Tireless progress of the Tokaido Shinkansen
-From Series 0 to Series N700S-

12th November, 2020

JR Central

General Technology Division

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Contents

1. Progress of Tokaido Shinkansen
2. Technological development
3. Latest model “N700S”
4. Overseas HSR deployment

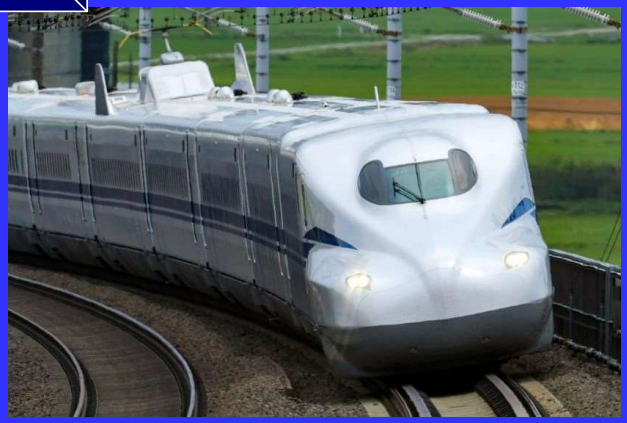
Inauguration of Tokaido Shinkansen

<Basic concept during the development stage>

1. **Maximum speed: 210km/h**
2. **Use of dedicated passenger rail**
   ≠interoperable with conventional lines
   -widened gauge width (standard gauge)
   -no level crossings
3. **Adoption of onboard signals**
   -unified signal system (ATC)
4. **Power distributed electrified train**

Tirelessly advancing technology development abide by the basic concept, the Tokaido Shinkansen has made rapid progress

Current Tokaido Shinkansen



① Safety and Reliability

Zero passenger fatality due to train accident

Average delay : 0.7min / train (FY2017 result)

② Mass Transportation

Service frequency: 373 trains/day (455 trains/day, largest number recorded on Aug 16, 2020)

Daily passenger volume: 477,000 passengers/day

Accumulated ridership: 6.4 billion passengers since inauguration in 1964

③ High-speed Transportation

Tokyo-Shin Osaka (515km) 2 hours 22 min

④Harmonization with the environment

Low noise and vibration level

Low energy consumption and CO2 emission

＜Speed Improvement＞

1964 : 210km/h

1986 : 220km/h

1992 : 270km/h

2014 : 285km/h

Progress since the establishment of JR Central

	Establishment of JRC (1987)	Present (as of 2018)）	
1. Speed	220 km/h	285 km/h	＋ 65 km/h
2. Travel time (Tokyo⇔Shin-Osaka)	2 hours 52 minutes	2 hours 22 minutes	(△ 30 minutes)
3. Number of train services	231 trains per day	373 trains per day	(＋ 61 %)
4. Average delay time	3.1 minutes per train	0.7 minutes per train	(△ 2.4 minutes per train)
5. Energy consumption	Series 0 (at 220 km/h)	Series N700 (at 220 km/h)	△ 49 %

Since the establishment of JRC, the Tokaido Shinkansen has dramatically developed due to tireless technological improvement and by using passenger dedicated track

Transition of Tokaido Shinkansen Rolling Stocks

1964 1985 1992 1999 2007 2020

1st Generation

2nd Generation

- Steel carbody
- Conventional bogie
- DC motor drive

- Aluminum alloy carbody
- Bolsterless bogie
- Asynchronous motor drive
  (VVVF control、Regenerative brake)

- Body inclining system
- Bogie vibration detection system
- Cruise control system
- Standard designed rollingstock
- Battery self-propulsion system

	Series 0	Series 100	Series 300	Series 700	Series N700	N700S
						
Operating Speed	210km/h	220km/h	270km/h	270km/h (Sanyo section: 285km/h)	285km/h (Sanyo section: 300km/h)	285km/h (Sanyo section: 300km/h)

New types of rollingstock have been introduced every 7-8 year since the establishment of JR Central (after 1992)

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JR Central's Basic R&D Cycle

○Acquiring various operation dataset from the rolling stock, ground equipment, or test cars

○ Verification through physical test operation on the commercial line

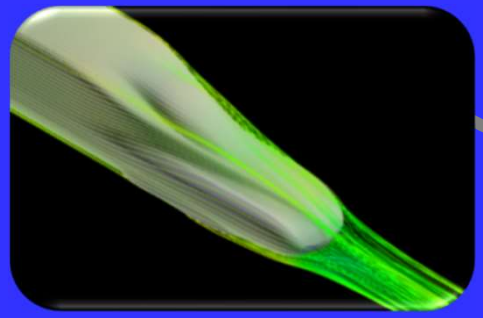
Goals

- Safe and reliable operation of the Shinkansen system

- Improvement of passengers' convenience and comfortability

- Efficient system operation

○ Analysis through computer-based simulation



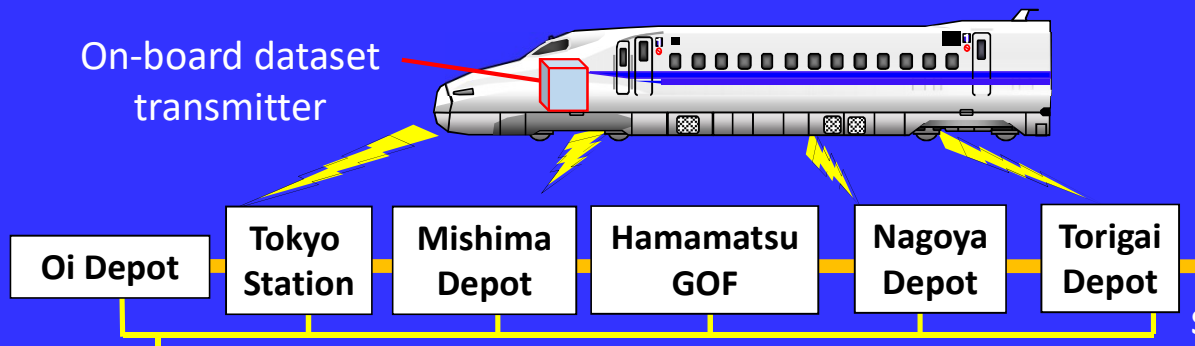
○ Verification through real-size test equipment

