Superiority of Railroad and Task

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1. Environmental situation and step-up of railroad role

Currently, Korean economy is facing a drastic increase of foreign loan resulting in IMF, high interest, and high real estate cost. Along with this low efficient economic system, Korea also has a problem of high logistics cost which amounted to 64 trillion won accounting for 16.3% of GNP in the year of 1996.

Therefore, it is needed to consider how to improve the competitiveness of transportation system. Establishment and implement of road-oriented traffic policy has caused road congestions which costed 14.7 trillion won(3.64% of GNP) and the increasing rate is about 2 trillion won each year.

However, the superiority and role of railroad has been remarkably issued with rising environmental problem. Compared with other transportation means, railroad is superior in the following ways : firstly, it is high density and mass transportation system. Referring to the 1996 data, average traveling distance per passenger was 36km, which is 5.7 times longer than 6.3km of road, and the average distance of freight per ton is 241.9km, which is 5.4 times longer than 44.8km of road. Secondly, it is economic means. It delivers 125.4 passengers per 1 hundred million won and 114.5 passengers per 1 hundred million won was delivered by road. It needs 3,941㎡ of land (assuming delivery of 10,000 passengers/hr) to construct 1 km of railroad whereas 12,883㎡ of land to construct 1 km of roadway resulting in 4 times more efficient in land use. For instance, for the construction of railroad of 677km between Los Angeles Basin and San Francisco Bay Area, railroad is shown to be much more economic than roadway according to the analysis between these two means. Thirdly, comparing the energy consumption figures(per capita · km), rail consumes only 90kcal, which is more than 10 times savings than 1,055kcal of road. Fourthly, it is environment friendly. Amount of NO_x emission per capita · km from commercial and private vehicles is 34.2 times and 19.5 times more than railroad. Lastly, 11,000 people were killed and 343,000 injured in road accident whereas 373 killed and 778 injured in railroad accident in the year of 1996.

As indicated above, superiority of railroad to road is also obvious theoretically in the respect of mass transport, punctuality, and safety. Especially, railroad is more economically efficient for the 300km-500km segment range. Seoul-Pusan and Seoul- YeoSu have distance of 444.5 km and 449.4km, respectively implying railroad is the most suitable means of transportation in Korea.

<Table 1. Characteristics for each means of transportation>

Type	Passenger	Freight	Remark
Road	1. short distance within region and city 2. distance less than 300km(intercity, interstate) 3. business, leasure, commuting 4. role of bus, taxi - public means inside the region - alternative means for subway, high-speed train in city - connecting means for high-speed trains	1. short distance within region and city 2. delivery to the destination in intermodal system 3. distance less than 300km 4. long distance delivery of small sized product	1. Land protection 2. Means for evacuation, natural disaster 2. Population dispersion, equalization
Railroad	1. intercity passenger transportation(300km-500km) 2. large city commuter delivery	1.mass transportation including freight liner(300km or longer)	1. centraliztion of city population 2. city's linear development
Port	1. tour	1. long distance delivery including car-ferry(500km or longer	1. development of large scaled industrial area
Airport	1. long distance transportation(700km or longer) 2. time savings	1. fast and flexible fare system	
Pipe line		1. mass transportation for medium and short distance	

