RECENT ENDEAVORS FOR ROAD-RAIL MODAL SHIFTING IN JAPAN

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ABSTRACT

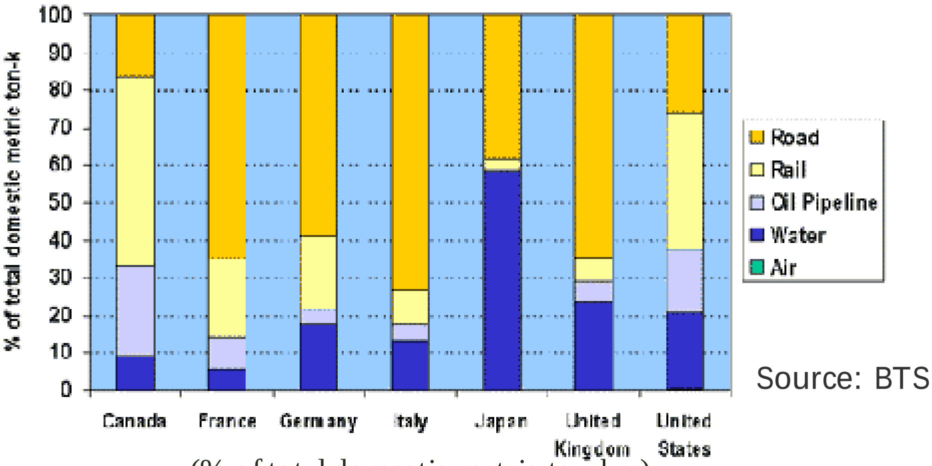
Road-rail or road-ship modal shift are considered as one of the promising countermeasures of emission reduction, as well as technological improvement of energy efficiency of vehicles, traffic congestion reduction, and so on. Recently, some of the projects subsidized by the government for railway freight transportation improvements begin to show the effects; increase of train capacity along the trunk rail line, improvements of container handling system at several freight stations, development of the brand new electric cargo train which can operate faster as the passenger express trains. This paper introduces these endeavors of road-rail modal shifting and shows that speed is indispensable for the success of rail transportation penetrating in the supply chain system and speedy parcel delivery service.
Keywords: Modal Shift, Japan Freight Railway Co., Containerization

INTRODUCTION

Road rail modal shift has been accelerated from 1997 when the Kyoto Conference on climate change took place by the Conference of Parties III (COP3) and the developed countries agreed to specific targets for cutting their emissions of greenhouse gases. Japan is trying to reduce CO2 emissions from energy sources to the same level as the base year 1990, while conducting overall measures to achieve "6% Reduction Commitment" emission in transport sector that occupy 20 % of the Japanese emission.

Road-rail or road-ship modal shift are considered as one of the promising countermeasures of such emission reduction, as well as technological improvement of energy efficiency of vehicles, traffic congestion reduction, and so on. Recently, some of the projects subsidized by the Japanese government for railway freight transportation improvements begin to show the effects; increase of train capacity along the trunk rail line connecting Tokyo and Fukuoka area, improvements of container handling system at freight stations, development of the brand new electric cargo train which can operate faster as the passenger express trains.

This paper introduces these endeavors of road-rail modal shifting and shows that speed is indispensable for the success of rail transportation penetrating in the supply chain system and speedy parcel distribution service.



(% of total domestic metric ton-km)

