Developing a Successful Rail Network
The Spanish Case

Chicago 21st March, 2012
DEVELOPING A SUCCESSFUL PASSENGER RAIL SYSTEM: SPAIN’S EXPERIENCE
Current railway scenario in Spain


- Infrastructure management and transport operation separation
- Opening of the freight railway market to competition

As of January 1, 2005
Current railway scenario in Spain

- **Strategic Plan for Transport Infrastructures 2005-2020**
  - 250,000 M€ (319 B USD)
  - 120,000 M€ (153 B USD)
  - until 2020, 48% of the total amount for railways

  - To ensure the funding of its activities
  - Commitment for improving the State’s network
  - Drawing up a new Multi-annual Contract

- **Extraordinary Infrastructure Plan**
  - Public-private PPP collaboration Plan
  - 17,000 M€ (22 B USD) for the next two years
  - ADIF: 10,000 M€ (13 B USD)

- **Next July**
  - PIVIT
  - New Investment Plan for Housing and Transport Infrastructure
# Ministry of Public Works investments

## Investment by mode of transport

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<thead>
<tr>
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<tbody>
<tr>
<td>RAILWAYS</td>
<td>(12,870 M USD)</td>
<td>(15,497 M€)</td>
<td>(16,765 M€)</td>
</tr>
<tr>
<td>AIRPORTS</td>
<td>(10,086 M€)</td>
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<tr>
<td>ROADS</td>
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<tr>
<td>PORTS</td>
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</table>

- **70%** increase from Average 2001-2004 to Average 2005-2008.
- **90%** increase from Average 2005-2008 to Average 2009-2011.
Public entity attached to Ministry of Transport & Public Works

Infrastructure Management

• Railway network of general public interest State owned

• Own assets:
  → Madrid- Sevilla HSL
  → HS network built by Adif
  → Stations and Logistic Services
  → Telecomunications network
  }
  Madrid- Toledo
  Madrid- Barcelona
  Madrid- Valladolid
  Córdoba- Málaga
  Madrid- Cuenca-Valencia / Albacete
  Orense - Santiago
Adif. Functions

- Administration, maintenance and renewal of State network, commissioned by the State
- Construction of new lines when commissioned
- Management of traffic operations on both networks, the State and the own one
- Maintenance and renewal of the own network
- Network Statement
- Capacity allocation to railway undertakings
- Collecting fees and charges for the access and use of infrastructure, stations and terminals
Adif. Global figures

- **1st investor company in Spain**, in 6 years (2005-2010)
  - 28.519 M€ (36.39 B USD)
    - High Speed: 23.576,2 M€ (30.08 B USD)
    - Conventional Network: 4.735,3 M€ (6.04 B USD)
    - Special Plans: 207,5 M€ (0.27 B USD)

- **2012 Staff:** 13.249
- **Fixed Assets**
  - 34.616 M€ (44.17 B USD)
- **Own Resources**
  - 15.521 M€ (19.80 B USD)

- **2012 Managed rail network:** 13.965 km (8,678 mi)
  - High Speed: 2.869 km (1,783 mi) Including 20 km (12 mi) Connection to France and 750 km (466 mi) with Iberian gauge
  - Iberian gauge: 11.096 km (6,895 mi)

- **2012 HS Lines Construction, Project & Study** 2.288 km (1,422 mi)
- **2015 - 2018 Objective HS Lines on Service** 5.600 km (3,480 mi)

- **Optical fibre network:** 16.386 km (10,182 mi)
- **Stations:** 1.570
- **Managed Traffic:** 1,8 M trains/year
  - 186,7 M train-km/año (20,1% HSL)
  - (120 M train-mile/year)
The success of the Spanish High Speed Rail Network
High Speed Lines. Landmarks

1992 - **Madrid-Sevilla**: 471 km (293 mi)

2003 - **Madrid-Lleida**: 468 km (291 mi)
(200 km/h – 125 mi/h - ASFA).
**Zaragoza-Huesca**: 79 km (49 mi)

