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The Transportation System of Shanghai*

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This paper summarizes the present situation of the transportation system of Shanghai, and the problems of the present system are clarified. To overcome those problems, some measures taken are presented for harbour and shipping, railway, highway, inland navigation, air transportation and transportation in urban districts. Finally, some results of recent research works are mentioned.

1. General Introduction

Shanghai is the largest industrial and harbour city, as well as an important center for economy, trade, science and culture of China. The city is situated at the east coast of the Eurasia continent. She is the door of the Yangtze Delta — the most industrialized region of China. The city consists of 12 urban districts and 9 rural counties with a total area of 6,148 sq.km, and a total population is 12.6 million. During the last ten years, the economy of the city developed with a growing rate of 5–10% annually. The volume of transportation is also increased year by year. In 1988, her gross national product amounted to 61.2 billion yuan (Chinese currency equals approximately 30 Japanese yen). Cargo traffic reached a total of 278 million tons and the passenger traffic in and out of the city amounted to 44 million person times. The transportation within the city's urban districts is also extremely busy. The jamming of roads is serious, a most troublesome social problem of the city. The transportation of the city is a comprehensive network composed of all forms of traffic serving the largest sea port of the country. The system can briefly be divided into two subsystems: one for transportation coming in and going out of the city, the other for traffic of the urban districts. The former includes the harbour and shipping, railway, highway, inland navigation and air transportation. The latter has the public passenger service, the cargo transfer within the city and the cross river traffic.

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The Transportation Office of Shanghai Municipal Government directs and regulates the work of transportation of the whole city. The Bureau of Transportation, Shanghai Port Authority, administrates the related affairs. State-owned enterprises of shipping, railway and air transportation also have offices in Shanghai to deal with the management of related business. The Transportation Dept. of City Police and the Supervisory Bureau of Safety at Sea are responsible for the maintenance of traffic order within the city and harbour, respectively.

2. The Present Condition

The present status of different categories and forms of transportation is described as follows:¹⁻⁴⁾

2.1. Harbour and Shipping

Shanghai is the largest sea port of China. The Huangpu River flows right through the city center. The Port of Shanghai is developed along that river upward for a length of nearly 66 km. There are 12 cargo loading and unloading wharfs with a total of 102 mooring berths, among which 4 are for container ships. Besides these, there are scores of wharfs owned by individual enterprises. There are mooring bouys for 97 ships in mooring basins. In some of these spots, loading and discharging operations are allowed. The natural depth of Tongsha Shoal at the mouth of the Yangtze River was only 5.7 meters. After being deepened by dredging, the depth is increased to 7 m now. So ships with 9.5 m draft, 20,000—30,000 ton deadweight can enter harbour at high tide. A transshipment facility is provided at Luhwa Shan Island, 70 nautical miles away from Shanghai, where larger ships of 100,000 ton deadweight can be accommodated. The ore ships of that size are half discharged there and then sail upriver to the big Baoshan Steel Plant. Private piers are built at the industrial districts of Baoshan and Gaoqiao, both are at the outlet of the Huangpu River and south bank of Yangtze River. At the north bank of Hangzhou Bay-Southwest of Shanghai, the large Jinshan Petroleum Chemical Plant owns piers for the unloading of crude oil carriers and loading of product carriers.

There are usually about 300 large ships in port. In 1988 the goods traffic reached a total amount of 133 million tons, among them 20% is from overseas, 45% from domestic coastal ports and 35% from ports of the Yangtze River. The cargoes coming in and going out of the harbour are mainly coal, petroleum, steel and iron, iron ore, building materials and timber. So most of the ships are bulk carriers. Export commodities of foreign trade are mainly textile and clothing, mechanical, and electrical instrument, and chemical engineering products. Equipments for industries are the most important import items. Formerly only general cargo ships were used, but container transportation has been developed rapidly in recent years. The container traffic reached a total of 300,000 units last year. The roll-on and roll-off transportation is also in use.