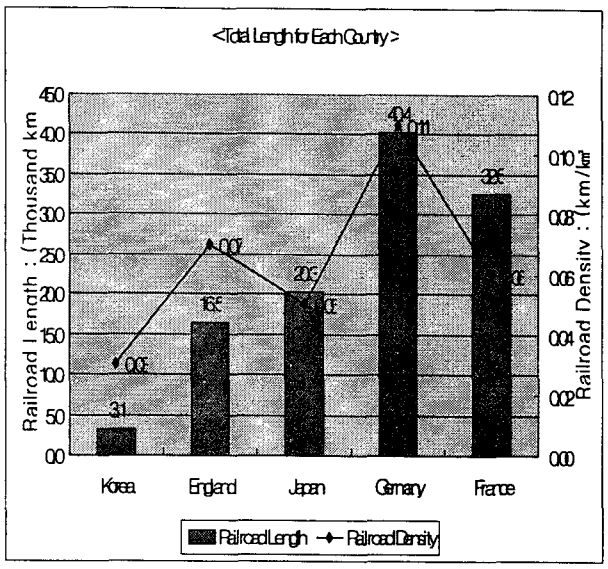
In fact, Korea has a great deal of advantage to develop railroad in the sense of small country land, high population density and congested road condition. Total length of railroad per area(㎞/㎢) is 0.03, which is less than 0.05 of Japan, 0.06 of France, and 0.11 of Germany. However, comparing transportation density per operating km(capita · km/operating km/365), Korea(30,543passengers) is the second highest among Japan(33,854), France(4,979), England(4,737), and Germany(4,135). And alongside the Seoul-Pusan line, 50-60% of total population is distributed, which is not less than Japan(Tokyo-Osaka line : 30 million), and France(Paris-Lyon: 6million including transfer passenger). This shows that the railroad has a great potential power

2. Current situation of transportation system and corresponding problems

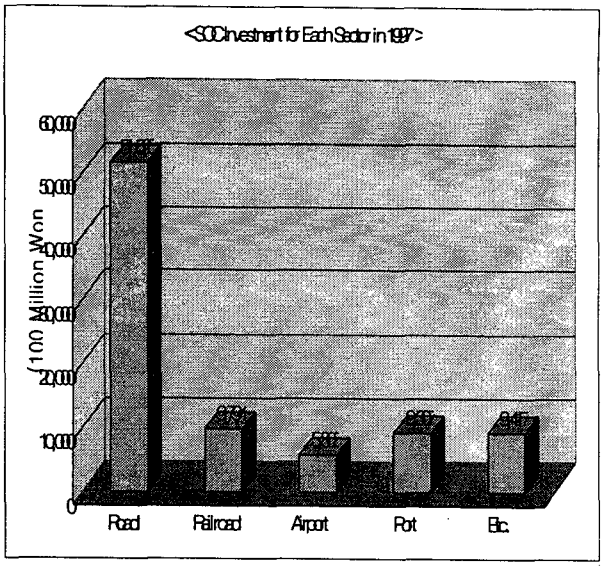
Key problem to Korea's current transportation system is mainly due to lack of investment on infrastructure. For road, total investment during 1962-1997 is 316,722 hundred million won, which is 4.5 times more than 70,366 hundred million won of road. Consequently, rail density(length/area) is 1/4 and 1/2 of Germany, and Japan, respectively.

For the past years, investment has been put on the road construction and as a result road transported 74.79% in 1996 which is 5.74 time more than railroad and this road-oriented transportation keeps increasing. Considering neighboring Japan, transportation rate by railroad is nearly 2 times more(28.83%) than ours. Similar result is shown in freight transportation. Road(47.91%) is 4.23 times more than railroad. The railroad transportation rate in

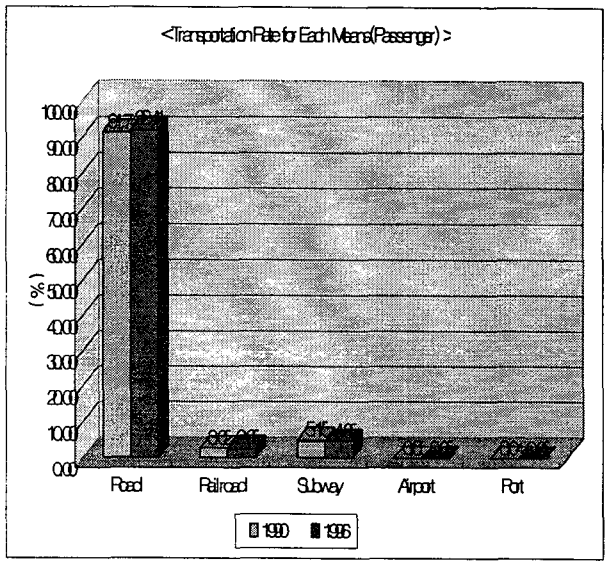
U.S.A(46.70%), France(27.78%), and France(21.88%) are also higher than ours.



