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Development of Korea-China Train Ferry System An Example of Short Sea Shipping in Northeast Asia

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Abstract

The train ferry, accommodating trains roll on and off, is often called as "Railway on the Sea" or "Blue High-way" since she can connect the railways or roads segregated by the sea and improve the accessibility and continuity of land transport systems. The ferry is especially appropriate to the intermodal transport routes mostly passing through the land but have relatively short sea segment. As the train ferry can considerably reduce the cost and time for cargo handling and modal shift and unnecessitates excessive initial investment on infrastructures such as large harbor cranes or vast container yards, introduction of train Ro-Ro ferries lessen the total transport cost for door-to-door transportation with full exploitation of the existing railway system.

All the ports placed in Shandong, Liaoning and Jiangsu provinces of China are connected to the hinterlands via well developed railway and road systems. Therefore, realization of the Incheon-Yantai train ferry system will link Korea railways to TCR and the 4,131-kilometer-long Longhai-Lanxin Railway, along the famous Eurasian Continental Bridge. In the present paper, the Incheon-Yantai train ferry will be introduced as a good example of an efficient multimodal short sea shipping system for Northeast Asia.

Keywords: train ferry, intermodal, short Sea Shipping, tCR, tKR, west development, ramp system

1 Introduction

Due to the recent increasing trade volume between Korea and China, the needs of an efficient intermodal transportation system between two countries are now growing rapidly. The integrated modes of air, sea, road and railway transport are considered as the most effective transportation system. The system is expected to be realized soon in the Yellow Sea region also and flourish as in Baltic Sea of Northern Europe.

With initiative of UN ESCAP, the new 'Silk Road', named by the Chinese government in conjunction with Trans China Railway (TCR), will be open to revive its historical role of connecting Asia and Europe in the past millenniums. The newly opened Silk Road and

'West Development Plan' of the Chinese government will further promote development of the economic belt along TCR.

Since the Korea-China train ferry, if once deployed, will link Trans Korean Railway (TKR) to TCR directly and shorten the distance at least 1,000km comparing to land only mode, the ferry system deserves great attention in Korea.

Being called "Railway on the Sea" or "Blue High-way", the train ferry can directly link the railway and road networks on either coasts of the sea to improve the accessibility and continuity of the land transport systems. The ferry is especially appropriate to the intermodal transport routes mostly passing through the land (usually, more than 800km) but have short sea segment. (usually, less than 300 nautical miles).

As the train ferry can considerably reduce the cost and time for cargo handling and modal shift and unnecessitate excessive initial investment on infrastructures such as large harbor cranes or vast container yards, introduction of train ro-ro ferries lessen the total transport cost for door-to-door transportation with full exploitation of the existing railway system.

2 Cargo Volume for Korea-China Train Ferry

A study performed at the Korea Railway Research Institute(KRRI) expects the trade cargo volumes for Korea-China Train Ferry as follows[1]:

2.1 Preconditions

One of the important factors to be considered in estimation of cargo volumes for Korea-China train ferry is whether;

- ☐ Seoul-Shineuiju railway (Kyungeui railway) will be connected and whether;
- ☐ the connection of Kyungeui railway will affect the shipping trade volumes between Korea and China.

The work for Kyungeui railway reconnection commenced in 2000 but the completion time, or even the feasibility, of the Kyungeui railway is still in doubt since it necessitates enormous amount of investment to fix the poor railway system in North Korea.

Moreover, the Korea-China train ferry is focused on the connection of TKR with TCR whilst Kyungeui railway is focused on the connection to Trans Siberian Railway(TSR) via Manchurian railway. Therefore, the operation of the Kyungeui railway will not notably affect the cargo volumes for Korea-China train ferry.

In the present paper, ports of Incheon and Pyeongtaek are selected in Korea, and Yantai and Dalian in China, as per operational harbors for Korea-China train ferry, since Yantai-Dalian train ferry is expected to be operable at the beginning of 2007. The preconditions for the case study are summarized in Table 1.

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[1] pp. 181-184, "Study on Intermodal System for Innovative Logistics System of Northeast Asia", KRRI, 2003.