There are more than 20 regular passenger service routes connecting Shanghai and ports along China coast and the Yangtze River. As to international service, passenger service between Shanghai and Hong Kong, also passenger liner service between Shanghai and Yokohama, Osaka and Kobe are provided. Also world cruising ships visit Shanghai Port very often. Last year there were 6.79 million passengers coming in and going out of the port, among which 35% were from other coastal ports, 60% from the Yangtze River and 5% from overseas. The passenger ships used are twin screw motor ships carrying about 1000 passengers and several hundred ton of cargoes. The passenger liners for Hong Kong service are of a more luxurious type. Twin hull passenger ships which have the advantage of a large deck area are also employed in coastal and river services.

2.2 Railway Transportation

Shanghai is the connecting spot of the busiest trunk lines of China, i.e. the Shanghai – Nanjing and Shanghai – Hangzhou rail lines. There are also suburban lines connecting the city center to large industrial districts Wujing, Minhang, Baoshan and Jinshan. Within the city's territory, the total length of rail lines in operation amounts to 280 km with 38 stations. Shanghai Station is the principal passenger terminal and Zenru Station is the most important auxiliary station; both are at the northern part of Shanghai. The South Station on the bank of Huangpu River is a connecting point of water and land transportation.

At present, there are 144 pairs of train in service every day. Among them are direct express services connecting Shanghai with capitals of 24 provinces. In 1988 the total amount of cargo carried by railway wagons was 36.46 million tons. Passengers carried were 28.38 million person times. The passenger traffic is increasing at a rate of 5.4–8.7% annually. As the total number of train passing a line is limited, the cargo traffic is almost remaining at a stagnation condition. The railway container transportation business has developed very quickly, but they mainly use the 5 ton small containers. Now the steam locomotives are almost replaced by diesel ones. The passenger cars have not much changed for many years. The speed of passenger trains is only 50–70 km per hr.

2.3 Highway Transportation

Shanghai is the east terminal of the 4 important state highways, which stretch to provinces on the western, southern, southwestern and northern part of China. Motor roads can reach every town of rural Shanghai. Within the city's territory, the length of highway totals 2,500 km. Besides the two newly built express highways, each of only about 20 km and a few main roads, most of the roads are narrow and the standard of road surface is low. In 1988, the road haulage amounted to 100 million tons. The cargoes transported are mainly building materials, industrial products, consumer goods and agricultural products. Road haulage has the advantage of door to door transportation. It is the most important means of feeding and distribution of cargoes for the sea port. The Shanghai Long Distance Motor Transport Corporation is responsible for the transport of large size industrial equipment, dangerous chemi-

cal goods, containers and special high valued articles. During the last few years, the firm also has operated 108 routes of pickup services, its operating region covering many provinces.

For the passenger service, there are 271 routes in operation, extending to many provinces and cities. The number of passengers carried by buses amounted 7.17 million person times last year.

The types of long haul vehicles used are mainly domestic made 5–10 ton trucks. For the purpose of efficiency, cost and carrying containers, the size of trucks is gradually increased, and new types of trucks and trailers were introduced from abroad. The size of passenger carriers is also increased and the seats are more comfortable now than those a few years ago.

2.4. Inland Navigation

Shanghai is situated among the well developed canal network of Yangtze delta. Besides Huangpu River, there are 242 navigable waterways including the famous Suzhou Creek, total navigable mileage is 2474 km, 22% of which, i.e. 536 km is suitable for 100 ton vessels. There are 30,000 vessels of all kinds, totaling 600,000 ton deadweight plying in these waterways. Everyday the number of vessels coming in and going out of Huangpu River amounts to 15,000 and the number of crafts passing the Suzhou Creek is about 6,000. A frequent scene shown on the water front is a tug towing a train of small barges. Inland navigation is also an important means of feeding and distributing cargoes for the Port of Shanghai. About 40% of transshipped cargoes are dealt with by river crafts. For instance, the coal from North China is transshipped at Shanghai by river crafts to neighbouring provinces. About 50% of the building materials required in Shanghai are carried in by river vessels.

The cargo traffic dealt with by inland water wharfs of the city totals 30 million tons per year and the passenger traffic amounts to 5 million. Here I should also mention that 3 catamaran passenger ferries each carrying 1,500 passengers and three conventional ferry boat with 300–800 seats ply at the estuary of the Yangtze River between the mainland and the three islands at the mouth of the mighty Yangtze River. The passenger traffic of these routes also amounts 5 million. Air cushioned fast service and a car-passenger ferry service are also offered last year between Shanghai and Chongming-the largest of the islands at the estuary.