2005/06 - **Lleida-Tarragona**: 95 km (59 mi)
**Córdoba-Antequera**: 100 km (62 mi)
**Toledo connection**: 21 km (13 mi)

2007 - **Madrid-Lleida**: 468 km (291 mi)
(300 km/h - 186 mi/h - since May 2007)
**Madrid-Valladolid**: 181 km (112 mi)
**Antequera-Málaga**: 55 km (34 mi)

2008 - **Tarragona-Barcelona**: 88 km (55 mi)

2010 - **Madrid-Cuenca**: 183 km (114 mi)
**Madrid-Albacete**: 315 km (196 mi)
**Madrid-Valencia**: 391 km (243 mi)
**Mollet – Girona**: 75 km (47 mi)
**Int. Connection to Francia**: 20 km (12 mi)

2011 - **Ourense – A Coruña**: 150 km (93 mi)
Adif’s High Speed Lines. Current situation

**New High Speed Line**
Ourense – A Coruña
150 km (93 mi)
In Service: December 2011

**HIGH SPEED NETWORK ENTRUSTED TO ADIF**
Total: 4,497 km (2,794 mi)

**New High Speed Line**
Madrid-Valencia/Albacete
438 km (272 mi)
In Service: December 2010
High Speed lines in Europe

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>IN SERVICE</th>
<th>UNDER PROJECT/CONSTRUCTION</th>
<th>PLANNED</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPAIN (Adif)</td>
<td>2.869* (1,783 mi)</td>
<td>2.050 (1,274 mi)</td>
<td>238 (148 mi)</td>
</tr>
<tr>
<td>FRANCE</td>
<td>2,036 (1,265 mi)</td>
<td>210 (130 mi)</td>
<td>2.616 (1,626 mi)</td>
</tr>
<tr>
<td>GERMANY</td>
<td>1.285 (798 mi)</td>
<td>378 (235 mi)</td>
<td>670 (416 mi)</td>
</tr>
<tr>
<td>ITALY</td>
<td>923 (574 mi)</td>
<td>-</td>
<td>395 (245 mi)</td>
</tr>
<tr>
<td>TURKEY</td>
<td>538 (334 mi)</td>
<td>815 (506 mi)</td>
<td>-</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>209 (130 mi)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>UNITED KINGDOM</td>
<td>113 (70 mi)</td>
<td>-</td>
<td>204 (127 mi)</td>
</tr>
<tr>
<td>SWITZERLAND</td>
<td>35 (22 mi)</td>
<td>72 (45 mi)</td>
<td>-</td>
</tr>
<tr>
<td>NETHERLANDS</td>
<td>120 (75 mi)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>-</td>
<td>-</td>
<td>1,006 (625 mi)</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>-</td>
<td>-</td>
<td>750 (466 mi)</td>
</tr>
<tr>
<td>POLAND</td>
<td>-</td>
<td>-</td>
<td>712 (442 mi)</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>-</td>
<td>-</td>
<td>650 (404 mi)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8.128 (5,051 mi)</strong></td>
<td><strong>3.525 (2,190 mi)</strong></td>
<td><strong>7.241 (4,500 mi)</strong></td>
</tr>
</tbody>
</table>

• Including 750 km (466 mi) of HSL with Iberian gauge (newly constructed) and 20 km (12mi) in Spain by TP Ferro as concessionary

2012 SITUATION HSL in Europe 8.128 km (5,051 mi)

2015 FORECAST HSL in Europe 10.407 km (2,190 mi)
Stations 2005-2011

18 HS Stations

Madrid Puerta Atocha

Málaga María Zambrano (VIALIA)

Cuenca Fernando Zóbel (Brunel Award 2011)

Valencia Joaquín Sorolla

High Speed Stations
New - Refurbished
VIALIA Stations
VIALIA Projets
NEW RAILWAY COMPLEX AT ATOCHA STATION

Future High Speed Railway Network in Madrid
An idea of real costs in Spanish HSL and Stations