Table 1: Preconditions for estimating cargo volumes

	Korean Ports	Chinese Ports	Kyungeui Railway
Case I	*Incheon/ Pyeongtaek*	*Yantai/ Dalian*	Not connected
Case II			connected

2.2 Cargo volumes for Case I

In this case study, it has been presumed that the Kyungeui railway is not connected. The cargo volume for train ferry in Incheon is expected to reach 1,972,000 tons of general cargo and 217,000TEU of containers in 2010, and 3,204,000 tons of general cargo and 345,000TEU of containers in 2030 with mean annual increase of 3.1% and 3.0% respectively, as the details are shown in Table 2.

Table 2 : Estimated cargo volume by train ferry from Incheon/Pyeongtaek to Yantai/Dalian (Kyungeui railway not connected)

Unit : thousand tons, thousand TEU

		2010	2015	2020	2025	2030
General Cargo	Oil product	448	530	628	789	704
	Fertilizer	364	432	513	645	575
	Machineries	1,051	1,188	1,345	1,596	1,465
	Steel product	109	126	144	174	159
	Total	1,972	2,276	2,631	3,204	2,902
Container		217	249	286	314	345

2.3 Cargo volumes for Case II

In this case, Kyungeui railway is assumed to be connected. Kyungeui railway begins at Seoul and ends at Shineuiju, a city borders on China, via Gaesung and Pyungyang. Beyond there, trains will cross the river to adjacent Chinese city Dandong and to reach Chinese railways. The total length of Kyungeui railway will be 486km upon completion and composed of single electrified railway. However, the construction work for 20km long segment from Munsan to Gaesung is suspended more than 4 years now.

Now assume that Kyungeui railway is operable and considerable amount of freight between Korea and China is transported by the railway. Train ferry freight to and from Dalian will be significantly affected by the railway but the freight between Incheon and Yantai will be sustained due to the high competitiveness of the train ferry in cost and time.

Consider the worst condition and assume 50% of the cargo volume between Incheon and Dalian is switched to Kyungeui railway. Then, cargo volume transported by the train ferry in Incheon will be 1,479,000 tons of general cargo and 162,000TEU of containers in 2010, and 2,403,000 tons of general cargo and 259,000TEU of containers in 2030. The

details are shown in Table 3.

Table 3 : Estimated cargo volume by train ferry from Incheon/Pyeongtaek to Yantai/Dalian (Kyungeui railway connected)

Unit : thousand tons, thousand TEU

		2010	2015	2020	2025	2030
General Cargo	Oil product	336	398	471	528	592
	Fertilizer	273	324	384	431	484
	Machineries	788	891	1,009	1,098	1,197
	Steel product	82	94	108	119	131
	Total	1,479	1,707	1,973	2,177	2,403
Container		162	186	214	236	259

Cargo volume transported by a daily service of train ferry carrying 74 rail wagons can be estimated as 74 wagon x 365day x 2 = 54,020 wagons = 108,040TEU. Thus, even in the worst scenario, cargo volume expected in 2010 exceeds the capacity of a daily train ferry service between Incheon/Pyeongtak and Yantai/Dalian.

3 The Trans China Railway (TCR)

The Trans China Railway (TCR) is also called as 'the New Silk Road' but, in fact, a portion of international railway begins at Lianyungang in the east and terminates at Rotterdam in the west with a total length of 10,870 kilometers.

It has been announced, however, on 12th September 1990 that the New Silk Road from Lianyungang to Rotterdam has been re-opened by connecting Lanzhou-Xinjiang Railway to the Kazakhstan railways.

The total length of TCR is about 4,131 kilometers and passing through Jiangsu, Shandong, Shanxi, Anhui, Henan, Shanxi, Gansu and Xinjiang provinces from east to west. At the east end, it radiates to Korea and Japan through the sea bridges and connected to the Eurasian railways running through more than 40 countries in the regions of the Central and Western Asia, Middle East and Europe. The number of countries connected by this railway system is almost 22% of whole countries. The countries occupy 39.7 million square kilometers, about 26.6% of the land in the world, and have the populations sum up to 2.2 billion, about 36% of the whole population on earth.