2.5. Air Transportation

The Hongqiao International Airport is at the west suburb of the city. The present 3,200 m long runway allows large plane to take off. There are 43 domestic flight routes to cities all over the country. There are also flights to Hong Kong, Osaka, Tokyo, San Francisco and Los Angeles. In 1988, the air goods traffic amounted to only 61,480 tons, and the passenger traffic reaches 1.75 million. The annual growing rate is 11–13%. Medium sized jet plane carrying about 150 persons and small planes holding about 30 persons are used in domestic services. Large planes such as the Boeing 747 and A-310 are used in international lines.

2.6. Transportation in Urban Districts

The area of urban Shanghai is about 140 sq.km with a population of 7.22 million, in addition there is always a 2 million flowing population coming from other places of the country. The total area of roads within urban districts is about 13.94 million sq.m, i.e. only 1.5 sq.m per person, which is an extremely low figure among large cities. As stated above the transportation within the city center consists of the public passenger service, cargo transfer within the city and cross river traffic.

Public Passenger Service: It is mainly operated by the City Public Transportation Company, which owns 5,000 large buses, operating 276 routes of totaling 2,000 km long. The average distance from a residential quarter to the bus stop is only 113 meters. The volume of passenger traffic amounts to 15.34 million person times per day and up to 1.3 million per hr in rush hours. Due to the large and intensive traffic, the vehicles used are large two-section buses with linkage connection, holding 150 persons. The company also owns 800 trolley buses of similar construction. These trolley buses run on the avenues. The time interval of succeeding buses is only 1.5–2 minutes in rush hours. These trolley buses are responsible for nearly 40% of the total passenger traffic. At present there are ten thousand taxi cabs in the city, but it is far from enough. The problem of 'Difficult to Call a Taxi' is still unsolved. The enterprises and government departments own 20,000 motor cars for their own use. There are only a few hundred private cars in Shanghai. The city inhabitant own 5 million bicycles, which serve as the principal means of transportation for personal use. The quantity of motorcycles is still small but is increasing rapidly.

Cargo Transfer within the City: There are 50,000 trucks, 300 tractors, 4,000 trailers and several thousand small vehicles in the city. Among them 7,000 trucks are owned by the state operated companies, which are responsible for the transport of bulk cargoes of large quantity, containers and special valuable commodities, the annual haulage reaches 100 million tons. Those firms are operated by collective ownership offer services for medium and small enterprises and are also responsible for the transport of food, fuel and other consumer goods. The amount of cargo transported is about 20,000 tons per day. Industries and enterprises own 20,000 trucks, the annual goods traffic also reaches 100 million tons. But the efficiency of operation is low. During the conjection and jamming of the road, the speed of trucks is only 20–30 km per hour.

Cross River Traffic: The Huangpu River and Suzhou Creek flow right through the center of the city. There are already many bridges over the latter allowing vehicles to cross the creek. There is only one large rail and road bridge on the upper reaches of the Huangpu River 30 km south of the center of city, no bridge being over that river in the urban districts. There are two tunnels at the south and central parts of urban districts respectively, allowing motor vehicles to cross the river. For pedestrians and those riding bicycles, the 21 ferry crossings have to be relied upon. The average distance between two crossing stations along the river is 4.2 km. These ferries on the average carry 820,000 passengers and 97,000 bicycles per day. The boats used are single deck twin screw diesel ships carrying 300–1,000 persons. The ferries can also carry motor cabs and other small vehicles. At five of these crossings

large double end car ferries carrying 14 trucks or buses are provided. Every day 16,000 large vehicles cross the river by this means.

3. Problems and Measures Taken

The present problem is that the service offered cannot match the rapidly increasing demand. The reasons for this short coming is lack of investment, so that the construction of infra-structures and renewal of equipment make little progress. At the same time the management and operation have to be improved. Detailed discussions will be given in the following.

3.1. Harbour and Shipping

The harbour is short of berths, so that the waiting time is long when a ship arrives, thus causing the rise of the cost of transportation.