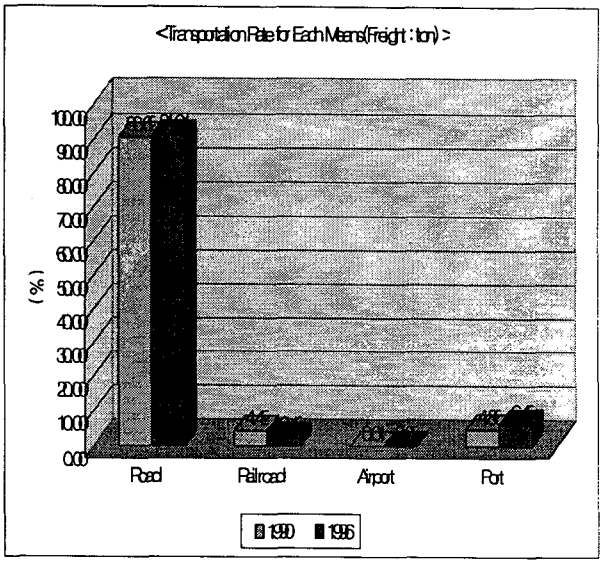
<figure 1. Total length for each country>



<figure 2. SOC Investment for Each Sector>



<figure 3. Transportation Rate for Each Means(Passenger)>



<figure 4. Transportation Rate for Each Means(Freight:ton)>

As the above data show, Korea has an unbalanced transportation system and this causes the dramatic increase in logistics cost. In 1996, transportation rate of railroad over 200km is 11.23%(freight : 36.64%), whereas in Japan it is 45.7% over 300-500km(1989).

3. Current railroad infrastructure and analysis of inter-region transportation rate

Due to the decrease in operating length, railroad is exposing many problems in competing with road. That is, 3,022km in 1961, 3,198km in 1971 and 3,120km in 1996(single track : 2,199km and double track : 901km). Only 98km increase in length since 1961. Most of rolling stocks are old : 17% of the 2,477 locomotives 13.9% of passenger cars, 53.3% of heating cars, and 17.1% of freight cars already exceeded 20 years of durability.

Electrification rate is 18%(industrial lines : 488.7km, metropolitan lines : 174.5km) and this is a relatively low rate compared with 59% of Japan, and 40% of France and Germany.

CTC rate is 27.5%(857.2km) and may cause terrible accidents. Comparing operating speed on main lines, even Sae-Ma-Eul express trains run in different speeds on different lines.

<Table 2. Electrification and double track rate for foreign countries>

Classification	Japan	England	France	Germany
Double Track Rate(%)	41	70	48	42
Electrification Rate(%)	59	30	40	40

Comparing operating times, airway takes 60 mins, railway 280 mins, and bus 320 mins, and private car 320 mins for Seoul-Pusan route. From this data railway is to some intent competitive. However, if waiting time until boarding and access time to rail station are considered, it will be less competitive and especially it is even worse on KwangJu- Pusan line taking 6 hours while 4 hours for bus or car.

Total passenger demand per day in 1996 was 73million and metropolitan area occupies 34.2%. Between HoNam and YoungNam region bus transportation is 61.3%, whereas railroad is only 15.1%.

More precisely, railroad takes 45% and bus takes 53% on Seoul-Pusan line, whereas the transportation rates are 13% and 86%, respectively on Seoul-KwangJu line implying that there exists significant unbalance of rail transportation on different lines.

