High Speed Rail: A global perspective

1st TEMPO Conference on sustainable Transport:
High-speed rail in Norway?
Oslo, 18 May 2010

Iñaki Barrón de Angoiti
Director of the Passengers and High Speed Department, UIC
Summary

- High speed is **expanding dramatically** around the world
- A **highly beneficial transport system for society**
- High speed **always needs public help**
- High speed is a **complex system**
- High speed conception is **not unique** and it must be adapted to each case
The UIC and the high speed rail
Possibilities of classic rail
High speed rail principles
Some facts & figures
Stations for high speed
The costs of high speed
High speed around the world
The future of high speed
Concluding remarks
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UIC: the International Union of Railways

> Since 1922

> 200 members on all continents

> Members are:

- Railways
- Rail operators
- Infrastructure managers
- Railway service providers
- Public transport companies
UIC in 2010: a continuous expansion
UIC Mission

Promoting the development of rail transport at world level, in order to meet challenges of mobility and sustainable development
UIC Objectives

• Facilitate *exchange on best practices* among members (benchmarking)
• Support members in their efforts to develop *new businesses*
• Propose new ways for *improving economic performances* of the railways

• Achieve *interoperability*, create *new world standards* for railways (including common standards with other modes)
• Develop *Centers of competence* (High Speed, Safety, Security, e-Business, …)
UIC Leaflets

UIC CODE

734

Adaptation of safety installations to high-speed requirements

R

UIC CODE

779-9

Safety in railway tunnels

R

UIC Reports

High speed rail
Fast track to sustainable mobility

高速铁路
可持续运输的快速发展之路

Fast track to Sustainable Mobility
Congress Proceedings (CD-Rom)
Congress Movie, Film (DVD)

17-19 March 2008
Amsterdam RAI The Netherlands
UIC Railway Statistics & publications

2008

Passenger-Kilometres (billions)

<table>
<thead>
<tr>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Δ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>636,2</td>
<td>643,1</td>
<td>643,6</td>
<td>658,7</td>
<td>2,7%</td>
</tr>
<tr>
<td>Africa</td>
<td>1,7</td>
<td>1,7</td>
<td>1,7</td>
<td>1,7</td>
<td>0,0%</td>
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<tr>
<td>America</td>
<td>12,9</td>
<td>12,8</td>
<td>13,3</td>
<td>14,0</td>
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<tr>
<td>Asia and Oceania</td>
<td>1,545,7</td>
<td>1,646,0</td>
<td>1,788,6</td>
<td>1,900,9</td>
<td>9,1%</td>
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<tr>
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<td>2,362,5</td>
<td>2,506,3</td>
<td>2,686,8</td>
<td>7,2%</td>
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</table>

Tonne-Kilometres (billions)

<table>
<thead>
<tr>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Δ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>2,519,6</td>
<td>2,646,6</td>
<td>2,813,6</td>
<td>3,103,0</td>
<td>10,3%</td>
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<tr>
<td>Africa</td>
<td>517,9</td>
<td>517,6</td>
<td>517,5</td>
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<tr>
<td>America</td>
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<td>3,515,5</td>
<td>3,540,2</td>
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<td>-0,7%</td>
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<tr>
<td>Asia and Oceania</td>
<td>2,713,2</td>
<td>2,872,6</td>
<td>3,096,9</td>
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<td>11,5%</td>
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<tr>
<td>World</td>
<td>8,746,0</td>
<td>9,177,1</td>
<td>9,585,1</td>
<td>10,204,1</td>
<td>6,5%</td>
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</tbody>
</table>

Length of lines (kilometres)

<table>
<thead>
<tr>
<th>Region</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>Δ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>348,312</td>
<td>349,458</td>
<td>348,788</td>
<td>349,000</td>
<td>0,1%</td>
</tr>
<tr>
<td>Africa</td>
<td>58,281</td>
<td>58,431</td>
<td>60,652</td>
<td>60,734</td>
<td>0,1%</td>
</tr>
<tr>
<td>America</td>
<td>398,392</td>
<td>399,972</td>
<td>400,563</td>
<td>397,573</td>
<td>-0,8%</td>
</tr>
<tr>
<td>Asia and Oceania</td>
<td>372,110</td>
<td>380,835</td>
<td>384,174</td>
<td>377,345</td>
<td>-1,8%</td>
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<tr>
<td>World</td>
<td>1,031,125</td>
<td>1,032,156</td>
<td>1,041,174</td>
<td>1,035,460</td>
<td>-0,5%</td>
</tr>
</tbody>
</table>

* Including Turkey and the Russian Federation
UIC activities on High Speed
Ongoing studies:

- Study on high speed under extreme weather conditions
- Necessities for future high speed rolling stock
- “High speed handbook”

