European High-Speed Rail: Strengths and weaknesses as we approach an uncertain future

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Timeline of high-speed rail in Europe

• High-speed rail in Europe took off after the 1974 petrol crisis.

• Europe’s energy dependency threatened internal mobility, so several Member States (of the EU) decided to develop a safe, fast, comfortable and ecological mode of transport in the form of high-speed rail lines.

• Italy was the first European country to inaugurate a high-speed rail line: the line from Florence and Rome opened in 1977.

• Shortly afterwards, France inaugurated its own “Trains à Grande Vitesse” (TGV) lines. Germany’s first high-speed lines, served by “Intercity Express” (ICE) trains, opened in the early 1990s, whereas Spain’s “Alta Velocidad Española” (AVE) high-speed service commenced operations in 1992.
Many countries
Many types
Now in process of changing to distributed traction from loco hauled

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Railteam is collaboration between Europe's foremost high-speed companies, currently DB (Germany), SNCF (France), Eurostar (UK, France and Belgium), NS Hispeed (the Netherlands), ÖBB (Austria), SBB (Switzerland) and NMBS (Belgium), but also two of their high-speed companies, Thalys and Lyria. It is possible that even more railway companies may join in the future.

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Europe:
Using night lights as a proxy for population

Importance of geography

High density
England
Low Countries

The Alps as a barrier separating
North Italy

East and North?
France
Key route Paris Lyon
Distribution of small cities

Spain
Madrid Barcelona
Distribution of even smaller cities

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Length of national high-speed rail networks in the EU – growth over time

Only includes trains travelling at speeds > 250kph on part of journey.

France, Germany, Spain dominate.

Source: EU Statistical Pocketbook 2017; UIC.
1. Segregated, separate HS train on HS track, Con. Train on Con. Track

2. Mixed HS train onto Con. Track

3. Mixed Con. Train onto HS track

4. Promiscuous Both types of train on both types of track

Examples

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Liège-Guillemins TGV station

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The rise and rise of the Low Cost Carriers (LCC)
A major displacement from long distance rail and growth in demand

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<table>
<thead>
<tr>
<th>Seikan tunnel</th>
<th>Comparison</th>
<th>Channel tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honshu Hokkaido</td>
<td>Connects</td>
<td>UK France</td>
</tr>
<tr>
<td>1939-40</td>
<td>Concept</td>
<td>1802</td>
</tr>
<tr>
<td>53.8 km</td>
<td>Length</td>
<td>50.5 km</td>
</tr>
<tr>
<td>23.3 km</td>
<td>Length under sea</td>
<td>38 km</td>
</tr>
<tr>
<td>Complex, faulted</td>
<td>Geology</td>
<td>Simple</td>
</tr>
<tr>
<td>Much leakage</td>
<td>Chalk</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Workers killed</td>
<td>10</td>
</tr>
<tr>
<td>50 freight trains /day + 30 shinkansen</td>
<td>Usage</td>
<td>400 trains/day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50,000 passengers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>54,000 tons freight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6000 cars</td>
</tr>
<tr>
<td>140 kph</td>
<td>Max speed</td>
<td>160 kph</td>
</tr>
<tr>
<td>Single bore + service</td>
<td>Twin bore +service</td>
<td></td>
</tr>
<tr>
<td>Duel stooded +narrow gauge</td>
<td>Standed gauge</td>
<td></td>
</tr>
</tbody>
</table>

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Safety on HSR: Japan-Europe Comparison

• Two philosophies:

  1. Crash avoidance
     • Japan from 1964
       • Dedicated system with different rail gauge
  2. Manage the risk
     • EU from 1981
     • Existing rail gauge enabled interoperability
     • Spanish system (2nd in the world by length) still has EU crashworthy standards
     • Interoperability and Safety Directives
       • Technical Specifications for Interoperability
       • Common Safety Methods

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Eschede derailment 3 June 1998

Pile-up under bridge: 101 fatalities

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Cause:
Fatigue failure of separate rim of resilient wheel
On 28 July 2013, the train's driver Francisco José Garzón Amo was charged with 79 counts of homicide by professional recklessness and an undetermined number of counts of causing injury by professional recklessness.
Strasbourg 2015

Test train

90kph overspeed on curve derailment

11 deaths

Rescue workers search the wreckage of a test TGV train that derailed and crashed in a canal outside Eckwersheim near Strasbourg, eastern France, November 14, 2015. © Vincent Kessler / Reuters

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Safety conclusions:

- Operation on dedicated HS lines is the lowest risk
- Operating HSR over conventional routes increases risk and imposes design constraints with significant cost
- Level Crossings and HSR do not mix well
- Transitions between different systems creates risks
- Integrating systems with different signalling and power creates risks – some of them unknown
- People are always going to make errors, and designing systems that do not deal with predictable human errors is the biggest source of risk to future HSR integration
- Simple / dedicated systems less susceptible to human error and technical incompatibility
Key report by European Court Of Auditors

The report says:

- In reality there is no European high-speed rail network

- There is only a patchwork of national high-speed lines, planned and built by the Member States in isolation.

