JR-East Shinkansen Technology

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East Japan Railway Company

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- Outline of JR-East Shinkansen network
- Features of Shinkansen rolling stock
- Control center for monitoring of Shinkansen operations
- Turn-back at Tokyo station
- Through service
- Countermeasures against natural disasters
- Environmental technology
- Riding comfort technology
- 3.11 Earthquake, restoration and recovery
- Future Plans
**Network of JR East**

<table>
<thead>
<tr>
<th>Category</th>
<th>Network</th>
<th>Gauge</th>
<th>Power supply</th>
<th>Max Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>High speed network</td>
<td>Dedicated guideway</td>
<td>1140km</td>
<td>Standard (1435mm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Through service into conventional line</td>
<td>277km</td>
<td>AC 20kv 50Hz</td>
</tr>
<tr>
<td>Category 2</td>
<td>Tokyo urban network</td>
<td>2550km</td>
<td>Narrow (1064mm)</td>
<td>DC 1.5kv 100km/h on Non-electrified</td>
</tr>
<tr>
<td>Category 3</td>
<td>Local network</td>
<td>3586km</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*After 2013 spring*
Features of JR-East Shinkansen network

1. Runs in 5 directions from Tokyo
2. Uses 3 types of rolling stock
3. Through-operation on converted conventional lines by hybrid type
4. Quick turn-back at terminal stations (12 minutes at Tokyo Station)
5. Maximum speed 320km/h
Features of rolling stock

Three types of JR East Shinkansen trains

**High speed**

*For longer trips*

- Series E2 275km/h
- Series E5 320km/h

**Hybrid type**

*For through service with coupling/uncoupling functions*

- Series E3 275km/h
- Series E6 300km/h

**Large capacity**

*For commuting*

- Series E4 240km/h
## Features of rolling stock

### Comparison of JR-East Shinkansen typical rolling stock

<table>
<thead>
<tr>
<th>Type</th>
<th>High speed</th>
<th>Hybrid type</th>
<th>Large capacity</th>
<th>High speed</th>
<th>Hybrid type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Series</strong></td>
<td>E2-1000</td>
<td>E3</td>
<td>E4</td>
<td>E5</td>
<td>E6</td>
</tr>
<tr>
<td><strong>Train Configuration (train length)</strong></td>
<td>8M2T (251m)</td>
<td>4M2T (128m)</td>
<td>4M4T (201m)</td>
<td>8M2T (253m)</td>
<td>5M2T (148.65m)</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>814</td>
<td>338</td>
<td>817</td>
<td>731</td>
<td>338</td>
</tr>
<tr>
<td><strong>Capacity /m</strong></td>
<td>3.24</td>
<td>2.56</td>
<td>4.06</td>
<td>2.89</td>
<td>2.27</td>
</tr>
<tr>
<td><strong>Approx. Max. axle load (loaded)</strong></td>
<td>13.2t</td>
<td>12.2t</td>
<td>16t</td>
<td>11.3t</td>
<td>10.8t</td>
</tr>
<tr>
<td><strong>Max. operating speed</strong></td>
<td>275km/h</td>
<td>275km/h 130km/h (on conventional)</td>
<td>240km/h</td>
<td>320km/h</td>
<td>300km/h</td>
</tr>
<tr>
<td><strong>Intermediate Car length</strong></td>
<td>25m</td>
<td>20.5m</td>
<td>25m</td>
<td>25m</td>
<td>20.5m</td>
</tr>
<tr>
<td><strong>Body width</strong></td>
<td>3380mm</td>
<td>2945mm</td>
<td>3380mm</td>
<td>3350mm</td>
<td>2945mm</td>
</tr>
<tr>
<td><strong>Motor power (continuous)</strong></td>
<td>300kW</td>
<td>300kW</td>
<td>420kW</td>
<td>300kW</td>
<td>300kW</td>
</tr>
<tr>
<td><strong>Coupling with (in normal operation)</strong></td>
<td>E3</td>
<td>E2</td>
<td>E4,E3</td>
<td>E6,E3</td>
<td>E5</td>
</tr>
<tr>
<td><strong>Electrical system</strong></td>
<td>AC25kV50Hz</td>
<td>AC25kV50Hz</td>
<td>AC25kV50Hz</td>
<td>AC25kV50Hz</td>
<td>AC25kV50Hz</td>
</tr>
<tr>
<td></td>
<td>AC20kV50Hz</td>
<td></td>
<td></td>
<td></td>
<td>AC20kV50Hz</td>
</tr>
<tr>
<td><strong>Signalling system</strong></td>
<td>DS-ATC</td>
<td>DS-ATC, ATS-P</td>
<td>DS-ATC</td>
<td>DS-ATC</td>
<td>DS-ATC, ATS-P</td>
</tr>
<tr>
<td><strong>Year in operation</strong></td>
<td>2002</td>
<td>1997</td>
<td>1997</td>
<td>2011</td>
<td>2013</td>
</tr>
</tbody>
</table>
State-of-the-art Series E5 & E6

**High Speed**
- Maximum commercial speed of Series E5 reached 320 km/h last.

**Through Service**
- Series E6 debuted last month
- Maximum commercial speed of Series E6 is planned to reach 320 km/h by 2014.
- Series E5 & E6 can be coupled and uncoupled automatically.