Figure 1 Share of Total Domestic Freight Activity by Mode, 1996

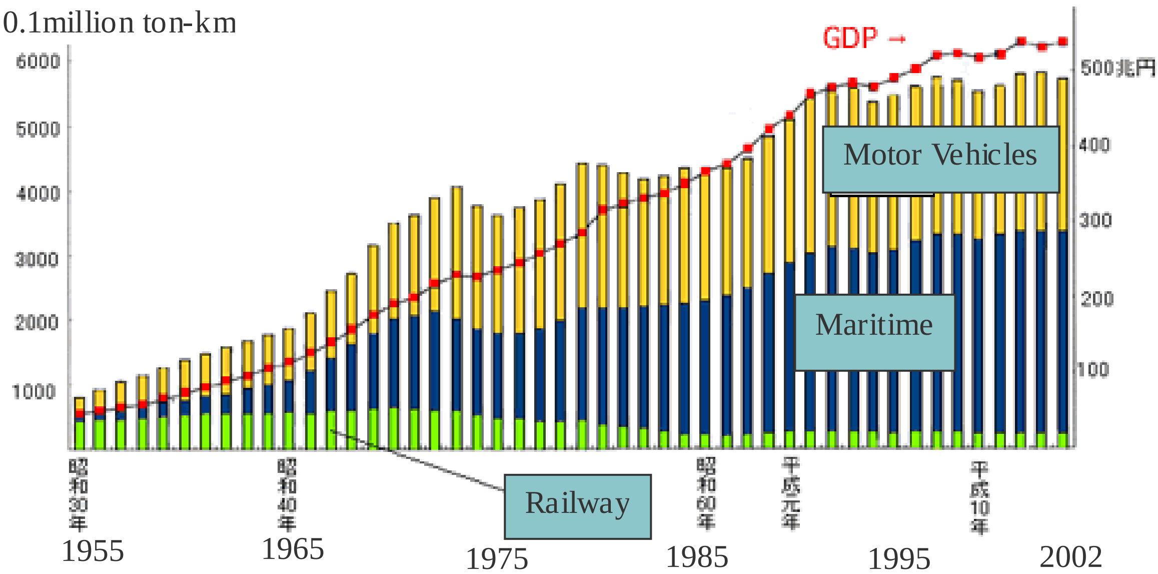


Figure 2 Freight Movement by Transport Mode in Japan

SKETCH OF JAPAN'S DOMESTIC DISTRIBUTION INDUSTRY

The physical distribution industry is contributing to transporting the raw materials and the product of the industrial activities such as the manufacturing, and daily goods such as food and petroleum dispensable for our life. At first, we should look the unique characteristics of Japan's distribution industry, based on the international comparison of modal share in domestic freight industry (**Figure 1**). That is extraordinary high share of domestic maritime transportation (58% in 1996 in ton-km base), and very small share of 3% occupied by railway, highly contrasted with high share of passenger railway (27% in 2003 in person-km base). This is caused by the geographic feature that Japanese major industries and cities have been locating along the coastal line in order to depend on the imported raw material and oil, which is observable in many other Asian countries, having coastal lines. Japanese railway is very strongly specialized in passenger traffic, contradictory with freight specialization of the US railway system.

As for the railroad freight, it shared most of the domestic land freight in the revival period after the World War II. In the rapidly growing period from 1955, it functioned as the basis to

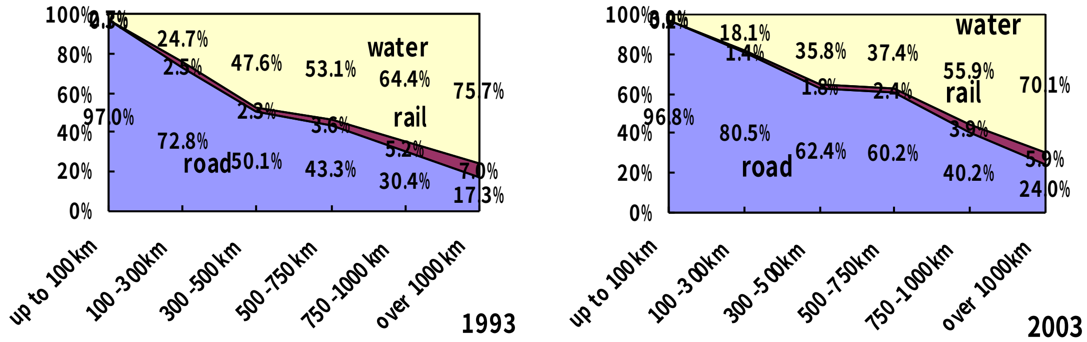


Figure 3 Modal Shares in Distance Bands

support industrial activities in the seaside industrial areas. However, since 1965, the share of railroad began to decrease, and the total movement by railway began to drop in 1970,as shown in **Figure 2**. There were many reasons for this lost of share. First one is the change of industrial structure from "heavy, solid, long and large type" to "light, thin, short and small type." The heavy industry type uses a lot of natural resources as coal and iron and much depended on the railroad transportation. However, as the industrial structure changed into the machine industry and the high technique industry and so on, transportation by tracks became relatively important, which have more flexibility. to cope with "the just-in-time system," to enable the cost reduction and productivity improvement. Railroad is favorable for the heavy and bigger freight quantity, while it is difficult to realize the transportation from the door to the door and flexible service to transport small-lot luggage immediately. The factor which hung a spur on this trend is the expansion of the road network. The motorization after the World War II stimulated the construction of the expressway network in Japan. The gasoline tax was given as the fund of the stable construction of the expressway network which can be trusted more. As a result the total distance of the expressway in Japan became favorably comparable with the other advanced industrial country. As the last reason, the repeated fee raise of the freight railroad service stimulated the movement of the customer from the railroad to the track. The increasing deficit and help from the government made the criticism of the Japanese National Railway management bigger. Then, to put the brakes on the increasing deficit, the Japanese National Railway raised the fare, but resulted in the further decrease of customers and income. The freight customer who left a railroad in this way shifted to the track and led to the flow of the division and the privatization of the Japanese National Railways after all.

When JNR was privatized in April 1987, it was split into six JR passenger railways and one rail freight carrier, JR Freight (JRF). Each passenger railway serves a specific region, but JR Freight offers services throughout Japan. This is because the policymakers felt that rail freight would be more efficient if one company had access to the entire national railway network. As Mizutani (1999) mentioned, with the privatization, the general performance of the JR freight improved, but it was not followed by the increase of the freight quantity of the railroad. Let us compare the market share of freight quantity disaggregated by the band of the distance. **Figure 3** shows the modal share in 1993 and 2003. The share of the track in the freight up to 100km is reaches 97 %. Here, the important point is that the freight to 100 km of transportation distance bands accounts for 89 % of the total freight quantity. On the other hand, in equal to or more than 1,001 km where the railroad is strong, it is only 0.4 % of the freight quantity. There is a limit to increase the railroad freight under the situation of little long-range freight quantity as shown here.

In the very long-range freight, the railroad just has competitiveness to the track but the important factor is the fare. Several reports have already analyzed the distance band where the railroad and track have relative superiority. For example, Kamata (2001) shows the threshold distance becomes around 500 km. However, as for this distance band, the predominance of the track is still kept, because of other factors such as transportation required time, the collection and delivery distance of the freight, lot size, difficulty of the handling, the degree of just-in-time requirement, the risk of the damage, and so on.