In order to relax the above difficult situation, efforts are made to tap latent potentialities of existing facilities. This includes the reconstruction of 11 berths of the old harbour, renewal of loading and discharging equipments, and enlargement of warehouses and stowage yards. On the other hand, new wharfs at Guangang and Baoshan are under construction. The former is at the middle reaches of the Huangpu River and the latter is at the estuary of the Yangtze River. These two wharfs are used for general cargoes and container shipment, with all together 16 berths being provided. The reconstruction of a passenger terminal and the construction of an international passenger terminal will be started soon. After the completion of these infra-structures, the cargo and passenger traffic will be increased by 20%. As for the long term measures, new harbours at the south bank of the Yangtze Estuary and north coast of Hangzhou Bay are projected.

3.2. Railway

The railway system has been running at overload conditions for many years, and coaches are usually over-crowded. Railway is still the main stay of land transportation of China. The rail passenger traffic is more than the combined total of other form of passenger traffic. The cargo traffic in tons of rail is less than that of road haulage, but its turn over in ton km is 7 times that of the road. After the completion of the new Shanghai passenger terminal the capacity of receiving trains is greatly increased. The equipment and technique of telegraph and signal are modernized and computer aided management is realized. But the task of capital construction of railway is still very heavy. The most urgent work is the completion of the double track project of Shanghai-Hangzhou line. The project of the outer circle line of Shanghai suburbs, the enlargement of the marshalling yard and the reconstruction of old warehouses and repair shops will be accelerated.

For long term projects: a new second passenger terminal and another marshalling yard will be constructed at the southern past of the city. Two rail-water transship-

ment terminals and a container transshipment station will be constructed at Yanghang in the northern suburb and Minghang at the south suburb. Suburban fast passenger trains from the city center to industrial centers: Baoshan in the north and Jinshan in the south are suggested. A railway across the Yangtze River for trains to the northern part of Jiangsu Province are also in projection.

3.3. Highway

Not enough road, inferior surface condition, and obsolete trucks and buses are the main problems of highway transportation. There is only 0.43 km motor road in length on every sq.km of the territory, this figure is low compared with other large cities. The traffic flow is high. On the average, every day there are 2,000 motor vehicles passing through trunk roads, 12,000 in busy sections, and the speed of vehicles is only 30 km per hour, which is only half of the economical speed.

The reconstruction of roads leading to the four state highways has already started. The quality of road surface will be upgraded. At suburban highway junction, goods exchange center is established to form a transport, storage and distribution center. The center also offers various kinds of services to vehicles from other parts of the country. The trends of the development of road transportation are large vehicles and containerization.

3.4. Inland Navigation

For inland water transportation of Shanghai, the problems are also obsolete facility, out of date fleet, and low efficiency. The waterways are strongly influenced by the Yangtze River, which brings large quantities of silt to cause the canals to become shallow. The clearance under many bridges are small, large crafts are unable to pass through during high tides. The facilities of inland wharfs are very primitive with warehouses and storage yards being small and they are concentrated along the Suzhou Creek. Therefore the renovation of inland water transportation should aim at deepening waterways for larger vessels and construction of wharfs. The dredging and deepening of the four large waterways from west to east, i.e. Wenzaobang, Suzhou Creek, Dianpu River and the Shanghai-Jiangsu Waterway, has already started. The project of deepening and widening a number of small creeks in order to create a new south to north main waterway the Youdungang to relax the over burdened Huangpu River, has also been settled.

For renewal of vessels, a fleet consisting of motor pusher and 300 ton barges will be developed to replace the existing small tow boat and barge train.

3.5. Air Transportation

The air transport has grown rapidly in recent years, but it still cannot match the fast development of commerce and tourism. The number of flights is not enough and the problem 'Difficult to Buy a Ticket' is still unsolved. The present 20,000 sq.m waiting hall is usually very crowded. Due to inefficient management, the average flying time per day of an aeroplane is only 5 hours, which is only half of the average of other advanced companies.

The construction of a new international waiting hall, and a new navigation building and the renovation of the runway are on hand. Further improvements for navigation, communication and weather observatory facilities will be made. In order to create good reputation and economic merit, the administration and operation should be further reformed.