<Table 3. Transportation per year>

Unit : 1,000 Passenger

Segment		Total	Railroad	Express Bus	Airport
Taegu, Pusan	Traffic	163,522	73,003	87,225	3,294
	Rate(%)	100	44	53	2
Kwangju	Traffic	55,380	7,029	47,600	1,307
	Rate(%)	100	13	86	1

Considering train operation, Suwon-ChunAn segment is already filled to capacity and YoungJu-AnDong segment and YoungChun-KyungJu segment on JungAng Line are facing the same situation. DaeJun- Pusan segment, JuLa line, and KyungJun line are 26%, 33%, and 28% free of capacity for operation. Considering future demand, DaeJun-KimChun segment and KimChun-SamLangJin segment will be fully occupied by the end of 2002, and 2005, respectively and all the lines will be full at 2020.

<Table 4. Bottleneck segments on main lines(1998)>

Unit : Number

Line	Segment	Capacity	Train Assignment			Remaining Capacity
			Passenger	Freight	Total	
Seoul-Pusan Line	SuWon-ChunAn	138	106	32	138	0
	ChunAn-TaeJon	134	97	37	134	0
JuLa Line	ChunJu-SunChon	28	12	15	27	1
ChungAng Line	JeChon-DoDam	40	11	26	37	3
	DoDam-YoungJu	33	11	19	30	3
	YoungJu-AnDong	38	16	22	38	0
	YoungChon-KyungJu	44	20	24	44	0
YoungDong Line	DoKye-DongHae	30	10	20	30	0
TaeBaek Line	JeChon-SsangYong	48	7	40	47	1

<Table 5. Year of reaching full capacity in lines>

Line	Segment	Capa-city	Dis-tance	Year of Reaching									
				2000	2002	2003	2005	2007	2010	2011	2013	2015	Beyond 2020
Kyungbu	Seoul-SuWon	153	41.5			●							
	SuWon-ChunAn	138	55.6	●									
	ChunAn-ChoChiWon	134	32.7	●									
	ChoChiWon-TaeJon	134	37	●									
	TaeJon-KimChun	123	87.8		●								
	KimChun-DongTaeGu	132	72.5				●						
	DongTaeGu-SamLangJin	135	69.6				●						
	SamLangJin-Pusan	134	47.8									●	
Honam	TaeJon-IkSan	104	87.9							●			
	IkSan-JungEup	68	43.5										●
	JungEup-SongJungRi	80	54.3										●
	SongJungRi-MokPo	36	70.6										●
Julla	Iksan-ChunJu	56	25.7								●		
	ChunJu-SunChon	28	133.8						●				
	SunChon-YeoSu	31	39.8										●
Chungang	ChungRyangRi-WonJu	52	108.2										●
	WonJu-BongYang	52	39.6										●
	BongYang-JeChon	106	7.1										●
	JeChon-SamKok	48	9.5		●								
	SamKok-DoDam	40	7.9	●									
	Dodam-DanSung	47	10.9						●				
	DanSung-YoungJu	33	35.6		●								
	YoungJu-AnDong	38	36.9	●									
	AnDong-YoungChun	32	89.2	●									
	YoungChun-KyungJu	44	42.3										●
Youngdong	YoungJu-ChulAm	28	87										●
	ChulAm-DoKye	29	25.2	●									
	DoKye-DongHae	30	36.3	●									
	DongHae-KangRung	25	45.1										●
Taebaek	JeChun-SsangYong	48	17.7	○									
	SsangYong-YoungWol	37	16.4										●
	YoungWol-JungSan	32	38.1	●									
	JungSan-KoHan	33	10.6										●
	KoHan-TaeBaek	24	15										●
	TaeBaek-BaekSan	34	8.7										●
Kyungjun	SamRangJin-MaSan	36	34.5					●					
	Masan-JinJu	23	66.9					●					
	JinJu-SunChon	20	78.6						●				
	SunChon-HwaSun	21	95.5						●				
	HwaSun-KwangJu	25	25.7										●
	KwangJu-SongJungRi	40	14										●
DN	KyungJu-UlSan	38	18.9										●
	Ulsan-HaeUnDae	30	53.7										●
	HaeUnDae-Pusan	37	39.7										●
	KyungJu-PoHang	34	33.5										●
CB	ChoChiWon-MokHang	55	88.1										●
	MokHang-BongYang	55	26.9										●
Accumulated Distance of Congestion Segments				259.3	392.2	433.7	593.5	694.9	1013.7	1101.6	1127.3	1175.1	2163.4

4. Discussion on reasonable transportation(carrying) rate for different means of transportation

1. Case study: Japan

(1) Energy saving means of transportation

In the respect of energy consumption rate per capita · km, commercial and private cars are 2.51 and 5.46 times higher than railroad. Accordingly, converting to railroad means energy saving in transportation.

