Crash Avoidance Principles and Shinkansen's Success

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Key features of Tokaido Shinkansen

IHRA
INTERNATIONAL HIGH-SPEED RAIL ASSOCIATION

➢ Safety and Reliability

- No passenger fatalities or injuries due to train accidents for 49 years
- Annual average delay: 0.5 minutes per train

➢ Mass Transportation

- High frequency: 323 trips per day (Max. 410 trips per day)
- Large capacity: 1,323 passengers per sixteen-car trainset
- Ridership: 409,000 passengers per day, 149 million passengers per year

➢ Environmental Adaptability

- Low energy consumption, low CO_2 emissions
- Low wayside noise, small ground vibrations along high-speed lines

Crash Avoidance Principles

The key to Japanese Shinkansen's record of safety and reliability lies in the philosophy of the complete elimination of the possibility of collision, what we call "**Crash Avoidance Principles**."

These core principles are :

(1) Dedicated high speed passenger rail service, and

(2) Proven Automatic Train Control (ATC) System

Dedicated High-Speed Passenger Rail Service

- Shinkansen is operated on dedicated high-speed tracks. No freight or other passenger trains on high-speed tracks eliminate the risk of collisions.
- Full grade separation, or no level crossings, eliminates the risk of collisions with any road vehicles.
- Separating right-of-way maintenance from daily operations temporally, there is no possibility of a collision with maintenance equipment.
- It is prohibited by law to trespass on the ROW or throw anything into the ROW.
- Appropriate intrusion prevention and detection measures along the corridor can prevent a collision with large objects entering or falling onto the tracks.

Proven Automatic Train Control System

- ATC system prevents train-to-train collisions and overspeed derailments.
  - ✓ It is a proven fact that there has been no train-to-train collisions and no overspeed derailments with ATC for nearly fifty years in Japan.
- All operations and movements of a trainset, including those in stations and maintenance facilities, are under full ATC control for the whole speed range from zero to maximum speed.
- High reliability of the ATC system is essential to realize highly-frequent operations.

Advantages of Crash Avoidance Principles

Crash Avoidance Principles naturally bring high frequency, large capacity and energy efficiency into high-speed rail system at the same time.

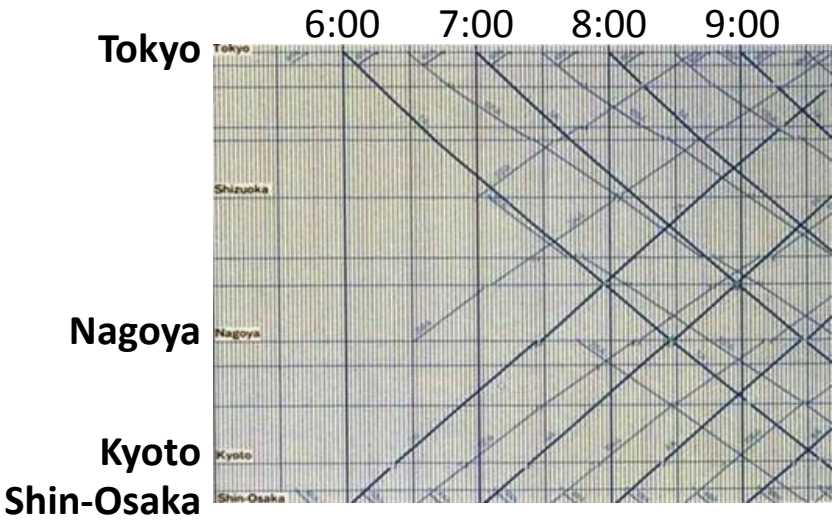
- Highly frequent and efficient operation can be realized, utilizing high-speed trainsets with equivalent traction and braking performance, since there are no slower freight or commuter trains on high-speed tracks.