PRESENT RAILWAY FREIGHT SERVICE BY JRF

The railroad business who acquire the permission of the freightage based on the Railroad Business Act exists by 26 companies at present (As of April 1st, 2004). JRF was started since the JNR reform in 1987 as the unique business body to manage domestic railroad freight business, which inherited the old JNR freight department. In the nationwide network, which contains feeder railways and the main trunk lines, it operates container trains and freight car trains. Seaside railroad companies were established by pooling by the Japanese National Railway, the local government and the private industrial company and so on all together to provide a transportation basis with the development of the seaside industry zone. With the top batter of the Keiyo Seaside Railroad Inc. in 1962, 11 companies were established and 10 of them are left on April 1st, 2004. They are transporting raw materials and products at the petroleum complex in the seaside part. Other private railroad companies are the companies mainly transporting passengers in urban area but the freight departments exist in 15 companies. They are transporting for the industrial companies where cement, coal, limestone, petroleum and so on are specifically needed since the past. When seeing share in the railroad freight, the JR Freight accounts for 70 % in ton-base, and 99 % in the ton-km base, because the JRF provides long average transportation distance. In income base, the JRF occupies 94% of share In this way, the JRF occupies the main body of the railroad freight transport.

The company's predecessor JNR abandoned the marshalling yard system on 1 February 1984, before the division and privatization, replacing it with a direct transport system linking transport bases. Containers are used mainly to transport consumer commodities over medium to long distances, whereas tankers and hoppers generally carry large bulk cargoes over comparatively short distances. About 683 freight trains operate each day throughout the country. Of these, 430 are container trains, while the remainders are trains of freight car service, hauling bulky freight in tankers and hoppers. The total distance traveled by these freight trains each day is about 226,000 km (188,000 km by container trains).

Container transportation by the railroad was begun in 1959 but constrained by the structure of tracks in those days, 10 feet long container was the limit. In 1971, 12 feet container (3.7 m length) appears and the improvements are continuing after that. At present, the 12 feet containers are mainly used in because they fit the domestic transportation service of small lot unit. In recent years, there is a movement that the loading load is expanded to cut down the transport cost by using larger 20 feet or 40 feet long containers with ISO standard, which also enable the multi-modal transport through international maritime and domestic railroad. As **Figure 4** shows, container service has increased in volume and become the major style of railway transportation, with inviting the freight type such as paper, pulp and industrial chemicals that had been transported by freight car service before. Those are helped by the introduction of new type containers such as the ISO tank containers and the refrigerated containers, and so on.

The container service is realized by combination of two types of trains. The trunk trains run in the long distance among the metropolises, such as the longest run of 37h47m between Sapporo and Fukuoka, while feeder trains link the base station and the stations in smaller

