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Project design on pan company's heavy-lifting cargo logistics service

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PROJECT DESIGN OF PAN COMPANY'S HEAVY-LIFTING CARGO LOGISTICS SERVICE

By

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is concluded for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of research paper: **Research on Project Design of Pan Company's Heavy-lifting Cargo Logistics Service**

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This research paper is a study of the method of the design of project logistics. By a deep research on Pan Company's heavy-lifting cargo logistics service and the company's heavy-lifting cargo transport resources, the paper constitutes a designing method of logistics project for Pan Company and applies this method to the large-scale petrochemical project (LPP) ---- Hainan refinery extend constructing (HREC) project.

A brief look is taken at present means and ingredients of the design of engineering logistics projects and at the historical developments behind them. The project logistics service of Pan Company and its heavy-lifting cargo logistics transport resources are examined.

In the designing process, a specific method of project design, evaluation and selection of logistics projects for large-scale petrochemical project is concluded. In this designing method, the research concluded seven processes for the design of LPP logistics project and each process has its own detailed procedures. For the evaluation and selection of optimal LPP logistics project, it applies the method of expert questionnaire as the methodology for the initial selection and prepares one questionnaire paper for several famous experts and engineers in order to carry out a detailed investigation and evaluation of the proposed overall logistics projects on ten closely related factors within three aspects. For the final optimal project evaluation and selection, the methodology of AHP is introduced and an AHP model is established.

Finally, the method of designing project logistics is applied in the case of HREC. An optimal logistics project is concluded step by step by this method in the last chapter. After the application of the method, the use of specific and systematic project designing method of project logistics service for Pan Company will give reference to the global HLC transport operators and LPP logistics service providers.

KEYWORDS: Large-scale petrochemical project, Heavy-lifting cargo logistics service, Pan Company, Hainan refinery extend constructing project, AHP model

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LIST OF ABBREVIATIONS

LPP	Large-scale Petrochemical Project
HLC	Heavy-Lifting Cargo
HREC	Hainan Refinery Extend Constructing
China No.1 Dalian base	China No.1 heavy machine manufacturing company Dalian base
China No.2 Deyang base	China No.2 heavy machine manufacturing company Sichuan Deyang base
DL Scheme	Logistics Scheme for equipments manufactured in China No.1 Dalian base
DY Scheme	Logistics Scheme for equipments manufactured in China No.2 Sichuan Deyang base
OP Scheme	Logistics Scheme for equipments manufactured in Other Places

Chapter 1 Introduction

1.1 Background and significance of the study

"First, second and third resources of profits" are fields that have brought great profits for business companies in the process of industrialization among all developed countries. Logistics, which is a new business field generating profits for commercial companies is regarded as the third resource of profits following natural and human resources. In recent years, logistics has become hotspot in the society. Logistics parks, logistics companies grow day by day. But because of the lack of service theory and capability, most of them can only provide basic logistics service such as: storage, transportation, etc. Demands have succeeded supplies in the market which caused a situation of fierce competition. There is rarely a company that can generate huge profits from this market. Also, the profits are less and less in the market. Many companies are facing embarrassing situations. However, some successful cases of engineering logistics project design are very good ideas. This kind of logistics service brings huge profits for both demanders and suppliers.

Project logistics has its broad extension and abundant insides. As to the extension side, there are many different engineering projects in different industries. As to its inside, every project is relatively independent. Although they have different characters, analyzing from logistics service, they are the whole processes of equipment purchasing, teardown, packaging, transferring, boxing, fixing, seaway transport, air transport, road transport, installing, adjusting, abandoning, reclaiming, even including all the process from product manufacturing to customer service after the delivery of product. According to this, engineering logistics is a service that provided by a logistics company for a certain part of the process or the whole process concerning the engineering project for the purpose of providing the investors the biggest security and the most convenience, decreasing the project cost and increasing the constructing speed of the project through the specialized logistics service.

Project logistics has been mature among developed countries. People who have researched the development of world logistics will find that almost all international logistics giants and aircrafts have their outstanding achievements in the project logistics field.

It not only creates huge profits, but also has great market potential and broad future. Firstly, because the process of global economic integration is becoming faster and faster and the trading of technologies, equipments, and products between different countries is becoming more and more broad and frequent. Project logistics is developed all over the world, which has provided the logistics suppliers a both competitive and cooperative surroundings. Secondly, China has entered WTO. Logistics companies of China will compete with WTO member countries equally. Thirdly, china has just walked out his first step on project logistics. There is many opportunities in this market. Fourthly, although the ability and service level of china's logistics companies are not as good as some developed countries, low-cost labors and less expenses is the biggest advantages of China. Fifthly, China has become the most active and attractive investment market in the world because of the fast development of its economy. Most companies among the "Best World 500 Companies" have invested or setup their research institutions in our country. China has become the global manufacturing base. Many foreign factories moved to China. Import volume of whole factory equipment from abroad increased year by year; export tendency of electrical machine products and whole set equipments which is made in China is very obvious. Manufacturers in China's coastal areas move to mid and west areas. Thus it can be seen that China has a wide market of project logistics. Logistics companies will have bright future if they exploit in this market.

The design of a logistics project is the key to the success of one project. A good logistics project can not only save the cost of the constructor, but also bring great profits to logistics companies. Transportation of supplies of national engineering project logistics such as nuclear power station, water power station, petrochemical projects needs great amounts of heavy-lifting transportation. Therefore, the logistics project design of heavy-lifting transportation is the key to the transportation of supplies of national engineering project. For the project logistics design, it always depends on the logistics service providers' experience and the design is not very systematic. Take Pan Company as an example from Chinese project logistics providers, there is not a very systematic method for the project design and evaluation in their company. This sometimes leads deficiency and increases costs when carrying out the project. Therefore, a systematic design and evaluation method of project logistics service will improve the efficiency and bring profits for the project logistics service providers. This paper is trying to constitute a specific and customized systematic designing method for Pan Company and give reference to others.

1.2 Contents and structure of the study

The paper is a deep research of Pan Company, expatiates and analyzes the heavy-lifting business of Pan Company and the method of the design of the HLC logistics project of a national construction project. It applies the designing method of logistics project of national construction project to HREC HLC logistics project designing process. And it gives a reference to other HLC logistics companies for their design of HLC logistics project.

Chapter one is introduction, including the background and significance of this topic, the structure of the study and literature review. In chapter two, the paper introduced the HLC logistics service of Pan Company, the outstanding achievements of the HLC logistics service and the competitive advantages of Pan Company in the HLC transport field. In chapter three, a method for designing the equipments supply logistics project for large-scale petrochemical engineering project is established. In the last chapter, the research concludes an optimal logistics project for the HREC engineering project by the designing method and evaluation tools.

1.3 Literature review

1.3.1 HLC transportation

Special Cargo Transportation is a division of logistics industry. It is a very specialized market segmentation. The special cargo transportation market can be divided into several segmented market. They are NPG transportation, ro-ro transportation, out of gauge and over weight cargo transportation and so on. Although the quick development of containerization has threatened the bulk carrier transportation market, container transportation still can’t compete with certain kind of special cargo transportation such as out of gauge and over weight cargo transportation under today’s shipping technology.

The so-called out of gauge and over weight cargo transportation is a relative concept.

There is no uniform concept or standard for this kind of cargo transportation in today's shipping industry. In normal condition, out of gauge and over weight cargo is the cargoes that are larger or heavier in size or weight than normal cargoes. Weight and size are the standards used to measure cargoes. In different periods, people have different concepts to out of gauge and over weight cargoes. In 1980's, cargoes over 30 tons used to be defined as out of gauge and over weight cargoes. But now, cargoes over 50 tons are defined as out of gauge and over weight cargoes. The same situation happens as to the dimension of the cargoes. The mostly used definition of out of gauge and over weight cargoes is the cargoes over 50 tons in weight and 8 meters in dimensions.

On the other hand, out of gauge and over weight cargo transportation can be divided by the type of ships. Out of gauge and over weight cargoes are always huge equipments or components of huge constructions. Normal bulk carriers can't load such big cargoes because of the limitation of lifting equipment and holding size. The reason for the transport of out of gauge and over weight cargoes is there are more and more huge constructions around the world nowadays, such as huge waterpower stations, huge specialized docks, and huge nuclear power plants. Those new technology-intensive and capital-intensive constructions always need huge equipments and components. They need the resources in the world scale. The manufacturing of those huge equipments isn't always able to be done in the users' place. Even if they are able to be produced in the buyer's place, it may be more economic for the constructors to buy them globally. So the out of gauge and over weight transportation exists because of those needs of the movement of huge equipments and components. This gives the opportunities to the special cargo operators. They use special carriers and technologies to transport those huge cargoes.

1.3.2 The introduction and development of international project logistics service

The word ‘project’ is often used to cover a large range of transport related activities. This is appropriate, and rather than try to narrow the definition many famous international project logistics providers embrace the entire spectrum of activity and offer experience, professionalism, equipment and skill to every type of project.

Such as SDV Industrial Project division which is globally represented and works closely with SDV Oilfield to provide specific services to the oil and gas industry and their engineering subcontractors. Despite SDV Industrial Project division, there are many other global logistics companies that providing customized project logistic service to large-scale engineering project contractors all around the world. This kind of logistics service providers in China are beginners in this transport fields.

Managing a construction project is a detailed skill requiring procedures, communication and, most importantly, planning. In a typical project scenario every one of the skills required of an international logistics company is called for, as well as many specialist skills and systems.

The role of the project logistics provider is to ensure that to the greatest degree possible the site receives the materials required in good time and perfect condition, and that site-work is not interrupted. Every component, no matter how big or small, must be accounted for, and sophisticated computer systems and physical procedures must be agreed and executed.

