germany	7.0	C
France	7.0	C
United Kingdom	7.0	C
Italy	6.3	D
USA	5.6	E
Mexico	3.2	FX
Chile	2.2	F
Morocco	4.3	FX
Egypt	2.9	F
Japan	7.7	C
China	5.6	E
India	4.1	FX
Taiwan	6.0	D

▪ Comparative analysis of Spanish railways in an international context

In the global evaluation of railways by indicators, Spain is in the intermediate band in relation to the different countries analyzed, obtaining a good rating in Capacity (7.6) and Safety (7.9); Sufficiently high in Resilience; Sufficient in Performance, Adaptability to the future and Sustainable Development; and Insufficient in Financing and Operation and maintenance.

It is worth highlighting the good rates obtained by Germany, France, United Kingdom, and Japan. The USA and China obtain a rating similar to Spain. Also noteworthy is the rating obtained by Chile and Egypt which is very insufficient.

Evaluation of Railways with indicators (Max 10)		
CRITERIA		
CAPACITY	7.6	C
PERFORMANCE	5.9	E
FINANCING	3.4	FX
ADAPTABILITY TO THE FUTURE AND SUSTAINIBILITY	5.8	E
OPERATION AND MAINTENANCE	3.4	FX
SAFETY	7.9	C
RESILIENCE	6.3	D
ENGINEERING AND INNOVATION	5.9	E
Evaluation by Objective Indicators	**5.8**	**E**
Indicators Considered: 67		

Evaluation of Railways by experts (Max 10)		
CRITERIA		
CAPACITY	8.2	B
PERFORMANCE	6.2	D
FINANCING	6.0	D
ADAPTABILITY TO THE FUTURE AND SUSTAINIBILITY	6.6	D
OPERATION AND MAINTENANCE	5.8	E
SAFETY	7.1	C
RESILIENCE	6.8	D
ENGINEERING AND INNOVATION	6.9	D
Evaluación by Experts	**6.7**	**D**
Responses Received: 33		

Key results of the report

Final evaluation of Railways (Max 10)		
CRITERIA		
CAPACITY	7.9	C
PERFORMANCE	6.1	D
FINANCING	4.7	FX
ADAPTABILITY TO THE FUTURE AND SUSTAINIBILITY	6.2	D
OPERATION AND MAINTENANCE	4.6	FX
SAFETY	7.5	C
RESILIENCE	6.5	D
ENGINEERING AND INNOVATION	6.4	D
Final Weighted Evaluation	**6.2**	**D**

- The high-speed rail network in Spain is one of the best in the world, with a track length of 3,487 km in 2020.
- It is expected that in 10 years the average user will have a high- performance railway station less than 50 km from their residence.
- The conventional network requires modernization improvements by renewing infrastructures, increase speed and lines electrification, also by implementing ERTMS-type Safety systems, as well as carrying out improvements in their efficiency and sustainability. In the long term, the transformation of track widths into the international gauge (1,435 mm) must be considered.
- It is necessary to improve the features and services of the railway network in medium-sized cities, as well as in the intermodal connections to ports.
- The investment made in recent years has focused exclusively on high speed, with no notable investments made in conventional lines. Political and territorial criteria have taken precedence over real demand and economic criteria. The extension of the high-performance network must be carried out in a balanced manner, taking into account the current demand and the economic and social profitability of the infrastructure network.
- Some experts believe that the involvement of private investment can improve the railway network. To do this, it is necessary to improve the bidding and execution processes of works.
- Railways require adequate planning to complete high-performance lines under construction before starting new infrastructure. It is also necessary to invest in conventional lines to improve service and performance.
- It is necessary to improve the management of the investment planning, trying to meet technical and profitability criteria. The decarbonization of the sector involves the progressive elimination of the use of fossil fuels.
- In general terms, ordinary conservation is well dimensioned, although there is a need for better managing and investing more in extraordinary conservation, particularly in the regionally owned railway network.
- The installed ITS systems are insufficient, as well as traffic surveillance to prevent reckless driving.
- The measures implemented to improve resilience in high-speed networks are good, but in conventional networks they are usually scarce or non-existent.
- The research being carried out by Spanish railway engineers is adequate. The digitalization of railway projects is essential for improving the entire process. Investing in digitization, such as BIM, should be a priority.
- Improvements are required in the digitalization of projects, in disaggregated demand studies and in the evaluation and selection of train energy.
- It is essential to increase rail freight transport, improving productivity and implementing advanced management systems. Experts facilitate the assessment, the analysis has been grouped into eight groups of common characteristics for all sectors, called “Criteria”.