<Table 6. Energy consumption rate for modes of transportation>

Classification	Passenger(kcal/Capita · km)			Freight(kcal/Capita · ton)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
Energy Consumption	100	251	546	118	624	2,153
Energy Consumption Efficiency (Railroad : 100)	100	251	546	100	528	1,824

(2) Labor efficiency

In passenger transportation, necessary man · hour to transport one unit is 902 and 1,856 for commercial and private cars, respectively with 100 for railroad and in freight transportation, it is 876 and 15,191. Therefore, rail transportation may result in saving in number of workers and working hours.

<Table 7. Man · hour for modes of transportation>

Classification	Passenger(Hour/1,000 Capita · km)			Freight(Hour/1,000 Capita · ton)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
man · hour	1.94	17.50	36.01	1.36	11.92	206.6
Labour Efficiency (Railroad : 100)	100	902	1,856	100	876	15,191

(3) Efficiency of land use

Comparing efficiency of land use for passenger/freight transportation, commercial and private cars are 295/114, and 610/2000 with railroad set to 100/100.

<Table 8. Efficiency of land use for different modes>

Classification	Passenger(m^2/Capita · km)			Freight(m^2/ton · km)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
Required Area	2.0×10^{-3}	5.9×10^{-3}	12.2×10^{-3}	3.5×10^{-3}	4.0×10^{-3}	70.1×10^{-3}
Land Efficiency (Railroad : 100)	100	295	610	100	114	2,000

(4) Safety

The number of traffic accidents per unit transportation for passenger/freight is 7,500/15,750 and 3,000/51,285 for commercial and private cars which is much higher than the case of railroad with 100/100.

<Table 9.Number of traffic accident for modes>

Classification	Passenger(Number/Capita · km)			Freight(Number/ton · km)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
Number of Accident	0.004×10^{-6}	0.30×10^{-6}	0.63×10^{-6}	0.007×10^{-6}	0.21×10^{-6}	3.59×10^{-6}
Rate (Railroad : 100)	100	7,500	15,750	100	3,000	51,285

(5) Air pollution

Emission of NO_x for passenger/ freight transport is 342,500/200,000 and 195,000/1,792,900 for commercial and private cars when the railroad is set to 100/100.

<Table 10. Amount of air pollutant for different modes>

Classification	Passenger(g/Capita · km)			Freight(g/ton · km)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
NOx	0.0008×10^{-1}	2.74×10^{-1}	1.56×10^{-1}	0.0014×10^{-1}	2.80×10^{-1}	25.1×10^{-1}
Amount of NOx Against Railroad	100	342,500	195,000	100	200,000	1,792,900

(6) Environment-oriented optimal carrying rate for each means of transportation

Carrying out the simulation to minimize the environmental damage, the best solution is to increase the share of railroad and commercial vehicles(truck and bus) and decrease the share of private car for passenger and freight. Especially, for freight transportation, railroad should be increased dramatically. From the result of the simulation it is expected to save about 24 trillion ¥ by converting the social saving into monetary value.

