Beyond the Shinkansen System – A Challenge of Japan to Realize Innovative Transportation Infrastructure

Keynote: SMART RANSPORTATION
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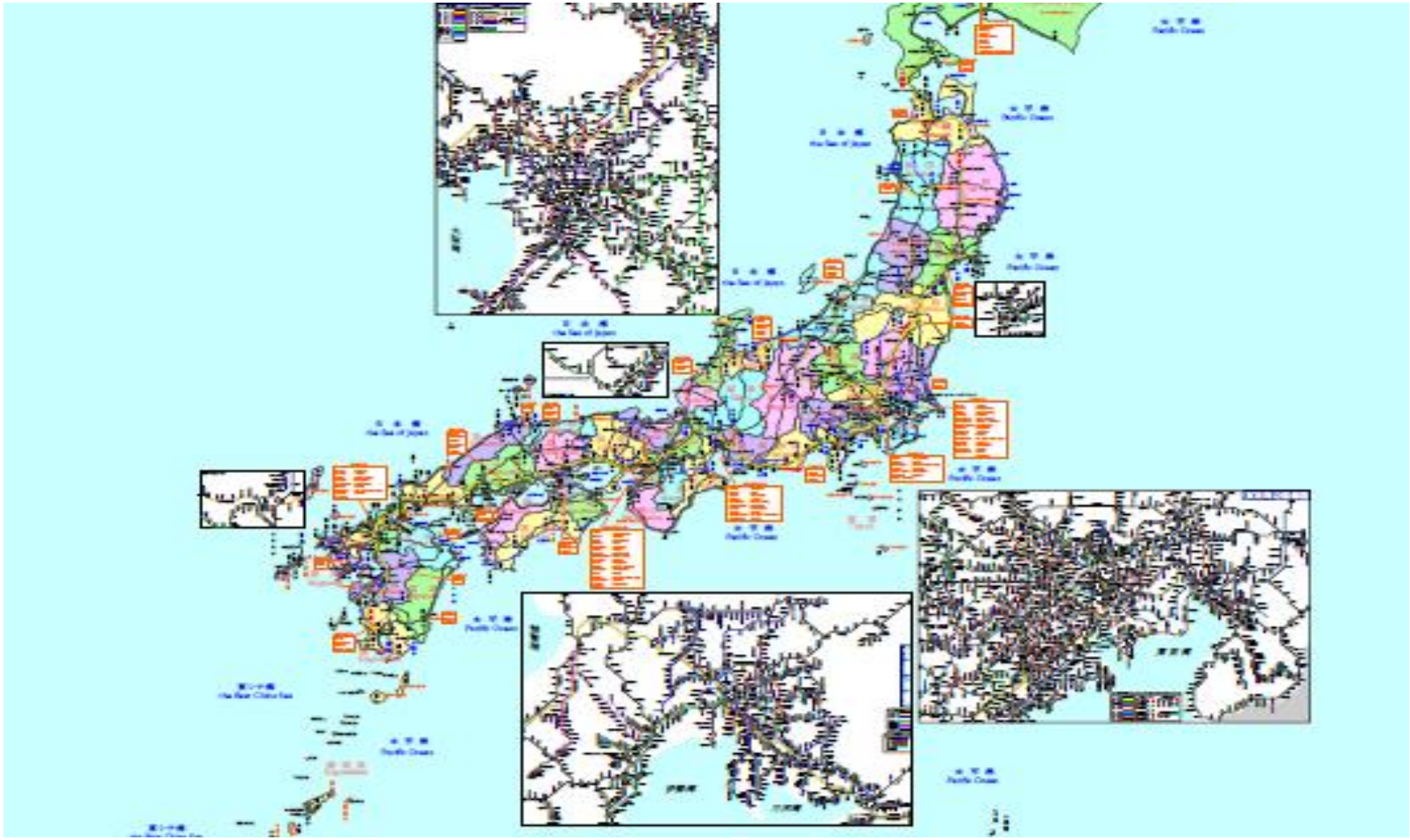
First, what is it like?

Past and Present

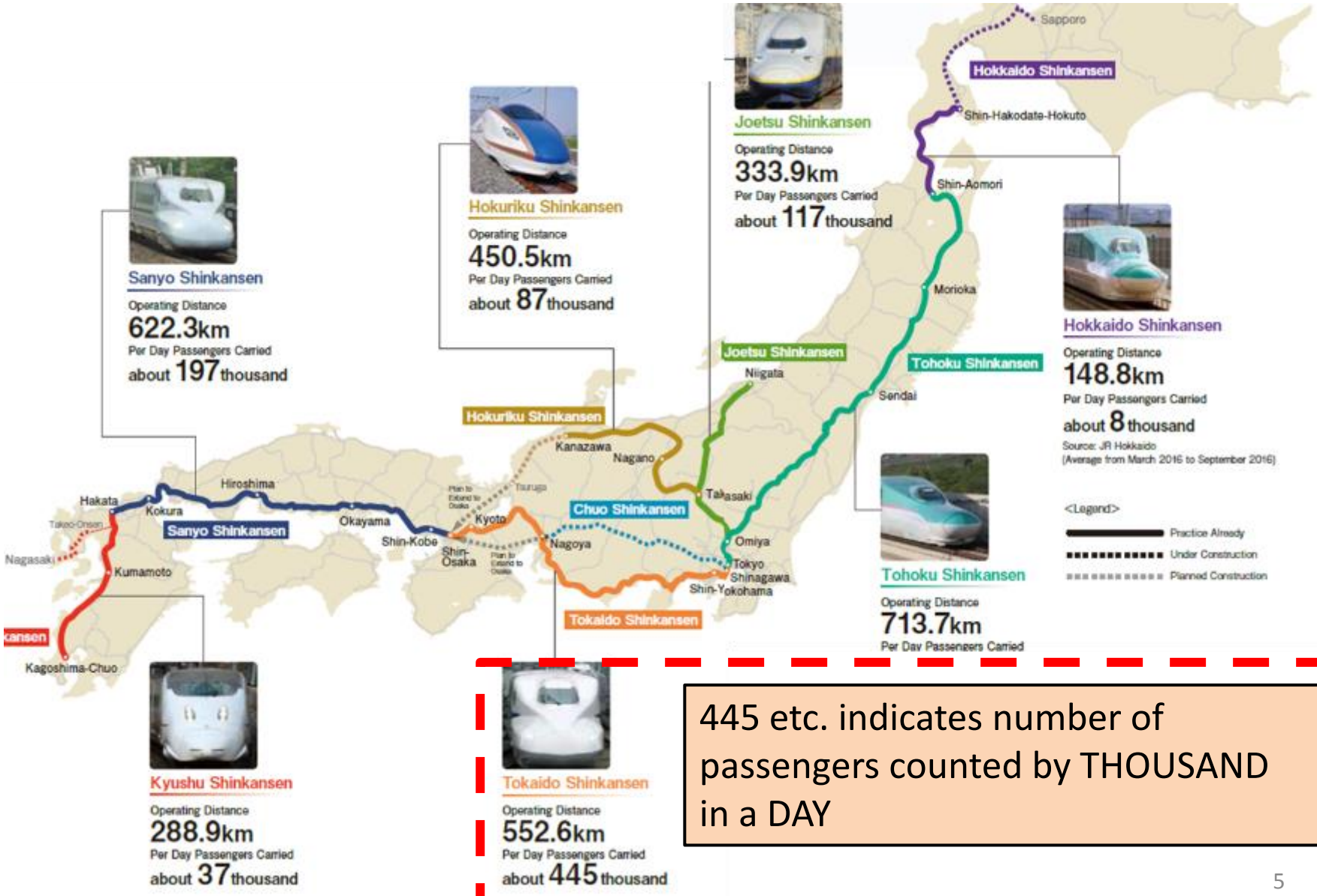
Railroad Network Has Been Developed in these 150 Years since Renovation in 1868



