Japan International Cooperation Agency (JICA)
Vietnam Railways

Study for the Formulation of High Speed Railway Projects on Hanoi-Vinh and Ho Chi Minh-Nha Trang Section

Technical Report No.7
Test Tracks
Technical Discussions on Semi-High Speed Railways
Work Shop

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Ⅰ. Test Tracks

1. Policy on the discussion of test tracks

Prior to starting the construction work of a high-speed railway, we select, discuss and compare five sections that are independently operable for revenue service and propose one appropriate for test runs. Based on the subjects of phased improvement and other issues, we will also discuss in this process the viability of the operation of passenger and freight trains on the same track from technical viewpoints and economy of the section at the initial stage and after implementation of improvement measures.

1-1 Sections for discussion

The principal purpose of the test track is to transfer technologies required for the management of high-speed railways, including implementation/control of train operation, marketing for railway businesses and upkeep/control of equipment/facilities, prior to the construction of two prioritized sections (284 km-long Hanoi (Ngoc Hoi)− Vinh section for north and 366 km-long HCMC (Thu Thiem) − Nha Trang section for south).

At the initial stage, we had already assumed two candidate test tracks: Hanoi (Ngoc Hoi) - Phu Ly section (Phu Ly line, 45.6 km in length) and HCMC (Thu Thiem) − Long Thanh section (Long Thanh line, 36.1 km in length), each existing in the northern and southern sections.

As these candidate test tracks will be included in the two prioritized sections, they can be appropriated to a part of revenue service lines after the construction work in the future. The routes envisaging development in the future will also be used for high-speed test runs. Furthermore, even the revenue service within the test run sections alone is assumed to attract passengers to some extent, given the large population in the wayside areas.

We have now adopted three test track candidates more for discussion: Hanoi urban railway line 6 (Noi Bai line), Hanoi − Hai Phong intercity railway line (Hai Phong line) and HCMC− Vung Tau intercity railway line (Vung Tau line). As these lines are in cities or in suburban districts, they require construction at comparatively early stages and imply transport demands to a certain extent even for revenue service operation within test track sections. See Table 1.1.1 for particulars of these five candidate test tracks.

Table1.1.1 Outline of candidate test tracks

No.	Section	Length	Major cities and population in wayside areas (10,000 persons)	
1	Phu Ly line Hanoi (Ngoc Hoi)−Phu Ly	45.6 km	Hanoi Phu Ly	670 8
2	Long Thanh line HCMC(Thu Thiem)−Long Thanh	36.1 km	HCMC Bien Hoa Long Thanh	780 80 20
3	Hai Phong line Hanoi (Gia Lam)−Hai Phong	89.5 km	Hanoi Hai Duong Hai Phong	670 32 190
4	Vung Tau line HCMC(Thu Thiem)−Vung Tau	77.4km	HCMC Vung Tau	780 32
5	Noi Bai line Hanoi (Ngoc Hoi)−Noi Bai	47.3 km	Hanoi	670

Source: Study Team

1-2 Method of discussion

1) Policy of discussion

The policy of discussion is as follows. Namely, we:

- No new estimation of the demand in the future, as it is not directly relevant to the appropriateness of test tracks.
- Assume operation of one to two trains per hour.
- Assume two six-car train sets for test runs.
- Adopt the HSR standards for equipment/facilities (tracks, stations, maintenance depots and electricity-related facilities) except for the Noi Bai line.
- Adopt unit prices in the “Study for the Formulation of High Speed Railway Projects on Hanoi-Vinh and HCMC- Nha Trang Sections” (hereafter referred to as “HSR-FS”) to calculate project costs except for Noi Bai line.
- Adopt work quantities for the Phu Ly and Long Thanh lines as per HSR-FS.
- Calculate work quantities separately anew for the Hai Phong, Vung Tau and Noi Bai lines.

2) Conditions of the test track (style/structure of transport and view into the future)

The style/structure of transport and view into the future on the test track are as follows.

- As a railway to transport passengers and freights (principally containers), we set the maximum train speed at 160 to 200 km/h at the initial stage and target 350km/h in the future except for the Noi Bai line.
- Regarding the Noi Bai line, we aim at train speed as high as possible by assuming a line profile of the Hanoi urban railway line 6.

- We start revenue service on the test track at the final stage of test runs and assume operation of HSR trains in the future.

1-3 Route plans

1) Routes

We plan routes as follows.

- We appropriate the route plans in HSR-FS as they are for the Phu Ly and Long Thanh lines.
- For the Noi Bai line, we adopt the route planned for the Hanoi urban railway line 6.
- We adopt new route plans for the Hai Phong and Vung Tau lines.

2) Concepts of route selection

We select routes based on the following concepts.

(1) Location of terminal stations

- We make efforts to locate terminal stations at city centers to esteem the convenience of passengers. This policy doesn't prevent locating terminal stations in suburban areas, however, in consideration of the difficulty/easiness of land acquisition and approaches to terminal stations.
- As a result of the policy in the foregoing paragraph, the Ngoc Hoi station or a railway node in Hanoi will play the role of a terminal for the Phu Ly and Noi Bai lines and Gia Lam the role of a terminal of the Hai Phong line.
- The HCMC Central station for the Long Thanh and Vung Tau lines is placed at Thu Thiem that is close to the city center and features convenient road accessibility.

(2) Location of intermediate stations

- As the distances between adjacent stations of HSR are assumed to be 40 to 50 km long, we determined to place intermediate stations between adjacent two stations, one at Hai Duong on the Hai Phong line where it crosses an existing railway and another at Phu My on the Vung Tau line where an industrial part exists.

(3) Routes between stations

- We adopt the routes planned in HSR-FS as they are for the Phu Ly and Long Thanh lines as mentioned above.
- For the Hai Phong line, we basically adopt a route along the existing line while assuming HSR whose minimum radius of curve R = 6,000 m, to avoid residential areas, industrial zones, parks, greenbelts and temples.
- For the Vung Tau line, we adopt a route to pass Phu My where an industrial park exists while assuming HSR whose minimum radius of curve R = 6,000 m, to avoid residential areas, industrial zones, parks, greenbelts and temples.

(4) Maintenance depots

- We place a maintenance depot at Thu Thiem as planned in HSR-FS for the Vung Tau line and one each for other lines at a large open space close to a terminal.

3) Basic dimensions of the selected routes

(1) Minimum radius of curve

- R = 6,000 m in principle.

(2) Maximum gradient

- The standard maximum gradient of Shinkansen (15‰)

(3) Train composition and lengths of trains/stations

- We prepare two six-car train sets for the test track. As the prices of rolling stock, we use the data in HSR-FS. The length of stations will be 260 m (equal to that of HSR).

(4) Maintenance depots

- We use the data in the JICA North-South HSR FS for the track layout and equipment/facilities.

4) Calculation of the project cost

- Regarding the project cost, we apply the unit costs of large-scale construction work categories in HSR-FS except for the Noi Bai line. We also count consulting fees, contingencies and taxes in the project cost.

2. Study results

We discuss below the special features and plan views of lines and present tables of structures and the project cost of each candidate route.

2-1 Phu Ly line

1) Feature of line

- This is a preceding section for a future high-speed railway.
- There are urban development plans considering the future HSR route.
- The route is short featuring comparatively low construction costs.
- The population in the wayside areas is small (e.g., 80,000, Phu Ly city).
- Large demands cannot be expected.
- The priority order of the project is low when viewed separately from others.
- Lands for the project shall be purchased.

2) Route map

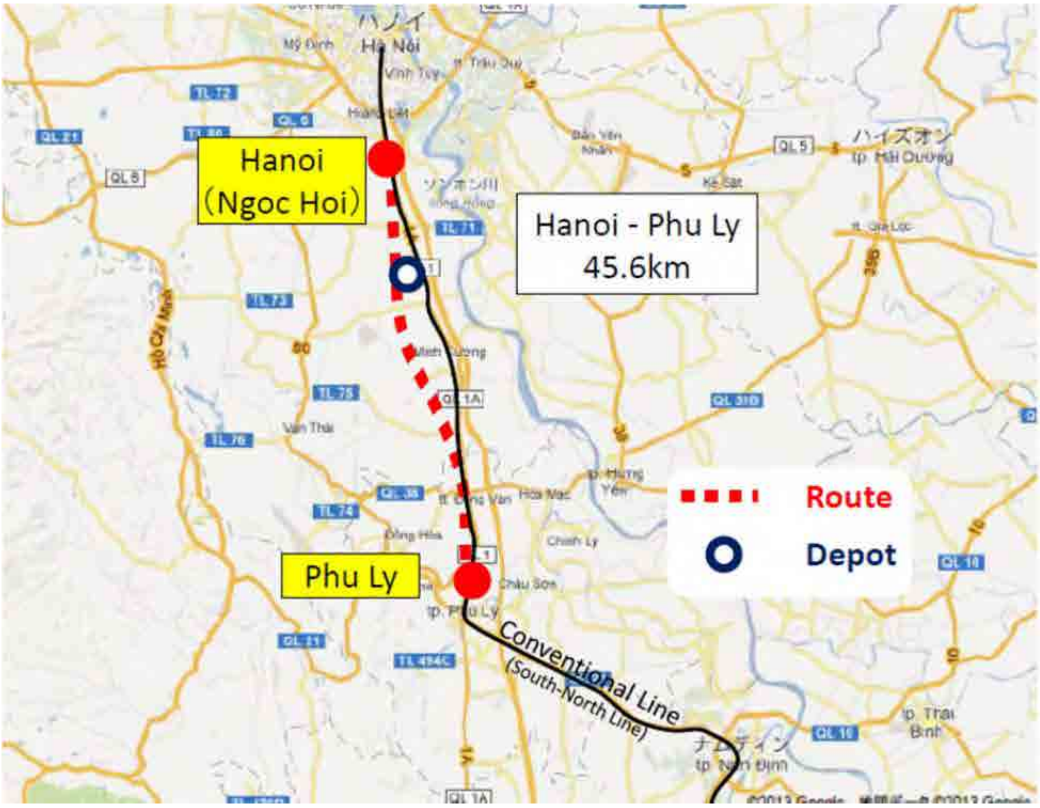


Fig. 2.1.1 Route map, Phu Ly line

Source: Study Team

3) Table of structures

Table 2.1.1 Structures, Phu Ly line

Section / Structure	Phu Ly line (Ngoc Hoi – Phu Ly)	
	Length (km)	Ratio (%)
Embankment	11.8	25.4
Cut	0.0	0.0
Viaduct	32.3	69.4
Bridge	0.9	2.0
Box culvert	0.2	0.5
Tunnel	0.0	0.0
Station	1.30	2.7
Total	46.4	100.0

Source: Study Team

4) Project cost

Table 2.1.2 Project cost, Phu Ly line (1 USD = 21,000 VND, 1 USD = 78 JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	12,304	65	1,367	651
2	Tracks	1,093	75	8,652	127
3	Stations	3,091	14	903	158
4	Power System	839	323	26,103	363
5	Signal and Telecommunications	218	163	12,747	173
6	Maintenance Depot and Workshop	1,077	63	3,402	114
	Subtotal (1-6)	**18,551**	**703**	**53,174**	**1,586**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	109	26
	Subtotal (1-8)	**18,987**	**729**	**53,724**	**1,633**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	28,140	0	0	134
	Subtotal (1-10)	**47,127**	**786**	**54,921**	**1,824**
11	Consulting service	759	28	2,131	64
12	Contingency (5%)	987	37	2,771	83
13	Tax	949	0	0	45
14	Total	**49,824**	**851**	**59,823**	**2,016**
	Project Cost per km	**1073.8**	**18.3**	**1289.3**	**43.4**

Source: Study Team

2-2 Long Thanh line

1) Feature of line

- This is a preceding section of the future North-South HSR
- Connection to the airport implies demands to some extent (related to the inauguration of the Long Thanh airport)
- The estimated demand for the airport is 141 thousand passengers per day in2030 and 35 thousand of them use the test line[1].
- Priority of the project is high.
- The route is short featuring comparatively low construction costs.
- Implementation of the project is governed by the progress of new airport project.
- Lands for the project shall be purchased.

2) Route map

Fig.2.2.1 Route map, Long Thanh line

Source: Study Team

[1] HSR-FS Summary Page 15-7

3) Table of structures

Table 2.2.1 Structures, Long Thanh line

Structure \ Section	Long Thanh line (Thu Tiem – Long Thanh)	
	Length (km)	Ratio (%)
Embankment	5.6	14.9
Cut	4.6	12.3
Viaduct	23.4	62.8
Bridge	1.6	4.3
Box culvert	0.1	0.3
Tunnel	0.0	0.0
Station	2.0	5.4
Total	37.2	100.0

Source: Study Team

4) Project cost

Table 2.2.2 Project cost, Long Thanh line (1 USD = 21,000 VND, 1 USD = 78 JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	9,601	51	1,067	508
2	Tracks	870	60	1,251	101
3	Stations	4,185	20	414	219
4	Power System	813	313	6,579	352
5	Signal and Telecommunications	189	141	2,961	150
6	Maintenance Depot and Workshop	1,276	74	1,559	135
	Subtotal (1-6)	**16,934**	**659**	**13,831**	**1,465**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	109	26
	Subtotal (1-8)	**17,371**	**685**	**14,381**	**1,512**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	5,880	0	0	280
	Subtotal (1-10)	**23,251**	**742**	**15,578**	**1,849**
11	Consulting service	695	26	553	59
12	Contingency (5%)	869	33	697	75
13	Tax	869	0	0	41
14	Total	**25,682**	**801**	**16,829**	**2,024**
	Project Cost per km	**690.4**	**21.5**	**454.2**	**54.4**

Source: Study Team

2-3 Hai Phong line

1) Feature of line

- The large population in the wayside areas (e.g., 320,000, Hai Duong city; 1,900,000, Hai Phong city) implies large demands.
- The line plays a role of transport between cities and within urban areas.
- 8 passenger trains and 12 freight trains for each direction go and return between Hanoi and Hai Phong per day.
- This time, the line is added as an alternative test line.
- Coordination with freight transport is required.
- Lands for the project shall be purchased.
- Nodes to future nationwide HSR networks are not decided yet.

2) Route map

- The Gia Lam station, Hai Phong line, is determined to be a terminal in Hanoi in consideration of the plan of Hanoi urban railway line 1.
- The new terminal on the Hai Phong side has been selected in consideration of freight transport and the situation that connection to the existing Hanoi station is difficult due to the non-availability of lands and difficulty of land purchase.
- We plan an intermediate station at Hai Duong and a maintenance depot at an open space close to the Gia Lam station.

Fig. 2.3.1 Route map, Hai Phong line

Source: Study Team

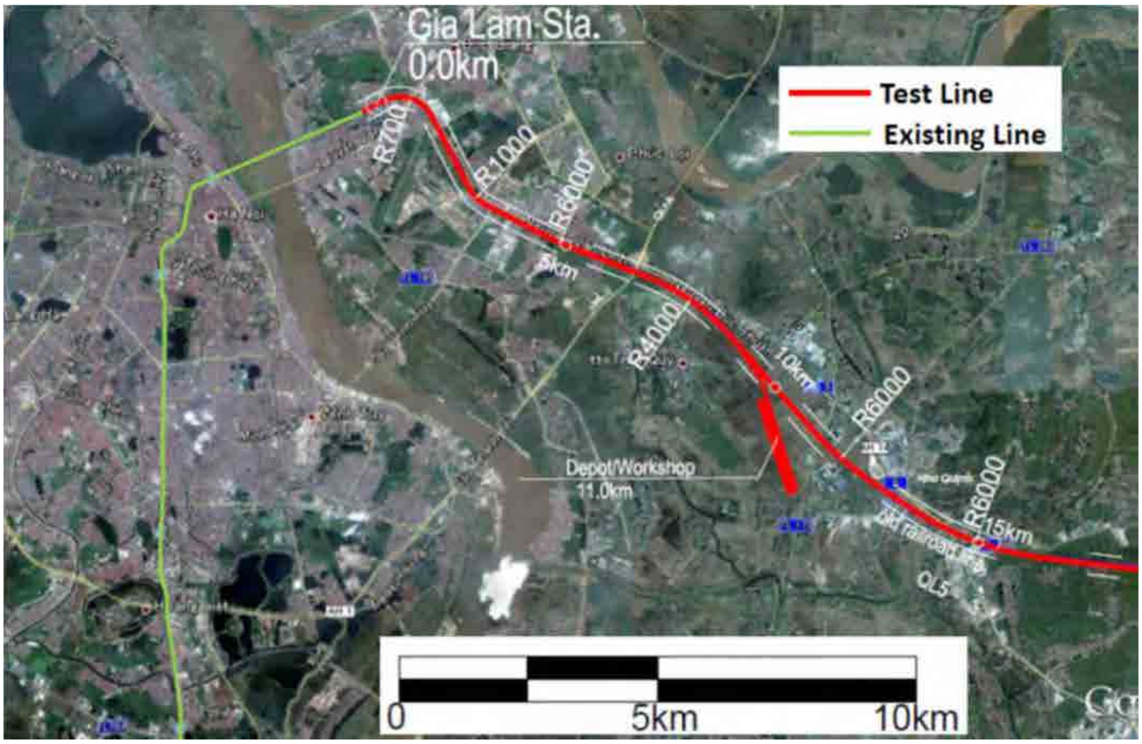


Fig. 2.3.2 Route map, Gia Lam area

Source: Study Team

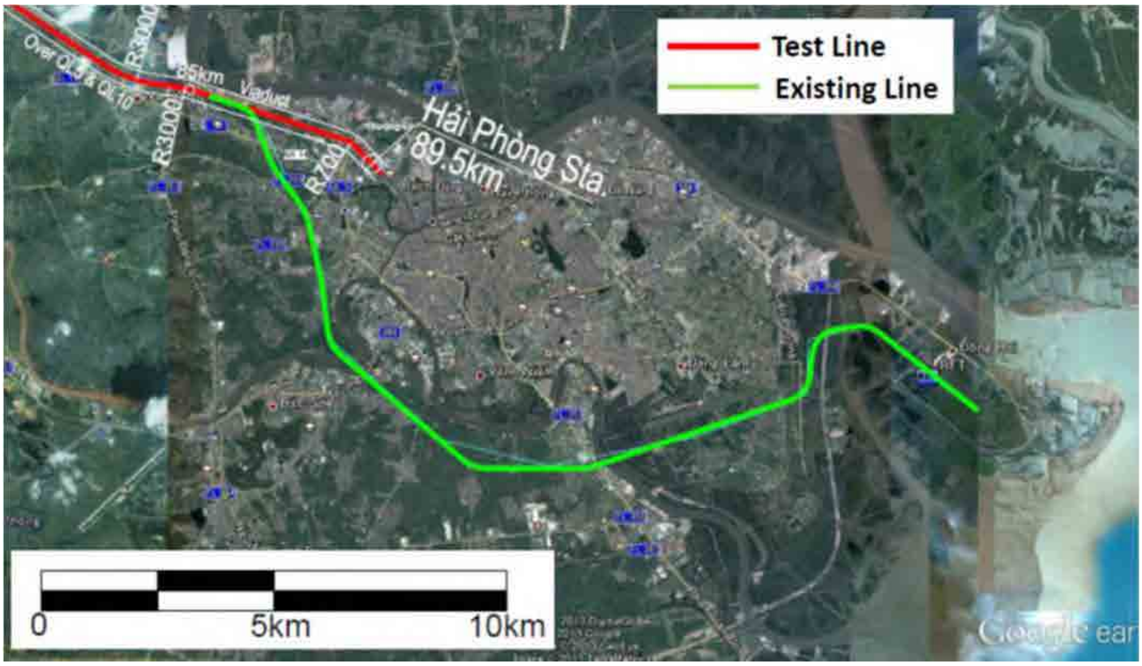


Fig. 2.3.3 Route map, Hai Phong area

Source: Study Team

3) Table of structures

Table 2.3.1 Structures, Hai Phong line

Structure \ Section	Hai Phong line (Gia Lam − Hai Phong)	
	Length (km)	Ratio (%)
Embankment	27.7	30.7
Cut	0.0	0.0
Viaduct	42.3	46.9
Bridge	17.8	19.8
Box culvert	0.7	0.8
Tunnel	0.0	0.0
Station	1.6	1.8
Total	90.1	100.0

Source: Study Team

4) Project cost

Table 2.3.2 Project cost, Hai Phong line (1USD=21,000VND,1 USD=78JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	28,942	153	3,216	1,531
2	Tracks	1,010	69	1,453	117
3	Stations	4,273	20	423	224
4	Power System	1,026	395	8,302	444
5	Signal and Telecommunications	254	190	3,984	202
6	Maintenance Depot and Workshop	1,143	67	1,398	121
	Subtotal (1-6)	**36,648**	**894**	**18,775**	**2639**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	109	26
	Subtotal (1-8)	**37,085**	**920**	**19,325**	**2,686**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	4,305	0	0	205
	Subtotal (1-10)	**41,390**	**977**	**20,522**	**2,948**
11	Consulting service	1,483	36	755	107
12	Contingency (5%)	1,928	47	982	139
13	Tax	1,854	0	0	88
14	Total	**46,656**	**1,060**	**22,259**	**3,282**
	Project Cost per km	**517.8**	**11.8**	**247.0**	**36.4**

Source: Study Team

2-4 Vung Tau line

1) Feature of line

- Demands for tourism are expected (140 thousand foreigners out of 3.3 million tourists in 2000).
- Vung Tau is a base town for offshore oil drilling.
- Population is small in wayside areas.
- Currently it is a 90-minutes trip by speedboat and 3-hour trip by bus to the town from HCMC.
- Now there is not enough technical information related to the line.
- Lands shall be purchased.
- Nodes to future nationwide HSR networks are not decided yet.

2) Route map

- We determined the Thu Thiem station in HSR-FS as a terminal, planned the Vung Tau station at an open space in the city and selected the Phu My station as an intermediate station in consideration of the commuter transport and freight transport to the industrial park.
- We selected a route having a few interferences (buildings) along national highway (NH51).

Fig. 2.4.1 Route map, Vung Tau line

Source: Study Team

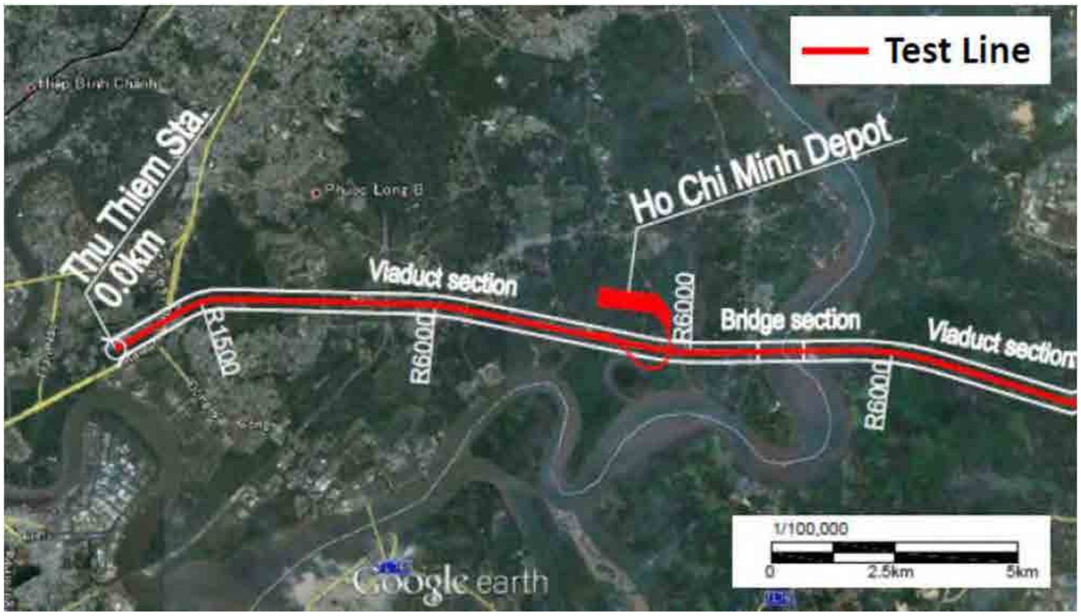


Fig. 2.4.2 Route map, Thu Thiem area

Source: Study Team

Fig. 2.4.3 Route map, Vung Tau area

Source: Study Team

3) Table of structures

Table 2.4.1 Structures, Vung Tau line

Structure \ Section	Vung Tau line (Thu Thiem − Vung Tau)	
	Length (km)	Ratio (%)
Embankment	32.1	41.5
Cut	0.0	0.0
Viaduct	33.7	43.5
Bridge	9.2	11.9
Box culvert	0.8	1.0
Tunnel	0.0	0.0
Station	1.6	2.1
Total	77.4	100.0

Source: Study Team

4) Project cost

Table 2.4.2 Project cost, Vung Tau line (1USD=21,000VND, 1USD=78JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	20,643	109	2,294	1,092
2	Tracks	833	57	1,198	97
3	Stations	4,934	23	488	258
4	Power System	881	340	7,132	382
5	Signal and Telecommunications	218	163	3,423	173
6	Maintenance Depot and Workshop	2,117	123	2,587	224
	Subtotal (1-6)	**29,626**	**815**	**17,122**	**2,226**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	109	26
	Subtotal (1-8)	**30,063**	**842**	**17,672**	**2,273**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	3,612	0	0	172
	Subtotal (1-10)	**33,675**	**899**	**18,869**	**2,502**
11	Consulting service	1,203	33	689	90
12	Contingency (5%)	1,563	43	896	117
13	Tax	1,503	0	0	72
14	Total	**37,944**	**974**	**20,454**	**2,781**
	Project Cost per km	**490.2**	**12.6**	**264.3**	**35.9**

Source: Study Team

2-5 Noi Bai line

1) Feature of line

- The dual role to implement transport in urban areas and function as an airport access railway implies demands to some extent.
- 9 million people used the airport in 2010.
- As the line alignment is constrained though railway lands are available, high-speed operation is difficult. (The minimum curve radius of existing line is 600 m apart from the both end stations.)
- Lands shall be purchased in consideration of the development plans in the future as the line will possibly be a North-South axis of a trunk line in Hanoi.
- Coordination with freight transport is required.

2) Route map

Fig. 2-5-1 illustrates a route map, Noi Bai line.

Fig. 2.5.1 Route map, Noi Bai line

Source: Study Team

3) Line layout

- The route is to have two double tracks, one is a test line and the other is a dedicated freight line, as it is not possible to suspend freight transport on this route.
- The freight line is double tracked at ground level by widening embankment to the west of the existing line.
- The whole section of the test line is elevated along the freight line except a part of it near to the airport which is to be underground.
- The test line has 9 passenger stations including the two in the airport area.

Fig. 2.5.2 Current track layout of Noi Bai Line

Source: Study Team

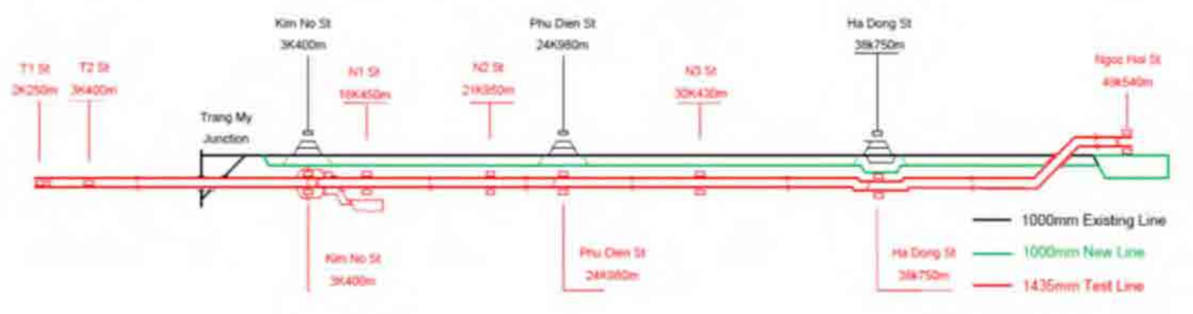


Fig. 2.5.3 Route map, Noi Bai line

Source: Study Team

4) Speed

- We assume non-stop train operation in designing the line, of which a 9 km-section allows operation at 160 km/h or over and a 4 km-section at 200 km/h or over.

5) Table of structures

Table 2.5.1 Structures, Noi Bai line

Section / Structure	Noi Bai line (Ngoc Hoi −Noi Bai)	
	Length (km)	Ratio (%)
Embankment	0.1	0.3
Cut	0.3	0.6
Viaduct	38.4	80.7
Bridge	1.7	3.6
Box culvert	0.0	0.0
Tunnel	5.1	10.7
Station	2.0	4.1
Total	47.5	100.0

Source: Study Team

6) Project cost

Table 2.5.2 Project cost, Noi Bai line (All)

(1 USD=21,000VND, 1 USD=78JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	19,330	102	21,478	1,023
2	Tracks	1,245	85	3,038	145
3	Stations	2,325	11	2,555	122
4	Power System	360	139	3,273	156
5	Signal and Telecommunications	573	427	9,549	455
6	Maintenance Depot and Workshop	1,675	98	3,723	177
	Subtotal (1-6)	**25,513**	**862**	**43,626**	**2,077**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	546	26
	Subtotal (1-8)	**25,950**	**889**	**44,613**	**2,124**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	851	0	851	41
	Subtotal (1-10)	**26,801**	**946**	**46,660**	**2,222**
11	Consulting service	1,038	35	1,767	84
12	Contingency (5%)	1,349	45	2,297	109
13	Tax	1,297	0	2,209	105
14	Total	**30,486**	**1,026**	**52,933**	**2,521**
	Project Cost per km	**644.5**	**21.7**	**1,119.1**	**53.3**

Source: Study Team

Table 2.5.3 Project cost, Noi Bai line (Test line only)

(1 USD = 21,000 VND, 1 USD = 78 JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	18,996	101	21,107	1,005
2	Tracks	1,039	71	2,535	121
3	Stations	2,325	11	2,555	122
4	Power System	360	139	3,273	156
5	Signal and Telecommunications	335	250	5,557	266
6	Maintenance Depot and Workshop	1,675	98	3,723	177
	Subtotal (1-6)	**24,730**	**669**	**38,770**	**1,846**
7	Maintenance Equipment	0	21	441	21
8	Equipment for Training	437	5	546	26
	Subtotal (1-8)	**25,167**	**695**	**39,757**	**1,893**
9	Rolling stocks	0	57	1,197	57
10	Land Acquisition and Compensation	711	0	711	34
	Subtotal (1-10)	**25,878**	**752**	**41,665**	**1,984**
11	Consulting service	1,007	27	1,573	75
12	Contingency (5%)	1,309	35	2,044	97
13	Tax	1,258	0	1,966	94
14	Total	**29,452**	**814**	**47,248**	**2,250**
	Project Cost per km	**622.7**	**17.2**	**998.9**	**47.6**

Source: Study Team

Table 2.5.4 Project cost, Noi Bai line (Freight line only)

(1 USD = 21,000 VND, 1 USD = 78 JPY)

	Item	Domestic currency	Foreign currency		Total
		Bil.VND	Mil.USD	Bil.VND	Mil.USD
1	Civil Works and Structure	334	2	372	18
2	Tracks	210	14	513	24
3	Stations				
4	Power System				
5	Signal and Telecommunications	238	178	3,971	189
6	Maintenance Depot and Workshop				
	Subtotal (1-6)	**783**	**194**	**4,856**	**231**
7	Maintenance Equipment				
8	Equipment for Training				
	Subtotal (1-8)	**783**	**194**	**4,856**	**231**
9	Rolling stocks				
10	Land Acquisition and Compensation	140		140	7
	Subtotal (1-10)	**923**	**194**	**4,996**	**238**
11	Consulting service	31	8	194	9
12	Contingency (5%)	41	10	252	12
13	Tax	39		243	12
14	Total	**1,034**	**212**	**5,685**	**271**
	Project Cost per km	**21.9**	**4.5**	**120.2**	**5.7**

Source: Study Team

3. Comparison between alternative ideas

3-1 Summary of project costs and other particulars

Table 3-1 shows a summary of project costs and other particulars.

Table 3.1.1 A summary of project costs and other particulars

Section/Length		Approximate project cost (per km)	Estimated demands	Line characters	Major cities in wayside areas (population)
1	Phu Ly line Ngoc Hoi−Phu Ly 45.6km	157 billion yen (3.39 billion yen)	The small wayside population implies only meager demands.	• Part of the North-South HSR • A suburban railway in the Hanoi Metropolitan zone	Hanoi (6.7 million) Phu Ly (80 thousand)
2	Long Thanh line Thu Thiem−Long Thanh 36.1km	158 billion yen (4.24 billion yen)	Airport access demands can be expected to some extent.	• Part of the North-South HSR • A Long Thanh New Airport access railway	HCMC (7.8 million) Long Tan (200 thousand) Bien Hoa (800 thousand)
3	Hai Phong line Gia Lam−Hai Phong 89.5km	256 billion yen (2.84 billion yen)	The large wayside population implies demands for suburban transport.	• Intercity transport from Hai Phong to Hanoi	Hanoi (6.7 million) Haiphong (1.9 million)
4	Vung Tau line Thu Thiem−Vung Tau 77.4km	217 billion yen (2.8 billion yen)	Large demands cannot be expected except for tourism.	• An access railway to resort tourist spots	HCMC (7.8 million) Vung Tau (320 thousand)
5	Noi Bai line Ngoc Hoi–Noi Bai 47.3km	194 billion yen (4.1 billion yen)	Demands are expected for transport in cities and for airport access.	• A suburban railway in the Hanoi Metropolitan zone • A Noi Bai airport access railway	Hanoi (6.7 million)

Source: Study Team

3-2 Table of comparison between alternatives

Table 3.2.1 compares different alternatives.

Table 3.2.1 Comparison between alternatives (1)

Alternative \ Evaluation item	Profitability of project	Presentation of performance to the nation	Viability of high-speed operation in the future	Availability of survey results	Position in the domestic plans of Vietnam	Possibility of early launching (project costs, FS and others)	Easiness of land acquisition	Operability of freight/baggage transport
Phu Ly line	△	△	○	○	○	○	○	×
Long Thanh line	○	○	○	○	○	○	○	○
Hai Phong line	△	○	○	△	△	△	△	○
Vung Tau line	△	△	△	×	△	×	△	○
Noi Bai line	○*	○	×	△	○*	○	○	○

* Evaluation as urban railways

Source: Study Team

Table 3.2.2 Comparison between alternatives (2)

Alternative	Merit	Demerit	Overall evaluation
Phu Ly line	1) High speed operation is possible	1) Demands cannot be expected much from this section alone	1) The project cost is the lowest 2) The section constitutes part of the North-South HSR 3) There are few large cities in wayside areas, from which large demands cannot be expected
Long Thanh line	1) High speed operation is possible 2) This section is usable for airport access	1) Launching is governed by the progress of the airport project 2) Lands shall be acquired in quantities	1) The short section requires only a small project cost 2) The section constitutes part of the North-South HSR 3) Demands can be expected for airport access transport
Hai Phong line	1) High speed operation is possible in the future	1) Surveys assuming a HSR have been inadequate 2) Project costs are high 3) Coordination is required with freight transport 4) Lands shall be acquired in quantities	1) The section deviates from the North-South HSR 2) Demands can be expected to some extent
Vung Tau line	1) Demands for tourism are expected	1) Existing surveys on railways have been inadequate 2) There are few needs for a HSR 3) Lands shall be acquired in quantities	1) Demands cannot be expected much 2) There will be few needs for a HFR in the future
Noi Bai line	1) Construction as an urban railway is prescribed in the master plan 2) Lands for railway use can be appropriated	1) Coordination is required with freight transport 2) The line profile doesn't suit high-speed operation	1) Existing lands for railway use are available 2) The line profile doesn't suit a HSR 3) We recommend to construct it as an urban railway and discuss through-operation of HSRs

Source: Study Team

4. Conclusion and proposal

We discussed above the appropriateness of candidate sections as a test track on the two sections (Long Thanh and Phu Ly lines) proposed in the HSR FS and three other alternatives: Hai Phong, Vung Tau and Noi Bai lines, each having both advantages and disadvantages to make differentiation difficult in decisive terms. If we dare to select one, the Long Thanh line may be the most appropriate.

As the purpose of the test track is to acquire relevant technologies in advance of the construction and operation of HSR on a full scale, we recommend, therefore, that a test-run section be constructed as soon as possible.

Ⅱ. Technical Discussions on Semi-High-Speed Railways

1. Summary

Regarding the standard-gauge semi-high-speed railway to run trains at a maximum speed of approximately 160km/h, we discuss below operating passenger trains and freight trains on the same line (hereinafter referred to as “mixed-train operation”), technical viability of speedup to 300 km/h or over in the future and economy at initial and improvement stage.

1-1 Backgrounds of discussion

Regarding the plan to construct a North-South high speed railway to connect Hanoi and HCMC in Vietnam, following questions have been raised by the Vietnam side.

- Only the passenger transportation is proposed on the new standard gauge track. Isn’t it possible to operate freight trains on the same track?
- The railway will be used to run trains at 160 km/h or less for the time being. Is it possible, however, to improve it to a high-speed railway to run trains at 300 km/h or over in the future?

We will present below our remarks on these questions from technological viewpoints and try to make the reports submitted by the Study Team in the past understood among Vietnamese personnel.

1-2 Method of discussion

Approximately two centuries have passed since the first railway in the world was inaugurated in the UK. In the meantime, railways have made remarkable development in great strides, with high-density mass transport having been realized in large cities and high-speed trains running at 300 km/h or over between cities. This development has been sustained by new powering systems, evolving from steam engines to internal combustion engines and further to electrical driving systems. Furthermore, the improvement of signal systems now guarantees the safety of high-speed and high-density transport.

On the other hand, the fundamental principle of the railway system has remained unchanged at all, in that trains run all the time relying on the friction force between iron rail and wheel. This friction and the centrifugal force generated on curves are based on the provision of nature, in which human wisdom can never intervene. What we can do is only to increase the friction coefficient by using new materials or investigate the frictional phenomena little by little through tests and analyses toward application of improvement measures.

In this chapter, we discuss the possibility of mixed train operation and upgrade in the future to the high speed railway from semi-high speed railway based on the various technical fields. Here, the meaning of semi-high-speed railway is a conventional standard gauge railway of which speed is around 160km/h.

2.Track structures

2-1 Influence of mixed-train operation on structures

1) Track gradient

As heavy-weight freight cars are hauled on the track in freight transport railways, restrictions on the track gradient are severer than in passenger transport railways. Therefore, it is difficult to flexibly change the track height along the topographic elevation. This increases the ground heights of structures and tends to increase construction costs as a result.

2) Passenger stations and freight stations

High-speed railways have a number of specific features. To ensure the safety of running trains for example, such railways have to eliminate level crossings with roads and adopt grade-separated intersections. Elevated structures are common between stations not to obstruct traffic. In consideration of the convenience of transfer to/from other transport facilities, passenger stations are constructed by viaducts in urbanized districts. At these stations, platform floors are distinctly separated from those of passenger concourses.
In the case of freight transport on the other hand, freight stations require large spaces to implement freight transshipment between trains and road vehicles. As it is not practical to construct such stations as a viaduct structure, freight stations are normally located at the ground level distant from passenger stations.
This means that branch lines are required between the elevated main line and distantly-located freight stations. Although it is possible to use the existing meter-gauge freight station as one in common with the high-speed railway, an approach structure is indispensable to the main line viaduct bridge of the high-speed railway.

Fig. 2.1.1Typical freight station (Kyoto Freight Station, Japan)

Source: Brochure of JR Freight

3) Train load

High-speed railway operators have been introducing lightweight rolling stock to save energy and prevent noise and vibration. The axle load of Shinkansen in Japan is approximately 13 tons. In addition, the power distributed traction system currently prevails among high-speed passenger railways across the world. Therefore, the trains of high-speed railways are now composed to avoid extremely heavy loads concentrated at particular points of a train set.

For freight transport, a train is normally composed of a locomotive and power-less freight cars, in which a heavy load concentrates on the locomotive. A 100-ton locomotive can normally haul freight cars having a weight of 1,200 ton in total on normal track gradients. In the case of a locomotive with six driving axles, the axle load is 17 tons. When the weight of freights is 1,600 tons, the weight and axle loads of the locomotive are 130 and 22 tons, respectively.

If we apply double-headed operation, two locomotives can pull 2400 ton with the total locomotive weight of 200 ton and 12 driven axles. Therefore, the axle load can be 17 ton.

The axle load of freight cars can be set arbitrarily in comparative terms. When the axle load is limited to 17 tons, the weight of a four-axle-car can be 68 tons. It is not difficult to make the axle load 17 tons or less by reducing the car length and weight of freights.

Thus, we can consider the design load for freight transport flexibly.

Fig. 2.1.2Simple T-PC 4 main girder bridge (L = 35 m)

Source: Study Team

In accordance with the designing standards in Japan, we calculated the difference in height of a 35m-span PC girder for a typical bridge in the cases of (1) 16-ton axle load high-speed passenger railways and (2) double heading operation by 21-ton axle load locomotives. See Table 2-1-1 for the results. In the latter case, the girder height is approximately 8% higher. As the construction cost is thought to be approximately proportional to the girder height, the value of 8% can be regarded as the component to increase the construction cost when a locomotive having heavier axle loads runs.

Table 2.1.1Comparison of Girder Height
between High-Speed-Rail and Freight-Rail

Item	High-Speed Rail	Freight Rail (D16E)
Vmax	350km/h	100km/h
Axle Load	16tf (Design)	21tf(Actual load)
Car Length	25.0m	16.92m
Girder Height (Japan)	2.6m	2.8m

Note) D16E is a standard gauge diesel locomotive made in China used in Vietnam

Source: Study Team

As mentioned above, when freight trains and high-speed passenger trains are run on the same tracks, the weights of freight train locomotives and bulk freight cars inevitably increase the structure construction cost. To avoid the increase of construction cost, the number of driven axle should be increased by connecting two locomotives, which is called double heading operation or locomotive operation in tandem.

2-2 Possibility of speedup

1) A case of Tokaido Shinkansen

The Tokaido Shinkansen railway was constructed at a design speed of 210 km/h and started revenue service in 1964. The maximum speed of the railway was maintained unchanged for a while, which was increased, however, step by step thereafter, in that it was increased to 220 km in 1985 and further to 270 km/h in 1992. Trains are now running at this speed.

The series of speedups were achieved by improving electric facilities and rolling stock without changing the radius of curve, which is one of the fundamental features of track. The maximum allowable speed is 255 km/h for example, for a track having such dimensions as: radius of curve 2,500 m, actual cant 200 mm and cant deficiency 110 mm. In raising train speed further, the air spring type car body tilting system is now used to compensate for otherwise deteriorated ride comfort. This system tilts the car body inwardly on curves by 1° (equivalent to a cant of 26mm) to subsequently increase the maximum speed to 270 km/h.

2) Maximum speed and radius of curve

Table 2.2.1 shows the relation between the radius of curve and the allowable maximum speed for standard-gauge railways. The trains with maximum speed of 360km/h require minimum curve radius of 6000 m. When Vietnamese people intend to upgrade a semi-high – speed railway to a high-speed-rail of 360 km/h in the future, the curve section of less than 6000m radius must be rerouted.

To raise train speed, it may be possible to adopt a car body tilting system as mentioned above. This method is applicable only to a limited extent, however, while requiring comparatively high rolling stock costs.

Table 2.2.1Radius of curve and train speed

Radius of curve (R) m	Train speed (V) Km/h	Cant (Cm) mm	Cant deficiency (Cd) mm	Length of transition curve (TCL) m
3000	276	200	100	540
4000	319	200	100	620
5000	357	200	100	695
6000	360	196	59	685

Note: Cant and Cant deficiency is fixed considering the safety for the overturning of vehicles.

Source: Study Team

3) Environmental countermeasures

Vietnam shall also consider countermeasures against vibration/noise and micro pressure waves in tunnel caused by high-speed trains.

The noise from viaducts includes various components: noise generated by the current collecting system, aerodynamic noise emitted from rolling stock sub- and super-structures and structure-borne noise. Railway operators in Japan have promoted speedups while implementing noise reduction measures to observe the environment preservation standards, Ministry of the Environment (formerly Environment Agency). For example, current collecting spark noise has been reduced by connecting high-voltage bus lines between pantographs and noise from car body substructures has been lowered by machining rail heads and wheel treads. Nowadays, aerodynamic noise is arousing keen attention among those concerned. Among various countermeasures, the fundamental one is contrivance of new track structures and installation of sound-proof walls. To facilitate application of such countermeasures, it is desirable to reckon in some increases in load beforehand in designing structures. For reference, Fig. 2-2-1 shows a concrete bridge with scenic beauty observing sound-proof balustrades.

Fig. 2.2.1A concrete bridge with scenic beauty observing sound-proof balustrades

Source: Study Team

Furthermore, it is desirable to have lands for tunnel buffering works prepared as a countermeasure against the micro pressure waves caused by high-speed trains running in tunnel. Some people view that tunnel buffering works can be omitted by enlarging the tunnel section. However, the cost to construct a large-section tunnel is prohibitively high. Perhaps for this reason, high-speed railways even in Europe are now adopting tunnel buffering works.

Fig. 2.2.2 A tunnel hood as a countermeasure against micro pressure waves

Source: Brochure of JR East

4) Summary

To prepare for speedups in the future, adopt large radii of curve and make arrangements in advance to allow insertion of considerably long transition curves, as mentioned above.

Be aware of the fact that track control techniques for high-speed railways are different from those for normal railways. As track irregularities of medium and long wavelengths affect ride comfort in the case of high-speed railways, tracks are maintained by 40m-versine and other methods. It is difficult with ballast less track to change cants and settings for medium and long wavelengths, while requiring prohibitive amount of costs. For this reason, it is desirable to consider future development in laying tracks for the semi-high-speed railway.

In case it is inevitable otherwise, adoption of the car body tilting system on rolling stock shall be considered.

3. Power supply system

3-1 Method of discussion on the power supply system

We discuss below the effect of speedups on the power supply system. Equipment/facilities used for the power supply system can broadly be divided into two categories: one for the trolley wire system and the other for substations. To raise train speed, wire tension shall be increased for the former, which little affects the costs of equipment/facilities, however. On the other hand, the latter is related to increases in energy consumption, which requires strengthening substations.

1) Train speed and powering energy

The powering energy E to run a train is proportional to the train weight (mass) m and the square of speed V as given by the following equation.

$$E = mV^2$$

Where:

E: Powering energy
m: Train weight (mass)
V: Train speed

When train speed is raised from 160 to 300 km/h with the train weight unchanged for example, the powering energy approximately 3.5 times as large is required from the calculation of $(\frac{300}{160})^2$=3.516.

2) Capacity of feeding substations

The capacity of the main transformer of feeding substations is determined to satisfy the hourly maximum electric power (KVA) and the short-time (approximately one minute) maximum electric power (KVA) per substation.

(1)Hourly maximum electric power per substation

This value is calculated by multiplying the following values.

i. Total weight of the relevant train
ii. Power consumption rate of the relevant train
iii. Interval between substations
iv. Hourly number of trains running in the up- and down-track directions in the section covered by a substation

For this purpose, read the train operation diagram to obtain the information on the following: a sum of the hourly numbers of trains of different categories (limited express trains, local trains, freight trains and others) operated on the section covered by a substation.

(2) Short-time maximum electric power

To calculate this value, multiply (i) and (ii) and add the product of (iii) and (iv) thereto.

i. Maximum starting current of the relevant train.
ii. Number of trains consuming “the maximum power specific thereto” (hereinafter referred to as “the specific maximum power”)
   Number of trains consuming the specific maximum power in the section (on the up- and down-tracks) covered by a substation
iii. Half of the maximum starting current
iv. Number of trains consuming half of the specific maximum power
   It is not conceivable that trains in the section covered by a substation all require the specific maximum power simultaneously. The number of trains shall be determined, therefore, on the assumption that some trains in the section wound be running while consuming only half of the specific maximum power.

(3) Speedup and installation of substation

As mentioned in the above paragraph 2), the capacity of the main transformer of a substation is determined by the numbers of trains of different categories (limited express trains, local trains, freight trains and others) operated on the up- and down-tracks of the section covered by the substation.

If the distance between stations is so short that notch-ins and notch-offs are required frequently, the power consumption rates of trains will increase even when train speed is low, and vice versa.

Of course, heavy-weight trains consume much power. The maximum starting current is also larger with high-speed trains than with ordinary trains.

When dimensions relevant to the above have been clarified, the capacity of the main transformer can correctly be calculated.

3-2 Application to the North-South high-speed railway in Vietnam

1) Distribution of substations

It is appropriate to distribute substations according to the following plan for the Vietnamese North-South high-speed railway where the maximum train speed is 160km/h at the initial state and 300km/h in the future.

(1) Install substations with their capacities, distance between substations and other particulars determined according to the initial train operation pattern. As substations are to be replaced/renewed normally 30 years later, additional ones will be installed at the time of speedup.

(2) The maximum interval between two substations shall be 65 km in length when voltage

drop is taken into account. Install substations at the maximum interval to ensure a supply voltage over the allowable minimum limit at the initial stage. To raise train speed in the future, install an additional one at the center between the two adjacent substations on each feeding section to cope with the increased load.

2) Substation construction cost

(1) Initial plan (160 km/h operation)

i. Number of substations (SSs):
   Assuming that the total distance is 1726 km same with that of existing line leaving a margin,
   1,726 km / 65 km = 26.5.
   Install 28 substations including one at the starting point.
   The cost to construct 28 substations is, therefore,
   3.5 billion yen/substation x 28 substations = 98 billion yen.

ii. Number of sectioning posts (SPs):
   Install a sectioning post at the center between two substations.
   This requires 27 sectioning posts in total.
   The cost to construct 27 sectioning posts is, therefore,
   0.9 billion yen/sectioning post x 27 sectioning posts = 24.3 billion yen.

iii. Number of sub-sectioning posts (SSPs):
   Install a sub-sectioning post at the center between a substation and a sectioning post.
   This requires 54 sub-sectioning posts in total.
   The cost to construct 54 sub-sectioning posts is, therefore,
   0.6 billion yen/sub-sectioning post x 54 sub-sectioning posts = 32.4 billion yen.
   By summing up the above, we obtain the following initial cost.

   <u>Approximate cost in total: 154.7 billion yen</u>

(2) Amount of additional investment cost at speedup (for 300 km/h operation)

i. Install a substation at the position of existing sectioning post (between substations)
   Installation of 27 new substations
   The cost is 35 billion yen/substation x 27 substations = 94.5 billion yen.

ii. Remodel each sub-sectioning post (equipped with two ATs and located at the center between a substation and a sectioning post) into a sectioning post (equipped with four ATs).
   Remodel 54 sub-sectioning posts as above.
   The remodeling cost is
   0.9 billion yen/sectioning post x 54 sectioning posts = 48.6 billion yen.

iii. Install a sub-sectioning post at the center between a substation and a sectioning post.