• Capacity

Indicators:
Experts:

Does the provision and capacity of the public works sector meet current demands?

FC Lines / 1,000 Inhabitants
Electrified FC lines / 1,000 Inhabitants
AV lines (speed> 250km/h)/ 1,000
Inhabitants FC Lines / Country Area (km2)
FC lines/Population density
Level Crossings / FC Lines
No Stations/km FC lines

	Rating	
Spain	7.6	C
Germany	8.2	B
France	8.1	B
United Kingdom	5.8	E
Italy	6.8	D
USA	5.4	E
Mexico		
Chile		
Morocco	3.3	FX
Egypt	2.9	F
Japan	4.8	FX
China	4.4	FX
India	3.6	FX
Taiwan		

Germany gets the best rating (8.2 out of 10), followed by France (8.1) and Spain (7.6). The poor rating obtained by Egypt (2.9), Morocco (3.3) and India (3.6) must be highlighted. The highest ratings were obtained by the European countries and the USA.

The indicators show that Spain stands out in the provision of high-speed lines, in electrified lines per 1,000 inhabitants and in the low number of level crossings on railway lines. However, Spain is rated as insufficient in the number of stations per line, in lines per area of the country and in lines due to population density. Spanish railways are well rated, especially in the high-speed network, which obtains the best rating along with China.

▪ Evaluation by experts and comments

1.1. How do you value the coverage of the territory and the high-performance infrastructure?	8.1	B
1.2. How do you value the coverage of the territory and the high-performance infrastructure?	8.2	B
1.3. How do you assess the capacity of the railway network to absorb current demands?	7.5	C
1.4. How do you assess the capacity of the current railway network to absorb the foreseeable future demands within the next 10 years?	9.0	A
Capacity Evaluation by experts	**8.2**	**B**

- The high-performance railway network is being expanded, building new lines and improving stations, so it is prepared to absorb the future demands. However, during the construction phase there may be side effects on the capacity and regularity of traffic.
- The initial forecast estimated that users would have a high-performance station less than 50 km away will be fulfilled when the lines under construction are completed, approximately within the next 10 years.
- In the conventional network, it is necessary to continue investing in its modernization, carrying out certain renovations, speed increases, lines electrification and Safety systems, as well as improving its efficiency and sustainability.

• Performance

Indicators:
Experts:

Is it adequate the current provision and physical conditions of the public works sector in order to meet current user expectations?

AV Lines/ FC Lines
Electrified FC Lines / FC Lines
Length of FC tracks / FC Lines
Internal passenger traffic per FC (10^6 Passengers-km)/ km FC roads Inland
Goods traffic per FC (10^6 tn-km)/km via FC
% Participation of freight transport in railways in the total land transport of goods
% Participation of passenger transport in railways in total land passenger transport
Quality index of transport and trade infrastructure. N.D.
Rail Service Efficiency (WEF)

	Rating	
Spain	5.8	E
Germany	7.0	C
France	7.0	C
United Kingdom	7.0	C
Italy	6.3	D
USA	5.6	E
Mexico	3.2	FX
Chile	2.2	F
Morocco	4.3	FX
Egypt	2.9	F
Japan	7.7	C
China	5.6	E
India	4.1	FX
Taiwan	6.0	D

In the "AV Lines / FC Lines" indicator, China stands out with 0.410, followed at a great distance by Spain (0.161) and Japan (0.148);.The fourth country with the best ratio is France (0.102). The rest of the countries present much lower ratios.

In the "Electrified FC lines" indicator / 1,000 inhabitants" France and Germany stand out (0.25), followed by Spain (0.217) and Italy (0.204). European countries are world leaders in electrification of railway lines. The "No. of steps" indicator at FC level/lines" shows the effort made by countries to eliminate it. Spain is in the best position of the European countries analyzed (0.194). Japan is in the worst position (1,067).