- High speed contribution to sustainable mobility
- High speed and the city
- High speed and territory management
- Maintenance of high speed lines
UIC High speed activities

Precedent studies:
• Reduction of time travel on classic lines
• Tilting trains
• Mix traffic on high speed lines
• Design of lines for speeds of 300-350 km/h
• Approval of new high speed lines
• High speed rail face to “low cost” concurrency
• Infrastructure charges for high speed services in Europe
• Modeling of regional traffic on high speed international lines
• …

• They are in the UIC website (High Speed) – www.uic.org
Training on UIC High Speed Systems

One week (5 days) Training Seminar, in which all the elements involved in a high speed system are analysed

7th THSS: 28 June – 3 July 2010, in Paris, UIC-HQ
7th World Congress on High Speed Rail

7 – 9 December 2010, CNCC – Beijing

High speed rail spearheading greener transport

Organized by UIC & MOR - CARS

The UIC and the high speed rail

Possibilities of classic rail

High speed rail principles

Some facts & figures

Stations for high speed

The costs of high speed

High speed around the world

The future of high speed

Concluding remarks
Increasing speeds

Some difficulties to implement high-speed rail systems (i.e. the cost) could suggest checking the possibilities of improving the performances of traditional rail networks.

Traditional networks could REPLACE or COMPLEMENT the high-speed system, due to the COMPATIBILITY between them.

This solution can be provisional or not.
Why the speed is limited?

- Technical reasons: track quality, traction power, dynamic effects, CAPACITY
- Limits on curves: comfort of passengers, lateral stability of the track, derailment, overturning
- Environment (noise, vibrations)
- Safety (braking distances, other motives)
- Economy (energy consumption, maintenance costs)
Some thresholds for conventional rail (magnitudes)

- Trains with axle vehicles: 100 km/h
- Without in cab help signaling: 140 km/h
- People on platforms: 160 km/h
- Lines with crossing levels: 160 km/h
- Trains with locomotive + cars: 200 km/h
- Limit for conventional rail: 200-230 km/h
Time or speed?

• The objective is reducing the time travel
• Reducing time travel ≠ Increasing speed
• Time travel or speed but with CAPACITY
• Time travel, speed or capacity but with RELIABILITY
• Time travel, speed, capacity and reliability but with ECONOMY
• In any case everything must be made with SAFETY
How to reduce the time travel?

- Improving motive power performances (accelerating / braking / maximum speed)
- Improving geometry, structure and profile of the track
- Improving signaling and control system
- Reducing policy for commercial stops
- ...

Basic issues of the speed on rails

For a single train:

- Maximum speed & minimum speed
- Constant speed as much as possible
- Commercial speed < 85 % maximum speed
Basic issues of the speed on rails

For all the trains on the line (traffic density):

- Homogeneity of speed = capacity
- Maximum differences of speed between the many different trains
  (if possible, no more than 50 km/h)
Operating with two different speeds

Train at 200 km/h = 80 minutes

One train at 200 km/h = 7 train paths at 300 km/h

TGV at 300 km/h = 53 minutes
Balancing capacity

Different types of trains

Stability
(“Impact of 1 minute delay of one train on other trains”)

L1 + L2 + L3 + L4 = Constant

UIC Leaflet 406
Balancing capacity

- French TGV line
- Metro line
- HS line with mixed traffic

Number of trains

Km/h

Stability

Types
Tilting trains principle

Figure 2: Principe des trains pendulaires.
Tilting trains

• Need to acquire special rolling stock (opportunity)
• Cost of the new rolling stock
• Cost of the maintenance
• Requirements for the infrastructure
• Performance to obtain and image
Tilting trains

Two types of tilting trains:

- Active
- Natural or passive (Talgo - Spain)
Active
Active
Natural
Natural
Some examples

- Mediterranean corridor
  Barcelona – Valencia, Spain  480 km

- West Coast Main Line
  London – Scotland, UK  640 km

- Lisbon – Oporto, Portugal  335 km
Spain
Portugal
Some examples

The maximum speed has been increased up to 200 – 220 km/h, by large infrastructure improvements

These improvements have been obtained by:

• Big investments
• Long times for works (even 15 years)
• Traffic disturbances during this time
The result:

- Progressively, the performance of rail services has been improved
- Consequently, the traffic demand has been increased
- Consequently, a new high speed line has been planned
The UIC and the high speed rail
Possibilities of classic rail

**High speed rail principles**

Some facts & figures

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High speed around the world

The future of high speed

Concluding remarks
Definition of high speed

Is a “new transport mode”, fully compatible with classic rail (SNCF, 1981)

High speed means at least 250 km/h
But the definition is not unique
(EU Categories I, II and III)

High speed & high performances
Intercity (UK): Important average speed at 200 km/h
Thresholds

Operating at more than (±) 200 km/h requires:
- special trains (train sets)
- special dedicated lines
- in-cab signalling

...and much more
Understanding high speed rail

High speed is a system

A very complex system, comprised by the state of the art of:

- Infrastructure
- Rolling stock
- Signalling systems
- Maintenance systems
- Management
- Station emplacement
- Operations rules
- Marketing
- Financing
- ...