The following are the regular means of HLC transportation:

(1) Heavy Lift and Oversize movements by Sea

More than any other industry Oil and Gas moves ‘the big stuff’. Upstream there are rigs, platforms and a whole range of sub-sea equipment, downstream there are modular installations, columns, pressure vessels and racks. Single pieces can range from hundreds, to thousands of tons.

A good international project logistics provider has to know all of the global heavy-lift resources, the carriers and specialist brokers, the marine superintendents and the local port and coastal authorities.

Many heavy-lift items and oversize pieces are destined for remote worksites, with geographic or physical limitations and a need for detailed planning and consulting often at design stage.

(2) Heavy Lift and Oversize movements by Air

The latest generation of heavy lift aircraft can transport an ever-increasing payload to some of the most remote sites in the world. The huge Antonov and Hercules aircraft can move significant payloads and sky-hook helicopters can be used where no landing field can exist.

A good international project logistics provider such as SDV has a great deal of experience in managing these heavy-lift movements and work with carriers to detailed technical specifications.

(3) Heavy Lift and Oversize movements on Land

Land movement of oversized or heavy items can be one of the most challenging areas of logistics. Most good international providers own extensive fleets of modular trailers and charter others worldwide. They have their own technical superintendents who can work out detailed plans for axle deployment, slings and pivots and who will research the route thoroughly to ensure that any obstacle can be circumvented and that the cargo and the surroundings remain safe.

On inland waterways barges provide an option, and in some countries rail is a possible transport method for heavy items.

The following are regular ingredients of the design of project logistics service:

(1) Feasibility Studies

Working closely with principals and engineers, project logistics providers are pleased to consult on project feasibility. Logistics is a significant issue, and there is little point in an engineer designing an item that cannot be delivered due to local limitations or infrastructure.

(2) Route Surveys

Planning the route is essential, particularly in the developing world. In order to deliver a large or heavy load, a detailed route survey must be undertaken. We take into account road surfaces, street furniture, obstructions, turning circles, safe overnight stops, security, fuel facilities, mobile workshop facilities, bridge and quay strength, axle weights, crew shifts, accommodation and a myriad of other details that are essential to project success.

(3) Modular Design Advice

It is always worthwhile to involve a logistics specialist in engineering design. The specialist will know the limitations of aircraft, ships, modular trailers and the physical and geographical characteristics of the site.

Often small design changes can save enormous amounts of time and money, not only with large or heavy-lift modules, but also small skids and equipment where, as an example, designing with 'container dimensions' in mind can make delivery much easier and possible using equipment already in place.

Pipeline engineers understand the cost juggling between shorter pipe sections / more welds and longer pipe / more delivery cost. Design advice from a skilled logistics provider will offer principals the information they need to make an informed decision.

(4) Site Delivery

In the project arena site delivery is now a standard item. It is an important step that providing all of the vehicles, trailers and traction units required to deliver cargo to site, and at site can offer cranes, fork-lifts and warehouse / stockpile management systems and personnel.

(5) Site Services

On site services are now a common part of some global project logistics providers' portfolio. Physical handling equipment is a small part of the site service many providers can offer. Materials and warehouse managements, maintenance facilities, supply-line management, refrigerated storage, mobile maintenance vehicles, waste disposal, hazardous materials storage and security are amongst the many site services. As each site is unique, site services should be tailored to individual needs.

(6) Executive Control Centers

Larger projects often require their own dedicated project team, acting as a separate company and responsible only to the success of the project itself. International providers should establish several Executive Control Centers of this type with differing mandates depending on the need of the client.

The Executive Control centre can be at any agreed location and may well involve representatives of client or contractor staff. In order to ensure close communication, project control teams should be frequently based in a regional office,

(7) The Project Team

Working alongside the client or engineer the project team will typically have a dedicated project manager and a number of specialist co-ordinators each looking after a section of the logistics (import, export air, export sea, IT, Land services etc).

Implant personnel can be allocated to the client’s office and site personnel or port operations are common positions in the team. Reporting is to agreed standards and method, often electronically on live time.

The project team will introduce themselves and have regular contact with the entire supply chain, including the carriers and hauliers, customs and agency organizations. They will also draw on the necessary skills within the company.

1.3.3 Design of transport project

The transport system mentioned here refers to the one for certain companies. Generally a good and efficient logistics project is needed not only to meet the needs of the customers, but to reach the aim of the company's operation as well. It goes as follows:

(1) Knowing the goals of transport

Before the goals of transport is determined, the company, goods-transportation oriented or manufacturing oriented, needs to know their user's demands. It is important to know the goals of its transport plan, including the transport stability or timeliness, for a company, especially in such situations as diversification of the goods or the transportation tools, or when the company's inner resources are limited. These goals can be carried out in different ways and sometimes all the goals should be reached as the supply chain has become more and more important. In close, different goals cause different plan.

(2) collecting information concerned in logistics process

There is huge amount of information concerned in logistics process, such as annual demand, daily demand, status in low-season and midseason, future of the operation process, kinds and sources of conveyance. The more a logistics company can get the information about the transportation, the more the logistics project designed will be suitable to the operation of the company and this will even have great benefits to the company's competitive advantage.

(3) related factors of logistics functions integration

Generally, related factors of logistics functions include cargo, customer, conveyance, personnel, route, departure place and destination, time needed for transportation. Only after the full understanding and effective integration of these related factors, a good logistics project can be designed.

(4) Completion of transport draft

After the above process, a designer can draft out the transport plan. What information a transport plan should contain is closely related to the logistics functional factors. Different factors a transport plan emphasizes on will cause different emphasis on a transport plan. Such as a logistics operator should put in his transportation plan daily maximum volume transported, kinds of conveyance used, transport route, time for transport, emergency plan and so on. Generally speaking, a logistics company should work out at least two plans for discussion.

(5) Correspondence between transport plan and customers

Since a logistics company designs a transport plan on purpose to meet the customer's need, the main content of a transport plan should correspond with customer's view in order to reduce the possible fall between actual work and customer's expectation.

(6) Deciding the transport plan

After the full correspondence and communication with customer, the modified transport plan should be a part of logistics service. Also, all related personnel must fully understand the plan in order to carry it out successfully.

1.3.4 AHP

AHP is a comprehensive, logical and structural framework, which allows to improve the understanding of complex decisions by decomposing the problem in a hierarchical structure. The incorporation of all relevant decision criteria, and their pairwise comparison allows the decision maker to determine the trade-offs among objectives. The application of the AHP approach explicitly recognizes and incorporates the knowledge and expertise of the participants in the priority setting process, by making use of their subjective judgments, a particularly important feature for decisions to be made on a poor information base. However AHP also integrates objectively measured information where this information is available.

The AHP is based on three principles: decomposition of the decision problem, comparative judgment of the elements and synthesis of the priorities.

The first step is to structure the decision problem in a hierarchy as depicted in Figure 1. The goal of the decision is at the top level of the hierarchy. The next level consists of the criteria relevant for this goal and at the bottom level are the alternatives to be evaluated.

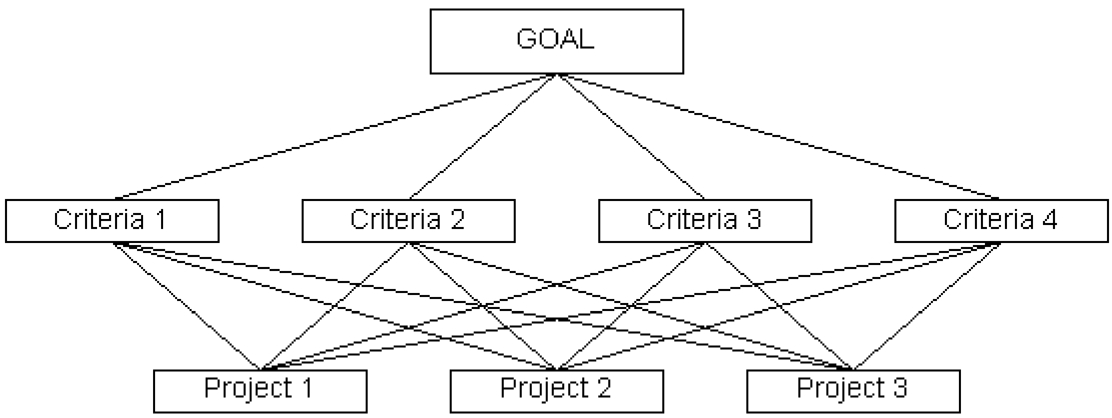

Figure 1 – The basic structure of the hierarchy
Source: The Analytical Hierarchy Process. Retrieved from the World Wide Web: http://www.isnar.cgiar.org/Fora/Priority/MeAnalit.htm

The second step is the comparison of the alternatives and the criteria. They are compared in pairs with respect to each element of the next higher level. For this relative comparison, the fundamental scale can be used. It allows to express the comparisons in verbal terms which are then translated in the corresponding numbers.

As the last step, we synthesize the comparisons to get the priorities of the alternatives with respect to each criterion and the weights of each criterion with respect to the goal. The local priorities are then multiplied by the weights of the respective criterion. The results are summed up to get the overall priority of each alternative.

Chapter 2 The HLC logistics service of Pan Company

2.1 Introduction of Pan Company

Pan Company is invested by P Logistics Company and N Shipping Agency Company. The main line of Pan Company is engineering project logistics. Possessed the certificates of first-degree highway Transportation Company, four types over-size goods haulage (superlative degree) and class A electric contract, the company has the ability to provide customers a series service such as ocean-transportation, unloading on the port, Custom declaration, tallying ashore, storage, road (railway or waterway) transportation and making delivery.