<Table 11. Simulation for optimal division of different modes(1990)>

Classification	Passenger(100million capita · km)			Freight(ton · km)		
	Railroad	Commercial Vehicle	Private Vehicle	Railroad	Commercial Vehicle	Private Vehicle
Present Division	3,447	862	4,546	206	1,550	691
Optimal Division	4,209	3,180	2,042	1,118	1,709	433
Conversion Rate (Present : 100)	122	369	45	588	110	63

<Table 12. Saving of social loss>

Classification	Energy Consume	man-hour	Occupation of Land	Number of Accidents	Environmental Damage
Present Division	552trillion㎉	34.7 billion	12,300㎢	592,000	100.0
Optimal Division	447trillion㎉	24.9 billion	9,400㎢	418,000	60.0
Saving	105trillion㎉	9.8 billion	2,900㎢	174,000	40.0
Currency Conversion of saving	1,070 billion￥	13,700 billion￥	7,250 billion￥	240 billion￥	1,843 billion￥
Conversion Unit	electricity 25￥/㎉	wage 1,400￥/h	50,000￥/㎢	578,000 ￥/case	only for noise and vibration

5. Tasks: Future works

(1) Increase of rail transportation and set up of efficient transportation system

Referring to the case of Japan(1990), carrying rate of passenger transportation (per capita · km) was 29.8% and the result of simulation was shown to increase to 36.5%, which is 1.22 times higher. For the freight transportation(ton · km), the reasonable rate is to be increased to 29.4% from present rate of 5.0%. The survey shows that there exists potential passengers of 24,381 on weekdays and 87,773 on weekends. In Korea, passenger carrying rate including subway passengers was 20.86% in 1996, and 11.31% for freight, and this figures show that the carrying rate by railroad should be increased significantly. Referring to the rail supporting policy of foreign countries, France supports railroad as the nation's key industry and completed high speed line between Paris- Lyon(1981, maximum speed of 270km). The total operating length reached 32,600km as of 1993. Of the total, the length for high speed lines is 4,700km being very competitive means of transportation compared to airway and road. England took practical policy. It developed HST running maximum speed of 200km/h and the total operating length is 16,500km(1993). In the neighboring Japan, Shin-Gan Line was opened in 1964 and the total operating length is 20,300km(1996). Investment on the railroad sector was 1,008 hundred million￥ in 1996 which is 4,366 times more than that of ours. Railroad bureau in transportation department makes policy and investment plan. Each privatized railroad company focuss on its rationalization of management and operation. For Germany, ICE started running on Hamburg-Muncheon segment in 1991 with the maximum speed of 280km/h, and the total operating length is 40,400km, which is 13 times longer than ours. Also operating tilting train(maximum speed of 160km/h) on the conventional lines since 1992, average speed on curved lines was increased up to 30%. In case of U.S.A, a new law of ISTEA(Intermodal Surface Transportation Efficiency Act) was established in 1991 and with this law more federal funds are put in to the construction of railroad. For freight, rail transportation was increased from 36%(1985) to 38%(1993).

(2) Logistics cost saving through rail transportation

One way to save logistics cost is delivering goods with train. If the carrying rate by rail was increased by another 5%, the transportation cost saving would amount to around 2,700 hundred million won and the total logistics cost is expected to be saved by 1 trillion won or so per year.

<Table 13. Amount of cost saving with increase in rail transportation

unit : million tons-km, million won>

Classification	Railroad	Road	Amount of Conversion	Saving of Logistic Cost
Base	12,947	19,114		
1% increment	13,076	18,985	129	53,729
2% increment	13,206	18,855	259	107,459
3% increment	13,335	18,726	388	161,188
4% increment	13,465	18,596	518	214,918
5% increment	13,594	18,467	647	268,647
10% increment	14,242	17,819	1,295	537,294
15% increment	14,889	17,172	1,942	805,941
20% increment	15,536	16,525	2,589	1,074,588

(3) Expansion of supply

Not only SuWon-DaeJun line segment but DaeJun-Pusan and DeaJun- KwangJu line segments should be expanded to 4-track line to improve the capacity. Besides, KwangJu-Pusan segment needs to be double-tracked. KangRung-Pusan segment will have to be newly constructed to improve the efficiency. Difficulties in purchasing ticket make potential passengers turn to the express bus.

(4) Key links connection through speed up of railroad

A recent survey shows that for the passengers who changed their mind from rail trip to airway, lower speed was the main reason and the corresponding rate accounts for 55.7%. Taking access time to airport into account, railroad is expected to have competitiveness if the speed is improved.