Network is extended mostly along coastal lines because 75% of Land is Inhabitable Mountain

Location of My Elementary School

Existing Shinkansen System Developed in these 50 years

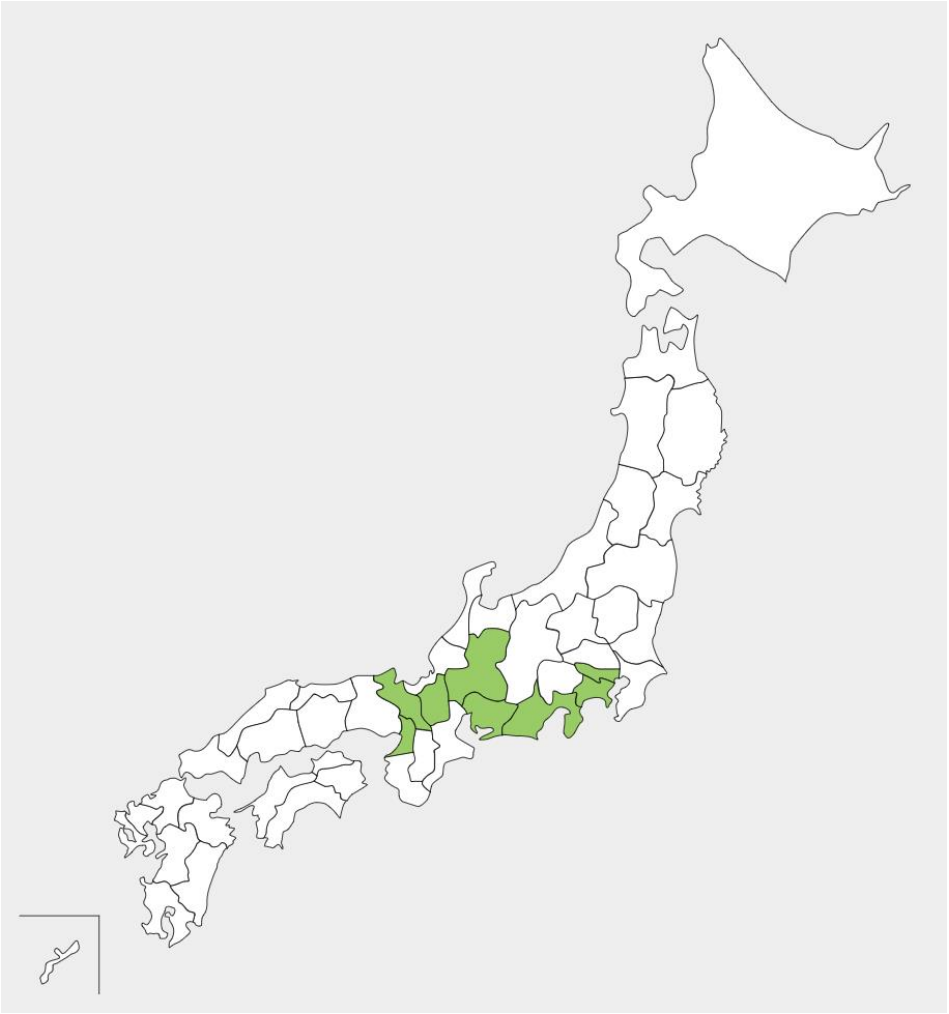


445 etc. indicates number of passengers counted by THOUSAND in a DAY

Tokaido GDP: 1,987 BUSD

46% of Japan's total GDP

Note: Tokaido means Eastern Coastal Area



Australia & NZ:	1,403
Italy:	1,826
Canada:	1,553
South Korea:	1,383
Russia:	1,366

FY2015, in BUSD

Kuala Lumpur to Singapore: 300-350 Km
London to Edinburgh: 534 Km
Washington, D.C. to Boston: 634 Km
Sydney to Melbourne: 824 Km

Facts with Pride

SDM System Design And Management

Zero Fatalities over 10 billion passengers

Average Delay /Service:

15 Secs. (FY 2015)

15 Services

Per Hour

450,000/Day

1600 Billion/Yr

Passengers

Dr. Yellow inspects the rail a few times every week.

Hot Debates When Started in late 50's

SDM System Design And Management

Conventional Wisdom held..

Must use, or be connected to, the existing rails to minimize cost and maximize network effect

Must be locomotive-drawn to reduce coach car noise and achieve crash resistance, as the Europeans do

Must run on embankment (remblai,) given that Japan is earthquake prone

Strong Voice of Support

SDM System Design And Management

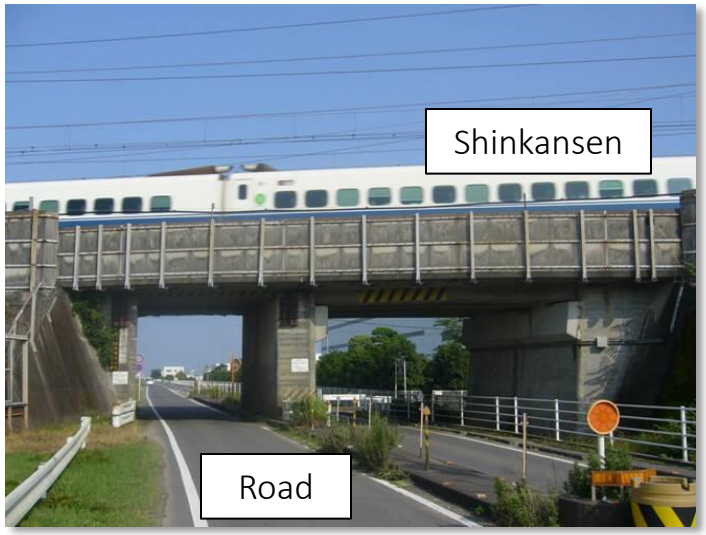
Dedicated, elevated tracks only for Shinkansen, with no level crossings