In matters of heavy haulage, the company owns advanced and superiority equipment. The self-owed SCHEUERLE 72 axles hydraulic self-propelled platform trailer that imported from Germany has the largest single cargo maximum load in China (reaches 2300 ton). And also the type is the most advanced and newest transported cargo for over-size goods. This type has advantage in wire-control proper motion, making join in modules, hydraulic lifting gear, control-lable round-angle turning gear and random integration in longitudinal and lateral way, etc. Recently, the company buys several German Benz 300-600 hp tractors.

Company owes aristocracies of intellect in the area of engineering management, technology and machines operating. In all the employees, there are 30 percents with senior and junior professional title, and 80 percents with associate degree or above.

The company has forward computer software, which are researched and developed by P Logistics Company, including The Decision-Making System for High-way Heavy Haulage, Simulation System of Several Parts Self-propelled roll-on/roll-off and Simulation System for Hoisting and installation of Heavy Goods on Special Boats.

After the founding, the company has provided successful logistics services for 19 different engineering projects. Most of them are national key large-scale construction projects comprising petrochemical industry, nuclear power plant, water power plant, fire power plant, for example, Nanhai Shell petrol-chemical integration project, Yantze BOC project, Shanghai Beyer project, Huatian Qishu power Plant project, steel structure of Runyang bridge project and the project of rebuilding Baosteel finishing mill. Especially in the project of Nanhai Shell, the SCHEUERLE 72 axles hydraulic self-propelled platform trailer broke the hardest record in our country twice in four days in roll-down from ship and highway transportation (The weight of single goods reaches 1284 ton).

Depending on the scale advantage, resource advantage and global operating network of P Group, Pan Company will provide convenient and quick service to customers and engineering projects at home or abroad.

2.2 Competitive advantages of the HLC logistics service of Pan Company

(1) Advantages of resources:

As a famous logistics company in China, Pan Company obtains advantages in resources over other logistics operators domestically.

Referring to equipment resource, Pan Company has the most advanced self-propelled platform trailer with the biggest carrying capacity domestically. This trailer was bought by P Logistics Company from German SCHEUERLE special type vehicle manufacturing Company. It has the advantage in wire-control proper motion, making join in modules, hydraulic lifting gear, controllable round-angle turning gear and random integration in longitudinal and lateral way, etc. This type of platform trailers can load cargoes with hundreds of meters in length, tens of meters in width and 2300 tons in weight.

This type of platform trailers consist of sixteen modules including two double row PPU platform trailers (including six axes), two double row three axes normal platform trailers, five double row four axes normal platform trailers, three double row five axes normal platform trailers, one double row seven axes normal platform trailer, one single row three axes normal platform trailer, one single row four axes normal platform trailer, one single row five axes normal platform trailer. Every module can be used independently and can satisfy the needs of 60-2300 ton dwt cargoes capacity. Every module can be easily put together freely in both horizontal and vertical direction. As per different transport requirement, the trailers can be put together into double row, three row, four row, five row, and so on. The biggest characteristics of this platform trailer is its easy manipulation, flexible turning over capability (maximum turning over angle is 65 degrees, effective for 55 degrees) and strong carrying capacity (28 ton dwt per axe).
PPU platform trailer is a six axes self-propelled hydraulic driven trailer. Every trailer has 12 driven axes which generate great pulling strength. Hydraulic driven system is benefit for controlling the trailer's speed. The speed of trailers can be controlled by the hydraulic system rather than brakes. It is benefit to the security of transport of HLC.

This type of trailer doesn't have a driving room. Its engine, hydraulic pump, and computer system are hanging on the platform trailer. They are on the same plane of the platform trailers meanwhile they can ascend or descend as needed. This type of platform trailers can be used together with other normal platform trailers. When transporting over-length cargoes, operators can control the trailer by a wire-controller at a proper position. That will broaden the view of operators in order to keep security.

This type of platform trailer has a favorable ascending capability. Its normal operating height is 1190mm and it can be ascended to 1575mm if necessary. When facing sky barriers, the platform trailer can be descended to 865mm height. In addition, this favorable ascending capability combined with special purpose seat can finish the work of loading and discharging safely, efficiently, and conveniently.

Meanwhile, Pan Company also has some other types of tractors. See table 1:

Table 1– Table of other tractors

Types	Brands	Number	Main parameters	traction modes
Heavy duty tractor	William TG300	6	300 ton traction power （14% vertical）	8×8
Heavy duty tractor	Benz 4160	2	250 ton traction power （10% vertical）	8×4
Heavy duty tractor	IVECO	2	250 ton traction power （10% vertical）	6×6
Heavy duty tractor	Benz 4861	2	300 ton traction power （10% vertical）	8×8
Heavy duty tractor	Benz 3850	2	200 ton traction power （10% vertical）	6×6

Source: Internal materials of Pan Company

On the aspect of human resource, Pan Company has numbers of logistics professionals.

Especially in the field of project logistics, Pan Company has professionals of HLC's road transport, railway transport, freshwater transport, sea transport, and multi-model transport management. Pan Company also have the priority of using p logistics company and n group's transport resources.

(2) Advantages of project management:

Pan Company has provided logistics services for many international and domestic engineering projects. The company has accumulated abundant management experience of both national and international projects. Especially in the project of China Ocean Shipping Shell, Yangtze BOC, Xia Men Oil & Chemical industry, Pan Company was the logistics service provider and accumulated a lot of managerial experience in the project logistics field.

With the cooperation with international and domestic project management companies, Pan Company began to know and got familiar with the management models, logistics linkages and requirements of SINOPEC, CTCI and some foreign project management companies such as: Stone & Webster, Fluor, Technip, Aker-Kvaener, Maison, TOY, Amec, JGC, and etc. The management level of Pan Company has reached a high level.

(3) Advantages of Technology:

Pan Company has its own "road heavy-lifting cargo transportation computer decision system" and "special vessel heavy-lifting cargo handling simulation system". These systems are at an advanced technical level around the world.

The "multi-model automatic ro-on/ro-off simulation system" developed by Pan

Company was applied successfully in several ro-on/ro-off operation of HLC. In the 2004 Hainan Shell Project, SCHEUERLE self-propelled platform trailer of Pan Company broke the national record by successfully rolling two equipment over 1,000-ton off the vessel continuously in five days. This system ensured the security of the carrying out of the ro-on/ro-off project designed. Pan Company also has its own bridge/road loading capacity calculation software and special heavy-lifting vehicle track simulation software. These technologies help Pan Company take the leader in project logistics field.

The "Global Intelligent Navigation System" which was developed together by Pan Company and Britain Royal Navy is a well-known and maneuverable system. This system can provide planning of sea transport route and enquiry of related port information. By using this intelligent navigation system, Pan Company can secure the dependability and availability of the sea transportation plan.

(4) Advantages of Custom clearance

Pan Company has a professional team of customer clearance with strict training and abundant experience.

Pan Company is a logistics company with considerable strength. It had a long history cooperating with Custom, Commodity Inspection Department and other Chinese governmental departments ,therefore, built a long and friendly cooperation relationships. It is one of the earliest companies that can connect directly to Custom's network and applied non-paper customer service. Pan Company's work quality and Custom applying speed all rank top among logistics enterprises. Its Custom clearance service was praised by Chinese Custom and government for several times. Meanwhile, Pan Company keeps a stable and good relationship with local port authorities, railway authorities and some other governmental departments. These relationships can help Pan Company provide an in-time, convenient, and efficient logistics service for its HLC transportation projects.

Chapter 3 Designing method of logistics project for large-scale petrochemical project

3.1 Technique standards of material supply logistics planning

LPP material supply logistics plan is always a combined transportation plan including road transportation, railway transportation, and water-way transportation. Transshipment between waterway and road transportation mostly depends on the usage of suitable ports and docks. Material supply logistics plan of LPP mainly takes use of constructed and new building roads, assistant passages, and HLC wharfs.

3.1.1 Technical standards of selecting or constructing transport highways

There is no industrial criterion or standard of constructing highways used for transporting HLC in China. The constructed and under-constructing highways used for LPP material supply are all referring to the "highway constructing technique standard" issued by ministry of communication and national standard "factory road designing criterion". Main technique guidelines are decided upon the above mentioned standards plus the constructing specification & scale, requirement of material supply during the construction period and geographic conditions of the construction area.

LPP material supply logistics plan should apply a reasonable technical standard of selecting a proper material supply highway according to the "highway constructing technique standard” (JTJ001-97) issued by ministry of communication and by considering the scale and duration of the construction, the transport volume and characteristics of material supply and the traffic demand during construction.

3.1.2 Technical standards of selecting or constructing HLC transportation wharf

HLC transportation wharf is a special transfer hinge for HLC transportation. Therefore, the technical standards of selecting or constructing the heavy-lifting cargo wharf depends on the loading capacity, loading size, and loading volume of LPP’s HLC transportation.

As per the experience of selecting and constructing the HLC wharfs, the standards of selecting and constructing the wharfs are as follows:

(1) Satisfying the requirement of the loading capacity of each HLC, the maximum loading size, and the number of HLC.

(2) Building berths over 500 tons.

(3) The construction of wharf should match the standards of sea-route.

(4) Designed low water level applies 95% of assured navigation draft level.

(5) Designed high water level applies 1/10 of frequency flood water level.

3.2 Project design of HLC material supply logistics service

3.2.1 Thoughts of project design

HLC transportation is different from other bulk cargo transportation. Its characteristics of over-weight and out-of-gauge decide that the project design of HLC transportation must under the condition of knowing well about the cargoes' size, weight, shape and quantities. Before the designment of the logistics project, we should firstly design separately different modes of transportation according to different places of delivery, delivery time, and cargoes' characteristics. Secondly, we design the specific project for the transportation of HLC in different routes. At last, we should analyze the whole material supply logistics project systematically and constitute the management project for the whole project.