This requires 108 sub-sectioning posts anew in total.

The cost to construct 108 sub-sectioning posts is, therefore,

0.6 billion yen/sub-sectioning post x 108 sub-sectioning posts = 64.8 billion yen.

By summing up the above, we obtain the following initial cost.

<u>Approximate amount of additional investment in total: 207.9 billion yen</u>

3) Summary

Of the cost of electric equipment/facilities, what is governed by train speed is the cost to construct substations. When the maximum train speed is 160km/h at the initial stage, which will be raised to 300 km/h in the future, the capacity of substations shall be 3.5 times as much at the time of speedup. This requires an additional cost for investment amounting to a little more than 200 billion yen.

4.Signal and telecommunication equipment/facilities

4-1 Braking distance and the maximum train speed

1) Braking distance

In accordance with “Enforcement of the Ministerial Ordinance on Technical Standards for Railways and a subsequent Ministerial Ordinance [1] on the Enactment of Ministerial Ordinances related to Ministry of Land, Infrastructure, Transport and Tourism”, it is stipulated in Japan that “the standard emergency braking distance of trains except those of Shinkansen shall be 600 m or less”.

The back ground of the stipulation is that the distance over which train drivers can recognize objects with naked eyes to ensure the safety of trains is limited to 600 m in the case of Japanese railways studded with level-crossings.

Furthermore, it is specified that the following minimum signal confirmation distance shall be guaranteed for different signals.

Signal category	Minimum visibility distance (m)
Home, departure, block and distant signals	More than 600m
Call-on signal	More than100m
Shunting signal	More than 200m
Repeating signal	More than 200m
Route indicator (home, departure)	More than 200m
Route indicator (shunting)	More than 100m
Preliminary route indicator	More than 200m

2) Maximum train speed of conventional railways

For conventional railways, the maximum train speed is limited to 130km/h or less in Japan according to the above Ministerial Ordinance, while it is allowed to be 160 to 200 km/h in the countries where regulations are not strict.

If the signal confirmation distance can virtually be extended by the following means, the train maximum speed will be raised without compromising safety.

(1) Adoption of quick train protection measures such as the train radio system that doesn’t rely on visual observation

(2) Construction of long tunnels or viaducts to eliminate level crossings.

(3) Measures to support the visibility of train drivers such as high-speed signal aspects

[1] Ministerial Ordinance to stipulate technical standards on railways (Ministerial Ordinance, Ministry of Land, Infrastructure, Transport and Tourism, enforced on March 31, 2002)

By implementing such measures, 160 km/h operation has already been started in Japan on several sections including 1,067 mm-gauge Hokuhoku line, Hokuetsu Express Corporation, and the 1,435 mm-gauge Narita Sky Access line[2] , Narita Rapid Railway Access Co., Ltd.[3] In these two cases, the 6-aspect 6-light signal system and LEDs are adopted to enable indicating a high-speed signal aspect (with two green lights on) to improve the visibility for train drivers.

A difference between Shinkansen railways and these two lines is that, whereas the former uses cab signals and an automatic train control (ATC) system, the latter adopts wayside signals and an automatic train stop (ATS) system with a speed checking function and imposes a forward watching obligation on train drivers.

In other words, it is a philosophy that safety is guaranteed at the maximum speed of 160 km/h or less, when wayside signals and an automatic train protection (ATP) system with a speed pattern checking function are used. However, this method is not affirmatively effective for speeds over 160 km/h.

4-2 ATP system for speeds less than 160 km/h

1) Automatic train stop device-Type S (ATS-S)

Under this system, the brakes are automatically applied within five seconds, unless the train driver takes the specified action when the train has approached a stop-aspect signal and a control signal has activated the alarm bell from the ground side to warn the driver. A ground coil to transmit an alarm signal is located at a point approximately 600m distant from ordinary signals and an additional one close to (20m distant from) dead stop signals.

The Japanese National Railways introduced the ATS-S system into all sections across the country, though it had the following drawbacks.

- It didn’t have a function to check train speed.
- The automatic train stop function didn’t work after the train driver had acknowledged the alarm of warning bell, with safety solely entrusted to his/her attention thereafter.

A security measure developed to cope with these subjects is the ATS-P system explained below.

2) ATS-P

The ATS-P system is an ATS version to use a car-borne speed pattern and ground coils

[2] Although the Narita Sky Access line is composed of four sections, each possessed by (1) Hokusoh Railway Co., Ltd., (2) Chiba Newtown Railway Co, Ltd., (3) Narita High-Speed Railway Co., Ltd. and (4) Narita Rapid Access Railway Co., Ltd., 160km/h operation is implemented only on the section possessed by Narita Rapid Access Railway Co., Ltd.

[3] Narita Rapid Railway Access Co., Ltd. holds railway facilities, with rolling stock possessed and operated by Keisei Electric Railway Co., Ltd.

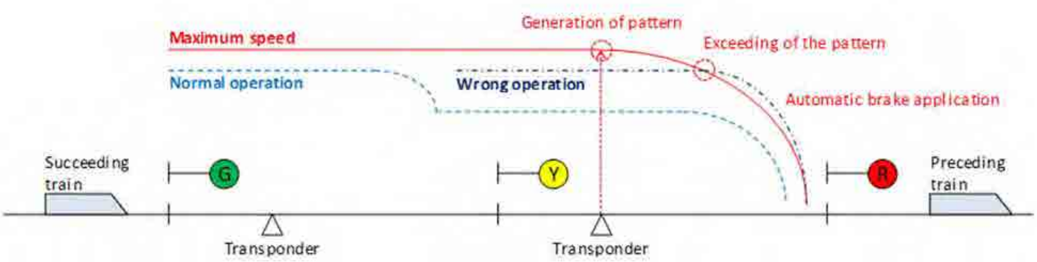
(transponders). Under this system, ground coils installed at several points before a signal send the information on the distance up to the red signal through digital transmission. The car-borne device generates a speed check pattern covering the distance up to the red signal, compares the train speed with the pattern, and applies the brakes in case the speed exceeds the pattern. As the pattern doesn't disappear, unless the signal aspect changes to a running-allowed side, accidents to violate signals can be prevented. This system can also cope with speed restrictions on turnouts and curves.

An image of the operation of ATS-P may be summarized as follows.

(1) When a train succeeding another has passed the ground coils (transponders), the digital data on the distance, gradients and other particulars up to the forward red signal is transmitted to the train.

(2) Based on the information transmitted thereto, the train creates a brake curve (stop pattern) according to its braking performance.

(3) The train compares its speed with the created stop pattern and activates the brakes, in case the speed has exceeded the pattern.



Source: Study Team

Fig. 4.2.1 An image of the operation of ATS-P

The fundamental functions of ATS-P includes: (1) prevention of signal violation, (2) prevention of excessive speed at turnouts, curves, down-gradients and other speed-limited places, (3) prevention of speeds exceeding the maximum speed specific to each train, (4) prevention of unattended backward movement of trains in upgrade section and (5) temporary speed restriction by portable ground coils.

Special features of ATS-P are as follows.

(1) Transmission and reception of digital data of multi-information are possible.

(2) The system cause no overreaches unlike the radio system.

(3) Bidirectional transmission is possible between trains and stations on the ground.

(4) High-speed transmission is possible.

(5) The quality of information transmission is remarkably high.

(6) Power can be transmitted from trains to the ground side.

4-3 Automatic train protection (ATP) system for high-speed railways

1) Analog ATC

The principal function of the ATS system explained in the foregoing section is to support the train driver and automatically stop the train when necessary, with the train driver still playing the leading role in train operation.

The braking distance of high-speed trains running at speeds higher than 200km/h is far longer than the visibility limit for wayside signals by train drivers. Even if a train driver applies the emergency brakes after noticing a stop signal or an obstacle ahead, therefore, he/she would not be able to stop the train safely within the required distance. Furthermore, as a momentary delay in applying the brakes in high-speed operation would lead to a serious accident, the ATS system doesn't guarantee safety, as it requires train drivers to apply the brakes after noticing a stop aspect on wayside signals.

Therefore, high-speed railways to run trains at speeds higher than 200km/h have introduced the automatic train control (ATC) system. The functions of ATC system are;(1) the cab-signal system to display signals on the driving stand in the driver's cabin, with the signals indicated in numerical figures in place of colors to represent train speed (signal-instructed speed) and (2) the speed control system that automatically controls and reduces the actual train speed down to the signal-instructed speed after comparing these two speeds.

The initial ATC system was called an analog ATC system and controlled trains based on the speed information sent from the devices installed on the ground. This was sort of a ground device initiative system.

An image of the operation of the analog ATC system is shown below.

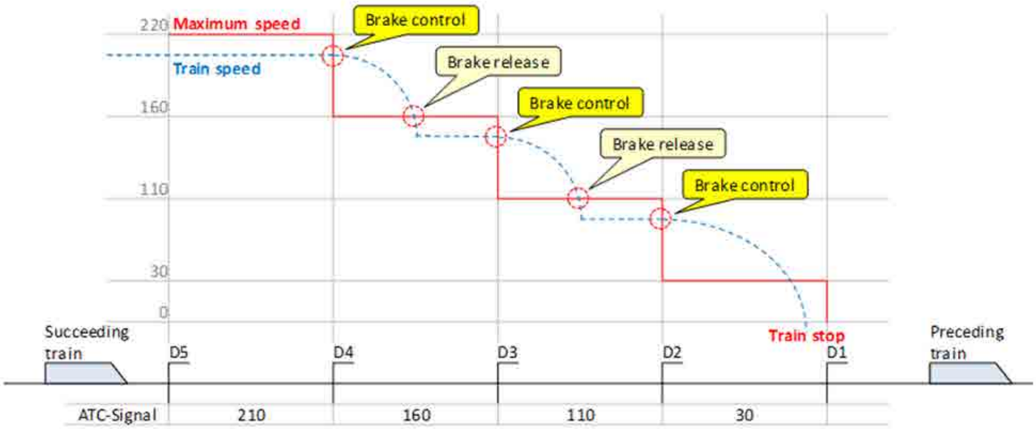
(1) The system uses analog signals for transmission between trains and the ground and transmits allowable train speed in each block section to the succeeding train based on the position of the preceding train.

(2) Signals are transmitted through the right and left rails, with the transmitted information received by trains through wheels.

(3) The succeeding train automatically controls the brakes when its speed is higher than the allowable speed in each block section or releases the brakes when the speed is lower.

(4) In each block section, the system repeats brake application and release motions to stop the train before the section where the preceding train exists.

(5) As ATC signals are continuously being transmitted through rails, trains can receive ever-changing information on train speed without interruption.



Source: Study Team

Fig. 4.3.1 An image of the operation of analog ATC system

The analog ATC is a proven and safe system based on the technologies developed for Tokaido Shinkansen that was inaugurated in 1964. Regarding this system, however, there are following subjects to be addressed.

(1) As the train is decelerated step by step according to the allowable train speed specified for track circuits, repeated brake application and release motions adversely affect ride comfort.

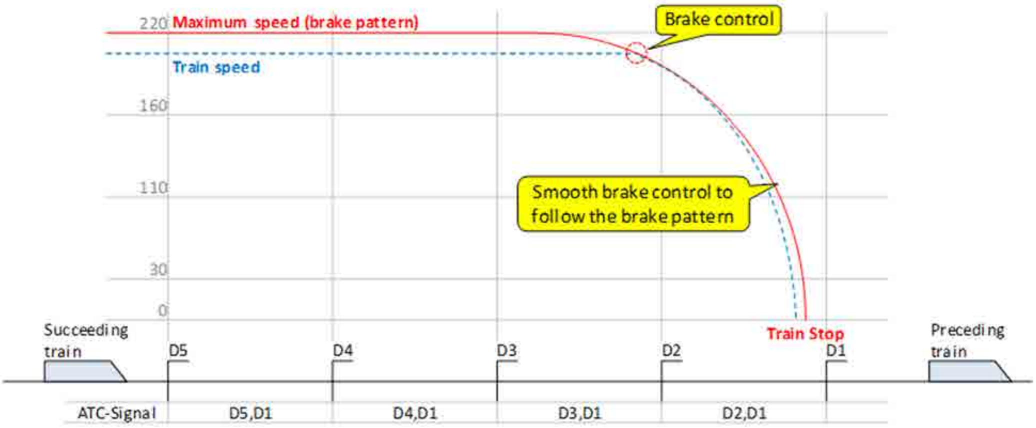
(2) As the allowable train speed for each track circuit is specified to accommodate trains with the worst braking performance, those having better brake performance shall run long distances at reduced speeds while suffering great time losses.

(3) The driver can confirm the allowable train speed specified for the section where he/she is running, but not that for the sections ahead.

2) Digital ATC

To solve the problems of the analog ATC system, a new digital ATC system has been developed. Whereas the former is “a ground side initiative system” to control train speed based on the speed information sent from the devices on the ground, the latter is “a car side initiative system” for car-borne devices (devices on the car) to calculate the most appropriate speed pattern based on the speed information signal up to the point where the train shall stop (stop point) sent from the devices on the ground.

An image of the operation of digital ATC system is as follows.



Source: Study Team

Fig. 4.3.2 An image of the operation of Digital ATC system

The digital ATC system features the following.

(1) The system implements digital bulk data transmission/reception between car-borne and on-the-ground devices.

(2) Creation of the most appropriate brake pattern by the car-borne devices based on the speed/position of the train and the position of the preceding train facilitates smooth brake control.

(3) The most appropriate brake control is possible for each train of different categories to cut the operation time between stations.

3) Comparison between ATS and ATC

Table 4-3-2 compares ATS and ATC.

ATS differs from ATC from various viewpoints. First of all, ATS uses wayside signal system while ATC applies cab signal system as a means of signal transmission. To send information from the ground to cars, ATS relies on transponders for discrete transmission, while ATC uses the left and right rails for continuous transmission. This difference in the information transmission system even affects brake control, in that the discrete type ATS makes judgment on brake control only at information reception, while continuous type ATC can make the judgment continuously. Regarding speed check, ATS is equipped with the function only on the ATS-P version and those adopted thereafter, in contrast to the ATC system of which all versions are equipped in principle with the function.

From the above, we can conclude that ATC is superior to ATS in terms of the relative security level.

Table 4.3.2 Comparison between ATS and ATC

Item for comparison	ATS	ATC
Signal transmission system	Wayside signal system	Cab signal system
Information transmission	Discrete transmission with transponders	Continuous transmission through rails
Brake control	Discrete judgment on brake control at information reception	Continuous judgment on brake control
Speed check function	Not equipped (ATS-S), Equipped (ATS-P)	Equipped
Relative safety level	Low	High

Source: Study Team

In foreign countries as well, railways running trains at around 200 km/h principally use ATC versions at high security levels as an ATP system. British Railways in UK relies on ATS to run trains at 200 km/h, while assigning two drivers to each train where trains run at speeds higher than 175 km/h to ensure the safety of train operation.

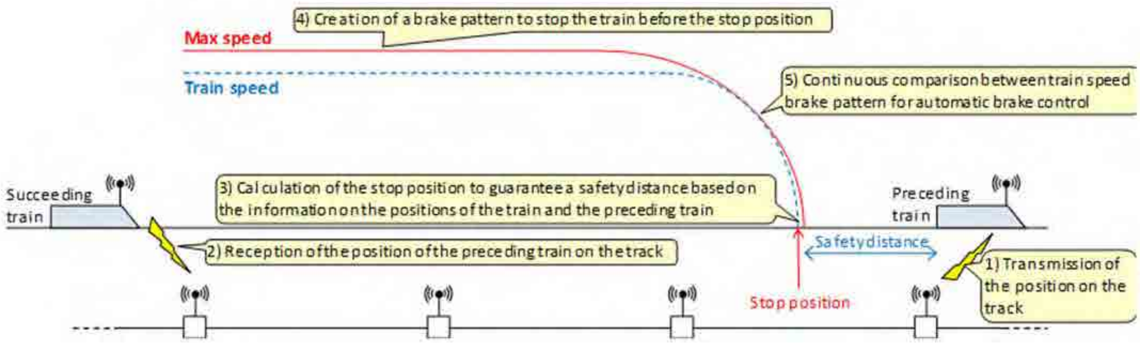
Table 4.3.3 Signal systems adopted by railways running trains at 230 km/h or less

Country	Japan	France SNCF	Germany DB AG	Italy FS	Austria OBB	Switzerland SBB	UK BR
Maximum speed	160 km/h	220 km/h	200 km/h	230 km/h	160 km/h	160 km/h	200 km/h
ATP	ATS-P	ATC	ATC	ATC	ATC	ATC	ATS
Signal system	Wayside signal	Cab Signal	Cab Signal	Cab Signal	Cab Signal	Cab Signal	Wayside signal
Block system	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic
Train detection	Track circuit	Track circuit	Track circuit	Track circuit	Track circuit	Track circuit	Track circuit
Remote train control	In operation	In operation	In operation	In operation	In operation	In operation	In operation
Level crossing equipment	Not equipped	Not equipped	Not equipped	Not equipped	Not equipped	Not equipped	Not equipped

Source: Study Team

4-4 Feasibility of CBTC

CBTC is an abbreviation of “Communication-Based Train Control System,” which is defined in IEEE 1474.1 as “a continuous automatic train control system using a high-precision train position detection system independent of track circuits to realize ATP through continuous large-capacity bidirectional transmission between trains and on-the-ground devices and car-borne/wayside data processing units, while having optional functions for automatic train operation (ATO) and automatic train supervision.”



Source: Study Team

Fig. 4.4.1 An image of CBTC system

Fig. 4.4.1.shows an image of a typical CBTC system. As stipulated in the above IEEE definition, the CBTC system integrates the systems for traffic control and train control (train position detection, signal control and point control, etc.) and is now used mainly for subways, new transit systems and others that are operated in urban areas independently of other railways. More than 100 railways have already adopted the system across the world.

Unlike the signal system based on the conventional fixed block system, the CBTC system has the following features. Namely, the system (1) doesn’t use track circuits to detect the train position; (2) uses wireless information transmission and (3) has eliminated blocks and controls train intervals continuously. For these reasons, the system has such merits as cutting the construction cost by the elimination of track circuits, possibility of parallel single track operation and flexible implementation of high-density operation through a moving block system. The CBTC system has been introduced, therefore, mostly into urban railways. On the other hand, it shall be verified whether the system maintains its function for high-speed operation at 160 km/h or over, as there are no records that the system has been adopted for railways where trains are running at speeds higher than 130km/h. Furthermore, there are no standard specifications prescribed in detail in the IEEE definition, either. There are a number of different versions, therefore, to possibly cause restrictions in system composition in the future in planning through-operation between different sections under different operators.

Under the moving block system, train lengths make a factor to influence the control of train intervals. In the case of freight trains of free composition, the number of freight cars shall be set for each train, which will make office duties complicated to potentially cause human errors and directly compromise safety.

Given the circumstances of its development, the most favorite ground for the CBTC system is independent passenger railways in small urban areas. To introduce CBTC into a section where freight trains run, therefore, it is required to have sufficient discussions and make efforts for verification.

4-5 Signal systems required for mixed-train operation

Based on the above discussions, we summarize below signal systems required for 160km/h operation of passenger- and freight-trains on the same tracks.

1) Signal aspects

Wayside ground signals may be adopted from the viewpoint of train drivers' visibility, if train speed is 160 km/h or less. In consideration of the necessities to prevent erroneous acknowledgment of signal aspects and increase train speed in the future, however, it is desirable to adopt the cab signal system. Elimination of wayside signals will cut the costs of construction and upkeep/control of the signal system.

2) ATP

The proven ATS-P system may be adopted, if train speed is 160km/h or less. To increase train speed further, however, it is desirable to adopt the ATC system that is capable of continuous information transmission to feature higher safety levels.

The costs of ATS-P and ATC are governed by the numbers of stations, blocks and routes to a great extent, it is difficult, therefore, to univocally state which is costlier or cheaper. Due to the drops of work efficiency and necessity of safety measures, however, the cost to upgrade ATS-P to ATC at a speedup is far higher than the cost to introduce ATC at the beginning. In discussing the adoption of a signal system, therefore, it is required to take into consideration the timing of speedup and renewal of the system.

3) Train detection

Sufficient discussion and verification are required prior to the adoption of train detection and moving block system to use CBTC for high-speed operation and mixed-train operation. It is recommended to adopt the track circuit type train detection system that is well proven for high-speed operation at the moment.

4) Others

To improve security, eliminate level crossings and introduce grade-separated crossings with roads into high-speed sections. Nowadays, bulk data transmission is essential for signal systems. This requires large-capacity telecommunication equipment/facilities in particular. To save man power and rationalize traffic control services, it is desirable to introduce a centralized traffic control (CTC) system.

5. Rolling stock

5-1 Rolling stock for 160 km/h and 300 km/h operation

1) Subjects for 300 km/h rolling stock

When compared with the rolling stock for 160 km/operation, that for 300 km/h operation shall cope with the increases in running resistance and brake distance. Table 5.1.1 summarizes the phenomena that will actualize in high-speed operation and countermeasures therefor.

Table5.1.1 Subjects and countermeasures for 300 km/h rolling stock

Phenomenon	Countermeasures
Increase in running resistance	• Increase in power output • Streamlining of head car nose profile • Smaller car body sectional area • Smoothing of car body surface • Lightweight rolling stock
Increased change in the air pressure in cabin	• Adoption of airtight car body structures • Ventilation system
Increase in noise	• Adoption of long nose head car • Smoothing of car body surface • Introduction of low-noise pantographs • Noise reduction plate • Bogie covers • Sound absorbing panels
Increase in rolling and vibration	• Adoption of bogies featuring high running stability (Extension of wheelbase, changed wheel profile) • Vibration suppression system
Increase in brake distance	• Velocity-adhesion brake pattern control • Braking force sharing control • Skid control • Incremental adhesion abrasive pad • Ceramic injection equipment • Segmented brake lining

Source: Study Team

2) Costs conceivable for 160 km/h and 300 km/h rolling stock

At the moment, we assume the rolling stock cost for 160 km/h operation and that for 300km/h operation as follows. However, take into account the fact that the costs are subject to change to a great extent depending on rolling stock dimensions and other factors when cars are actually procured.

Table 5.1.2 Comparison of rolling stock costs

Rolling stock	Cost per car (assumption)
For 160 km/h operation	US$ 2.5 Million
For 300km/h operation	US$ 3.8 Million

* Calculated at the rate of US$ 1 = 100 yen

Source: Study Team

3) Service life and replacement period of rolling stock

The service life of rolling stock is approximately 15 to 20 years. In Japan, however, the actual replacement period is largely governed by the financial situation and management policies of railway operators. Shinkansen cars are normally replaced in approximately 15 years. There were some cars used for nearly 30 years in the past, however, after renewal work was implemented for passenger rooms. In the case of conventional narrow-gauge railways on the other hand, most cars are used for principal lines first, then transferred to local lines, with cabin accommodations and major components renewed, and used thereafter for a long period of time.

In planning procurement of 160 km/h rolling stock for the high-speed railway in Vietnam, it seems to be a good policy to discuss whether used cars for high-speed operation in other countries cannot be appropriated, in case the 300 km/h operation time arrives in a short period of time. If used cars can be employed, it may be possible to start revenue service operation at 200 km/h or over immediately after inauguration at a small investment cost as the track alignment is tailored for high-speed operation, in case powering and signal systems can cope with.

5-2 Freight transport under the mixed-train operation

1) Discussion of powering system (distributed and concentrated traction systems)

Freight trains normally use a power concentrated system to haul freight cars by a locomotive at the head. Under this system, train sets can flexibly be compose of freight cars of various categories, while facilitating car coupling/decoupling at terminals on the way. On the other hand, large locomotive axle loads are required to ensure sufficient tractive force, with the maximum speed and acceleration/deceleration performance becoming inferior to those of power distributed system.

If the speed and acceleration/deceleration of freight trains are low on high-speed railways where both passenger trains and freight trains run, all trains will substantially victimize transport efficiency. Therefore, freight cars on high-speed railways shall have high-speed and acceleration/deceleration performance equivalent level to those of passenger trains.

The Shinkansen railways in Japan are used to transport passengers only. To increase the rapidity of freight transport on conventional narrow-gauge lines on the other hand, power distributed type container freight cars have been developed and put in practical use. This rolling stock (series M250 electric cars) is called a “super rail cargo” train, having acceleration/deceleration performance and maximum service speed 130 km/h, which are equivalent to those of passenger EMUs on conventional narrow-gauge line.

To implement mixed-train operation on the new high-speed railway, freight trains shall also run at a maximums speed of 160 km/h or over to raise the transport efficiency of passenger and freight trains. To ensure this maximum speed and high acceleration/deceleration performance, we recommend adoption of power distributed container freight cars based on the concept of “super rail cargo.” As normal freight cars and bulk cars, we recommend adoption of bulk containers when necessary, as the current upper limit of train speed seems to be approximately 100 km/h.

2) An outline of the high-speed container freight train.

An outline of the high-speed container freight train presumably to be used for mixed-train operation on the new high-speed railway is as follows.

- Assumed speed: 160 to 200 km/h
- Length of train: 200 m (4M6T)
- A car accommodates marine containers 40ft x 1 or 20ft x 2 (20TEU)
- Loading capacity: Approximately 320t

Following figures illustrate an image of the train and train composition, respectively.

Fig. 5.2.1 An image of high-speed container freight train

Source: JIC

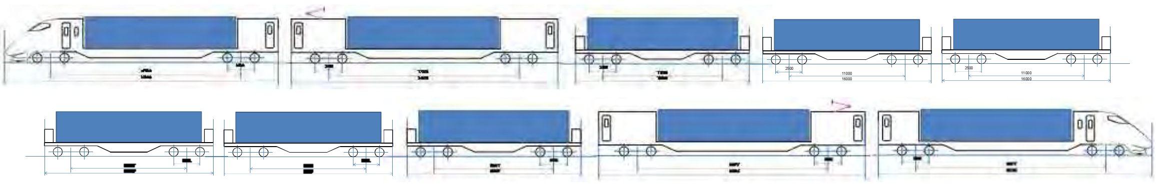


Fig. 5.2.2Composition of a high-speed container freight train

Source: JIC

3) Subjects of high-speed container freight train

To realize the above-mentioned high-speed container freight train, there are some subjects to be addressed.

One is the necessity to limit the axle balance (difference in load between axles) within 10% like that of passenger trains to prevent snake motion and ensure stable running. Car weights and wheel loads shall be checked when containers are being loaded. It may be required to load dead weights in empty containers when necessary.

Another is the strength of containers to withstand the pressure changes that may occur when the train enters tunnels or cross high-speed trains. When two trains cross each other at high speed, pressure change takes place as shown in Fig. 5.2.3.

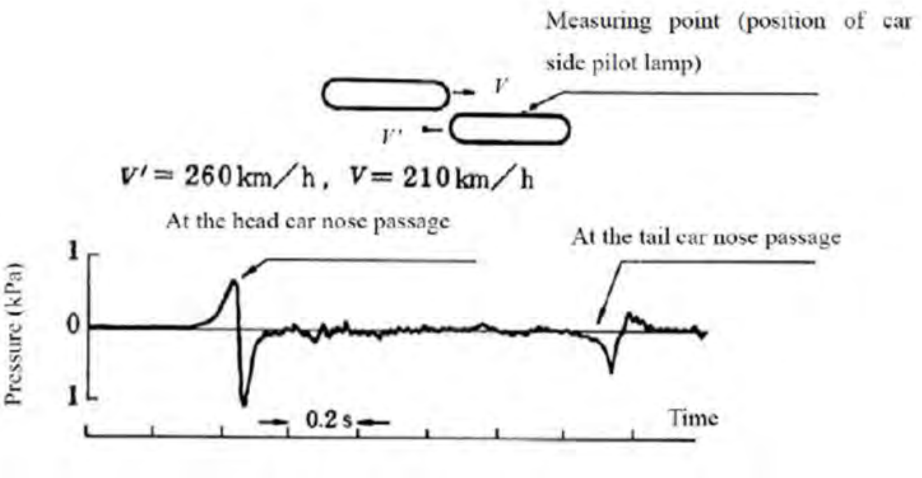


Fig. 5.2.3 Pressure changes at two-train crossing

Source: JIC

If a container breaks due to pressure changes to scatter cargos, a derailment or other serious accidents may occur. Therefore, it shall be verified in advance whether containers can withstand such pressure changes.

Whereas containers are normally maintained under the responsibility of their owners, there are some containers that are superannuated to bear corrosion on their outer plates. Such containers may probably be broken failing to endure the pressure changes. For these reasons, therefore, it will be required for railway operators to implement quality control including container checks beforehand in transporting containers by high-speed railways. As a means to ensure the quality control for containers, it may be an idea to limit consigners.

4) Feasibility of body-mount high-speed container freight train

It may facilitate drawing a train operation diagram for passenger/freight mixed-train transport system and raise the transport efficiency of high-speed railways, if the speed of container freight cars were increased further to run at the same speed as that of passenger trains. For this purpose, it is also conceivable that containers be accommodated in airtight car bodies, which is similar to the “train on train” system now under development to transport passengers and freights through the Shinkansen track structure in the Seikan tunnel.

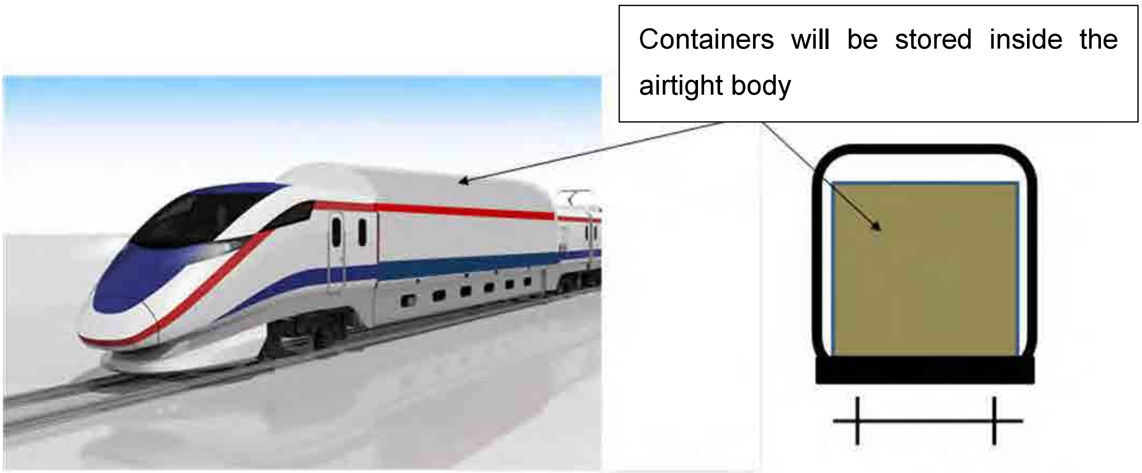


Fig. 5.2.4 An image of body-mount high-speed container freight train

Source: JIC

The above measure protects containers against pressure changes and reduces the possibility of their breakage. Furthermore, as containers are placed in a car body, articles in the container will not scatter outside the freight cars even when a container door erroneously opens.

On the other hand, there are several demerits for the body-mount type freight cars, in that they become heavier and more expensive. Furthermore, the car size becomes larger to make the car body subject to pressure change more strongly when the train crosses other trains running in the opposite direction on the adjacent track. Thus, unloaded cars shall be verified against the possibility of overturn. Consequently, it may become indispensable to load dead weights on empty cars depending on the circumstances.

It is also required to discuss where the opening to be located to load/unload containers through and how to handle containers. For the convenience of container handling, it is desirable to locate the opening on the car side, which necessitates, however, durability against pressure changes and measures to cope with the erroneous door opening accidents while the train is running.

It is also conceivable to adopt an airtight cubicle to house a container from the end plate side first and mount the cubicle thereafter on the freight car. See Fig. 5.2.5. This double-step method is advantageous from the viewpoint of safety, though disadvantageous in terms of the car weight and container handling time and labor.

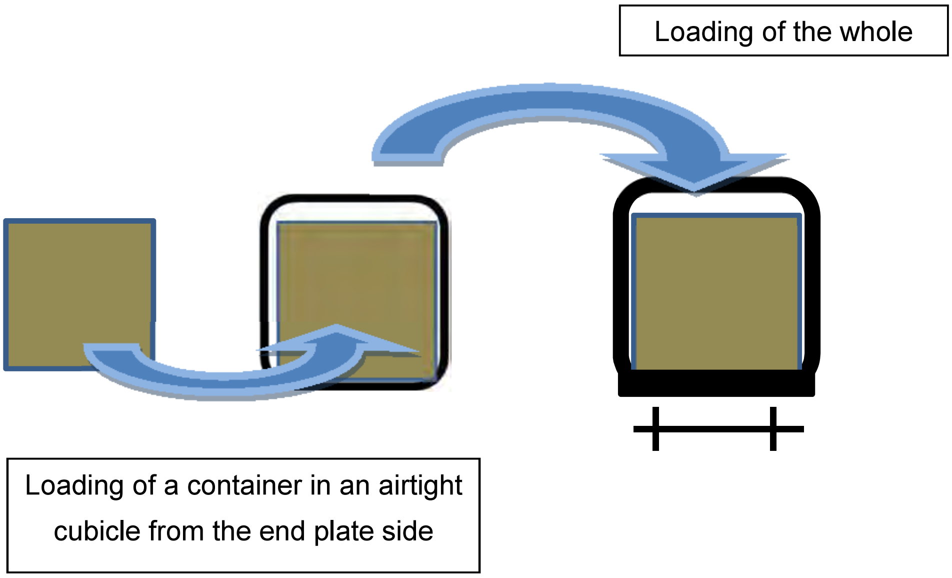


Fig. 5.2.5 Loading a container on a body-mount freight car

Source: JIC

6. Train operation

In this section, we discuss the effect of the difference in train speed on the train operation diagram when passenger and freight trains run on the same track, by comparing two cases where the maximum speed of passenger trains is 160 km and 300 km/h, respectively, while that of freight trains is 120 km/h, on the assumption that 22 trains in total run in each direction, which is close to the number of trains in the present train operation pattern in Vietnam.

6-1 Train operation diagram (Case1)

We assume the maximum speed of 160km/h for passenger trains and 120 km/h for freight trains and set the running time and the number of trains as follows.

1) Running time

We assume the scheduled speed as 90%, 71% and 75% of the maximum speed for express trains, ordinary trains and freight trains, respectively. These trains run between Hanoi and HCMC (Hoa Hung St.) approximately in the running time shown in Table 6.1.1.

Table 6.1.1 Approximate running time between Hanoi and HCMC (Hoa Hung St.)

(Case 1)

Train type	Passenger train		Freight train
	Express	Ordinary	
Running time	10:58	13:51	17:32
Remarks	Midway station (for stopping): Vinh,Hue,Da Nang, Nha Trang		

Source: Study Team

2) Number of set trains

We set (1) seven inter-city trains in each direction for the section between Hanoi and HCMC by referring to the present number of the trains running on the said section, (2) five intra-regional trains in each direction in the Hanoi area and (3) another five in the HCMC area. See Table 6.1.2 for the number and types of trains between Hanoi and HCMC.

Table 6.1.2 Number and types of trains between Hanoi and HCMC (Case 1)

Train			Hanoi	Vinh	Hue	Da Nang	Nha Trang	HCMC
Passenger	Express					(2)		
	Ordinary	Over-night				(5)		
		Intra-Regional		(2)	(3)		(3)	(2)
	Total (passenger)			12	10	10	10	12
Freight						(10)		
Total				22	20	20	22	22

Source: Study Team

As the running time between Hanoi and HCMC is more than 10 hours, we assume that passengers tend to select overnight trains. Thus, we set five ordinary roundtrip trains to run in the nighttime and two express roundtrip trains in the daytime. Furthermore, 10 freight trains in total run the whole section in each direction between Hanoi and HCMC.

3) Train operation diagram (Case 1)

See Figure 6.1.1 for the train diagram we have drawn for Case 1. This diagram clarifies the following.

(1) The difference in the running time between overnight passenger trains and freight trains in the Hanoi − HCMC section is approximately four hours. It is enough for most of the freight trains, therefore, to shunt passenger trains at most only once on the way. Therefore, we judge that freight trains can reach the destination approximately in 18 hours and 30 minutes, or one hour or so later than when they don't shunt passenger trains at all.

(2) Most of passenger and freight trains run in the nighttime. It is impossible, therefore, to secure a four- to five-hour interval between two trains at night. This means that track maintenance work shall be implemented in short intervals between trains at night or during the daytime.

(3) We assumed above a scenario to cover 24 hours a day. This train operation diagram suggests that there is an ample margin to increase the number of trains to cope with the increases in the demand for transport.

4) Remarks for attention

It is thought that the maximum speed of 160 km/h can be coped with by the wayside signal system and automatic double-track block system.

As the signal equipment/facilities for 160 km/h operation, introduce the ATS-P system to control train speed while supporting train drivers, as it is absolutely necessary to prevent their erroneous signal device manipulation.

South-North Line (Passenger 160km/h, Freight 120km/h)

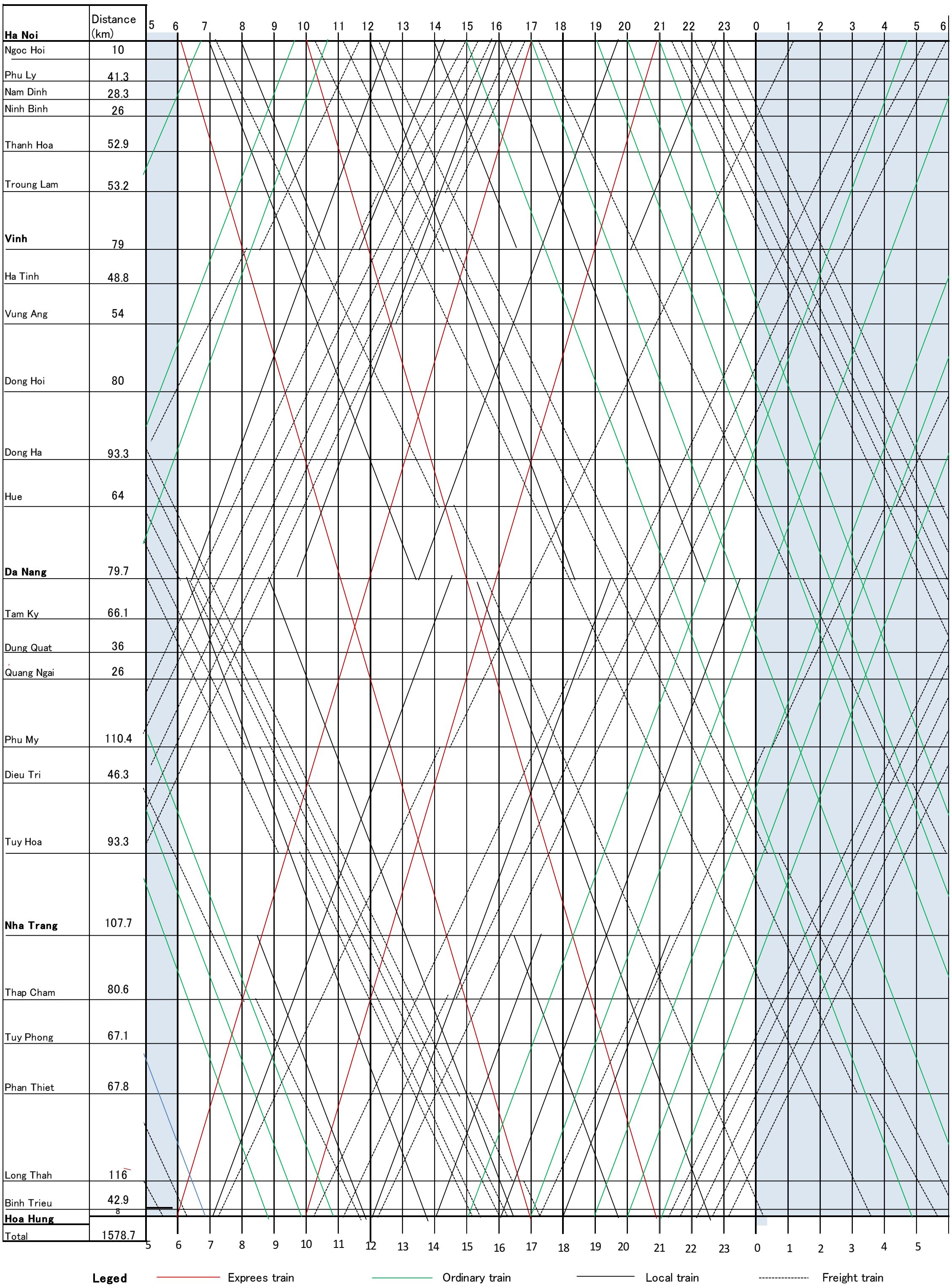


Fig.6.1.1 Train operation diagram
for 160 km/h passenger trains and 120 km/h freight trains

Source: Study Team

6-2 Train operation diagram (Case 2)

We assume the maximum speed of 300 km/h for passenger trains and 120 km/h for freight trains and set the running time and the number of trains as follows.

1) Running time

We assume the scheduled speed as 90%, 71% and 75% of the maximum speed for express trains, ordinary trains and freight trains, respectively. These trains run between Hanoi and HCMC (Hoa Hung) approximately in the running time shown in Table 6.2.1.

Table 6.2.1 Approximate running time between Hanoi and HCMC (Case 2)

Train type	Passenger train		Freight train
	Express	Ordinary	
Running time	5:51	7:25	17:32
Remarks	Midway station (for stopping): Vinh, Hue, Da Nang, Nha Trang		

Source: Study Team

2) Number of set trains

In the same way as in Case 1, we set (1) seven inter-city trains in each direction for the section between Hanoi and HCMC, (2) five intra-regional trains in each direction in the Hanoi area and (3) another five in the HCMC area. As the through-operation trains on the section between Hanoi and HCMC, the running time is approximately five hours and 51 minutes with express trains and seven hours 25 minutes with ordinary train, we set all trains to run within the time zone from 6:00 to 24:00.

Regarding the through-operation passenger trains between the two largest cities, we set four roundtrip express trains and three roundtrip ordinary trains on the assumption that passengers tend to select express trains on a preferential basis. In addition, we set 10 freight trains in each direction for through-operation between Hanoi and HCMC like in Case 1.

As it takes 17 hours or over for freight trains to connect the two cities, we run freight trains even within what is called the track maintenance time zone from 0:00 to 6:00, while avoiding crossings between up- and down-trains in this time zone as far as possible.

See Table 6-1-2 for the number and types of trains between Hanoi and HCMC in Case 2.

Table 6.2.2 Number and types of trains between Hanoi and HCMC (Case 2)

Train			Hanoi	Vinh	Hue	Da Nang	Nha Trang	HCMC
Passenger	Express		→	→	→ (4)	→	→	
	Ordinary	Over-night	→	→	→ (3)	→	→	
		Intra-regional	→ (2)			→	→ (3)	
			→	→ (3)	→		→ (2)	
	Total (passenger)		12	10	10	10	12	
Freight			→	→	→ (10)	→	→	
Total			22	20	20	22	22	

Source: Study Team

3) Train operation diagram (Case 2)

See Figure 6.2.1 for the train diagram we have drawn for Case 2. This diagram clarifies the following.

(1) The difference in the running time between passenger and freight trains is as large as 10 to 12 hours. The running time of freight trains is 20 to 23 hours, three to five hours longer than the scheduled time, as they have to shunt high-speed trains at midway stations.

(2) On long station-to-station sections, a sufficiently long time interval shall be secured between a freight train running ahead and a high-speed train running behind. This requires shunting stations to be equipped with two to three siding tracks for freight trains.

(3) In approximately 100 km-long sections between stations, it is impossible to run freight trains, unless the headway between two high-speed trains is 40 minutes or over. In other words, if freight trains run on such sections, the headway between high-speed trains shall be extended, to subsequently cut the number of high-speed trains.

4) Remarks for attention

To cope with the maximum speed of 300 km/h of passenger trains, it is required to introduce a cab signal system to rely on ATC.

For freight cars as well, the above-said system is indispensable to totally eliminate erroneous signal device manipulation by train drivers.

Operation of freight trains during what is called the track maintenance time zone from 0:00 to 6:00, requires installation of bidirectional operation equipment/facilities between the up- and down-tracks to make it possible to provide maintenance services alternately for up- and down-tracks.

South-North Line (Passenger 300km/h, Freight 120km/h)

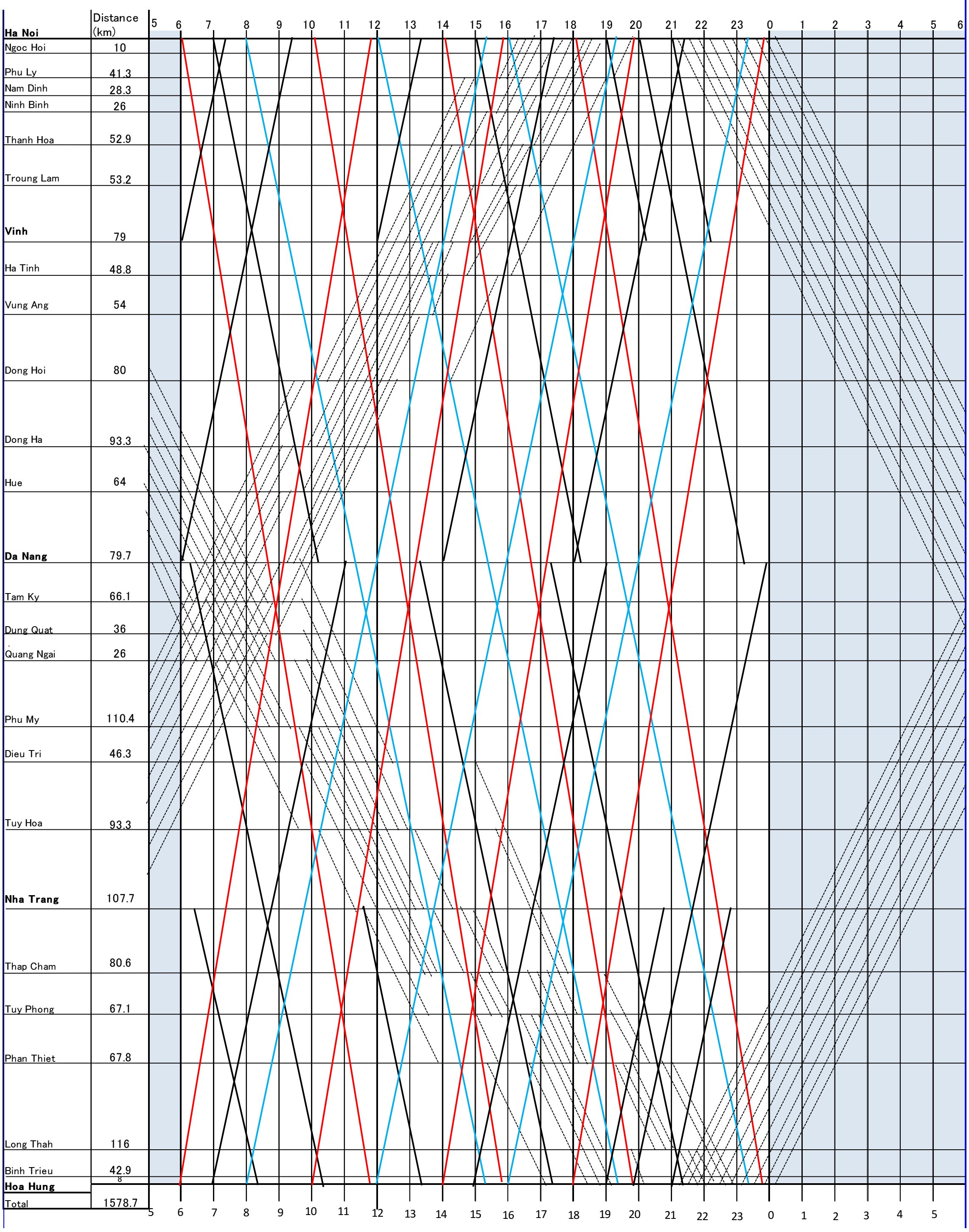


Fig. 6.2.1 Train operation diagram for 300 km/h passenger trains

Source: Study Team

6-3 Subjects and a conclusion

1) Overtaking and two-train crossing

(1) High-speed two-train crossing (between freight and passenger trains)

When a two-train crossing occurs between a passenger train and a freight train, running at 300 km/h and 120 km/h respectively, the relative speed reaches 420 km/h. A chaotic accident may occur, if the freight train derails or freights loaded thereon scatter in such a situation. This requires that carefully thought-out safety measures shall be taken for freight trains.

The section between Hanoi and HCMC is 1,600 km long. For such a long section, it is not possible to separate the operation time zone between passenger and freight trains or take measures to avoid two-train crossings at midpoints between stations.

It is necessary to contrive ground equipment/facilities and the structure of rolling stock to ensure the safety of freight train operation.

(2) Track layouts in station yards

For midway stations of HSR, track layouts such as the one in Fig. 6.3.1 are adopted depending on the train stopping pattern. Discussions on train operation diagrams indicate that one or two refuge tracks are required additionally for freight trains at some stations.

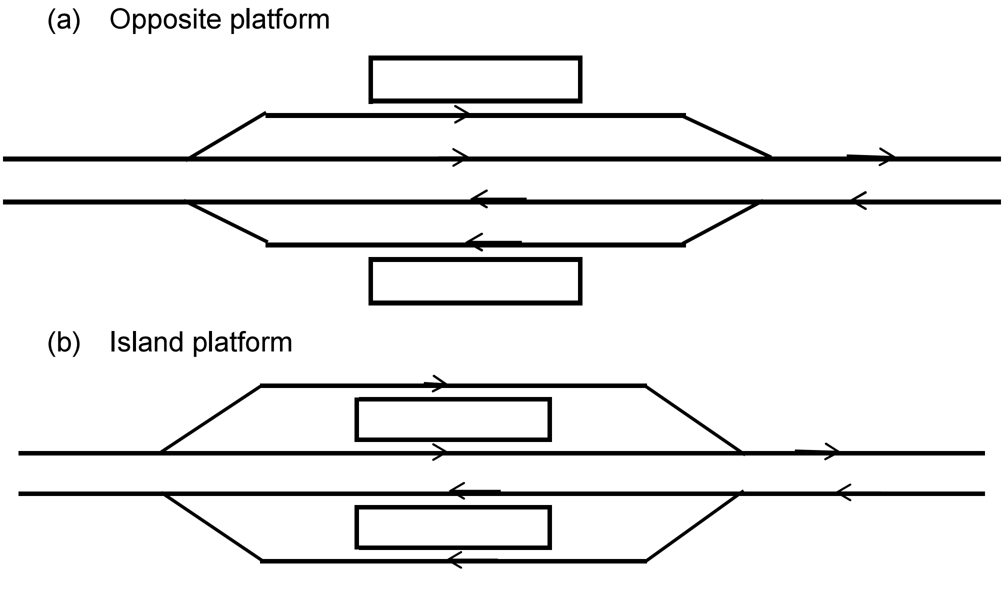


Fig. 6.3.1 Track layouts at HSR midway stations

Source: Study Team

2) Conclusion

In the above, we assumed the numbers of passenger and freight trains and the maximum speed of freight trains as 120 km/h, created train operation diagrams in two cases to run passenger trains at a maximums speed of 160 km/h and 300 km/h, respectively, and verified the feasibility of the train operation diagrams.