- Because the Shinkansen system departs from conventional rail regulations and/or standards which aim at interoperability, high-speed rolling stock can have wider carbodies with larger seating capacity.
  - ✓ Three by two seating for Shinkansen trains versus two by two seating for other high-speed trains

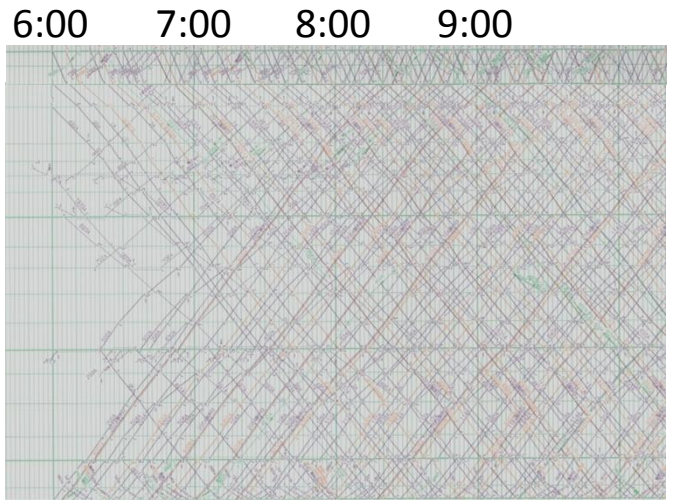
- Weight of rolling stock can be reduced significantly, because there is no need to incorporate crashworthiness features into the rolling stock system.
  - ✓ Axle load: 11-12 tonnes for Shinkansen trains versus 17 tonnes for other high-speed trains

Highly-Frequent and Efficient Operation

Train Diagram (1964)



Train Diagram(2013)

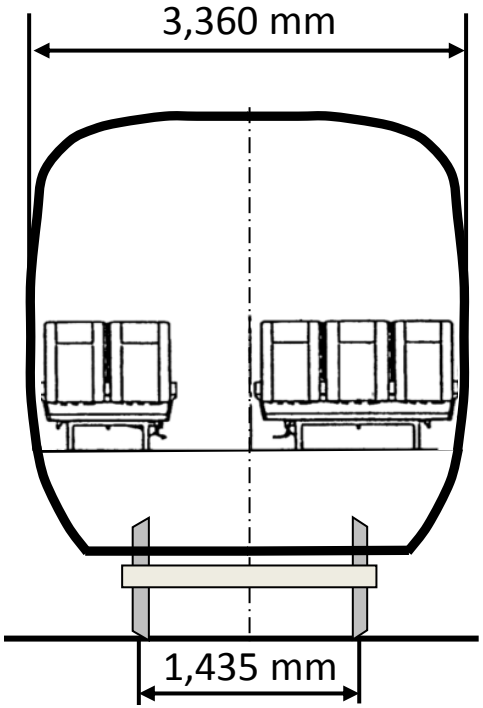


	1964	2013
Maximum trips per hour	2	15
Trips per day	60	323*
Travel time	4hr 10min	2hr 25min

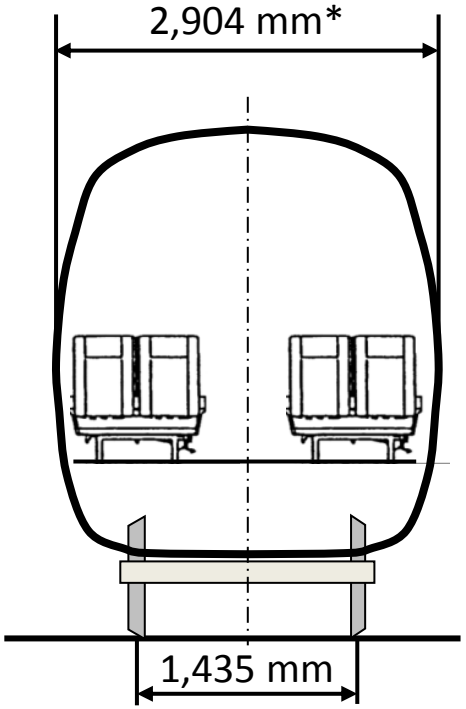
* Not including extra services

Large Seating Capacity

Series N700 has a wider carbody, enabling three by two seating, while the carbody width of European high-speed trains are limited by the clearance diagram of conventional rails.