▪ Evaluation by experts and comments

2.1. How do you value the benefits that the railway network provides to users?	7.7	C
2.2. How do you value the existing equipment and services for passenger transport in the stations of the Spanish railway network?	7.5	C
2.3. How do you value the existing equipment and services for freight transport in the stations of the Spanish railway network?	5.1	E
2.4. How do you assess the situation of the connections of the Spanish railway network with the port network?	5.2	E
2.5. How do you assess the situation of the connections of the Spanish railway network with urban mobility modes?	6.3	D
2.6. How do you consider the coverage of the railway network territory?	7.1	C
2.7. How do you assess the information provided to the user in incidents that occur on the railway network?	4.8	FX
Performance Evaluation by experts	**6.2**	**D**

- It is necessary to develop proper management to overcome the disparity between the excellent railway services provided in major urban centers and the insufficient services in smaller cities.
- The information about incidents affecting regularity is not always provided to the user on time and is inadequate.
- High-performance lines provide good service under conditions of reliability, safety, and adequate comfort. However, conventional lines require modernization to achieve satisfactory performance.
- It is necessary to improve intermodal connections to the ports, particularly the railway connections. In general, railway stations require improvements in vehicle parking facilities and a reduction in fees.

• Financing

Indicators:
Experts:

What investment is allocated for financing the public works sector? Which amount is invested in the creation of infrastructure? And what about operations and maintenance?

Investment in FC / national GDP (current €)
Investment in FC / inhabitants (current €/ inhabitants)
Investment in FC/km of FC lines (current €/ km lines)
Investment of FC/Country Area (km2) (€ streams/km2)
FC investment/Internal passenger traffic per FC (10^6 Passengers-km) FC investment/Internal freight traffic per FC (10^6 tn-km)
Investment in FC / total investment in land transport infrastructure

	Rating	
Spain	3.4	FX
Germany	4.5	FX
France	7.0	C
United Kingdom	9.3	A
Italy	4.8	FX
USA	2.6	F
Mexico	3.4	FX
Chile		
Morocco		
Egypt		
Japan	7.8	C
China	5.4	E
India	2.6	F
Taiwan		

The investment in railways as a % of GDP, the average rating of the countries analyzed is 0.34%; with a maximum of 1.13% reached in 2015 by China. Spain has a very low rating (0.18% of GDP).

Japan and India present high ratings (0.38% and 0.4%). Within the European countries, the United Kingdom (0.53%) and France (0.48%) are the ones that invest the most. An insufficient situation is observed in Spain, as it is among the countries that spend the lowest percentage of GDP. The low investment made in railways and their lack of stability translates, in the medium and long term, into a serious deterioration in the infrastructure heritage value. Financing needs will increase exponentially if low investments continue.

▪ Evaluation by experts and comments

3.1. Do you consider sufficient the current investment in the high-performance railway network?	7.4	C
3.2. Do you consider sufficient the current investment in the conventional railway network?	5.5	E
3.3. What do you think about how the investment in the railway network is being managed?	6.1	D
3.4. What do you consider about the current involvement of private investment in the railway network?	5.1	E
Financing Evaluation by experts	**6.0**	**D**

- In the recent years, investment has been high in high speed and very small in the conventional lines. Political and territorial criteria have prevailed over the real and economic demands. The extension of the high-performance network must be carried out in a balanced manner, taking into account economic and social profitability.
- Some experts believe that the involvement of private investment can improve the railway network. To do this, it is necessary to change the bidding and execution processes of the works.
- Railways require an adequate planning to complete high-performance lines under construction before starting new infrastructure. It is also necessary to plan adequate investments in conventional lines to improve service and performance.

• Adaptability to the future and sustainability

Indicators:
Experts:

Is the capacity and performance of the public works sector prepared to meet the future expectations and demands? Are the resources and investment adequate to cover the future needs of the sector? How are initiatives which provide environmental sustainability are being applied? Are active measures being applied to meet the established objectives for decarbonizing public works and transportation?