As a result, we have concluded that there are no significant problems in creating a train operation diagram when Case 1 (regarding the maximum speed of passenger trains 160 km/h) is applied to the Hanoi − HCMC section. From the viewpoint of safety as well, Case 1 (regarding the 160km/h operation of passenger trains and 120km/h operation of freight trains) is judged as feasible, when operation security equipment/facilities are introduced to support train drivers, given a precedent case of Shinkansen in Japan where passenger train run at a maximum speed of 140 km/h and freight trains at a maximum speed of 110 km/h through the Seikan tunnel.

There are several problems, however, regarding the 300 km/h operation of passenger trains. The difference in the running time between passenger and freight trains extends the running time of the latter to a great extent and makes installation of siding tracks inevitable in sections where the station-to-station distance is long. In this manner, it causes a number of problems in the train setting process, while restricting the degree-of-freedom in drawing train operation diagrams. Furthermore, there are a number of subjects to be addressed regarding the safety measures against two-train crossings between freight trains and high-speed passenger trains.

Based on the above, we conclude that sharing the same tracks with freight and passenger trains shall be avoided and passenger trains shall run on the tracks for exclusive use, in case the maximum speed of passenger trains is 300 km/h.

7. Epilogue

We describe below what is related to this Chapter.

1) Feasibility of speedup

To raise the train speed of a standard-gauge semi-high-speed railway designed for160 to 200 km/h operation at the initial stage to 300 km/h later, provisions shall appropriately be made beforehand. In concrete terms, design radii of curve to be 6,000 m or over and insert transient curves of adequate lengths before and after each curve.

At a speedup, renew rolling stock and strengthen power supply equipment/facilities.

Wayside ground signals to rely on drivers' attention are applicable, in case the maximum train speed of the semi-high-speed railway is 160 km/h or less and there are no level crossings or other obstacles along the route. In this case as well, introduction of the ATS-P system having a speed check function is indispensable to totally eliminate erroneous handling of signal devices by train drivers. When the train speed is higher than 160 km/h, however, adopt the ATC system, as wayside ground signals cannot cope with.

2) Mixed-train operation to run passenger and freight trains on the same tracks

In the mixed-train operation system, important subjects are guaranteeing the safety of freight trains and the difference in the train speed between passenger and freight trains.

From the viewpoint of train operation, as the speed difference between passenger and freight trains becomes larger, the track capacity becomes extremely smaller. Furthermore, larger differences in train speed necessitate more siding tracks at midway stations for the purpose of overtaking freight trains by passenger trains.

To maintain as high a safety level for freight trains as that for passenger trains by applying measures to prevent derailment and freight-scattering accidents, there still remain a number of pending subjects.

For these reasons, there are no merits for Vietnam to venture mixed-train operation by the high-speed railway.

If we review the current issue at the starting point, a subject is where to position freight transport by rail. Freight transport is not a running race to struggle for rapidity, but rather esteems punctuality and trustworthiness of the collection and delivery of cargos. It is also required for freight transport to minimize the time and labor for transshipment to/from the transporting facilities by road and air and to/from other railways.

In this sense, the existing railway network has already acquired competitive power to enjoy a sizable share in the domestic freight transport business. Freight transport by the high-speed railway is also required to implement transshipment to/from the existing railway network.

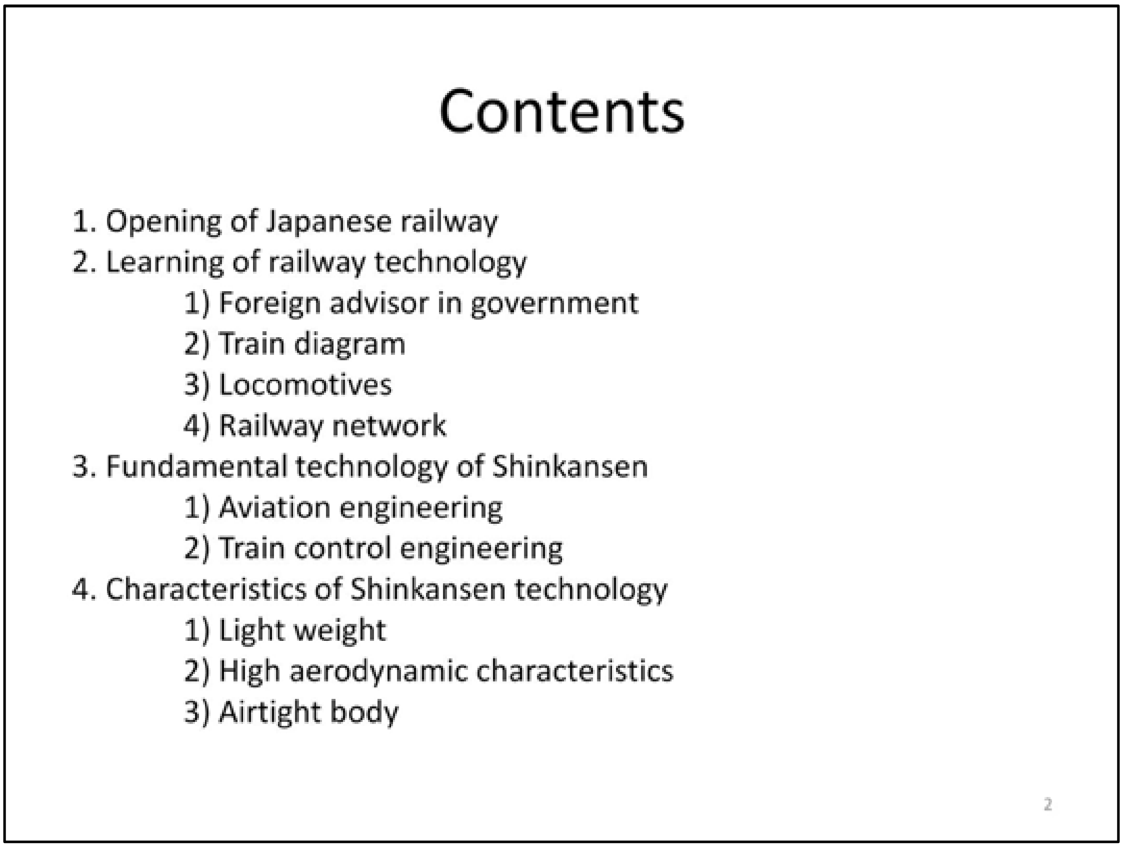
Ⅲ. Work Shop

Work Shop

Technical view points on the maximum train speed and mixed train operation

Japan International Consultants for Transportation Co., Ltd.

Development of Shinkansen Technology
A history of Japanese railway technology that will describe how Shinkansen Technology has evolved.



These are the contents to explain today.

1. To begin with, let me show you when railway started in Japan and in some other countries.
2. Then, I will explain the way how we learned railway technology.
3. Next, I will talk about the fundamental technology that Shinkansen is based on.
4. Finally I will talk about characteristics of our technology.

1. Opening of Japanese railway

Nation	Year	After UK	Topics
UK	1825		
France	1830		
USA	1831		
Germany	1835		
India	1853		1840-1842 Opium war
Indonesia	1864		
Japan	**1872**	47	
China	1876		
Burma	1877		
Malaysia	1885		1887- Union Indochinoise
Thailand	1893		1894-1895 the Sino-Japanese war
Vietnam	**1905**	80	1904-1905 the Russo-Japanese war

Modified from the 100 years History of JNR

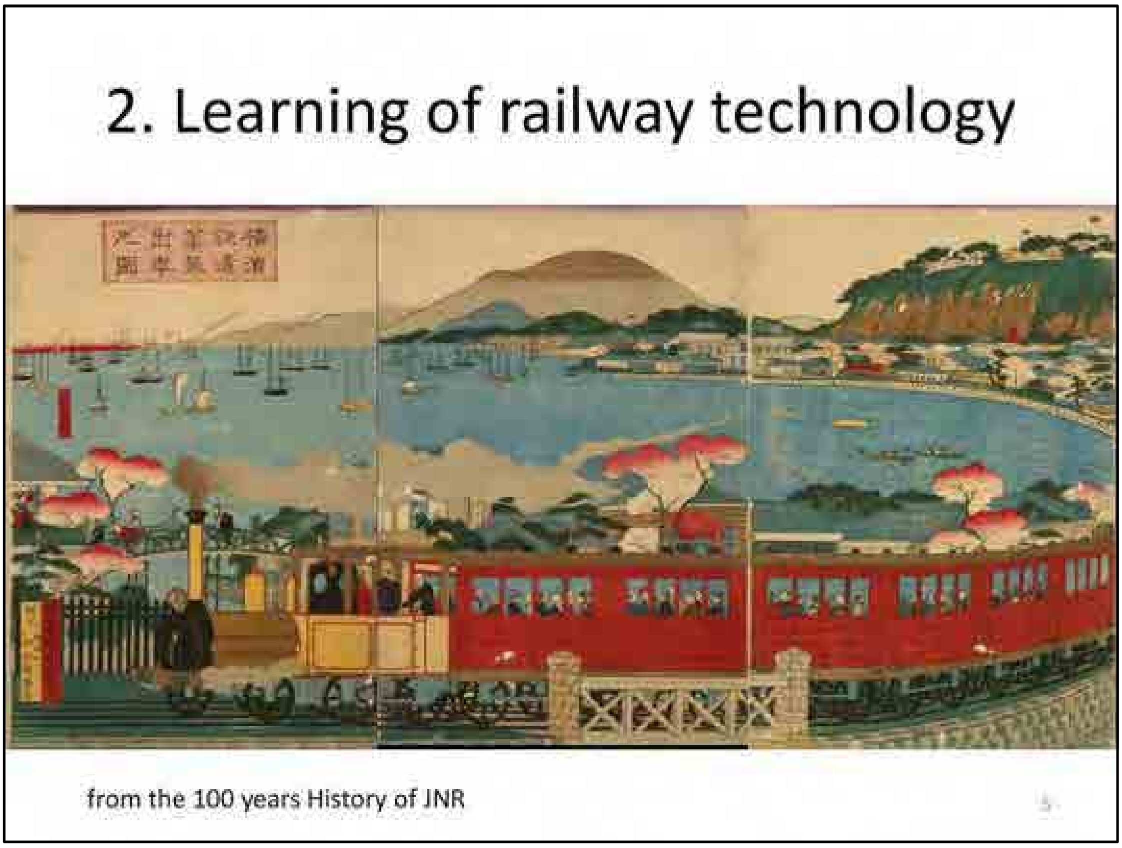
3

Opening of Japanese railway

1. Japanese railway was opened in 1872, 47 years after UK's.
2. Vietnamese railway was opened in 1905, 80 years after UK's.
3. In those days, Asian countries were under threat of invasion by European countries and America.
4. Hong Kong was ceded as the result of Opium War.
5. Vietnam was invaded by France in 1887.
6. Japan kept independence, fighting against China and Russia.

Opening Ceremony

1. As stated before, the opening year was 1872.
2. The railway was 29km long running between Tokyo and Yokohama.
3. Tokyo is a Japanese capital and Yokohama has a trade port.



2. Learning of railway technology
1. At first, a concession system was considered, that is to have foreign companies invest, build and operate..
2. Nelson Lay, an English businessman, got the concession and began financing in London.
3. The Japanese government grew doubtful about his way of business and canceled the concession paying compensation.
4. The Japanese own management of railway business pushed the technological independence.

2.1 A foreign advisor in government

1. The necessary technology was provided by foreign a advisor in Government.
2. This is a British civil engineer, Edmund Morel who engaged in railway construction in many countries.
3. He was the first foreign engineer–in–chief appointed by the Japanese government.
4. He suggested applying wooden sleeper instead of expensive iron sleepers.
5. He took his Japanese engineers into his own house for lectures.
6. Following his advice, Japan established the Ministry of Public Works, which introduced foreign technologies and their application.
7. But Morel had suffered from tuberculosis before his arrival in Japan, and died in Yokohama in 1871, shortly before the opening ceremonies for the railway.
8. His grave in the "Foreigners' Cemetery" in Yokohama is designated as a "national railway memorial".

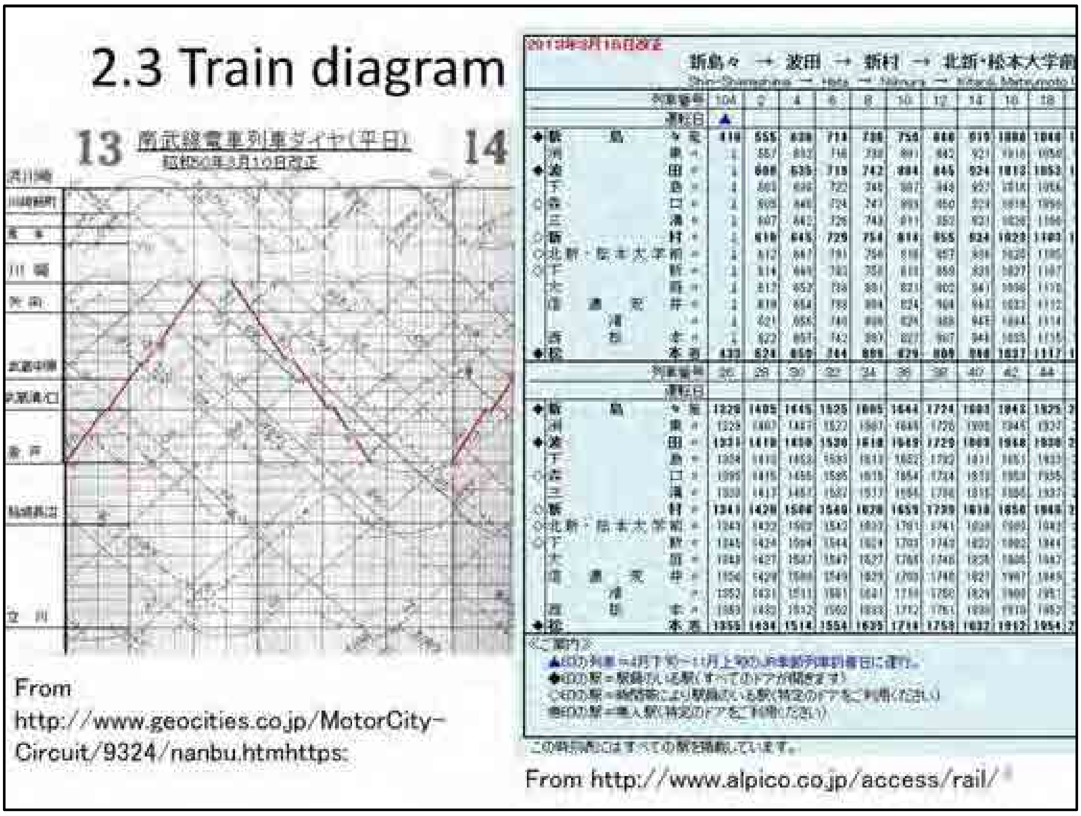
2.2 Salary of foreign advisor

Occupation	Salary （¥1）
Director	2000
Engineer in chief	700–1250
Principal engineer Duputy engineer	300–750
Assistant	160–420
Locomotive superintended	330–450
traffic manager	500–600
Secretary	320–550
Store keeper	250–
draughtman,clerk	50–200
	¥1=1000USD

Modified from the 100 years History of JNR

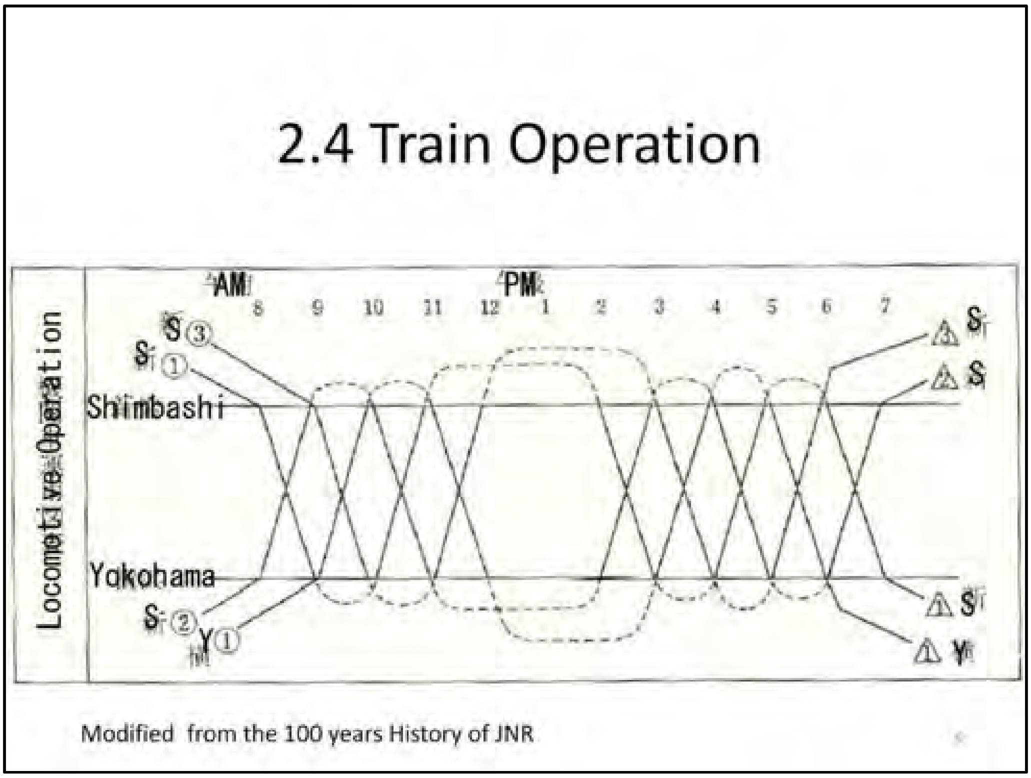
7

2.2 Salary of foreign advisor
1. The number of foreign advisors in government peaked at 527 people in 1875.
2. They were British, American, French and German.
3. Their monthly salary is shown here. In those days, ¥1 was around 1000USD of today.
4. Their work continued until 1901.



2.3 Train diagram

1. Some of the foreign advisors took little interest in technology transfer.
2. Mr. Page, arrived in Japan in 1874 as a traffic manager in Kobe, is called the founder of Japanese diagram with sarcasm.
3. He drew train diagrams and converted them into time tables keeping himself in his room, and showed only time tables to Japanese people.
4. At first, Japanese staffs admired his tables which were complex but perfectly consistent.
5. But the Japanese staffs gradually solved the mystery of his secret of train diagram, and they learned to use diagram by 1889–1895.
6. This means that it took almost 20 years for the Japanese to master train operating technology.



2．4 Train operation

1. Train diagram is a fundamental tool for the railway management.
2. This is the diagram of 9 shuttles between Shimbashi and Yokohama.
3. How many locomotives are required? The answer is four excluding those for maintenance.
4. How about the passing sidings? One with a sidetrack.
5. How many arrival and departure sidings are necessary for Shimbashi and Yokohama? Two tracks are required for each terminal station.
6. With a train diagram, we can estimate the quality and quantity of the railway equipment.
7. We can even estimate the time necessary for the turn around operation and time interval .
8. I' m a civil engineer, but I studied how to draw a run curve and train diagram by myself. I would like to suggest you do the same.

2.5 The first Locomotive

1. This is the No.1 locomotive, type 150.
2. In those days, locomotives were produced in UK, transported to Yokohama and assembled by foreign advisors in government.

2.6 Locomotives

No	Type	Axle	Weight(t)	Manufacturer	Inability
1	150	1B	23.5	Vulcan Foundry	X
2	160	1B	21.7	Sharp Stewart	
3	160	1B	21.7	Sharp Stewart	
4	160	1B	21.7	Sharp Stewart	
5	160	1B	21.7	Sharp Stewart	
6	A3	1B	22.3	Avonside Engine Work	
7	A3	1B	22.3	Avonside Engine Work	
8	190	1B	25.6	Dubs&Co.	X
9	190	1B	25.6	Dubs&Co.	X
10	110	1B	22.3	Yorkshire Engine Work	X

Modified from the 100 years History of JNR

2.6 Locomotives
1. Totally, 10 locomotives were imported for Tokyo – Yokohama.
2. This section was supposed to become a branch line of Tokyo – Osaka, so light-weight tank locomotives were selected instead of tender type.
3. The table indicates the vulnerability of each locomotive.
4. Every locomotive was produced in Britain, but manufacturers varies because of their rush of business at that time.
5. From the view point of maintenance work, a unified standard is favorable.
6. On the other hand, the result would have been even worse if unified with a bad engine type.

2.7 Homemade locomotive (First domestic made locomotive)

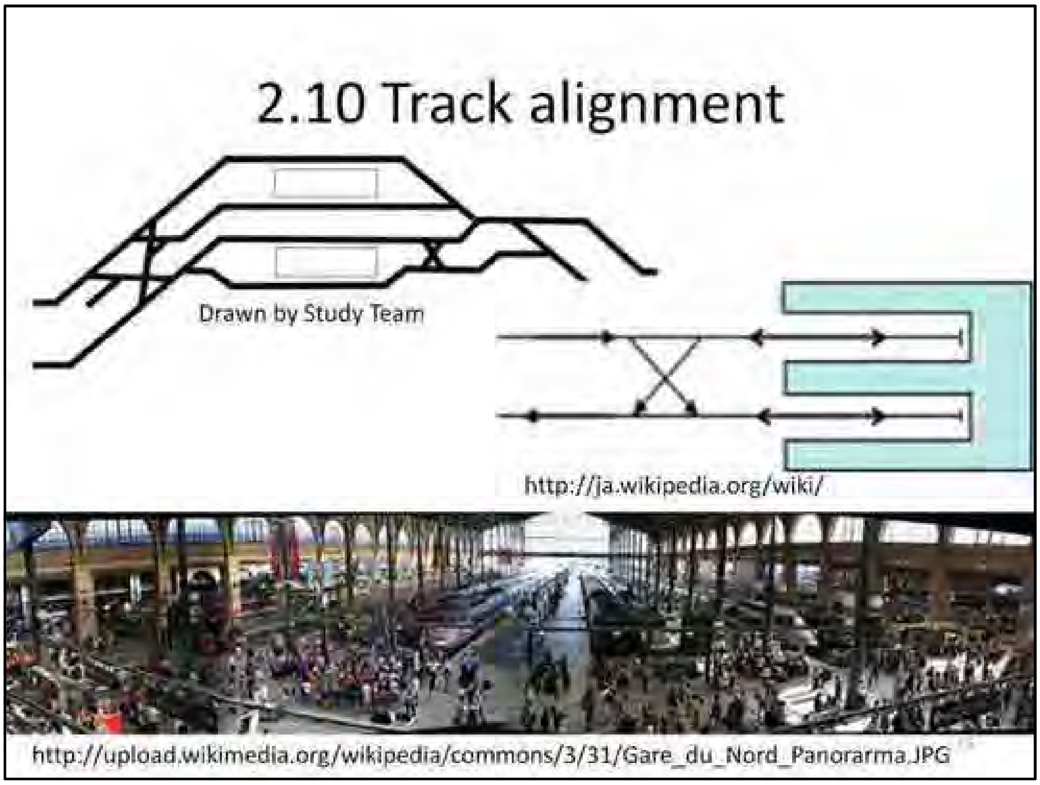
1. In 1893, 21 years after the railway opening, the first home (domestically) made locomotive was manufactured in Kobe factory.
2. It was type 860 tank locomotive with an axle arrangement of 1B1.
3. Almost all the fundamental parts, such as wheels, boiler and cylinders were imported.
4. R. Francis Trevithick, a foreign advisor in government, superintended the design and fabrication.
5. All the fabrication work was completed by Japanese alone except R. F. Trevithick.
6. He is one of the grandsons of Richard Trevithick (13 April 1771 – 22 April 1833) who was a British inventor and mining engineer from Cornwall.
7. Another grandson, Francis Henry Trevithick, worked as a superintendent of Shimbashi works, and completed “Abt system” railway of 66.7/1000 at Yokogawa.

2.8 All-Japanese locomotive

1. All-Japanese locomotive, Type 9600, appeared 42 years after the railway opening.
2. World War 1, which began in 1914, pushed domestic production as a result of difficulty in importation of parts.
3. The traction force of steam locomotive is affected by the boiler size.
4. This locomotive applied driving wheels of small diameter under its big boiler. (In case of standard gage, a boiler is set between the big driving wheels.)
5. This locomotive was a suitable match for Japanese geographical features, even though the maximum speed was only 65 km/h because of the high gravity center and small wheels.

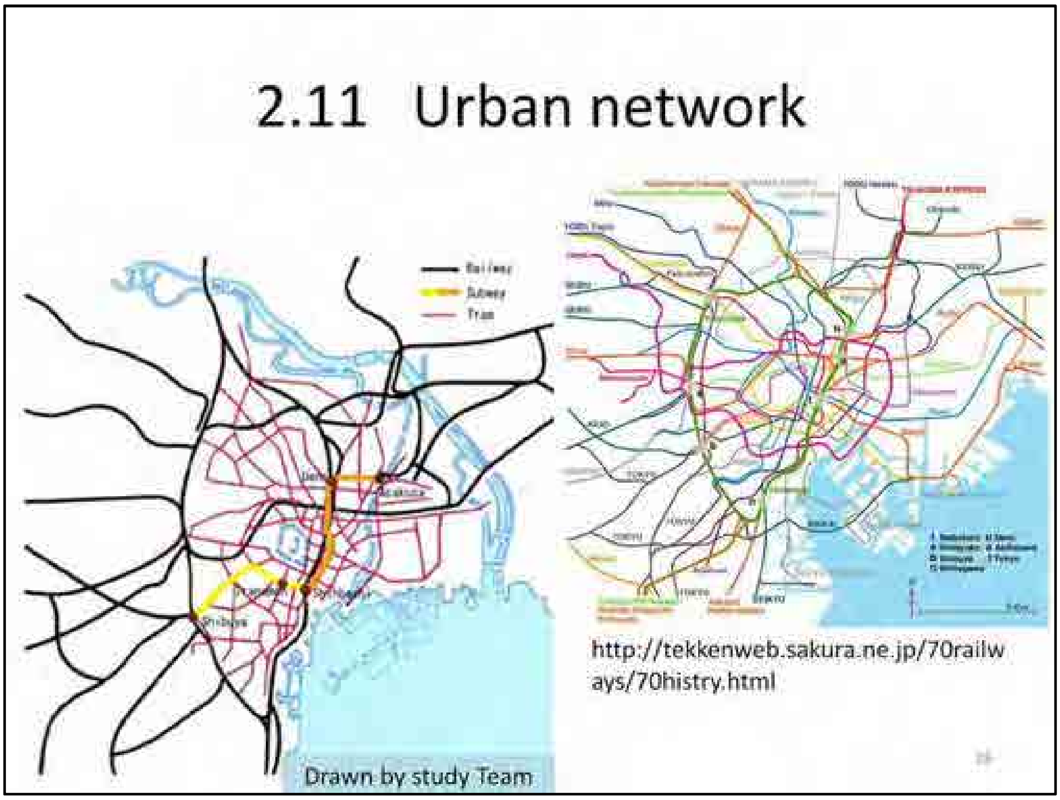
2.9 Railway opening years in Tokyo

1. This picture shows the opening year of each line.
2. The first was the south line to Yokohama, the next was the north line to Kumagaya, then the connecting lines between the north and south.
3. In those days, Kumagaya was the center of the silk industry and Yokohama was a trade port.
4. The railway construction in downtown fell behind as shown here.
5. A remarkable point is the location of Tokyo station, which allows pass through operation.
6. The idea came from a foreign advisor Mr. Bulzer, who might have been influenced by his home town Berlin.
7. In Berlin, a combination of a circular and a pass through line is applied.



2.10 Track Alignment

1. The alignment on the left shows the current Tokyo underground station, which allows pass through train operation.
2. The number of departure and arrival trains is over 320 per day.
3. The alignment on the right is the dead end station, of which capacity is very low compared to a through station.
4. The photo below is The North Paris Station which is a typical dead end station. Many trains are sitting at platforms without carrying passengers.



2.11 Urban railway network

1. The development of Japanese railway is not always satisfactory.
2. The left is the network in 1939, and black lines are ordinary railway.
3. Yellow and orange lines shows subways, and red lines are tram.
4. Most of radial black lines are private railways, and they wanted to extend their lines into the down town.
5. But Tokyo local government didn't accept it considering the area is the territory of its tram. This was the big mistake of urban planning.
6. As a result, serious congestion at terminal stations wasn't solved until we realized run through operation which connected different suburban lines.
7. The right figure shows the current network.
8. It should be noted that there is no difference in transportation capacity depending on gauge.

3.1 Shinkansen technology

1. We studied railway technology from Europe, and developed our own technology.
2. The construction of a bullet train line extending 988.4km from Tokyo to Shimonoseki, began in 1940 during the world war Ⅱ.
3. The expected maximum speed was 200km/h in the electrified section and 150km/h in the non-electrified section.
4. Even though the work was suspended because of the worsened battle situation, this plan became the basis for the Shinkansen.
5. Shinkansen introduced the aircraft technology which had been developed during the war.
6. The left figure shows “Oka”, a suicide rocket, controlled by a pilot targeting enemy warships.
7. It carried one ton of explosive compound, but didn’t have landing wheels, since it was not meant to come back.
8. Mr. Miki was the development chief of this weapon, and he took charge of the design for Shinkansen body in the institute of railway engineering.
9. One of his colleagues, Mr. Matsudaira who had worked for the improvement of the Zero Fighter, solved the vibration problem of Shinkansen vehicles.
10. Another his colleague, Mr. Kawabe who had been specialist of radio communications, developed ATC, automatic Train Control system.

4. Characteristics of Shinkansen

Target	Equipment	Requirement	Means: Original	Means: Current	Unable case
High speed	Rolling stock	Max. speed	210km/h	320km/h	
		Performance	AC25KV		
		Weight	Axial load 16 t	17t	
		Power	Multiple unit system		
	Track	Running stability	Standard gauge1435mm		
			Min. curve radius 2500m	4500m	
Safety	Train control	Triplexed system	ATC		
		Centralized control	CTC		
	Natural disaster	Earthquake		Brake by preliminary tremors	Meteoritic bombardment
	Man-made disaster				Terrorism
Environment	Noise control		Tunnel hood		

Drawn by Study Team

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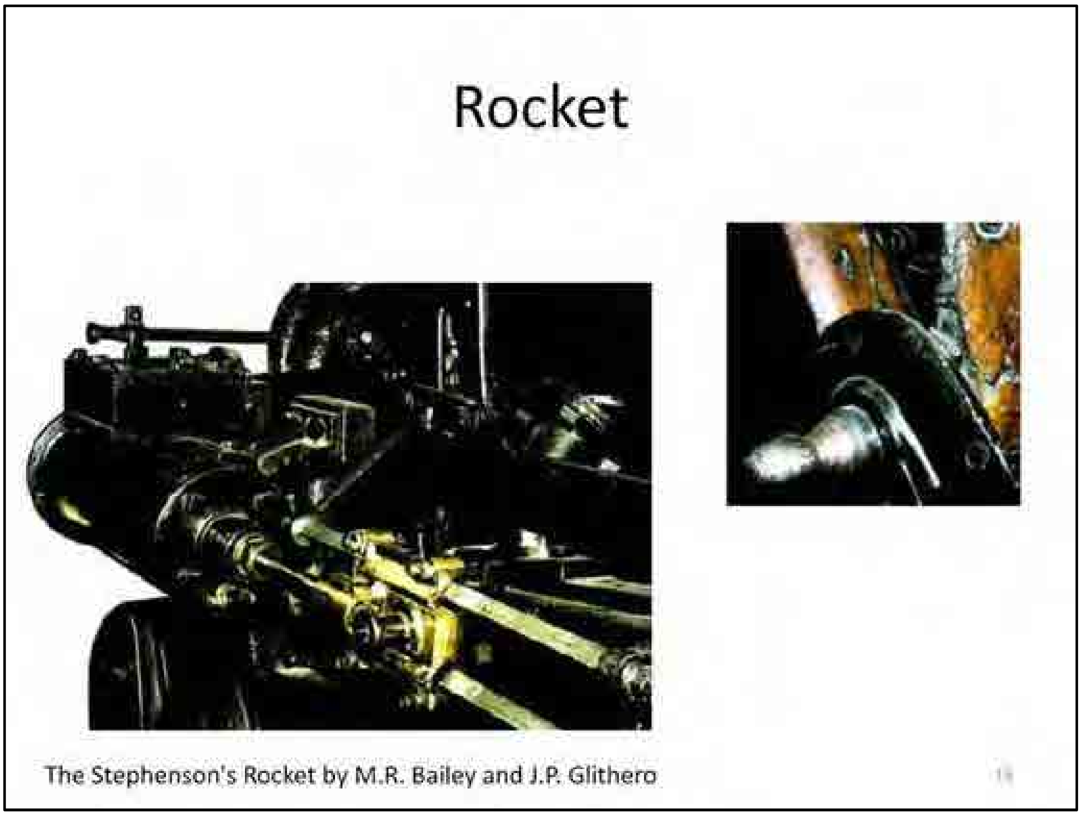
3.2 Characteristics of Shinkansen

1. This table shows the characteristics of Shinkansen.
2. In short, it is an optimized and simplified system, having a clear target.
3. It specializes exclusively in high speed passenger transportation with no freight transportation.
4. It lightens the weight of rolling stocks and saves energy costs.
5. The light rolling stocks reduces axle loads and bridge costs.
6. The high aerodynamic capacity enables a smaller tunnel cross section, saving construction costs.
7. These are the characteristics of Shinkansen.

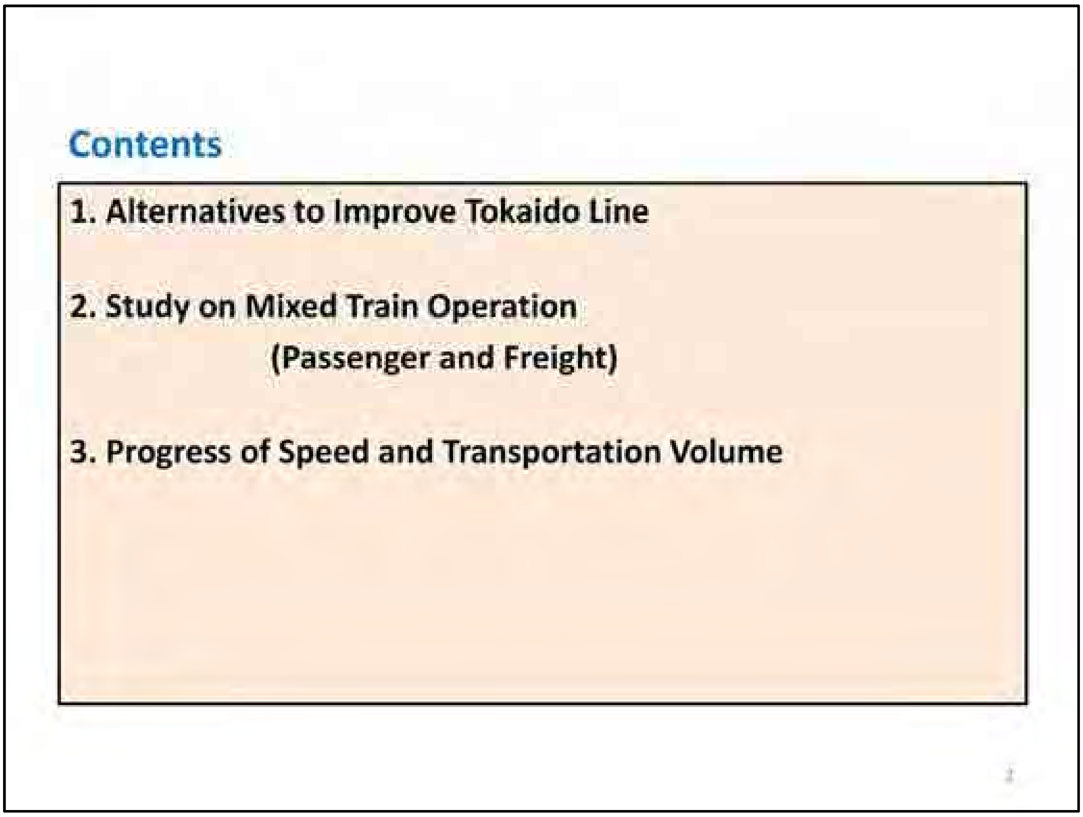


The Stephenson's Rocket by M.R. Bailey and J.P. Glithero

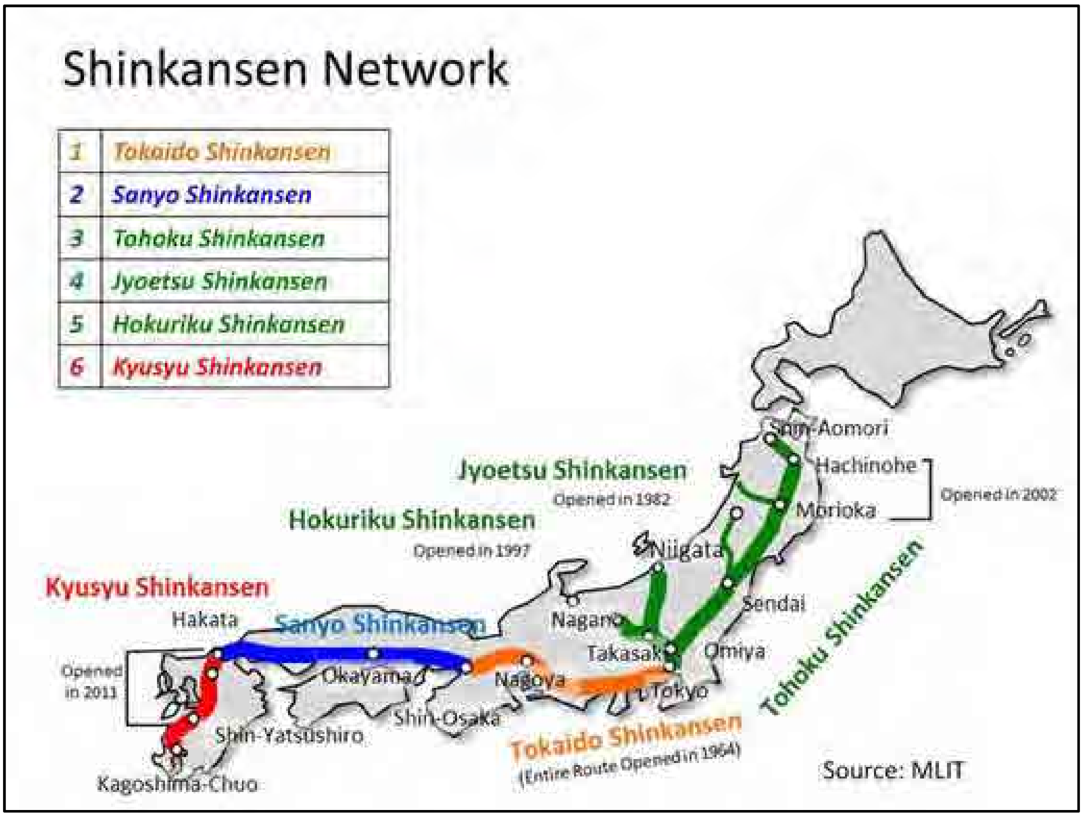
3.3 Rocket

1. Finally, let me introduce the Rocket, which was put to practical use by George Stephenson, after Trevithick.
2. The left shows the crank connecting the piston and the wheel. It is made of bronze.
3. The right shows the spoke of driving wheel. It is made of wood.
4. In those days, steel was difficult to process. Therefore, these materials were applied at the sacrifice of durability.
5. Railway technology has been developed receiving benefit from the development in various other fields.
6. I hope you can see that in these pictures, and visit the railway museum in York, UK to see the Rocket..

(Self-introduction)
I will explain about the initial study on Tokaido Shinkansen.



The contents are shown here..
1.At first, I will explain the situation of the Tokaido corridor.
And explain the alternatives considered in those day, showing the demand forecast and line capacity.
2. Next, I'll explain about the construction standards from the view point of mixed train operation.
The freight operation was seriously considered in those days, but abandoned.
I'll explain those matters.
3. After the opening the Tokaido Shinkansen, we have speed up using the same infrastructure.
I will explain as well.



First, I would like to discuss the backgrounds of constructing Shinkansen Lines in Japan.
This is the Shinkansen network map in Japan.
There are 6 operating Shinkansen lines in Japan, and they are roughly divided to two types by the background.
Tokaido and Sanyo Shinkansen Lines are divided to the type of demand following.
And Tohoku, Jyoetsu, Hokuriku, Kyusyu Shinkansen Lines are divided to the type of Investment for development.

Outlook of Tokaido Existing Line (TEL)

・Socio-economic condition in 1954-1955

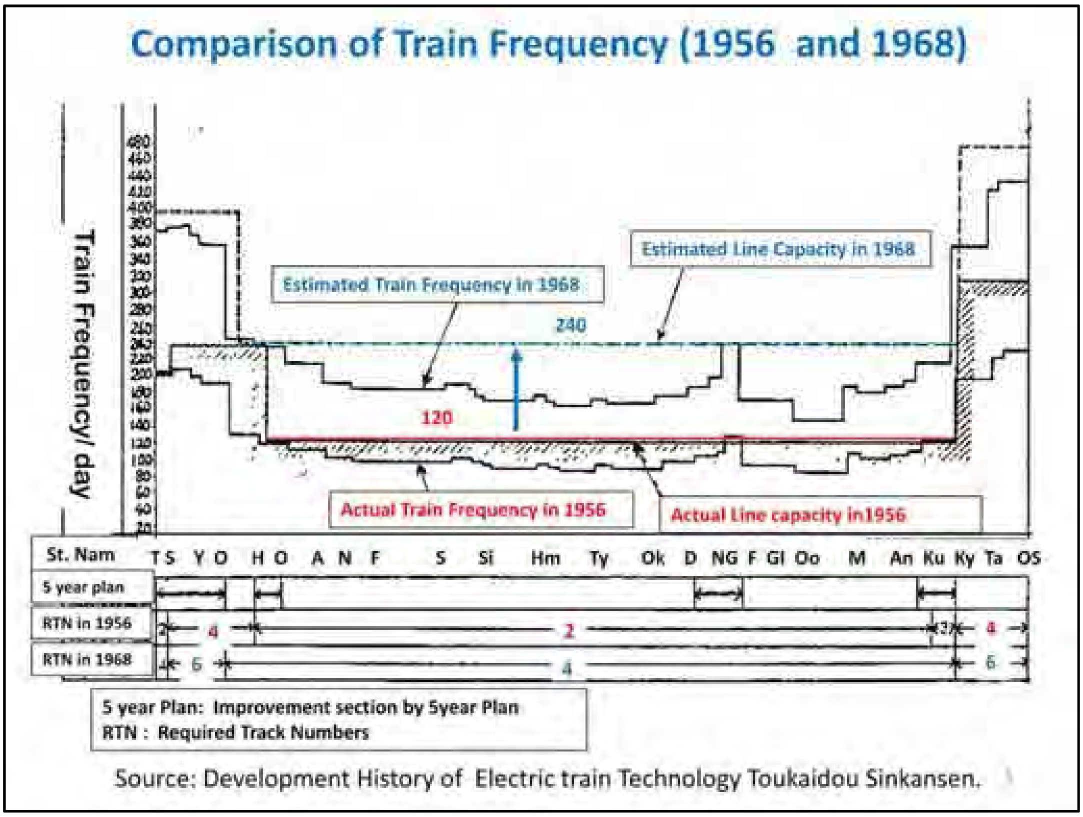
Item	TEL (A)	Nation wide(B)	A/B
Population in 1955	29.977 mil. along TEL	89.275 mil.	33.6%
National income in 1954	2,504.3bil. ¥ (6.96bil. $)	6,132.2bil.¥ (17.03bil.$)	40.8%
Industrial Product in 1954	3,578.5bil.¥ (9.94bil.$)	6,055.0bil. ¥ (16.82bil.$)	59.0%

・Traffic condition in 1955

Item	TEL (A)	Nation wide(B)	A/B
Passenger- kilometers	23.01bil.	98.08bil.	23.5%
Ton-kilometers	10.41bil.	46.92bil.	22.5%
Operating distance	556.4km	20,000km	2.8%

Source: Study Team

1. The upper table shows the socio-economic condition of Tokaido corridor.
As you see, 34% of Japanese population, 41% of national income and 59% of industrial product concentrated along the Tokaido existing line.
2. The lower table shows the traffic condition of Tokaido Railway line.
Only 2.8% of the whole Japanese line transported 22-23% of passenger and cargo.



This picture compares the actual traffic in 1956 and estimated future traffic condition in 1968.

1. Transportation volume

Future demand was estimated assuming 4.5 % of annual growth until 1961, and then 3.5% per year.

The volume in 1959 was considered to become 1.6 times of 1955.

The shift to an express way was assumed to be 3.6 % of passenger and 8.1 % of cargo.

2. Train frequency

The capacity of double track railway is 120 trains per day.

Therefore additional double track is considered to be necessary before 1963.

To solve the problem, three alternatives were presented.

Alternatives to improve Tokaido Line Study in 1955

Item		Narrow Gage 1067mm	Standard Gage(1435mm) Concentrated traction system	Standard Gage(1435mm) Distributed traction system
Train Type	Passenger	EC	EC (Electric Car)	EC (Electric Car)
	Freight	EL Drawn	EL Drawn	EC (Container)
Train Speed (km/h)	Passenger Max Freight Max	140~150 100	200~250 150	200~250 150
	Passenger Average	100~120	160~200	160~200
Time distance (Tokyo~ Osaka)		4h40~ 5h30	2h45~ 3h30	2h45~ 3h30
Construction Cost		153.1bil.¥ (0.43bil.$)	178.3bil.¥ (0.47bil.$)	138.9bil.¥ (0.39bil.$)
Rolling stock Cost		23.9bil.¥	15.2bil.¥	23.6bil.¥

1US$=360Yen

Final Estimation of Construction Cost 172.5bil.¥ → Construction Cost for completion 380.0bil.¥ (1,056mil.$)

Source: Study Team

Alternatives to improve Tokaido line
1.Following alternatives were proposed.
① Additional 1067mm of double track
② Additional 1435 mm of double track, Electric cars for passenger and locomotive drawn train for freight.
③ Additional 1435 mm of double track, Electric cars both for passengers and freight
2. The alternatives ③ was thought to be reasonable in those days.
The estimated construction cost became doubled when the whole work finished.

Investigation on Shinkansen Freight Train

1.Freight train demand for Tokaido Shinkansen was estimated as follows;
- 22bil.tonkm in 1975
- 23% of whole railway demand along Tokaido line

2.Planning condition of TKS freight train
- Freight car capacity : 25t(5t × 5peaces) per car
- Train capacity: 750t (30 cars, train length 477m)

3.Estimated freight train frequency in 1964 and 1975

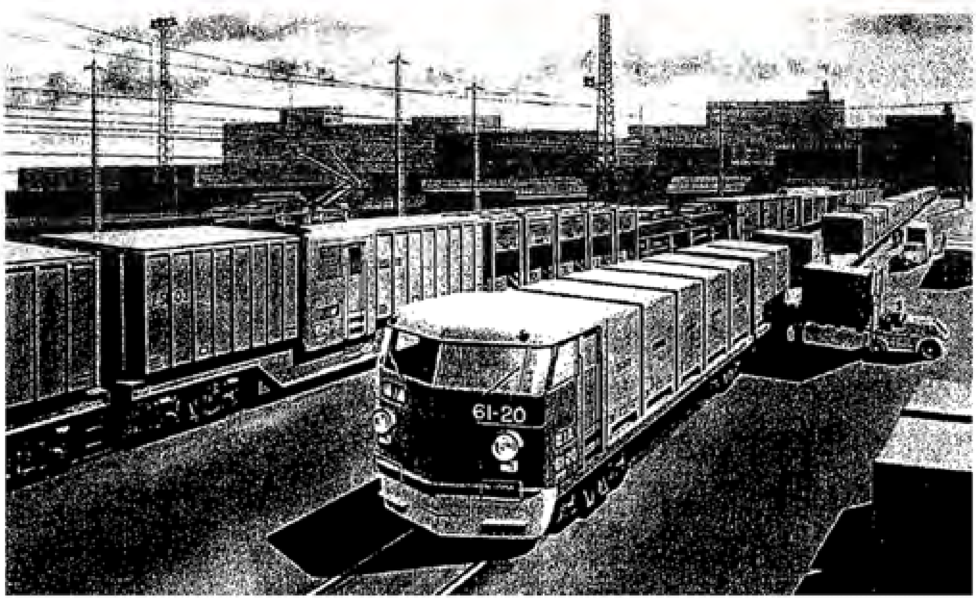
Section	1964 (trains/day/one-way)	1975 (trains/day/one-way)
Tokyo-Shizuoka	10	26
Shizuoka -Nagano	11	26
Nagoya-Osaka	8	24

4.Others
1)1435mm gauge /Transport type : Large Container or Piggyback system
2)Maximum speed passenger train 250km/h, freight train 150km/h
3)Scheduled time between Tokyo~ Osaka: 5h 30min
4)Freight station : Tokyo, Shizuoka, Nagoya, Osaka
5)Operation time :Midnight (10PM~5AM)
6)Stoppage of freight transportation service : Saturday

Source: Study Team

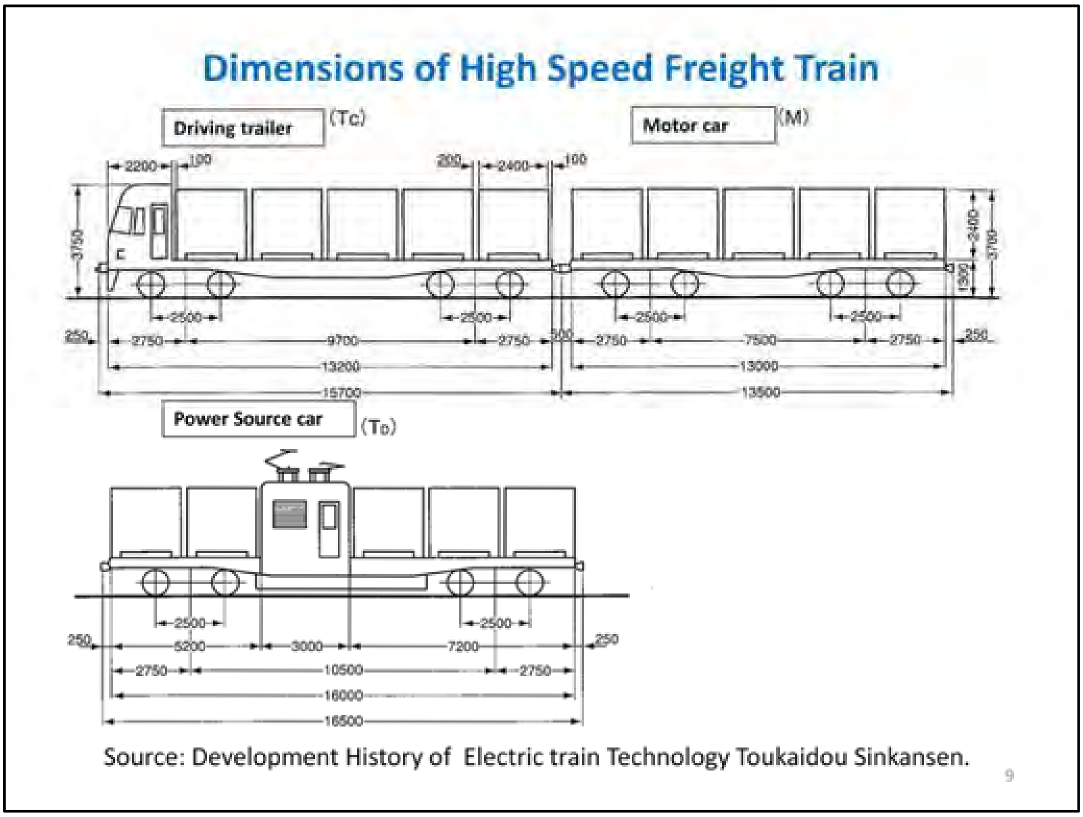
Now, I explain the plan of Shinkansen freight train in those days.
1. The estimated Shinkansen demand was as follows;
  (1) 22 bil. ton km in 1975
  (2) 23 % of railway transportation. (77% is existing railway)
2. The transportation system was considered as follows;
  (1) Five containers on one cargo vehicle
  (2) One train consist of 30 cargo vehicles, totally 750 ton and 477m of train length
3. The required freight train numbers is shown in this table.
4. The concept was followings;
 (1) Gage is 1435mm and transportation by piggyback or container.
 (2) Maximum speed is 150km/h.
 (3) Time distance between Tokyo and Osaka is 5 hours 30 minutes.
 (4) Four cargo terminal stations were considered, Tokyo, Shizuoka, Nagoya and Osaka.
 (5) Cargo train operation time was considered to be midnight (10PM – 5 AM).
 (6) No freight train operation on every Saturday night for track maintenance.