Worked continuously and substantially on system-wide challenges such as earthquake counter measures, noise/vibration mitigation, and improvement of ride comfort on curve sections

Overview of the operation dataset collection and analysis system

○Rollingstock condition monitoring

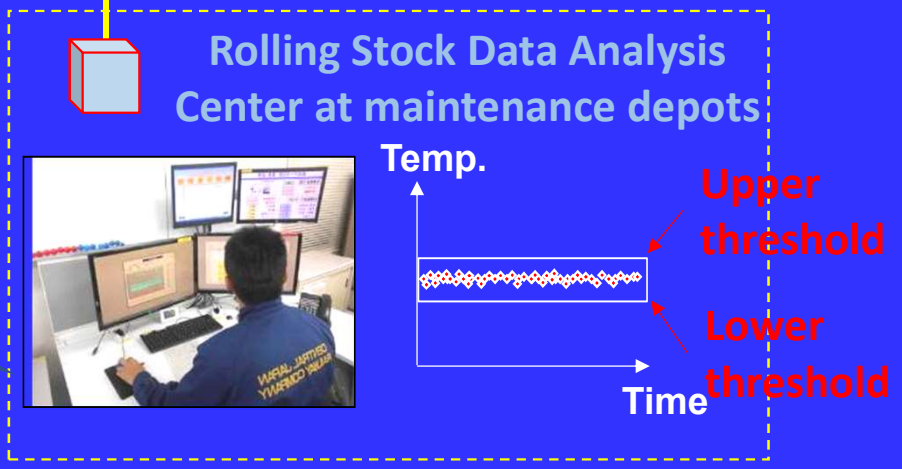
・Transmit data to 16 wayside on-ground receivers including maintenance depots, stations, and overhaul facility

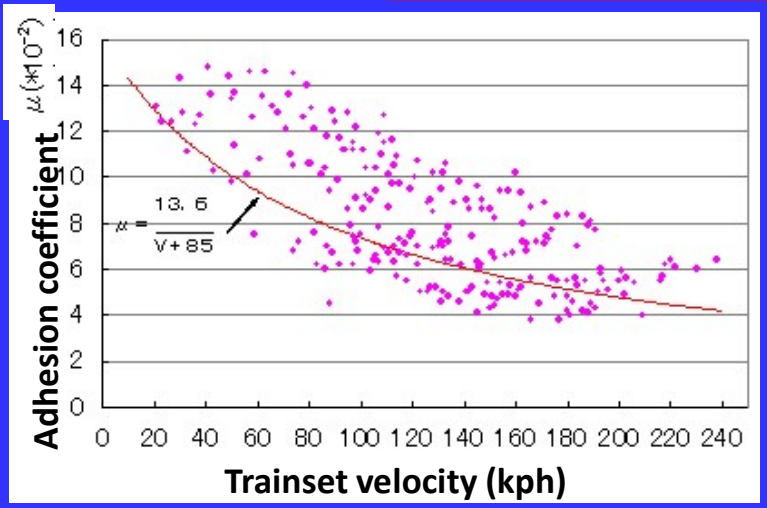


Monitored components

ATC, bogie, body reclining system, slide doors, HVAC, brake, brake control unit, electric circuit etc.

Operation data analysis of rollingstock components and on-ground facilities





Commercial line test operation using N700S Verification Testing Trainset

- On March 2018, the N700S Verification Testing Trainset was developed to carry out long- term test runs on the commercial line.
- Newly developed components were equipped which were continuously monitored, and various parameters were tracked and recorded.
- Tested ability of “standardized car” through
  1) 8-cars operation, 2) operation by changing motor car/trail car portfolio (14M2T, 16M)
- With series of long-term test run, technological abilities of N700S were confirmed
  e.g. 360kph operation, battery-based self-propulsion

Komaki R&D Center

Test machine for track's resistance against trainset vibration and weight

Civil structure test system

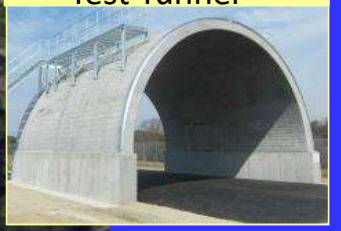
Research Building

Lab Building A

Triaxial load test equipment for civil structures

Test truss bridge

Test Tunnel



OCS test equipment

Lab Building C

Lab Building D

Lab Building B

- Opened in: July 2002
- Place: Komaki city, Aichi
- Employees: Approx. 130

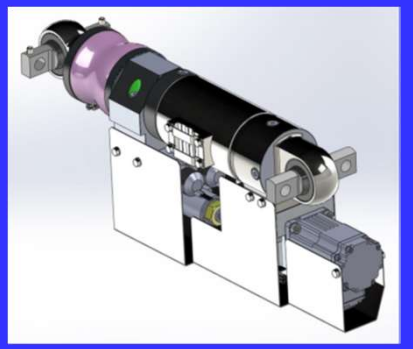
Vehicle Dynamic Simulator

- A device established to research train ride comfort. The research is targeted to develop better ride experience on the R2,500m curve, the steepest curve along the Tokaido line.
- Composed of 6-axle power cylinder and straight-line motion device, the simulator can accurately recreate the centrifugal force vibration.