- **Real costs in Spanish HSL:**
  - Infrastructure: 10.3 – 30.9 M USD/mile
  - Track: 3.5 – 4.1 M USD/mile
  - Electrification: 1.6 – 2.7 M USD/mile
  - Signaling and telecom: 2.3 – 6.8 M USD/mile
  - Total Cost: 19.3 – 42.9 M USD/mile

- **Unit Cost for large and medium-sized stations**
  - Medium-sized: 20 - 65 M USD
  - Large: 65 - 260 M USD

![Image of train and station](image.png)
Travel time reduction in High Speed Lines
SPAIN. A World Leader in High Speed Rail

- City center and urban transport connection by new High Speed lines (27 cities), raising to 44 with double gauge High Speed trains
- Punctuality commitment: (99.6%) total ticket refund if 5’ delay
- The second longest HSL in the world: Barcelona - Málaga: 1.121 km (697 mi)
- Speed achievement: 90% of the route, speeds of at least 310 km/h (193 mph)
- Safety: 0 Accident

Cost and construction efficiency

Lower cost per line in Europe 15 Million €/km (31 M USD/mi)
4 years overall time from construction to operation

307 HS trains per day

111.500 seats/day of HS

25 YEARS OF EXPERIENCE IN THE COMPLETE DEVELOPMENT PROCESS OF HIGH SPEED
Overcoming speed limits imposed by infrastructure
## Conventional Network (State owned) main features

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Length (km - mi)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional network</td>
<td>11.846 km (7,361 mi)</td>
<td>(incl. 750 km–466 mi- HS)</td>
</tr>
<tr>
<td>Single track:</td>
<td>8.600 km (5,344 mi)</td>
<td></td>
</tr>
<tr>
<td>Double track:</td>
<td>3.246 km (2,017 mi)</td>
<td></td>
</tr>
<tr>
<td><strong>Type A</strong> (more than 50 trains/day)</td>
<td>3.933 km – 2,444 mi</td>
<td>(33%)</td>
</tr>
<tr>
<td><strong>Type B</strong> (15-30 trains/day)</td>
<td>2.681 km – 1,666 mi</td>
<td>(23%)</td>
</tr>
<tr>
<td><strong>Type C</strong> (less than 15 trains/day)</td>
<td>3.088 km – 1,919 mi</td>
<td>(26%)</td>
</tr>
<tr>
<td>Commuters</td>
<td>2.144 km – 1,332 mi</td>
<td>(18%)</td>
</tr>
<tr>
<td>Electrified lines</td>
<td>6.581 km – 4,089 mi</td>
<td>(55%)</td>
</tr>
<tr>
<td>Lines with automatic block</td>
<td>6.974 km – 4,334 mi</td>
<td>(59%)</td>
</tr>
<tr>
<td>Lines with automatic liberalisation Block</td>
<td>1.983 km – 1,232 mi</td>
<td>(17%)</td>
</tr>
<tr>
<td>Lines with telephone block</td>
<td>2.484 km – 1,544 mi</td>
<td>(21%)</td>
</tr>
<tr>
<td>Lines with CTC</td>
<td>8.086 km – 5,025 mi</td>
<td>(69%)</td>
</tr>
<tr>
<td>Lines that allow speeds from 180 to 220 km/h</td>
<td>501 km (4%)</td>
<td></td>
</tr>
<tr>
<td>(from 112 to 137 mi/h)</td>
<td>311 mi</td>
<td></td>
</tr>
<tr>
<td>Lines that allow speeds from 140 to 160 km/h</td>
<td>4.805 km (41%)</td>
<td></td>
</tr>
<tr>
<td>(from 87 to 99 mi/h)</td>
<td>2,986 mi</td>
<td></td>
</tr>
<tr>
<td>Lines that allow speeds from 100 to 140 km/h</td>
<td>3.528 km (30%)</td>
<td></td>
</tr>
<tr>
<td>(from 62 to 87 mi/h)</td>
<td>2,192 mi</td>
<td></td>
</tr>
<tr>
<td>Lines that allow speeds less than 100 km/h</td>
<td>3.012 km (25%)</td>
<td></td>
</tr>
<tr>
<td>(less than 62 mi/h)</td>
<td>1,872 mi</td>
<td></td>
</tr>
</tbody>
</table>
New needs but also new possibilities. Examples