Imaginary Picture of High Speed Freight Train



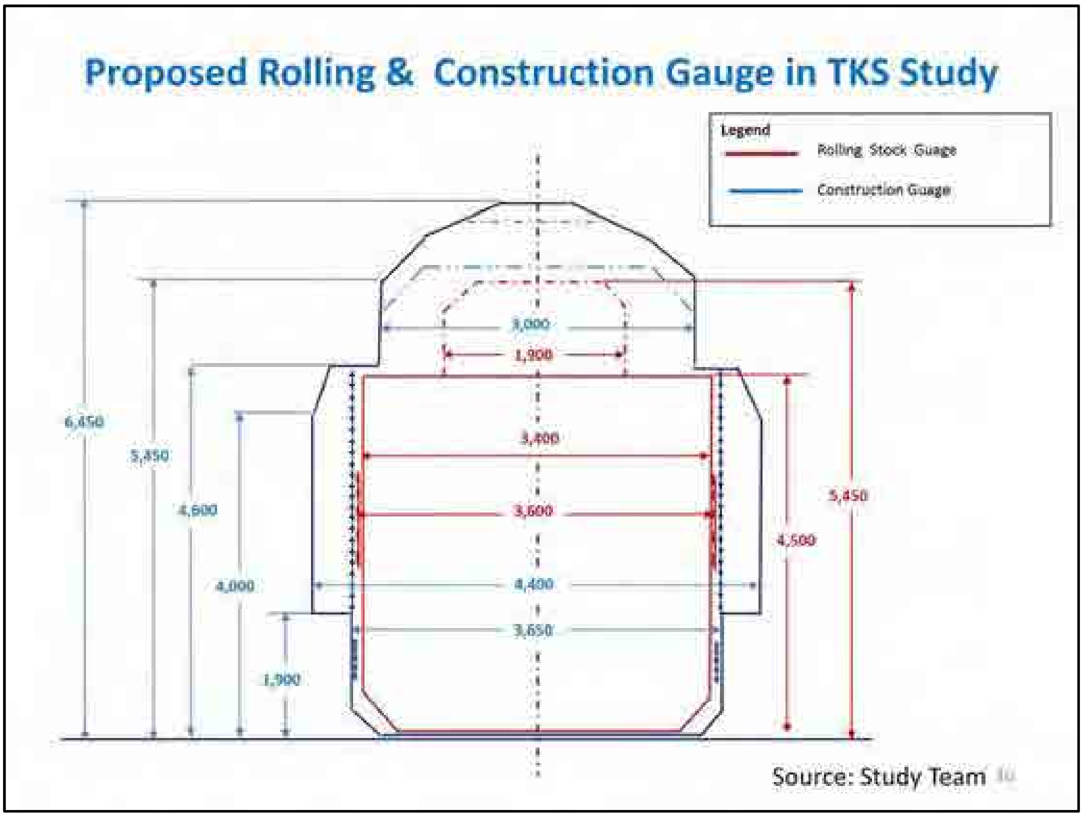
Source: Development History of Electric train Technology Toukaidou Sinkansen.[8]

This is a n imaginary picture of high speed freight train.

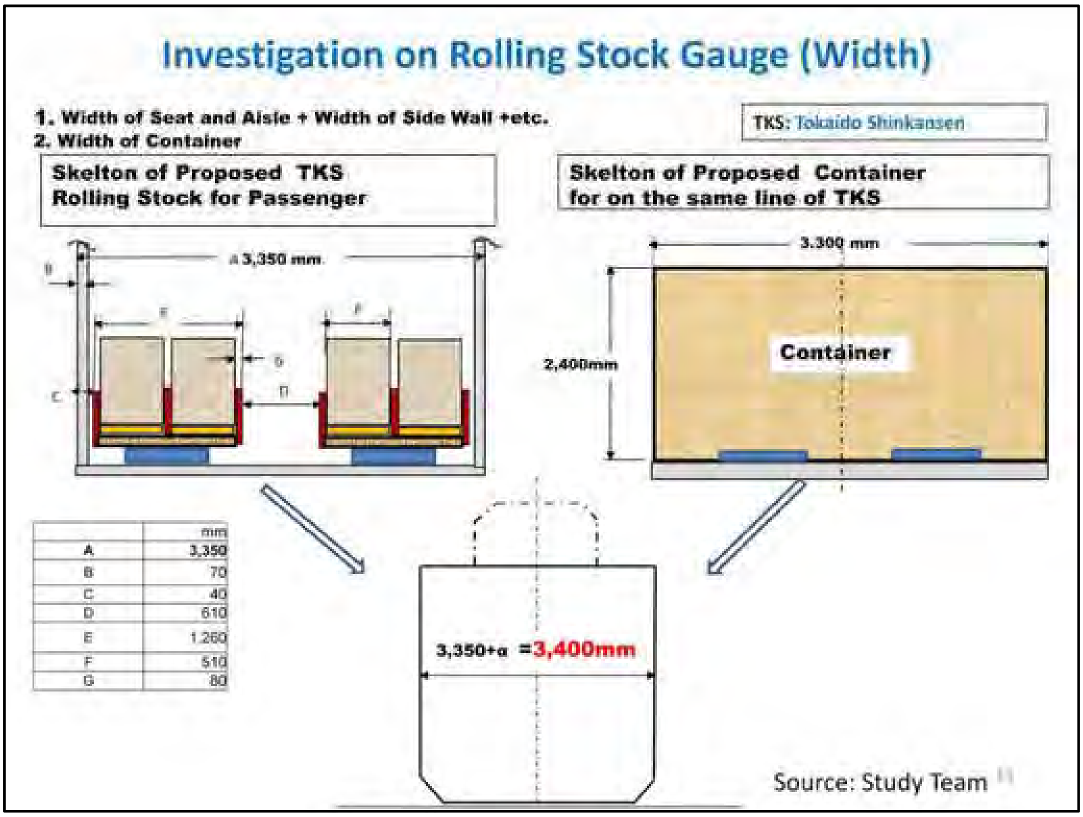


This figure shows the dimension of high speed freight train.

1. A train consists of driving cars, motor cars and power source cars.

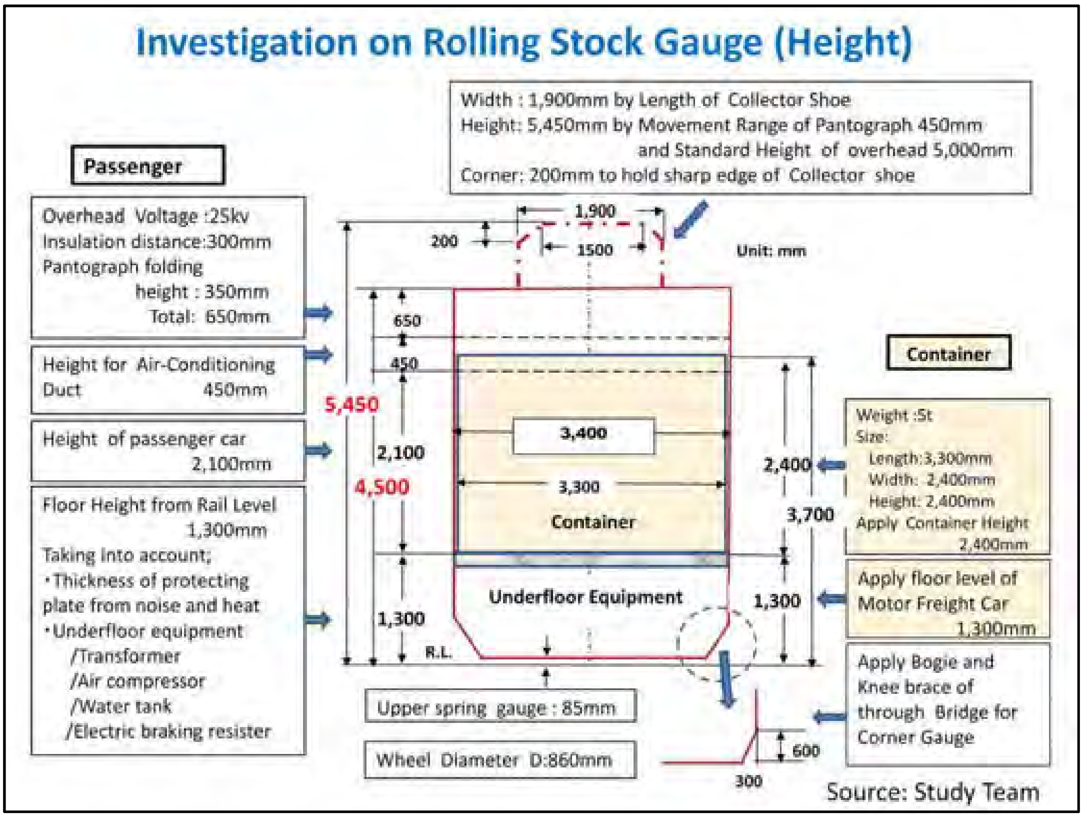


Proposed rolling stock gauge and construction gauge
1. This is a rolling stock and construction gage proposed for Tokaido Shinkansen.
2. From now, I'll explain the back ground of these values.



Investigation on rolling stock gauge

1. The width of passenger car: 3350mm
   Adding following values;
   - The thickness of outside sheathing (B)
   - The space between outside sheathing and seat (c)
   - The gangway width (D)
   - The maximum size of seat (E)
2. The width of freight car: 3300mm
   The container size was considered as shown in the figure, considering;
   - shared use with existing railway
   - and adaptability with road traffic.
3. Adding margin, 3400mm was proposed for HSR rolling stock gauge.



Investigation on the height of rolling stock gauge

1. The height of rolling stock gauge: 5450mm

The lowered pantograph height from rail level is 4500mm, including;

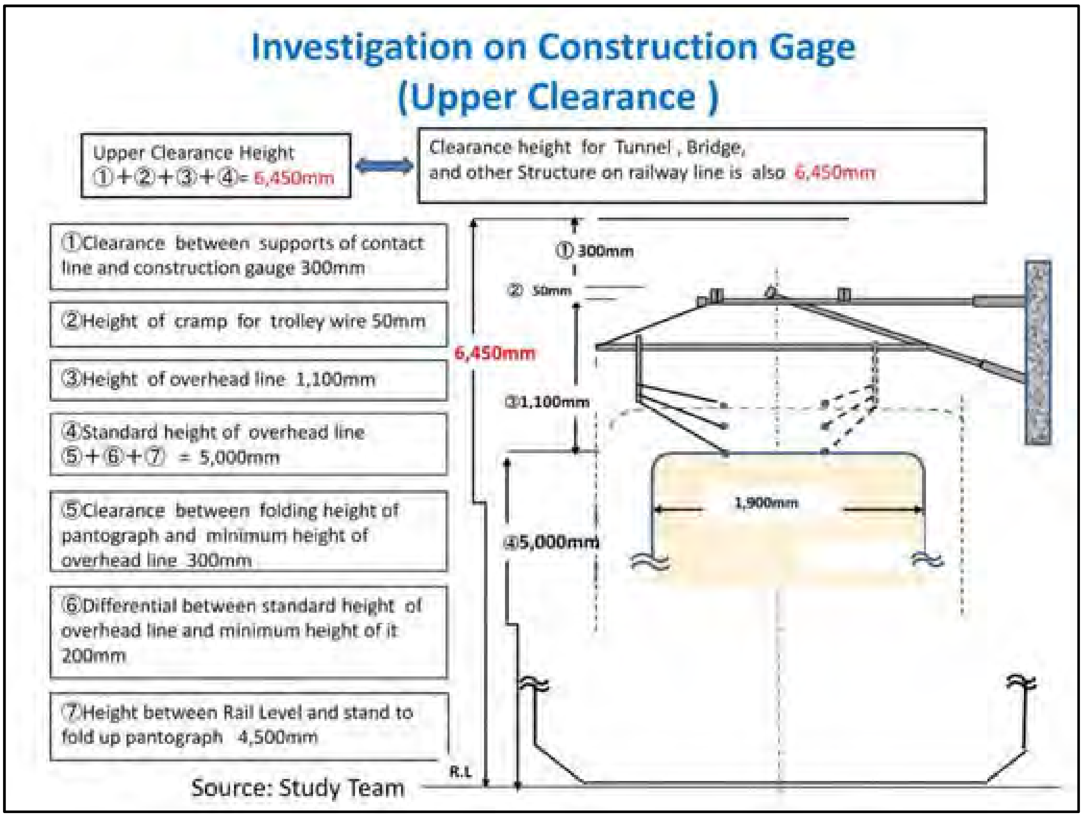
1) The length from floor to rail level
2) The height of cabin
3) The height of duct for air conditioner
4) The insulation distance for 22kv and the lowered pantograph height from roof

Adding the margin including the difference of pantograph height and minimum insulation distance, 5000mm is required.

Finally 5450 mm is taken considering the moving range of pantograph.

2. Container car

The floor height was same with passenger car, and 2400mm from the floor to the upper surface of container.

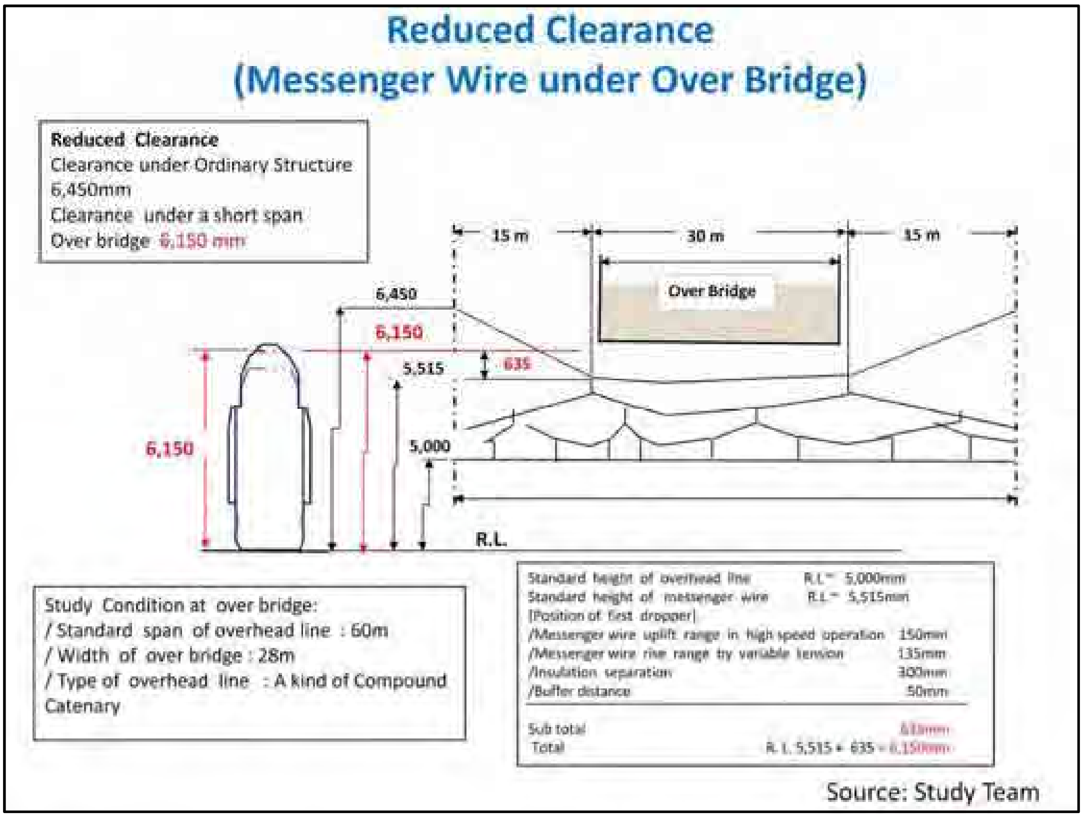


The height of construction gauge (Upper clearance)

1. The height of construction gage for the structure such as tunnel and bridge is;

The standard height of overhead contact line	5000mm
The height of catenary	1100mm
The height of suspension cramp	50mm
The insulation distance	300mm

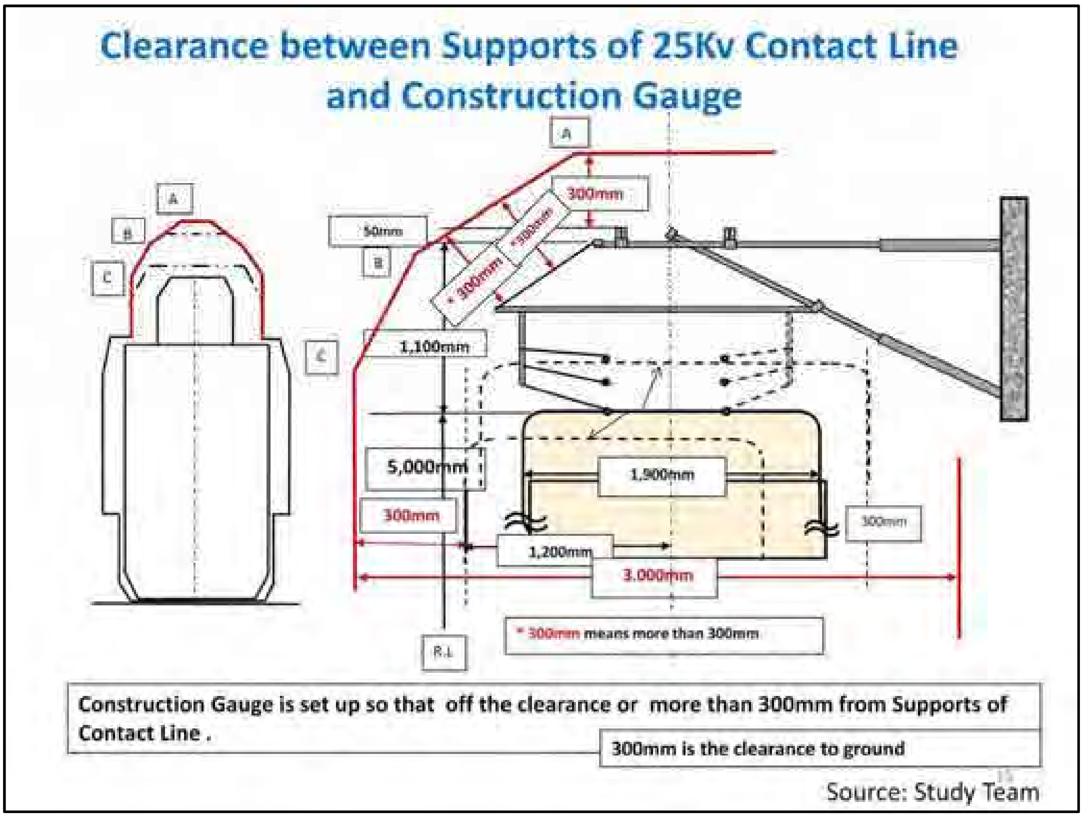
2. Adding these values, the height of construction gage is 6450mm



Source: Study Team

Reduced clearance under over bridge

1. The clearance height can decreased to 6150mm for the short span structure such as over bridges.
   This utilizes the sag of catenary.
   Detailed estimation is shown in the picture.



The offset distance between the supports for 25 KV contact line and construction gauge

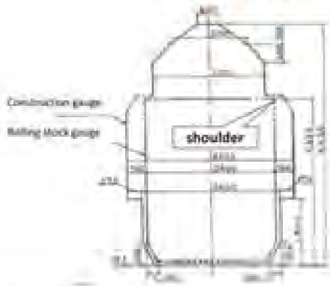
1. Required distance from pantograph to horizontal direction

Maximum movement of pantograph	156mm
Insulation distance	300mm
Vibration and margin	
Total	550mm

2.The width of construction gauge

The width of pantograph	1900mm
Required distance from construction gauge	550x2 mm
Total	3000mm

Investigation on Clearance Gauge (Height and Width at Shoulder)



1. For the investigation of clearance gauge, followings are taken account.
   1) Vehicle dynamics
   2) Blowout of air cushion
   3) Tolerance limits of track maintenance

2. Shoulder height

The shoulder height of rolling stock gage moves up from 4500mm to 4600mm, influenced by followings;
1) Blowout of air cushion: 6mm
2) Tolerance limits of track maintenance: 15mm
3) Passing at vertical curve: 9mm
4) Margin: 70mm

3. Shoulder Width

The lateral movements of vehicle shoulder are;
1) Vehicle dynamics: 97mm
   =(Max. of Rolling 87mm and Yawing 97mm)
   For the estimation of Rolling, the moved up shoulder height is applied.
2) Blowout of cushion: 51mm
   = 35X3800/2600
   where 3800 is from floor to shoulder level
   2600 is the distance between cushions
3) Tolerance limit of track: 42mm
   where 20mm of track center tolerance
   22mm caused by rail level difference 7mm
   =7mmx4500/1435
   where 4500 is shoulder height
   1435 is track gauge
4) Margin: 110mm

The total is 300mm
=97+51+42+42

The width of construction gauge is 4000mm at 4600 mm of possible shoulder level.
=2x300+3400mm of rolling stock gage width

Source: Study Team

Construction gage at shoulder

1. Height
   The height of rolling stock gage at the shoulder is 4500mm.
   As shown in the figure, the height of shoulder moves up 100mm possibly.
   Therefore 4600mm is adopted for the shoulder height.
2. Width
   The possible movement is 300 mm including margin, as shown in the picture.
   Therefore 4000mm was adopted at the shoulder level.

Track Spacing

Investigation on Track Spacing

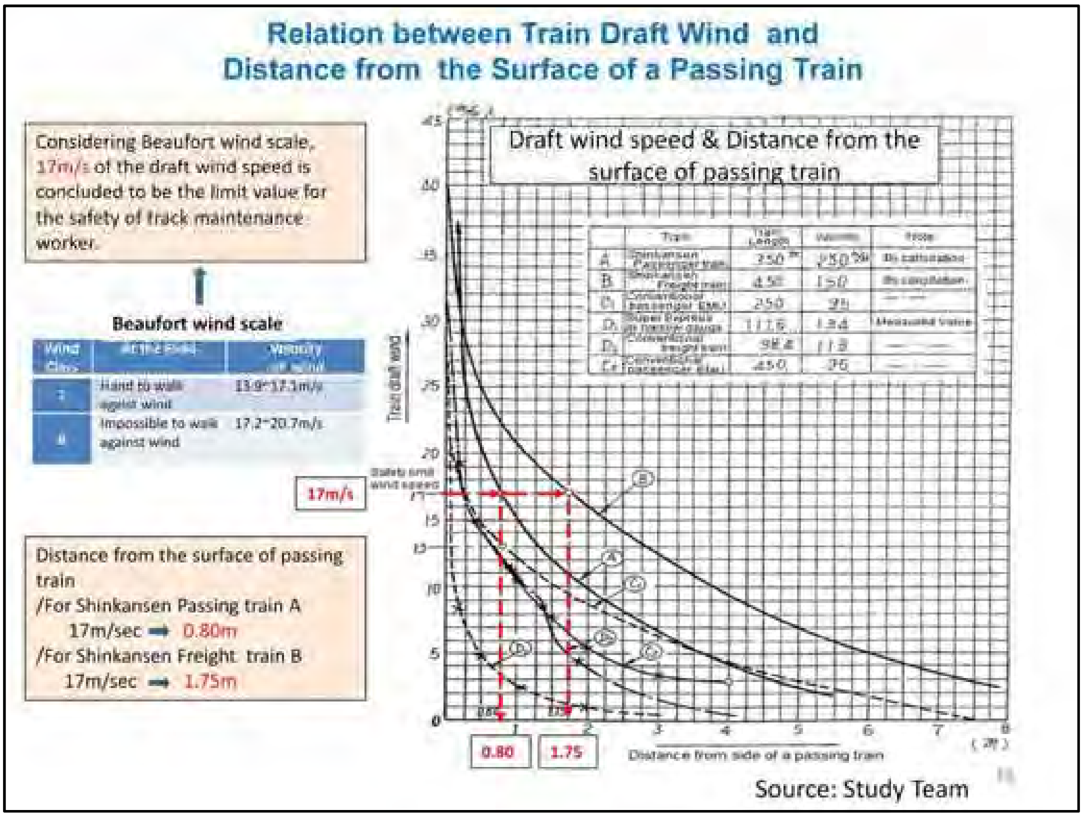
- Train draft pressure is proportional to the square of relative velocity.
  /The relative speed is 500km/h, when 300km/h train passes by 200km/h train.
- The draft pressure is influenced by the following factors.
  /Roughness of train surface
  /Distance between trains
- The estimated track spacing which cause same draft pressure is;

Train type	EC+EC		EC+Freight		Freight+Freight	
Relative velocity (km/h)	400	500	300	400	250	300
Width of car body (m)	3.5 3.4	3.1 3.4	3.1 3.4	3.1 3.4	3.1 3.4	3.1 5.9
Track Spacing (m)	3.6 3.9	3.9 4.2	4.7 5.0	4.8 5.1	4.6 4.9	5.4 5.9

- The track spacing of 4.2m was adapted, considering;
  /Target speed of 250km/h for passenger and 150km/h for freight train
  / Width of 3.4 m for car body

Source: Study Team

The track spacing
1. Considering the train draft pressure, 4200mm was adopted.
 1) The value of train draft is a function of relative speed, roughness of train surface, and distance between trains.
 2) The items in the table makes the same level of the train draft.
 3) Considering the future train speed of 250km/h, 4.2 m was adopted for the track spacing.



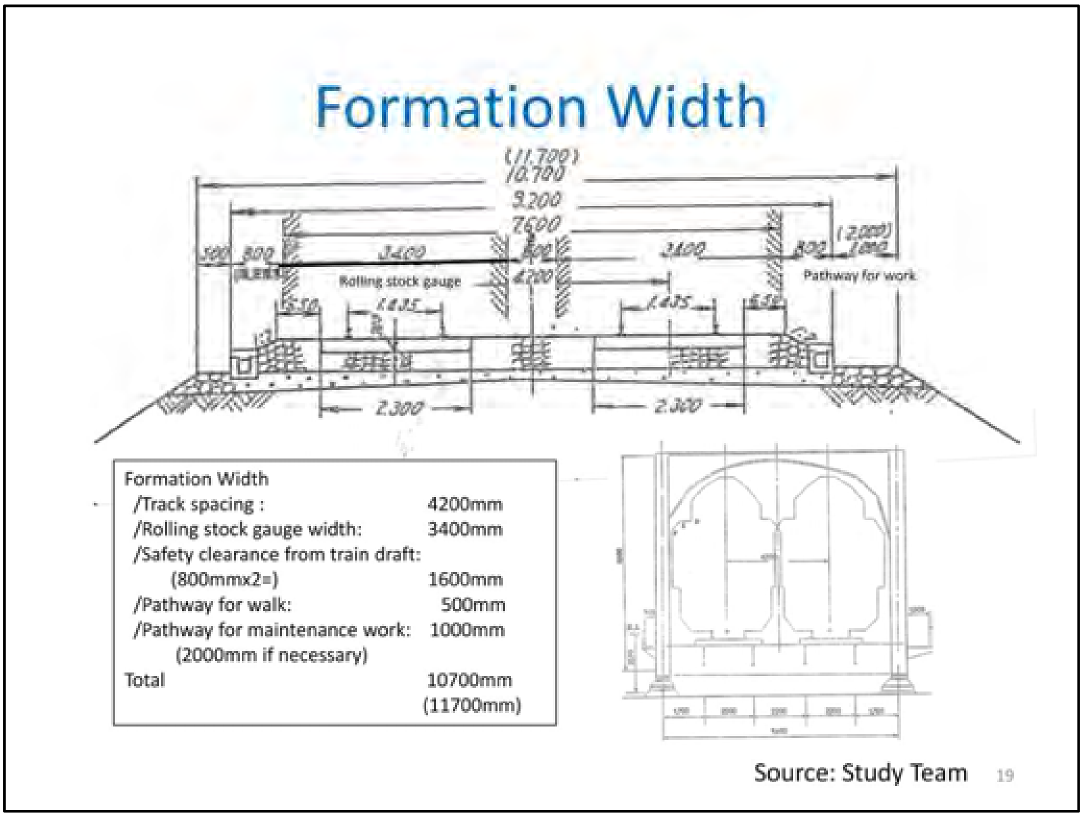
The effects of train draft on track maintenance.

1. Effects on maintenance worker

   1) Taking account the Beaufort wind scale, 17m/s of wind speed (Level 7 or 8 in the scale) seemed the limit of wind speed.

   2) The right figure indicates the relation between wind speed and distance from the train surface.

   3) The line A shows the train draft by 250km/h, future speed.
   From this, 0.80 m was considered to be the safety distance from train.



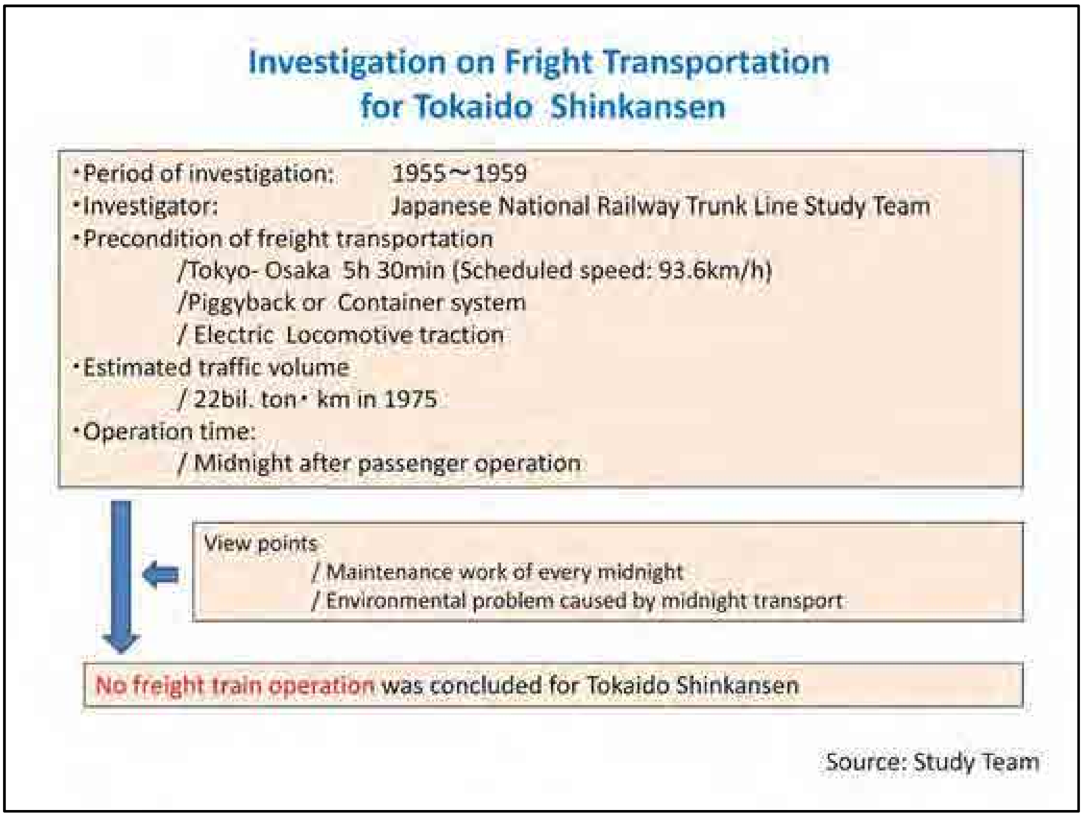
Formation Width

1. Decision factor of formation width

The factors are;

1) Track maintenance
2) Safety of worker from train draft
3) Necessary pathway for walking and working

The estimation is shown in the picture, and the width of 10700mm was concluded.



Investigation on freight train operation

1. Process

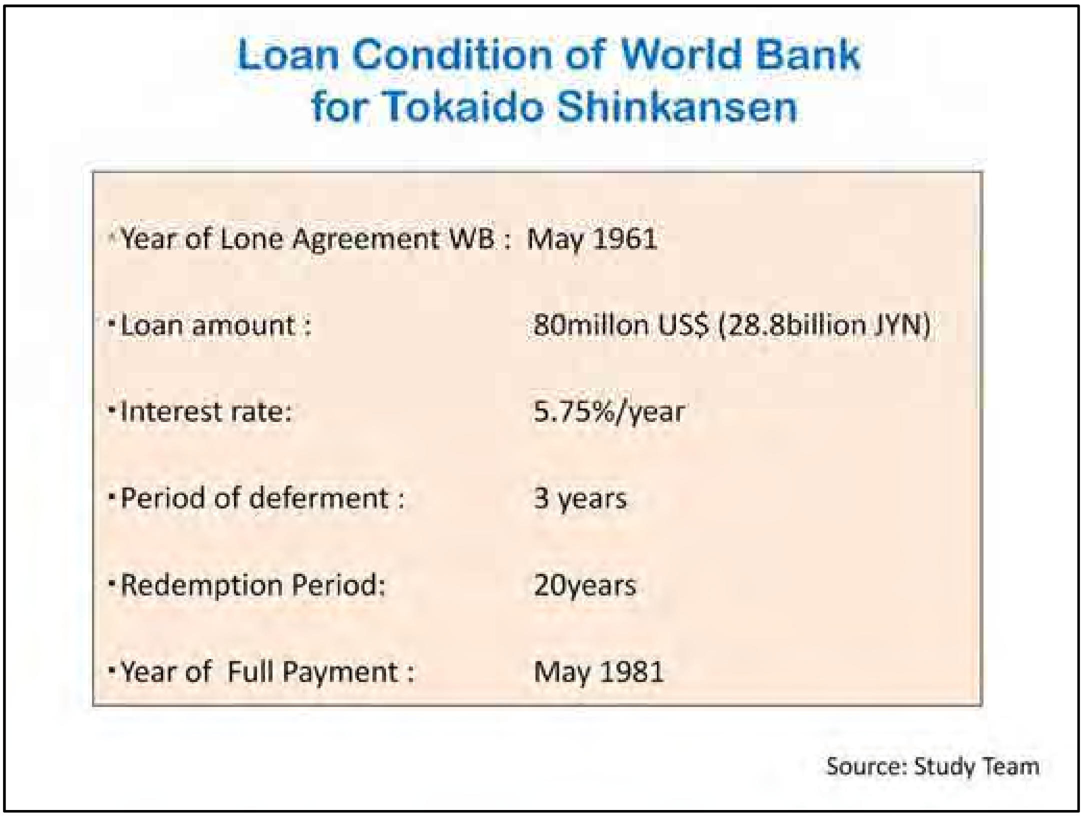
As shown in the picture, the study team of considered the way of freight transportation.

The transportation was assumed as follows

Max. speed 150km/h (Average 93.6km/h),
5h30m from Tokyo to Osaka
Locomotive traction
Piggyback or container system

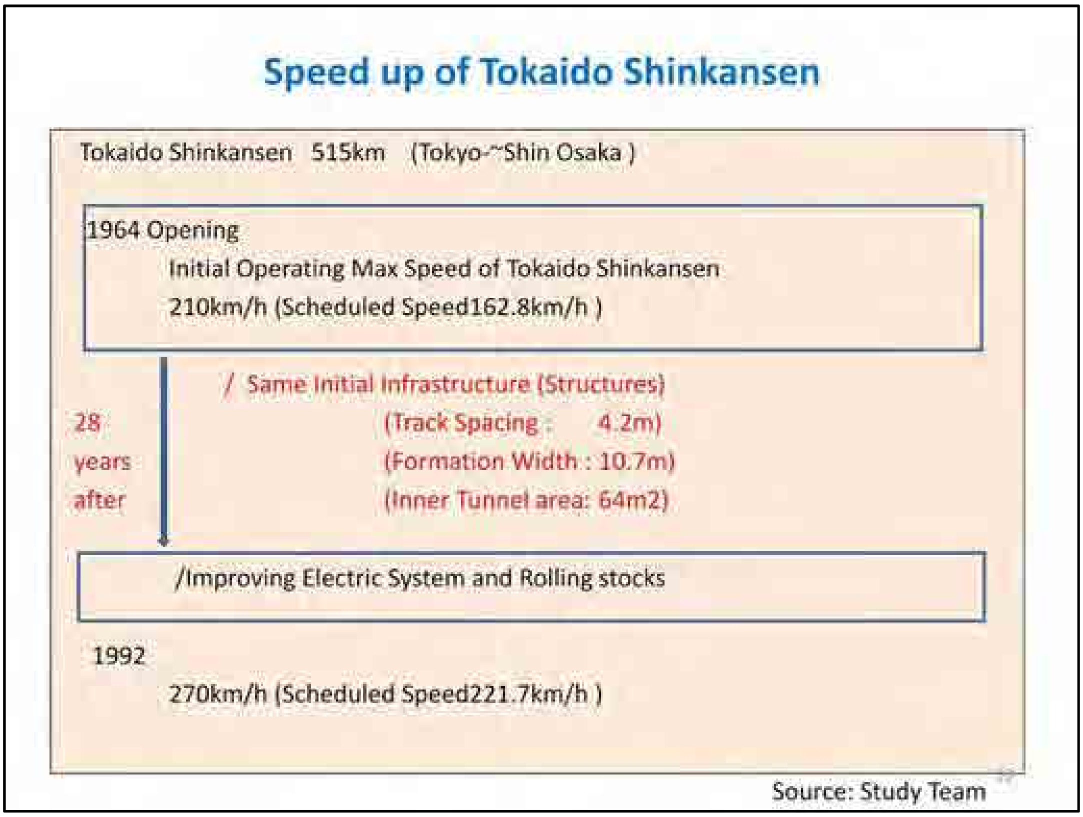
Finally, the freight train operation was abandoned by the following reasons.

Maintenance in midnight
Environmental program

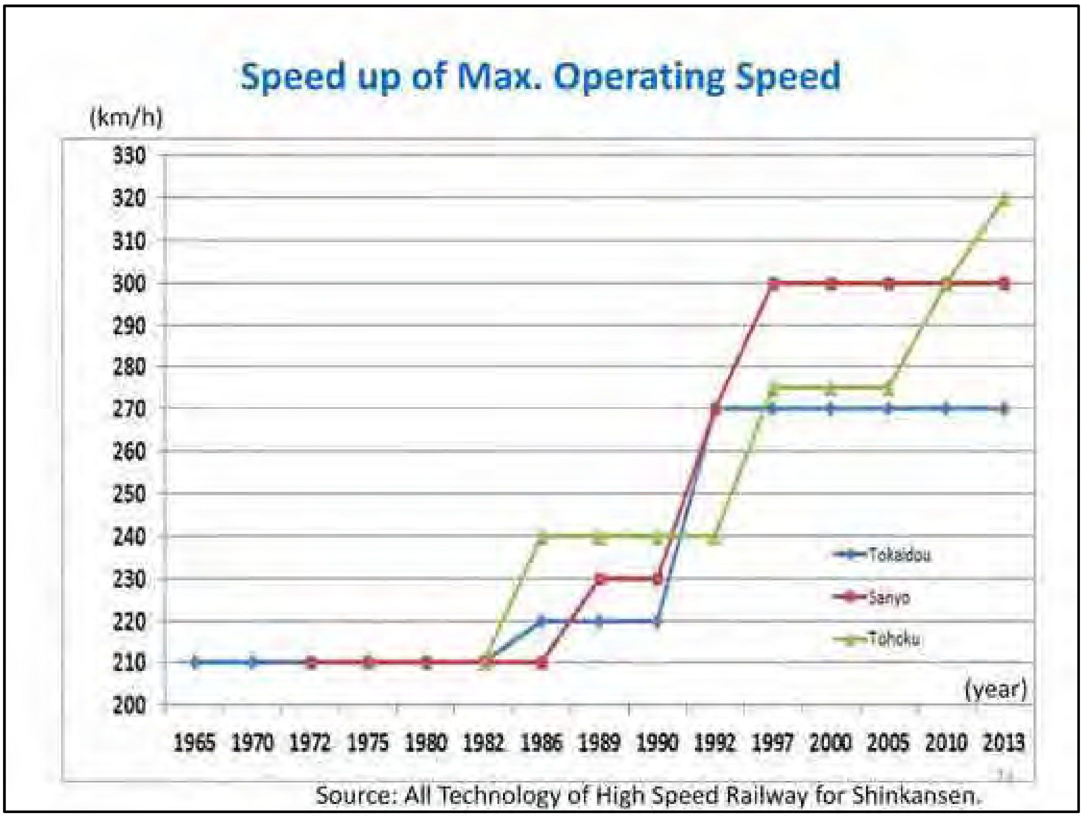


Loan Condition from World Bank for Tokaido Shinkansen

1) A part of the Shinkansen construction was financed by World Bank.
2) The loan condition is shown in the picture



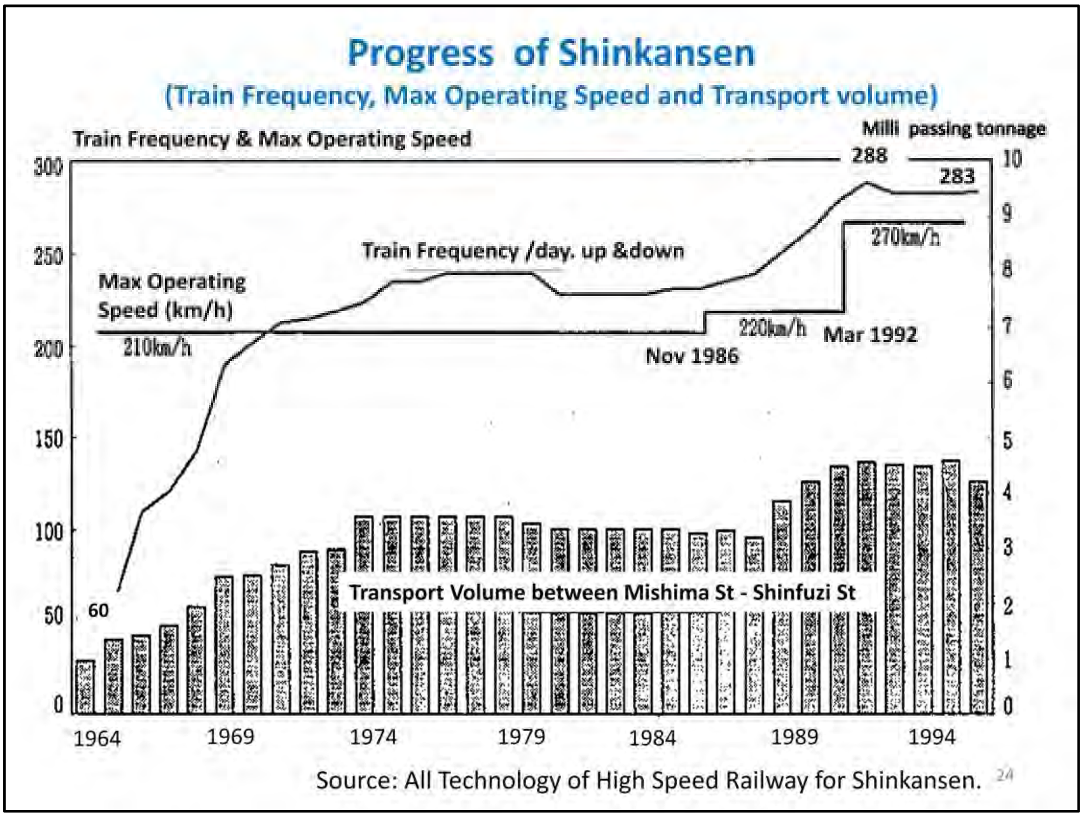
The speed up of Tokaido Shinkansen
1) The speed was opened with a maximum speed of 210km.h (Average 162.8km/h)
2) Even though the basic infrastructure is not changed, maximum speed increased to 270km/h (average 221.7km) by the improvement of rolling stock and electric facilities.



Speed up of Tokaido, Sanyo and Tohoku Shinkansen

1) Sanyo and Tohoku Shinkansen aimed 270km/h of maximum speed
   For this, the track spacing was widened to 4300mm
   The formation width and tunnel section are same with Tokaido Shinkansen

2) Now the maximum speed is 300km/h for Sanyo and 320km/h for Tohoku.



Progress of Tokaido Shinkansen

1) This figure shows the progress of Tokaido Shinkansen, indicating train numbers, maximum speed and transport volume.

Progress of Shinkansen Transport

Item	Tokaido		Sanyo		Tohoku	
Year	1965 Open	1997	1975 Open	1997	1982 Open	1997
Operating max Max Speed (km/h)	210	270	210	300	210	275
Schedule Speed (km/h)	163	221		242		211
Train Frequency Up & Down/day		285		245		288
Transport Volume Average Passenger thousand/day	85	360		200		203
Year	2007 (Tokaido+ Sanyo)				2007	
Transport Volume Average Passenger thousand/day	587				230	

Source: All Technology of High Speed Railway for Shinkansen.

The progress of Tokaido, Sanyo and Tohoku Shinkansen
1) This table shows speed, frequency, transport volume of each Shinkansen.

Construction Standards of Shinkansen

Item	Tokaido	Sanyo	Tohoku
Design Max Speed (km/h)	Opening 210	Opening 260	Opening 260
Gauge (mm)	1,435	1,435	1,435
Max Gradient (‰)	20 (within 1km)	15	15
Min Curve Radius (m)	2500	3500	4000 Now 6000
Min Vertical Curve (m)	10,000	15,000	15,000
Max superelevation (mm)	200	190	180
Max superelevation Deficiency (mm)	110	115	90
Transition Curve Type (mm)	Diminishing Sine Half Wave Length	Diminishing Sine Half Wave Length	Cubic Parabola
Formation Width (m)	10.7	11.6	11.0(Elevation)1 1.4(Fall)
Track Center (m)	4.2	4.3	4.3
Track Type	Ballast PC Sleeper 60kg	Ballast & Slab PC Sleeper 60kg	Slab &Ballast (5-2-0.19)m PC Sleeper 60kg

Source: Study Team

Construction standards,

1) This table shows the construction standards.
   The difference is shown in the minimum curve radius and track type.
   The minimum curve radius becomes to 6000m for the Tohoku extension from Morioka.
   From the Sanyo extension from Okayama, slab track becomes popular.

