An Overview of Japan’s High-Speed Railway: Shinkansen

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1. Japan’s Current High Speed Rail Network

2. The Main Features and the Advantages of the Shinkansen

3. Toward the Introduction of High Speed Rails in India
   - India: country with high potential for high speed rail
   - construction scheme of the Shinkansen
   - the benefits brought by the Shinkansen
Japan’s railway network is approximately 20,000 km long. The network stretches through all parts of Japan.

<table>
<thead>
<tr>
<th></th>
<th>Japan</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>378,000 km²</td>
<td>3,165,596 km²</td>
</tr>
<tr>
<td>Population</td>
<td>128 million</td>
<td>1,210 million</td>
</tr>
</tbody>
</table>

Sources: Census of India  (March 1, 2011)
Census of Japan  (June 1, 2011)
World Railways Today (Japan Railway Technical Services)

※ The figure represents the total kilometers of the railways of the six Japan Railway Companies (JR).
The total length of Japan’s railways is one eleventh the length of US railways.

International comparison of total railway lengths (FY2003)

- U.S.A: 225,500 km
- Russia: 86,660 km
- China: 71,898 km
- Canada: 68,254 km
- India: 63,122 km
- Japan(※): 20,071 km

Source: World Railways Today (Japan Railway Technical Service)

※ The figure represents the total number of kilometers of railways under the six Japan Railway Companies (JRs).
The annual number of Japan’s railway passengers is ranked among the world’s largest.

<table>
<thead>
<tr>
<th>Country</th>
<th>Passengers (billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan*</td>
<td>8.84 billion</td>
</tr>
<tr>
<td>India</td>
<td>6.92 billion</td>
</tr>
<tr>
<td>Germany</td>
<td>1.9 billion</td>
</tr>
<tr>
<td>China</td>
<td>1.52 billion</td>
</tr>
</tbody>
</table>

*The figure represents the annual number of railway passengers carried by the six Japan Railway Companies (JR). 

Source: The UIC Statistics Database
Japan is the third in the world next to India and China in the number of railway passenger-kilometers.

- India: 838 billion
- China: 788 billion
- Japan*: 244 billion
- Russia: 154 billion

Source: The UIC Statistics Database

*The figure represents the annual number of railway passengers carried by the six Japan Railway Companies (JR).
Current High Speed Rail (Shinkansen) Network

Ministry of Land, Infrastructure, Transport and Tourism

Total Length: 2,388 km

- **JR East**
- **JR Central**
- **JR West**
- **JR Kyushu**

- Under Construction
- Planned line

**Current High Speed Rail (Shinkansen) Network**

- **Tohoku Shinkansen (675km)**
  - Completed: 1982
  - 2015

- **Tokaido Shinkansen (515km)**
  - Completed: 1985
  - 1991

- **Sanyo Shinkansen (554km)**
  - Completed: 1975
  - 1972
  - 1982

- **Kyushu Shinkansen (257km)**
  - Completed: 2004

- **Hokuriku Shinkansen (117km)**
  - Completed: 1972
  - 1992
  - 1997

- **Yamagata Line**
  - Completed: 1964
  - 1975
  - 1999
  - 2002

- **Akita Line**
  - Completed: 1982
  - 2004

- **Joetsu Shinkansen (270km)**
  - Completed: 1992
  - 1997
  - 2002

- **Shinkansen**
  - Completed: 1982
  - 12 Mar 2011
  - 4 Dec 2010

- **Sendai**
  - Completed: 1991
  - 1999
  - 2002

- **Niigata**
  - Completed: 1992
  - 1997

- **Nagano**
  - Completed: 1982

- **Morioka**
  - Completed: 1997

- **Hachinohe**
  - Completed: 2002

- **Shin-Aomori**
  - Planned line

- **Shin-Hakodate**
  - As of 2011

- **Sapporo**

- **Tokyo**
  - Completed: 1985

- **Ueno**
  - Completed: 1991

- **Omiya**
  - Completed: 1985

- **Nagoya**
  - Completed: 1964

- **Nagasaki**
  - Completed: 2004

- **Okayama**
  - Completed: 1992

- **Kagoshima-Chuo**
  - Completed: 2004

- **Shin-Yatsushiro**
  - Completed: 2004

- **Shin-Osaka**
  - Completed: 1972

- **Shin-Hiroshima**
  - Completed: 1992

- **Shin-Yokohama**
  - Completed: 1992
The number of Shinkansen passengers has been steadily increasing since the start of operations in 1964.

