Introduction of High-Speed Rail in Japan

Atsushi YOKOYAMA
Director of Japan Railways Group Paris Office
Paris, France
<table>
<thead>
<tr>
<th>Line</th>
<th>Section</th>
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<th>Max. Speed (mph)</th>
</tr>
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<tbody>
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<td></td>
<td><strong>1483.3</strong></td>
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*Length: mileage in revenue service

Converted from narrow gauge to standard gauge

Japanese Shinkansen Network
History of relationship between USA and Japan on Railways

- Japanese railway history started in 1872. From the beginning of this history, USA has played an important role for Japanese railway development.
  - The first terminal station in Tokyo (Shimbashi station) in 1872 was designed by an American, R.P. Bridgens.
  - Mainly in eastern and northern area of Japan, engineers from USA contributed to the construction of the Japanese railway system.

- USA and Japan still continue to have a good cooperation.
  - Japanese National Railways cooperated on the project of the improvement of the northeast corridor in USA – Improvement of substations, tunnels, bridges etc.
Geography of Japan

- **Land area**
  380 thousands km²
  1/26 of USA, equal to Montana

- **Population**
  127.8 millions
  2/5 of USA

- **Population density**
  343 people/km²
  11 times of USA
  2007 data
Japan National Railway was privatized and divided in 1987.

- 6 passenger railway companies
- 1 freight railway company
- Other companies
Passenger trains are operated on Conventional (1067mm narrow gauge) lines & Shinkansen (High speed, 1435mm standard gauge) lines.

- Passenger companies own infrastructure.

### JR Passenger Companies

<table>
<thead>
<tr>
<th>Company</th>
<th>Network (Mile)</th>
<th>Staff (persons)</th>
<th>Transport Volume (1000 passengers / day)</th>
<th>Transportation Revenue (M USD / day)</th>
<th>Company operating Shinkansen</th>
</tr>
</thead>
<tbody>
<tr>
<td>JR Hokkaido</td>
<td>1552.8</td>
<td>7,964</td>
<td>346</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>JR East</td>
<td>4675.2</td>
<td>52,763</td>
<td>16,412</td>
<td>39.5</td>
<td>✓</td>
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<tr>
<td>JR Central</td>
<td>1224.2</td>
<td>19,016</td>
<td>1,410</td>
<td>26.6</td>
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<tr>
<td>JR West</td>
<td>3120.5</td>
<td>28,362</td>
<td>4,942</td>
<td>17.8</td>
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<tr>
<td>JR Shikoku</td>
<td>531.1</td>
<td>2,414</td>
<td>133</td>
<td>0.6</td>
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<tr>
<td>JR Kyushu</td>
<td>1318.0</td>
<td>6,741</td>
<td>806</td>
<td>2.8</td>
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<tr>
<td>Total</td>
<td>12421.1</td>
<td>117,260</td>
<td>24,049</td>
<td>89.0</td>
<td></td>
</tr>
</tbody>
</table>

74% of total railway network length in Japan

2006 fiscal year
1USD = 118YEN (3.2007)
What is Shinkansen?

- Tokaido Shinkansen opened in 1964. *Between Tokyo and Shin-Osaka to increase the capacity of the most congested Tokaido line*

- Shinkansen (means ‘New trunk line’ in Japanese) is a system of high speed with concepts:
  - Dedicated high speed track with 1435mm standard track gauge
  - *national network is 1067mm N.G.*
    - (closed system independent from the conventional line, no level crossing)
  - Distributed powered rolling stock (EMU)
  - ATC signal system
  - Centralized traffic control system
  - etc
  - Most of these assure high speed operation with high safety

- The maximum line speed was 210km/h(131mph). Currently it is 240km/h(150mph) - 300km/h(187mph).
- Two Shinkansen lines were converted from conventional lines by changing gauges.
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Shinkansen Network (1987)

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International Practicum on Implementing High-Speed Rail in the United States

Shinkansen Network (2010)
Shinkansen in the near future

- Extension
- Speed-up
- Introduction of new rolling stock

Kyushu Shinkansen
Open in 2011

Hokuriku Shinkansen

Hokkaido
Shinkansen

Tohoku Shinkansen
Open in 2010

Direct service between Sanyo and Kyushu shinkansen
Shin-Osaka – Kagoshima-Chuo
Approx 5h -> 4h

N700 “Sakura”

Series E5

Introduced in 2011 at 187mph,
at **199mph in 2013**.
Tokyo-Aomori:
3h59 -> approx. 3h05 (2013)
Shinkansen share vs Airplane

Rail share vs Air

Area – Area 2008 fiscal year

* Necessary to change trains at Hachinohe

Made from the data on JR East, JR Central, and JR West homepage.
Impact of introducing new HSR line

**Tohoku Shinkansen extension**
(Morioka-Hachinohe)
---
Tokyo Metropolitan - Aomori
Approx. 370 - 440 miles

**Kyushu Shinkansen**
(Shin-Yatsushiro – Kagoshima-Chuo)
---
Fukuoka - Kagoshima
Approx. 185 miles

Made from the MILT report of national passenger flow data in 2005
Traffic volume of Shinkansen

In 2006 fiscal year, the number of passengers on Shinkansen was 932,000/day on average.