*Most Shinkansen lines constructed later than Tokaido Shinkansen curves are around R4,000

Major Outcome of the research

- Body Inclining System
- Suspension system
- Speed improvement on curves
- Feedback to rail maintenance management



Low-Noise Wind Tunnel

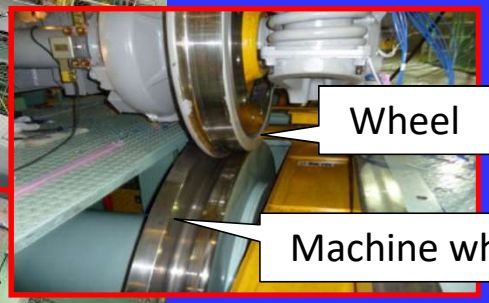
- A device developed to mitigate Tokaido Shinkansen's "noise issue".
- With background noise level as low as 78dB(A), the wind tunnel can conduct tests for high wind speeds of up to 350km/h.

Major Outcome of research

- Optimization of nose shape
- Low noise pantograph
- Cover-all hoods between cars

Rolling Stock Field Test Simulator

- A device that can “reproduce running condition of the commercial line” and “demonstrate test items which cannot be conducted on the commercial line”.
- The machine can recreate running dynamics by not only rotating the machine wheel but also rotating the wheel by activating the train motor.
- Maximum test running speed is 350km/h.



Major outcome of the research

- Central Fastening Brake Disk
- Bogie Vibration Detecting system
- Double Helical Gear
- Six-pole Driving Motor

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Concept of N700S

○ About N700S

- A next-generation and fully remodeled Shinkansen rolling stock, incorporating the results of JR Central's continuous R&D

  ⇒ "S" of "N700S" stands for "Supreme"

- Commercial service started from July, 2020

  40 trainsets are planned to put into service in three years

○ Concept

1. Pursue further safe and reliable transportation

   Shorten brake distance in the case of an earthquake etc.

2. Strengthen the ability of responding to emergencies

   Realize the world's first self-propulsion system for HSR, enhance security by installing more on-board CCTV and emergency communication device, enable the use of toilets even under long-term power outage

3. Strengthen competitiveness of the Tokaido Shinkansen

   Improve riding comfort and quietness, enhance ride comfort by installing power outlets to all passenger seats etc.

4. Reduction of system total cost

   Reduce system running cost

5. Realization of "standard designed rolling stock", applicable to various alignments worldwide

   Prove running performance of 16-cars (14M2T and 16M) and 8-cars (8M)

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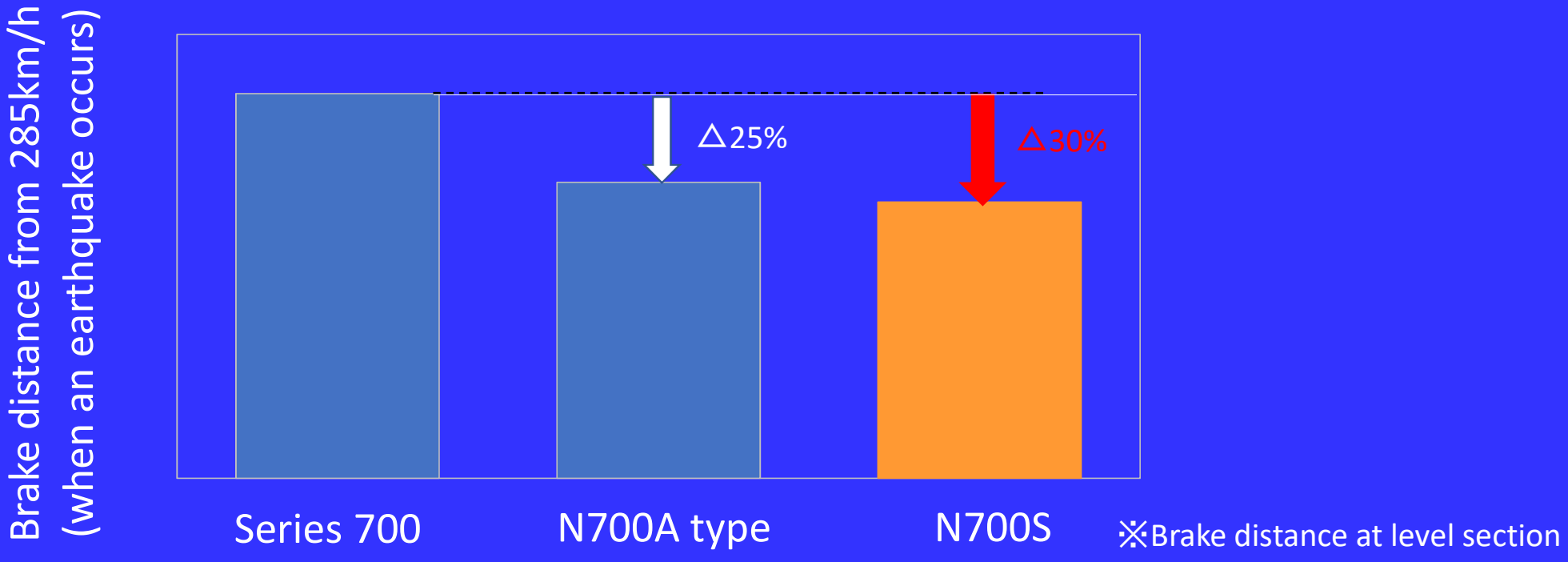
Shortening of brake distance

○Brake distance per rolling stocks
(in the case of an earthquake: 285km/h [177mph] → 0 km/h)



Reduced 30% of brake distance compared to Series 700

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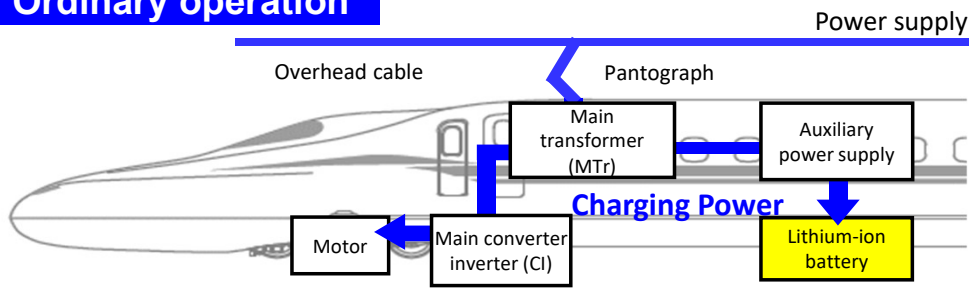
Battery-based Self-propulsion System