For the long term project, a new airport will be built on the southern bank of the Yangtze River, 25 km north-east of the city center. A second runway in the old Hongqiao Airport is also projected.

3.6. Transportation in Urban Districts

The congestion of roads, and crowding in buses become an extraordinary problem restraining the economic development and the execution of the opening policy. The reason of such a difficulty is of course that the area of roads is too small, many roads are narrow and irregular. Especially there is no south to north avenues and no bridge crossing the Huangpu River. The things are becoming worse and worse, as many roads are still occupied by retail salers and are also used by new construction fields for piling materials. Therefore the first thing to do is the clearance of road obstacles. Progress has been made this year. Assigning roads only for mechanized or manual vehicles and organizing one way traffic are the other measures. Compulsory measures for the enforcement of regulations of road and traffic are taken recently. At the same times 'Bottle Neck' and congested road sections are widened, such as the avenue to the airport is reconstructed to a 4 lane road for double traffic. Many bus stops are recessed from the line of the road. In so doing the speed of vehicles is increased.

The construction of the first subway leading from the southeastern part of the city to the new rail passenger terminal and the big bridge across the Huangpu River in the southern part of the city have started last year.

For the long term projects, a second bridge or tunnel on the northern part of the city is projected. Many roads will be renovated and elevated roads will be built, in order to form a network of several circular and diagonal avenues. The subways are also planned in similar manner. By the end of the century, when these projects are completed, the condition of urban district transportation of the city will be greatly improved.

4. Results of Some Research Works

In the field of transportation, investigations on the selection of harbour site, railway line, type and structure of bridges, ships, vehicles, and cargo loading and discharging facilities were carried out. In these research works modern methods of system analysis and engineering economics were used. The author has contacted with some of these research works. Some of their results are briefly described in the following.

4.1. Research on an Integrated Transportation Model of Shanghai

The research group was first divided into 6 sections. A preliminary planning of rail, road, inland navigation, harbour and shipping, and air transport subsystems was carried out. The investigation included: the present capacity, forecast of traffic, the problems existing and preliminary planning for the next ten years. After that integrated analysis was performed.

This project utilized the system dynamics model to investigate the relations between transportation and the economic development of the city. The conclusion is that: If the present total amount and structure of investment is unchanged, then the industrial production and transport trade will continue to increase, but agriculture and commerce will stagnate or shrink after 5 years. If the investment on transportation is increased to relax the already very tight condition, the whole economy will gain a healthy growth.

From the analysis we can also see that the volume of cargo turnover of sea port and volume of cargo traffic are closely connected with the development of national economy. Therefore the capital construction of port facilities, rail road and highway should be emphasized.

The following facts are recognized:

1) The demand on transport of construction trade, heavy industries and commerce are heavy.

2) The transport trade is largely dependent on heavy and light industries.

3) The quantity of transport of energy (coal and fuel oil) of Shanghai is very large, amounting to 40% of the total traffic. The energy consumption per unit value of product of metallurgical and chemical industries is large. They are 5.33 and 4.67 kg, respectively (coal). Those of mechanical, electrical industries and construction trade are 1.47 and 1.01 kg, respectively, and those of the light industries and agriculture are only 0.58 and 0.48 kg, respectively. Therefore in order to reduce the burden of transportation, it is suggested that the development of steel and chemical industries should be restricted, and resources should be diverted to the development of manufacturing industries, such as the textile, mechanical, electronic and instrument industries.

The project also investigated the problem of time value in transportation.

Total expenditure of transport

$$P = R(L/V + t) + aL$$

where R is the value of time, V – the speed of vehicle, L – distance transported, t – waiting time, a – freight or passenger rate.

According to the present condition of China, the following conclusion is drawn: for those persons whose time value R is less than 0.66 yuan per hour are advised to take the slow local train; for those whose R=0.66–2.09 yuan per hr should take the ordinary fast train; for those whose R=2.09–8.28 yuan per hr, it is worth while to take the express train; for those whose R value exceeds 8.28 yuan per hour, it is suitable to ride on aeroplanes.