**HISTORIC LINE**

(since 1884)
LENGTH: 52 mi
SPEED: 43-50 mph
JOURNEY TIME: 55’
BIGGEST TUNNEL: LA PERRUCA (1,908 mi)

**NEW HS LINE**

(under construction)
LENGTH: 30 mi ▼ 33 %
SPEED: 155 mph ▲ 312 %
JOURNEY TIME: 15’ ▼ 73 %
BIGGEST TUNNEL: PAJARES (16 mi)

**HSL Madrid-Valladolid**

155 mi → 112 mi ▼ 28 %
2h 20m → 0h 50m ▼ 71 %

**HSL Madrid-Seville**

354 mi → 292 mi ▼ 18 %
6 h → 2h 20m ▼ 61 %
Lines Upgrade / Improvement

Max. speed 160 ➔ 200 ➔ 220 km/h
(100 ➔ 125 ➔ 137 mph)
Lines Upgrade / Improvement

LEVANTE CORRIDOR
SESEÑA - LA ENCINA

Line Kilometers: 334,9 (208 mi)

Weighted average of Maximum Speed = 187 Km/h (116 mph)
Lines Upgrade / Improvement

Weighted average of Maximum Speed = 197 Km/h (122 mph)

MEDITERRANEAN CORRIDOR

ALICANTE – SALOU

Line Kilometers : 444,9 (276 mi)
Improvement Actions on Conventional Lines

Objective of Investments

Progressive improvement of line performances with Interoperability standards on the rail subsystems
- Infrastructure
- Energy
- Signalling control & command
- Traffic operation & management
- Maintenance

Type of Actions

- Improvement existing infrastructure
- Bypass on complicated layouts
- Doubling lines when necessary

Final Objective

High performance infrastructure for mixed traffic
Strategies for line modernization (I)

Objectives.

- Rail competitiveness versus other transport modes. Achieved by reducing travel time and increasing line capacity.
- Avoid, when possible, environmental effects and expropriation processes (reducing investment volume) if using existing rail corridor.

Modernization Procedures.

Critical elements:

- Affected traffic (impact on timetables)
- Infrastructure improvement needs
- Risk of effects on infrastructure facilities

Basic types of modernization/upgrading:

- Using the existing track.
- Doubling and modernization of the existing single track.
- Double track sections, modernization.
Strategies for line modernization (II)

USING THE EXISTING RAIL TRACK
- It is not possible to enlarge the infrastructure
- Low traffic and limited alternative routes.
- Change of the whole track.

This procedure is only used in case of high scope actions.

DOUBLING AND MODERNIZATION OF THE EXISTING TRACK
When there is single track with satisfactory operational speed (140-160 km/h; 87-100 mph), speed can be changed to 200-220 km/h (125-137 mph) by:
- Doubling infrastructure adding a new platform.
- Implementing a new track.
- Interrupting rail services on the existing track in order to carry out improvement works.

This option is used both in routes and in stations
Strategies for line modernization (III)

DOUBLING AND MODERNIZATION OF THE EXISTING TRACK (Cont.)

Routes:
– Previous works (transfer of facilities to the opposite side of the future additional track).
– Excavation / construction of the new platform.
– Unloading materials and previous electrification works.
– Track and catenary assembly.
– Safety and communications facilities.

Stations:
At the same time works on general sections are being carried out, the double track structure in station is adapted.

– To assess the needs of new stations as well as the enlargement of passing tracks.

To highlight:
– Adaptation to 200 – 220 km/h (125-137 mph)speeds
– Adequate level of compatibility with rail traffic.
– Longer work periods than the execution of bypass.
– Non suitable for speeds higher than 220 km/h. (137 mph)
– Effect on rail operation.
Strategies for line modernization (IV)

DOUBLE TRACK SECTIONS MODERNIZATION

Assuming that the layout is suitable for target speed and has a consolidated support platform.