Structure of Shinkansen

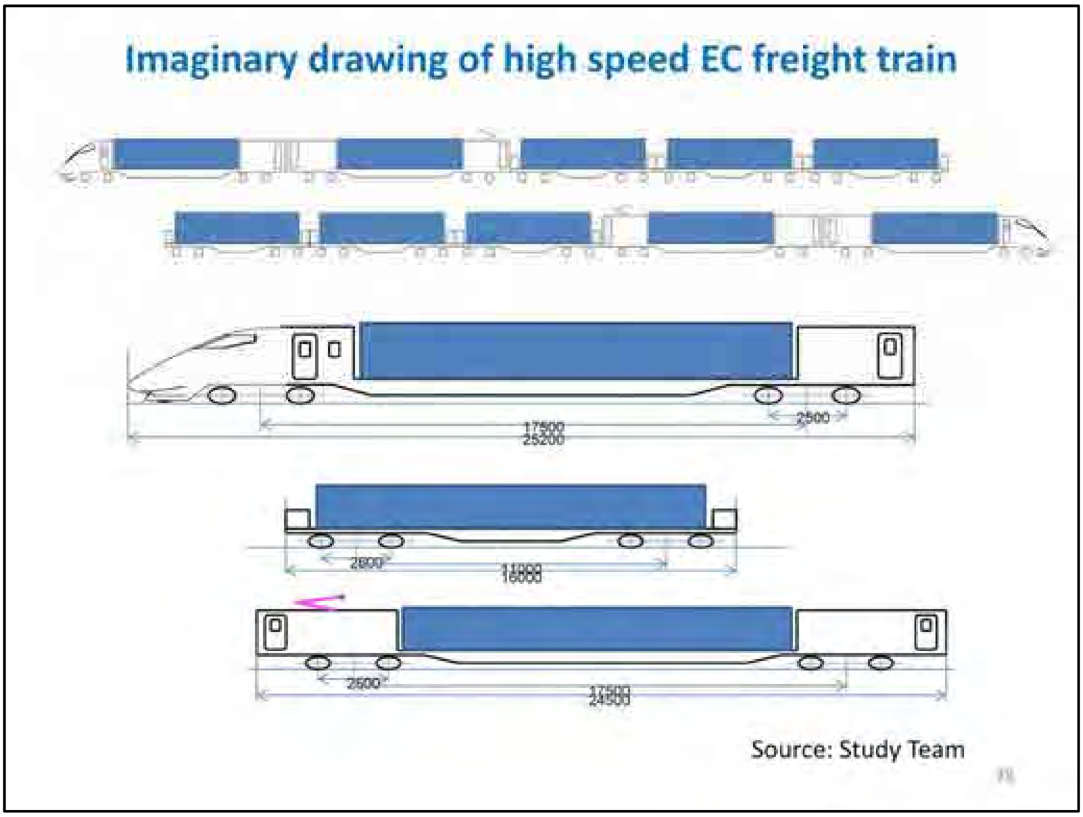
Item		Tokaido	Sanyo		Tohoku
Opening year		1964	1972	1975	1982
Railway Length		515km	554km		496km
Section		Tokyo-Shin Osaka	Shin Osaka-Okayama	Okayama-Hakata	Tokyo-Morioka
Station Number		16	6	13	18
Average Distance Between Stations		34km	30km	34km	28km
Earth work	Fill	230km(45%)	9km(5%)	35km(9%)	
	Cut	44km (8%)	3km(2%)	23km(6%)	
	Total	274km(53%)	12km(7%)	58km(15%)	23km(5%)
Viaduct		115km(23%)	75km(45%)	86km(22%)	236km(48%)
Bridge		57km(11%)	20km(12%)	31km(8%)	121km(24%)
Tunnel		69km(13%)	58km(38%)	222km(55%)	116km(23%)

Source: Study Team

The structure of each Shinkansen

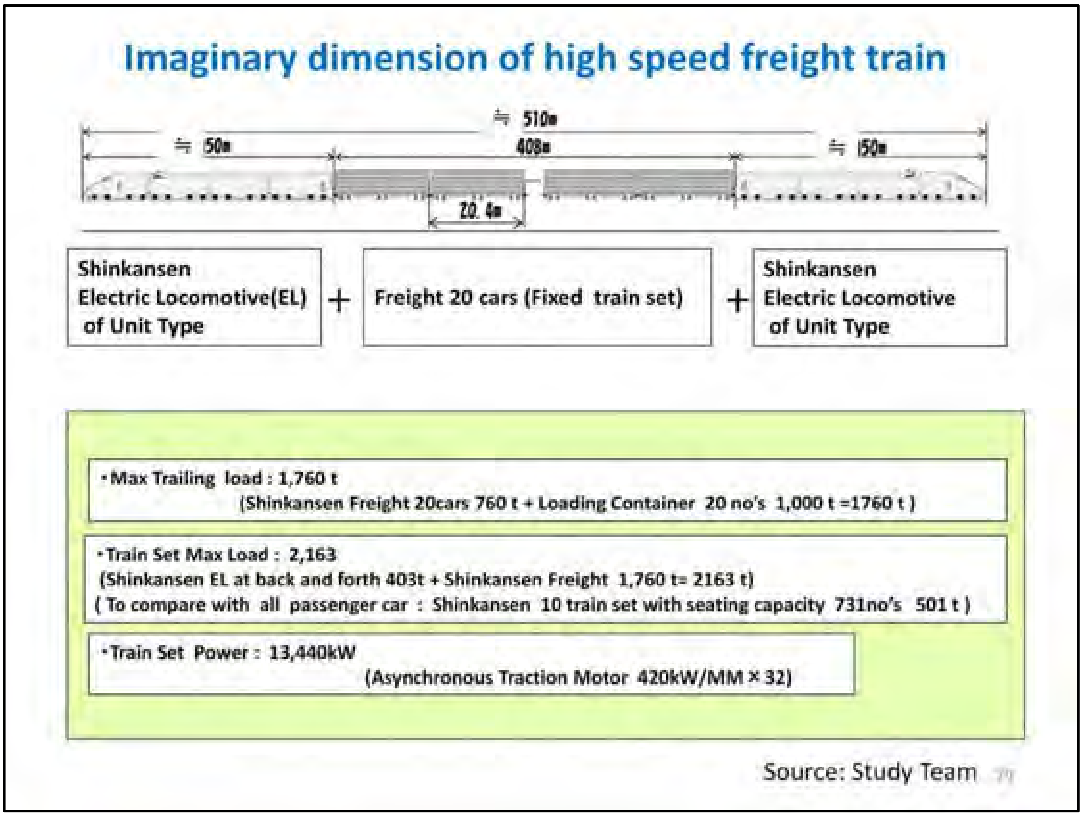
1) The operating distance of each line is around 500km, and the station spacing is around 30km.

2) The percentage of earth structure was nearly 50% for Tokaido Shinkansen, but it becomes only 13 % in Sanyo. For Tohoku, earth structure is only 5%.



The image of EC freight train

1. This is only an imaginary drawing, and there is no firm concept.



Estimated Specification for HSR freight train.

1. Followings are rough specifications.

   HSR type
   20 cars with 1000t are pulled by locomotives
   1760 t of maximum traction load
   2163 of total train weight
   13440kw of output

The image drawing of HSR freight train.

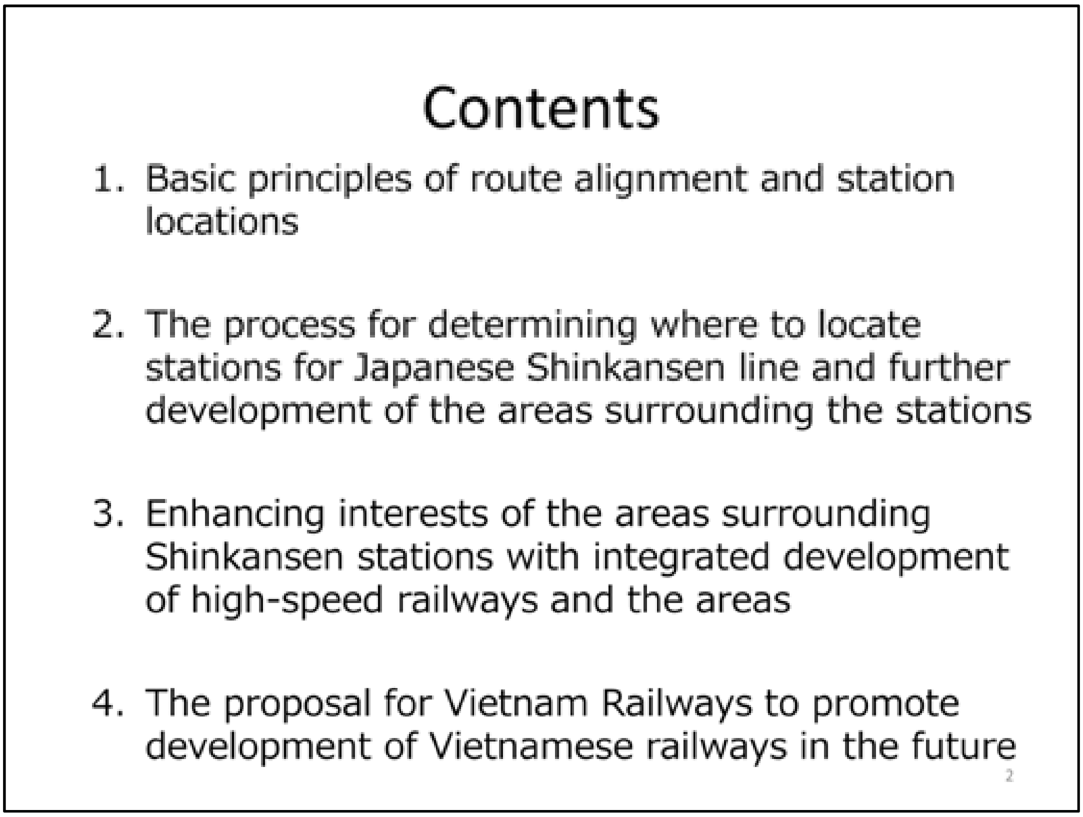
1. This is an image of a high speed freight train, EC type.

Thank You

Source: Study Team

Thank you.

Thank you for attending the meeting today. I am Nakano, working for Japan International Consultants for Transportation Co., Ltd. (JIC). I would like to make a presentation titled "The Railway Route Planning for Japanese High-speed Rails and the Process for Determining the Locations of Station."



At the start of today's session, let me give you contents of my presentation.

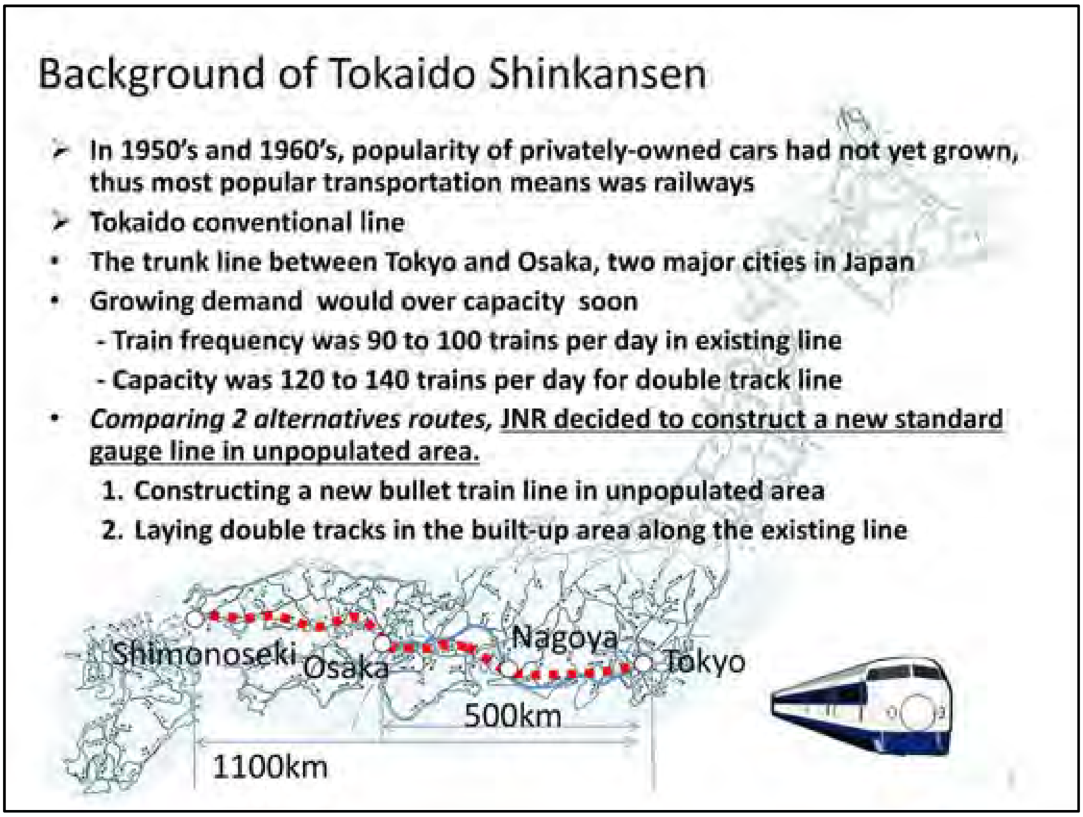
I would like to tell you four key topics:

1. Basic principles for planning railway route and determining where to locate stations for Japanese Shinkansen line
2. The background for determining where to locate stations for Japanese Shinkansen line and further development of the areas surrounding the stations
3. Enhancing interests of the areas surrounding Shinkansen stations with integrated development of high-speed railways and the areas
4. Proposal for Vietnam Railways to promote development of Vietnamese railways in the future

1. Basic principles of route alignment and station locations

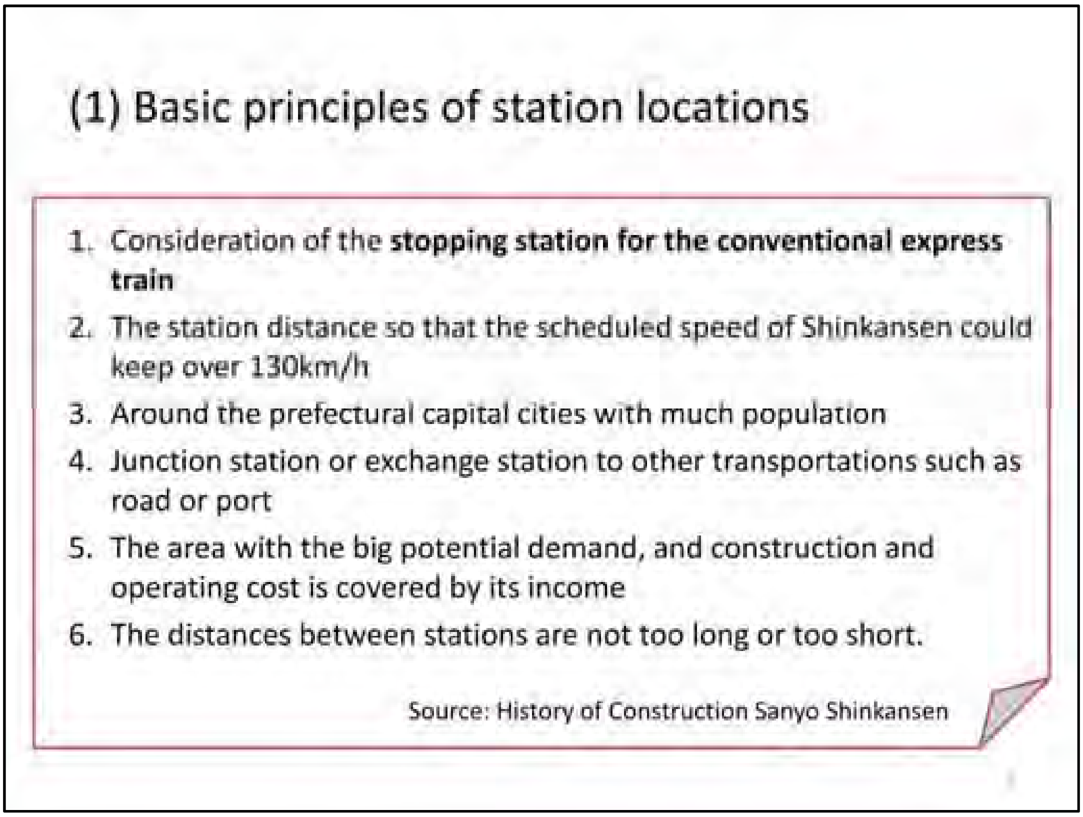
3

First topic is about the Basic principles of route alignment and station locations



First, I would like to discuss the background of constructing high-speed railways in Japan. In 1950's and 1960's, Japanese National Railways (JNR) was making construction planning for a Shinkansen line. During the period, popularity of privately-owned cars had not yet grown, thus the number of passenger vehicles were very small in Japan. Therefore, in the period, most popular means of transportation was railways. Because growing demand for railway transportation exceeded the transportation capacity of Tokaido conventional line, the trunk line connecting Tokyo and Osaka, two major cities in Japan, expansion of transportation capacity was needed.

As train frequency was limited to 90 to 100 trains per day in the form of a one-way trip, and transportation capacity was 120 to 140 trains per day, it was concerned that Tokaido conventional line would be overloaded in the near future. JNR were studying feasibility for laying double tracks in the line. Finding that it was more economical to construct a new bullet train line in the area away from residential district than to lay double tracks in the built-up area along the conventional line, JNR decided to construct Tokaido Shinkansen Line with railways of 1,435 mm gauge.



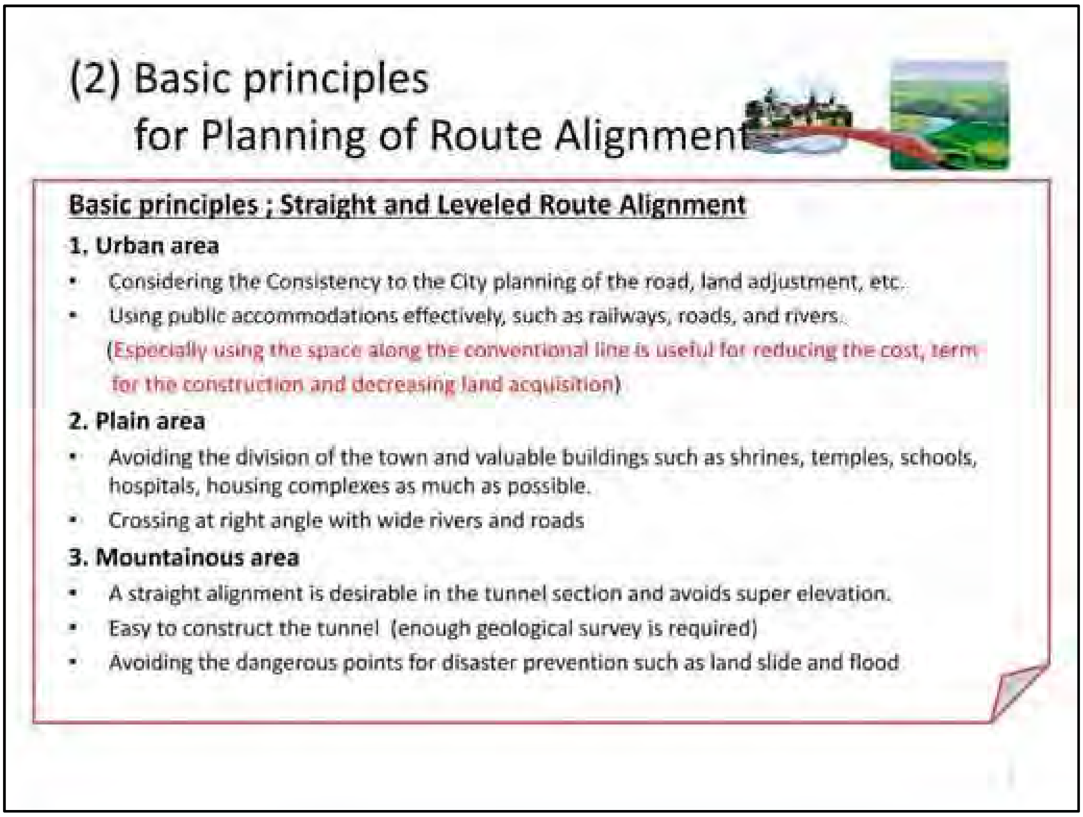
First, I'd like to discuss the Basic principles about Determining where to locate stations.
First, Considering the existing station for the conventional express line
Second, the number of station should be limited for the scheduled speed of Shinkansen could keep over 130km/h when it stops at every stations.
Third, prefectural capital, or the city near to the prefectural capital which has much population in railway station sphere.
Fourth, Junction station, or Convenient station to exchange to other transportations such as road transportation.
Fifth, stations which has the potential of new demand, and all of the cost for new station is covered by its income form the passengers of new station
Sixth, The distances between stations should not be too long or too short.

Distance between the HSR stations

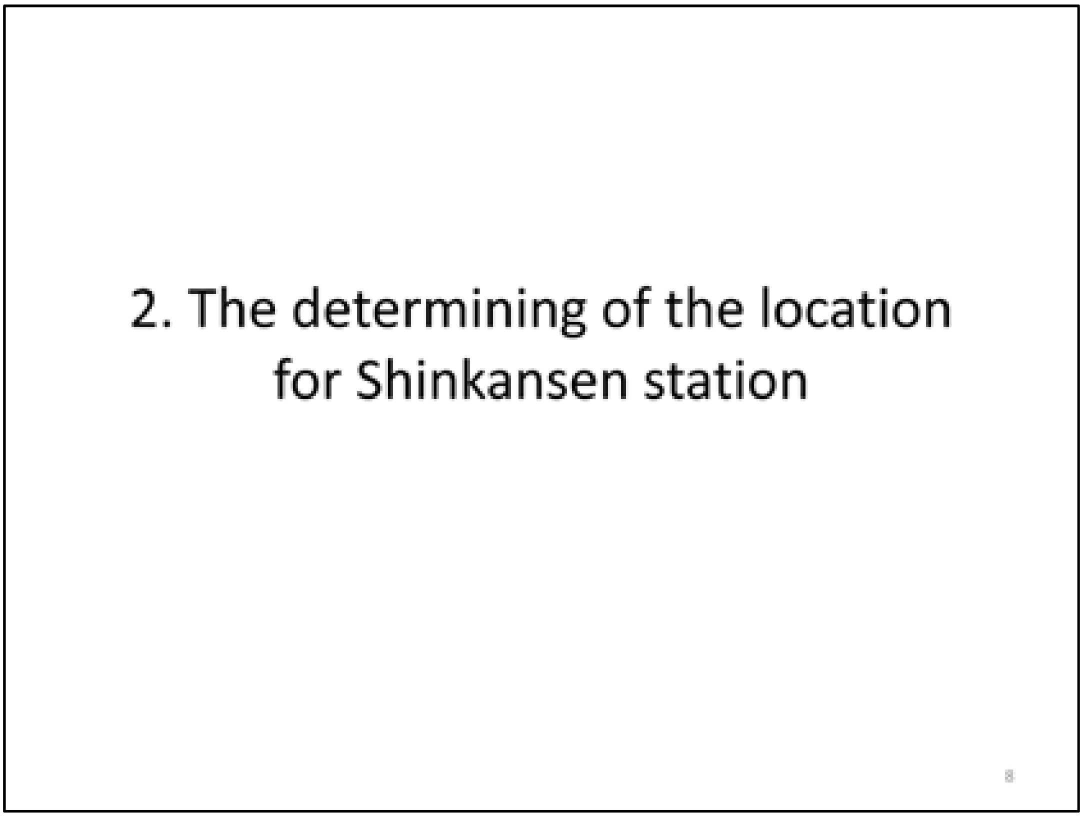
- Acceleration distance to 300km/h is 15km and deceleration distance from 300km/h to 0 km/h is 8 km. To make use of the high-speed performance, longer station distance is favorable.
- For the maintenance work, less than 50 km of station distance is favorable.
- To get passengers at middle of the line, station distance is becoming shorter than when Shinkansen started operation.

	Tokaido	Sanyo	Tohoku	Jyoetsu	Hokuriku
Maximum Distance	Maibara-Kyoto 68.1 km	Kokura-Hakata 55.9 km	Omiya-Oyama 48.9 km	Takasaki-Jyomokogen 41.8 km	Ueda-Nagano 33.2 km
Minimum Distance	Tokyo-Shinagawa 6.8 km	ShinOnomichi-Mihara 10.6 km	Tokyo-Ueno 3.6 km	Nagaoka-Tsubamesanjyo 23.6 km	Karuizawa-Sakudaira 17.6 km
Average (At Opening)	46.9 km	36.9 km	38.8 km	33.7 km	23.5 km
Average (2003)	32.2 km	30.8 km	29.7 km	33.7 km	23.5 km

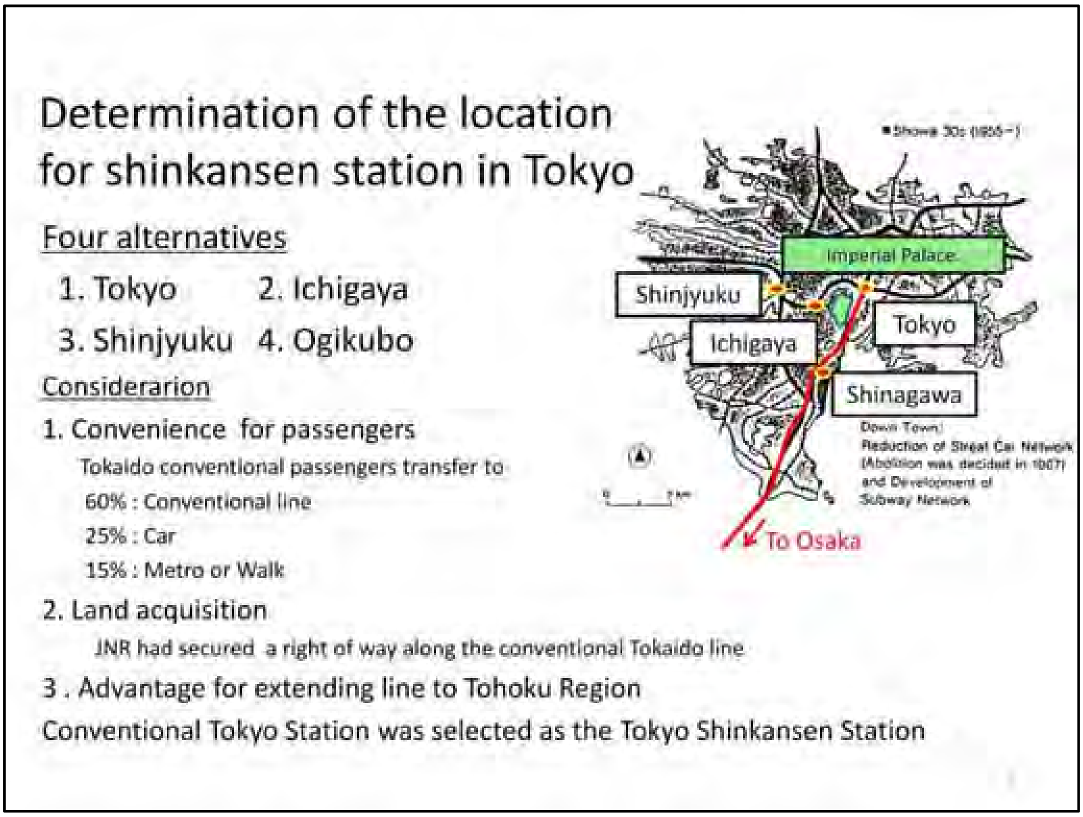
Speaking of the distance of the HSR stations, the Best distance between HSR stations is said 50 km.
Because, acceleration distance to 300km/h is 15km and deceleration distance from 300km/h to 0 km/h is 8 km. To make use of the high-speed performance, so longer distance is preferable for HSR.
However, for maintenance reason, we need to place stations each 50 km at least.
In Japan, distance between stations are becoming shorter to get more passengers at the middle of the line.



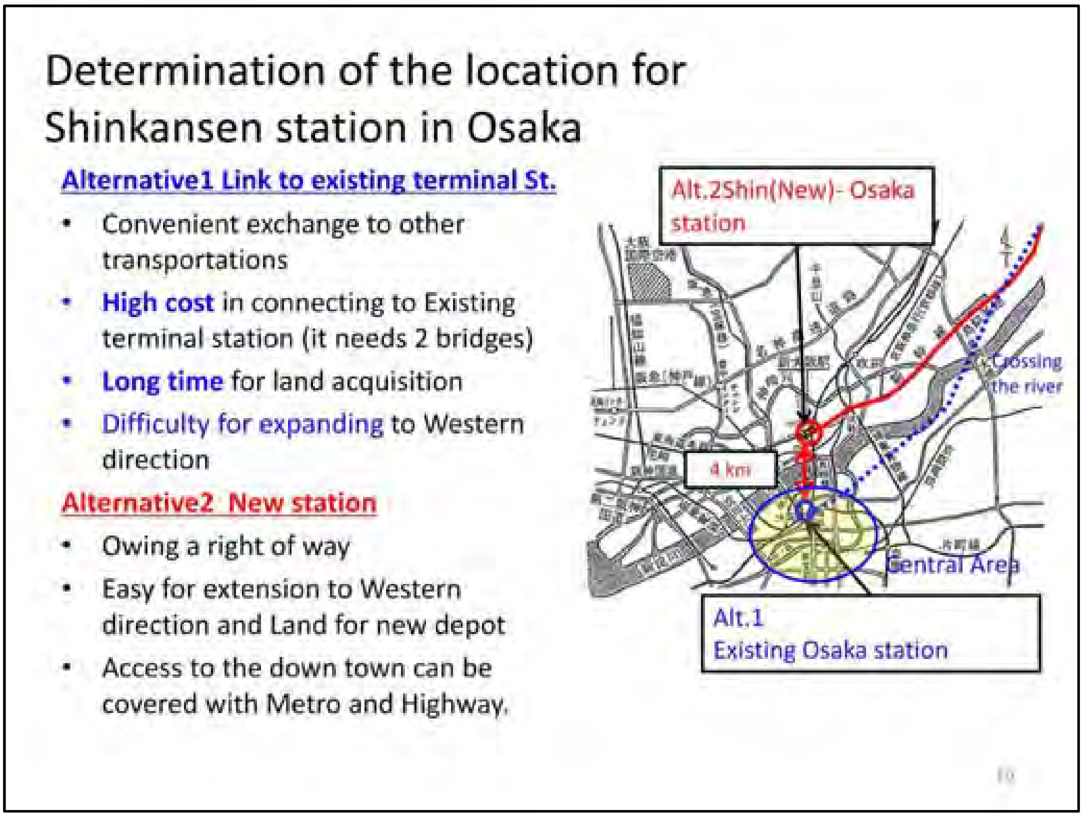
Next is the basic principles for planning the railway route.
Basic principle for all area is Strait and Leveled Route.
In urban area,
Considering the Consistency to the City planning of the road, land adjustment is important.
And, using the space along the conventional line is useful for reducing the cost, term for the construction and decreasing land acquisition.
In Plain area,
We have to avoiding the division of the town and valuable buildings such as shrines, temples, schools, hospitals, housing complexes as much as possible.
And we have to cross wide rivers and road at right angle.
In Mountainous area,
A straight alignment is desirable in the tunnel section, and we need enough geological survey.
Also, avoiding the dangerous points for disaster prevention such as land slide and flood is very important.



Next topic is about the background for determining where to locate stations for Japanese Shinkansen line and further development of the areas surrounding the stations.



First point is about determination where to locate Tokyo station, the start point of Tokaido Shinkansen line.
We had four possible locations in Tokyo metropolitan area: Tokyo, Ichigaya, Shinjuku and Shinagawa.
Based on the above principles, we evaluated and selected the best location giving the first priority to passengers' convenience, easiness of securing construction land, and ability of line extension to the northern district.
Tokyo station of the conventional line was selected as the Tokyo Station for Tokaido Shinkansen Line, with all things considered:
-Tokyo station of the conventional line was most convenient for passengers, 60 % of whom transfer from Shinkansen line to the conventional line;
-Tokyo station had an advantage for extending line to the northern district; and
-originally, JNR had secured the railway land in the area around Tokyo station along Tokaido line.



Second point is about the process for determining where to locate Osaka station for Shinkansen line, the last terminal.

It was decided to construct a new station near Osaka Station of the conventional line with all things considered. Osaka Station of the conventional line, the existing terminal station, was most convenient if connected to The Shinkansen station, however had two disadvantages:

-it would have needed much cost for constructing two bridges over Yodogawa River connecting Shinkansen Line to Osaka Station; and

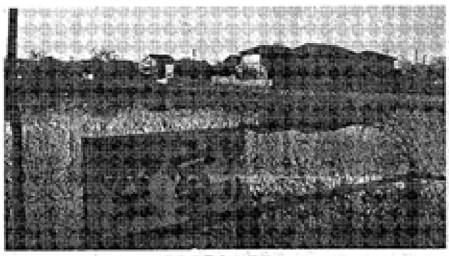
-it would have taken long time for securing construction land at Osaka Station, the center of the city.

JNR originally owned railway land. The operation body could secure the depot provided for the future extended line to western districts in the location where a new station was planned to be constructed, and confirmed its convenient accessibility to the city center following successful inauguration of Osaka municipal subway.

The location of Shin-Osaka Station (Flood area)

新淀川北岸一帯は大正14年の第2次市域拡張で市域に編入された

地区内は土地が低くよく浸水した（西中島小学校付近）



Source: "Construction of Shin- Osaka" by Osaka City（1975.Dec.25）

11

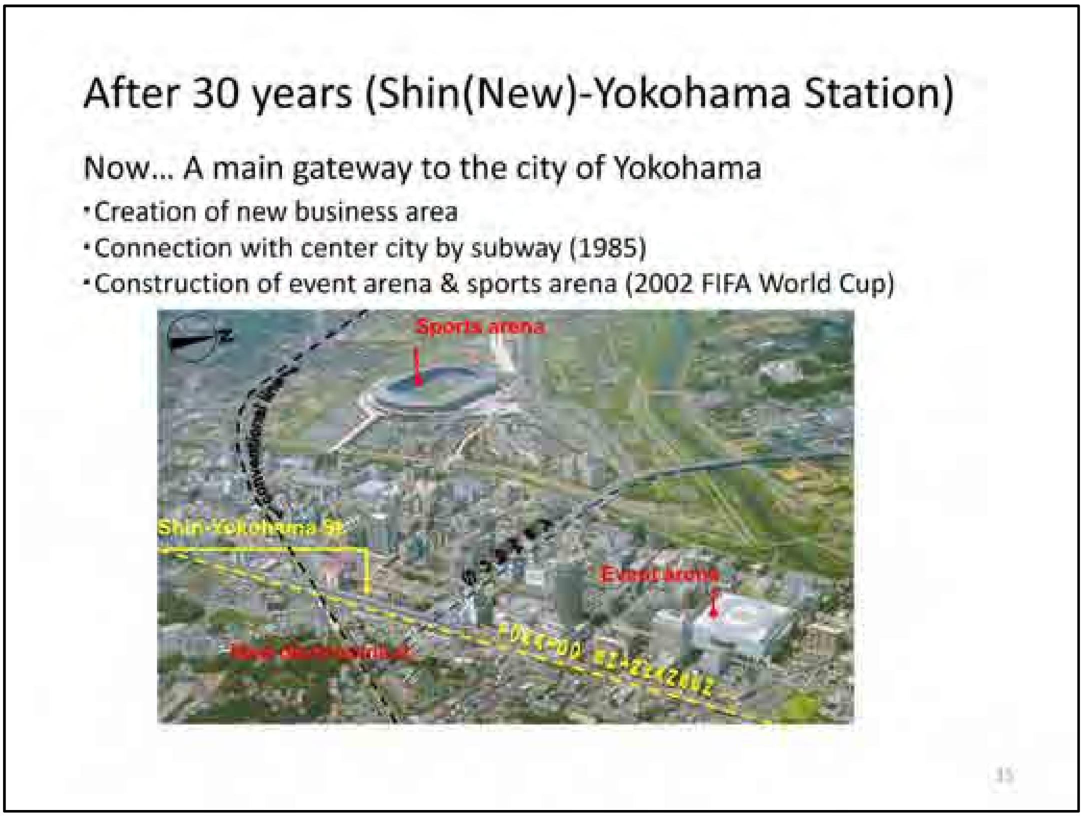
This is the location where the new station for Shinkansen line in Osaka (named Shin-Osaka station) was constructed. Originally, the location was a rural, flood-prone area.

JNR took the opportunity of opening Shin-Osaka station to conduct urban development. After 20 years of opening of Shin-Osaka station, the area surrounding the station becomes a city lined with buildings as shown on the picture.

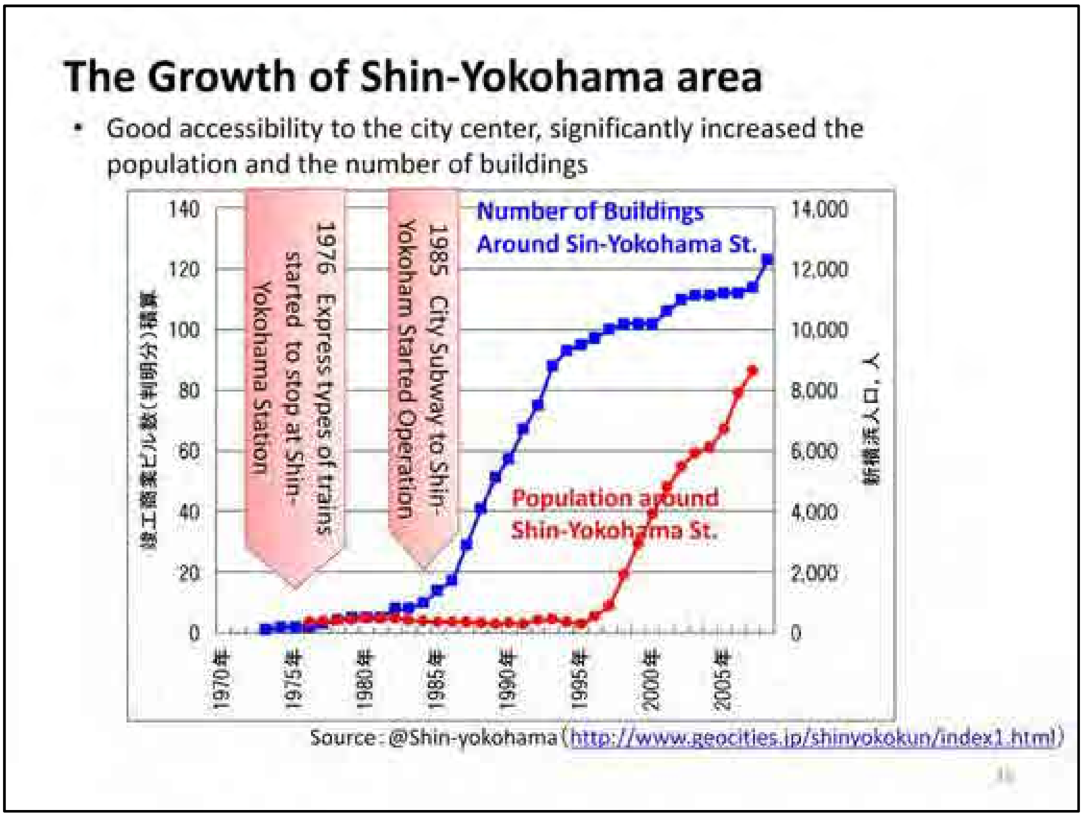
Third is about the key points for determining where to locate stations lying between Tokyo and Osaka. It is essential that the location should have:
-population in town of railway station range of more than 100 thousands;
-a major station of conventional line including a branch station or a station where limited express trains stop, which is expected to increase demand and attract passengers
-appropriate distance to next stations (neither too close, nor too distant)
-an existing station of the conventional line
-a straight line in alignment

Nine stations were constructed at intervals of 50 km between Tokyo and Osaka for Tokaido Shinkansen line.
Most of them connect to the existing station of the conventional line and only two were newly constructed in the suburban area where no station had existed by that time.
Another five stations were newly constructed at the request of local residents after starting operation of Shinkansen.

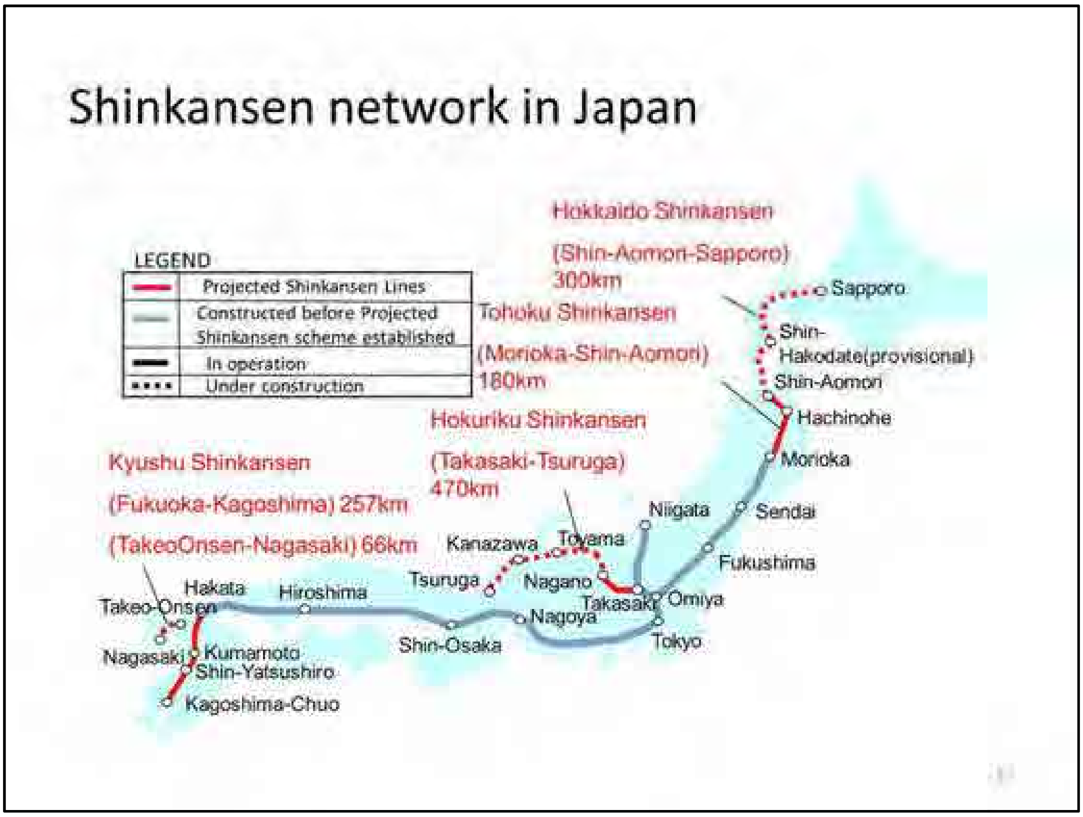
Shin (New)-Yokohama station was constructed as a new station in suburban area as to allow Shinkansen trains to run in improved high speed on the straight line.
The reasons why Shin (New)-Yokohama station was built at the suburban area, far from the conventional line station are because:
-Tokaido Shinkansen line and the conventional line are connected at Tokyo station, Shin (New)-Yokohama station has no need for connection;
-Shin (New)-Yokohama station has an easy access from Tokyo south western residential area; and
-Shin (New)-Yokohama station is near to the center of Yokohama city.
Originally, the location was a rural area.



After 30 years of opening of Shin (New)-Yokohama station, the area surrounding the station becomes a big city and deserves to be called the entrance to Yokohama city.

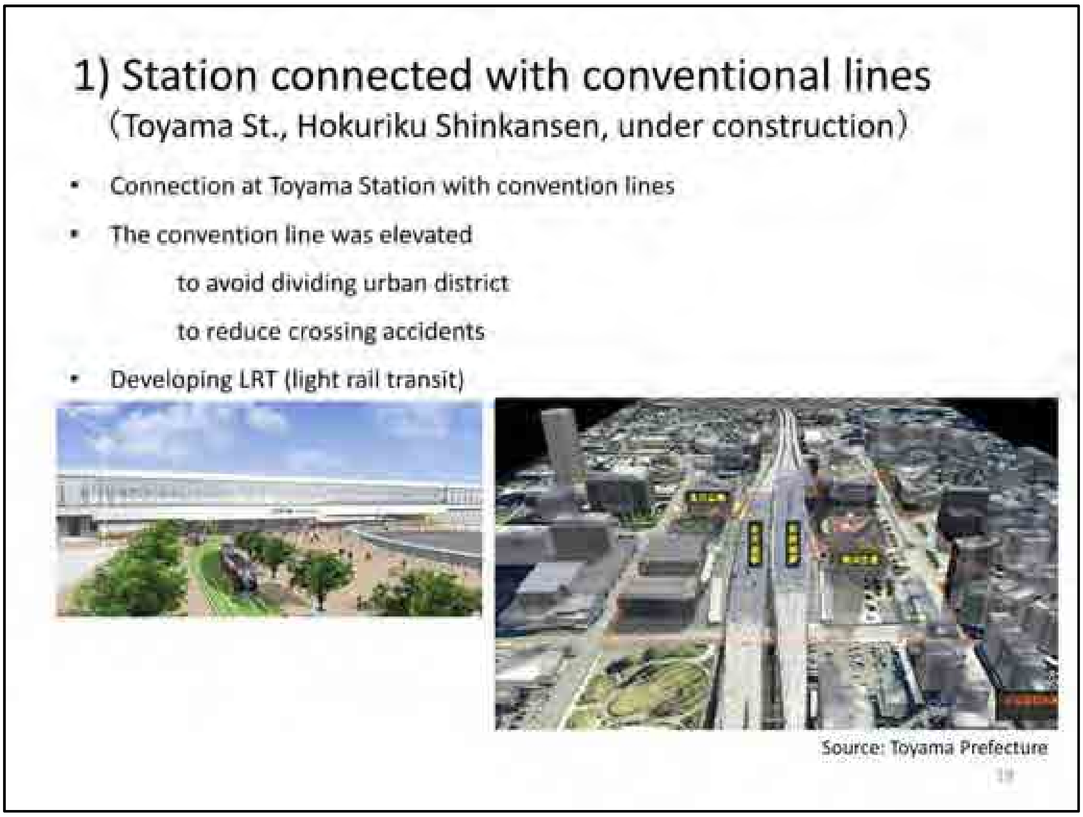


Tokaido Shinkansen line started operation in 1964. Some ten years later, special express trains came to stop at Shin (New)-Yokohama. The history of development for the area surrounding Shin (New)-Yokohama clearly shows that population and number of buildings in the area have not increased for ten years since 1976.



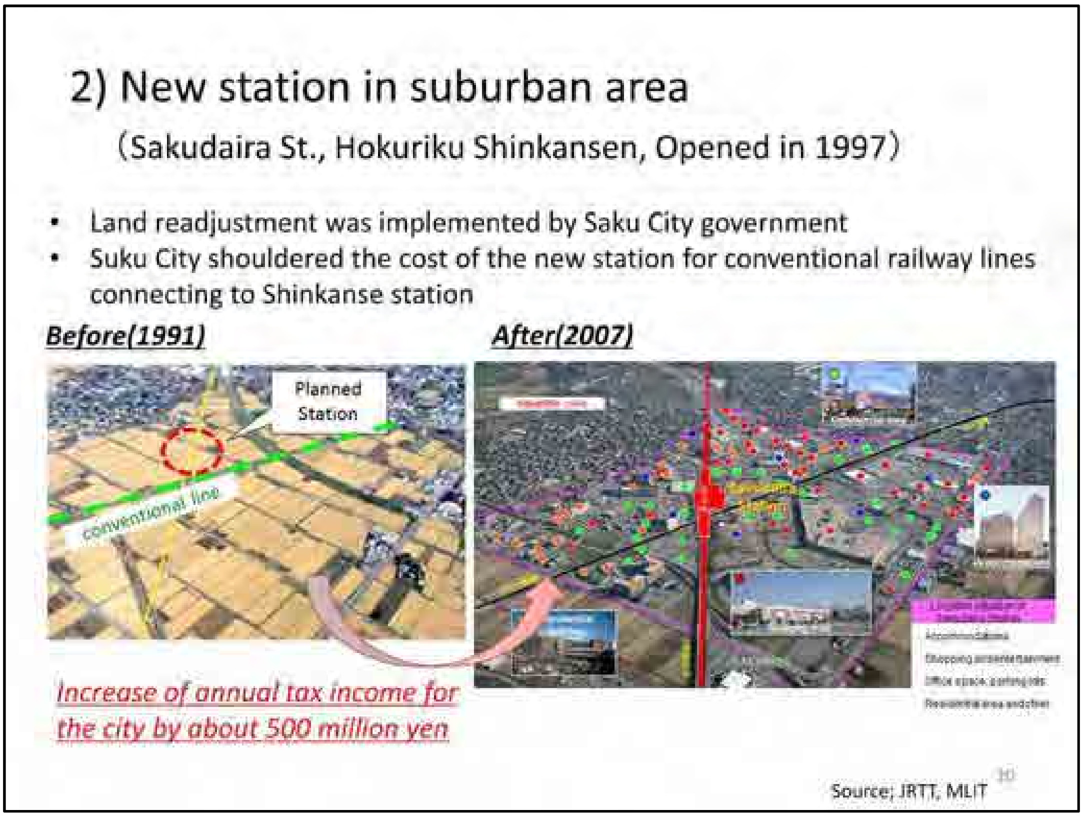
Since then, the Shinkansen line has been developed step by step. Current Shinkansen railway network is as shown on the screen.

Third topic is about enhancing interests of the areas surrounding Shinkansen stations with integrated development of high-speed railways and the areas.