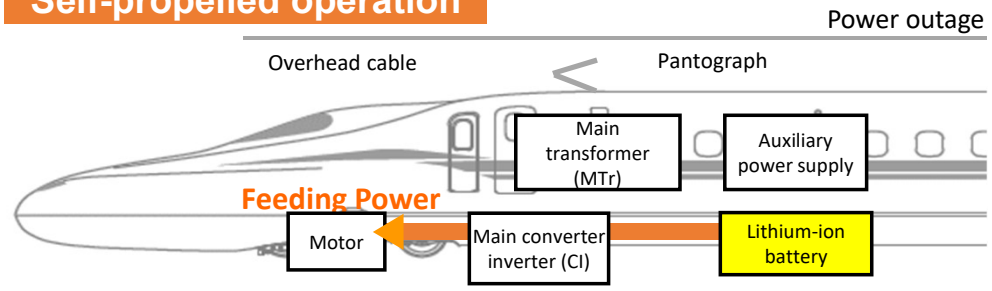
○ Outline of the system

Ordinary operation



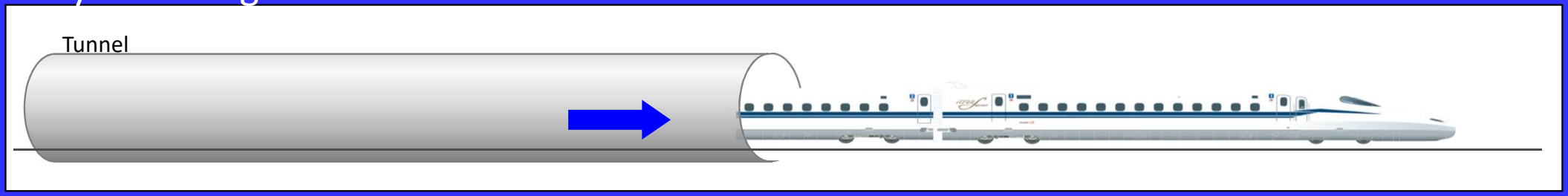
Charging power to the battery from the overhead cable

Self-propelled operation



Supply power to traction from battery

○ System usage



During extended power outage at the time of natural disasters, the system will avoid trains stopping inside tunnels and on bridges, and reach a safe location where passenger evacuation is easier.

Improved safety under emergencies such as natural disaster

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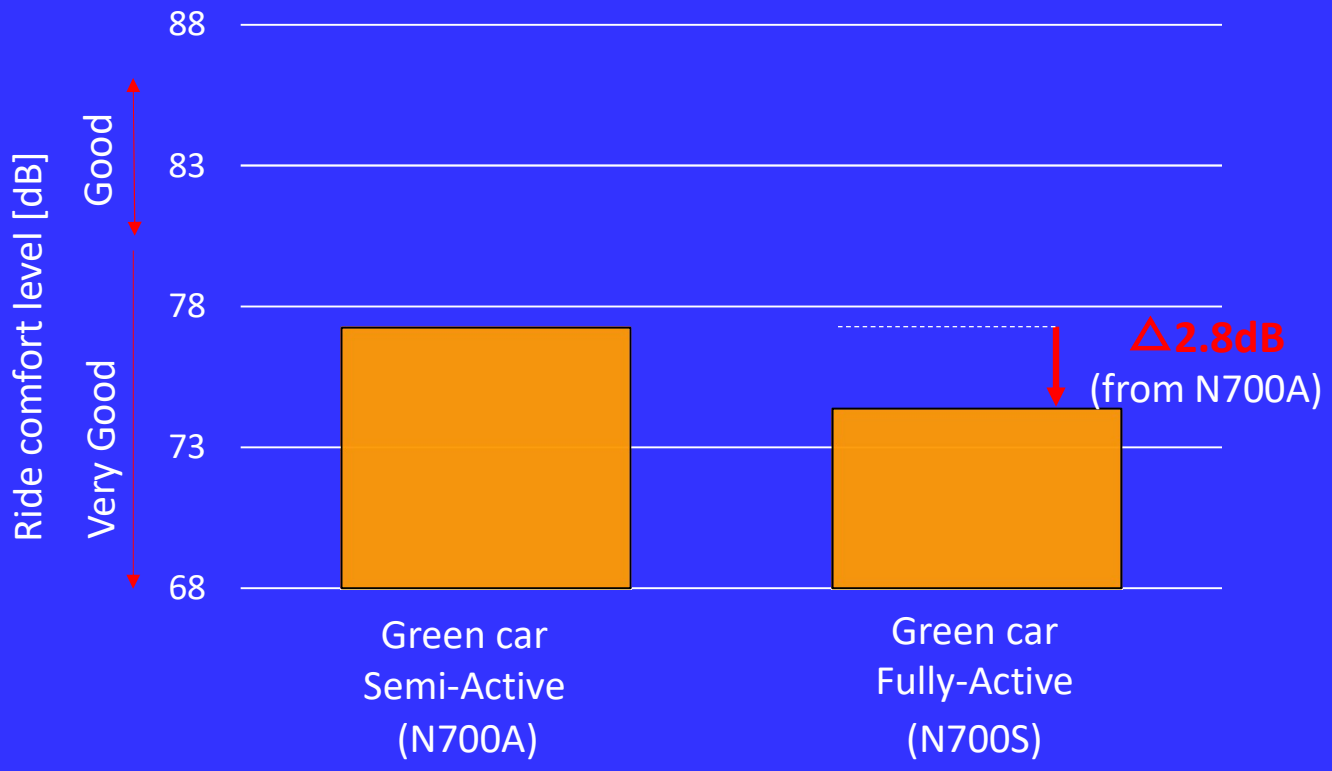
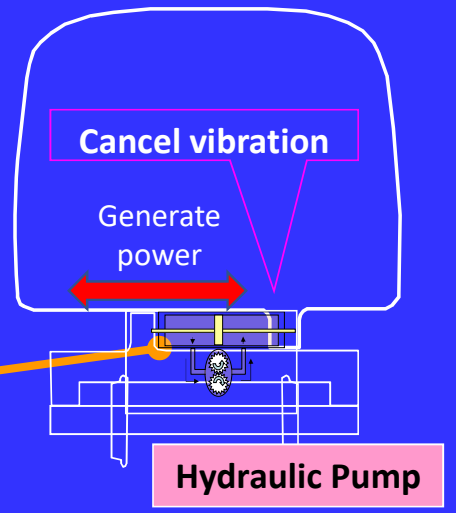
Fully-active Suspension System