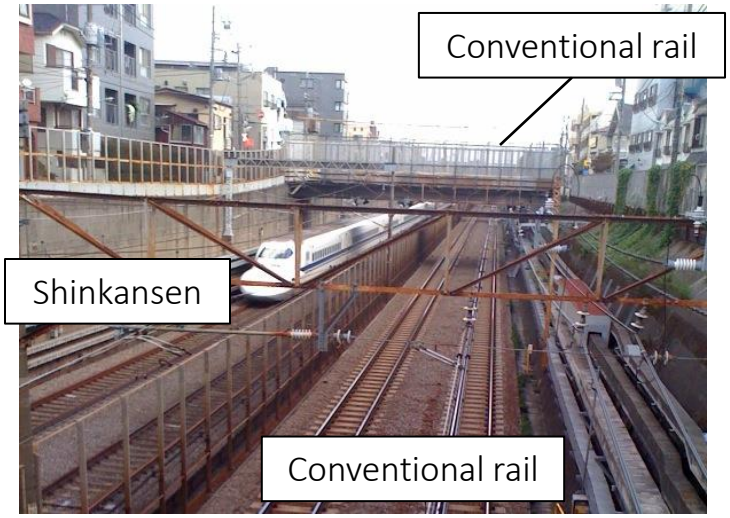
Separated tracks each for west-bound and east-bound

No need to prepare for head-on collision, especially with freight train

Summing up: Good Service

- Shinkansen is operated on dedicated high-speed tracks. No freight or other passenger trains on high-speed tracks.
- Full grade separation, or no grade crossings.
- Separating right-of-way maintenance from daily operations temporally, there is no possibility of a collision with maintenance of way equipment.





Furthermore..

Special law prohibits humans from entering the tracks: elevated tracks made it possible

ZERO incident track record

“System of Crash Avoidance”
Safety ensured by the initial design

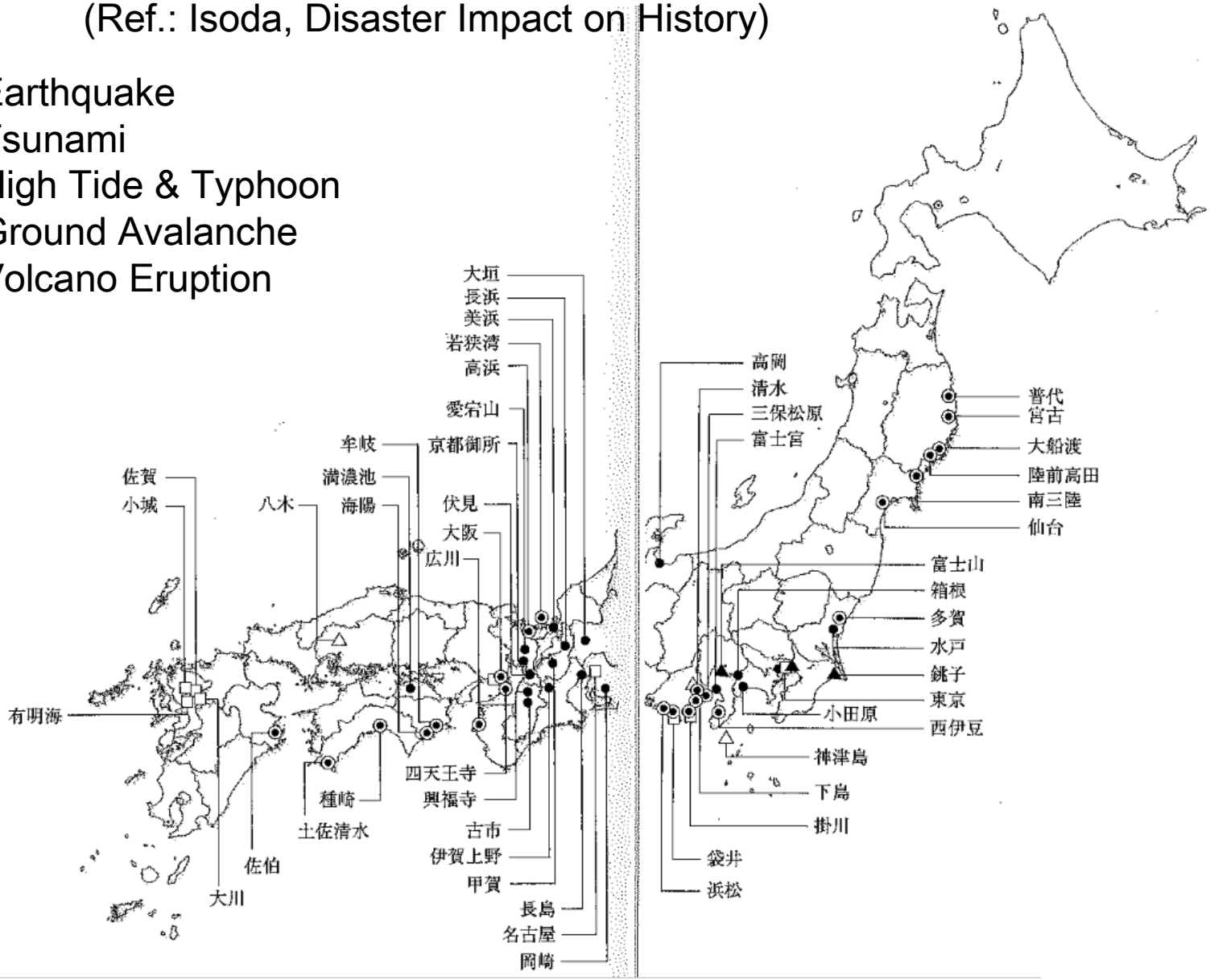
But, remember that it is just a matter of luck.