That is, each key link should be reached within 3 hours from link to link with operating speed of 130km/h and maximum of at least 180km/h.

<Table 14. Operating time between key links : Maximum of 180km/h>

unit : hour

from \ to	Seoul	TaeJon	TaeGu	PuSan	UlSan	KwangJu	ChunChon
Seoul	-	1.4	2.7	3.7	3.7	3.0	0.7
TaeJon	1.4	-	1.3	2.3	2.3	1.6	2.1
TaeGu	2.7	1.3	-	1.0	1.0	2.9	3.5
PuSan	3.7	2.3	1.0	-	0.6	2.9	4.4
UlSan	3.7	2.3	1.0	0.6	-	3.5	4.4
Kwanglu	3.0	1.6	2.9	2.9	3.5	-	3.7
ChunChon	0.7	2.1	3.5	4.4	4.4	3.7	-

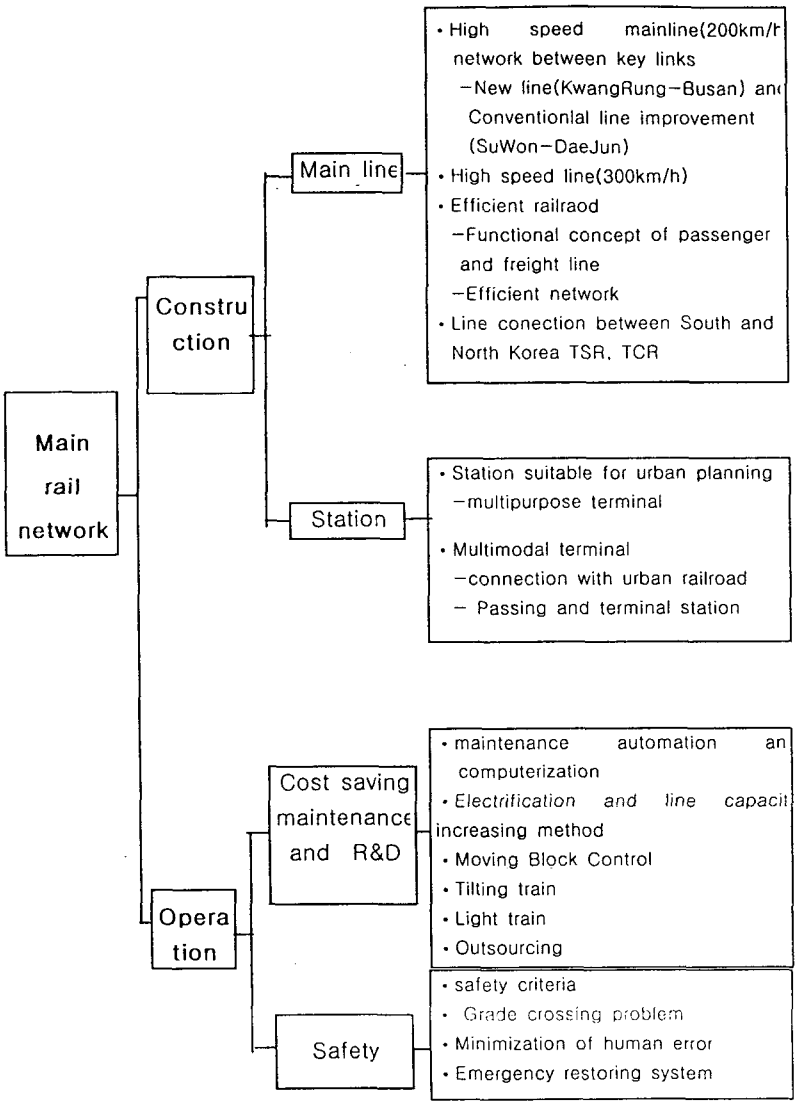
In the operational aspect, we should improve productivity through automation and make necessary plans to save costs. Also for safety, emergency restoring system, grade crossing safety plan, and safety criteria should be provided.