Growth in the annual number of Shinkansen passengers

(million passengers)

Source: Railroad 2009 through Figures, Shinkansen (Sankaido)
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Utmost Safety

- Single-braking control → more comfortable ride
- Brake pattern stored in the on-board device
- Digital – ATC
  Automatic train control device
- Trackside protection facilities
- COMTRAC/COSMOS
  Traffic control system
- High speed inspection train
  Electric/track inspection system

Fatalities to date: **ZERO** for 47 years
since the start of operation in 1964
Reliability: Highly-frequent Services

Up to 14 services per hour thanks to train control technology

Departure information at a Shinkansen station

Average delay time:
less than 1 min for 47 years
Environmentally Friendly Mode: Railway

Excellent environmental performance

\( \text{CO}_2 \) emission comparison

- 7.5: Automobile
- 5: Airplane
- 1: Shinkansen
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Shinkansen Series E5</th>
<th>Shinkansen Series N700</th>
<th>A train</th>
<th>B train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainset (cars) - Seats (No.)</td>
<td>10 - 731</td>
<td>16 - 1323</td>
<td>20 – 750</td>
<td>16 - 858</td>
</tr>
<tr>
<td>Train Weight (ton) *</td>
<td>454</td>
<td>635</td>
<td>766</td>
<td>818</td>
</tr>
<tr>
<td>Train Weight/Seat (ton/seat)</td>
<td>0.62</td>
<td>0.48</td>
<td>1.02</td>
<td>0.95</td>
</tr>
</tbody>
</table>

*Unloaded train data

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### Lower CO2 emissions & Energy consumption

- **Train weight per seat**

  - E5: 0.62
  - N700: 0.48
  - A train: 1.02
  - B train: 0.95

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The car body of the Shinkansen is wider than that of any other high speed rail train.

<table>
<thead>
<tr>
<th>Type</th>
<th>Width (mm)</th>
<th>Seat Pitch (mm)</th>
<th>Seats/Car (No./car)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series E5</td>
<td>3350</td>
<td>1040</td>
<td>73.1</td>
</tr>
<tr>
<td>Series N700</td>
<td>3360</td>
<td>1040</td>
<td>82.7</td>
</tr>
<tr>
<td>Train A (TGV-R)</td>
<td>2904</td>
<td>900</td>
<td>37.5</td>
</tr>
<tr>
<td>Train B (ICE3)</td>
<td>2950</td>
<td>920</td>
<td>53.6</td>
</tr>
</tbody>
</table>
The excellent air tightness of the car body of the Shinkansen allows for tunnel cross sections to be constructed small.

**Tunnel Cross Section**

- **Shinkansen**: 64 m²
- **TGV・ICE**: 90 m²

**Size of lanes**
- Small
- Large

**Distance in-between**
- 4.3m
- 4.5m
- 6.25m
- 4.75m
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High Speed Railway Corridors in India

“Indian Railways Vision 2020”

( ): Population (million people)

- Amritsar (1.1)
- Chandigarh (1)
- Delhi (11)
- Patna (1.7)
- Ahmedabad (5.6)
- Howrah/Kolkata (5.6)
- Mumbai (12)
- Haldia (0.2)
- Pune (3.1)
- Hyderabad (6.8)
- Vijayawada (1)
- Bangalore (8.4)
- Chennai (4.7)
- Ernakulam (0.6)

(Source of population of Indian cities: Census 2011)
The Similarity in Population Distribution

Ministry of Land, Infrastructure, Transport and Tourism

(Source of population of Indian cities: Census 2011)

Population Unit: million people

Mumbai

Surat

Vadodara

Nadiad

Ahmedabad

Chennai

Bangalore

Tokyo (23 wards)