TCR is connected to the Central Asian and European countries via Allah mountain pass, and consequently, shortens the total haul distance from Korea to these countries about 2,000 kilometers than using TSR which begins at eastern ports in Russia. Moreover, if origin and destination of the cargo is within East, Southeast, Central and West Asia then the use of TCR becomes more attractive.

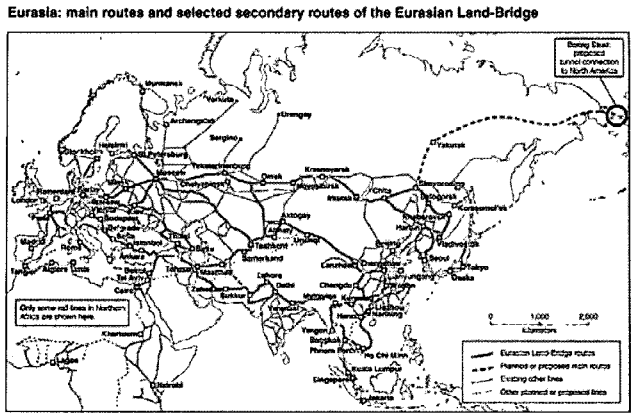

Figure 1: The Eurasian land-bridge

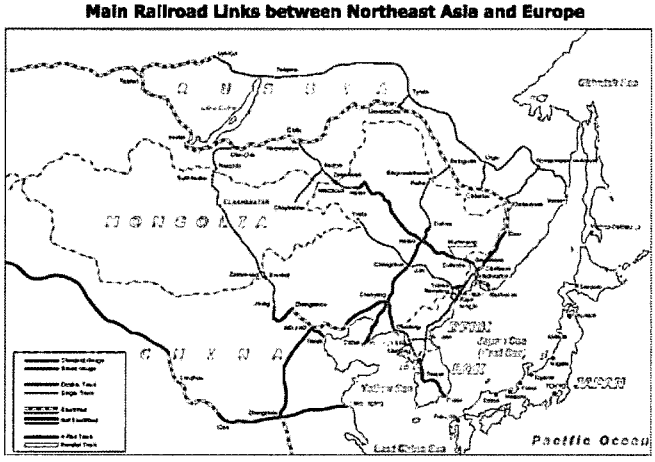

Figure 2: Main railway system in NE Asia

The Trans China Railway as a part of New Silk Road is not only a traffic channel, but an important link that can promote commodity circulation, technical and cultural exchange among Asian and European countries and more importantly enhance friendship among various peoples and countries.

■ New Silk Road as Economic Band

The New Silk Road economic band in China, to be found along TCR, goes all the way across China from east and west. Major cities in the band are eager to construct the 'Land-Bridge' economic zones as some typical examples are listed below, among others.

- □ Xuzhou and Lianyungang; center of Huanghuaihai economic zone
- □ Zhengzhou; center of Central Plains economic zone
- □ Xi'an; center of Kuan-chung economic zone
- □ Lanzhou; center of economic zone of the main streams of Yellow River

- Urumchi; center of Xinjiang northern slope economic zone.

The New Silk Road economic band is also to supports the 'West Development Plan', one of the most important state policies of China.

4 Assessment of Train Ferry Routes

4.1 Routes between Seoul and Moscow

■ Route 1: Train Ferry-TCR–TSR

Consider a train starts Incheon to Yantai by a train ferry and then proceeds to railways from Yantai to major TCR station Xuzhou via Jinan. Once reaches TCR, the train heads to Wulumuqi where the train crosses the border to reach Alashankou, Kazakhstan, The train continues its trip through Druzhba, Actogay, Karaganda and Astana until it reaches Petropavlsk, the northern end of Kazakhstan and a branch of TSR, from where the train heads for Moscow by TSR. The total length of the voyage will be 8,673 km.