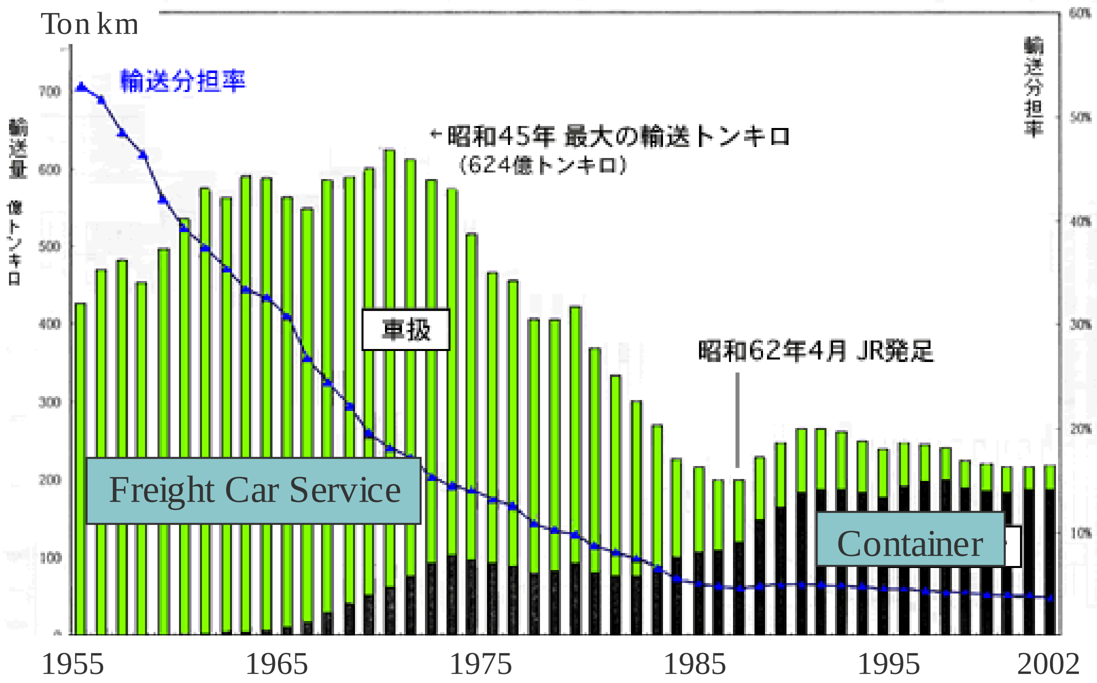


Figure 4 Two Types of Railway Freight Service

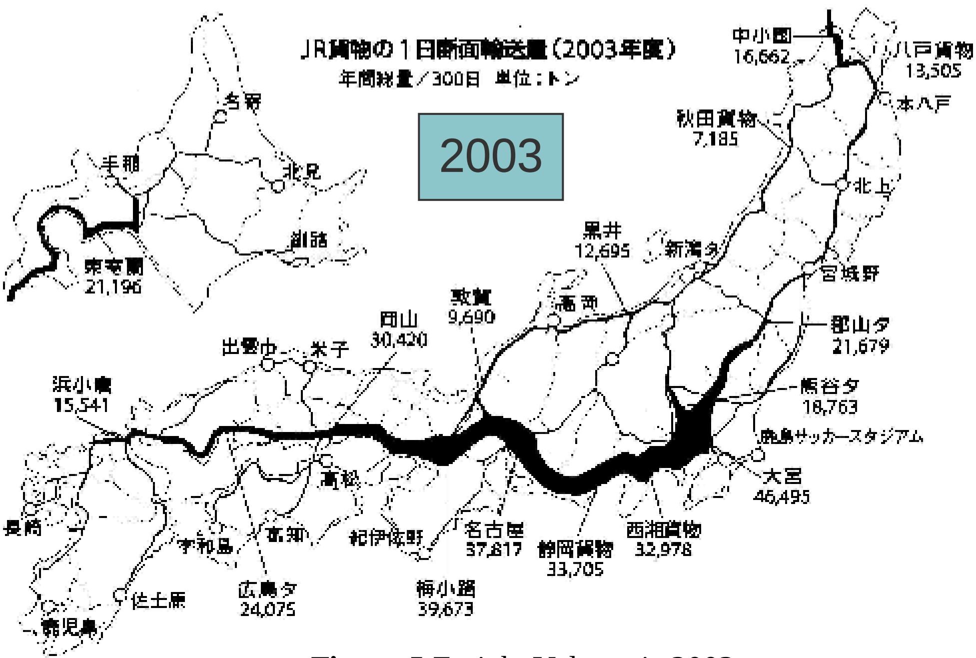


Figure 5 Freight Volume in 2003

cities. When the quantity does not reaching to the volume for preparing one train, they prepare a scheduled truck service. It is more convenient and shortens the lead time by the dispatch of several tracks in stead of gathering all freight of the day into one train. The center which only such substitution tracks depart from and arrives on are located in 16 cities, and complement 137 container freight stations.

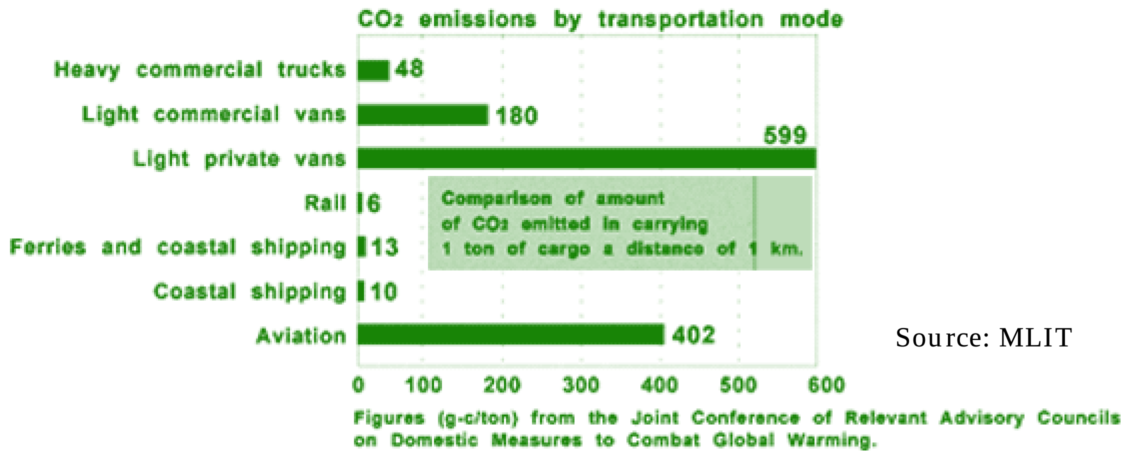
Starting from Tokyo, the average train operation distance of 900km reaches west to Hiroshima and north to Hakodate, but trunk line operation covers longer than them, from Fukuoka in the west to Sapporo in the north, as shown in **Figure 5**. Around the JNR times when an expressway did not prevail, rail network like the capillary was required. After the JNR reform in 1984, it made leave only the competitive section and concentrated on the long-range non-stop service among the great cities, where a great deal of luggage is running.

Table 1 Recent Trend of CO2 Emission in Japan by Sector

(Unit: Million ton of C-equivarent)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	%
Transport Sector	57.65	60.25	61.7	62.24	65.36	67.16	68.9	70.01	69.92	70.88	21.22
		4.5	2.42	0.86	5.02	2.75	2.59	1.61	▲ 0.12	1.37	
Energy Conversion	21.08	21.42	21.71	21.51	22.58	22.59	22.28	22.76	22.85	23.55	7.05
		1.61	1.34	▲ 0.91	4.96	0.07	▲ 1.38	2.14	0.42	3.05	
Industries	133.65	132.92	129.93	128.28	133.25	133.57	135.49	134.75	129.34	134.73	40.33
		▲ 0.55	▲ 2.25	▲ 1.27	3.87	0.24	1.44	▲ 0.55	▲ 4.01	4.16	
Households, Office	71.63	74.16	77.59	75.65	81.48	82.73	82.33	81.37	80.64	84.13	25.18
		3.53	4.62	▲ 2.50	7.71	1.53	▲ 0.49	▲ 1.17	▲ 0.89	4.32	
Other Sectors	22.62	24.34	26.07	24.34	28.41	26.15	28.2	27.54	20.95	20.79	6.22
		7.58	7.11	▲ 6.62	16.73	▲ 7.98	7.84	▲2.34	▲23.92	▲ 0.75	
Total	306.64	313.09	317	312.02	331.08	332.2	337.2	336.42	323.72	334.09	100
		2.1	▲ 1.25	▲ 1.57	6.11	0.34	1.5	0.23	▲ 3.77	3.2	