No causality when Chuetsu earthquake happened in 2004

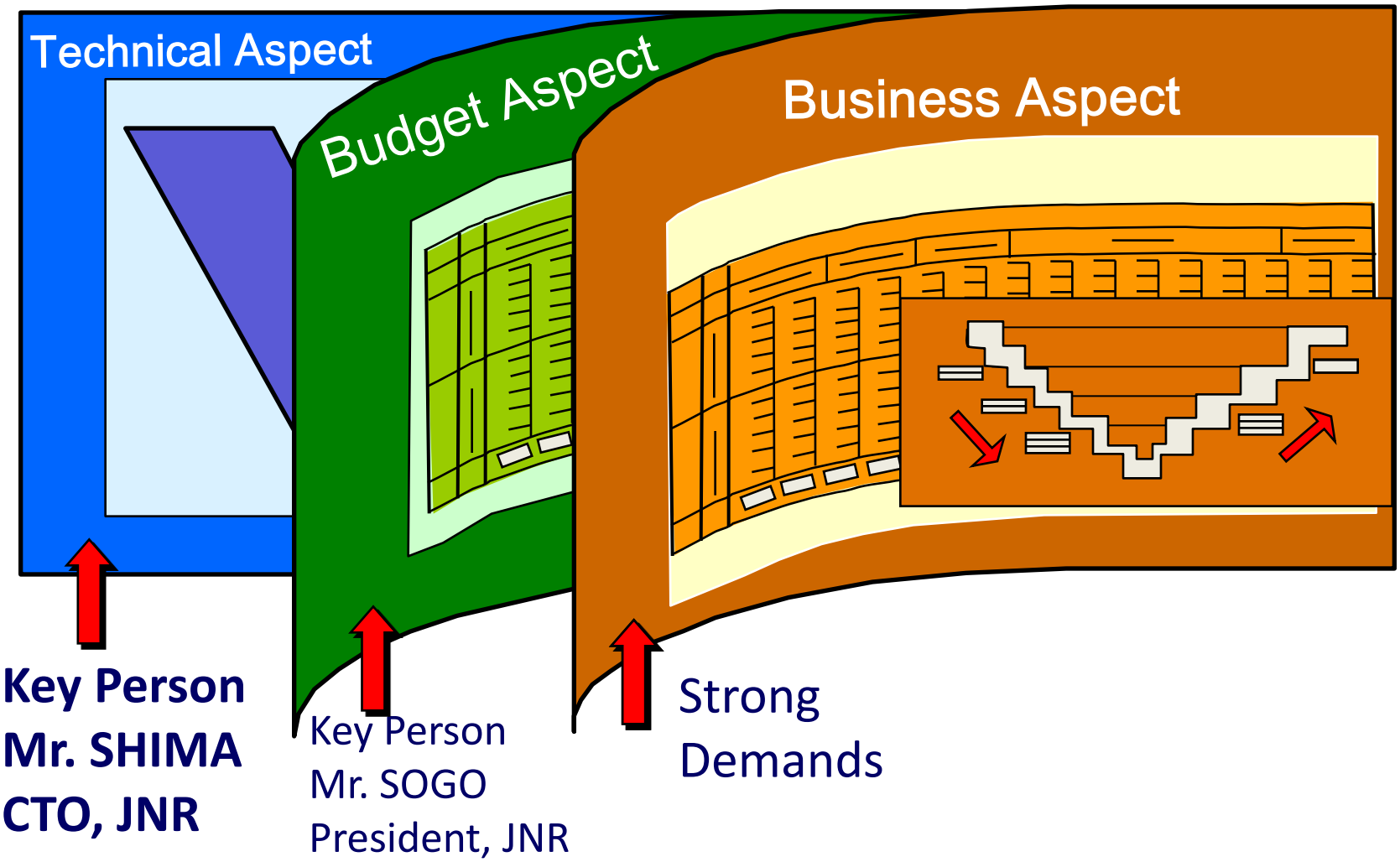
Remember Natural Disasters that Attacked Japan from 1550 to 2011

(Ref.: Isoda, Disaster Impact on History)

- : Earthquake
- : Tsunami
- : High Tide & Typhoon
- : Ground Avalanche
- : Volcano Eruption



Three Aspects of Project Cycle



The Foundational Design continued

SOME TECHNOLOGICAL ASPECTS

Automatic Train Control (ATC) System

- ATC system prevents train-to-train collisions and overspeed derailments. There have been no train-to-train collisions and no overspeed derailments with ATC for 54 years.
- All operations and movements of a trainset, including those in stations and maintenance facilities, are under full ATC .
- High reliability of the ATC system is essential to realize highly-frequent operations.

As Technology Advanced

- Weight: 970t/consist → 700t
- Acceleration: 1.2km/h/s → 2.6km/h/s
  (270km/h in 3 minutes)
- Height: 3,975mm → 3,600mm
- Electric power consumption down by 32%

Ref. (*Tokai Ryokyaku Tetsudo 20 Nenshi*, p. 777, p. 798, all comparing the initial "0" version and the type "700." Further advancement has been made of late.)

Locomotive-Hauled vs. Distributed Traction

Locomotive Hauled Consist

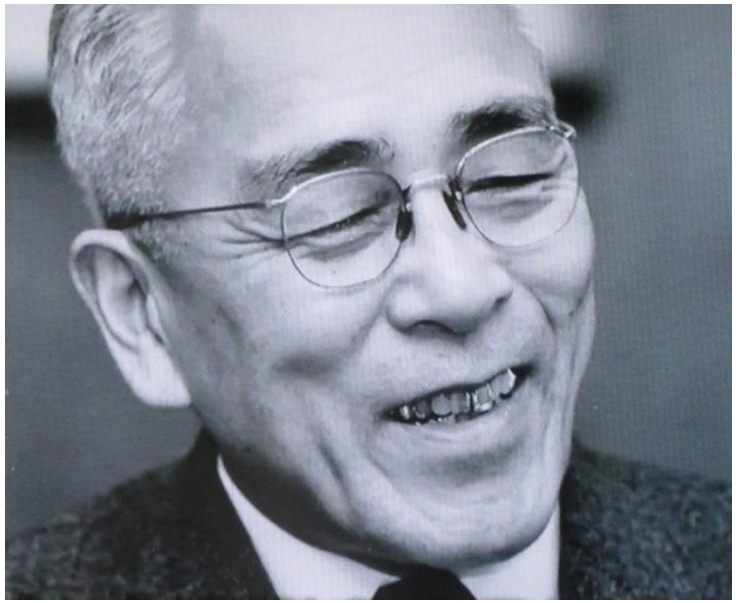
- When the locomotive fails, the whole halts
- The locomotive cannot get lighter beyond a limit
- For heavy locomotive, the infrastructure gets costly to build/maintain

Distributed Traction/Electric Multiple Unit (DT/EMU) are free from the drawbacks noted above.

Benefits of DT/EMU

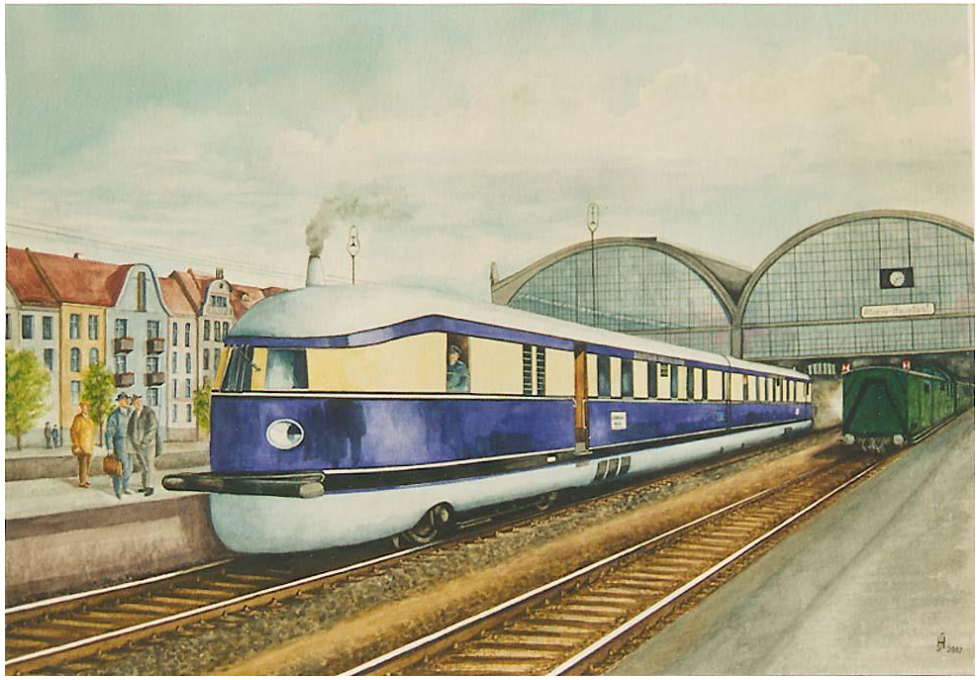
- Inbound trains turn into outbound with no difficulty (Engine turntable unnecessary)
- Operational frequency rises as a result
- Motor gets smaller, quieter, and lighter
- Motor turns into brakes, which generates electricity – Renewable energy system
- The length of consist earns variability