Before the logistics project is made, transport conditions of HLC material supply must be firstly considered, which includes:

(1) Conditions at the delivery place: conditions of railway delivery, conditions of highway delivery, conditions of waterway delivery.

(2) Conditions at the reception place: conditions of loading & discharging with railway delivery, conditions of loading & discharging with highway delivery, conditions of loading & discharging with waterway delivery.

When designing logistics projects and transport routes respectively according to the different resources of cargoes, the selecting and new building of transport highways and HLC wharfs are the main considering factors.

When designing the detailed schemes, we have to have a comprehensive idea of the heavy-lifting equipments built in that manufacturing place beforehand, including equipments name, numbers, sizes, single weights, delivery times, equipments characteristics and so on. Then, a detailed design of schemes can be constituted through the following procedure:

(1) Equipment analysis and transport arrangement design

The Equipment analysis and transport arrangement design is the analysis of names, quantity, size, unit weight, delivery times and characteristics of the equipments. The transport arrangement plan is made according to manufacturer's delivery timetable. By analyzing the parameters of equipments, we can fully understand their characteristics and functions, reasonably arrange the transport times and lay sound foundation for the following logistics project design.

(2) Transport route design

Based on the fully understanding of the starting points, destinations, transport arrangement and characteristics of equipments, we choose from the optional transportation modes and transfer places to draw up different transport route schemes. As for LPPs, we usually take the manufacturing places of equipments as the starting points and the construction site as the destination, harmonize various transportation modes and transfer places to form different schemes in view of different situations.

(3) Conveyance design

This part of design includes the analysis of parameters of conveyances, equipments, optional transportation modes and alternative conveyance combinations. How to combine the conveyances, whether or not such combinations can reach goals of transport and being efficient enough are all rely on this comprehensive analysis.

(4) Handling design

This part comprises the analysis of handling modes, wharf conditions of loading, discharging and transfer ports as well as proposed handling schemes, the latter of which is based on consideration of economical efficiency, feasibility and convenience of different handling modes and evaluation of port conditions.

(5) Overall project design

The overall design consists of permutation and combination of sub-schemes as well as drawing up overall project list. The design and combination of sub-schemes in various links determine the ultimate logistics scheme.

(6) The evaluation of overall project and selection of ultimate project

As for logistics project selection of equipment supply to LPPs, it includes preliminary filtration and ultimate selection. The former evaluates every alternative overall projects from 11 indices based on the questionnaires retrieved from the engineering and logistics experts in the industry. Then by grade comparison among different projects, we select the ultimate one from the top three projects.

In this research paper, I establish analytical hierarchy model to conduct the ultimate selection, applying theories of AHP and excel software to further select from the three chosen projects.

Figure 2 shows the designing flow of logistics project of LPP.

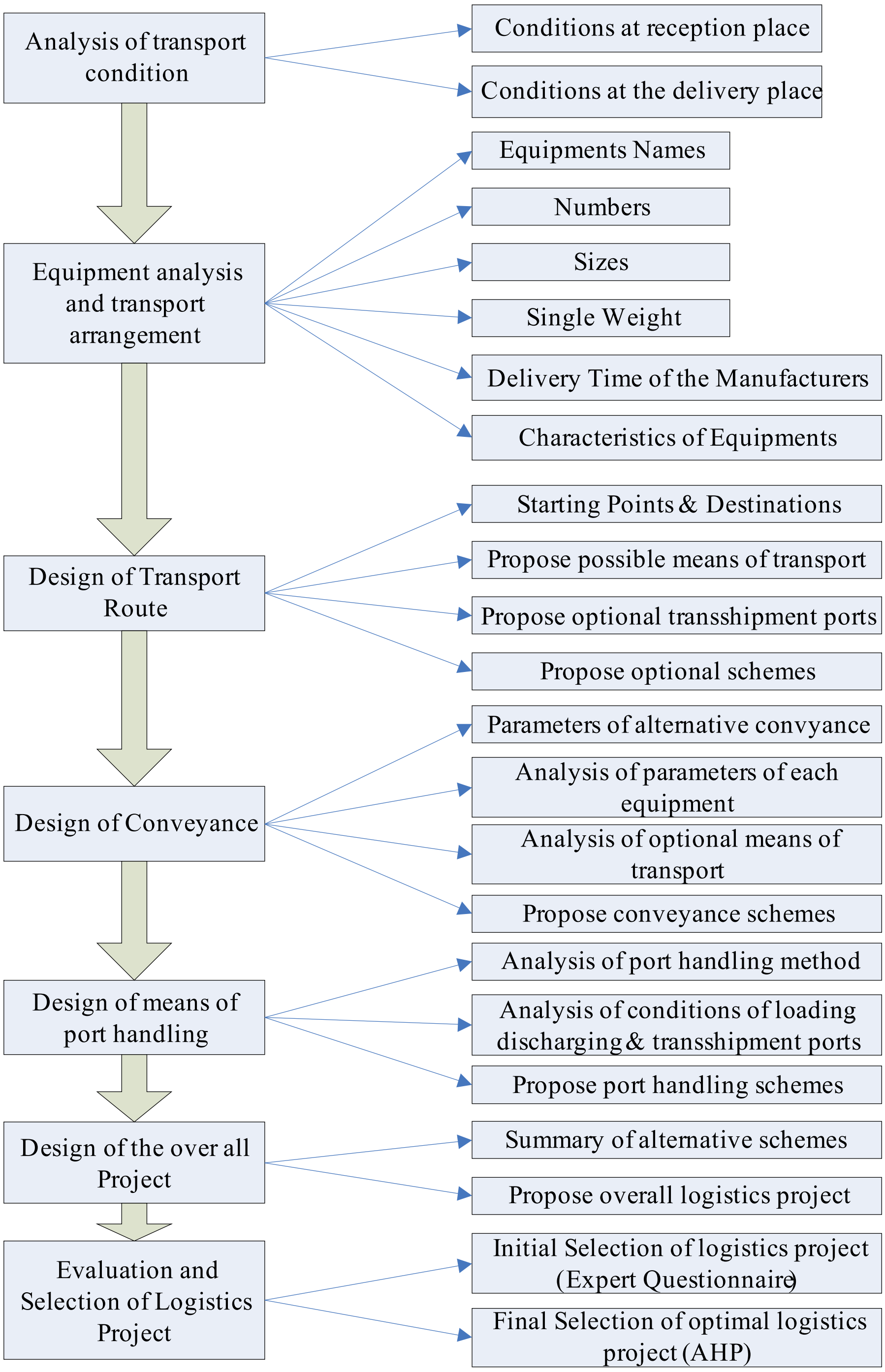

Figure 2 – Designing flow of logistics project of LPP

In sum, HLC material supply logistics project design is a complicated and diversified, meanwhile, a systematic and holistic process of design. The designing process must not only design the detailed projects according to different cargoes' size, weight, delivery place, transport routes and so on, but also secure the whole logistics project's feasibility, safety, and coordination with the engineering project.

3.2.2 Goals of project design

The design of LPP material supply logistics project is the important precondition to guarantee the construction material needed to be delivered to construction site in-time, safely, and effectively. Therefore, the fundamental goal of project design is to satisfy the demand of equipments and materials needed in the construction of the engineering project.

The development and construction of LPP in China is normally on the basis of constructing as needed, and developing gradually. The design of material supply logistics project should consider the requirement of equipments of related oil & chemical industry engineering project and make a plan as a whole. Meanwhile, the material supply logistics project should also keep coordinating with local communication layout.

LPP material supply logistics project design should take optimizing the communication layout as its goal. The essential factors are: distance, duration and volume of traffics.

The material supply logistics project should be feasible and considering the effect of the transportation to the surroundings, and the maneuverability of the estimated investment of the project.

3.2.3 The evaluation of transport projects of HLC for LPP

3.2.3.1 Decision criteria analysis

Considering the designing ideas and purposes of transport project as well as various functional positioning of its constituting parts, referring to research results of experts and applying AHP, the paper sums up eight decision criteria from the aspects of harmony between environment and project, comprehensive utility and economical efficiency of alternative projects to select the optimal one, which is based on the transport route of this objective project and survey of logistics projects concerning HLC supply to domestic LPP.

(1) Harmony

The paper compares the combinative degree and harmony between different equipment supply schemes and overall project as well as construction progress of LPP from the macro aspect.

1) The harmony with the overall project of LPP

Whether the logistics project corresponds with the development of relevant petrochemical project from the view of its overall structure must be considered.

2) Harmony with the local communication and transport around the LPP.

(2) Comprehensive utility

The comprehensive transport guarantee capacity and effect degree of different projects on the project construction can be estimated from the aspects of transport distance, time and capacity of HLC supply logistics project.

1) Transport distance: the average overall distance between the equipments manufacturer and the construction site of LPP.

2) Transport time: the average transport time and cycles between those two places to evaluate the time-effectiveness of various projects.

3) Transport capacity: the road transport capacity, carrying capacity of HLC wharfs and transfer capacity of railway transfer stations.

(3) Feasibility

The implementary difficulty and feasibility of proposed projects can be estimated from the aspects of transport costs, harmony among schemes and operability of overall logistics project.

1) Transport costs: the using costs of conveyances, transfer costs of equipments and the effect of transport costs and auxiliary facilities on the overall logistics project.

2) Harmony among schemes: the harmony and match among schemes determines whether the combination of those schemes could be the optimal one which is resource-saving and the most efficient.

3) Operability of overall logistics project: the operability of detailed tasks of logistics

project and flexibility of project expansion or shrinkage.