FC Lines with Speed > 160 km/h / FC Lines
Level Crossings / FC Lines
% Passengers-km FC / Passengers-km (FC, Road, airplane)
% t-km FC / t-km (FC, Road, river, maritime, pipeline)
CO2 emissions from the CCFF/FC Lines
Electrified lines / Km FC Lines
% Renewable energy in transportation/Energy consumed
Development of Transportation-related Climate Change Mitigation Technologies (OECD)

	Rating	
Spain	5.8	E
Germany	6.6	D
France	6.9	D
United Kingdom	6.5	D
Italy	6.5	D
USA	4.6	FX
Mexico	3.8	FX
Chile	1.1	F
Morocco	7.8	C
Egypt	1.1	F
Japan	5.5	E
China	7.2	C
India	3.7	FX
Taiwan		

The preparation of infrastructure for future demands is related to the relationship between high-speed lines and total lines; with the elimination of steps to level; with traffic percentages of people and goods in relation with the total traffic in land transport modes and electrified lines. The related ratios with passengers-km traveled by rail in relation to passengers-km tours through all modes of land transportation, indicates the railway use.

The ratings are very changeable: from the minimum that Spain has (3.87%), to the maximum that the USA has (36.8%) and China (20.8%). It is well known that rail transport of goods and passengers in Spain is very limited, despite the extension of the high-speed network. In this sense, Spain has an important challenge in order to raise these percentages in the coming years and become comparable with the countries around us.

▪ Evaluation by experts and comments

4.1. Do you consider that the expansion plans for the railway network take into account the adaptation to user demands?	6.7	D
4.2. How do you value the strategy for offering private rail transport services?	6.7	D
4.3. What do you consider about the adaptation of the railway network to the climate change effects?	6.9	D
4.4. How do you assess the actions that are being taken to reduce CO2 consumption in the railway network?	6.8	D
4.5. How do you assess the actions that are being taken to reduce CO2 consumption in rolling stock?	6.9	D
4.6. How do you value the programs for adapting railway infrastructure to new technologies and information to users?	6.6	D
4.7. Do you consider adequate the measures adopted to reduce the environmental impact and waste treatment?	5.9	E
Adaptability to the future Evaluation by experts	**6.6**	**D**

- It is necessary to take into account multidisciplinary demand studies which consider multiple factors and interoperability with other modes of transport, as well as the users opinion.
- The railway is the most efficient mean of land transport, so its use should be encouraged in a balanced way in the territory, always prioritizing technical interests over political ones.
- The decarbonization of the sector involves the progressive elimination of the use of fossil fuels and the implementation of new cleaner energy systems for trains. There should also be a focus on the entry of private operators, which will improve competition and efficiency in network management.

• Operation and maintenance

Indicators:
Experts:

Are the public works being operated and maintained in accordance with the current needs? Is the necessary investment being made to ensure the adequate conservation and maintenance?

Investment in O&P / national GDP
Investment in O&P / inhabitants Investment in O&P / km FC lines
Inversión en O&P / Inversión total en FC
Investment in O&P / Total investment in FC
Investment in O&P / Domestic passenger traffic by FC (€)
Investment in O&P / Internal merchandise traffic by FC (€)
Operating expense / Number of stations (€)
Operating expense / km of FC lines (€)
Operating expenses / Population (€)
Operating expense / Million t-km (€)

Rating		
Spain	3.4	FX
Germany	9.2	A
France	5.4	E
United Kingdom	6.2	D
Italy	6.4	D
USA	4.0	FX
Mexico		
Chile		
Morocco		
Egypt		
Japan	9.7	A
China	2.3	F
India	4.5	FX
Taiwan		

Operating expense / Million t-km (€). Investment in Operations and maintenance It is very difficult to separate from investment in infrastructure creation.
The investment needs for the operation, conservation, and maintenance are related to the infrastructure conditions and adaptation needs to new requirements, both technical and functional. The Investment that would be necessary for a proper conservation is being debated among experts Although there is no general consensus, it is considered that the necessary conservation investment should be between 2% and 4% of the heritage value, depending on the infrastructure condition.

▪ Evaluation by experts and comments

5.1. How do you value the investment in conservation and maintenance of the railway network?	5.8	E
5.2. Do you consider that the means applied to the operation, conservation and maintenance of the railway network are adequate to meet the demands of users?	5.9	E
5.3. How do you assess the state of conservation and maintenance of the conventional network roads?	5.1	E
5.4. How do you assess the measures adopted in relation to winter traffic and the incidents that occur on the railway network?	6.4	D
Operation and maintenance Evaluation by experts	**5.8**	**E**

- In general terms, ordinary conservation is well dimensioned, although there is a need to manage better and invest more in extraordinary conservation, particularly in the regional owned railway network.
- It is necessary to change the railway conservation model, including indicators which allow the situation to be evaluated.