*The number of Shinkansen trains is about 900 per day.
Revenue of Shinkansen

**JR East**
- Network length: 4022.7 miles
- Transportation Revenue (b Yen): 1241.6
- Conventional line: 654.2
- Shinkansen line: 490.9

**JR Central**
- Network length: 881.2 miles
- Transportation Revenue (b Yen): 1085.6
- Conventional line: 343.4
- Shinkansen line: 106.5

**JR West**
- Network length: 2721.4 miles
- Transportation Revenue (b Yen): 438.2
- Conventional line: 400.2
- Shinkansen line: 343.5

2007 Fiscal Year
Shinkansen has strong points as

- Safe
- Faster
- Punctual, Reliable

No fatal accidents in 45 years
300km/h (Sanyo Shinkansen)
Average delay time per train:
0.6min (Tokaido, 2008, 323 trains/day)

Frequent
15 trains/hour at maximum

Environmental friendly
Less energy consumption, Low noise,…

“Average delay time”: total “delay time” of all trains/ total train number, and the “delay time” is counted if it is more than 1 minute.

Data between 1999-2006
Remarks

- Customer oriented management has led the positive cycle surrounding Shinkansen business.
  - Effort in good service and good management
  - Good customer evaluation
  - Profit
    - Investment for further improvement
    - Better service and better management...

- Good service includes Safety, Reliability and Punctuality.

- Strong points have been continually improved in 45 year history.

- Technical solutions often depend on circumstances of lines.
## Infrastructure

<table>
<thead>
<tr>
<th>Line name</th>
<th>Tokaido</th>
<th>Sanyo</th>
<th>Tohoku</th>
<th>Hokuriku</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section of line</td>
<td>Tokyo - Shin-Osaka</td>
<td>Okayama - Hakata</td>
<td>Omiya - Morioka</td>
<td>Takasaki - Nagano</td>
</tr>
<tr>
<td>Year opened</td>
<td>1964</td>
<td>1975</td>
<td>1982</td>
<td>1997</td>
</tr>
<tr>
<td>Maximum speed (mph) initial/present</td>
<td>130/168</td>
<td>130/186</td>
<td>130/171</td>
<td>162/162</td>
</tr>
<tr>
<td>Track gauge (mm)</td>
<td>1435</td>
<td>1435</td>
<td>1435</td>
<td>1435</td>
</tr>
<tr>
<td>Permissible axle weight (t)</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>Dominant Track type</td>
<td>Ballast</td>
<td>Slab</td>
<td>Slab</td>
<td>Slab</td>
</tr>
<tr>
<td>Distance between centers of main tracks (m)</td>
<td>4.2</td>
<td>4.3</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Minimum curve radius (m)</td>
<td>2500</td>
<td>4000</td>
<td>4000</td>
<td>4000</td>
</tr>
<tr>
<td>Maximum designed cant (mm)</td>
<td>200</td>
<td>200</td>
<td>180</td>
<td>200</td>
</tr>
<tr>
<td>Cross section area of tunnel (m²)</td>
<td>60.5</td>
<td>63.4</td>
<td>63.4</td>
<td>63.4</td>
</tr>
<tr>
<td>Maximum gradient (if needed)</td>
<td>1.5% (2%)</td>
<td>1.5% (2%)</td>
<td>1.2% (1.5%)</td>
<td>1.5% (3.5%)</td>
</tr>
<tr>
<td>Electrical power supply</td>
<td>AC25KV 60Hz</td>
<td>AC25KV 60Hz</td>
<td>AC25KV 50Hz</td>
<td>AC25KV 50/60Hz</td>
</tr>
<tr>
<td>Signal type</td>
<td>Digital ATC</td>
<td>ATC</td>
<td>Digital ATC</td>
<td>ATC</td>
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</table>
Operation control system

Systematization of train and crew planning, train operation control and maintenance and management of rolling stock, track, electricity, signal and communication

Example: New Comprehensive Shinkansen System (COSMOS) for EJR
Environmental Friendliness

Energy consumption

- Train: 100
- Bus: 178
- Airplane: 403
- Automobile: 595

Assumed Train = 100

CO2 emission

- Shinkansen: 100
- Bus: 317
- Airplane: 500
- Automobile: 750

Assumed Shinkansen = 100

Data source: http://www.mlit.go.jp/tetudo/shinkansen/shinkansen3_2.html

- Low energy consumption mode itself + further development for low energy consumption
- Regenerative brake, Light weight rolling stock, Aerodynamic structure,…
Shinkansen and the world

- Some Shinkansen technologies have been transferred to
  China-Taiwan: Rolling stock (700 -> 700T), Signaling system (ATC), …
  China: Rolling stock (E2-1000 -> CRH2), …

- These technologies were modified to meet the local situation (local standards, systems,…) by the local railway operators.

- HSR system should be fitted to social and natural local situation even in case of transfer.

- There is no unique HSR standard in the world. Original technical standard for HSR system will be necessary in accordance with the local situation.
Thank you very much for your attention.