Series N700 Shinkansen
(Large capacity)



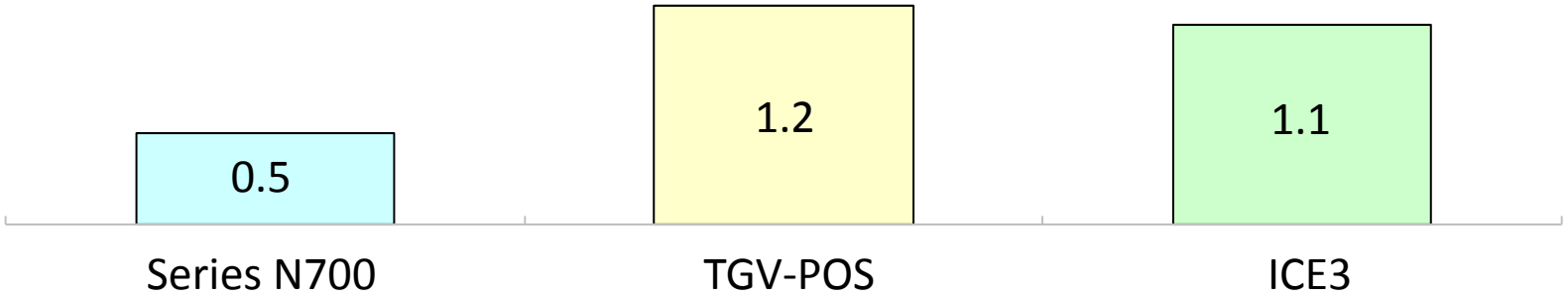
European high-speed trains
(Small capacity)

*TGV POS , “20131101_database_Rollingstock HS trains,” UIC

Energy Efficiency

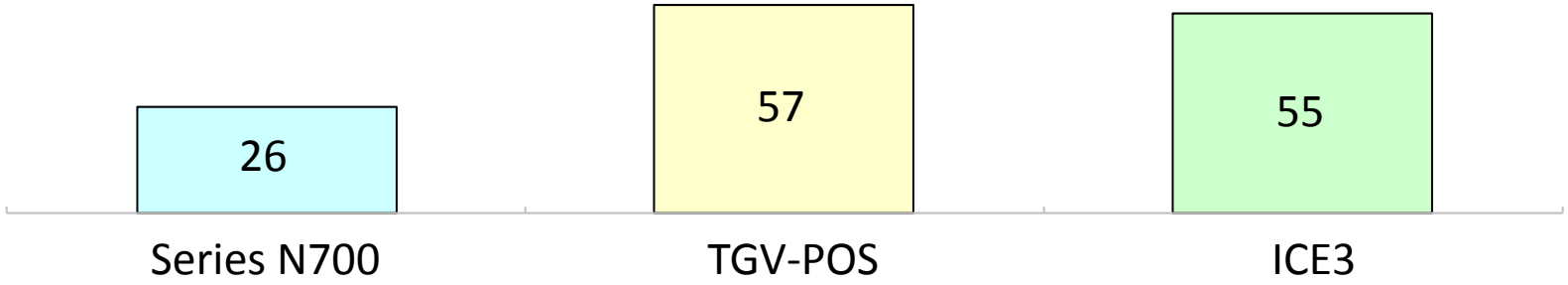
Larger seating capacity and light-weight rolling stock have synergistic effects of reducing the energy consumption per seat. Shinkansen's weight per seat is half that of comparable European high-speed trains. As a result, the energy consumption per seat is also half that of European's.