Note: Second row for each sector shows change in percent relative to the previous year



Source: MLIT

Figure 6 CO2 Emissions by Transportation Mode

The JRF is putting power on the improvement of infrastructure in the westward trunk line from the Tokyo Metropolitan Area. It is because there is a bottleneck in the northward trunk line connecting Tokyo and Hokkaido Island. Even though the Seikan Tunnel is a double track but, the sections between Aomori and Hakodate besides the tunnel is a shingle truck. Then, compared to the westward trunk line to Fukuoka, the northward line has less traffic volume, even though the Hokkaido-Honshu connection by rail through the tunnel possesses several advantages than the track which must use a ship. Basically, there is little quantity of the physical distribution in the northward line. The JRF decided to compete in the market of westward transportation with the larger pie, instead of competing on the small pie of the northward line.

MODAL SHIFT AS AN ENVIRONMENTAL ISSUE

In 1997 the Kyoto Conference on climate change took place by the Conference of Parties III (COP3) and the developed countries agreed to specific targets for cutting their emissions of greenhouse gases. Japan promised to reduce CO2 emissions from energy sources to the same level as the base year 1990, and conducting several measures to achieve “6%

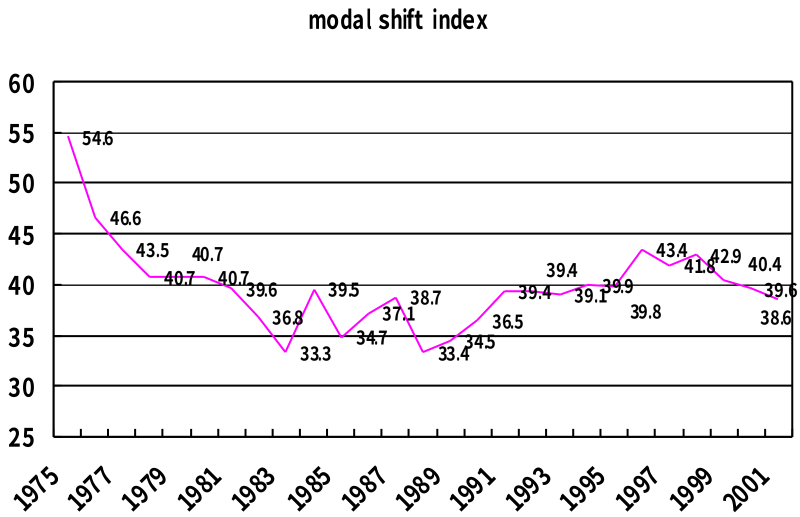


Figure 7 Recent Trend of the Modal Shift Index

Reduction Commitment" emission in the transport sector that occupy 20 % of the Japanese emission. But seeing the rate of increase since 1990, the transportation sector marks the biggest expansion of emission, compared with the industrial and household sectors, as shown in **Table 1**. When comparing a railroad with the track for business use about the environment load, the CO2 emission per ton kilo transportation is about 1/8 (**Figure 6**), and the energy consumption become about 1/6. The railroad freight is then excellent in the point of environmental load reduction in the transport sector.

The Japanese Cabinet Meeting declared the "New Comprehensive Physical Distribution Policy Guideline" in July, 2001, which aims to build the physical distribution system to attack the global warming problem. It will promote the utilization of the marine and railroad transportation which have little environment load. As the quantitative index of modal shifting, it defined "Modal Shift Index" as the share of marine and railroad in the long-range transportation of longer than 500 km, and the goal was set as exceeding 50% by 2010. **Figure 7** shows the trends of the index after 1975, showing that the index is gradually dropping in the recent years from 43.4% in 1998.

ENDEVORS FOR SERVICE IMPROVEMENT

In order to realize the modal shift, capacity expansion of railway freight is indispensable, but the financial and management power of the JRF is too fragile to do it by herself. The JRF inherited old rolling stocks from the JNR in 1987, but not the immobile stocks such as land. After the economic bubble, the decrease of the demand made deficit in 1993 to 2000, then the JRF paid attention how to cut the cost by labor restructuring in the shrinking strategy. After 2001, although the JRF marks profit, but it is far from the satisfactory amount based on the expected return rate if the stock will be opened in the market. As a result, there is no financial room to invest by herself on the projects required for the modal shift. The JRF is borrowing of a track from the JR passenger companies by the minimum rental charge, "avoidable cost." It is calculated by the additional cost in the system by the operations of the freight trains, in addition to the passenger train operations. If being a full cost, the track rental charge might become 14,500 million yen (2003), about five times of the present charge. As a result, there is no negotiating power to ask infrastructure improvement or more number of the freight trains.