■ Route 2: TKR-TMR–TSR

Now a train starts Seoul toward Shineuiju through Kyungeui railway, then crosses the river to reach Dandong, the border city of China. From where, the train passes through Shenyang, Changchun and Haerbin and proceeds to Trans Manchurian Railway to reach Manzhouli. Then the train crosses the border and arrives at Chita, a branch of TSR to head for final destination. The total length of the route is 8,927 km.

Table 4 and 5 shows the distance matrix of the routes 1 and 2 and Figure3 shows a route map.

Table 4: Distance matrix for train ferry route (km)

Incheon	In-cheon							
Yantai	500	Yantai						
Jinan	1,024	524	Jinan					
Xuzhou	1,341	841	317	Xu-zhou				
Urumchi	4,769	4,269	3,745	3,428	Urumch i			
Druzhub a	5,265	4,765	4,241	3,924	496	Dru-zhuba		
Petro-Pavlsk	6,645	6,145	5,621	5,304	1,876	1,380	Petro-Pavlsk	
Perm	7,236	6,736	6,212	5,895	2,467	1,971	591	Perm
Moscow	8,673	8,173	7,649	7,332	3,904	3,408	2,028	1,437

Table 5 Distance matrix for TKR route (km)

Seoul	Seoul							
Shineuiju	486	Shin-euiju						
Shenyang	770	284	Shen-yang					
Man-zhouli	2,249	1,763	1,479	Man-zhouli				
Chita	2,723	2,237	1,953	474	Chita			
Ulan Ude	3,280	2,794	2,510	1,031	557	Ulan Ude		
Petro-Pavlsk	6,899	6,413	6,129	4,650	4,176	3,619	Petro-Pavlsk	
Perm	7,490	7,004	6,720	5,241	4,767	4,210	591	Perm
Moscow	8,927	8,441	8,157	6,678	6,204	5,647	2,028	1,437

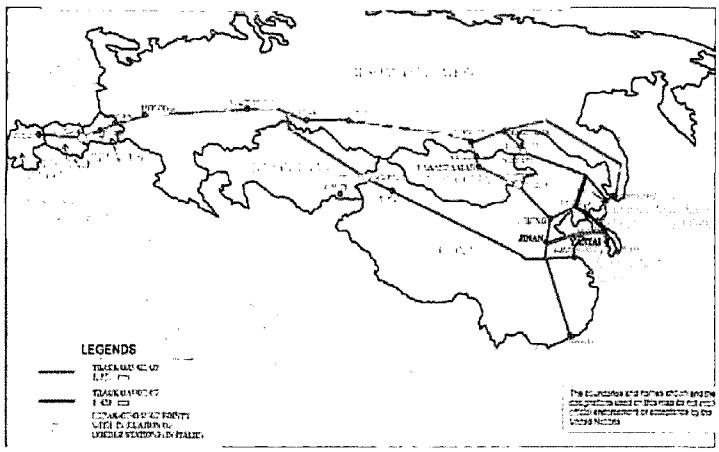

Figure 3: Map for train ferry and TKR routes

4.2 General Assessment on the Routes

■ Distance

Trip distance of the Seoul-Moscow routes are 8,673km if using Korea-China train ferry, slightly shorter than the 8,927km long TKR-TMR-TSR route. However, if the final destination is among Central Asian countries such as Kazakhstan and Uzbekistan etc., the discrepancy becomes even wider to reach about 2,000km and use of Korea-China train ferry becomes more efficient.

■ Border Crossing

Route 1 passes through 3 borders among Korea, China, Kazakhstan and Russia whereas Route 2 goes through North Korea, China and Russia.

■ **Railway Gauges**

Korea and China railways adopt standard gauge of 1,435mm, while Russia and Kazakhstan railways adopt wide gauge of 1,520mm. Consequently, Route 2 consists of 2,249km long standard gauge segment between Seoul and Manzhouli and the remaining 6,678km of wide gauge. Route 1 has much longer 4,745km segment of standard guage between Yantai and Alashankou.

■ **Population**

Along Route 1, the 2,377km long segment from Yantai to Lanzhou is a highly populated region of more than 400 persons per square kilometer. On the other hand, Route 2 has 1,476km of high population density region between Seoul to Daqing.