3.2.3.2 The evaluation system of logistics projects of equipments supply to LPP

Based on the principles of science-based, comparability, comprehensiveness, feasibility and harmony as well as the above analysis, the paper takes the hierarchical analysis model which consists of the eight criteria from three aspects as the evaluation system of equipments supply project selection to meet the material demand of LPP. (See figure 3.)

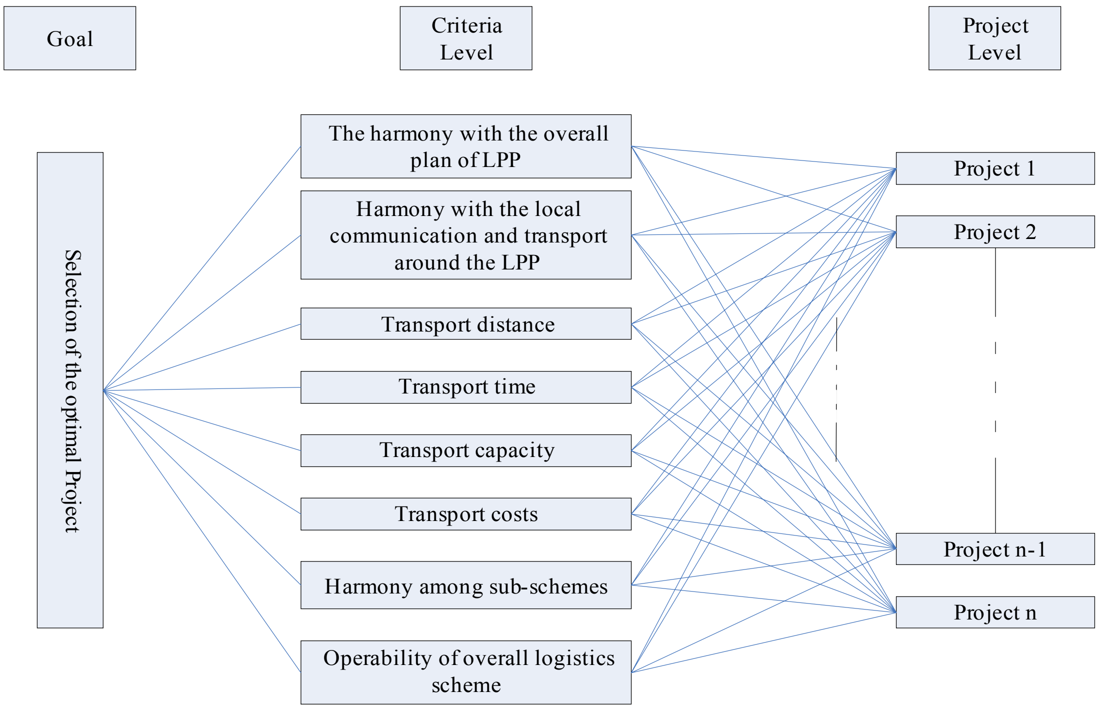

Figure 3 – Hierarchical analysis model for heavy-lifting equipments supply project selection of LPP

3.2.4 Evaluation method of logistics project

After establishing hierarchy model for equipments logistics project, this research applies AHP to compare alternatives and criteria in pairs and construct the comparative judgment matrix, then calculate the maximum eigenvalues and eigenvectors of criteria and project levels and conduct the consistency inspection, as the last step, calculate the overall maximum eigenvalue, eigenvector and consistency.

(1) According to the goal of logistics project selection of equipments supply, the judgment matrix of criteria level is made. (See table 2.)

Table 2 – Judgment matrix of criteria level

Optimal logistics project	Harmony between logistics project and engineering project	Harmony with communication and transport	Transport distance	Transport time	Transport capacity	Transport costs	Harmony among schemes	Operability of logistics project
Harmony between logistics project and engineering project								
Harmony with communication and transport								
Transport distance								
Transport time								
Transport capacity								
Transport costs								
Harmony among schemes								
Operability of logistics project								

(2) Constructing the judgment matrix between criteria and project levels in turn and calculating the corresponding maximum latent root and maximum eigenvector of this matrix.

As is shown in table 3, judgment matrix of project level in view of criterion of harmony between project and scheme is constructed.

Table 3 – Judgment matrix of project level in view of criterion of harmony between project and scheme

Harmony between logistics project and engineering project	A	B	C
A			
B			
C			

As is shown in table 4, judgment matrix of project level in view of criterion of harmony with communication and transport is constructed.

Table 4 – Judgment matrix of project level in view of criterion of harmony with communication and transport

Harmony with communication and transport	A	B	C
A			
B			
C			

As is shown in table 5, judgment matrix of project level in view of criterion of transport distance is constructed.

Table 5 – Judgment matrix of project level in view of criterion of transport distance

Transport distance	A	B	C
A			
B			
C			

As is shown in table 6, judgment matrix of project level in view of criterion of transport time is constructed.

Table 6 – Judgment matrix of project level in view of criterion of transport time

Transport time	A	B	C
A			
B			
C			

As is shown in table 7, judgment matrix of project level in view of criterion of transport capacity is constructed.

Table 7 – Judgment matrix of project level in view of criterion of transport capacity

Transport capacity	A	B	C
A			
B			
C			

As is shown in table 8, judgment matrix of project level in view of criterion of transport costs is constructed.

Table 8 – Judgment matrix of project level in view of criterion of transport costs

Transport costs	A	B	C
A			
B			
C			

As is shown in table 9, judgment matrix of project level in view of criterion of harmony is constructed.

Table 9 – Judgment matrix of project level in view of criterion of harmony

Harmony among schemes	A	B	C
A			
B			
C			

As is shown in table 10, judgment matrix of project level in view of criterion of operability of overall logistics project is concluded.

Table 10 – Judgment matrix of project level in view of criterion of operability

Operability of logistics project	A	B	C
A			
B			
C			

(2) Applying the scale of 1 to 9, the study compares the alternatives and criteria in pairs with respect to each element of the next higher level as for certain attribute and conduct the level unit rank and overall rank. The explanation of nine scales is shown in table 11.

Table 11 – Fundamental scale for pairwise comparisons

Explanation	Scale
Equally important, likely or preferred	1
Moderately more important, likely or preferred	3
Strongly more important, likely or preferred	5
Very strongly more important, likely or preferred	7
Extremely more important, likely or preferred	9
Intermediate values to reflect compromise	2, 4, 6, 8
Converse comparison	1/bij

Source: The Analytical Hierarchy Process. Retrieved from the World Wide Web: http://www.isnar.cgiar.org/Fora/Priority/MeAnalit.htm

(4) Applying the sum/product method and root method, the maximum eigenvectors of various judgment matrices and level unit rank are conducted to list the comparison sequence of all elements of this level compared with the higher level. Then based on the results of unit rank, the level overall rank is conducted to get the order of elements compared with the further higher level. This paper adopts excel software to make the level unit rank and overall rank, with the advantages of easy operation, large calculation volume and high accuracy.

(5) Based on the results of level overall rank, the ultimate selected project is confirmed.

Chapter 4 Application case-----HREC engineering project heavy-lifting equipments supply logistics project design

4.1 Brief Introduction of HREC engineering project

HREC engineering project is a key engineering project developed by the government in Yangpu Development Area, Hainan Province. Total investment on this project exceeds 10 billion. After the construction, the annual refinery capability of Hainan Refinery will increase about 8 million ton. The whole project is contracted to SEI (Sinopec Engineering Incorporation).

Large quantities of equipments for this engineering project should be purchased from factories all around the country. All equipments have to be transported to the construction site in Yangpu, Hainan province from factories in different places as planned according to the order of installation and rate of progress of manufacturers. The equipments required to be transported are mostly over-length, over-width, over-height, and over-weight (maximum weight 717 tons). The total weight to be transported is very huge (nearly ten thousand tons). The delivery places are in north-east, north-west, south-west of China and southern, northern and eastern China. The transport modes involve railway, highway, freshwater, coastal and etc. Therefore, the logistics project of HREC engineering project is a very complicated project logistics service.

4.2 Transport volume of HLC in HREC engineering project

Heavy-lifting equipments of HREC engineering project are manufactured by 17 factories in 13 cities of China. So the jumping-off points of transportation spread all over the country. Total equipment number is 95 pieces. Most of which are out-of-gauge equipments. Among them, there are 41 over-length equipments. The longest one is about 24 meters. The widest one is about 5 meters and the highest one is about 5 meters. There are 14 pieces of equipments ranging from 40 tons to 100 tons, 17 ranging from 100 tons to 400 tons, 6 above 400 tons. Among which the heaviest is 717 tons (2 pieces). Details refer to table 12.