○Fully-active Suspension System
(Average riding comfort level at 285km/h [177mph] section)



Fully-active
Suspension System



Cancel vibration by generating power from hydraulic pump

Further improved passenger ride comfort

Concept of N700S

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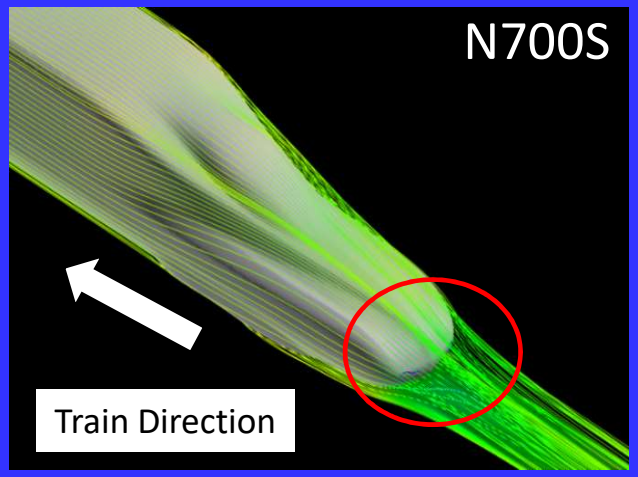
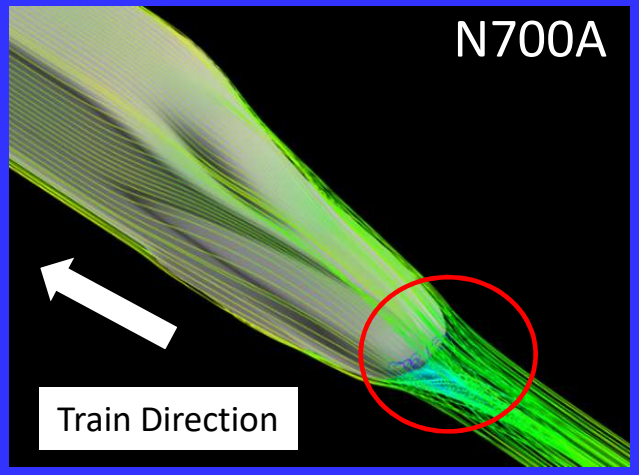
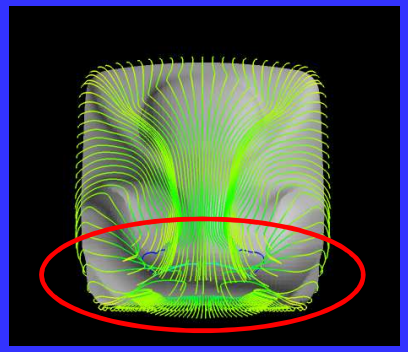
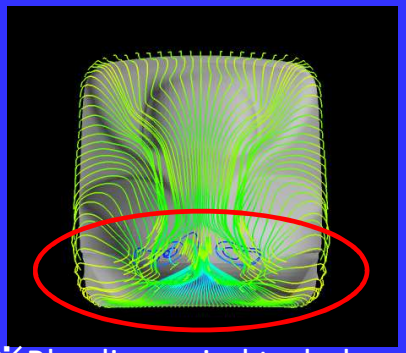
N700S (Nose shape)

○An optimized nose shape the “Dual Supreme Wing Shape” developed from Series N700









※Blue line: wind turbulence

By creating edges on both sides, the running wind aligns reducing tunnel boom, wayside noise, and rear car oscillation.

Concept of N700S

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Concept of technical development for rolling stocks

○Standardization

・Seating capacity per car

⇒ Realize efficient and flexible operation by unifying the capacity for all rolling stock type

・Underfloor equipment

⇒ Save labor force by standardizing maintenance works

・Component parts

⇒ Improve manufacturability, quality, and reduce cost by decreasing number of types