Considering all of them is fundamental
High speed is not unique

- Many different commercial concepts of high speed (including services to customers, marketing, etc.)
- Many different types of operations (maximum speed, stops, etc.)
- Different ways to operate classic trains (in particular, the impact on freight traffic)
- Capacity and cost vary in each case
Performances for customers

- Commercial speed
- Frequency
- Accessibility
- Comfort
- “Freedom”
- Total time of travel
- Reliability
- Price
- Safety
- ...

Examples of time travel reduction

- Rome – Naples
- Rome - Milan
- Madrid - Barcelona
- Madrid - Seville
- Cologne - Frankfurt
- Paris - Stuttgart
- Paris - Marseille
- Paris - Brussels
- Paris - Amsterdam

Time travel (hours)

Before high speed ■ With high speed
How train travel time influences market share

If HS travel time is 4 hrs or less, HS rail captures 50+% of combined air/rail traffic
High speed advantages for society

- Offers a high capacity of transport (up to 400,000 passengers per day, Tokyo – Osaka)
  - Permits reducing traffic congestion
  - Helps economic development
  - Shapes land-use
- Respects the environment:
  - Efficient use of land (1/3 motorway)
  - Energy efficiency (x 9 planes / x 4 cars)
- Is safe
High speed advantages for society

- **Capacity**
- **Environment**
- **Safe**
Capacity
High speed increases capacity

- Introduces more capacity in the transport system:
  - New high speed line capacity
  - Released capacity in classic lines
  - Optimising the operations by separation of traffic
- But the capacity of new high speed lines is very variable
Density of population
Operation on high speed lines

High speed trains

“Classic trains”

High speed lines

Conventional lines
Operating with two different speeds

Train at 200 km/h = 80 minutes

One train at 200 km/h = 7 train paths at 300 km/h

TGV at 300 km/h = 53 minutes

Paris-Montparnasse

Tours-Montlouis

225 km
Balancing capacity

Number of trains

Speed

Different types of trains

L1 + L2 + L3 + L4 = Constant

UIC Leaflet 406
Environment
## Land occupancy

### Some ratios on land occupancy:

- **Average**: 3.2 ha/km
- **Average motorways**: 9.3 ha/km

### Parallel layout with a motorway:

- Paris – Lyons (1981 – 1983): 60 km (14 %)
- Paris – Lille (1993): 135 km (41 %)
- Cologne – Frankfurt (2002): 140 km (71 %)
- Milan – Bologna (2008): 130 km (72 %)
Parallel layouts

High speed line Paris – Lille (TGV Nord)
Parallel layouts

High speed line Cologne – Frankfurt
Energy efficiency comparison

Traffic units carried (number of passengers x km) for one unit of energy (kilo-equivalent of petrol, kep)

(1 mile = 1.6 km, 1 kWh = 0.086 kep)

Source: SNCF (Fr. RR), ADEME (France’s EPA), 1997
Comparison of carbon emissions

Magnitude of CO2 emissions per person (in a 600 km trip):

- 80 kg if travelling by plane (the weight of the passenger)
- 13 kg if travelling by high speed train (the weight of his/her suitcase)
External costs (average)

External costs = Part of the ticket paid by society

Magnitude of external costs in a medium-distance corridor, non-rush hour and without considering congestion (€ per 1000 passenger km)
Safety
Safety evolution in European railways

Passengers injured in accidents per Bn passenger km

Classic railways

High speed rail (250 km/h or more)
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High speed started in Japan in 1964
High speed started in Japan

High speed was introduced in Japan:
- To solve capacity problems
- Technologic advancements came later

The first world high speed line was inaugurated in 1964, between Tokyo and Osaka (515 km)
High speed started in Europe in 1981
High speed was introduced in Europe:

- To solve capacity problems
- By application of technological advancements during the 70’s

The first European high speed line was inaugurated in 1981, between Paris and Lyons (420 km)
World high speed network
High speed world network

World network (V ≥ 250 km):

12.505 km of lines in operation
11.755 km of lines under construction
17.579 km of lines planned

April 2010
Expected evolution of the world HS network
Expected evolution of the world HS network

km


Total

Asia

Europe

Others
High speed rolling stock
High speed train sets* in operation in the world:

Maximum speed 200 km/h or more: 2.228

Maximum speed 250 km/h or more: 1.667

* and trains operating on dedicated high speed lines

April 2010
Ratio rolling stock / infrastructure

Number of train sets per 100 miles of HS line
Possible evolution of world fleet

Total number of train sets

Europe

Europe

2010

2025
Maximum speeds
Evolution of maximum speed on rails

- **Maximum speed in tests**
- **Maximum speed in operation**

<table>
<thead>
<tr>
<th>Year</th>
<th>Maximum speed in operation (Km/h)</th>
<th>Maximum speed in tests (Km/h)</th>
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<tr>
<td>1955</td>
<td>100</td>
<td>300</td>
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<tr>
<td>1958</td>
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<td>300</td>
</tr>
<tr>
<td>2009</td>
<td>600</td>
<td>500</td>
</tr>
</tbody>
</table>

World rail speed record: 574,6 km/h – France, April 2007
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Stations for high speed

Stations represents a very strategic issue from the beginning of any high speed project

Most important issues:

• How many stations in a big city?
• Where?
• Functional design
• Size
• Accessibility
Stations for high speed

Different points of view:

- Infrastructure manager or owner
  (traffic, business, etc.)
- Railway undertaking
  (operations, cleaning, crew, catering, etc.)
- City
  (transport, multimodality)
- Customer
  (comfort, total time travel, cost)
City C (h million inhabitants)

v million passeng./year
City C (h million inhabitants)

\[ v = v_1 + v_2 + v_3 \]

\[ v \text{ million passeng./year} \]

City C (h million inhabitants)
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Funding/Calculating Costs

- High Speed requires significant investment, including public funding
- Consequently, need detailed studies on traffic forecasting, costs and benefits
- Examine all impacts, positive and negative (including calculating costs of doing nothing)
Magnitude costs of high speed in Europe

Average costs in Europe

Construction of 1 km of new HSL: 12 M €
Maintenance of 1 km of new HSL: 70,000 € / year (+ renewal)

Cost of an HS train (350 places): 20/25 M €
Maintenance of a HS train: 1 M € / year
(2 € / km - 500,000 km / train & year)
Key elements to reduce costs

- Knowledge of high speed systems & elements
- Definition of max. speed and performances
- Standardisation
- Optimum cost high speed rail system
- Financing
- Market procedures

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# High speed rail systems in the world

<table>
<thead>
<tr>
<th>In operation:</th>
<th>Planned:</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Argentina</td>
</tr>
<tr>
<td>Germany</td>
<td>Brazil</td>
</tr>
<tr>
<td>Italy</td>
<td>Canada</td>
</tr>
<tr>
<td>Spain</td>
<td>India</td>
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<tr>
<td>Belgium</td>
<td>Indonesia</td>
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<tr>
<td>The Netherlands</td>
<td>Iran</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Mexico</td>
</tr>
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<td>Japan</td>
<td>Morocco</td>
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<td>Poland</td>
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<td>Portugal</td>
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<tr>
<td>Turkey</td>
<td>Saudi Arabia</td>
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<tr>
<td>USA</td>
<td></td>
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</tbody>
</table>
High speed rail systems around the world

- V > 250 km/h in operation
- V ≤ 200 km/h in operation
- High speed in project

High speed rail systems around the world

- V > 250 km/h in operation
- V ≤ 200 km/h in operation
- High speed in project
Korea

In operation (29/03/2004)

Under construction
European HS Network

Situation as at 04.2010

Information given by the Railways

UIC - High-Speed
Updated 01.02.2010
OG/IB
European HS Network

Forecasting 2025

- $v \geq 250$ km/h
- $v \geq 250$ km/h Planned
- $180 \leq v < 250$ km/h
- Other lines

Information given by the Railways

UIC - High-Speed
Updated 01.02.2010
OG/IB

Technical interoperability

The European high speed rail network must be as homogeneous as possible

From the technical point of view, the first objective is **interoperability**

The availability of a common system for traffic control (**ERTMS**, **ETCS**) is essential

Importance of **HIGH SPEED RAIL STANDARDS**
Turquía
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The future of high speed rail

• High speed technology is fully competitive today but new developments are necessary if we want to keep this competitiveness for the next 20-30 years.

• Developments in new technologies immediately follow the implementation of the first high speed system in any country.
Globalisation
Capacity
Capacity

**Shinkansen loading gauge**

- 3,360 mm
- 1,435 mm
- (3,400 mm)

**European loading gauge**

- 2,904 mm (TGV-POS)
- 1,435 mm
- (3,150 mm)
New prototypes becoming series trains
New prototypes developed by the industry
New prototypes developed by the industry
Appearance of new private operators (Europe)
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- A **highly beneficial transport system for society**
- High speed **always needs public help**
- High speed is a **complex system**
- High speed conception is **not unique** and it must be adapted to each case
Complement, more than compete
Don’t forget that we’re working for customers
Thank you very much for your kind attention

Iñaki Barrón de Angoiti
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www.uic.org