Table 12 – List of equipments to be transported in HREC project

Number	Name	Quantity	Size（mm）	Unit weight（ton）	Production place
1	Hydrogenation reactor A	2	Φ4600×12000	607	Dalian
2	Hydrogenation reactor B	2	Φ4600×15400	717	Dalian
3	Hydrogenation purified reactor	1	Φ3800×13500	449	Dalian
4	Hydrogenation cracking reactor	1	Φ3800×15560	531	Dalian
5	Hot high separate pot	2	Φ4600×10500	162	Deyang
6	Hot high pressure separator	1	Φ3600×7920	240	Deyang
7	Recycle hydrogen desulphurization tower A	2	Φ2000×19200	172	Deyang
8	Recycle hydrogen compressor entrance drip pot	2	Φ2400×5000	102.3	Deyang
9	Feed/high heat exchanger	2	Φ1000×8350	50.7	Fushui
10	Hydrogen mixed/high heat exchanger	2	Φ850×6745	16.2	Fushui
11	Hot high fractional gas/low fractional oil heat exchanger	1	DEU1200	45	Fushui
12	Recycle hydrogen desulphurization tower B	1	Φ2200×16600	173	Fushui

13	Heat low pressure separator	1	Φ3200×6300	44.1	Fushui
14	Cold high pressure separator	1	Φ2800×8600	157.5	Fushui
15	Pot	1	Φ800×3600	9.86	Fushui
16	Recycle hydrogen pot	1	Φ2600×5000	105.4	Fushui
17	Hot low separate pot	2	Φ2600×9000	40.55	Fushui
18	Separator	2	Φ600×2700	7	Fushui
19	Recycle hydrogen compressor	1			Shenyang
20	Recycle hydrogen compressor	2			Shenyang
21	Compressor	1		100	Shenyang
22	Transforming of recycle hydrogen compressor	1			Shenyang
23	First class Transforming of recycle hydrogen compressor	1			Shenyang
24	Gas Turbine	1		65	Lanzhou
25	Regenerator	1	Φ1980×20200	19.58	Lanzhou
26	Feed / Effluent Exchanger	2	Φ1400×9540	94	Lanzhou
27	Hot high fractional gas/ hydrogen mixed heat exchanger	1	DEU1400	70	Lanzhou
28	First reforming reactor	1	Φ1450×13668	55	Lanzhou
29	Second reforming reactor	1	Φ2350×13668	55	Lanzhou
30	Third reforming reactor	1	Φ2350×13668	55	Lanzhou
31	Fourth reforming reactor	1	Φ2450×13668	55	Lanzhou
32	Deoxidation segment	1	Φ2750×13668	55	Lanzhou
33	Cold high separate pot	2	Φ2800×(178-4.5) ×6000	139.7	Lanzhou
34	Desorption gas compressor	2			Shenyang
35	New hydrogen compressor	3			Shenyang
36	First air cooler of reactive products	4		11.542	Harbin
37	Second air cooler of	8		26.68	Harbin

	reactive products				
38	Lean Amine feed pump	2	GSG150-360/9S		Dalian
39	Reactor feed pump	2	GSG150-360/12S		Dalian
40	Centrifugal Compressor	2		122.5	Xi'an
41	AV71-12 Axial Flow Compressor	1		122.5	Xi'an
42	AV90-14 Axial Flow Compressor	1		122.5	Xi'an
43	Ammonia compressor	3		12	Beijing
44	Isomerization cycle compressor	2			Wuxi
45	Pre-hydrogenating reactor cycle compressor	2			Wuxi
46	Air cooler of hot high fractional gas	8		24.49	Wuxi
47	Compressor	4		17	Shanghai
48	Pre-hydrogenating reactor feed heat exchanger	2	Φ300×900	26.6	Nanjing
49	Pre-hydrogenating reactor	1	Φ2600×(36+3) ×10600	26.82	Guangdong
50	Dechlorination reactor	1	Φ2600×(36+3) ×10600	26.72	Guangdong
51	Isomerization reactor	1	Φ2400×30 ×13600	26.11	Guangdong
52	Flue gas expander	1			Yangpu

Source: Internal materials of Pan Company

4.3 HREC engineering project HLC material supply logistics project design

4.3.1 Analysis of transport condition

Before the design of detailed logistics project, there must be an analysis of transport condition for different modes of transport according to the conditions of delivery cities, cargo characteristics, conditions of highways, port capacities and etc.

(1) Conditions at reception place:

(a) Conditions of railway delivery: jumping-off points are mostly big or medium cities of China. The highways, railways and railway freight stations in all jumping-off points are all in good condition for the transport of the project equipments. So all equipments adapt to railway transportation should be transported by train (equipments under the first class out-of-gauge degree). The specification of first class out-of-gauge degree of railway transport is shown in figure 4.

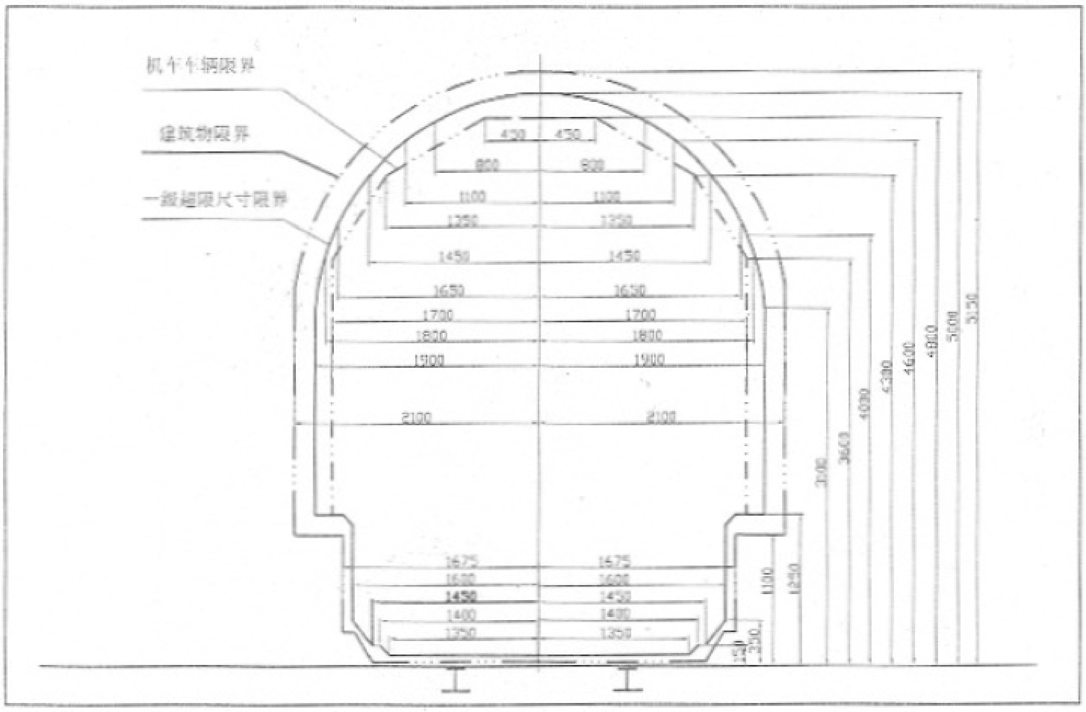

Figure 4 – Specification of first class out-of-gauge degree of railway transport

Source: Yu Changguo. (1998.03) Economist University: "Technics for management of equipments supply for Large-scale Petrochemical Project".

(b) Conditions of waterway delivery: Analyzing from the equipment list, equipments that can't be transported by train are mostly from Dalian, Liao Ning Province and Deyang, Sichuan Province. These equipments have to be transported by the combination of highway and waterway transportation.

All equipments manufactured in China No.1 Heavy-lifting equipments production factory Dalian base are over 400 tons in weight. It is impossible to transport them by train. China No.1 Heavy-lifting equipments production factory Dalian base is located in Dalian cotton island. The factory has its own sea wharf in good condition. It is close from the factory to the wharf. The road linking the factory and wharf is suitable for the transport of heavy-lifting equipments. But there is no crane on the quay. So the loading and discharging of cargoes have to use floating crane or apply ro-on/ro-off model.

China No.2 heavy-lifting equipment production factory which is located in Deyang, Sichuan Province is another important supplier. The factory has its own railway. But most of the equipments needed are not available for railway transportation. Therefore, equipments manufactured in Deyang are transported to Le Shan all by large trailers. Then, making use of huge quay crane in Le Shan port, the equipments will be transferred to river vessels and transported to Shanghai along Yangtze River. After the transshipment in Shanghai, they will be shipped to Yangpu harbor in Hainan Province by sea.

(3) Conditions at the delivery place:

(a) Conditions of loading & discharging with railway delivery: At present, Guangdong-Hainan Railway has been opened to traffic. Hainan Zhan Zhou Station is the nearest railway station to the construction site (about 75 kilometers). But the road connecting Zhan Zhou railway station and highway is still under construction. So Zhan Zhou railway station is not a suitable place for discharging. Another big railway station suitable for HLC discharging is Hai Kou South Station. This station has 20-ton gantry crane. And it directly connects with the west line of Hainan speedway to Yangpu Development Area. The road condition is very well.

Zhan Jiang is one of the biggest coastal cities of Guangdong Province. It has good infrastructures of port and railway facilities so that it is very convenient to organize the loading, discharging and storage of heavy-lifting equipments. Therefore, it is better to establish an equipment storage & distribution center in Zhan Jiang in order to arrange an in-time delivery of equipments and effective delivery control.

Equipments arriving Zhan Jiang can be transported to Hai An Port by highway and then be ferried across Qiong Zhou Straits to Xiu Ying Port or Xin Port in Hai Kou for discharging. All wharfs on both sides of Qiong Zhou Straits are equipped with tides adjusting platform for ro-ro discharging which is convenient for the trailers' up and down the vessel. Meanwhile, the ferries operate between Qiong Zhou Straits are designed for cargoes and trailers calculated together 4.8 meters maximum in height, 4.8 meters maximum in width and 200 tons maximum in weight.

Highways from Xin Port and Xiu Ying Port to Yangpu construction site are all A Class highways and speedways. Cloverleaf junctions passed are all over 4.8 meters in height. Therefore, all the highways meet the requirement of transportation.

(b) Conditions of loading & discharging with waterway delivery: There is no exclusive wharf for the construction of Hainan Refinery extending constructing engineering project. Therefore, Yangpu harbor which is 7 kilometers from the construction site is the best one to choose as the port of discharging. Yangpu harbor has 6 berths now, including one 3,000-ton work ship berth, two 20,000-ton multi-purpose berths, two 35,000-ton multi-purpose berths, one 35,000-ton container berth and other affiliated establishments. The sea-route of Yangpu harbor is 9.2 meters deep and 150 meters wide. 30,000-ton vessels can navigate freely on this sea-route. The depth of water satisfies the requirement of the navigation of HLC vessels and the operation of floating crane. The maximum lifting capability of general cargo wharf is only 40 tons. For equipments under 40 tons, we should use wharf's multipurpose gantry crane to discharge the cargo and load them to trailers. For equipments exceed 40 tons, we can apply ro-on/ro-off model or use floating crane, derrick crane or crawler crane to discharge and load. The wharf is a caisson gravity wharf. The stacking capacity is $3t/m^2$ for the quay and $6t/m^2$ for the yard which meet the requirement of ro-on/ro-off model.