Hideo SHIMA, the Father of Shinkansen



- Chief architect of the Shinkansen system, but was well known as a designer of steam locomotive D-51
- 1969 Recipient, Asia's first, of James Watt International Medal (2nd awardee: Henry Ford)
- First Head, National Space Development Agency

Shima Were Insisted …

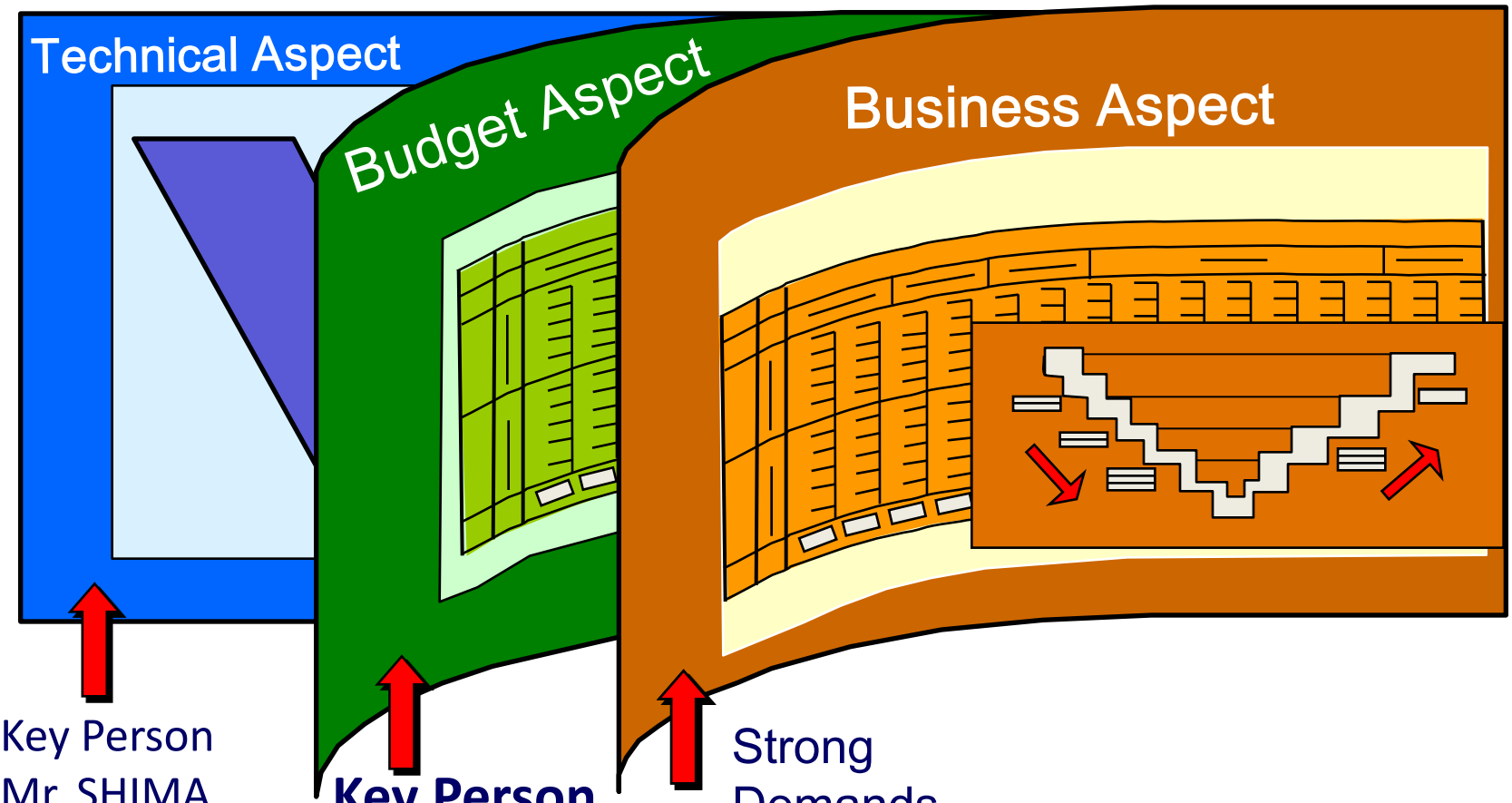


Ref.: Dankichi Takahashi, et.al., *Shima Hideo no Kaigai Ryoko: 1936-1937,* pp. 181-186

- Shima got the inspiration that would lead to the system of distributed traction
- He gained the prescience when he saw “Fliegender Hamburger” during his grand tour in Europe, 1936