Moreover, Route 1 passes twelve big cities of more than one million population on the route; Yantai, Weifang, Zibo, Jinan, Xuzhou, Zhengzhou, Luoyang, Xi'an, Lanzhou, Wulumuqi, Ekaterinburg and Perm. Along Route 2, only eight big cities of over million population are present; Pyungyang, Shenyang, Changchun, Haerbin, Nobosibirsk, Omsk, Perm and Ekaterinburg.

■ **Climate Condition**

Route 1 mostly lies south of 40 degrees north latitude. Climate of Yantai-Lanzhou region is winter arid; Lanzhou-Alashankou desert alpine; Arashankou-Petropavlsk steppe; Petropavlsk-Moscow taiga. But Route 2 passes mostly north of 50 degrees north latitude, the regions of frigid winter arid climate where more than 120 days per annum stay below zero, and necessitate special measures to prevent frozen rupture of the cargo.

■ **Transportation Networks**

Route 1 is tied to various transportation networks within China. The 4,131 kilometer long TCR connects with major railways and roads pass through the country longitudinally and transversely as well as waterways branches off the Changjiang(Yangzi) river.

On the contrary, Route 2 suffers from poor transportation networks. TSR has no connection midway other than BAM railway.

■ **Tourism**

Route 1 has excellent resources for tourism. The ancient cities of China such as Jinan, Zhengzhou, Luoyang, Xi'an and other Central Asian towns along Silk Roads provide abundant resources for tourism, contrary to poor tourism assets of Route 2.

4.3 Train Ferry- the Shortest Route to TCR

It is apparent that Korea-China train ferry considerably shortens the distance to TCR from Korea since the ferry directly connects two countries' railway systems across the Yellow Sea as shown in Figure 4.

To compare the distances from Seoul to TCR via Train Ferry and through TKR, Xuzhou a city 223km apart from Lianyungang is selected and the distances from Seoul (or Incheon) are measured.

The distance from Incheon to Lianyungang by the sea is 646km and Lianyungang apart from Xuzhou by 223km, hence the distance to TCR via train ferry totals up to 869km.

The length of TKR from Seoul to Shineuiju is 486km, from Shineuiju to Dandong is 4km, and from Dandong to Xuzhou via Shenyang and Tianjin is 1,682km, and so the distance to TCR through TKR sums up to total length of 2,172km.

Therefore, the Korea-China train ferry shortens the distance from Seoul to TCR by about 1,300km.

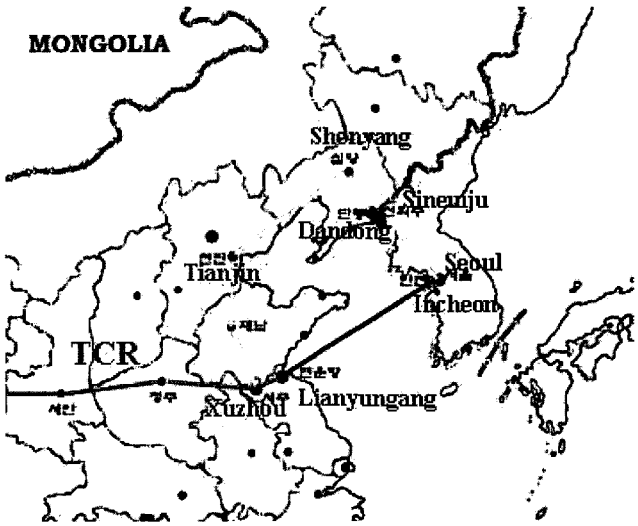

Figure 4: Comparison of transport routes from Korea to TCR

5 Technological Aspects of Train Ferry

5.1 Train Ferry

The vessel is to be built as a Rail/RoPax ferry with transom stern, bulbous bow with slant stem, twin rudders and twin screw propellers driven by four sets of medium speed diesel engines.

The vessel must have main and upper decks unremitting from stem to stern, transverse and longitudinal bulkheads as shown on Figure 5.