Two possible strategies: Modernization with work intervals (8-9 hours).
Modernization with permanent cuts on one track

Modernization with work intervals (8-9 hours)
- This strategy does not guarantee quality objectives because it makes rigorous treatment of the platform difficult.
- Classic concept of track renewal.

Process:
- Preliminary works: land movement (cuttings, embankments), drainage, etc., it is not necessary to cut traffic, only limit speed.
- Intervals (8-9 hours): track scrap, ballast removal, platform compacting, etc. until traffic restitution on provisional track.
- Additional works to complete operations, tamping, soldering, etc.
Modernization with permanent track cuts on one track

Similar to the previous process, an Automatic Banalised Blocking must set up first, to guarantee single track running in both directions.

Actions are carried out in stations simultaneously. If it is possible they should not be beside the section where works are being carried out.

To highlight:

- Adaptation to 200 – 220 km/h (125-137 mph) speeds
- Adequate level of compatibility with rail traffic.
- Longer work periods than the execution of bypass.
- Non suitable for speeds higher than 220 km/h. (137 mph)
- Effect on rail operation.
Strategies for line modernization (VI)

Line modernization viability
In order to guarantee the viability of the modernization/upgrading process, a comprehensive inventory is needed:

- **Documentation of the existing line** regarding all issues: layout, sections, bridges and civil engineering works, drainages, facilities, etc.
- **Photogrammetric** flight and restitution of possible use areas.
- Delimitation of the rail infrastructure **property area**.
- Description of the **geotechnical** features of rail infrastructure.
- Performance analysis of the **stability of cuttings and embankments**
- Situation of the **longitudinal drainage** in platforms and catch-water drains.
- Assessment of the **state of the embankment**.
- Assessment and survey of **singular structures**.
- Inventories of the **electrification system**, canalization and laying.
- Description of the rail **telecommunications systems**.
- Identification of the **external communication and energy networks**.
Lines Upgrade / Improvement

- Doubling of track (from single track case)
- Local new track sections/alignments to increase Max. Speed
- Track with UIC60 rail and monobloc concrete sleepers
- Installation of new jointless turnouts:
  - Deviations: 100 km/h (62 mph)
  - Siding tracks: 100 km/h (62 mph)
- New Catenary suitable for 220 Km/h (137 mph)
- New Signalling Equipments
- Elimination of Level Crossings
- Fencing
- Elimination of steel bridges without ballast
Spanish technology
SPANISH STRENGTH IN RAILWAYS TECHNOLOGY

- **Tunnels:** Guadarrama Tunnel, 28km (17 mi), 5th worldwide; Pajares Tunnel, 25km (16 mi), 6th world record in drilling with tunnel boring machine: 90 meters/day (0.056 mi/day)
- **Viaducts:** world record using the launched deck method
- **Track:** world record in commercial operation sector, 405 km/h (252 mph)
- **Switches:** 350 km/h (217 mph) switches, to be crossed at 220 km/h (137 mph) through a deviation
- **2 km/day (1.2 mi/day) track laying over ballast** achieved
- **Catenary:** Spanish HS catenary (350 km/h - 217 mph + 10%) interoperable TSI
- **Sub-stations:** own design 2 x 25 kv
- **Maintenance technologies:** laboratory and track examination trains
- **R+D+i:** energy efficient, raising ballast, track models...
Track quality in Spain continues its improvements

- **Automatic track gauge switches** for international and Spanish gauge performed at 30 km/h (19 mph)

- Technology of **three rails track** for Spanish and international gauge
Interoperability. Gauge exchangers
Spain has set up ERTMS in 1,712 km (1,064 mi) of High Speed lines (48% out of the total km in Europe; and more km than any other European country)

Madrid- Barcelona line is pioneer in using ERTMS:
- March 2006: speed increase from 200 to 250 km/h (from 125 to 155 mph)
- October 2006: speed increase to 280 km/h (174 mph)
- May 2007: speed increase to 300 km/h (186 mph)
- October 2011: ERTMS level 2, speed increase to more than 300 km/h (186 mph)