POLITICO-ECONOMIC ASPECTS

The Three Aspects of Project Cycle



Key Person
Mr. SHIMA
CTO, JNR

Key Person
Mr. SOGO
President, JNR

Strong
Demands

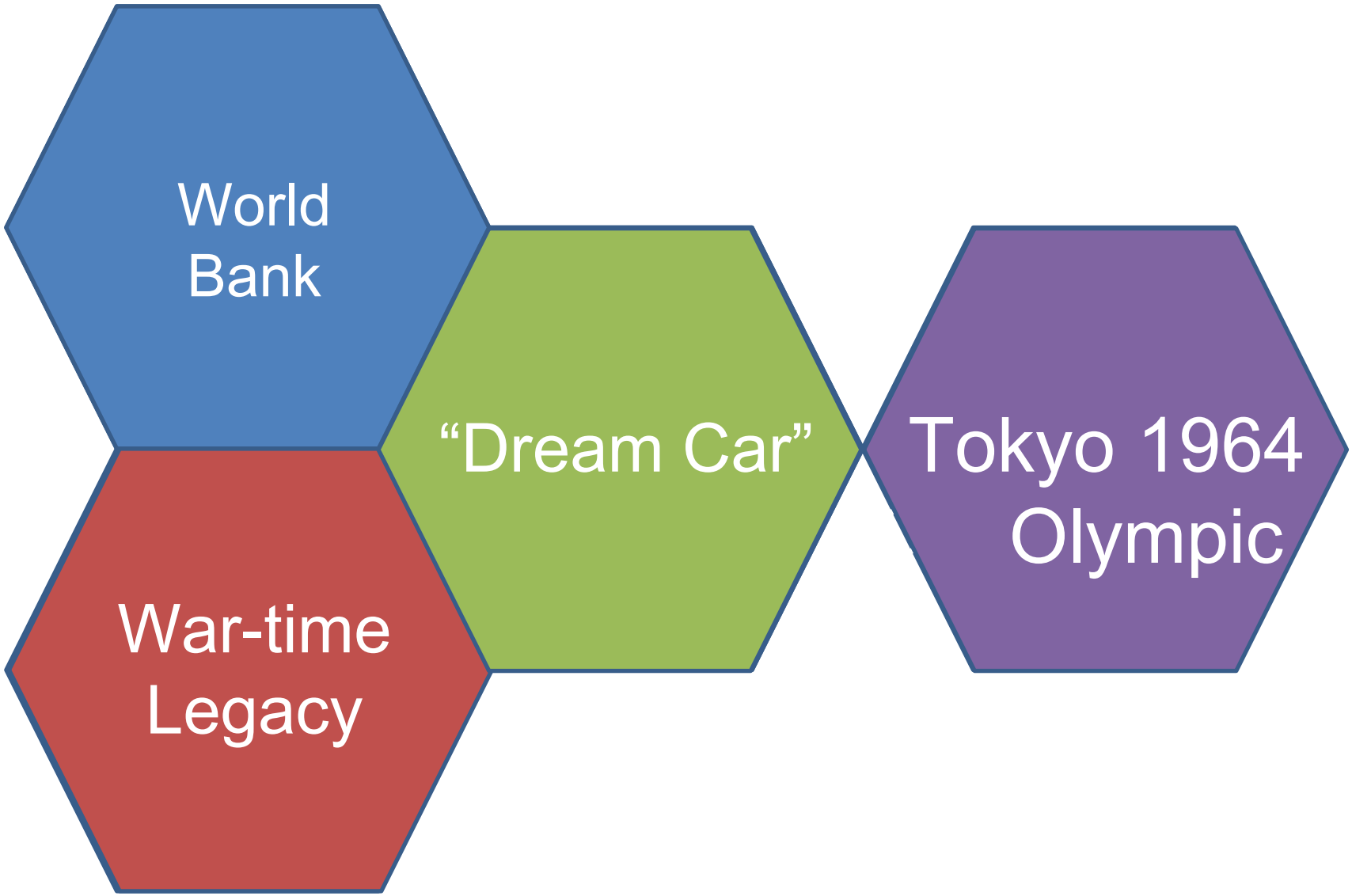
Hard Negotiation with World Bank

- ***JNR President Sogo*** played a key role in assuring the national budget for Shin-kansen by introducing the World Bank money.
- " Distributed traction is experimental", by so saying the ***World Bank*** initially rejected Japan's request for funding the Shinkansen project. ***Mr. Shima*** invited the World Bank delegate to demonstrate safety by the verification tests, leading to success.
- ***World Bank fund was about 7.5% of the total cost but has assured the yearly-based budget of Japan!***

Relief of Mr. Sogo, Ex-President of JNR, is displayed on Shin-kansen Platform of Tokyo Station

“Effort will make it happen.”