On the road from Yangpu harbor to the construction site, there is no bridge and the pavement is all bitumen which satisfies the requirement of transportation. However, some parts of the highway need to be rebuilt to allow the over-length cargoes to pass.

4.3.2 Equipment analysis and transport arrangement

4.3.2.1 Equipment analysis and transport arrangement of heavy-lifting equipments produced in China No.1 Dalian base

Table 13 – List of heavy-lifting equipments produced in China No.1 Dalian Base

Number	Name	Quantity	Size（mm）	Unit weight（ton）	Delivery time
1	Hydrogenation reactor A	2	Φ4600×12000（T/T）	607	07-6-30
2	Hydrogenation reactor B	2	Φ4600×15400（T/T）	717	07-7-30
3	Hydrogenation purified reactor	1	Φ3800×13500（T/T）	449	07-8-15
4	Hydrogenation cracking reactor	1	Φ3800×15560（T/T）	531	07-8-15

Source: Internal materials of Pan Company

As is shown in the equipments list provided by Hainan Project in table 13, there are 6 equipments manufactured in DL Base. They are the heaviest 6 pieces among all equipments in Hainan Engineering Project. The heaviest one of them reaches 717 tons in weight while the lightest reaches 499 tons and all equipments are of concentrated weight. As per the experiences, the diameters shown in the table should be the inner diameters. Considering that the equipments are all very heavy, the thickness of equipments' layer is expected to be 350mm. Therefore, the figure of diameters should increase 700mm and the size of envelopes and bases should add to the length of equipments. The length should increase 4500mm. Figure of weight in the table doesn't include the base's weight. So the actual weight should increase 40 tons each if every base is considered to be 10 tons. In view of safety, the size and weight should use the figures in table 14.

Table 14 – Sizes and weights of equipments (designing parameters of logistics project)

Number	Name	Quantity	Size (mm)	Unit weight (ton)
1	Hydrogenation reactor A	2	Φ5300×16500	647
2	Hydrogenation reactor B	2	Φ5300×19900	757
3	Hydrogenation purified reactor	1	Φ4500×18000	489
4	Hydrogenation cracking reactor	1	Φ4500×20060	571

After understanding and analyzing the characteristics of this batch of equipments, the transport arrangement of the 6 equipments is proposed according to the delivery schedule. The 1st batch of transport is 2×647-ton hydrogenation reactors on June 30th, 2007; the 2nd batch are 2×757-ton hydrogenation reactors on July 30th, 2007; and the 3rd batch are one hydrogenation purified reactor of 489 tons and hydrogenation cracking reactor of 571 tons on August 15th, 2007.

4.3.2.2 Equipment analysis and transport arrangement of heavy-lifting equipments produced in China No.2 Deyang base

As is shown in the equipments list provided by Hainan Project in Table 15, there are 7 equipments manufactured in Deyang Base.

Table 15 – List of heavy-lifting equipments produced in China No.2 Deyang Base

Number	Name	Quantity	Size（mm）	Unit weight （ton）	Delivery time
1	Recycle hydrogen desulphurization tower	2	Φ2000×19200	172	07-11-15
2	Recycle hydrogen compressor entrance drip pot	2	Φ2400×5000	102.3	07-11-15
3	Hot high fractional pot	2	Φ4600×10500	162	07-08-15
4	Hot high pressure separator	1	Φ3600×7920	240	07-10-25

Source: Internal materials of Pan Company

The equipment characteristics of this batch are also analyzed before logistics project design in order to find the transportation mode and transport route according to the sizes, weights and shapes of various equipments.

As the 2nd largest manufacturer of heavy-lifting equipments of HREC engineering project, China No.2 Deyang Base supplies 7 equipments of over 100 ton each, which are also concentrated weight. Based on the same reason with Dalian Base, I moderately adjust the sizes and weights of equipments manufactured by Deyang Base which are shown in table 16.

Table 16 – Sizes and weights of equipments (designing parameters of logistics project)

Number	Name	Quantity	Size（mm）	Unit weight（ton）
1	Hot high fractional pot	2	Φ2400×23700	182
2	Hot high pressure separator	1	Φ2800×9500	260
3	Recycle hydrogen compressor entrance drip pot	2	Φ5000×1500	122.3
4	Recycle hydrogen desulphurization tower	2	Φ4000×12420	192

After understanding and analyzing the characteristics of this batch of equipments, the transport arrangement of the 7 equipments is also proposed according to the delivery schedule. The 1st batch of transport is two hot high fractional pots with gross weight of 364 tons on August 15th, 2007; the 2nd batch is one 260-ton hot high pressure separator on October 25th , 2007; and the last batch are four equipments which should be delivered on November15th, 2007, there are two recycle hydrogen compressor entrance drip pots and two recycle hydrogen desulphurization towers with the overall weight of 626.6 tons.

4.3.2.3 Equipment analysis and transport arrangement of heavy-lifting equipments produced in other places

Apart from 13 oversize, overweight and over-limit equipments produced in China No.1 and 2 Bases, the initial reported list of HREC project also include 82 equipments manufactured in and shipped from many other places such as Lanzhou, Shenyang, Fushun, Harbin, Xi'an, Beijing, Nanjing, Shanghai and Guangdong. Their weights are mostly below 100 tons, however there are comparative heavy equipments, among which the heaviest one is the 173-ton recycle hydrogen desulphurization tower B produced in Fushui, Liaoning Province and the lightest one are 2×7-ton separators also produced there. Therefore, these equipments from such production places could be transported by railway, and can be divided railway transport of general cargoes and overlimit cargoes in view of their shapes and sizes.

Appendix 1 shows the transport arrangement based on the delivery schedule of equipments.

4.3.3 Design of transport route

4.3.3.1 Transport route design of equipments manufactured in China No.1 Dalian Base

After thoroughly understanding and carefully analyzing of the characteristics and transport arrangement of the equipments manufactured in China No.1 Dalian Base, the study will begin to design the transport route scheme of this batch of heavy-lifting equipments.

Since all the equipments manufactured in China No.1 base are over 400 ton in weight, huge in volume while height and width exceeding the "Boundary Dimensions of Railway 1st Class Exceeding Limits", they are not able to be transported by railways. So waterways or highways are proposed to be chosen for the equipments' transportation.

As per the characteristics of this batch of equipments and the analysis of the conditions of starting points, destination's wharfs and transport highways, two transport route schemes are proposed as follows:

DL Scheme 1:

Equipment received at No.1 Dalian factory-----Dalian Cotton Island Wharf-----Cotton Island Warf loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

DL Scheme 2:

Equipment received at No.1 DaLian factory-----DaLian Cotton Island Wharf-----Cotton Island Warf loading, on ocean vessel-----Tianjin New Harbor-----Tianjin New Harbor discharging-----Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

4.3.3.2 Transport route design of equipments manufactured in China No.2 Sichuan Deyang Base

After thoroughly understanding and carefully analyzing of the characteristics and transport arrangement of the equipments manufactured in China No.2 Sichuan Deyang Base, the study will begin to design the transport route scheme of this batch of heavy-lifting equipments.

Although there is a line of leased railway in China No.2 Sichuan Deyang Base, it is impossible to transport this batch of equipments by this leased railway line because the height and width of this batch of equipments also exceed the "Boundary Dimensions of Railway 1st Class Exceeding Limits". All equipments in this manufacturing place are over 100 tons in weight and very large in volume. As per the limitations mentioned above, the transportation of this batch of equipments is proposed by the using of waterways or highways.

As per the characteristics of this batch of equipments and the analysis of the conditions of starting points, destination's wharfs and transport highways, two transport route schemes are proposed as follows:

DY Scheme 1:

Equipment received at No.2 Deyang factory-----Sichuan Leshan wharf-----Leshan wharf loading, on river boat-----Shanghai Harbor-----transshipment (from river boat to ocean vessel)-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

DY Scheme 2:

Equipment received at No.2 Deyang factory-----Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

4.3.3.3 Transport route design of equipments manufactured in other places of manufacture

After thoroughly understanding and carefully analyzing of the characteristics and transport arrangement of the equipments manufactured in Lanzhou, Shenyang, Fushun, Harbin, Xian, Beijing, Wuxi, Nanjing, Shanghai, Guangdong. The paper will begin to design the transport route scheme of this batch of heavy-lifting equipments.

OP Scheme 1:

As per the principle of providing an economic, reasonable, safe, reliable, and timely delivery logistics service, it is proposed to establish an assembly center in Zhanjiang to co-ordinate the railway transport operation. Zhanjiang is a large coastal city in Guangdong Province. It has good port and railway infrastructures for the multiple organizations of handling and storage of cargoes arrived.

For the factories who have their leased railway lines, it is proposed that the equipments shall be loaded on the freight train at the leased railway lines and then transported to Guangdong Zhanjiang. For those who don't have a leased railway line, it is proposed that the equipments shall be loaded on the trucks at their factories then transported to local railway freight station and transferred to freight train for the further transportation to Zhanjiang.

Equipments discharged in Zhanjiang should be loaded on trucks and road transported to port of Haian in Guangdong Province, then ferry to Haikou New Harbor and finally delivered at construction site of HREC engineering project.