- This patchwork system has been constructed without proper coordination across borders: high-speed lines crossing national borders are not amongst the national priorities for construction, even though international agreements have been signed and provisions have been included in the TEN-T Regulation requiring core network corridors to be built by 2030.

- This means a low EU added value of the EU co-funding of high-speed rail infrastructure investments.

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Overview of EU co-funding for high-speed rail by Member State (2000-2017)

Source: European Commission.

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Assessment of time from planning to operation

<table>
<thead>
<tr>
<th>Audited high-speed rail lines and Munich-Verona stretch</th>
<th>Planning started</th>
<th>Work started</th>
<th>In operation*</th>
<th>Years since planning</th>
<th>Duration of work in years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlin - Munich</td>
<td>1991</td>
<td>1996</td>
<td>2017**</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>Stuttgart - Munich</td>
<td>1995</td>
<td>2010</td>
<td>2025*</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Eje Atlántico</td>
<td>1998</td>
<td>2001</td>
<td>2015</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Madrid - León</td>
<td>1998</td>
<td>2001</td>
<td>2015</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Milan - Venice</td>
<td>1995</td>
<td>2003</td>
<td>2028*</td>
<td>33</td>
<td>25</td>
</tr>
<tr>
<td>Turin - Salerno</td>
<td>1987</td>
<td>1994</td>
<td>2009</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Munich - Verona</td>
<td>1986</td>
<td>2003</td>
<td>2040*</td>
<td>54</td>
<td>37</td>
</tr>
</tbody>
</table>

* Expected.
** 52 km not before 2018. Source: ECA.

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Cost comparison of high-speed versus conventional rail: Venice – Trieste

<table>
<thead>
<tr>
<th>Design configuration</th>
<th>Design speed (km/h)</th>
<th>Cost (billion euro)</th>
<th>Travel time (min)</th>
<th>Savings (million euro/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 km/h new high-speed line</td>
<td>300</td>
<td>7.5</td>
<td>55</td>
<td>570</td>
</tr>
<tr>
<td>Upgraded conventional line</td>
<td>200</td>
<td>1.8</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

Source: ECA.

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Door-to-door travel analysis on selected high-speed lines

<table>
<thead>
<tr>
<th>Mode of transport</th>
<th>Distance</th>
<th>Time</th>
<th>Price (euro)</th>
<th>Time</th>
<th>Price (euro)</th>
<th>Time</th>
<th>Price (euro)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MADRID, Puerta del Sol - BARCELONA, Plaça de Catalunya</td>
<td>607-698 km</td>
<td>10:40-18:20</td>
<td>138-190</td>
<td>10:40-18:40</td>
<td>180</td>
<td>10:00-16:40</td>
<td>95-142</td>
</tr>
<tr>
<td>ROME, Piazza del Campidoglio - MILAN, Piazza del Duomo</td>
<td>572-661 km</td>
<td>6:30-8:00</td>
<td>227-253</td>
<td>6:30-7:00</td>
<td>140</td>
<td>6:30-8:00</td>
<td>146</td>
</tr>
<tr>
<td>BERLIN, Potsdamer Platz - MUNICH, Marienplatz</td>
<td>587-654 km</td>
<td>16:20-18:00</td>
<td>36-49</td>
<td>15:00-21:00</td>
<td>40</td>
<td>17:00-23:00</td>
<td>45-79</td>
</tr>
<tr>
<td>PARIS, Place de la Concorde - STRASBOURG, Place du Château</td>
<td>466-548 km</td>
<td>11:30-12:00</td>
<td>124-128</td>
<td>9:00-23:00</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>High-speed rail</td>
<td>6:00-8:20</td>
<td>6:00-9:00</td>
<td>159-181</td>
<td>6:50-9:00</td>
<td>23-205</td>
<td>8:30-10:30</td>
<td>66</td>
</tr>
</tbody>
</table>

Source: ECA.