Some Luck Factors



Shin-Yokohama Station in 1960

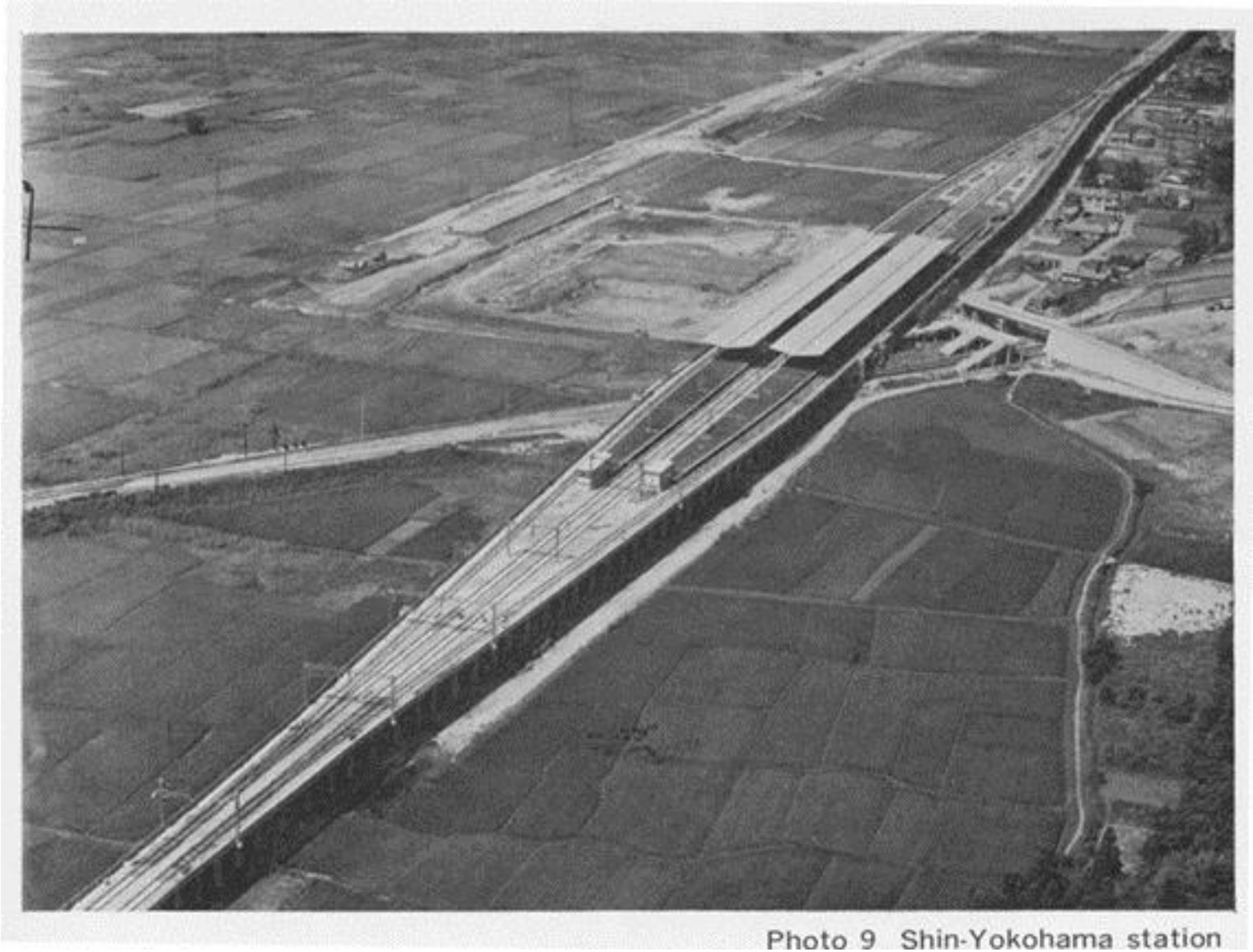


Photo 9 Shin-Yokohama station

Shin-Yokohama Station in 1970

Shin-Yokohama Station in 2018

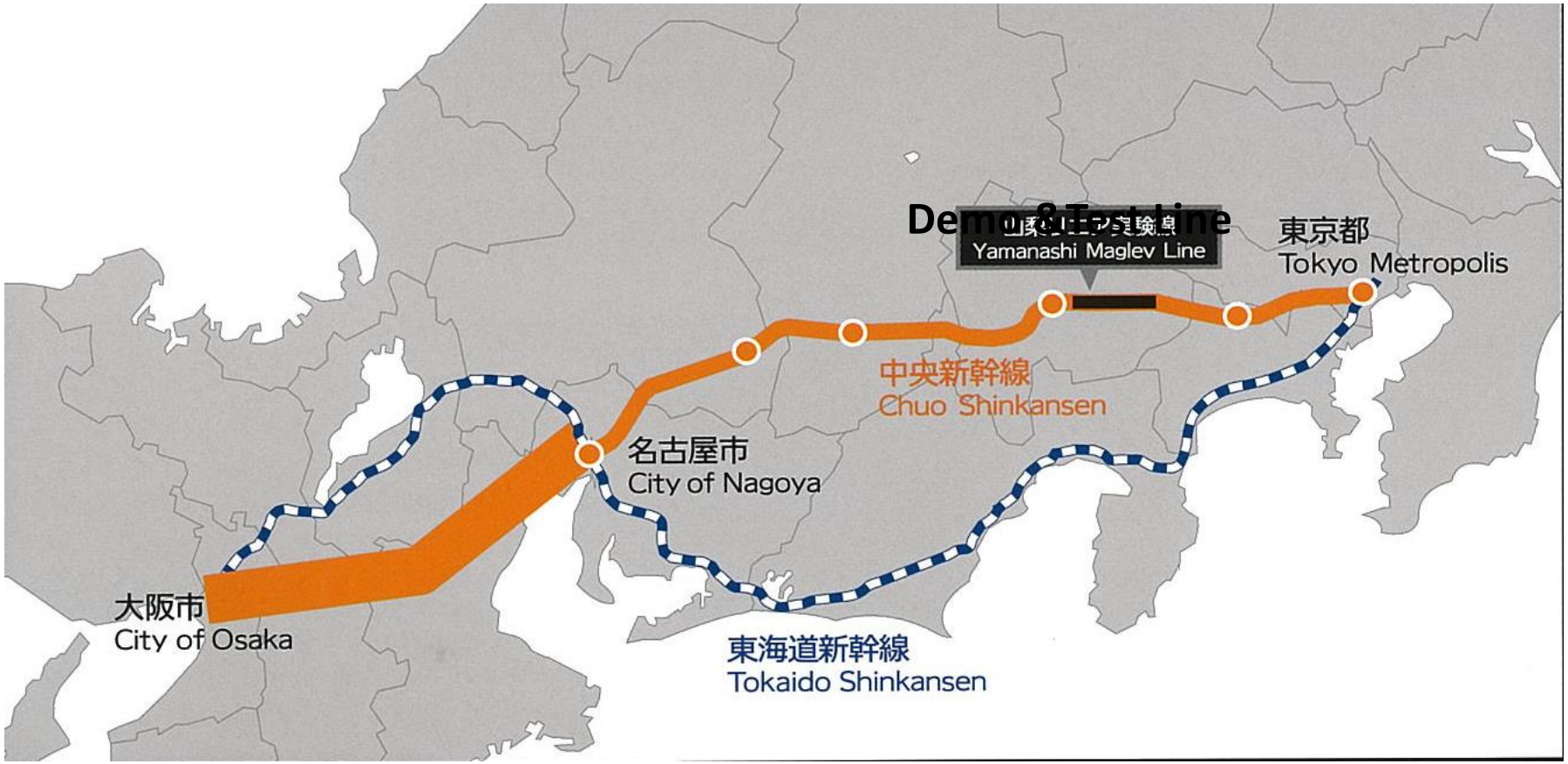
SDM System Design And Management

Needless to Say

- A complex system of systems. ***A wholeness matters***
- Sub-systems included:
  - Rail/material, length and curves
  - Power conversion/feeding (pantograph design)
  - Power line wiring (its tensility)
  - Signal systems
  - Reduction of vibration and hazardous side effects
  - Maintenance and maintainability
  - ***Moral and Skills of workers and drivers***


And Near Future

Next Challenge: **Maglev**



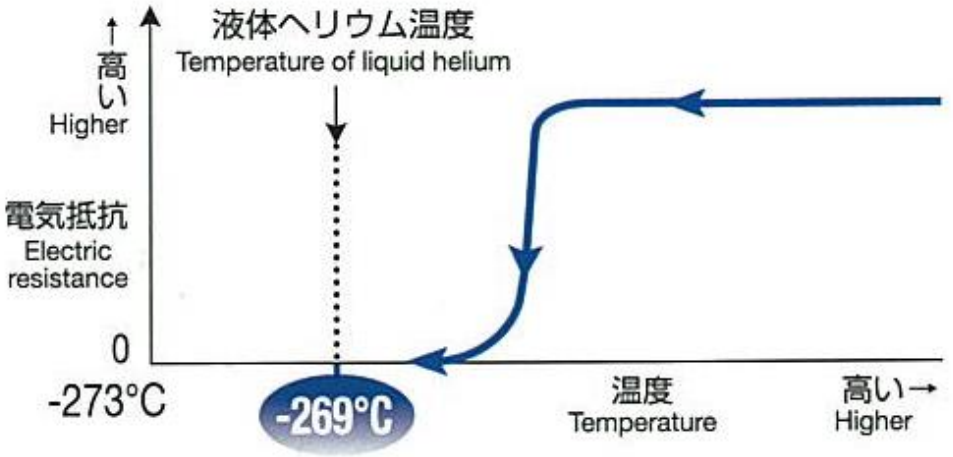
Target: 500 km/h to run Tokyo/Osaka in 67 min.
And Provision against E/Q, Tsunami & Eruption

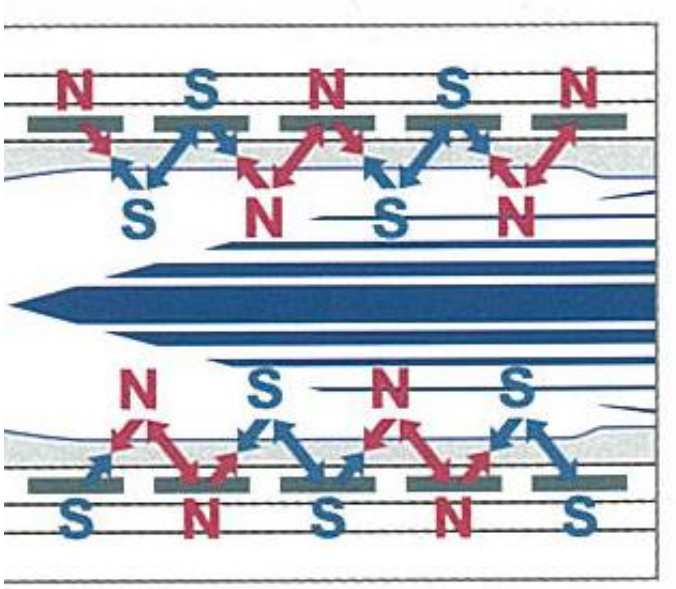
What about Innovation?