Shin-Yokohama

Shin-Osaka

Nagoya

Nagoya

Kyoto

Shin-Osaka

Hamamatsu

Toyohashi

Shizuoka

Okayama

Shin-Osaka

Tokyo

100km

1,000km
### The Competitiveness among the Other Transport Modes

#### Passenger shares for the modes of passenger transport between Tokyo and Fukuoka

<table>
<thead>
<tr>
<th>Route</th>
<th>Railway</th>
<th>Bus</th>
<th>Airplane</th>
<th>Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo–Nagoya</td>
<td>71%</td>
<td>5%</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Tokyo–Osaka</td>
<td>77%</td>
<td>19%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Tokyo–Okayama</td>
<td>64%</td>
<td>34%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Tokyo–Hiroshima</td>
<td>55%</td>
<td>42%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Tokyo–Fukuoka</td>
<td>9%</td>
<td>90%</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Inter-Regional Passenger Mobility Survey FY 2007

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**Population of cities (2008)**

- Tokyo: 8.3 million
- Nagoya: 2.2 million
- Osaka: 2.6 million
- Okayama: 0.69 million
- Hiroshima: 1.2 million
- Fukuoka: 1.4 million

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**Distances**

- Tokyo to Nagoya: 366 km
- Osaka to Okayama: 733 km
- Hiroshima to Fukuoka: 894 km
- Fukuoka to Hiroshima: 1,175 km
(1) Tokaido and Sanyo Shinkansen

The construction costs were fully covered by **loans**.

- This line covered the most densely-populated areas in Japan.
- The profit was enough to return the loans within 7-8 years of the start of operations.
(2) Tohoku and Joetsu Shinkansen

A large part of the cost* was still covered by loans.

* The government funded 13% of the construction.

The profit was not large to return the loans.

The construction cost placed a heavy burden on the Japanese National Railways (JNR).

It led to the privatization of the JNR in 1987.
After 1997,
- central and local governments pay for the construction cost.
- operators (JRs) no longer shoulder the burden of the construction cost.
- this scheme ensures the sustainable operation of the JRs.

*JRTT: The Japan Railway Construction, Transport and Technology Agency*
Kyushu Shinkansen: Hakata - Kagoshima-Chuo (250 km)

Phase 2: Hakata - Shin-Yatsushiro opened in March 2011

Phase 1: Shin-Yatsushiro - Kagoshima-Chuo opened in March 2004

**Significant time saving**

<table>
<thead>
<tr>
<th>Before Opening</th>
<th>3’ 40”</th>
</tr>
</thead>
<tbody>
<tr>
<td>After phase 1 opening (Shin-Yatsushiro - Kagoshima-Chuo)</td>
<td>2’ 12”</td>
</tr>
<tr>
<td>After opening of entire line (phases 1 &amp; 2) (Hakata - Kagoshima-Chuo)</td>
<td>About 1’ 20”</td>
</tr>
</tbody>
</table>
■ Huge impact on local economies
as a result of the increase in visitor numbers

the entire line opened in March 2011

Ripple Effect on Economy of Kagoshima Prefecture

Visitors to Kagoshima Prefecture

Increased by 24.5%
(year-on-year basis)

460 million dollars
(since the opening of the entire line)

Source: Kagoshima Regional Economic Research Institute
Before

Area around Shin-Yokohama station

30km from Tokyo Station
5km from the center of Yokohama City

Shinkansen

Conventional line

1962
After

Area around Shin-Yokohama station

Now… front entrance of Yokohama City
Area around Sakudaira station

Planned Station

conventional line

Hokuriku Shinkansen

165km from Tokyo Station
1.5km from the center of Saku City
After

Area around Sakudaira station
(10 years after opening) = Year 2007
Hakata Station (Kyushu Shinkansen)
Contribution to job creation and regional economic development

infrastructure construction
Wide-ranging Benefits of Shinkansen

Contribution to job creation and regional economic development

rail track maintenance
Contribution to job creation and regional economic development

rolling-stock manufacturing
**Conclusion**

Japan can cooperate with India on the development of high speed rails in India.

**Policy approaches**
- nationwide railway network development
- administration that values railway safety

**Long experience in developing the Shinkansen**
- financial scheme
- regional development

**Technologies**
- safety and reliability
- environmental sustainability
- small infrastructure

**Experience and expertise**
- rail business
- commercial development in and around the station
- a wide range of other businesses
Thank you