○Downsizing and weight reduction of underfloor equipment

Enables to install new equipment

【Examples of newly installed equipment】

・Carbody tilting system

・Fully-Active Suspension System

・Battery-based Self-propulsion System

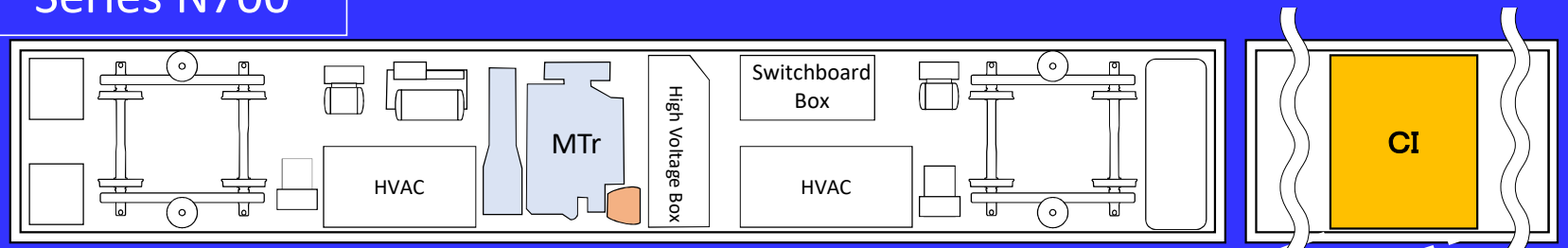
・Strengthened monitoring system

・Improved cabin comfort and amenities

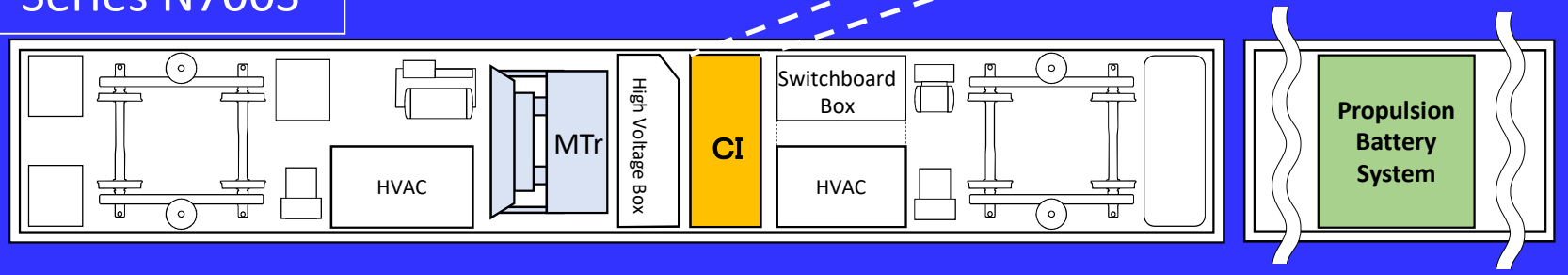
Downsizing of underfloor equipment

MTr : Main Transformer
CI : Converter/Inverter

Series N700



Series N700S

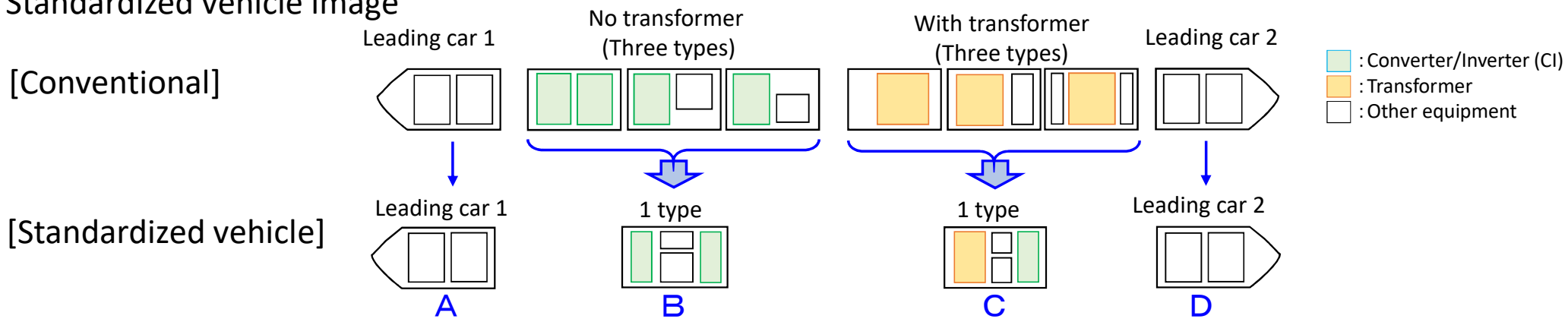


Enabled to add new equipment on vehicles

Standardized underfloor equipment

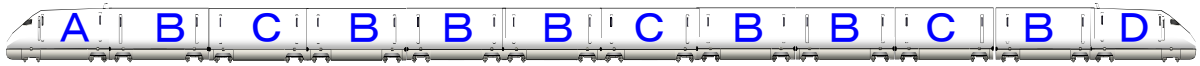
○Reduced car types from 8 to 4 by optimizing underfloor layout

Standardized vehicle image

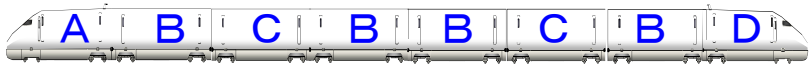


Tokaido-Sanyo Shinkansen (16-cars trainset)

Ex. 12-cars trainset



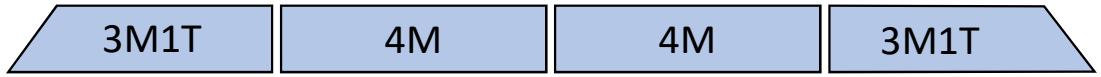
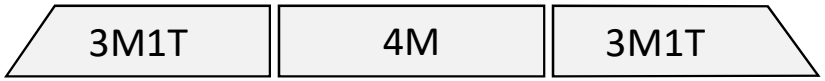
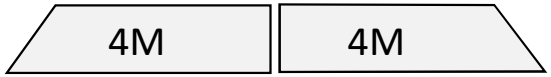
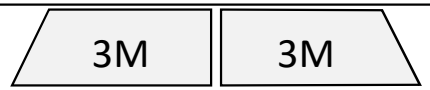
Ex. 8-cars trainset



Without modifying the basic design, gave flexibility to change the number of trainsets and ensure the same level of system reliability as the Tokaido Shinkansen

Realization of the “standard designed rolling stock”

Thanks to substantial downsizing and weight reduction, realized a rolling stock standardization which can be customized to **demands overseas (e.g. Texas, Taiwan)**