■ Main Characteristics of the Train Ferry

- □ Loa × B × D (m) : 222 × 28 × 9.5
- □ Depth to upper deck (moulded) 14.70 m
- □ Draft design (moulded) 6.00 m
- □ Vehicle carrying Capacity :

  - ♦ Rail Wagon : 16.32 m × 62 units or 13.50 m × 74 units
  - ♦ Bus : 90 units
  - ♦ Medium vehicle : 6p × 50 units

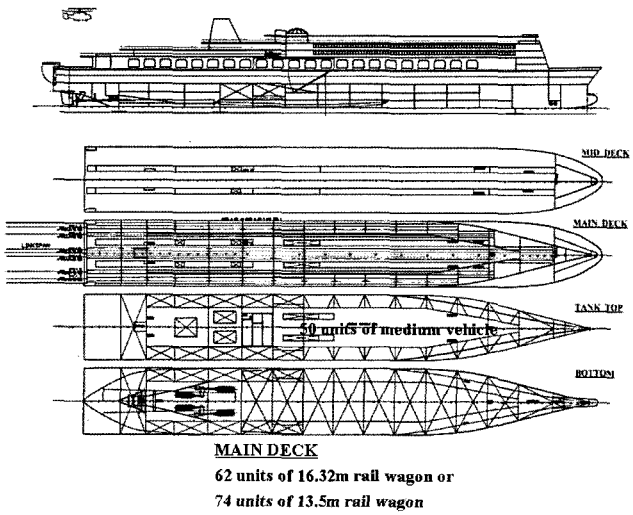

Figure 5: General arrangement of train ferry

5.2 Ramp System

Train ferry is a roll-on roll-off (Ro-Ro) ship. Contrary to the other cargo ships, freights are on wheels and roll on and off the ship by themselves. Hence difference in heights of the ship loading deck and the quay must be overcome by proper measures.

Practical methods for overcoming the height difference are use of ramps, ship docks, freight elevators or vertically moving freight deck, or changing the ship draught by ballasting. All the methods have been used at least for a while in the past, among which ramps are generally used in these days.

The most important parameters for designing the ramps of Ro-Ro ships are, among others:

- slope of ramp
- change in slope
- allowable height difference
- width
- load capacity
- ship's list
- Type of ramp (on shore or shipborne)

■ Slope and change in slope

The maximum slopes of railways and changes in slope are regulated by international railway standards. According to the Union Internationale des Chemins de Fer, slopes of the railways should not exceed 3.5 degree and the maximum changes in slope under 2.5 degree per one wagon length.

For automobiles, the maximum operable slope depends on the friction between their tires and the ramp. Higher ramp slope slows down the cargo flow and requires more powerful engines, eventually leads to increase in air pollution. The ramp slopes are generally kept below 10°.

The allowable maximum change in slope for the vehicles depends on their geometries.

The bottom of vehicles from bumper to bumper should not contact with the ground. For articulate vehicles such as flatbed trucks, the changes in ramp slope should not exceed the maximum slope change allowed for the joint. The maximum allowable changes in slope are 10° for the most vehicles.

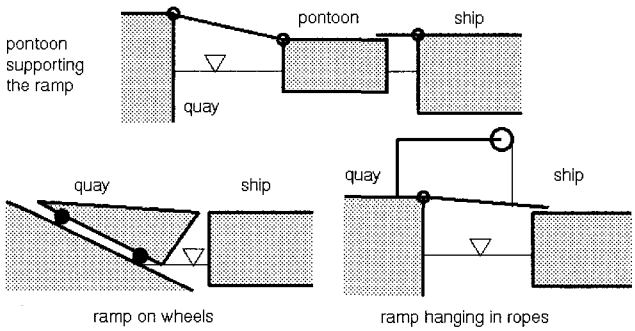

Figure 6: Various types of ramps

Figure 6 shows various functional types of shore ramps. Most ramps are operated by hydraulic cylinders or ropes powered by hydraulic or electric winches. Ramps mounted on hydraulic cylinders, screws or gear racks are also possible. Hydraulic driven shipborne ramps may share the power with mooring winches to reduce costs. The changes in water depth have to be also accounted when designing the ramp. Water depth of the river may depend on the local climate. In the Yellow Sea coastal area, the tidal differences occur with period of about 12 hours.