4.2. The Selection of Site of a New Harbour⁵⁾

After preliminary investigation, four candidate sites, i.e. Qiyakou, Luojing, Waigaoqiao at the southern bank of the Yangtze Estuary and Jinshanzui at the northern bank of the Hangzhou Bay were considered. After analysing the results of about 50 feasibility study reports, two rounds of Delphi Technique are used and 44 specialists were invited. Discussions with harbour authorities were carried out. Then 9 categories (70 items) of factors with significant influence to the selection of the site of a harbour were determined as the criteria of appraisal. These factors are: government policy, technology, economy, relation to the development of the city and Neighbouring Provinces, Connection with National Transportation Network, resources, protection of environment, influence of other important projects, and military considerations. Weights were assigned to the items considered, according to their relative importance. Measures of merit for all the items were determined. A mathematical model was built up for quantitative evaluation. Thus a Satisfaction Value for each of the four candidate sites was obtained;

Site	Jinshanzui	Waigaoqiao	Qiyakou	Luojing
Satisfaction Value	0.78767	0.78240	0.73931	0.67265

Jinshanzui harbour has the advantage of the largest cargo turnover, and shortest capital recovery period. Waigaoqiao harbour has the advantage of the lowest capital investment and shortest building period. Both can be selected as the site of the prospective harbour.

4.3. Research Work on Shallow Draft Large Deadweight Cargo Ships^{6,7)}

The scale economy has strong effect on transportation business. Several years ago the cost of carrying iron ore from Australia (7200 nautical miles away) to Shanghai by vessels of different size were as follows:

Deadweight of Vessel in tons	16,000	30,000	50,000	100,000
Cost of Transportation in yuan/ton	20.95	15.43	13.17	11.03

The carrying capacity of cargo ships which ply along China coast is growing with the economic development of the country. But the increase in size of ships will be limited by the water depth of the navigating channel and harbour. For the principal seaports of China coast, the water depth are 6–10 m.

The shallow draft large capacity cargo ships have already gained reputation. For instance the bulk carrier 'Zhejiang 117' has 5.8 m draft with 8628 ton deadweight and service speed of 11.3 knots. The ship has operated already for three years showing good economical performance.

For many years, bulk carriers of 16,000 and 25,000 ton deadweight with 8.8 and 9.8 m draft respectively carried coal from ports of North China to Shanghai. It is suggested now to keep the draft at 9.5 m and increase the deadweight of the ship to

35,000 tons (for conventional ship the draft should be 11 m). The length breadth ratio of shallow draft ships is small and the breadth draft ratio is large. Investigations were carried out on resistance and propulsion, steering and manoeuvrability, and seaworthiness of this type of ship. Experiments in ship model basins were also carried out. The results are encouraging. In economy, the unit cost of transportation will be 19% lower than that of 25,000 ton ship.

4.4. Research on Self-Unloading Bulk Carriers⁸⁾

The purpose of this project is to reduce capital investment of wharf, to raise the efficiency of unloading cargoes and to increase the annual carrying capability of the ship. The result is the reduction of transportation cost.

There are already several types of domestic built self unloading barges in operation. These barges were developed mainly for distribution of bulk cargoes in harbours. The advantages of less investment, reduced operation cost, and high productivity are realized.

Investigations were carried out on the feasibility of using self unloading bulk carriers to transport coal along China coast. The results showed that for China coast coal trade, the ship of less than 6,000 ton deadweight is not economical due to large investment and high operating cost. For routes of turnaround distance within 700 nautical miles, 6,000 ton self unloading ships begin to show superiority. 12,000 ton carriers have good economical performance in China coast coal trade. The results are even better for large ships.

5. Conclusions

From the above discussions we can see that the transportation of Shanghai is a large complex system which consists of rail, road, inland navigation and air transportation with the seaport as its center of operation. The present problems are that the demands exceed the service supplied, the existing facilities are obsolete and also under inefficient management. Present measures for solving these problems are clearing of obstacles, strengthening weak links, reformation of administration and management and enforcement or regulations to promote the order of operation.

But in the long run, the progress of capital construction and the modernization of facilities must be accelerated, and capital investment funds should be sought. The Municipal Government approval of a policy to promote rapid development of transportation trade is suggested. At the same time, the transportation enterprises should put forward much effort to reform its management and operation, in order to offer efficient service of superior quality, to win good reputation and to create good condition for the rapid development of economy of the city.

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