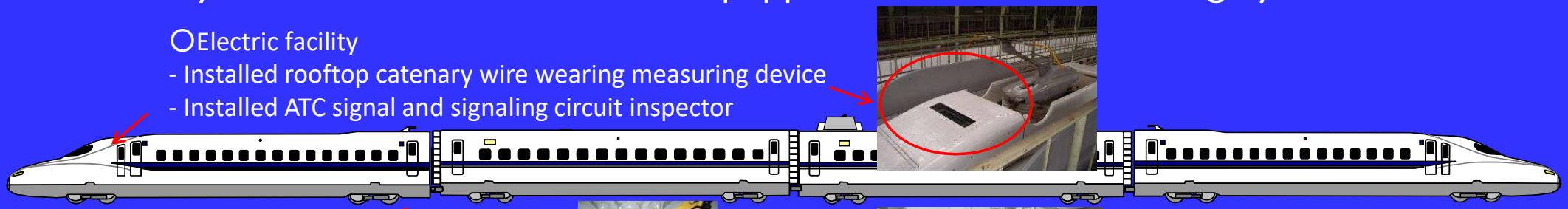
Cars	MT ratio	Train set configuration
16	14M2T **(Tokaido Shinkansen)**	
	16M	
12	10M2T **(Taiwan)**	
8	8M **(Texas)**	
7	7M	
6	6M **(Nagasaki (Plan))**	

- Trainset arrangement is flexibly adjustable (trainset length, capacity)
- MT ratio can be customized in accordance with the local demand
- Capable of applying reliable and high quality equipment identical to the Tokaido Shinkansen

Benefits of the “standard designed rolling stock” (Next generation monitoring system)

○Some newly manufactured trainsets are equipped with Track Monitoring System

○Electric facility
- Installed rooftop catenary wire wearing measuring device
- Installed ATC signal and signaling circuit inspector



○Track
- Installed rail condition monitoring sensor system

Monitors track height

Monitors rail unevenness, line, gauge, level, and flatness

Device Name (s)	Measurement Items
Catenary wire wearing measuring device	catenary wire wearing, heights, etc
ATC signal and signaling circuit inspector	ATC signal and return current flowing in rails
Rail condition monitoring sensor system	rail unevenness, line, gauge, level, and flatness

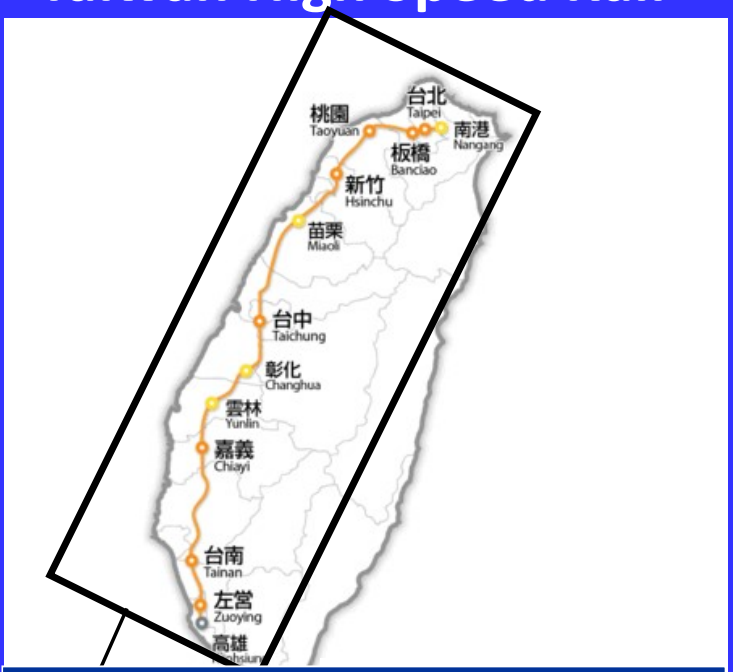
Further improved effective and precise maintenance

Contents

1. Progress of Tokaido Shinkansen
2. Technological development
3. Latest model “N700S”
4. Overseas HSR deployment

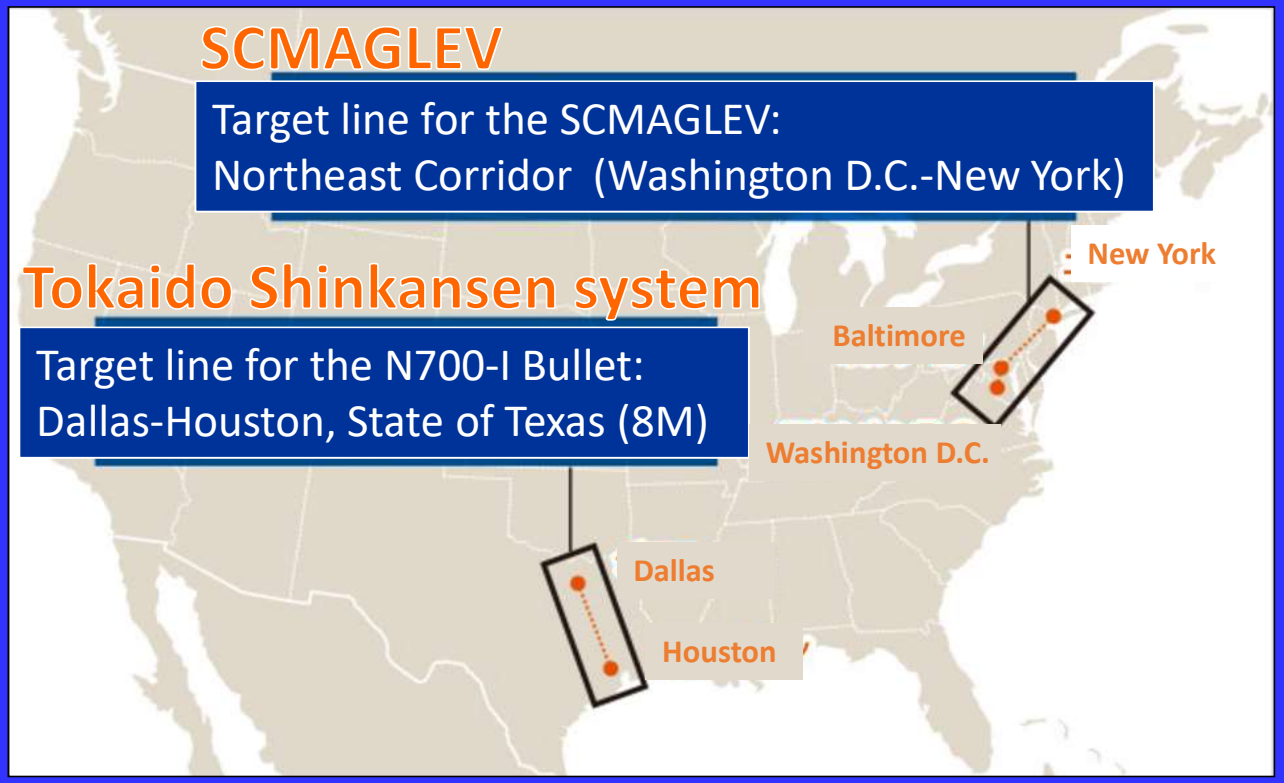
Overseas deployment of the world's finest level of high-speed rail technology