Weight per Seat (tonnes per seat)



Source : " World High Speed Rolling Stock," UIC High Speed website
: " Les rames TGV POS de la SNCF," Chemins de Fer №504,2007/3, P5-16
: " High-Speed Railways of the World (Rolling stock) ," JREA 2005 VOL.48 №4,P46-53

Energy Consumption per Seat (Wh/km/seat)



JRC carried out simulation based on public data assuming 50km level tracks between stations the simulation used data from.
TGV: "TGV POS PREPARES to enter service," Railway Gazette International, Dec. 2006, P784-785
ICE: " ICE Multiple Unit for the European High-Speed Rail Services of German Rail (DB AG) and Netherlands Railways (NS)," Technical Information, Siemens AG

Key to Success for High-Speed Rail

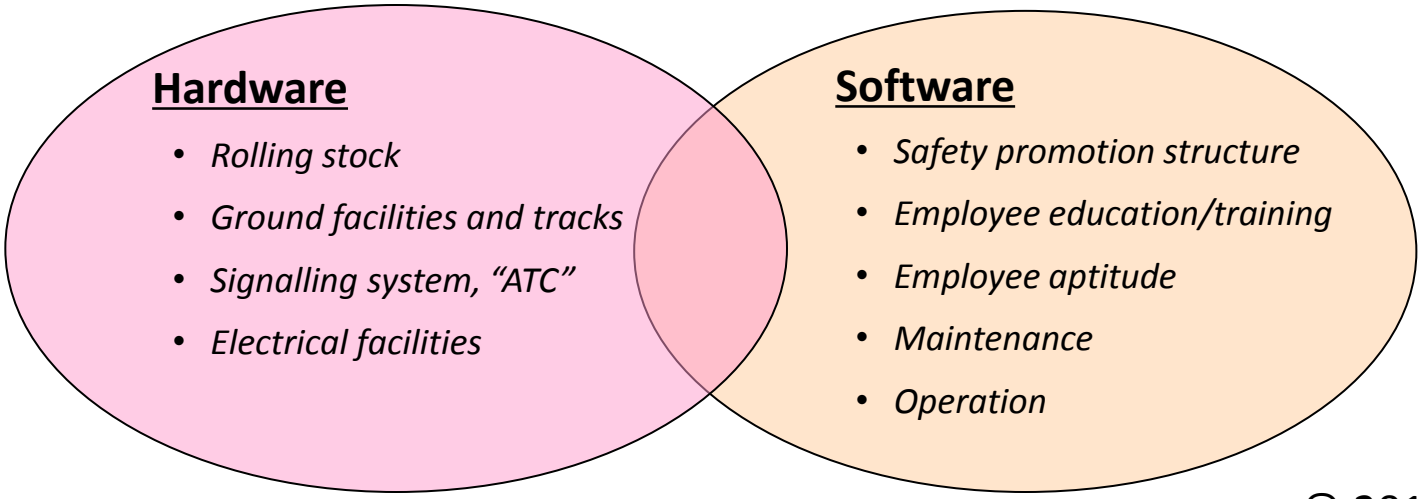
- Key to Japanese success has been not an interoperable but a dedicated high-speed passenger rail system.
  - Dedicated high-speed rails with an advanced signalling system, minimizing risk of collisions and enjoying advantages of the Crash Avoidance Principles.
  - Interoperable high-speed rails sharing tracks with conventional rails, accepting a certain level of risk of collisions.
- The Shinkansen system has been improved over fifty-year operations and is a proven high-speed rail system.
  - Continual monitoring and improvement are hallmarks of Shinkansen developments, almost eliminating unexpected risks.
- Integrated management of the Shinkansen system is indispensable to continue improving safe operations into the future.

Integrated Management of HSR System

The proven Tokaido Shinkansen system has been established by integrated management for nearly fifty years.

- The high-speed rail system is composed of not only hardware but also software, both of which are living systems that interact with each other.
- Therefore, it is vital for our railways to manage both Hardware and Software in an integrated way to improve safety.

Integrated Management of HSR System



Japanese Shinkansen's Education and Training

Implementing education and aptitude tests lead to employee's compliance with regulations and inhouse rules.

Taiwan High Speed Rail Corporation's Education and Training in Operation