Considering the demand for the distribution service, it is the most efficient to depart

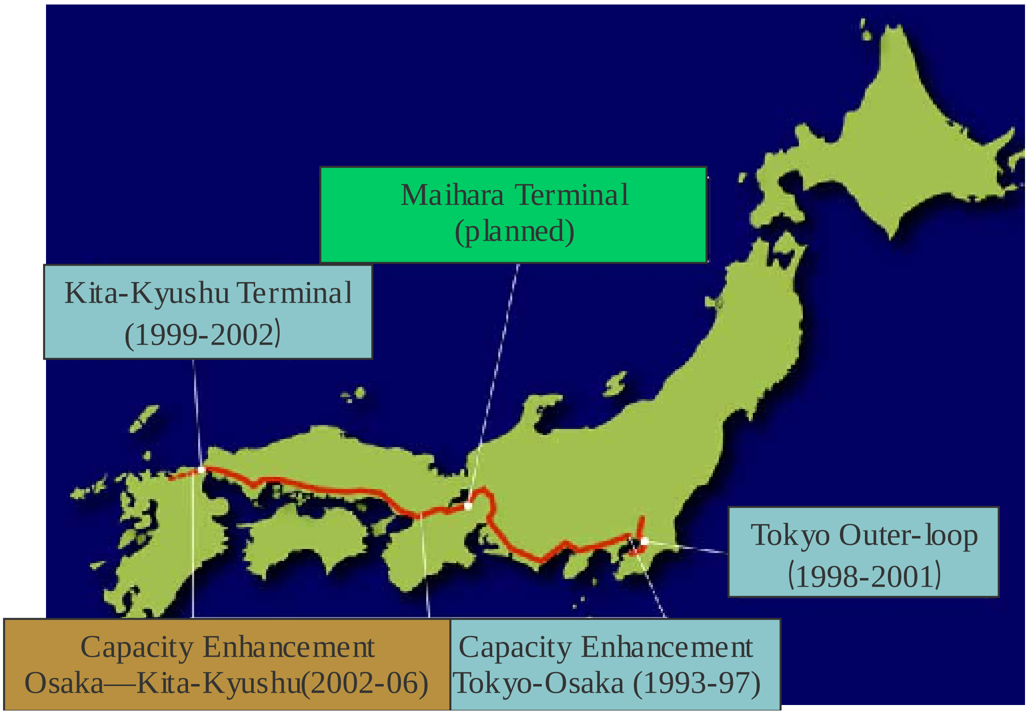


Figure 8 Capacity Enhancement Projects Subsidized by the National Government

factories at night after production by the evening and to arrive to the market by the following morning. Therefore, night becomes rush time of the track in expressways, as well as the railway transportation of the middle distance such as Tokyo-Osaka. However, each passenger company of JR set 3 or 4 hours of no train operations to make a room for rail check and maintenance, freight trains cannot run too in the hours. Moreover, in the rush hours in the morning, the commuter trains have priority and freight trains must be operated before the rush hours begin. As a result, the room for the freight trains is very limited and difficult to be increased in number.

Since 1993, capacity expansion project enable the operation of the longer trains began in the Tokaido Line between Tokyo and Osaka, using the interest-free fund from the Government. The project enabled the operation of a 650 ton train consists of 26 container carrier cars, instead of the former 500 ton train of 20 cars. In order to make a train long, the siding line in stations must be made long to wait for the passing train came behind and go earlier. Locomotives pulling the train must have enhanced power and the power stations providing electricity must be also enhanced. Those investments took 12,400 million yen and completed in 1997. Similar investment is continued in the Sanyo Line between Osaka and Kita-Kyushu since 2002 and the completion is estimated in 2006.

Location and equipment of base terminal is sometimes decisive for the efficiency. The old freight station at Hama-Kokura in Kita-Kyushu city, one of the two cities in Kyushu having million inhabitants was one inefficient example. If trains from the Nippo Line running along the Eastern coast of the Kyushu Island want to enter the station, they must go to Moji and change the directions there. The station was such designed to suit for the old way of transportation, freight car service, had been considered as a focal point to be improved. The new Kita-Kyushu Freight Terminal was opened in 2002, at the locations along the main trunk line avoiding the unnecessary detours, with modern equipment handling containers. The half of the improvement cost was provided from the national (20%) and the local (30%) government. Similar improvement of transportation route for Chiba City was completed in 2001 by making the Tokyo Outer-loop (Musashino and Keiyo) Line operatable for freight trains, with help of the subsidy from the national government, as shown in a map (**Figure 8**).