(5) Financing

Traffic tax should be distributed more to railroad sector from current rate of 18.2% to 40%. In Japan, 1 hundred million ¥ of rail fund is raised to support rail construction authority and local government supports 15% of the total amount in constructing Shin-Gan Line. In France, there is an example that the local government paid for construction of stations and sold them to the third party. The above illustrations imply that cooperation of local residents is necessary to build local rail construction and operation.

(6) Full support for Infrastructure

Government should fully support track and rail maintenance cost. RFF of France, Infra department of Germany, and Rail construction authority of Japan are responsible for investment in infrastructure. In 1991, 42,770 hundred million won and, 27,690 hundred million won were supported in France and Germany, respectively and 87,309 hundred million ¥ in Japan in 1994.



<figure 5. Main Rail Network Plan>

(7) Various fare system and quality service

Currently, rail fare is proportional to the traveling distance only and this fare system should vary according to services. Our fare system should be allowed to determine fare rate flexibly within some upper limit. Long traveling time and difficulties in ticket purchase were the main reasons to avoid railroad. Considering the boarding rate on weekdays(67.3%) and weekends(100.4%), it is necessary to introduce new fare schemes to convert weekend passengers to travel during weekdays.

(8) Efficient use of railroad lines

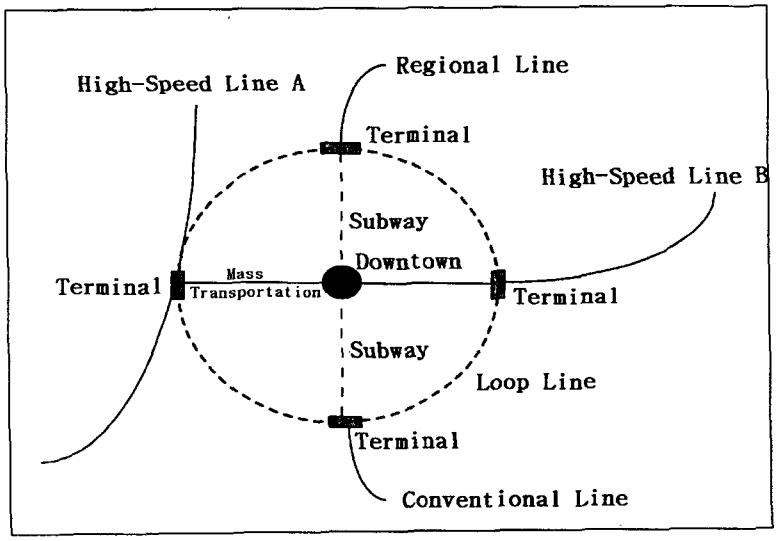
Firstly, break down the whole network into purpose-based lines such as priority line, local line, and other special lines. In Germany, priority line is used mainly for long distance passengers and dedicated high speed freight transportation.

Local line is used for mass transportation within the region. To raise the efficiency of operation, change the current operating system to long distance oriented operating system. Considering average traveling distance of Sae-ma-Eul express(291.52 capita · km) and Mu-Gung-Wha train (183.7 capita · km), it is quite feasible to change to long distance operating system.

(9) Intermodal system

Station should be constructed as a link to connect main line and urban railroad. The intermodal system should be in such a way that the railroad is the long distance backbone on the land, and the trucks provide local feeder service at origins and destinations. In states, one key element in ISTEA is the requirement that the federal government designate additional road routes that would serve as intermodal connectors to ports airports, and rail terminals.

More than 100 Amtrak cities are in advanced stages of planning and building multi-modal passenger terminals. In switzerland, "Rail and Bus 200" is based upon a system of optimal connections at numerous junctions throughout the country. Intermodal transportation accounts already today for 38% of the total freight transit traffic through Switzerland and the growth of intermodal traffic is 8% per year over the last ten years.



<figure 5. Model of Future Rail Station(Large City)>