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The report concludes:

*High-speed rail operations have many advantages but there is no realistic long term EU plan, and there is no truly EU high-speed network*

The Commission’s target of tripling the length of the high-speed rail network (reaching more than 30,000 km in 2030) is not supported by credible analysis. We consider it unlikely that this target will be reached, because it takes around 16 years for high-speed rail infrastructure to be planned, built, and to begin operations.

*There is no genuine European high-speed rail network: there is only a patchwork of national high-speed lines.*

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High-speed rail route passenger density comparison by country

- China
- Japan
- Korea
- Taiwan
- France
- Germany
- Spain
- Italy

Daily traffic density 1000 pass km/route km

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### Key HSR Data per Member State

<table>
<thead>
<tr>
<th></th>
<th>HSR – completed (km)</th>
<th>HSR - completed and in construction (km)</th>
<th>Total Cost – completed (million euro)</th>
<th>Total Cost - completed and in construction (million euro)</th>
<th>EU co-funding - completed and in construction (million euro)</th>
<th>Pass-km (billion)</th>
<th>Population (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>2 675</td>
<td>3 827</td>
<td>31 015</td>
<td>53 554</td>
<td>14 071</td>
<td>13.4</td>
<td>46.2</td>
</tr>
<tr>
<td>France</td>
<td>2 548</td>
<td>2 628</td>
<td>38 395</td>
<td>40 382</td>
<td>1 406</td>
<td>49.0</td>
<td>67.0</td>
</tr>
<tr>
<td>Italy</td>
<td>1 144</td>
<td>1 280</td>
<td>31 812</td>
<td>41 912</td>
<td>724</td>
<td>20.0</td>
<td>60.6</td>
</tr>
<tr>
<td>Germany</td>
<td>2 141</td>
<td>2 331</td>
<td>28 506</td>
<td>34 105</td>
<td>2 694</td>
<td>27.2</td>
<td>82.8</td>
</tr>
</tbody>
</table>

### Calculated Key performance indicators

<table>
<thead>
<tr>
<th></th>
<th>Total Cost - completed / km</th>
<th>Total Cost - completed and in construction / km</th>
<th>Total Cost - completed / capita</th>
<th>Total Cost - completed and in construction / capita</th>
<th>Total Cost - completed / km / capita</th>
<th>Total Cost - completed and in construction / km / capita</th>
<th>EU co-funding / capita</th>
<th>Pass-km (mil) / km HSR</th>
<th>Pass-km / capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>12</td>
<td>14</td>
<td>671</td>
<td>1 159</td>
<td>0.25</td>
<td>0.30</td>
<td>305</td>
<td>5.0</td>
<td>290</td>
</tr>
<tr>
<td>France</td>
<td>15</td>
<td>15</td>
<td>573</td>
<td>603</td>
<td>0.22</td>
<td>0.23</td>
<td>21</td>
<td>19.2</td>
<td>731</td>
</tr>
<tr>
<td>Italy</td>
<td>28</td>
<td>33</td>
<td>525</td>
<td>692</td>
<td>0.46</td>
<td>0.54</td>
<td>12</td>
<td>17.5</td>
<td>330</td>
</tr>
<tr>
<td>Germany</td>
<td>13</td>
<td>15</td>
<td>344</td>
<td>412</td>
<td>0.16</td>
<td>0.18</td>
<td>33</td>
<td>12.7</td>
<td>329</td>
</tr>
</tbody>
</table>

**Note:** For France and Italy, the numbers exclude cross-border connections Brenner Base and Lyon - Turin tunnels; Pass-km for Italy is the latest publicly available estimate.

**Source:** ECA, national administration, infrastructure managers and railway operators.

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Damage from HS2 ‘will be worse than thought’

“The line to Birmingham, Leeds and Manchester will lead to the destruction of almost 900 homes, 1,000 business premises and at least 61 ancient woodlands”.

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Warning of power blackouts and end to Eurostar trains under no-deal Brexit

The Times 13 Oct 2018

Ministers are hoping to strike bilateral deals with France, the Netherlands and Belgium to keep services running but if these are not completed in time then they would have no legal basis to operate due to licence and border issues.
Concluding remarks:

HS rail started in Europe in 1974

Spain now has the largest route, France and Germany probably best established

“Captive” running on dedicated track is somewhat limited

Accidents have happened to HS trains on conventional track

Many lines terminate in old city centres

Cross border running is rather limit no European wide system exists
UK has many fast and frequent routes on conventional line, but now building HS Eurostar from London to Paris and Brussels (and beyond) is the only example in the world of an undersea rail connection between countries

Threats exist from LCC airlines, Brexit, financial perturbations within the EU and terrorism

Therefore future growth is less than certain

Thank you for your kind attention