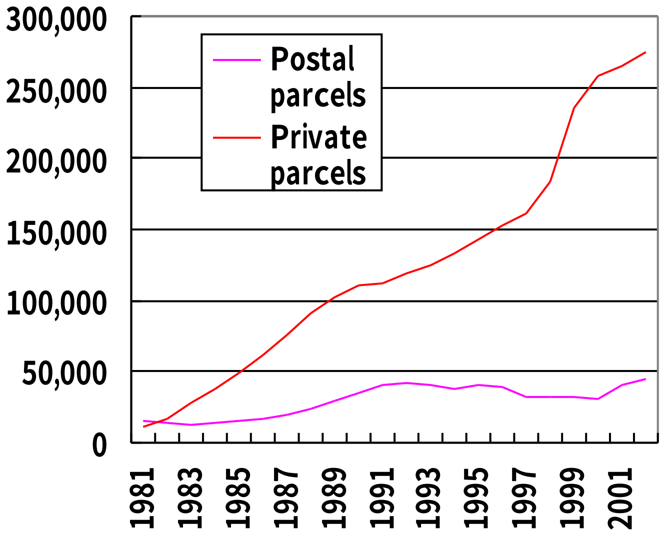


Figure 9 Rapid Growth of Parcel Delivery Service

Table 2 Time of the Fastest Train between the Major Cities

From	To	1990.3	2005.3	%changed	From	To	1990.3	2005.3	%changed
Tokyo	Sapporo	17:27	17:13	-1%	Osaka	Sapporo	27:27	25:06	-9%
Tokyo	Sendai	6:02	5:25	-10%	Osaka	Sendai	15:02	14:33	-3%
Tokyo	Niigata	5:24	5:33	3%	Osaka	Niigata	8:29	8:17	-2%
Tokyo	Kanazawa	9:26	9:37	2%	Osaka	Hiroshima	7:55	7:45	-2%
Tokyo	Nagano	9:53	8:00	-19%	Osaka	Takamatsu	5:40	5:54	4%
Tokyo	Nagoya	6:10	6:57	13%	Osaka	Fukuoka	9:43	9:15	-5%
Tokyo	Osaka	7:07	6:12	-13%	Sapporo	Fukuoka	39:53	37:47	-5%
Tokyo	Okayama	10:18	10:30	2%	Sendai	Fukuoka	27:59	28:09	1%
Tokyo	Hiroshima	11:12	13:02	16%	Sandai	Sapporo	13:34	13:18	-2%
Tokyo	Takamatsu	12:07	12:46	5%	Niigata	Sapporo	18:21	18:49	3%
Tokyo	Fukuoka	17:48	17:16	-3%	Niigata	Fukuoka	31:21	29:14	-7%
Nagoya	Sapporo	28:14	28:50	2%	Kanazawa	Takamatsu	18:14	17:37	-3%
Nagoya	Sendai	13:46	14:08	3%	Kanazawa	Fukuoka	20:43	16:25	-21%
Nagoya	Osaka	8:29	8:17	-2%					
Nagoya	Hiroshima	11:28	8:51	-23%					
Nagoya	Fukuoka	13:24	13:01	-3%					

Speed is a priority throughout modern society and in railway freight service, speed can be increased by making infrastructure more efficient, and reducing distribution lead time. As described before, the container trains must be often operated overnight, in order to meet the growing needs of parcels delivery industry (**Figure 9**). Due to the environment surrounding a track service such as the diesel exhaust gas regulation around Tokyo Metropolis and the obligation of the speed limiter up to 90km/h , delivery time and cost are increased. In recent years, in the intermediate-range section of 500 - 800 km, the needs to want to convert into the railroad transportation from the track are rising.

As JNR container trains were limited to a top speed of 95 km/h, but new locomotives and freight wagons manufactured since 1987 have increased top speeds to 100 or 110 km/h. These faster speeds are seen mainly on trunk lines. **Table 2** shows the running hours of the fastest train between the major metropolises in 1990 and 2005. We can find that the half of the pairs are reachable in 10 hours, depart around 21:00 after the sorting work at the delivery base and arrive at 6:00 in the next morning. For the longer distance, most of OD pairs are now served in 34 hours, enabling the delivery in the second morning after the shipment.

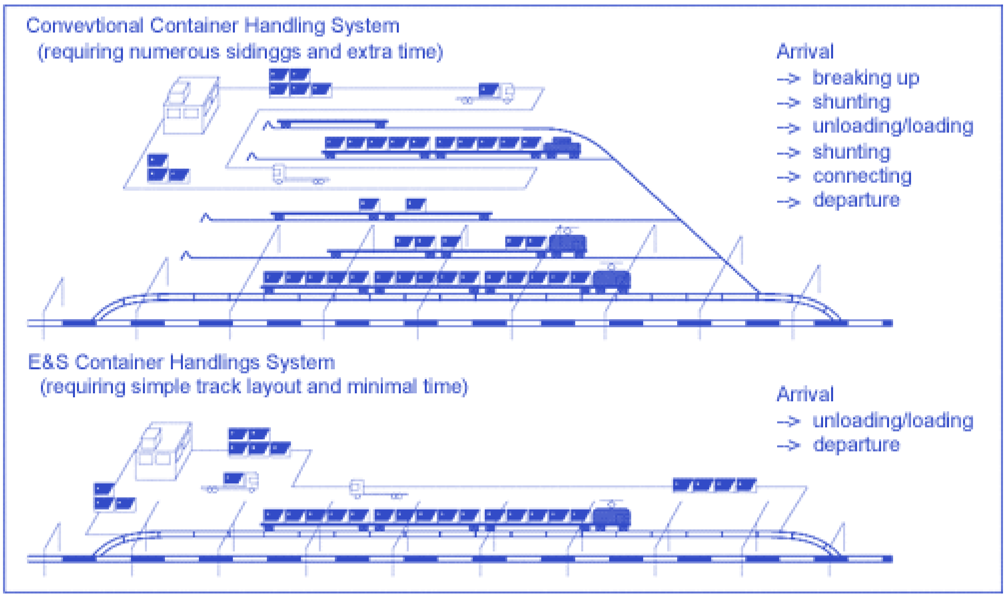


Figure 10 Effective and Speedy Container Handling System (E&S)

Table 3 The Authorized Experiments of Modal Shift by the MLIT

Fiscal Year	experiments	way of reduction			Planned Reduction of CO2	Proposed Grants	Effectiveness
		Shift to rail	Shift to water	Improve Tracks	t-CO2	1,000 yen	t-CO2/ mil.yen
2002	7	4	3	0	23,606	141,310	167
2003	35	30	5	0	35,656	229,797	155
2004	32	22	7	3	33,594	237,351	142
total	74	56	15	3	92,856	608,458	153

In order to shrink the lead time, facilities in freight station are also affective. Under the old system still used at most freight stations, container trains are switched to an out-of-the-way siding for loading and unloading. But under the new Effective and Speedy Container Handling System (E&S) method (**Figure 10**), container trains switch directly to a convenient subsidiary main track, stop for unloading and loading at a platform, and then depart as soon as loading is completed. Unloading and loading became faster, reducing stopping time and increasing the overall operation speed of the train. This E&S method is now used at 26 freight stations in Japan. This system become realized not only by the introduction of powerful and effective loading machines, but also by the support of information system dispatching the machine operator from where to where he should move the right containers in the short stopping duration.