Series E5

Series E6
Control Center Management

One Floor Management

Chief

Transportation Section

Passenger Section

Rolling Stock Section

Driver/Conductor Section

Track Section

Power Supply Section

Signal/Telecommunication Section

System Section
Integrated intelligent transport management system

COSMOS (Computerized Safety, Maintenance and Operation Systems of Shinkansen)

COSMOS is designed to consist of seven subsystems in a dispersed pattern: even if one of the subsystems fails it will not affect the remainder.
Turn back at Tokyo station

- Alighting passengers and cleaning crew on stand-by
- Car cleaning
- Automatic seat rotation

- Train Arrival
  - Passenger alighting
  - Train car cleaning, magazine replacement and seat rotation
  - 44 crews work for cleaning of 16-car train
- Train Departure
  - Passenger boarding

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Through service

Local city

Intermediate station

Uncoupling

Coupling

E3 series

E2 series

No transfer

E2 series

E3 series

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The conventional lines were improved in the following three ways:
- constructed standard gauge instead of the narrow gauge.
- constructed additional rail to the narrow gauge as above.
- constructed standard gauge next to narrow gauge.
Countermeasures against natural disasters

Against earthquake

**Reinforced pillars**

Great Hanshin-Awaji Earthquake (1995)

Viaducts:
- A seismic reinforcement to prevent shear failures
- No critical destruction to major structures by March 11, 2011 earthquake; only bending failures

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Countermeasures against natural disasters

Against earthquake

“Early Earthquake Detection System”

The coastline seismometer detects a primary wave

Signal is transmitted to the power supply substation

**Power is automatically shut down**

Train detects the power shutdown and emergency brakes automatically applied

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Countermeasures against natural disasters

Protection from snow damage of infrastructure and train

Sprinkler
Environmental technology

Noise-abatement technology

The main noise sources Shinkansen:
- Noise from current collection system
- Aerodynamic noise from the car body upper part
- Noise from the car body lower part
- Aerodynamic noise from the car body lead part

Long-nose Leading Car

Full Bogle Cover & Sound-absorbing Panels
Smooth Covers Between Cars
Pantograph Noise Insulation Panels
Low-noise pantographs
=Countermeasures on the Ground=

- Construction or extension of tunnel entrance hood
- Improvement of tunnel entrance hood
- Block sound waves

To reduce noise

To reduce micro-pressure wave

Environmental technology

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Reduced energy consumption, higher speeds

Reasons:
1. Light weight
2. Improvement of power control
3. Improvement of braking system
With the latest technologies, including car-body tilting equipment to negotiate curves and a full active suspension to suppress lateral movements of the car body, ride quality is further enhanced in our high-speed operations.
Riding comfort technology

Track maintenance with riding comfort filter

Improved riding comfort filter

Evaluate high frequency vibration
High speed operation technology

Power supply system: Catenary

Wave propagation speed must be fast enough = lighter weight and higher tension

Design parameters

Speed, Capacity, Strength against vibration
Avoiding breakage, Low maintenance work,..

Heavy compound catenary system

Lighter weight and high tension
-introduced to newly extended lines

CS catenary system

Material, diameter, tension, structure…

Heavier weight but high tension
Aimed at reducing vibration by pantograph
Riding comfort technology

Introduction of the highest grade seats car with excellent service

GranClass

on the Series E5
Outline of the Tohoku Region Pacific Coast Earthquake

- **Date and time of occurrence:**
  At approximately 14:46 on Friday, March 11, 2011

- **Strength of the earthquake:**
  Magnitude 9.0 on the Richter scale
  (The largest in the recorded history of Japan)

- **Number of deaths and missing:**
  18,591 (As of December 26, 2012)
  (Resulting from earthquake-induced shock and vibration, tsunami and fire)
Damage to JR East

- **Shinkansen**
  - Toppled electrification masts
  - Distorted pillar
  - Fallen ceilings on the platform

- **Conventional line**
  - Large-scale landslide
  - Collapsed embankment
  - Tracks washed away by tsunami

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(1) Reinforcement of infrastructures

(2) Detect the earthquake and stop the trains as quickly as possible

(3) Prevent trains from a large scale deviation in case of a derailment
Enforcement of viaduct

Designed by former regulation
Antiquake Designn
After the emergency brakes on the train running at 270 km/h were applied, in the next 100 seconds this train ran approximately 4,200 meters and stopped.
A Shinkansen derailed, but did not deviate on a large scale, because the parts of car bogie caught the rail head to halt.
Consequences of the Earthquake & Tsunami

- **Shinkansen (HSR):** 27 trains in service (Tohoku Shinkansen: between Tokyo and Shin-aomori) at moment of earthquake
  - Aseismic reinforcement
  - Early earthquake detection system
  \[\Rightarrow\text{No derailment of commercial trains}\]

- **Conventional lines:** 670 trains in service at moment of earthquake
  Station staff and train crews successfully led our customers to emergency evacuation areas before the tsunami hit.

- Customer fatalities : 0
- Customer injuries : 0

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Damaged concrete masts

Repaired concrete masts

**Clarified weakness and fact**

<table>
<thead>
<tr>
<th>Type of mast</th>
<th>Broken</th>
<th>Leaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron masts</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Concrete masts</td>
<td>120</td>
<td>416</td>
</tr>
</tbody>
</table>

Concrete masts with mortar foundation cannot stand as long as those with sand filled foundation when a bigger earthquake hits.

Developing a new type mast which may bend, but not break in earthquake.
Restoring Shinkansen Operation after 3.11

◆ Tohoku Shinkansen

![Map of Tohoku Shinkansen with key dates and locations]

- **M9.0** on **Mar 11**
- **M7.2** on **Apr 7**
- **Mar 15**
- **Mar 22**
- **Apr 12, 13**
- **Apr 23**
- **Apr 25**
- **Apr 29**

Restored whole operation at the 50th day after 3.11

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Future Plans

New Shinkansen Segments opening soon

3 years from now (to Shin-Hakodate)
Tohoku Shinkansen Extension

2 years from now (to Kanazawa)
Hokuriku Shinkansen Extension

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Future Plans

High-speed

Technological development to exceed 320 km/h

In the future we will speed up to 360 km/h.
Thank you for your attention