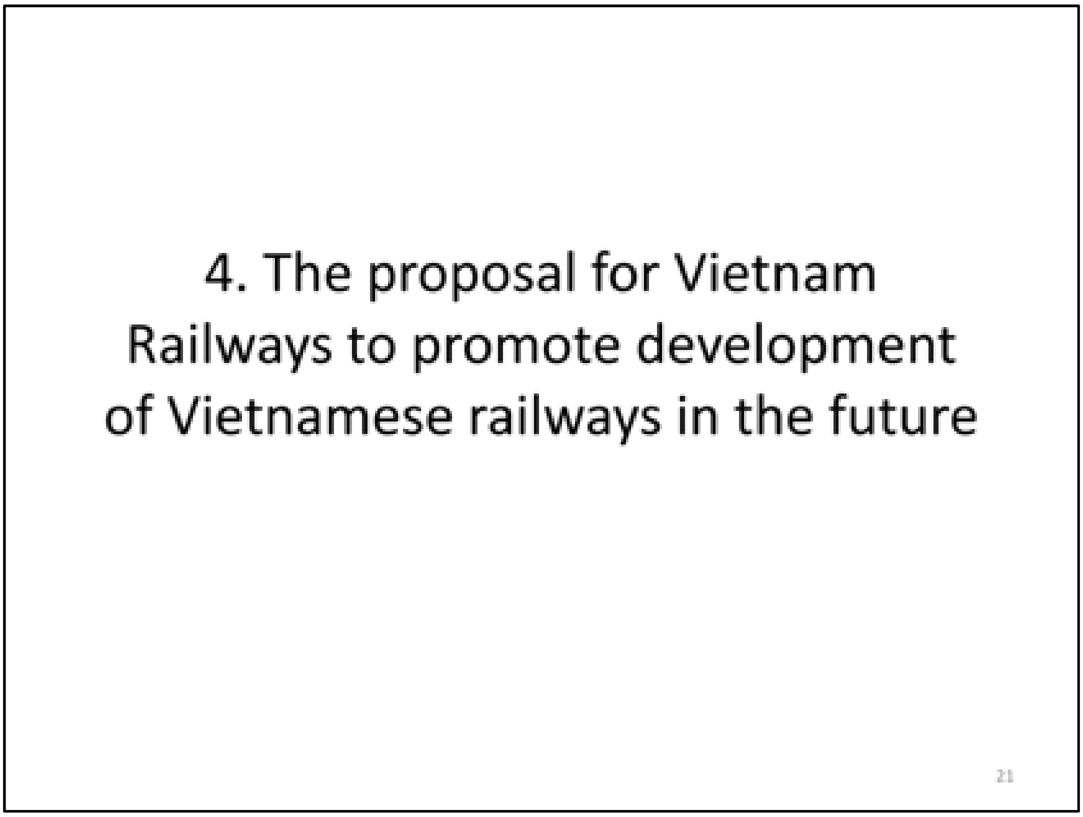


This is a case of Toyama station of Hokuriku Shinkansen line now under construction. JR, in corporation with the city government, plans to develop the existing Toyama station of the conventional line and newly constructed Toyama station of Hokuriku Shinkansen line all together. The project pursues the compact town development initiated by public transportation and prevention of highly suburbanized cities caused by motorization through following efforts:

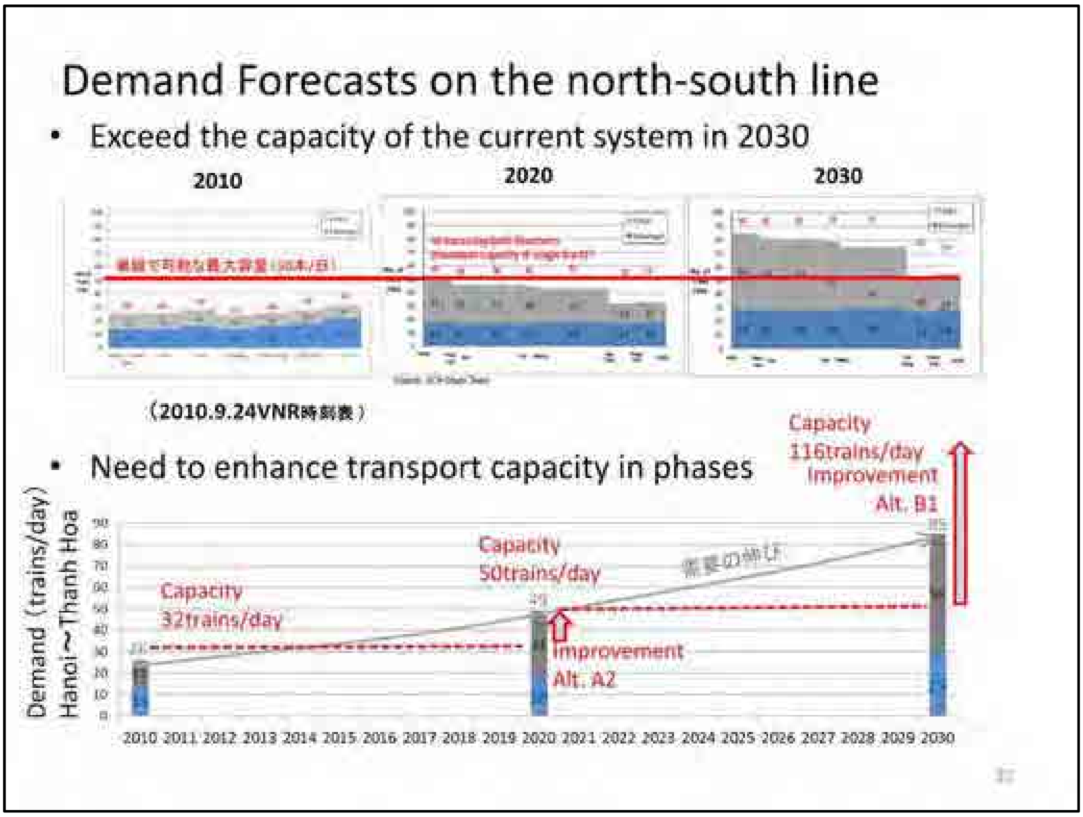
-connecting Toyama station of the convention line to that of Shinkansen line;
-elevating the convention line to prevent cut off of the roads;
-reducing accidents at a crossing; and
-developing LRT (light rail transit).



This is a case of a newly constructed station locating in the rural area between Tokyo and Osaka, about 150 km away from Tokyo.
Integrated with the development of Shinkansen line, the city government took an initiative to conduct the land readjustment for the area surrounding the station which was constructed away from the existing city area.
Securing of better accessibility to roads and the convention lines and development of commercial land along the line significantly enhanced interests of the area surrounding the station, the operation of which caused remarkable effects, contributing to the growth of the city and increase of annual tax income for the city by about 500 million yen.



Fourth topic is about the proposal for Vietnam Railways to promote development of Vietnamese railways in the future.



JIC Study Team forecasts the demand for railway transport on the north-south run of Vietnam Railways as shown on the screen. To cope with increase in transport volume, Vietnam Railways needs to enhance transport capacity in phases.

Current train frequency of the conventional line between Hanoi and Thanh Hoa is 32 trips per day. Demand is expected to surge and exceed the capacity of the current system in the near future.
The option A2 can increase the transport capacity up to 50 trains per day on the single-track rail with improvement on the track.

It is forecasted that building double-track railways or constructing new railways is needed to cope with further surging demand and compensate for insufficient transport capacity with single-track rail.
For example, option B2 can increase the transport capacity up to 116 trains per day on double-track, electrified rail.

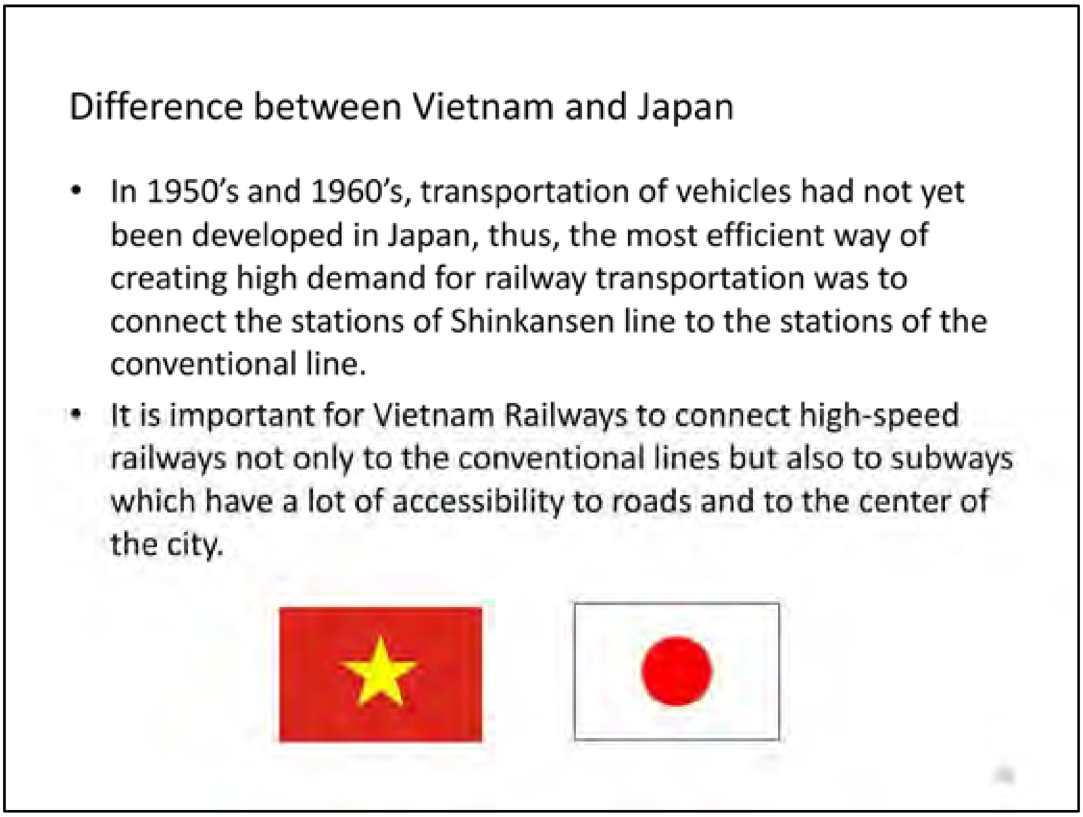
Proposing improvement plans by JICA study

	A1 Increase Safety	A2 Increase Capacity by single truck	B1 Increase capacity by double truck (Meter Gauge)	B2 Increase Capacity by double truck (Meter Gauge)	HSR (Standard Gauge)
Target year	2015	2020	2030	2030	
Capacity	32 trains/day (Current)	50 trains/day	116 trains/day	122 trains/day	
Operating Speed	90km/h (Current)	90km/h (Current)	120km/h	150km	
The Fastest Traveling Time	30.0h (Current) →29.1h (▲0.9h)	29.1h→25.4h (▲3.7h)	25.4h→15.6h (▲9.8h)	15.6→12.7h (▲2.9h)	
Main improvement options	44 Bridge-improvements Tunnel- repair mending	Improvements for Bottlenecks - Khe Net Pass - Hai Van tunnel CTC systems	ATS Bridge improvement Earth works Expanding Depot	ATS Double truck Grade separation Electrify	
Total Cost	1500US$ million	1800US$ million	14,500 US$ million	27,700US$ million	

To cope with surging demand for the future, it is required to choose suitable options.

JIC Study Team is proposing improvement plans to Vietnam Railways as shown on the screen.
Option A1 is to ensure the moving train safety currently under working including bridge renovations. Option A1 can't achieve increase in transport capacity.
Option A2 is to promote the transport capacity on the single-track rail by 2020, including reduction of some bottlenecks like Khe Net Pass and Hai Van Pass tunnels.

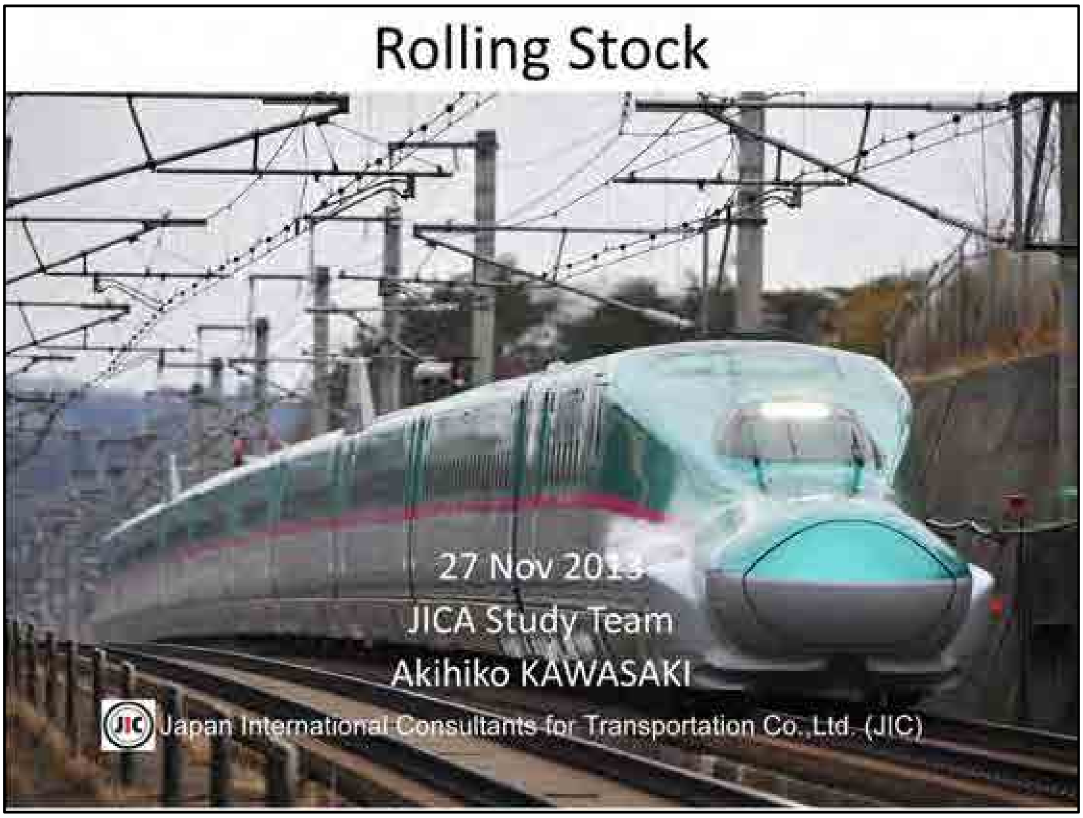
Option B1 is to strengthen transport capacity by doubling a gauge by 2030.
Option B2 is to build double-track, electrified railways (1,435 mm gauge) to increase maximum train speed.
To cope with surging demand for the future, it is required to choose suitable options.
In making successful choice of double-track, electrified railways (1,435 mm gauge), separating from the conventional line, and attaining high-speed operation, Japanese Shinkansen line has preferable influence on the regional economies in Japan.



In 1950's and 1960's, transportation of vehicles had not yet been developed in Japan, thus, the most efficient way of creating high demand for railway transportation was to connect the stations of Shinkansen line to the stations of the conventional line.
How about the current situation in Vietnam? It is important for Vietnam Railways to connect high-speed railways not only to the conventional lines but also to subways which have a lot of accessibility to roads and to the center of the city.

We have been living in different countries and days, however, we now share basic principles. To conclude, I would like to underline that you can contribute to promote ever-lasting development in Vietnam if you make a suitable plan for introducing high-speed railways based on our fundamental principles for railway route planning I discussed today.

Thank you for your attention.


Rolling Stock
27 Nov 2013
JICA Study Team
Akihiko KAWASAKI
Japan International Consultants for Transportation Co.,Ltd. (JIC)

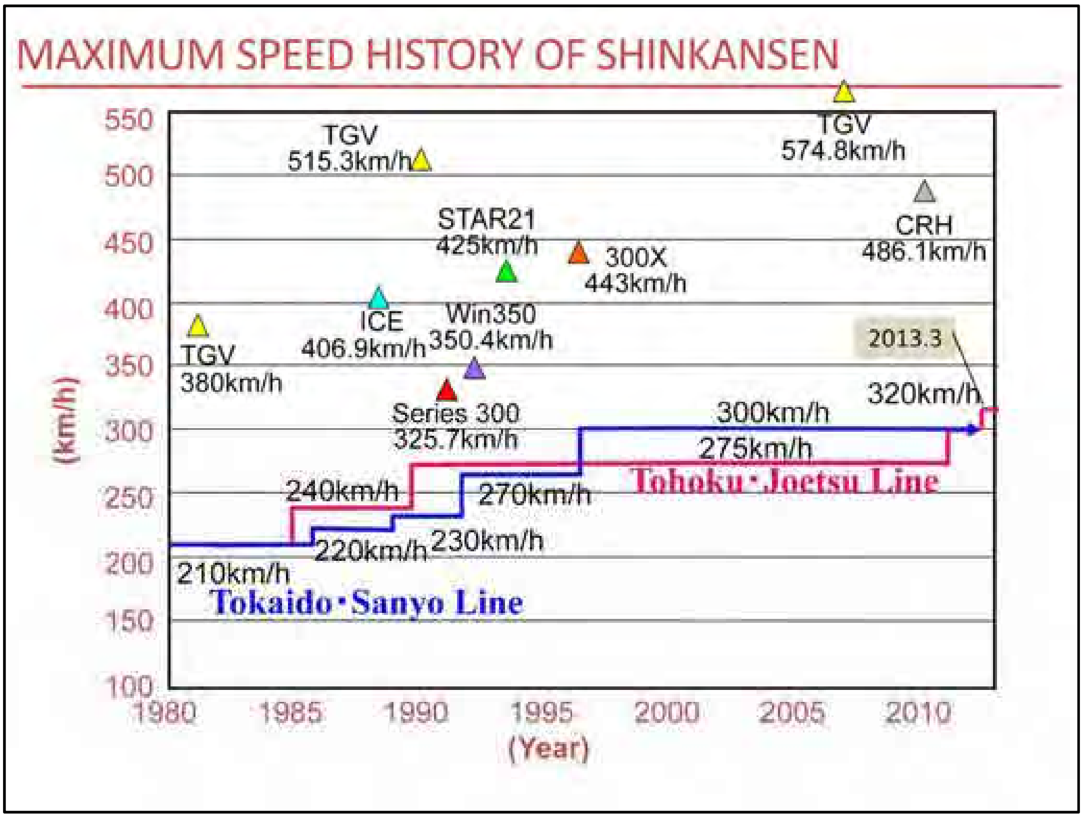
Contents

COMPARISON OF HIGH SPEED ROLLING STOCK

Series	E5 	N700 	TGV POS (France) 	AGV (Italy) 	ICE3 (Germany) 	CRH3C (China) 
Max Speed (km/h)	320	300	320	300	320	300
Train set Formula	8M2T	14M2T	2L8T	EMU-11	4M4T	4M4T
Train Length (m)	253	404.7	200	202	200	200
Train Width(mm)	3350	3360	2904	3000	2950	3260
Train Weight (t)	452	635 (Estimated)	383	374	435	425
Seats	731	1323	357	450	413	556
Max. Axle load (t)	13.1	11.4	17.0	16.5	16.0	17.0
Seats/ 100m	289	327	179	223	207	278
Weight/ Seat (t)	0.62	0.48 (Estimated)	1.07	0.83	1.05	0.76

This table is the comparison of world high speed rolling stock.
As you know, Series E5 and N700 are Japanese rolling stock, TGV and AGV are French, and ICE is German.
CRH3C is the Chinese made rolling stock but it is the widened version of ICE.

E5, N700, and CRH have wider body and 5 abreast seats in 1 row, therefore they have larger passenger capacity.
To be taken notice is the weight per seat.
If this weight is light, it needs less energy to carry passengers.



Until the middle of the1980s, the maximum speed of the Shinkansen was 210kmh on all lines.

Then late in the 1980s, the measure of the improvement in maximum speed came to be actualized.

In 1989, The maximum speed was raised up to 230km/h on Tokaido and Sanyo Shinkansen and in1990, 275 km/h operation was realized on Joetsu Shinkansen.

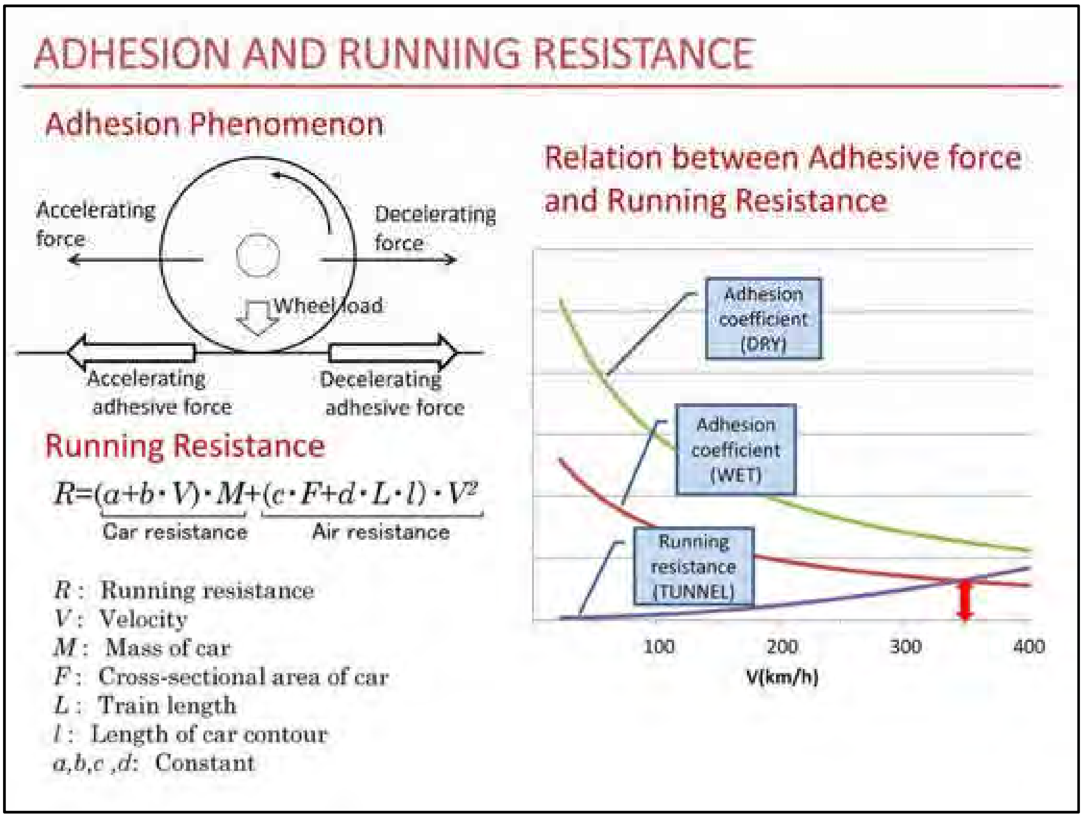
Furthermore, on Tokaido and Sanyo Shinkansen, 270km/h operation by newly developed Series 300 was started in 1992

And 300km/h operation by Series 500 was started in 1997.

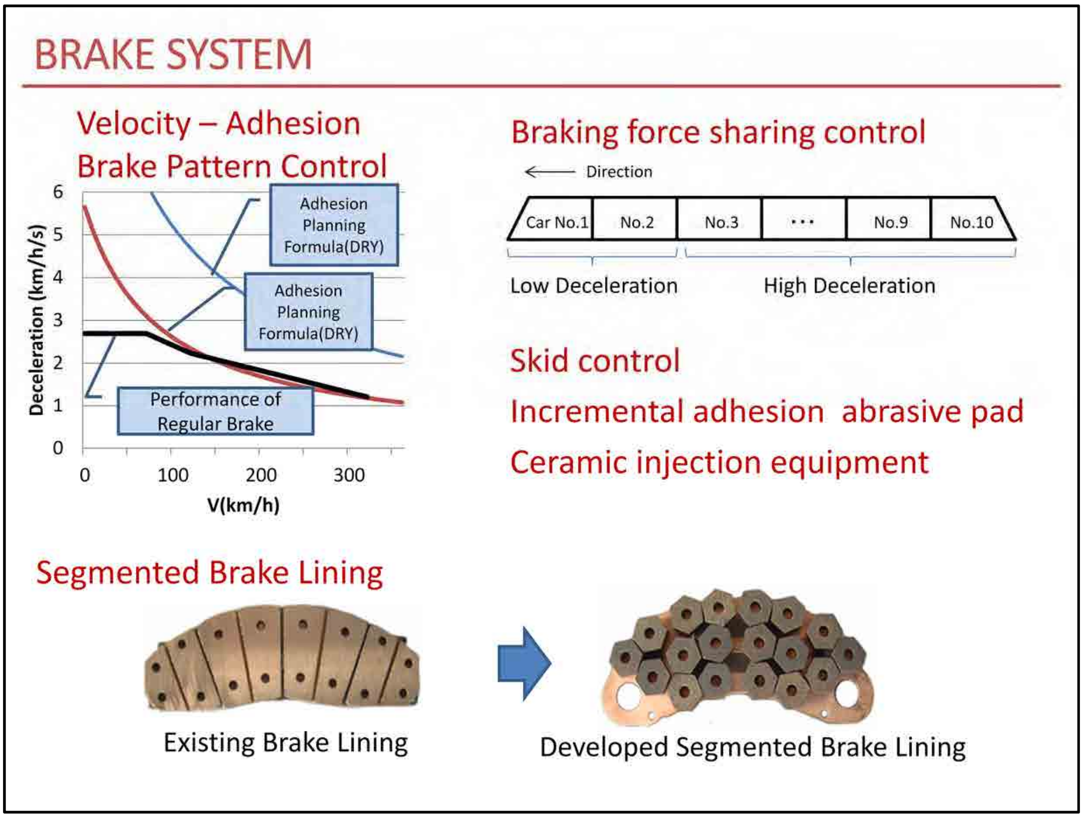
In 2013, the 320km/h operation, the fastest speed in Japan, was started by Series E5.

In record of the high speed testing train, 443km/h by 300X in 1996 is the fastest record of Japan.

In the world, 574.8km/h by the TGV testing train in 2007 is the fastest.



Rolling stock can accelerate and decelerate by the adhesion of the wheel and the track. The running resistance of rolling stock is the sum of the car resistance which is the frictional loss accompanying a movement of rolling stock, such as a frictional resistance between wheel and track, and a frictional resistance of a wheel-set shaft bearing, and the air resistance of rolling stock.
Although a running resistance is generally shown by such formula, it is difficult to actually calculate, then it is usually measured by running test.
The relationship between adhesion and running resistance is as this graph.
Since the running resistance increases while the adhesion declines as train velocity increases, running resistance will exceed adhesion at a certain velocity.
Since the train could not accelerate more than this velocity, this velocity is the limit speed for the train running by the iron wheel on the iron track.
However, by reducing the air resistance with the improvement of the rolling-stock shape, it is possible to raise the limit speed.



When the braking force becomes larger than adhesion, a wheel will slide on the track without rotating.
If the slide occurs, braking distance will be extended, and also it becomes a cause of the wheel flat which is a partial abrasion of a wheel.
Since a adhesion declines in a high-speed area as stated previously, the Shinkansen brake is controlled to met the adhesion plan formula like this graph.
This system is the velocity-adhesion brake pattern control.

In addition, “Braking force sharing control”, “Skid control”, “Incremental adhesion abrasive pad” and “Ceramic injection equipment” etc. are used as the measures which prevent the skid and prevent the braking-distance extension.

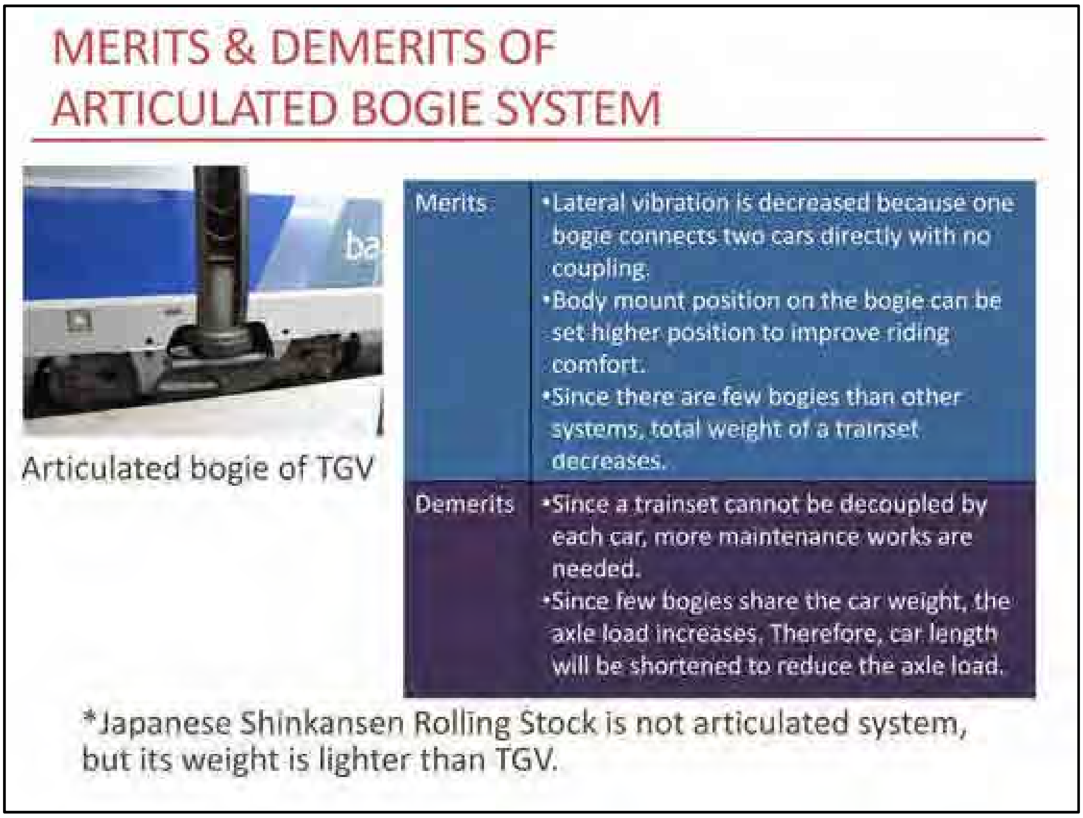
“Braking force sharing control” is the control system which weakens the braking force of the first and second cars of the train and adds the braking force of other cars using the tendency that, on the moist track, the adhesive coefficient falls near the lead car of the train, but it shows comparatively high value after the 3rd car.

“Skid control” is the control system which weakens temporarily the braking force of the slipped wheels to re-adhere.

“Incremental adhesion abrasive pad” which is equipped to increase the adhesion of the wheel pushed against a wheel tread lightly at braking and suppress the depression of the adhesive coefficient.

“Ceramic injection equipment” is the equipment which injects ceramic particles between wheel and track for stopping the train fast at the time of emergency.

Moreover, with improvement of the maximum operation speed, the lining which has high coefficient of friction from high speed area to stoppage is needed.
For this reason, the segmented brake lining shown in this figure is developed and used.

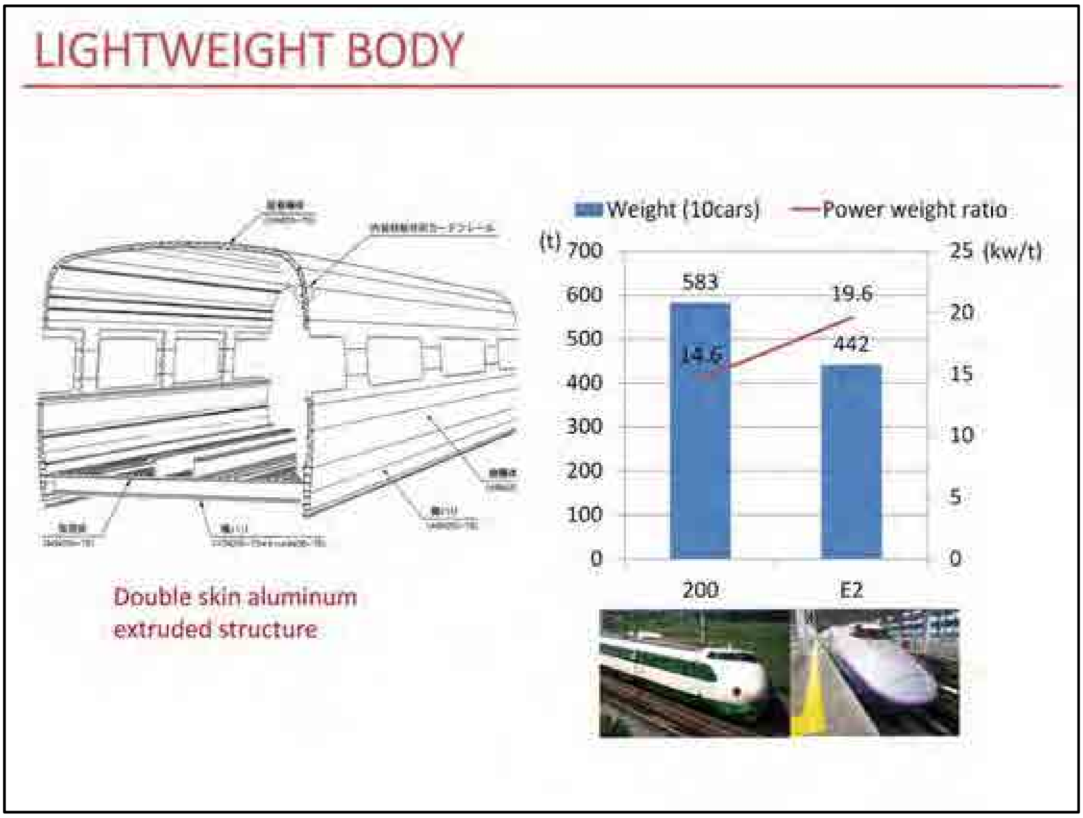


Articulated bogie system, adopted to TGV and its series, is one of the bogie systems which allocates a bogie between two car body sections.
Articulated bogie system as compared to general bogie system reduces vibration to provide riding comfort and due to fewer numbers of heavy bogies, the weight of a train will be lighter.
Due to smaller number of bogies, the weight sustained by a bogie becomes heavier, and to reduce the burden, the length of a vehicle becomes shorter.
Other disadvantage includes that much maintenance is required due to the structure disabling easy disconnection of rolling stock.
Comparing the AGV of articulated bogies system and E5 system of general bogie system, E5 is actually lighter.
Even considering comfort, there is no much difference between articulated bogie system and general bogie system at this time.

COMPARISON BETWEEN POWER CONCENTRATED SYSTEM AND POWER DISTRIBUTED SYSTEM

	Power Concentrated System	Power Distributed System
Merits	•Since Power units (noise source) and coaches are separated, coaches are less noisy. •Since power units are few and concentrated, maintenance works are somewhat less.	•Since equipments are dispersed, axle load is light. •More traction axles contribute to higher acceleration and deceleration with electric brake. • Train can run with higher speed on up gradient section. •If some units have trouble, the train can keep running. (Redundancy)
Demerits	•Axle load of power unit is too heavy. •Since coaches can not use electric brake, brake linings are exhausted early. •Since passenger can not ride on power units, train capacity decreases.	•Since equipments are dispersed, maintenance works are somewhat more. •Coaches on traction system are little more noisy.

TGV of France adopts power concentrated system, but the other rolling stocks adopt power distributed system.
The power concentrated system has advantages of fewer number of power units requiring much maintenance, and the quietness of passenger coaches away from the source of noise in power units, but also disadvantages of heavier axle load of the power unit, and, because passenger coaches cannot use electric brake, the abrasion of break lining is large, and it requires much maintenance.
On the other hand, the power distributed system employed by Japan from the beginning can reduce axle load by distributed location of devices. Due to many power axles in spite of lighter axle load, full power can be obtained and that is advantageous in climbing a slope.
Because many cars can use electric brake, abrasion of the brake can be reduced, and the cars can be driven continuously even if some brakes in the train have problem. However, much maintenance is required because of the many number of motor cars.
In recent years, by adoption of VVVF control method and AC motors, motor cars do not require much maintenance, and power distributed system is more advantageous.



The weight saving of rolling stock has many merits, such as reduction of construction cost and maintenance cost of ground facilities, reduction of energy required for train running, and improvement in an acceleration-and-deceleration performance.

As for Series 200 systems and Series E2, although the body is made from aluminum in both sides, Series E2 attained approx. 24% of weight saving by the weight saving of body and equipments.

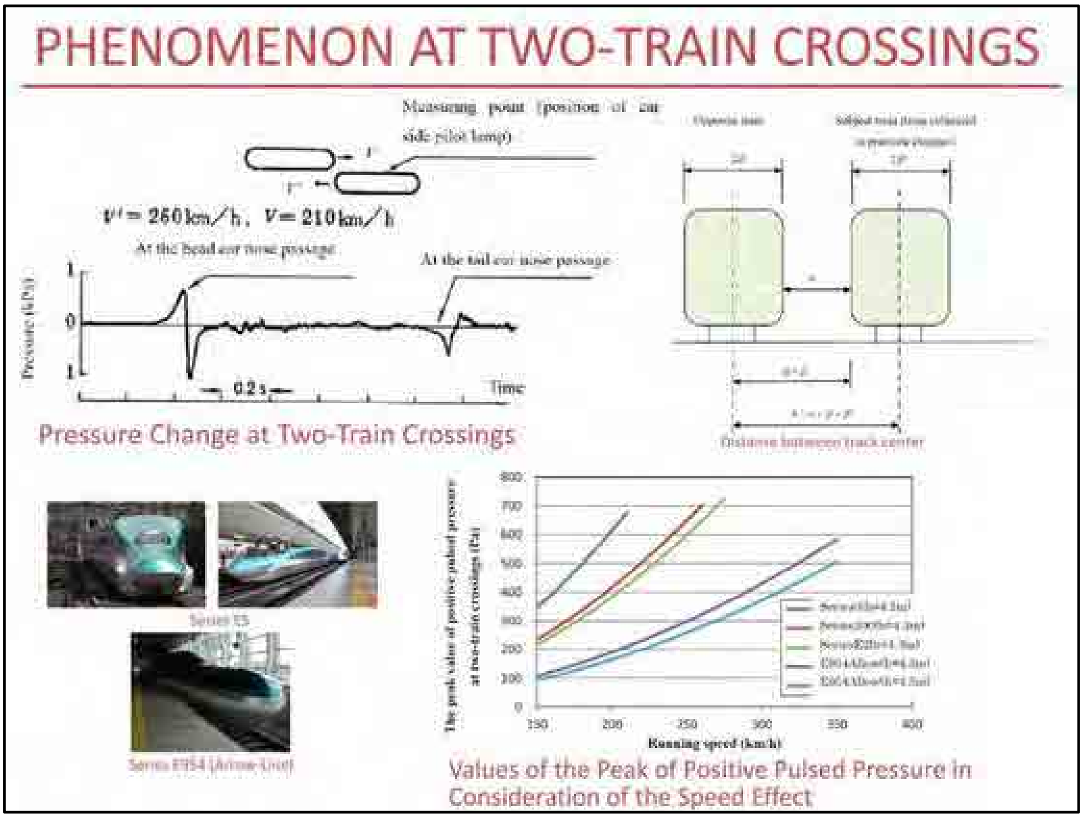
The double skin aluminum extruded body which made the stiffness and the weight saving compatible is used for a car body in recent years.

CRASH SAFETY

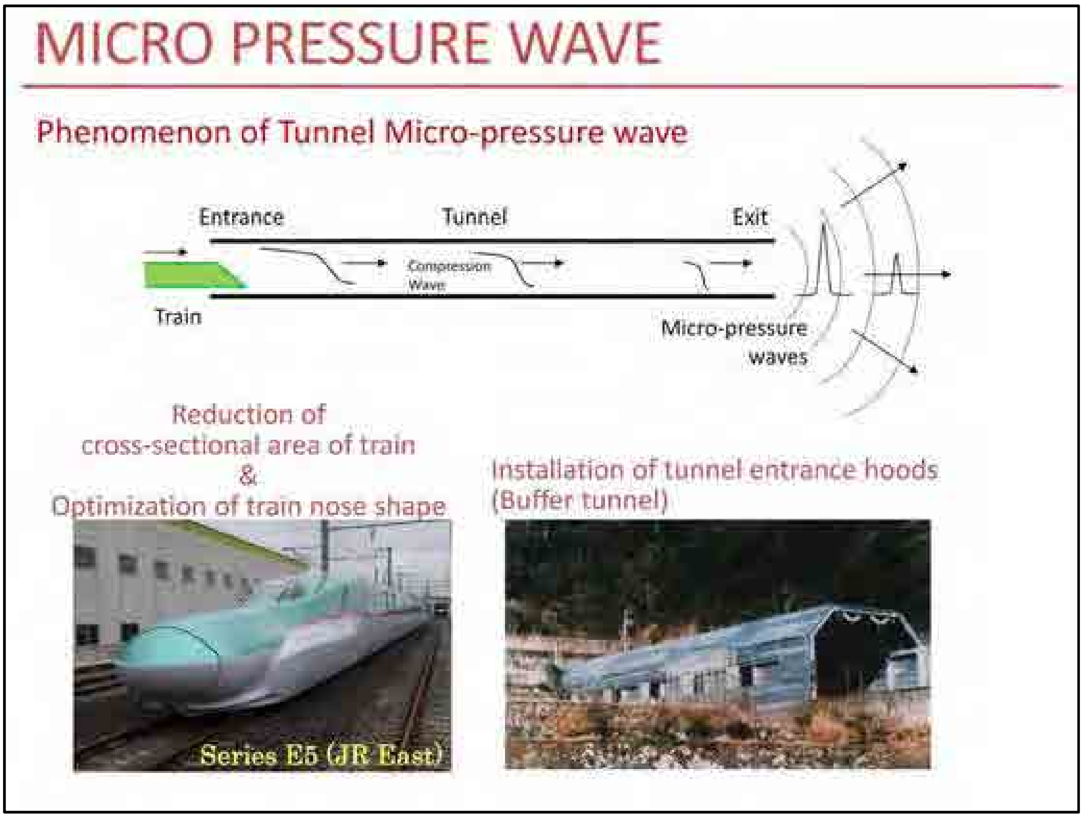
Standards regarding Compressive force of rolling stock end & Crash safety

		Japan (JIS E7106)	Europe (EN 12663, EN15227)
Static Condition	Force at coupler	･Shinkansen : 980kN	2000kN
Crash Condition	Collision scenarios and collision obstacles	None	1. Identical train unit, 36km/h 2. 80t wagon, 36km/h 3. 15t deformable obstacle, 110km/h 4. Small, low obstacle, (Obstacle deflector requirements)
	Deceleration limit	None	Mean llongitudinal deceleration limit: 5G(49m/s^2)
	Overriding	None	Overriding shall be resisted at the train unit extremities and between the vehicles comprising the train units.

This table is the comparison of the Japanese and European loading condition in the static-load conditions and crash conditions which are taken into consideration for body design.
In Japan, since it has thought that the prevention of train collision is important, there is no specific regulation about the car body strength supposing a collision, but a duty of the design in consideration of strict crash safety is imposed to the car body in Europe.
For the rolling stock for Vietnam high speed train, as long as operating on the exclusive track without a level crossing etc. and whenever the advanced signaling system such as ATC is adoptedion , it is thought that it is not necessary to take a collision into consideration to the car body design.
But it seems that the increase in the weight of a rolling stock is not so large even when based on the Europe standards.



When two trains cross, mutual aerodynamic influence acts on the both trains.
The influence becomes larger the speed becomes higher.
As written in the final report, in order to determine distance between track center in Vietnam high speed line, the pressure to the rolling stock at the time of train sets passing at 350 km/h was examined.
The peak value of the pressure caused by E954 series, a high speed testing train of JR East, passing at 350 km/h, even if the distance between track center is 4.3 m which is a standard value of the Shinkansen, is smaller than the present condition (for example, situation in which E2 series runs at 275 km/h).
Because the front shape of E5 is based on that of E954, it is assumed that the result will be equivalent.

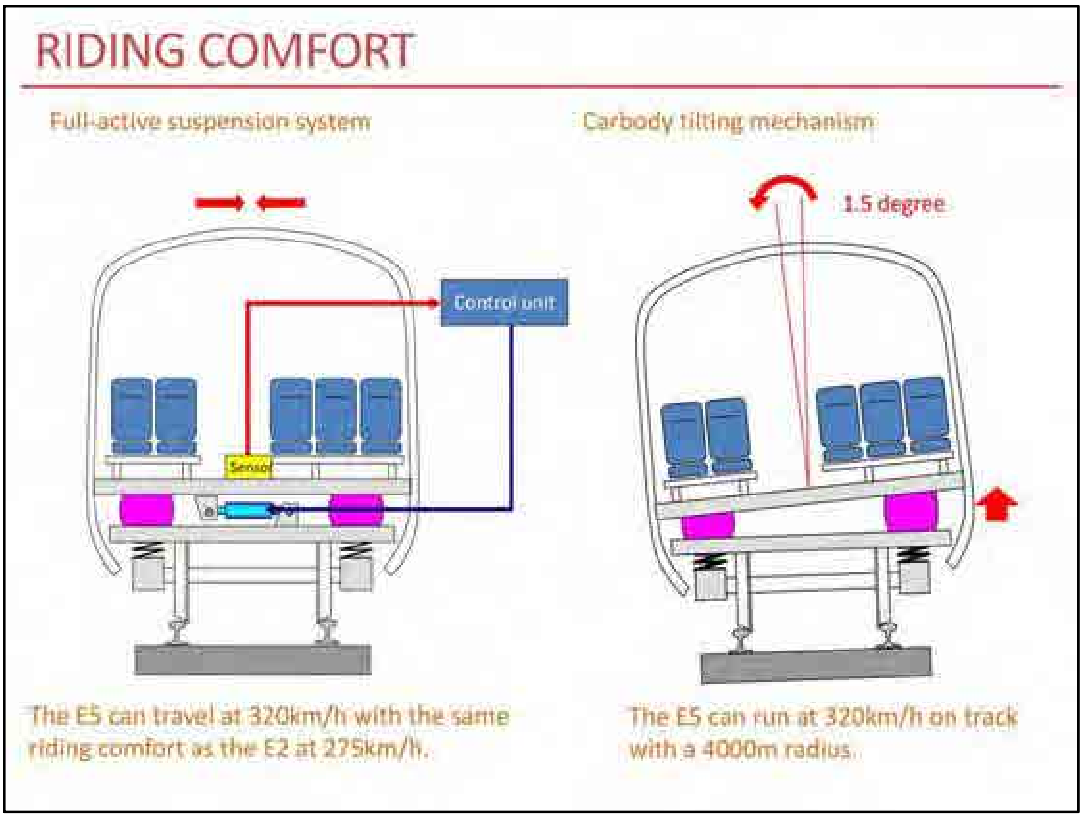


After commencement of the Sanyo Shinkansen (between Okayama - Hakata) where many long tunnels with slab track constructed, the tunnel micro pressure wave became a problem.
The micro pressure wave is the phenomenon that a pressure wave in the tunnel is generated by the train goes into and when the wave reaches the opposite side of the tunnel, it generates an impact sound.

The pressure of the micro pressure wave is proportional to the cube of the velocity, and also the ratio of the cross-section-area of the tunnel and train, front shape of the train, and length of the tunnel, etc. influence the pressure.
Moreover, it is severer in the tunnel with slab track than in the tunnel with ballast track.

As the countermeasure of the ground structure side, a buffer tunnel is installed at the entrance of the tunnel to change the cross section form of the tunnel gently.
Meanwhile, there are several countermeasure of rolling stock, such as the reduction of the cross section area of the car body and optimization of the front shape of the train, etc.

In order to meet environmental standards of Japan with improvement in the train speed, additional countermeasures such as low-noise pantograph, noise reduction plate, smooth covers between cars, full bogie cover and noise-absorbing panels, etc. are installed.



With improvement in the train speed, the vibration becomes large and the running comfort gets worse.
Therefore, the Shinkansen rolling stock in recent years installed the active suspension with the actuator in the position of connecting the body and bogie which suppresses lateral vibration and improves the running comfort.
As a result, lateral vibration of Series E5 running at 320 km/h keeps equivalent level to the conventional rolling stock at 275km/h.

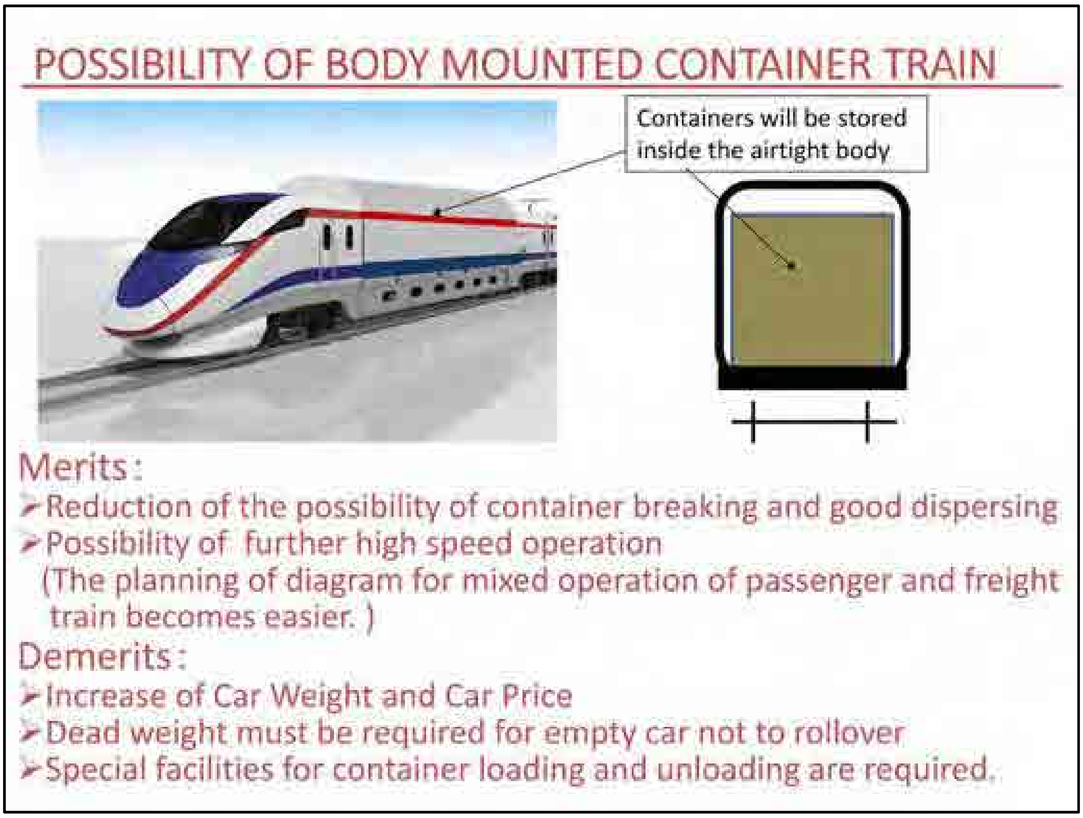
Moreover, in Japan, since the velocity is improved over the assumed speed at the time of line establishment, in order to improve the passenger comfort in a curved line, the tilting mechanism which controls the air springs to tilt body is installed.
By this system, it is possible to run on a curved line 4000 m in radius by 320 km/h of top speeds.

If the mixed operation of passenger and freight will be conducted on the new constructed line, high speed freight transport by power dedicated container train shall be considered.
This is an image figure of the high-speed container train.

Assumed specifications of this train are below,
Target Speed: 160 – 200km/h
Train length: 200m（4M6T）
Max Loading Capacity: Approx. 320t 20TEU

One of the issues to be considered for this train is how to secure the wheel load balance within 10% like the Shinkansen passenger train for the stable running.
For securing wheel balance, checking weight of containers and wheel balance at the time of loading shall be required.
If necessary, the dead weight for the empty container might be also required.

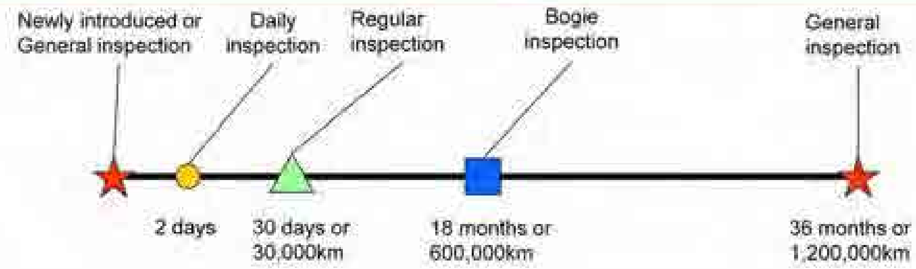
Another issue is the durability of the container against air pressure fluctuation which arises at the time of passing with the high speed passenger train or at the time of entering the tunnel.
If a container breaks and goods disperse, there is a risk of serious accidents, such as derailment.
Therefore, the durable verification to the pressure fluctuation of containers shall be required.
Moreover, although the maintenance of container is owner's responsibility, the quality management of containers such as inspection by railway operator shall be needed for high speed container transportation.