A standardization of the Korea-China train ferry system including ship and harbor facilities is necessary before inauguration of the system in accordance with the mutual agreements.

Train ferries will operate at Chinese ports Yantai and Dalian in 2007 and ramp systems have been already installed in the ports. Therefore, ramp systems for Korean ports should be compatible to these ramps to allow smooth loading/unloading of trains and trucks. In addition to that, stern door of the ferry should be designed to meet harbor conditions of both countries.

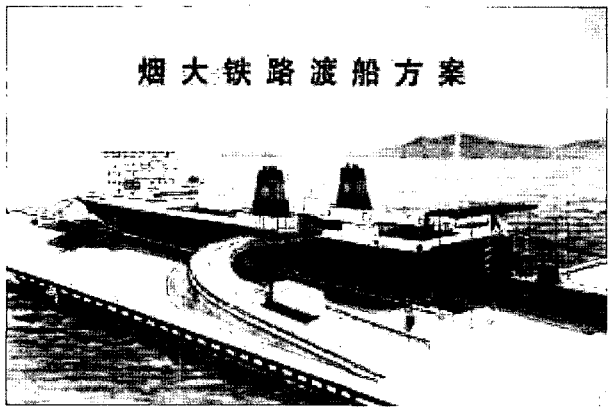

Figure 9: Schematic view of Yantai/Dalian train ferry and ramp system

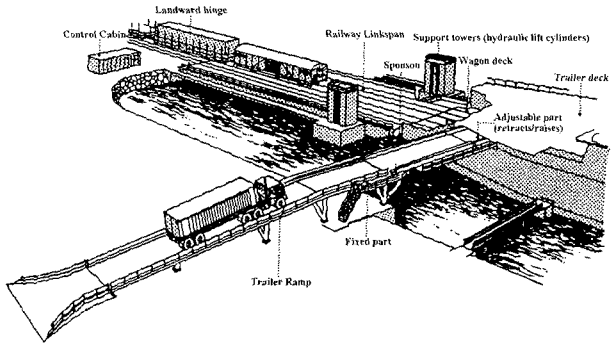

Figure 10: Schematic diagram of train ferry Loading/Unloading

In this context, desirable ramp systems for Korean harbors are pontoon mounted types.

6 Conclusions

Korea-China train ferry crossing the Yellow Sea will be one of the most competitive multimodal transport systems if once deployed.

Korea-China train ferry system should not be considered merely as simple connection of the coastal ports of the both countries, but considered as an innovative system to link Korean peninsular to Eurasian continent. The train ferry is a fine example of Short Sea Shipping System between Korea and China and can generate a new common market for both countries.

It is recommended that the Korea-China train ferry would be designed as a multi purpose ship carrying trains and vehicles as well as passengers and may operate between Incheon and/or Pyeongtaek in Korea and Yantai and/or Dalian in China. Figure 11 shows these routes and other potential Train Ferry routes in Northeast Asia in future.

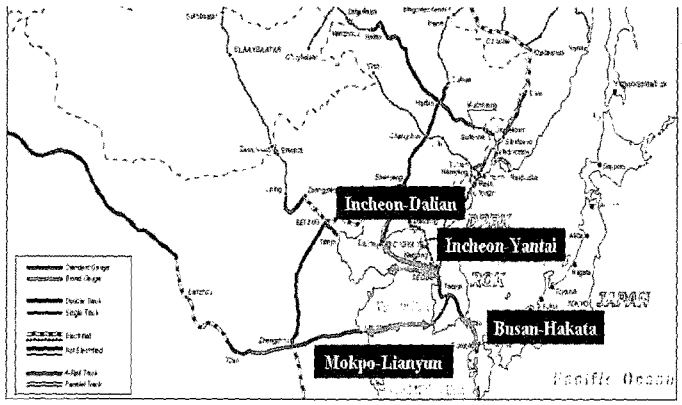

Figure 11: Possible train ferry routes in NE Asia

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