This system has been set up in Córdoba- Málaga, Madrid- Valladolid, Madrid-Valencia/Albacete and Ourense-Santiago lines.
Spanish experience in ERTMS

- Ourense-Santiago ERTMS L1
- Madrid-Valladolid ERTMS L1-2
- La Sagra-Toledo ERTMS L1-2
- Madrid-Sevilla LZB Trains ERTMS NSTM LZB
- Córdoba-Málaga ERTMS L1-2
- Madrid-Lleida ERTMS L1-2
- Zaragoza-Huesca ERTMS L1
- Lleida-Barcelona ERTMS L1-2
- Madrid-Valencia / Albacete ERTMS L1-2
DaVinci system

The Spanish DaVinci system was designed to manage HS lines.

- Integration of all telecommands in the HSL allowing centralized real time operation
  - Centralized Train Control CTC
  - ERMTS central post
  - Energy Supply
  - Communications Supervision (Fixed and mobile communications)
  - Auxiliary supervision systems
  - Video surveillance

- In addition includes the following environments.
  - Simulation and Training
  - Integrated reconstruction of events
  - Validation and testing environments

The DaVinci experience
Adif lines
FEVE lines
London & Medellín Underground
Morocco lines
Lituanian lines
A new experience: Public Private Partnership PPP for financing ADIF’s investments
New PPP program for HSR lines

Why a PPP program?

• Accelerate investment to boost job creation during a recession

• Support Public investment with Private investment in a Budget deficit scenario

Why a new approach?

• Apply to HSR previous experiences already implemented in other modes

• Projects ready to be tendered
New PPP program for HSR lines

- A new contracting model for High Speed actions by Private-Public Collaboration contracts.
- An unique contract for projects growing up, works implementation and maintenance carrying out for a 20-25 years period.
- A suitable method has been set up for paying the maintenance.
- Development of specific technical documentation.

Private-Public collaboration advantages (for both sides)

- Transfer of the technical and technological risks associated with building and availability.
- Guarantee the company in charge of design and implementation stays for almost all the life cycle.
- Guarantee quality, reliability and availability levels
New PPP program for HSR lines

- **Procurement body**: adif

- **PPP projects based on the availability of the infrastructure**

- **Scope:**
  - Signaling & Communications
  - Electrification
  - Track
  - Roadbed & civil works—In discussion

- **Contracts include:**
  - Final Design
  - Construction/Installation
  - Assets replacement
  - MOW for 20 - 25 years

- **100% construction, availability & maintenance risk on concessionaire**
New PPP program for HSR lines

Deferred and Availability payments during O&M MOW
60% construction costs
Equity & debt paybacks

Equity
10%

Private debt
50%

40% construction costs

Concessionaire

Private partners
10%
90%

Dividend Concessionaire

Debt paybacks
Financial Entities

Maintenance costs
MOW contractor

Construction costs
Contractor
Availability payment model

The availability payment is focused to achieve quality and reliability since the establishment of the Global Product Design, through the Building and the Maintenance.

Aspects to check in the operational phase:

- **OPERATIONAL AVAILABILITY**: to measure traffic regularity.
- **FUNCTIONAL AVAILABILITY**: to verify that the corrective maintenance is carried out in a suitable way.
- **RELIABILITY**: to measure quality from a design point of view, as well as from a preventive and predictive maintenance.
- **QUALITY**: to verify geometric parameters and functional conditions of the facilities
HSL Albacete - Alicante

- **Albacete-Alicante (177 km; 110 mi)**
  - Traffic Control facilities.
  - Fix Telecommunications and GSM-R
  - Security and safety
- Investment amount: **213 M€** (272 M USD)
- Availability services amount: **165 M€** (211 MUSD)
- Come into service: **2012**
- ERTMS-N2 system installation with ASFA as a support system
- 20 years of maintenance.
Thank you for your kind attention