RECENT ENDEVOR BOOSTING THE ROAD-RAIL MODEL SHIFT

The modal shift doesn't move ahead, if the customers or forwarders get profit and feel incentive. In order to boost the model shift movement, the Ministry of Land, Infrastructure and Transport (MLIT) and began the promotion system to grant the proposals by which the constant effect can be expected in 2002. One third of the introduction cost is provided by the MLIT. **Table 3** shows the numbers of the authorized experiments, about 3 out of 4 of which are the proposals aiming to a road rail modal shift.

Amongst the authorized experiments, most prominent one is the 5 year project of

Figure 11 The Super Rail Cargo Train (2005)

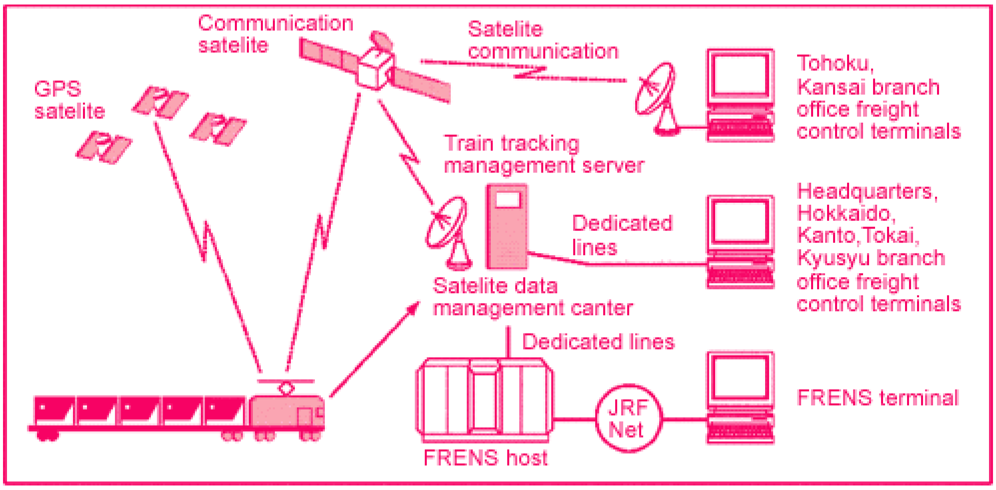


Figure 12 Freight Tracking System of the JRF

developing the firstly developed power-diffused express container train running at top speed of 130km/h, the highest speed of freight trains in the world on narrow gauge system. In March 2005, the new M250 express container train, 'Super Rail Cargo' began to be operation between Tokyo and Osaka in 6 hour 11 minutes, departing Tokyo at 23:14 and arriving in Osaka at 5:36. The train consists of 16 cars including 4 motor cars arranged at both ends, 28 of 31 feet containers can be loaded in total. (**Figure 11**)

This train carries exclusively the containers of Sagawa Transport Co., one of the major delivery service providers in Japan. Considering the gigantic development cost of the new train system, this train does not be paid without full of transportation. The Sagawa Transport promised to purchase all container service regardless to the demand fluctuation. Therefore at the present, here is no possibility of expanding the train service in different OD pair or in different time range. This example shows that speed is indispensable for the success of rail transportation penetrating in the supply chain system and speedy parcel distribution service.

For the further modal shifting, there is the essential structural problem for railway transport to be solved. When dispatching a train with the loading freight quantity of 650 tons, it carries 130 containers that one is 5 tons, but it is difficult to find one customer company buy all of those every day. Therefore, the timetable are planned to match larger number of possible customers and become “the greatest common divisor.” On the other hand, the track can make a transportation plan which was matched with each customer.

Another handicap of the train service is the small flexibility in case of accident or natural disaster, which is the other side of the coin of the reliability free from congestions. A train cannot change the route such as tracks running away from congested expressway to general road or making a detour along Chuo Expressway instead of Tomei Expressway.

Recently, there are customers selecting the track for more stable and reliable transportation. The JRF are trying to tackle this problem introducing the advanced information technology. A GPS receiver and radio system are now installed on each locomotive as **Figure 12**. In case of disruption to schedules due to an accident or natural disaster, the system automatically tracks and reports all freight trains' positions, estimated length of delay and other vital information which is relayed to the customer. Adding to that, the JRF tries to prepare tracks, relieving the stopped train at the intermediate freight station. However, such system requires extra number of stations as well as tracks, resulting extra cost.

CONCLUSION

Considering the larger negative externality of road transportation than rail and maritime, we should stimulate the model shift endeavors, with help of new technology such as IC tag or GPS systems, without incurring extra price for the service. In order to realize more flexible transportation, standards of containers and loading machines should be common for all modes of freight transport. And sooner or later, we must be faced to the problem of infrastructure development. It is too large issue to be solved by one company, the JRF, and requires wider political discussions including customers, forwarders, local and national governments.

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