- Use of ***superconductor technology*** to produce extremely strong magnetic field (the difference from using strong permanent magnets in normal atmosphere)
- Use of interaction between strong magnetic field and ***electric coils on the ground***
- Adoption of linear motor principle with coils distributed on ground and strong magnets installed in the vehicle

Note: Figures captions in the following slides are taken from pamphlet "LINEAR GUIDE" published by JR Tokai.

Propulsion System

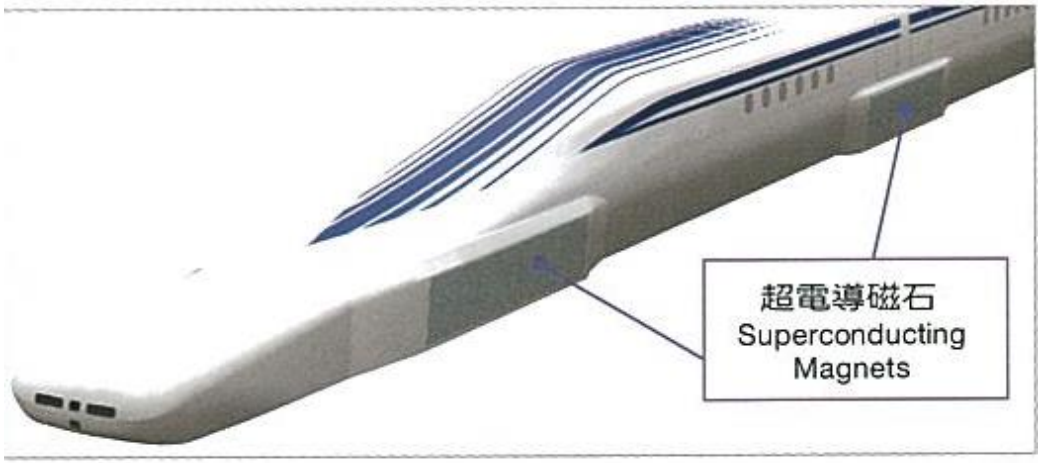


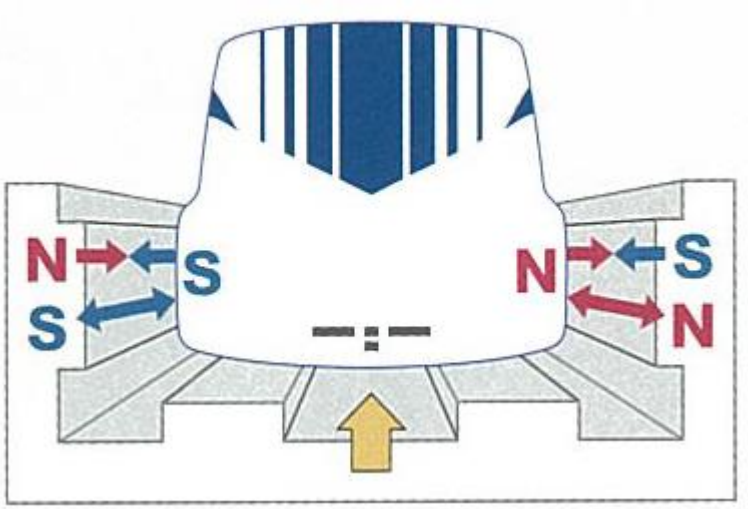


Propulsion force is produced by interaction (repulsive or propulsive) between Propulsion Coils on the ground and Superconducting Magnets built in the vehicle.

Ref.: “LINEAR GUIDE” published by JR Tokai.

Levitation System

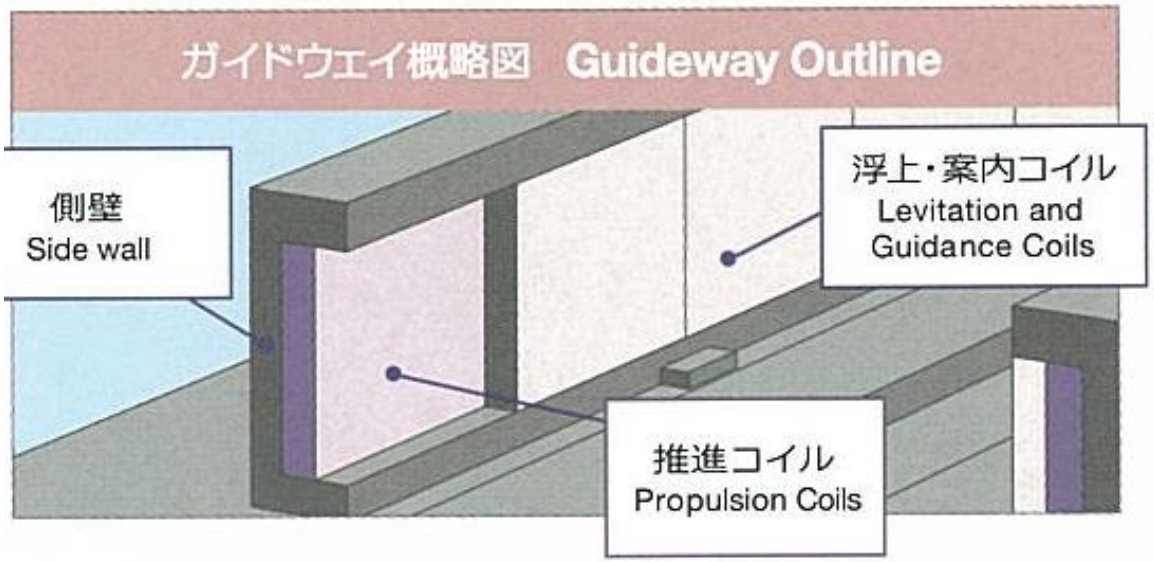


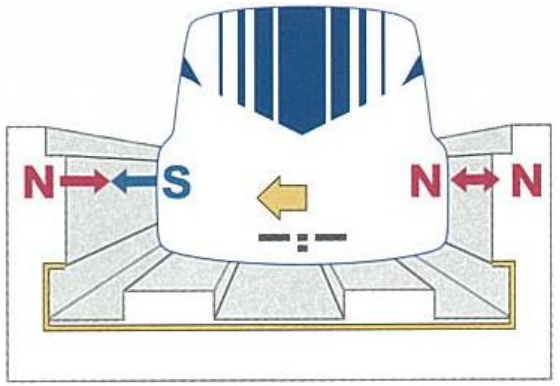


Levitation and Guidance forces are produced by interaction (repulsive or propulsive) between Guideway Track on the ground and Superconducting Magnets built in the vehicle when it passes through at high speed..

Ref.: “LINEAR GUIDE” published by JR Tokai.

Levitation & Guidance





Levitation & Guidance Coils on the guideway keep the vehicle by attractive force (far side) and repulsive force (near side) to keep the vehicle in the center of the guideway.

Ref.: “LINEAR GUIDE” published by JR Tokai.

Test Vehicle Open to Public

SDM System Design And Management

Passengers Can Feel Maglev marked 500 km/h

And What Next?

HYPERLOOP-type transportation using Submerged Floating Tube(SFT)

- *Development of SFT*
- *Channel between Korea and Japan*