Technical consulting for Taiwan High Speed Rail



Taiwan High speed Rail corridor:
Nangang-Kaohsiung (10M2T)

Two projects in the U.S.

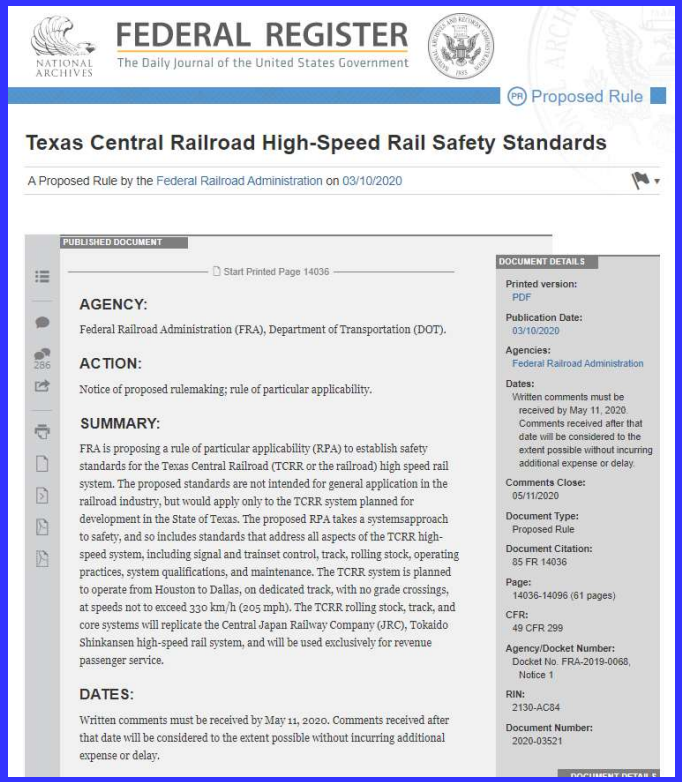


Promote overseas deployment

with the basic concept of Tokaido Shinkansen

Rule of Particular Applicability (RPA) for Texas HSR Project

- The RPA was published by the Federal Railroad Administration (FRA) specific to the Texas HSR project as the Code of Federal Regulations (CFR)
- The RPA establishes the minimum safety standards to allow Texas Central Railroad to replicate the service-proven systems and operations of the Tokaido Shinkansen system with its 55-year safety record
- The RPA is based on a systems approach to safety, which incorporates standards of the high-speed system, including signal and trainset control, track, rolling stock, operating practices, system qualifications, personnel qualification and maintenance



FEDERAL REGISTER
The Daily Journal of the United States Government

Proposed Rule

Texas Central Railroad High-Speed Rail Safety Standards

A Proposed Rule by the Federal Railroad Administration on 03/10/2020

PUBLISHED DOCUMENT

Start Printed Page 14036

AGENCY:

Federal Railroad Administration (FRA), Department of Transportation (DOT).

ACTION:

Notice of proposed rulemaking; rule of particular applicability.

SUMMARY:

FRA is proposing a rule of particular applicability (RPA) to establish safety standards for the Texas Central Railroad (TCRR or the railroad) high speed rail system. The proposed standards are not intended for general application in the railroad industry, but would apply only to the TCRR system planned for development in the State of Texas. The proposed RPA takes a systemsapproach to safety, and so includes standards that address all aspects of the TCRR high-speed system, including signal and trainset control, track, rolling stock, operating practices, system qualifications, and maintenance. The TCRR system is planned to operate from Houston to Dallas, on dedicated track, with no grade crossings, at speeds not to exceed 330 km/h (205 mph). The TCRR rolling stock, track, and core systems will replicate the Central Japan Railway Company (JRC), Tokaido Shinkansen high-speed rail system, and will be used exclusively for revenue passenger service.

DATES:

Written comments must be received by May 11, 2020. Comments received after that date will be considered to the extent possible without incurring additional expense or delay.

DOCUMENT DETAILS

Printed version: PDF

Publication Date: 03/10/2020

Agencies: Federal Railroad Administration

Dates: Written comments must be received by May 11, 2020. Comments received after that date will be considered to the extent possible without incurring additional expense or delay.

Comments Close: 05/11/2020

Document Type: Proposed Rule

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Page: 14036-14096 (61 pages)

CFR: 49 CFR 299

Agency/Docket Number: Docket No. FRA-2019-0068, Notice 1

RIN: 2130-AC84

Document Number: 2020-03521