• Safety

Indicators:
Experts:

Is the public works sector safe for users? Are effective measures being implemented to ensure safe performance and operations?

No fatalities / 100 km FC Lines
No. fatalities / Million Population
No. of victims/Inland passenger traffic by FC (one hundred million passengers-km)
No. of fatalities/inland passenger traffic by FC (one hundred million passengers-km)
No. Accidents / 100 km FC Lines

Rating		
Spain	7.9	C
Germany	3.9	FX
France	7.6	C
United Kingdom	9.3	A
Italy	7.1	C
USA	8.6	B
Mexico		
Chile		
Morocco		
Egypt		
Japan		
China		
India		
Taiwan		

The indicator "No. fatalities / 100 km FC Lines" presents an average of 0.21 Fatalities, with variations between countries; from a minimum of 0.002 presented by the USA to a maximum of 0.354 presented by Germany.
Spain has 0.141, a figure that is in the intermediate band of the countries. The second subindicator analyzed "No. fatalities / Million of Population" presents rates that are in tune with the first indicator; Germany stands out (1.637) and the lowest figure is presented by the United Kingdom (0.329). Spain is close to the lowest value (0.488). The indicator "No. Fatalities/Internal passenger traffic per FC (one hundred million passengers-km)" has an average rate of 0.075, with a maximum of 0.133 (Germany) and a minimum of 0.009 (USA). Spain is close to the average rate (0.08).

▪ Evaluation by experts and comments

6.1. How do you assess the measures currently adopted to prevent accidents on the railway network?	7.0	C
6.2. How do you assess the level of accidents that occur on the conventional railway network?	7.7	C
6.3. How do you assess the equipment of the conventional railway network for preventing or reducing the side effects of accidents?	7.4	C
6.4. What do you consider about the measures adopted for reducing accidents on the conventional railway network in the future?	7.1	C
6.5. How do you value the investment that is being made regarding the safety of the conventional railway network for preventing or reducing the side effects of accidents?	6.5	D
Safety Evaluation by experts	**7.1**	**C**

- The installed ITS systems are insufficient, as well as traffic surveillance to prevent reckless driving.
- The exclusive reference taken by the number of deaths must be expanded so it also considers the number of accidents and their causes, in this way the accident rate will ameliorate by improving the passive safety of vehicles and infrastructure. It is advisable to prioritize low-cost actions, which report a great return on investment for the decreasing accidents. The mobility needs of vulnerable users must be met.
- Conventional network equipment must be improved.

• Resilience

Indicators:
Experts:

When threats and adverse incidents happen, what is the public works capacity to prevent, protect and minimize the consequences for users, the environment, the economy and for the national Safety? Is the public work prepared to recover its initial state within a reasonable timeframe when the threat or adverse incident has ceased?
Are there alternatives to attend the service provided?

No. of stations / FC lines
No. of nodes / no. of stations
Rail density / Highway density
km of AV/ Country surface (km2)
Transportation infrastructure. GCI Score (WEF)

	Rating	
Spain	6.3	D
Germany	7.7	C
France	5.7	E
United Kingdom	6.5	D
Italy	7.2	C
USA	4.5	FX
Mexico	3.1	FX
Chile	1.2	F
Morocco	1.4	F
Egypt	4.2	FX
Japan	9.5	A
China	3.7	FX
India	4.2	FX
Taiwan	6.4	D

To analyze resilience, It is necessary to have data relating to the technical characteristics of the railway design. As it hasn't been possible to obtain all this data from the railways altogether (as it would be a very laborious job), It was decided to take into consideration the indicators that, in an indirect way, can provide some data about the resilience of the railway network.