Furthermore, Storing containers inside the airtight body can also be considered.
It is a system similar to the Train-on Train system with which development is promoted for the mutual use of Seikan Tunnel by Shinkansen passenger trains and conventional freight trains.
Thereby, the load of pressure fluctuation will not be applied to a container, and the possibility of container breaking will be reduced.
Moreover, since the container is stored inside the car body, even when the container door opening occurs, the possibility that goods may disperse disappears.
Furthermore, it may be able to improve the velocity of container train just like the high speed passenger train.
Although it seems that there are no needs of transporting the container itself so much high speed, diagram planning for mixed operation of passenger and freight train becomes easier and utilization of new line will be improved significantly.

Meanwhile, as demerits, it is assumed that the car weight and the car price will increase.
In addition, since the car body becomes large and the pressure fluctuation by the passing train will also be enlarged, verification is required in whether there is any possibility of rollover in the case of empty load.
In this case, it is thought that deadweight becomes indispensable.
Moreover, a special facilities for container loading and unloading will be required.

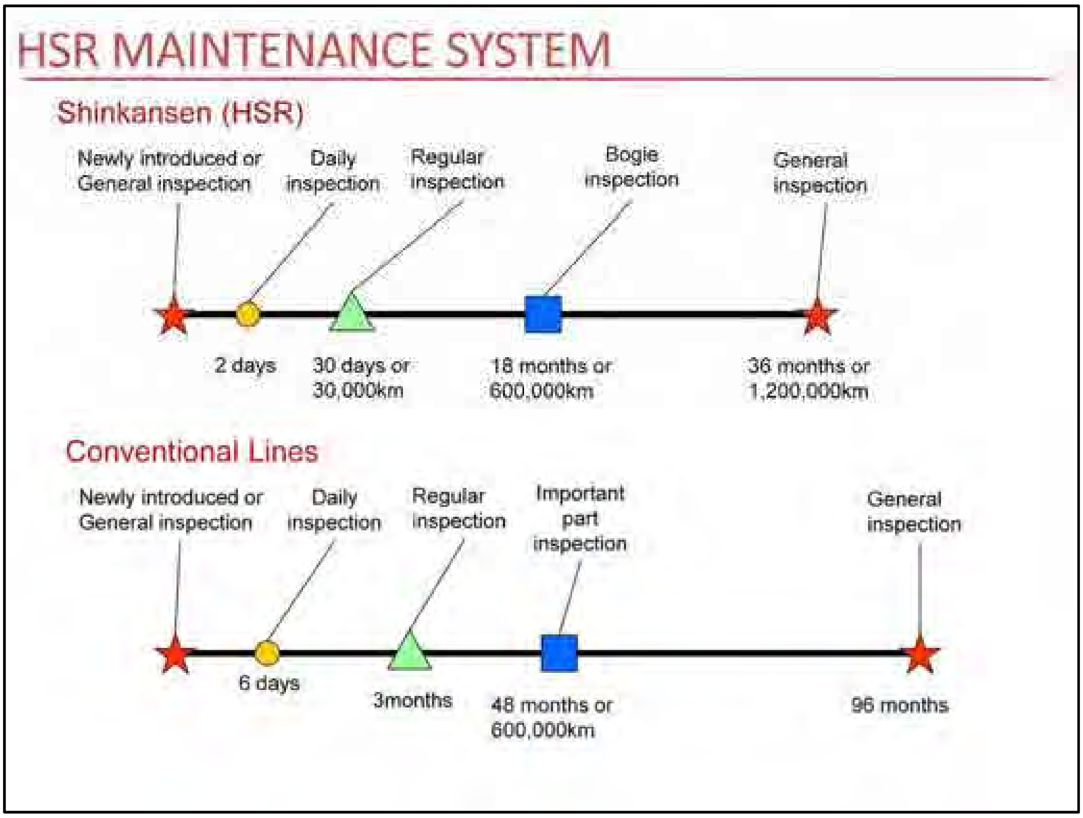
HSR MAINTENANCE SYSTEM



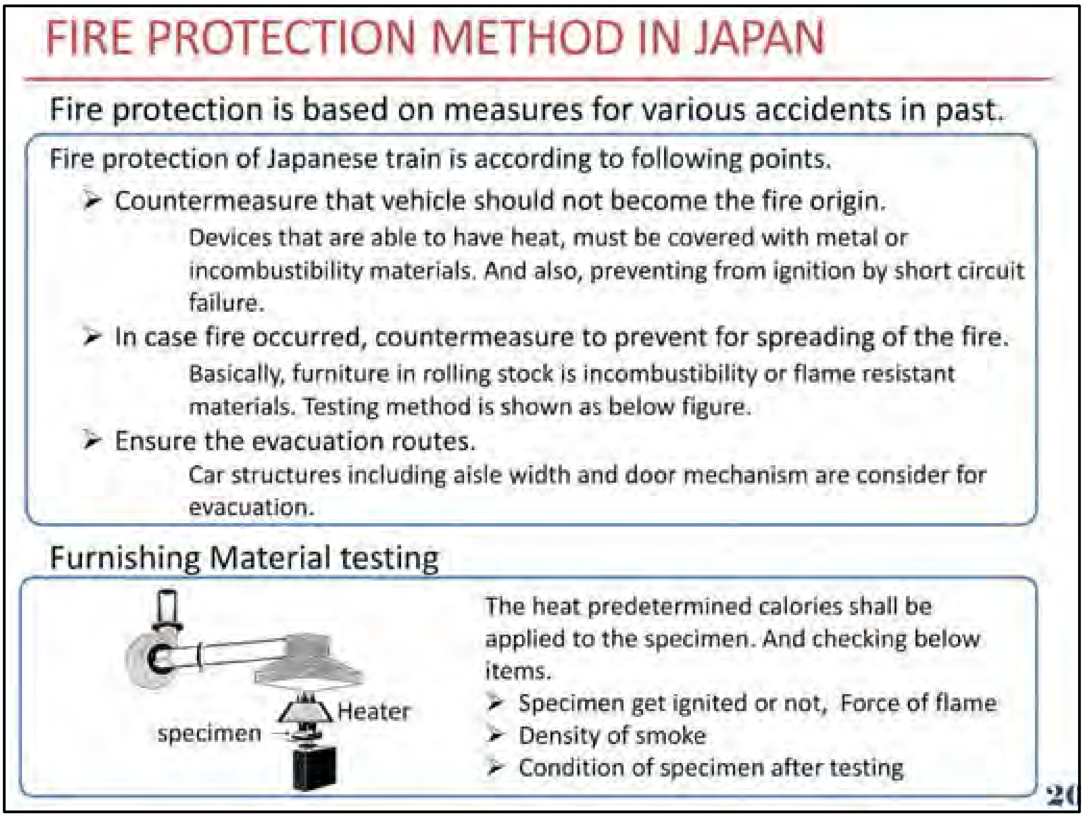
Inspection	Period	Contents
Daily Inspection	Within 2days	Brief inspection of equipments Supplement or replacement of consumables
Regular Inspection	Within 30 days or 30,000km	Inspection to check conditions and motions of mechanical and electrical equipments
Bogie Inspection	Within 18 months or 600,000km	Inspection of important parts of bogie
General Inspection	Within 36 months or 1,200,000km	Detail inspection of whole car body and equipments

As shown in this table, there are four types of inspection For Shinkansen rolling stock.

Daily Inspection is conducted in the midnight after daily operation within every two days for brief inspection of equipments and supplement or replacement of consumables.
Regular Inspection is conducted within 30days or 30,000km for mainly checking conditions and motions of mechanical and electrical equipments.
Bogie Inspection is conducted within 18 months or 600,000km for inspection of important parts of bogie by replacing the bogie of train.
General Inspection is conducted within 36months or 1,200,000km for detail inspection of whole car body and equipments.



This is the comparison of the inspection period of the Shinkansen rolling stock and the conventional rolling stock in Japan.
In consideration of the safety in high speed operation, the maintenance of the Shinkansen is raising the frequency of the inspection rather than the conventional line.

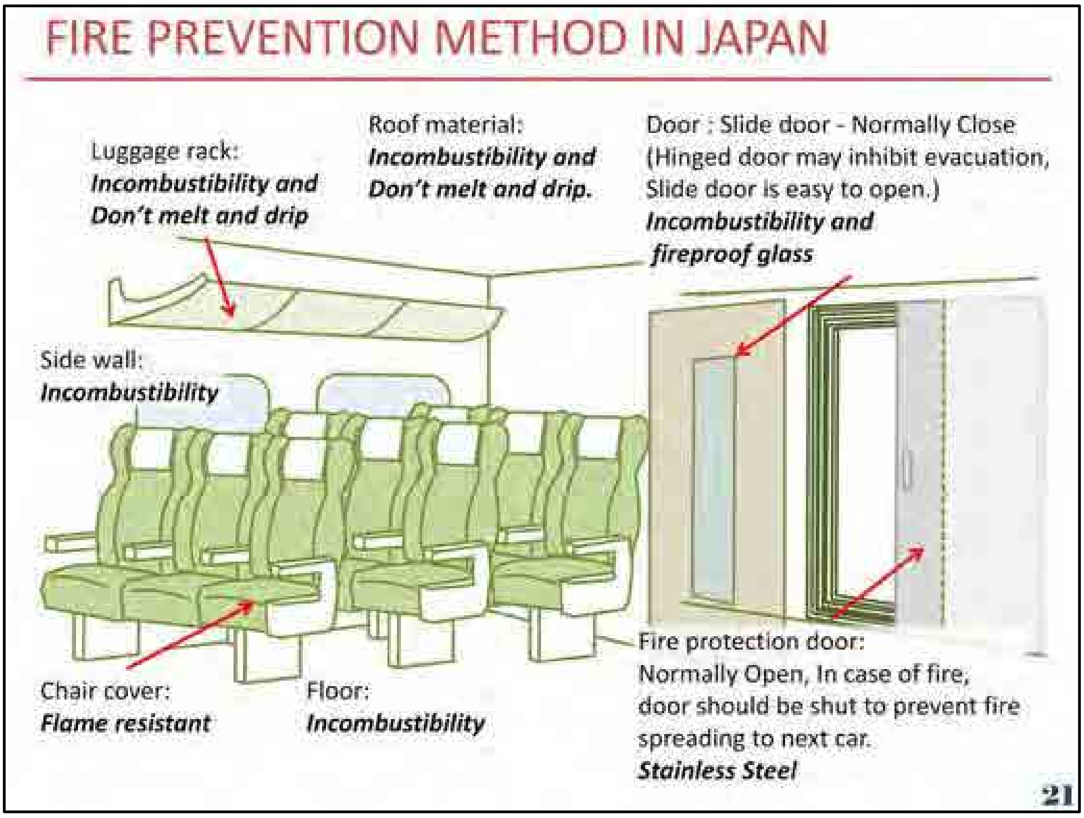


Fire protection method for rolling stock is specified in the "Approved Model Specifications" of "Ministerial Ordinance to Provide Technical Regulatory Standards on Railways" in Japan

There are the measures such as

- Countermeasure that vehicle should not become the fire origin.
- In case fire occurred, countermeasure to prevent for spreading of the fire.
- Ensure the evacuation routes for the minimization of injuries in the event of fire.

The testing method to determine the incombustibility is also mentioned in the "Approved Model Specifications" .

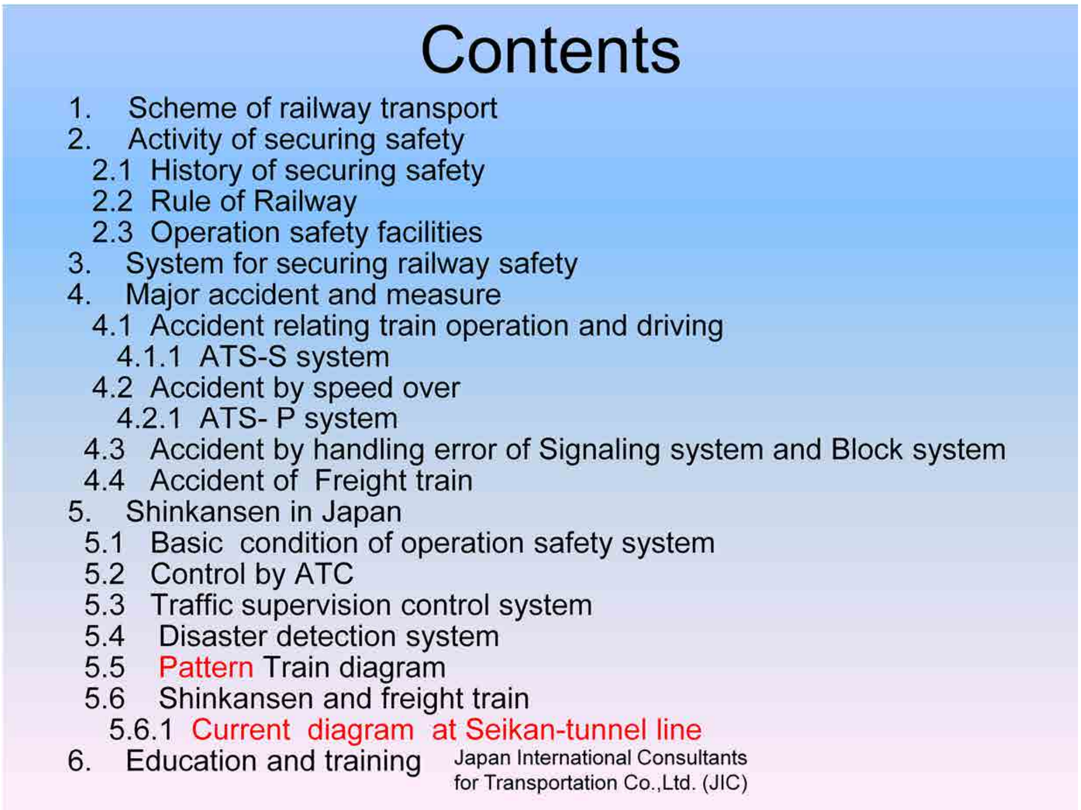


As shown in this slide, Japanese Shinkansen rolling stock uses these incombustible materials.
In addition, roof materials and luggage rack materials shall have resistance to melting and dripping.

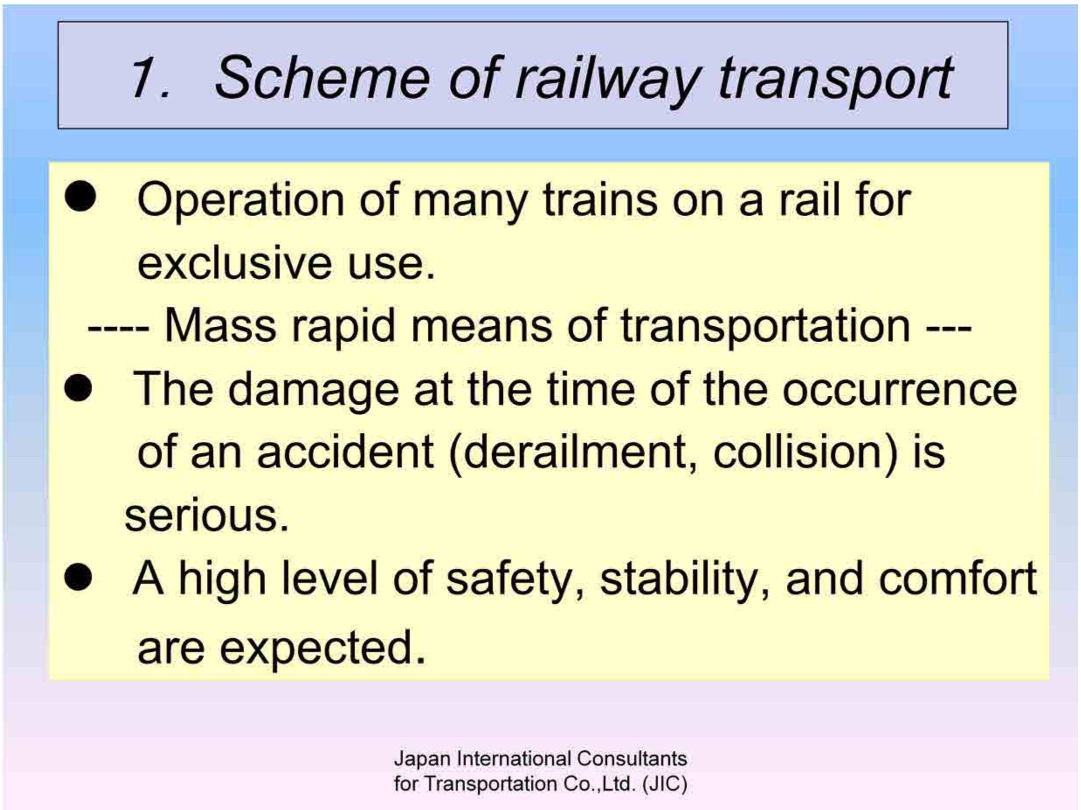
TSI, technical specification for interoperability in Europe, states about fire control after the detection or breakout of a fire. Rolling stock should have fire prevention partition and fire prevention wall that protect passengers and crew from heat and smoke of fire and keeps the train running for at least more than 15 minutes. Also, fire detectors shall be installed to the equipment room, sleeping cars, crew's room, gangway and where heat emitting devices are installed. Once a detector is activated, it needs to be informed to the driver, and supply of high voltage and fuel shall be automatically cut off.
To enable the train to run until it stops at a safe place, TSI also specifies that brake shall not work automatically, and that minimum 50% of traction shall be secured, even if equipment goes wrong by fire.

I'm Matsumoto from Japan International Consultants for Transportation. At the former Japanese National Railways and JR East, I was in charge of planning railway operating facilities, managing drivers of Shinkansen trains and conventional trains, and so forth for many years. After that, I was involved in railway planning activities in other countries through a JR-affiliated company. I now work as a technical consultant for JIC, which was established in April last year. While I have not worked with all that many countries, I have experience working in Indonesia, Vietnam, and India.

Today, I would like to explain train operation activities from the perspective of operating safety.



This shows the topics that I intend to discuss in this presentation. Since there are some parts where content is repeated, I will omit the explanations for those sections.



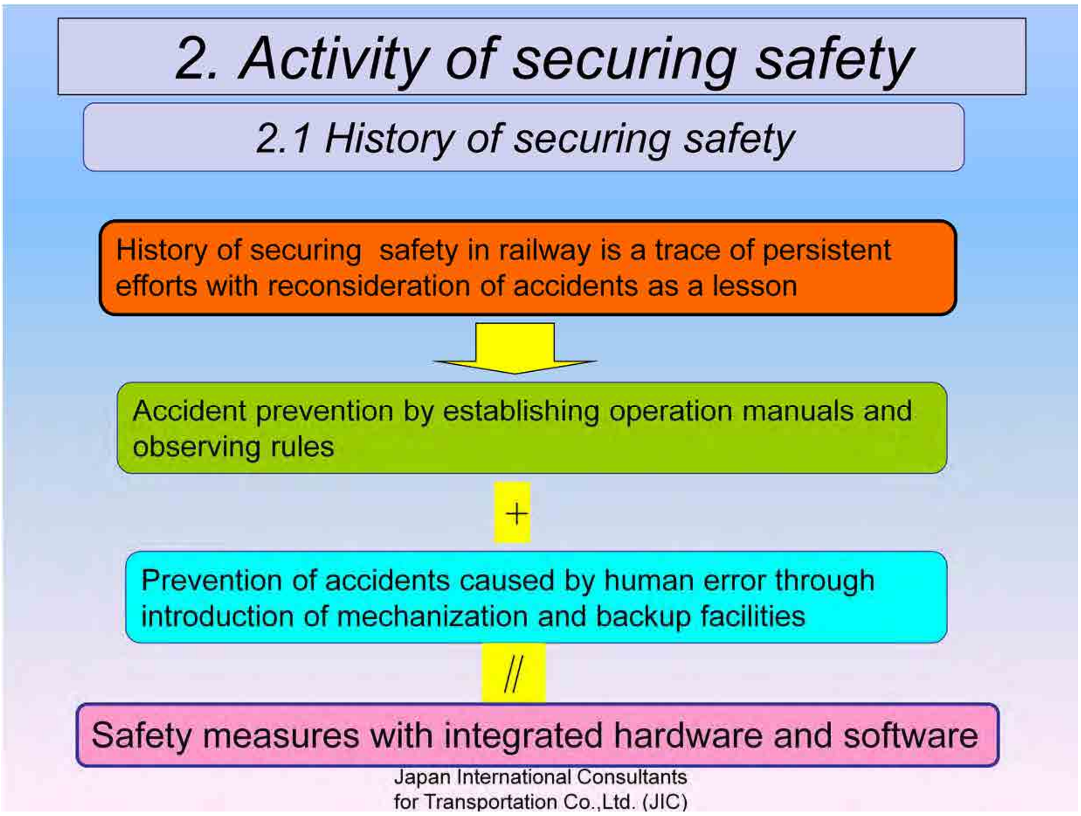
1. First, while they may be obvious, I would like to discuss the distinguishing features of railway transportation.

Broadly speaking, railways have three special characteristics, as shown in the explanation on the slide.

First, trains are operated on dedicated rails in large numbers. In other words, trains are a mechanism for mass, high-speed transportation.

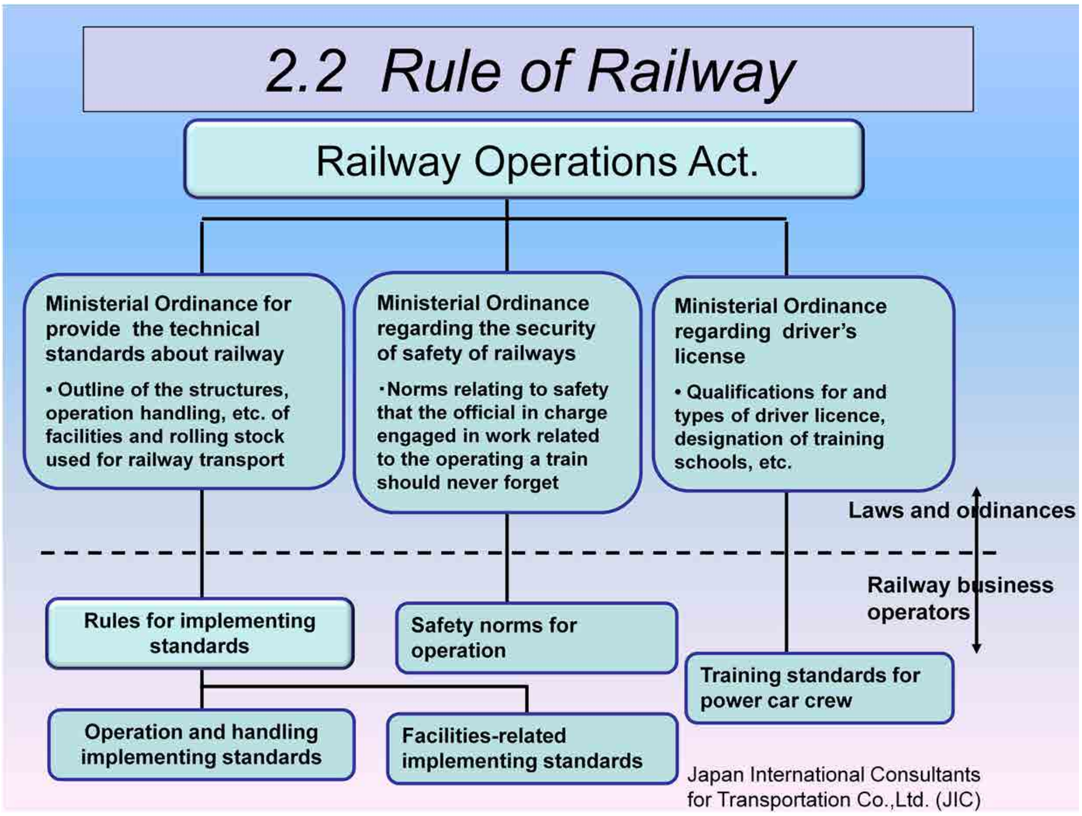
Second, if an accident such as a train derailment or collision occurs, the damage is enormous. There is also a significant social impact.

Third, as a result of this, high standards of safety, stability, and comfort are required. Railway safety systems have been designed based on valuable lessons from past accidents.



2.

2.1. This shows that the history of railway safety has been established as a result of strenuous effort, based on lessons learned from valuable past experiences. The red section refers to reflection on past accidents, the green section refers to creation of manuals and rules, the blue section refers to introduction of backup systems such as mechanization, and the pink section at the bottom points out the importance of integrating “soft” and “hard” safety measures.



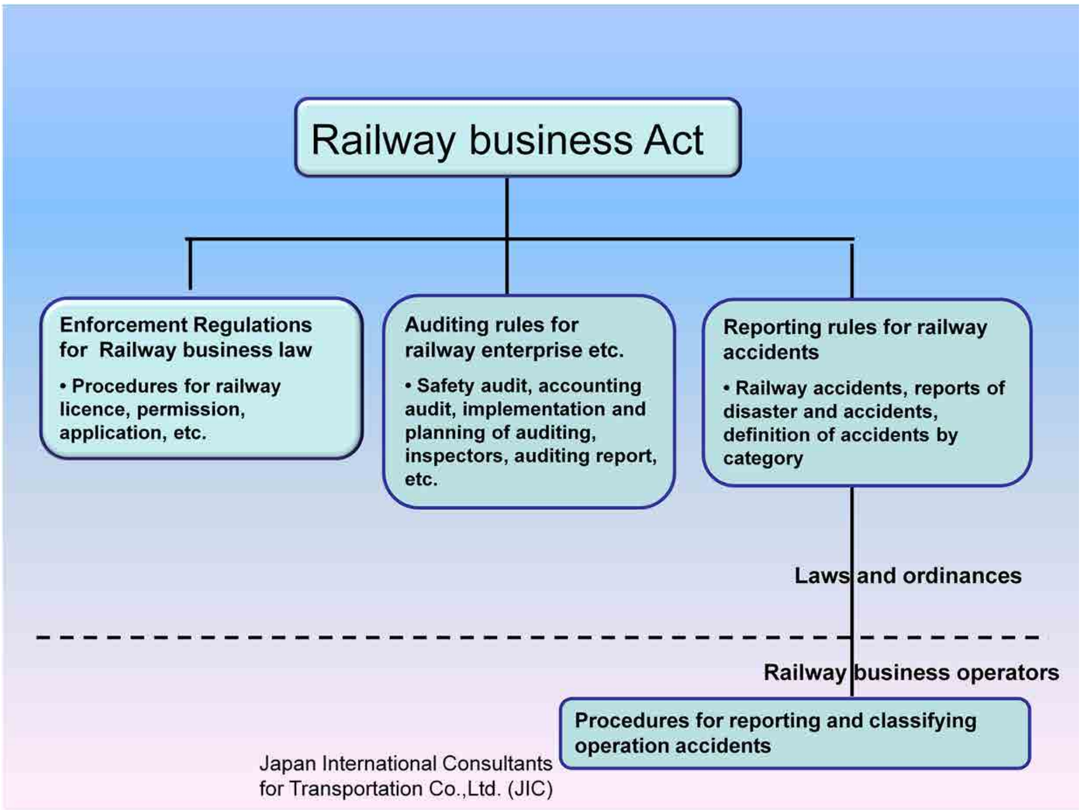
From a "soft" perspective, rules exist for operating railways. This slide shows the relationship between national laws and ordinances and regulations created by companies in Japan. National laws in Japan relating to railways include the Railway Operation Act and the Railway Business Act.

The Railway Operation Act stipulates basic items for the operation of railways, such as the structure of rolling stock, the structure of facilities, the handling of operation, administration, qualifications, etc., while the Railway Business Act stipulates matters relating to types of railway business, railway operating licenses, construction plan approval, railway facility inspections, accident reports, and so on.

Based on these national standards, the country's various railway business operators have determined their own standards of practice.

At the top, we have the Railway Operation Act, and on the left of the slide, we have the ministerial ordinance on technical standards for railways, which stipulates basic principles for facilities used in railway transportation, structure of rolling stock, operation handling, and so on. Based on this, the various railway business operators have stipulated their own standards of practice for operation handling and equipment use. In the middle, we have the ministerial ordinance for ensuring the safety of railways, which stipulates norms relating to safety that absolutely must not be overlooked by the people involved in operation. This ordinance was stipulated based on reflections following an accident that occurred half a century ago, on April 24, 1951, inside Sakuragicho Station on the Negishi Line, when a train came into contact with a dangling overhead wire. The train caught fire due to the resulting short circuit, and 106 people died and another 92 were injured in the disaster. On the right, we have the ministerial ordinance for driver's license.

Next



Here we have the Railway Business Act. It stipulates matters relating to railway licenses, equipment inspections, accident definitions, reporting when accidents occur, and so on.

As this shows, various types of rules have been stipulated for operating railways safely.

2.3 Railway operation safety systems

Facilities in railways for ensuring safety of train operation are called “operation safety facilities.”

The following three items are the most basic types of operation safety facilities.

First, there are blocking devices, signaling devices, and ATCs for keeping a safe operating interval between trains that are running.

Second, there are interlocking devices for securing the passage of trains inside stations.

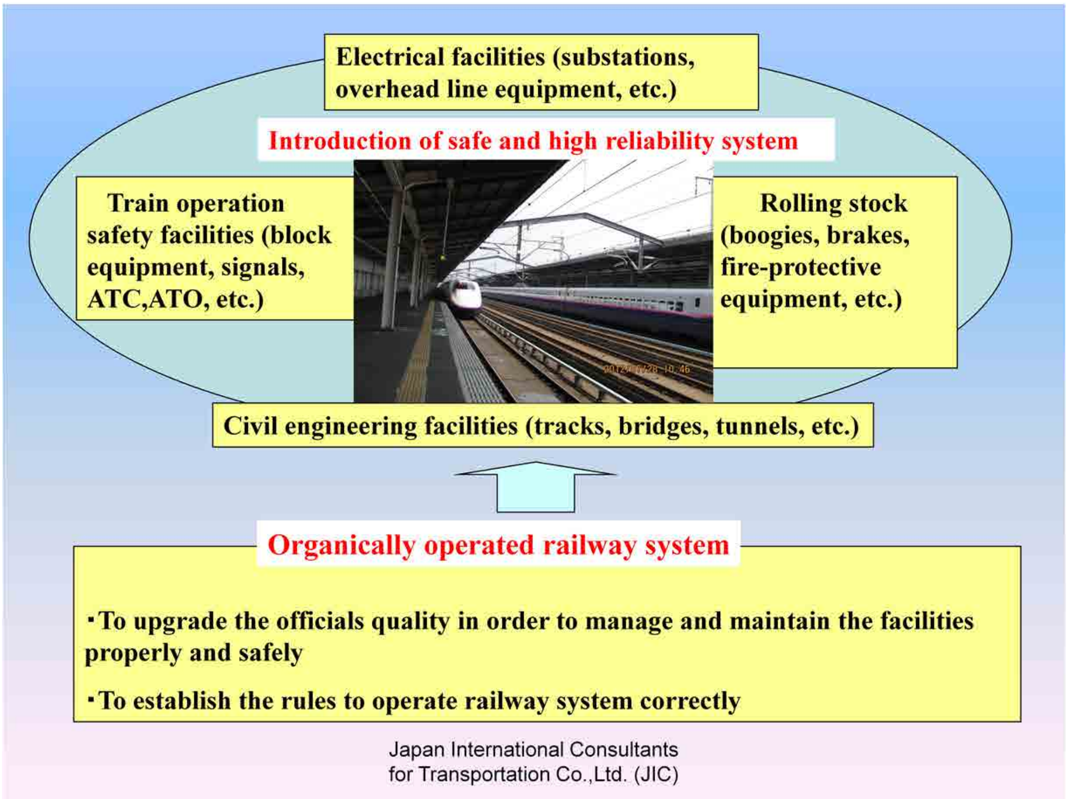
Third, there are various warning devices for protecting trains, which detect abnormalities in the tracks on which trains run, rolling stock, and so forth.

These operation safety facilities have changed considerably based on past accidents and increase in train numbers, and are gradually becoming more sophisticated. However, since it is the driver on board who actually operate trains, no matter how sophisticated the operation safety facilities are, incidents occur from time to time due to human oversight. The facilities that have been developed therefore include ATSs (automatic train stop devices) as well as ATCs (automatic train control devices), which are linked to train speed control and signal indication systems.

3. Railway systems are comprised of personnel, such as officials, and facilities, such as tracks, operation safety facilities, and rolling stock. Railway transportation depends on organically linking personnel and facilities.

There are rules for handling both of these elements correctly. Safe, stable railway transportation is ensured by implementing these rules properly.

Next



This slide shows the relationship between personnel and facilities indicated on the previous slide. When it comes to systems for ensuring a high level of railway safety, it is necessary to link civil engineering facilities, operation safety facilities, electrical facilities, and various rolling stock facilities with each other in a balanced way. It doesn't matter how great the train is – you can't provide comfortable service with a rickety track.

That means railway transportation depends on these facilities being precisely and safely managed and maintained. Personnel and rules play an essential role in managing these matters.

Next

Operation control system and safety facilities

Operation control	Control contents	Basic facilities		Modernized facilities
Route control	Route setting control	・Interlocking devices		ARC,PRC,CTC
Train interval control	Train interval control Train headway adjustment control	・Blocking devices ・Signaling devices	ATC	ATO
Train operation	Stopping control	Handling by driver (ATS)		
	Deceleration control	Handling by driver		
	Acceleration control Fixed point control Constant speed operation control	Handling by driver		
Train group control	Operation plan, control, etc	Train dispatching telephones Train radio, facsimiles, etc.		CTS、CTC, COSMOS etc.
Operation surveillance control	Obstacle detection control, etc.	Anemometer、pluviometer、fallen rock warning devices, etc.		Disaster prevention control system

Japan International Consultants for Transportation Co.,Ltd. (JIC)

This slide summarizes the relationship of operation control systems to the operation safety facilities I have discussed so far. Operation control systems have been broadly classified into five items.

Route control organizes the route, and in general, interlocking devices are used by aboveground personnel, while modernized facilities include the likes of PRC, which is mentioned here.

The second type of system is interval control. Control systems for preserving or adjusting the interval between trains include blocking devices and signaling devices, as well as ATCs and the like developed for the purpose of interval control.

The third one is operation control, which is handled by drivers and involves operation maneuvers such as stopping, accelerating, and decelerating.

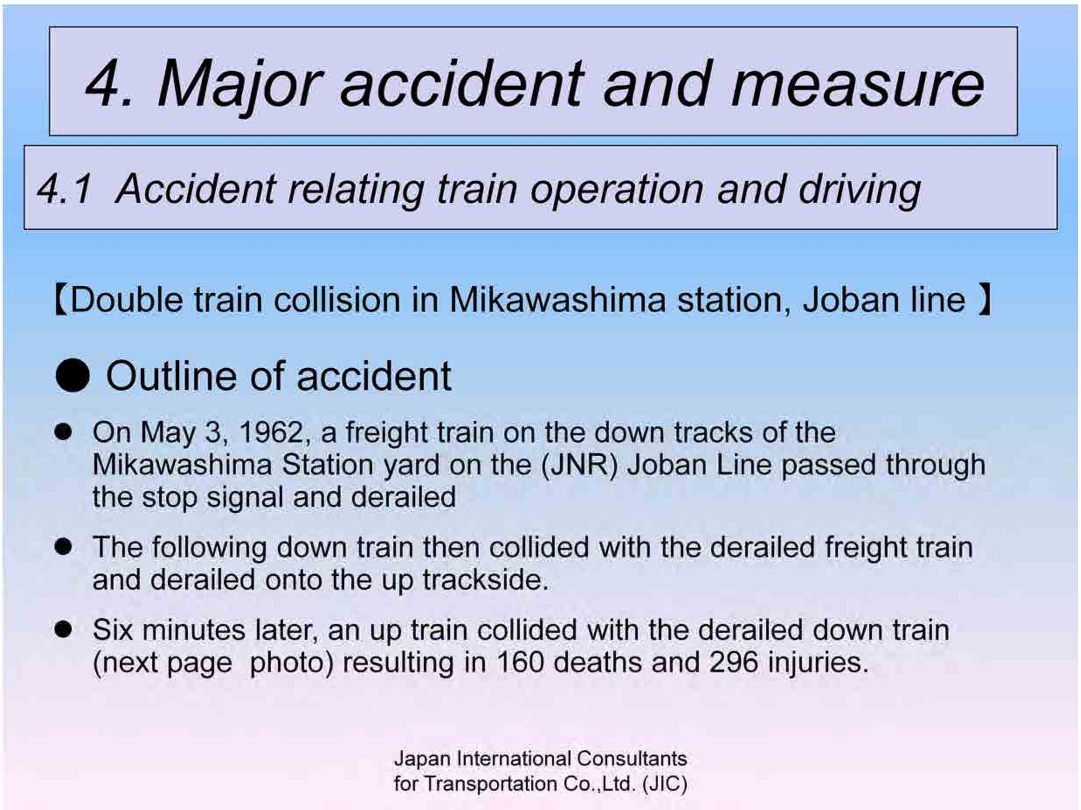
Partially mechanized operation systems include ATSs and ATCs, as well as ATOs, which are automated systems.

The fourth type of system is train group control, which manages trains as an overall group based on a variety of information from the operations room. With the CTC as a base, total operation management is performed in conjunction with the next system – the surveillance system for disasters and so on.

Disaster surveillance is the fifth type of system. It serves to prevent train accidents using information about earthquakes, wind speed, and the like.

Through the enhancement of these operation control systems, railways have become more modernized and more safely and accurately operated.

Next



4. Major accidents and countermeasures

I will now explain how operation safety facilities have developed based on past accidents, using some examples of major accidents.

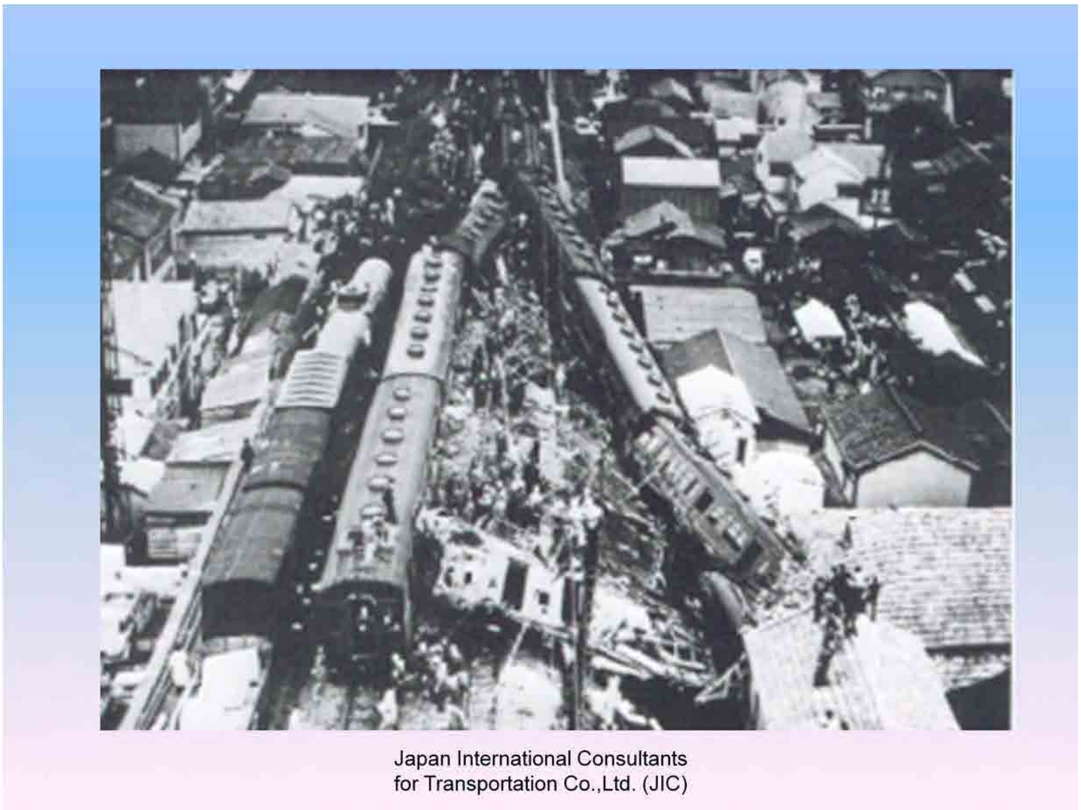
4.1 This is an example of an accident related to train operation and handling

In this accident, which occurred at Mikawashima Station, a freight train on the down track that was supposed to stop passed through the down-track stop signal, plunged into the safety siding, and derailed. A passenger train on the down track then collided with it, and it derailed onto the up track. Even worse, a double collision occurred six minutes later when an advancing up-track passenger train struck the down-track passenger train. This disaster caused 456 deaths and injuries, ranking as the worst in the history of Japanese National Railways.

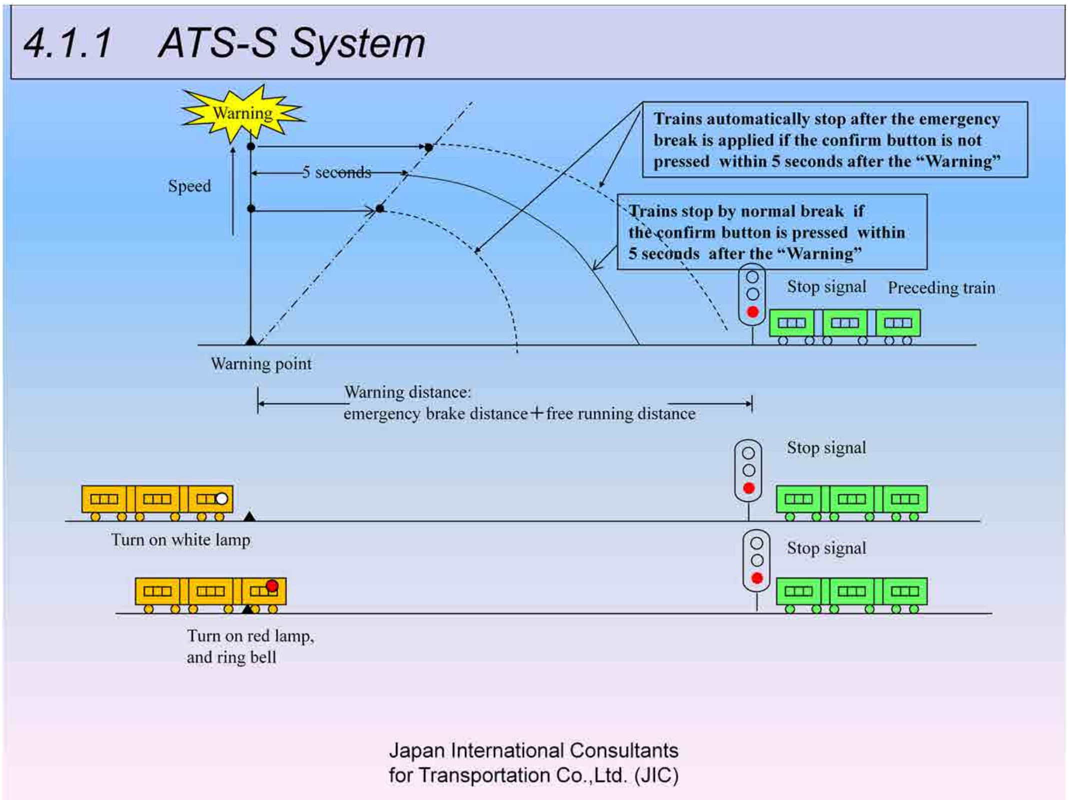
As a result of this accident, Japanese National Railways developed on-board warning devices and installed automatic train stop (ATS) devices on all lines (completed in 1966), which issue an alarm when there is a red signal and, if the driver does not respond within five seconds, automatically applies the brake.

In addition, a notable question in this accident is why, even though there was a six-minute period after the derailment of the down-track passenger train, the down-track passenger train crew and the Mikawashima Station staff took no measures to stop the up-track passenger train?

If measures had been taken to stop the up-track train, the accident would perhaps have caused less damage. It is important to provide regular training so that personnel will be able to respond right away when there is an abnormality.



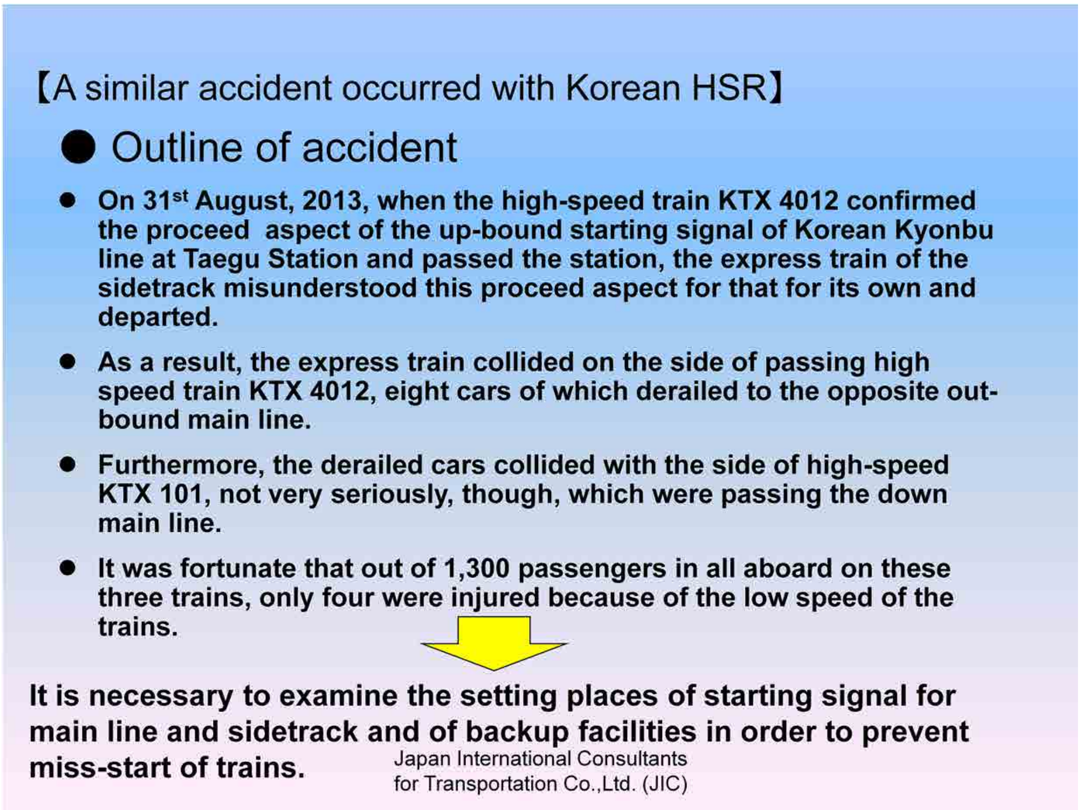
This is a photo of the accident scene. The freight train on the left derailed first, then the train in the middle collided with the derailed freight train, diverged onto the up track on the right, and collided with an up train on that track.



The ATS-S system was introduced at that time due to the collision at Mikawashima Station.

With this system, in order to ensure smooth train operation in line sections where train operating frequency is high, such as the Tokyo area, if the driver pushes a confirmation button within five seconds of an alarm caused by a red signal, the safety function will be deactivated and the train will be able to keep running, relying on the driver's vigilance.

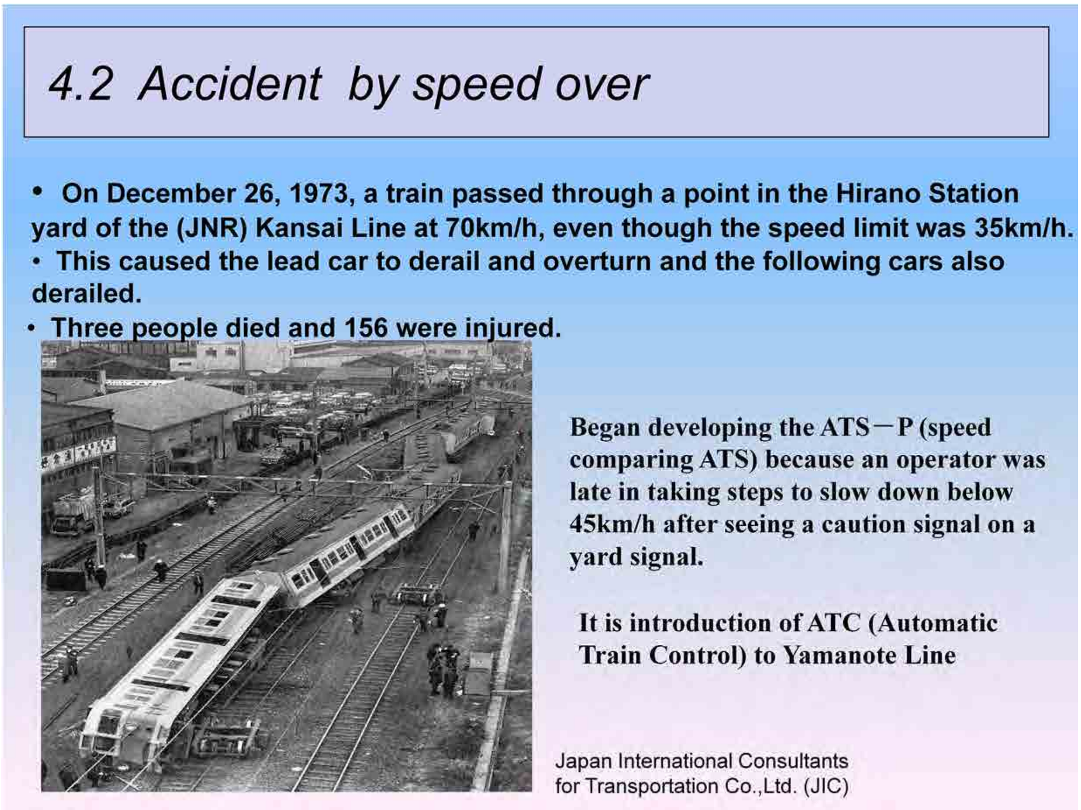
However, installing a function like this that deactivates the ATS safety function in order to ensure smooth train operation was a remote cause of later major train accidents. This system was therefore not good enough.



There was recently a similar accident caused by a train passing a stop signal.