▪ Evaluation by experts and comments

7.1. How do you assess the capacity of the railway network to recover, on a reasonable timeframe, the initial service condition when adverse situations occur?	7.2	C
7.2. How do you assess the measures adopted to prevent the railway infrastructure of the conventional network from natural or provoked incidents?	6.2	D
7.3. How do you assess the measures adopted to prevent the railway infrastructure of the high-speed network from natural or provoked incidents?	7.5	C
7.4. How do you value the existing alternatives to the railway network in Spain when there is a cut in the service?	6.0	D
7.5. How do you assess the contingency plans that are applied in the railway network to prevent infrastructure failures?	7.0	C
Resilience Evaluation by experts	**6.8**	**D**

- The measures implemented to improve resilience in high-speed networks are good, but in conventional networks, they are usually scarce.
- The prevention of climate or provoked contingencies due to natural disasters is not sufficiently implemented as the railway does not have good elasticity for responding to possible contingencies. The mobilization of resources in the event of contingencies must increase.
- There are computer applications and detection and communication systems that must be implemented in the railway networks for preventing and notifying possible contingencies. However, the participation of train drivers in the prevention cannot be eliminated or limited.

• Engineering and Innovation

Indicators:
Experts:

Are the resources allocated to engineering in the design, construction, conservation, management and operation of the public works sector are adequate? Is the investment made in innovation appropriate? What new techniques, materials, technologies and operating methods are being implemented for improving public works? Is progress being made in digitalization, monitoring and sensorization during the public works complete cycle? Is the information adequate for users?

Increase in AV lines / FC Lines (2019/2015)
Innovation index. ND Gain Index
% of GDP allocated to Gross Domestic Expenditure on R&D
Gross domestic expenditure on R&D ($)/Population
% of GDP allocated to expenditure on basic research
Total number of personnel in R&D per 1,000 employees
% of GDP of private financing allocated to R&D
% of GDP of financing public destined for R&D
Number of railway transport patents/Mill. inhabitants
Digitization. Participation in new technologies. GCI (WEF)
Digitization. ICT Infrastructure Index. (ND Index)
Digitization. % of people who use the internet
Engineering. Regulatory transparency (OECD)
Engineering. Barriers to competition (OECD)
Engineering. Restrictions on movement (OECD)
Engineering. Restrictions on the entry of engineers from abroad

	Rating	
Spain	5.9	E
Germany	8.5	B
France	8.2	B
United Kingdom	7.1	C
Italy	5.7	E
USA	9.1	A
Mexico	3.7	FX
Chile	3.6	FX
Morocco	3.7	FX
Egypt	2.4	F
Japan	8.6	B
China	6.6	D
India	4.2	FX
Taiwan	2.8	F

To analyze the innovation status indicators, it was chosen to consider the conditions of R&D&I in the different countries globally, for analysing the condition of the railways. Therefore, the database and indicators contained in the following report have been selected: Main Science and Technology Indicators, Volume 2021, published in 2022 by the OECD. The global evaluation of the Engineering criterion and innovation by indicators gives the best ratings to the USA (9.1), Japan (8.6), followed by Germany (8.5), France (8.2). Spain obtains a rating of 5.9, under China (6.6).

▪ Evaluation by experts and comments

8.1. Do you consider that the investment made in the engineering design, construction, management and conservation of the network is adequate?	6.4	D
8.2. How do you evaluate the knowledge and technical attitude of current railway engineers?	7.8	C
8.3. Do you consider the knowledge imparted in universities to engineers to be suitable and aligned with new technologies?	6.0	D
8.4. How do you value the use of new techniques and materials in the construction, conservation and maintenance of infrastructures?	7.3	C
8.5. How do you assess the measures adopted in the public tender to favor the innovation?	6.1	D
8.6. How do you assess the adaptation of the conventional railway network to the most recent safety systems?	7.1	C
8.7. How do you value the research, development and innovation that is being developed in Spain in relation to the railway network?	6.7	D
8.8. How do you value the current technology that is being applied on the Internet?	7.5	C
8.9. How do you consider the progress in digitalization and monitoring of the behavior of the elements of the railway network?	7.1	C
Engineering and Innovation Evaluation by experts	**6.9**	**D**

- In Spain there is great human and professional value in the railway field that must be preserved and promoted.
- The research being carried out by Spanish railway engineers is adequate. The digitalization of railway projects is essential for improving the entire process. Investing in digitization, such as BIM, should be a priority.
- Improved investment is required in new communication systems for driving assistance and railway blocking.
- It is necessary to develop railway infrastructure in a balanced way throughout the Spanish territory, taking into account multiple criteria and not exclusively those related to politics.

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