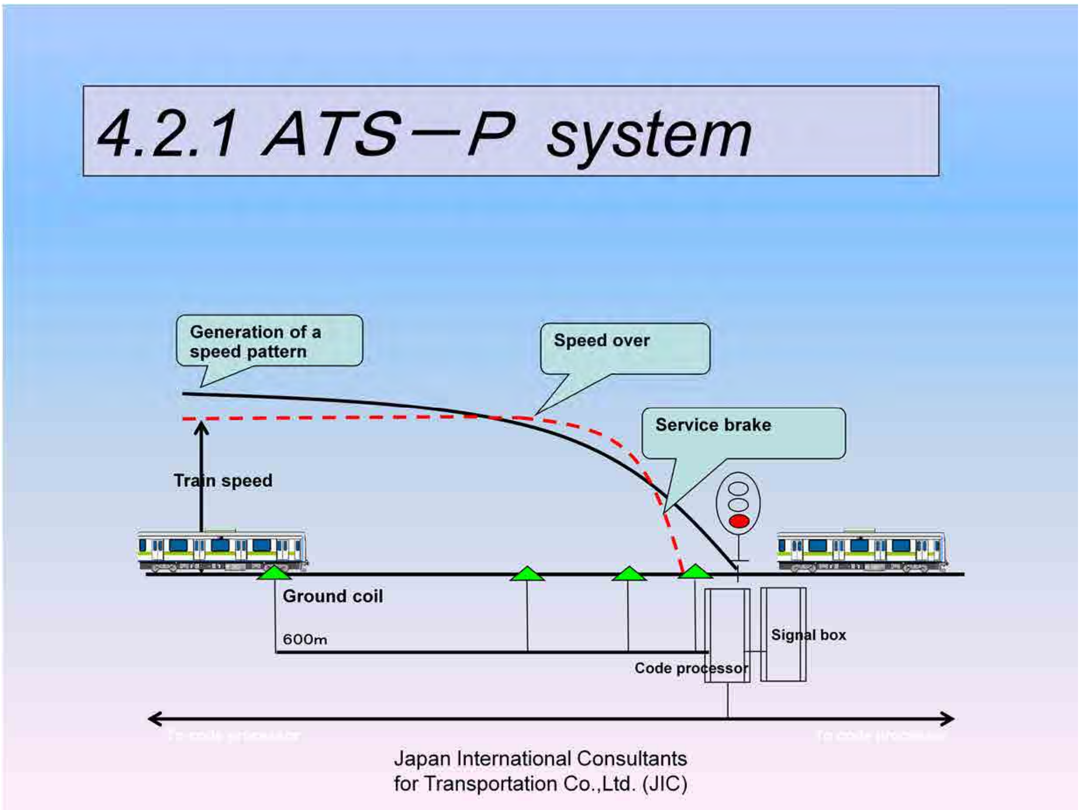
The accident occurred in Japan’s neighbor, South Korea. Like the Mikawashima Station accident in Japan, it was a double collision in which a train passed a stop signal. Imagine if the high-speed train had been running at high speed – the accident would have been truly disastrous. This is an example of an accident in which backup facilities played an important role.

This is a photo of the scene.



4.2 Accident caused by excess speed

This was an accident that occurred due to a driver entering at a speed that exceeded a point’s speed limit, and since it was caused by a blind spot in the ATS-S system’s functions (no speed verification function), and similar accidents later occurred, Japan National Railways at the time advanced the development of a new type of ATS that automatically creates a braking pattern on the train in response to the signaled speed limit and decelerates and stops the train while checking its speed.



This shows the operating principle of the ATS-P system. In accordance with a signal from a transponder installed aboveground, a deceleration pattern is automatically generated on the train, and if the train’s speed exceeds this, it automatically applies the brakes, so this system improved safety considerably compared to the ATS-S system that was originally introduced.

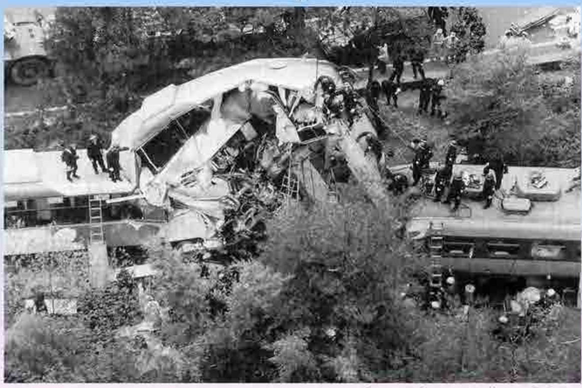
To show the ATS-S system that was originally introduced using this slide, if a train were to pass the area of the ground coil on the left, a warning buzzer would sound, and if the driver did not press the confirmation button within five seconds, the emergency brake would be applied. Conversely, if the confirmation button was pressed within five seconds, the ATS function would be deactivated, and the ATS would not operate even if the driver ignored a red signal, which was a flaw with this system.

With the ATS-P system, if the signal in front is red, there is no need for a confirmation process like in the ATS-S system, since the driver runs the train at a speed below the braking pattern with normal brake handling, and if the train in front moves during pattern generation and the signal is showing, it is possible to increase the speed thanks to a ground coil for pattern elimination.

This slide describes a derailment on a high-speed railway in Spain caused by excess speed. Unfortunately, no exceed speed backup facilities had been installed in this section of the line.

4.3 Accident by handling error of Signaling system and Block system

- **On May 14, 1991, a substitute block system (command type) was being used in a single line section of the (private railway) Shigaraki Kogen Railway due to the failure of a departure signal.**
- **During this time, a deadhead diesel train collided head-on with an extraordinary diesel train between station yards resulting in 42 deaths and 614 injuries.**



When the stationmaster used the substitute block system, he ordered the departure of the deadhead train without verifying that there were no trains between the station yards.

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4.3 This is an example of an accident due to signaling and blocking handling errors. As explained here, the accident involved a small private railway company.

This accident occurred because a signal was malfunctioning and departures were being directed with a substitute blocking system, but the substitute blocking system was fundamentally flawed and it failed to perform a basic check to see if there were any trains on that section of the line.

It is important to provide regular training on how to handle abnormal situations.

【Train collision in the high-speed railway in Wenzhou City, Chinese】

- **On 23rd July 2011, a high-speed train collided with a preceding high-speed train which had stopped because of a thunderbolt in the elevated line in Wenzhou city China.**
- **Of the train which collided from behind, four cars dropped from the elevated line, which was 20 several meters high, to the ground. 40 people died and 192 were injured.**
- **It is said that the train operation control system, which is believed to be the safest, is to blame having had a serious defection, but the details are not known.**
- **When a usual operation safety system cannot be used, the substitute block systems shown below are enforced with the Japanese Shinkansen.**
  - **Command type system/detective type system for double track operation.**
  - **Pilot and dispatching system/pilot and detective system for single-track operation.**

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This is an accident that occurred on a high-speed line in China. Under normal circumstances, if the preceding train has stopped, a stop signal will automatically be shown to the following train and it should stop, but in this case, it did not stop and crashed into the rear of the preceding train. It is believed this was due to a systemic problem. It is also not clear what kind of measures were taken by the OCC when the abnormality occurred. When equipment malfunctions, it is necessary to properly direct handling in accordance with orders.

This is a photo of the scene.

4.4 Accident of Freight train

【Double collision in Tokaido Freight line (JNR)】

- **On 9th November 1963 a freight train of the formation of 45 cars was running on the Tokaido down-bound freight line at approximately 60km/h, when the third car from the rear which was a 2-axle box car suddenly derailed followed by the two connected cars, and caused a great trouble for the Tokaido up-bound passenger line that ran parallel with it.**
- **An up-bound passenger train and a down-bound passenger train approached at the same time to the site of the derailment.**
- **The up-bound passenger train collided with the derailed freight train and was flicked out to the down-bound line and collided to a down-bound passenger train. 160 people died and 120 were injured in total.**
- **It was concluded that this derailment was caused by a complicated "combination of factors" such as the load state of the freight train, the formation ratio of empty cars and loaded cars, the state of the track, running speed, accelerating and decelerating force, etc.**

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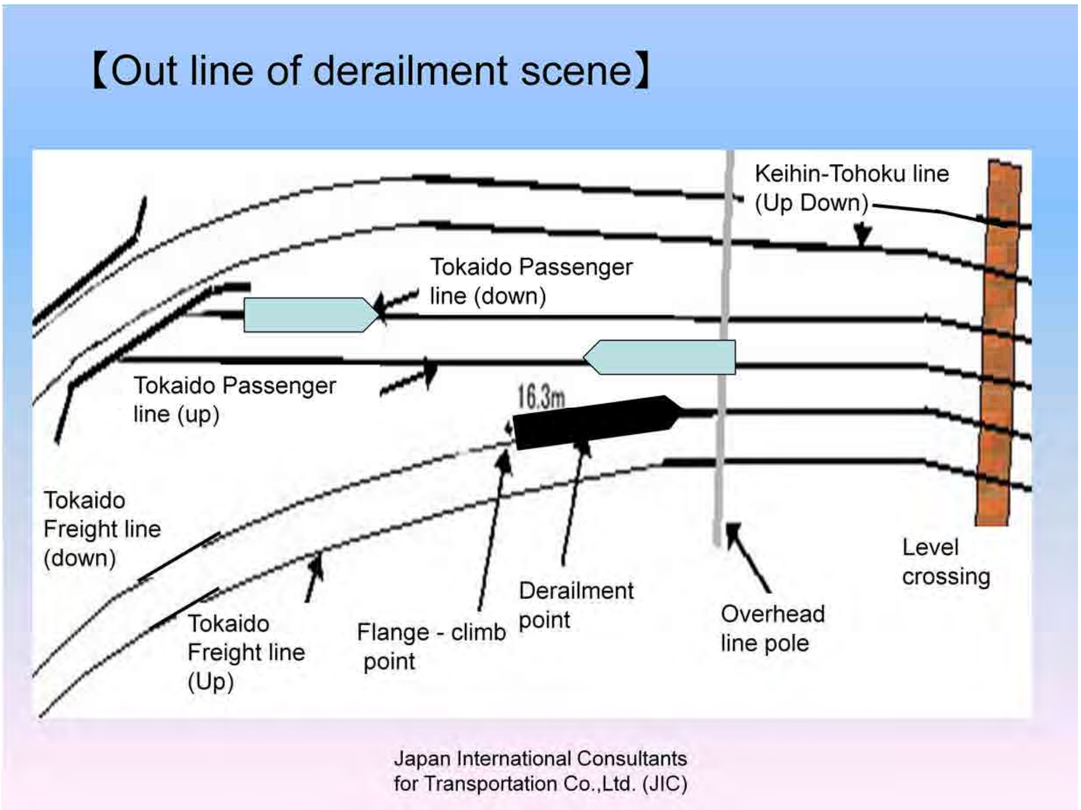
4.4 So far, we have looked at accidents that could have been prevented if there had been proper handling by the personnel involved or accidents that could have been prevented if full backup facilities had been installed. This was an accident involving the complex intertwining of various issues, including the track, rolling stock, train structure, train speed, and acceleration and deceleration speed.

As indicated in the accident summary, it was presumed to be a derailment by multiple causes, in which various conditions were combined, including the track, the freight train, the freight train's cargo, the coupling position of the empty cars and loaded cars, the train speed, the acceleration and deceleration speed, etc. Countermeasures were undertaken, including provision of lubricators and installation of track protection equipment in curved sections. At that time, other similar accidents occurred on Japanese National Railways.

However, two-axle freight cars of the kind that derailed in this accident were mostly retired when Japanese National Railways was divided into new companies.



This outline shows the relationship between the train that derailed and the passenger train.

This is a photo of the accident scene.

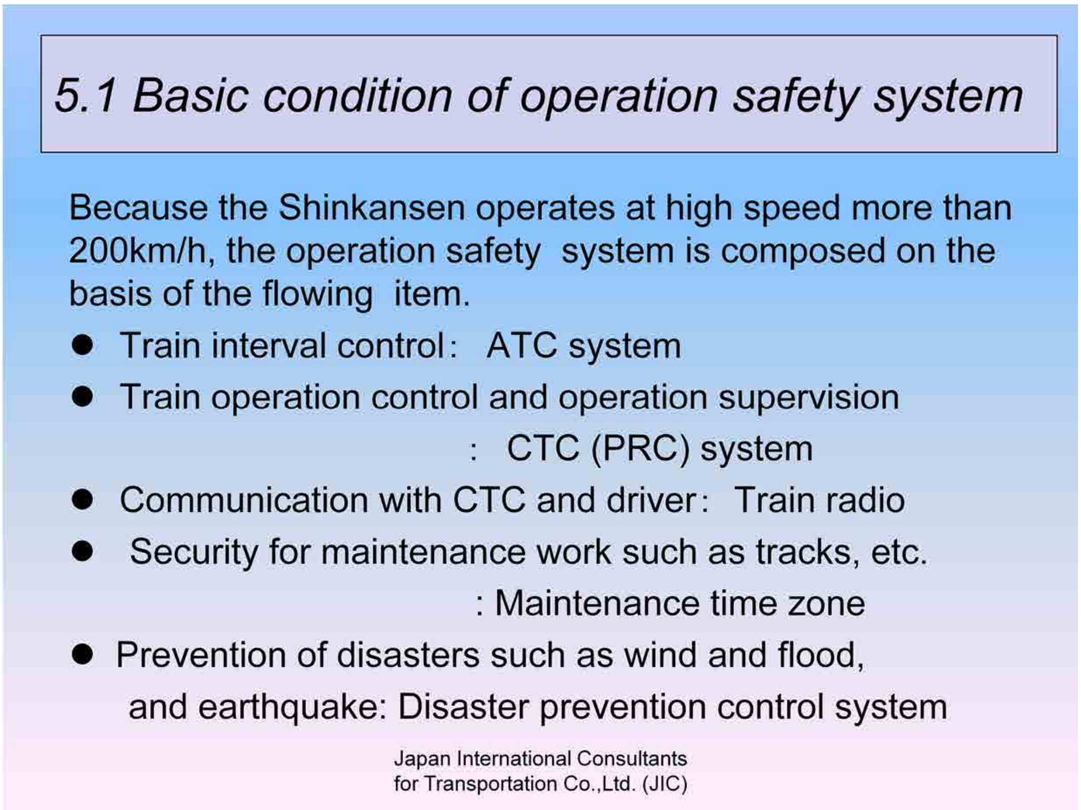
5. I will now give you a simplified explanation of Japan's Shinkansen.

Launched in October 1964, the Shinkansen was created in conjunction with the Tokyo Olympics held at that time.

Today, it has 2,388 service kilometers.

Fifty years have passed since it opened, but to date, there has not been a single accident in which passengers were killed or injured. Today, it is used by 300 million passengers per year.

The maximum speed at which it operates is 320 km/h on the Tohoku Shinkansen between Tokyo and Morioka.



5.1 Basic items of the Shinkansen's safety system

As indicated here, the safety system basically consists of the following five conditions:

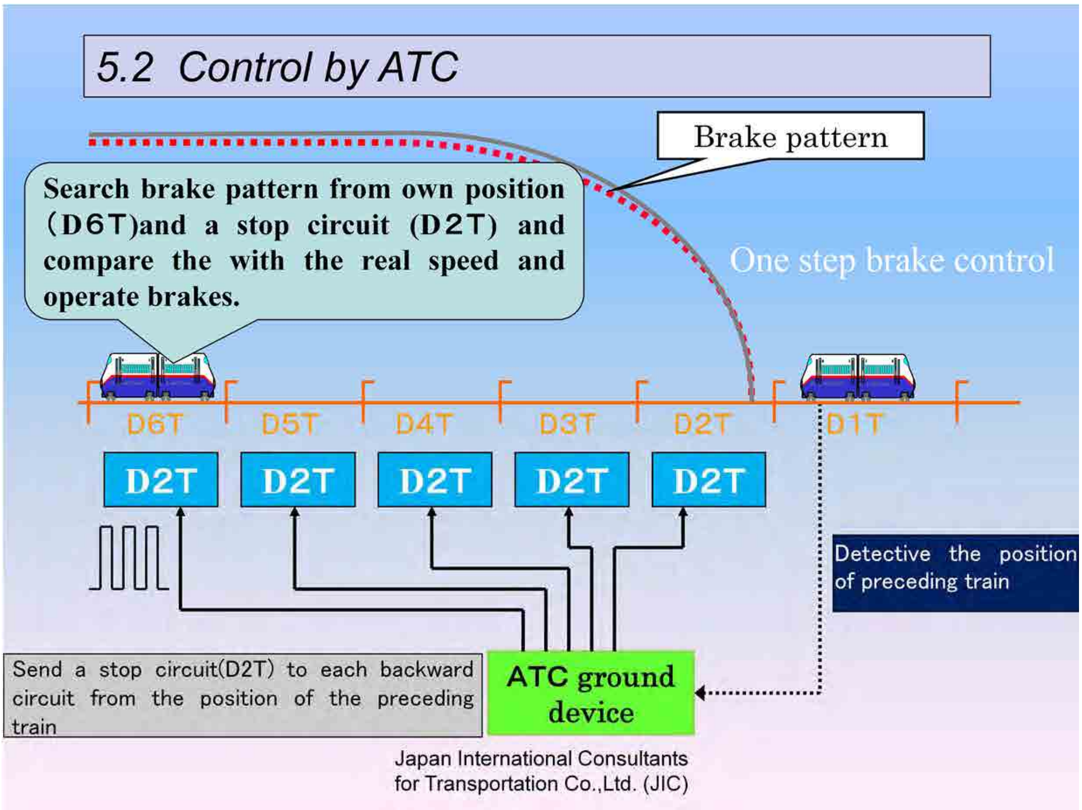
The first is the machine-based ATC system that ensures safe train intervals.

The second is train operation control, which is centrally managed via CTC and PRC.

The third is direct communication between the driver and OCC via the train's radio.

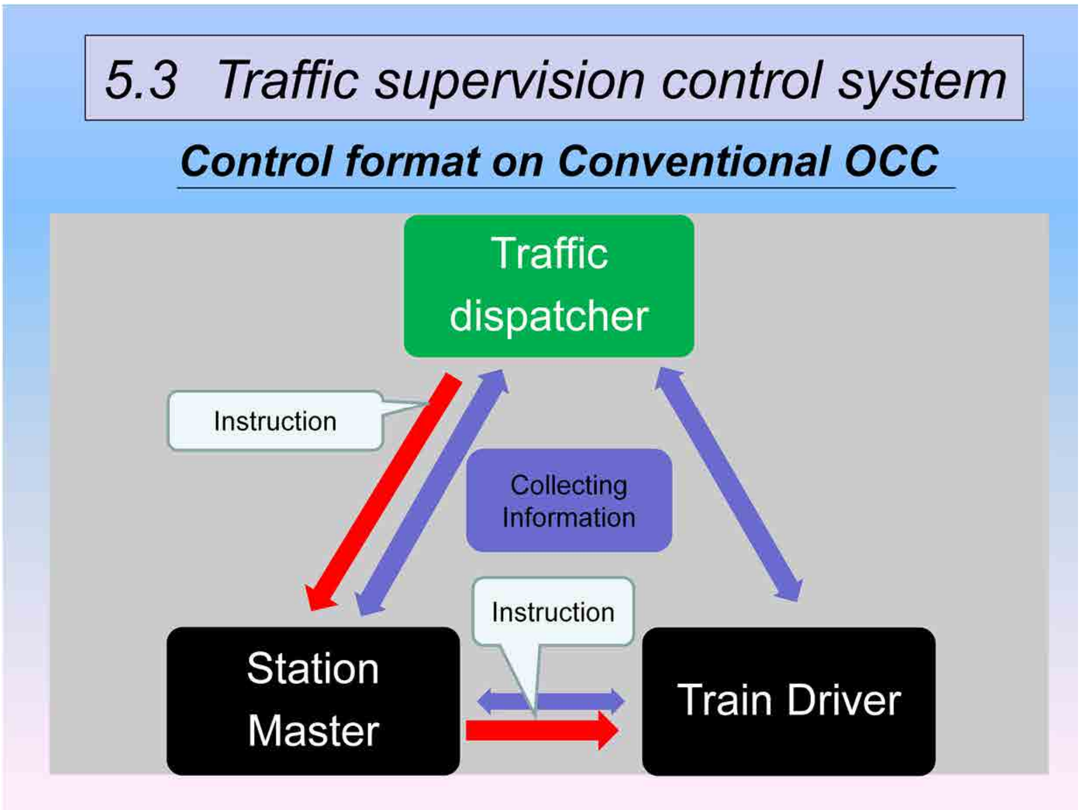
The fourth is the setting aside of maintenance windows for tracks and so forth from midnight until 6 a.m. in order to ensure their safe operation.

The fifth is the introduction of a disaster prevention and detection system in order to prevent accidents due to bad weather, earthquakes, and other natural disasters.



5.2 ATC-based control

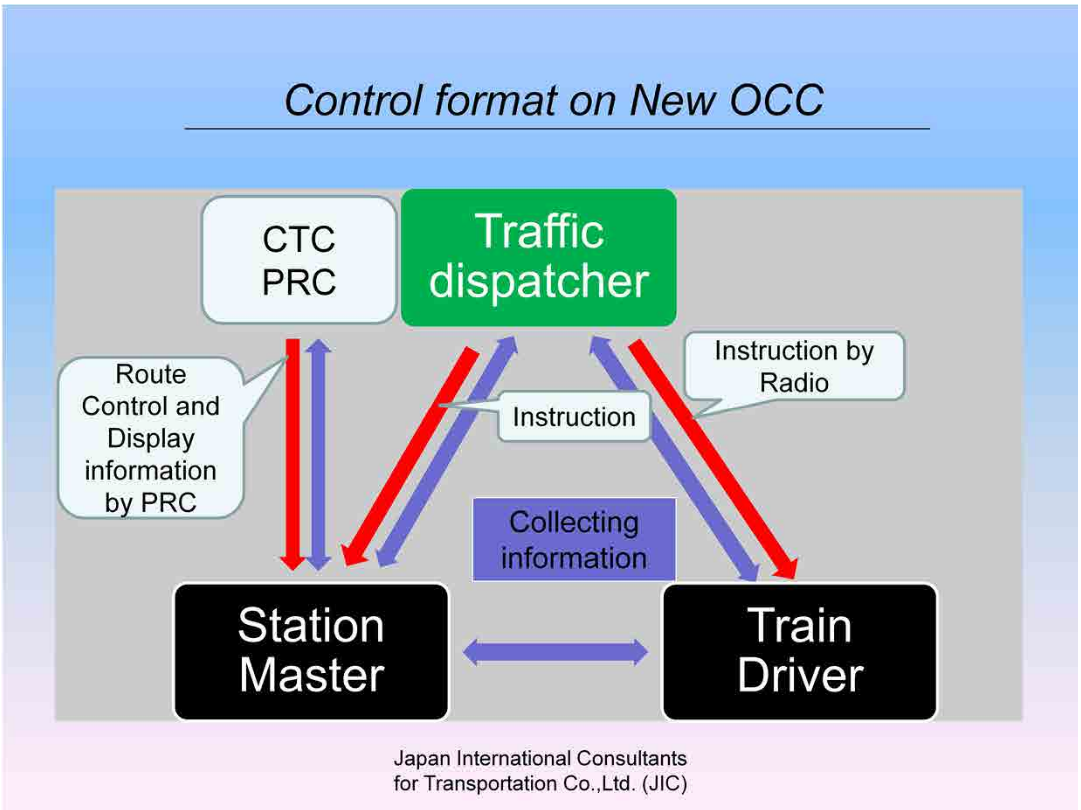
As shown in this diagram, when the preceding train is stopped, this information is transmitted to the following train. In this case, the information passed on to the following train is to stop on the track circuit behind the preceding train (D2T). The following train generates a braking pattern, which is determined based on its actual speed, and comes to a stop.



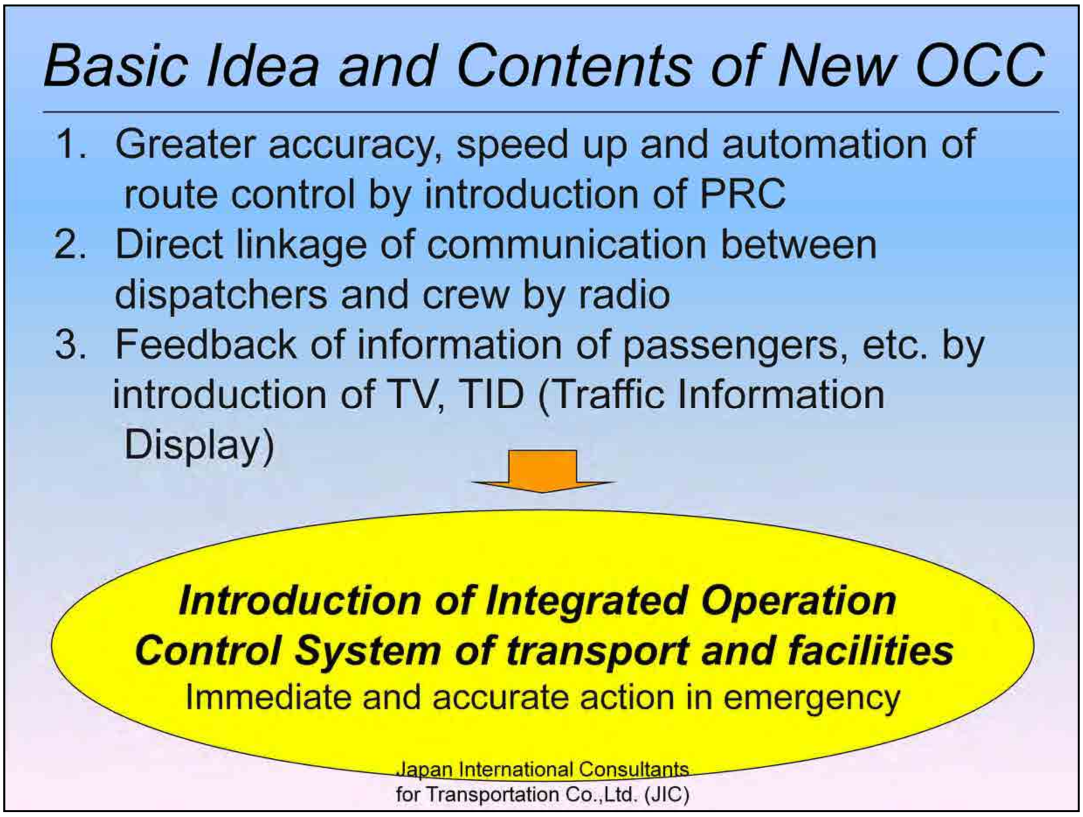
Next, I will explain the transportation control system.

As shown in this slide, conventional train operation management was performed via the station master, based on transportation instructions, but the system was lacking in speed and precision.

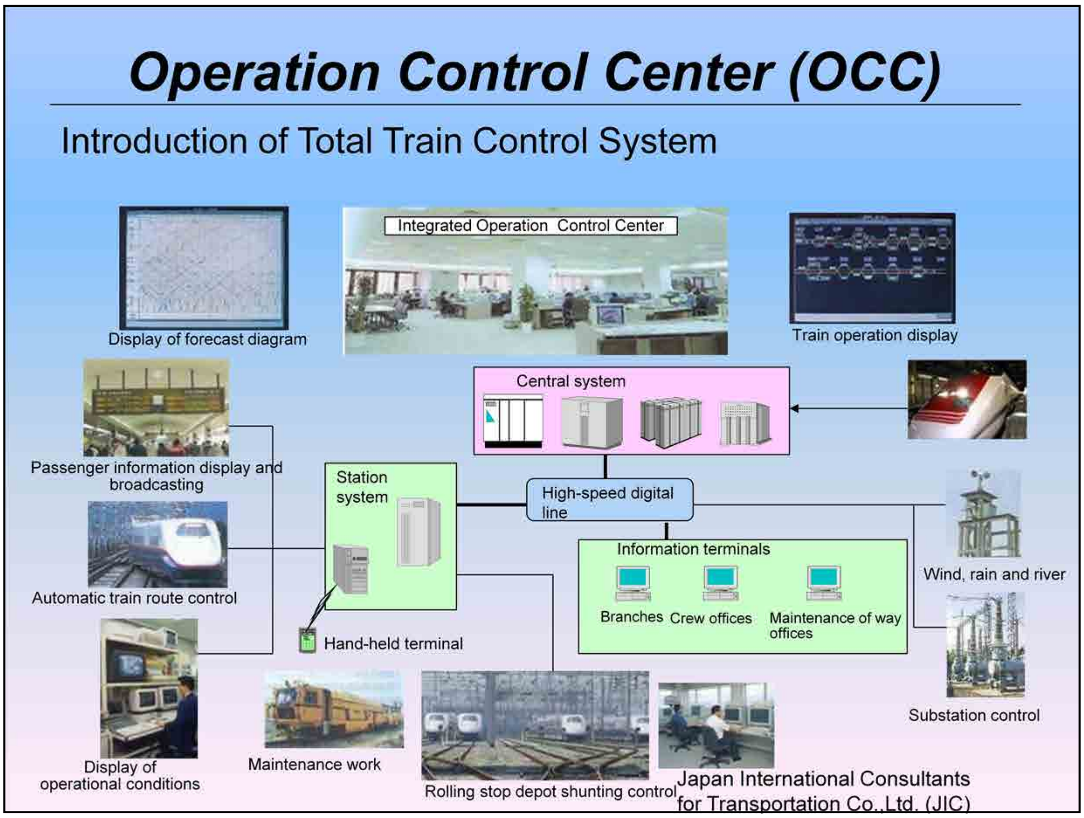
With increased train density, diversification of train types, and increase in the number high-speed trains, there was a need for rapid and precise transportation control.



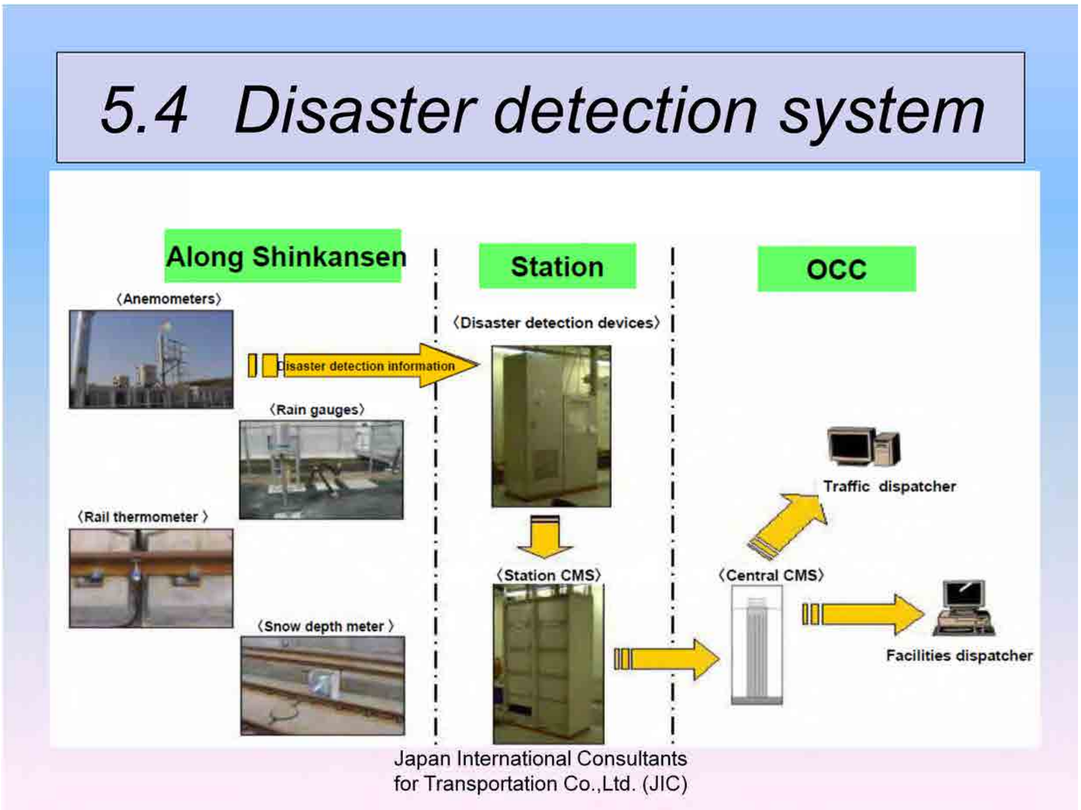
This is an example of modernized transportation control based on the introduction of CTC and PRC. The speed and safety of route control for trains at each station was improved with the introduction of CTC and PRC. What's more, it became possible to issue rapid, precise instructions to drivers via radio. In addition, a variety of information collected and displayed at the CTC is delivered to stations and so on, and train group control is now rapid and stable.



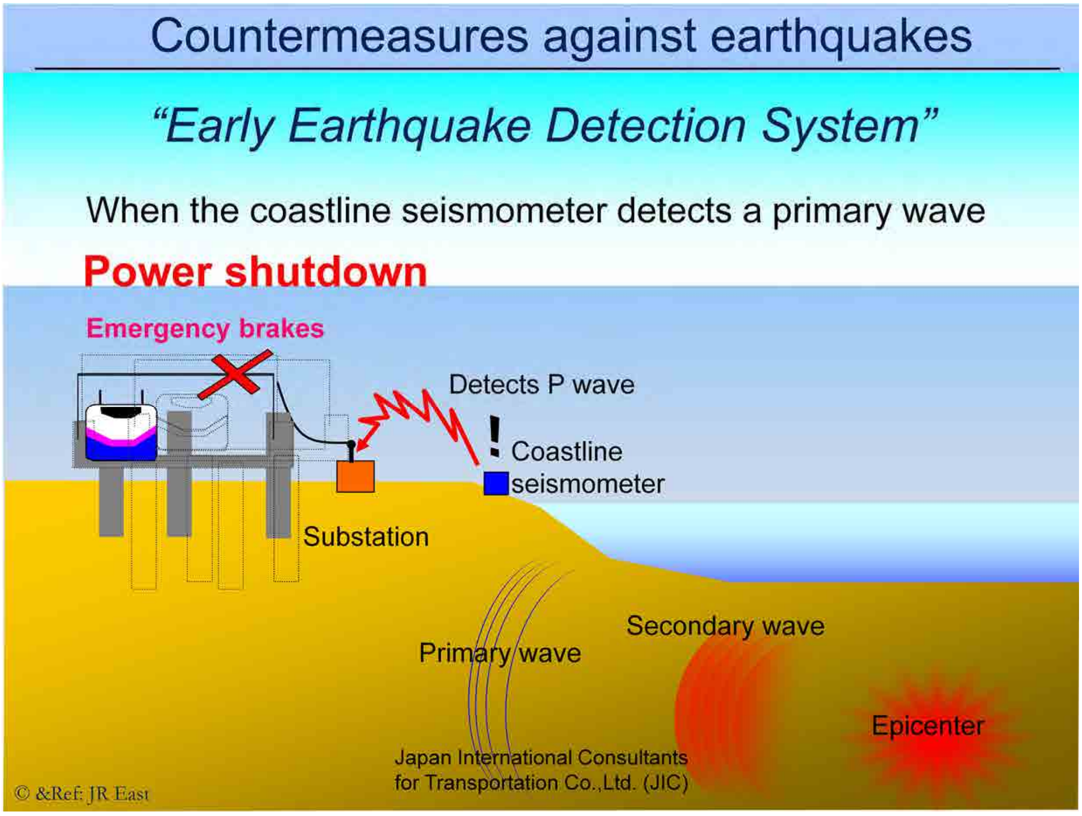
This organizes the basic concept of transportation control discussed in the previous slide. On Shinkansen lines and high-density sections in major cities, transportation is more diverse and facilities have also become more complex and sophisticated, so integrated transportation control systems have been introduced that do not just control transportation but combine transportation with facilities, which monitor facilities, control disaster prevention in light of climate conditions such as wind and rain, operate rolling stock, and so on. These make it possible to rapidly respond to all kinds of events.



The Shinkansen command system incorporates the latest computer technology and information and communications technology and integrated systems that systematize tasks such as train and crew planning, train operation control, maintenance management for rolling stock, tracks, power, signals, communications, and so on.



This shows railway disaster detection facilities, using examples from shinkansen lines. Anemometers and rain gauges are also installed on conventional lines. Operating rules stipulate as a standard that if, for example, the wind is between 20 m/s and 25 m/s, train speed will be lowered to 160 km/h or less; if it is between 25 m/s and 30 m/s, it will be lowered to 70 km/h or less, and if it exceeds 30 m/s, operation will be stopped. Warnings and regulation standard values are also stipulated for rainfall amounts, snowfall amounts, and rail temperatures, with the aim of preventing accidents caused by natural disasters. The rules stipulate regulation values for snowfall amounts and rail temperatures due to the fact that shinkansen trains are operated at high speed.

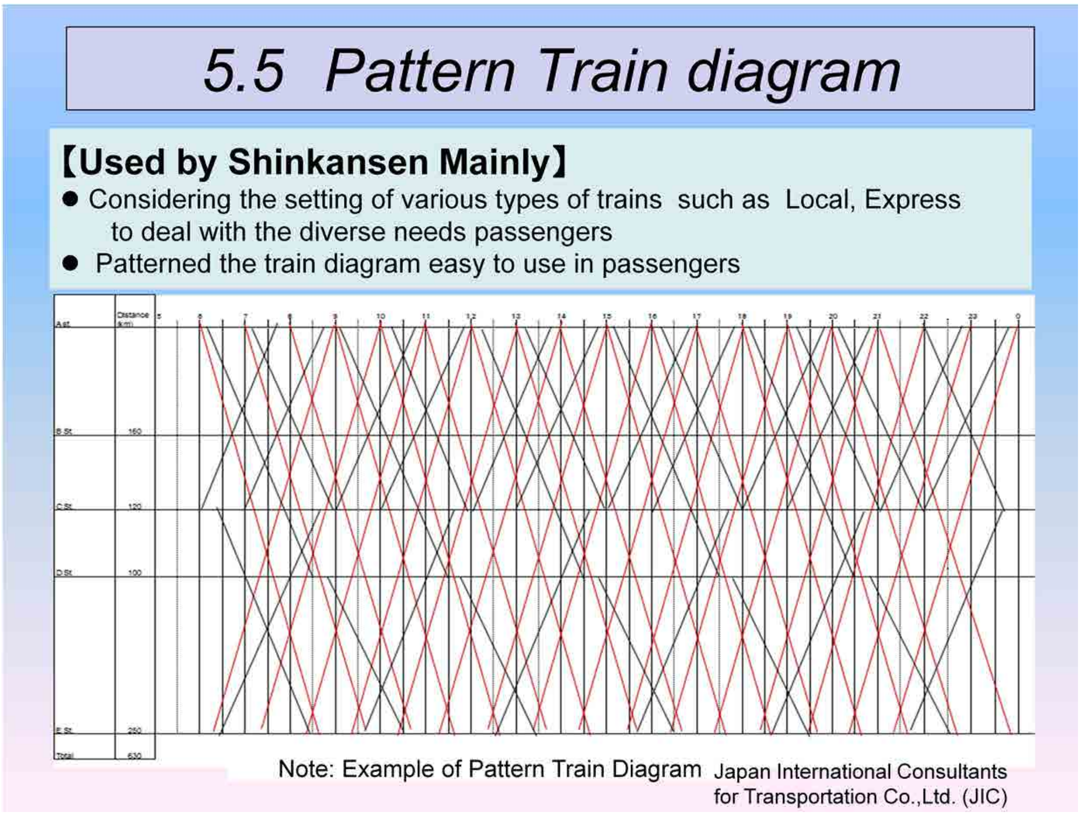


This shows the system for early recognition of earthquakes and prevention of train accidents.

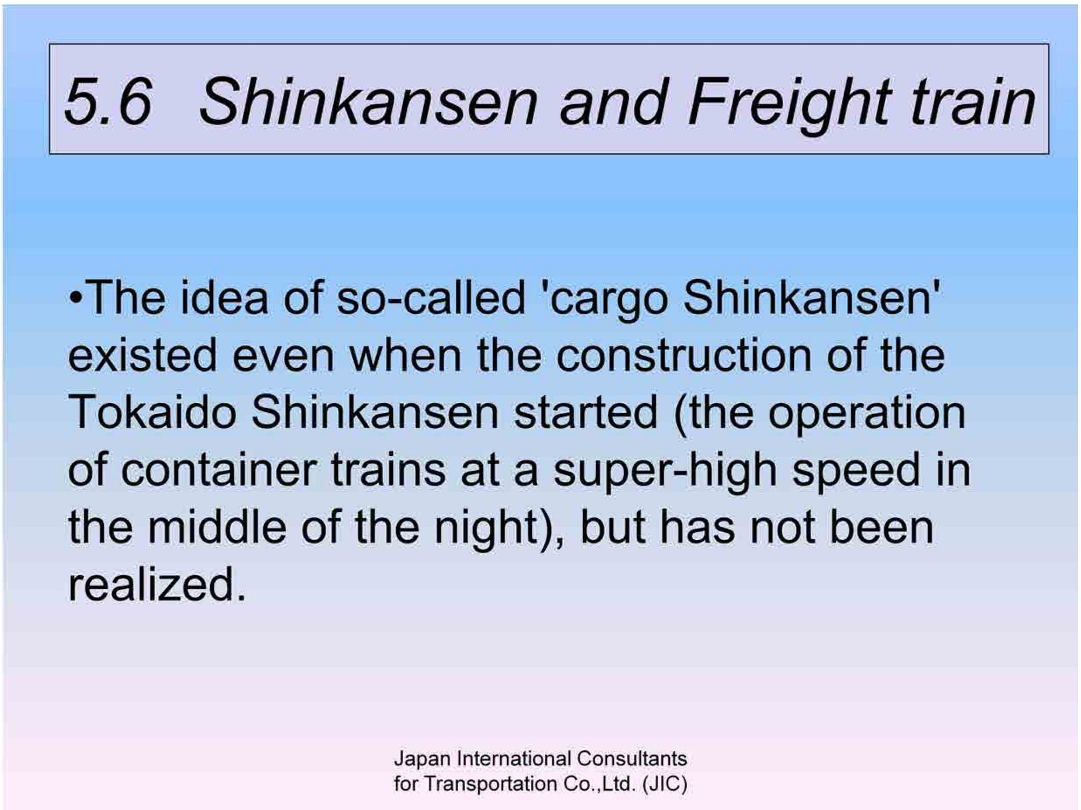
This is an example of the Shinkansen's early earthquake detection system. If an earthquake occurs, a wave parallel to the earthquake's path (the first wave) is the first to arrive. This is known as the P wave (primary wave), and as shown here, it arrives rapidly, at a speed of 8 km per second. The Shinkansen early earthquake detection system therefore uses this rapidly arriving P wave to prevent major damage due to the earthquake. When a substation seismometer detects 40 gals from a P wave, the system will stop substation transmission. When a railway line's transmission stops, the system will activate the ATC emergency brake and stop the train. In other words, when an earthquake occurs, this system lowers the train's speed or stops it before the full-blown secondary wave (S wave) hits, preventing major damage due to the earthquake. After a train has been stopped, it is decided whether to then operate it at reduced speed or suspend operation, based on the magnitude measured by seismometers along the line.

As I'm sure you all know, on March 11 two years ago, a major earthquake struck eastern Japan – a catastrophe that left over 20,000 people dead or missing due to the tsunami and collapsed buildings. At the time of the earthquake, many trains were running on the Tohoku Shinkansen line, but thanks to the activation of this earthquake system, these trains were able to lower their speed or stop before the big earthquake hit, and there was not a single fatality or injury on board. This is an example where the early earthquake detection system was deployed effectively.

NB: At the time of the earthquake, 18 trains were in operation on the JR East Shinkansen line, including five trains running at a speed of 270 km/h.



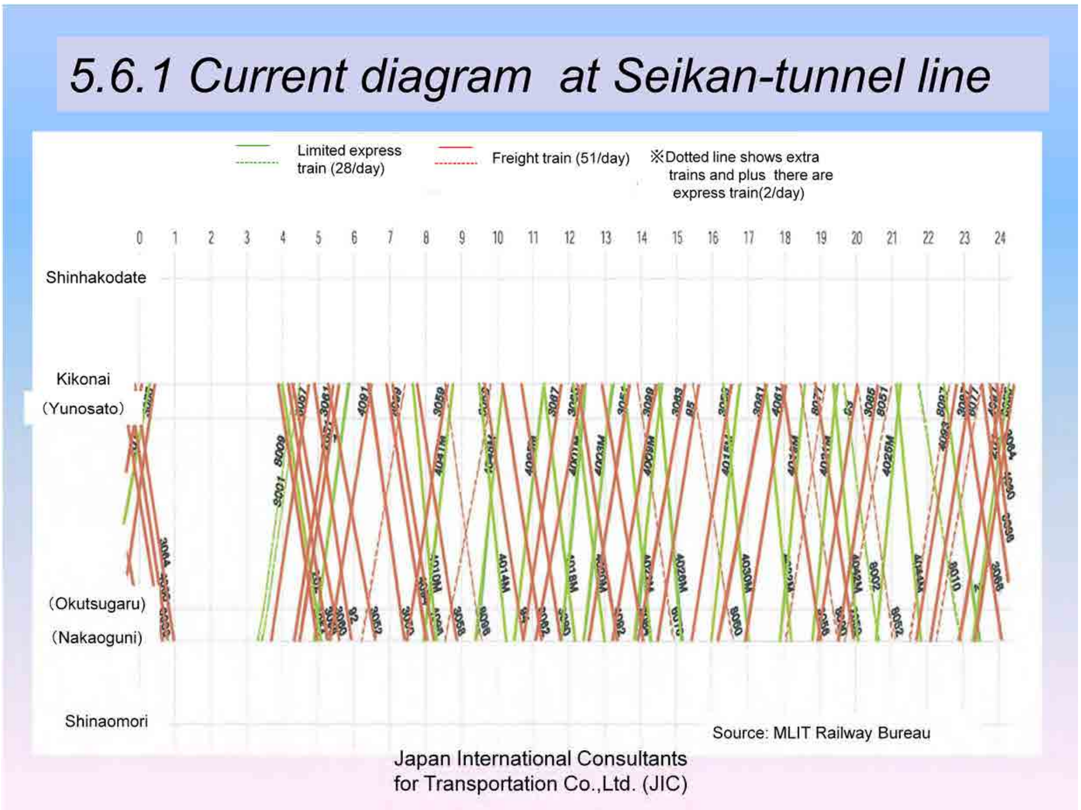
5.5 This is an example of a pattern train diagram. It is a hypothetical diagram that takes into account distances for Shinkansen trains and so forth and operation of high-speed trains. By creating diagrams for super-express and express trains at fixed intervals with exact times (e.g., on the hour and at half-past), it is possible to design schedules that facilitate train usage for passengers. These diagrams are also created for conventional lines.



5.6 Operation of Shinkansen and freight trains

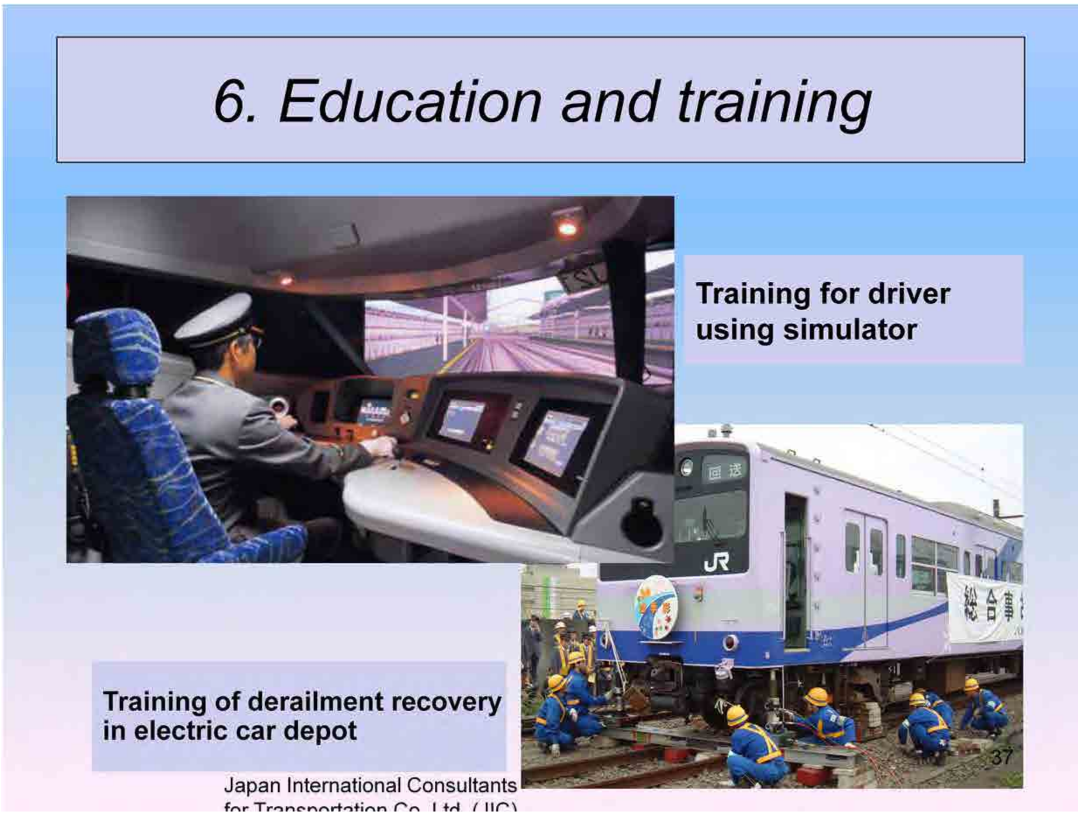
In Japan, operating freight trains at high speeds (150 km/h) on Shinkansen lines has been considered since the planning of Shinkansen construction began, but it cannot be completely ruled out that there is the possibility of freight trains derailing on Shinkansen lines. Since there is still room to enhance the cargo transportation capacity of conventional lines by setting aside maintenance windows and shifting passenger trains to Shinkansen lines, at the present time, running freight trains on Shinkansen lines is not being considered.

There is a single exception, however – the operation of Shinkansen and freight trains in the Seikan Tunnel that connects Honshu and Hokkaido.



The Seikan Tunnel was constructed according to Shinkansen standards, but at the moment, conventional (narrow-gauge) passenger trains and freight trains are operated in it. In particular, there is considerable passage of freight trains between Hokkaido and Honshu. As shown in the diagram, freight train transportation is more frequent than passenger trains, with 51 freight trains and 30 passenger trains. The operating speeds are 140 km/h for passenger trains and 110 km/h for freight trains.

Construction of the Hokkaido Shinkansen line between Shin-Aomori and Shin-Hakodate is currently underway, and how to manage operation in the shared section of the line (82 km, of which 54 km is tunnel) once the Shinkansen line is complete is now being considered, but nothing has been concluded yet.



6. Today, I have talked about various issues, but there is one request I would like to make. Railway safety systems are built on rolling stock, tracks, signaling equipment, and so on, but as I discussed earlier, it is human beings who run these railway systems. Safe operation is made possible by the people involved fully understanding the systems and handling them properly. As a result, training and education of personnel is extremely important. To conclude my presentation, I would ask that you please make it a rule that everyone concerned receives this education and training. Thank you for your attention.


Thank You for Your Attention
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