OP Scheme 2:

As per the principle of providing an economic, reasonable, safe, reliable, and timely delivery logistics service, it is proposed that equipments manufactured in Lanzhou, Shenyang, Fushun, Harbin, Xian, Beijing, Wuxi, Nanjing, Shanghai, Guangdong shall be transported by the manufacturers' leased railway line or from the local freight railway station directly to Haikou South Railway Station, crossing Qiongzhou Strait through Guangdong-Hainan Railway and then transferred to road transportation, delivery at construction site of HREC engineering project.

Haikou South Railway Station is a large rail freight station equipped with 20-ton gantry crane and with direct road access to West line of Hainan expressway connecting Yangpu Developing Zone. Road condition is good and meets the requirement of the transportation of equipments.

4.3.4 Design of conveyance

First of all, the study shall analyze the special purpose vehicles and general marine vessels owned by Pan Company before designing the transport schemes. Pan Company is specialized in project logistics service and owns many specialized and technically advanced heavy cargo vehicles. As is shown in table 17, Pan Company owns 25 heavy cargo vehicles totally. 14 of them are heavy duty tractors with different traction capabilities ranging from 200 tons to 300 tons. 4 of them are heavy duty trailers with maximum carrying capacity of 500 tons. It also owns 2 over-length cargo trucks with maximum carrying capacity of 1000 tons and 4 low platform trailers with maximum carrying capacity of 200 tons. The most advanced and newest of them is the 72 axes self-propelled trailer purchased from German. All those tractors, trucks and trailers are owned by Pan Company. Except the self-propelled trailer's safety speed is limited under 30 km/h, all tractors, trucks and trailers' maximum speed can reach 100 km/h. These conveyance are main force of Pan Company's carrying capacity.

Table 17 – Diameters of Pan Company's special purpose vehicles

Type	Brand	Number	Main Parameter	Driving Mode	Maximum Safety Operational Speed
72 axes self-propelled flat trailer	SCHEUERLE	1	Maximum traction capability 2300 ton	2×PPU driving platform	30 km/h
low platform trailer	SCHEUERLE	4	Maximum traction capability 200 ton	6×6	100 km/h
over-length cargo truck	SCHEUERLE	2	Maximum traction capability 1000 ton	16×16	100 km/h
heavy duty trailer	SCHEUERLE	4	Maximum traction capability 500 ton	8×8	100 km/h
heavy duty tractor	William TG300	6	Maximum traction capability 300 ton	8×8	100 km/h
heavy duty tractor	Benz 4160	2	Maximum traction capability 250 ton	8×4	100 km/h
heavy duty tractor	IVECO	2	Maximum traction capability 250 ton	6×6	100 km/h
heavy duty tractor	Benz 4861	2	Maximum traction capability 300 ton	8×8	100 km/h
heavy duty tractor	Benz 3850	2	Maximum traction capability 200 ton	6×6	100 km/h

Source: Internal materials of Pan Company

As per table 18, flat barges are main water carrying capacities of Pan Company. There are totally 8 flat barges owned by Pan Company. They are H5001, H3001, H3002, H1001 flat barge. Each type has 2 barges. The main parameters are shown in table 18.

Table 18 – Diameters of Pan Company's barges

Type	No.	DWT	Main Parameters (m)			Fully Laden Draft	Cargo Area		Maximum DWT per Square Meter (ton/m^2)
			Loa	Beam	Depth		Length (m)	Width (m)	
H5001 flat	2	5000t	90.30	22.10	4.42	4.00	72	19	Strengthen area: 21

barge									Non-strengthen area: 8
H3001 flat barge	2	3000t	67.10	18.30	4.27	3.56	55	16	Strengthen area: 12 Non-strengthen area: 5
H3002 flat barge	2	3000t	60.35	20.00	4.30	3.30	42	18	Strengthen area: 8 Non-strengthen area: 5
H1001 river barge	2	1000t	65.11	18.82	4.20	3.33	54	16	Strengthen area: 4 Non-strengthen area: 2

Source: Internal materials of Pan Company

4.3.4.1 Design of conveyance of equipments manufactured in China No.1 Dalian Base

There are two schemes proposed for China No.1 Dalian Base. Both of them adopted the transportation method with the combination of sea transport and road transport. The difference is that scheme 1 used the land-sea-land model while scheme 2 used the land-sea-land-sea-land model. The route of scheme 2 is more complex than scheme 1. All land transport should choose highways and Pan Company's trailers or tractors because this batch of equipments exceeds the "Boundary Dimensions of Railway 1st Class Exceeding Limits".

Based on the two schemes' design of transport route, the conveyance for these two schemes is designed as follows:

DL Scheme 1:

Equipment received at No.1 Dalian factory-----Dalian Cotton Island Wharf-----Cotton Island Warf loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

This scheme applied the model of land-sea-land with the concentration on sea transportation. The land transportation includes road transportation from China No.1 factory to Dalian Cotton Island Wharf and from Hainan Yangpu Harbor to construction site of HREC engineering project. Distance from China No.1 factory to Dalian Cotton Island Wharf is 500 meters. Distance from Hainan Yangpu Harbor to construction site is 6982 meters. Both of them are short distance road transportation. The water transportation includes HLC ocean transportation from Dalian Cotton Island Wharf to Hainan Yangpu Harbor. The waterway transportation distance is 1833 nautical miles (nm).

There are totally 6 equipments manufactured in China No.1 Dalian Base. They are 2 × A type hydrogenation reactors (single weight 607 tons), 1 × B type hydrogenation reactors (single weight 717 tons), 1 × hydrogenation refining reactors (single weight 449 tons) and 1 × hydrogenation cracking reactors (single weight 531 tons). After the security analysis, the expected safety guaranteed weights are 647 tons, 757 tons, 489 tons and 571 tons respectively. Analyzing according to the equipments' weight and the type of heavy duty vehicles of Pan Company, there are three types of heavy duty vehicles that can apply in this scheme. They are 72 axes self-propelled flat trailer (maximum carrying capacity 2300 tons), over-length cargo trucks (maximum carrying capacity 1000 tons) and heavy duty trailer (maximum carrying capacity 500 tons). The different combinations of all these types of heavy duty vehicles can be applied to scheme 1 for the short distance road transportation. Additionally, the 500-ton heavy duty trailer can only be used to transport the 449-ton hydrogenation refining reactor because of the limitation of its carrying capacity.

Referring to the choice of ocean shipping vessels, it not only depends on the cargo's weight and size but also lies on the handling method and port choice applied in the scheme. The most popular and economic type of vessels applied in the HLC seaway transportation, especially the large-scale engineering project heavy-lifting equipments' seaway transportation, is flat barge. The carrying capability of flat barge mainly depends on the loading capacity of the strengthen area and non-strengthen area of the barge's deck. As a result, 5000-ton flat barge is more suitable for the long distance ocean transportation and great weight heavy-lifting equipments. Referring to the weight of the equipments manufactured in China No.1 Dalian Base and parameters of Pan Company owned huge flat barges, it is proposed to apply the 5000-ton flat barge in this scheme for the heavy-lifting equipments' ocean transportation.

DL Scheme 2:

Equipment received at No.1 DaLian factory-----DaLian Cotton Island Wharf-----Cotton Island Warf loading, on ocean vessel-----Tianjin New Harbor-----Tianjin New Harbor discharging-----Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

This scheme applied the model of land-sea-land-sea-land with the concentration on land transportation. It is more complex than the first scheme. The land transportation includes the short distance heavy-lifting equipments transportation from China No.1 Dalian Base to Dalian Cotton Island wharf and from Yangpu Harbor to construction site of HREC project and the long distance heavy-lifting equipments transportation from Tianjin New Harbor to Guangdong Zhanjiang Harbor. The distance from Tianjin New Harbor to Guangdong Zhanjiang Harbor is very long. According to the requirement in “highway constructing technique standard” which is the standard for choosing HLC transport highways, national highways are the best choice to meet the requirements. Here, in this scheme, it is proposed to choose national highway No.103 (from Tianjin New Harbor to Beijing), No.106 (from Beijing to Guangzhou), and Guangzhou Zhanjiang section of No.325 (from Guangzhou to Zhanjiang) as the highways for transportation. The total transport distance reaches 3128 km and the transport route covers Beijing, Tianjin and provinces of Hebei, Henan, Shandong, Hubei, Hunan and Guangdong. The waterway transportation includes short distance ocean transportation from Dalian Cotton Island wharf to Tianjin New Harbor and from Guangdong Zhanjiang Harbor to Hainan Yangpu Harbor. The distance is 242 nm and 166nm respectively.

In view of the equipment weight and distance of road transport, it is proposed to apply the combination of 72 axes self-propelled flat trailer, 1000-ton over-length cargo truck and 500-ton heavy duty trailer in this scheme. For further consideration of the delivery time of this batch of equipments, high speed vehicles are preferred in the long distance road transportation. So the combination of 1000-ton over-length truck and 500-ton heavy duty trailer are preferred for the Tianjin New Harbor to Guangdong Zhanjiang transport.

The seaway transportations of this scheme are all short distance coastal sea transport. Therefore, 3000-ton or 5000-ton flat ocean barges are initially proposed to be applied in this scheme.

After the design of the means of transportation for the equipment manufactured in China No.1 Dalian Base, the proposed logistics schemes for the transportation of heavy-lifting equipments manufactured in China No.1 Dalian Base are summed as follows:

DL Scheme a:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 500 meters short distance road transport to Dalian Cotton Island Wharf-----Cotton Island Warf loading, on 5000-ton flat ocean barge-----1833 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck.

DL Scheme b:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500 meters short distance road transport to Dalian Cotton Island Wharf by 72 axes self-propelled flat trailer-----Cotton Island Warf loading, on 5000-ton flat ocean barge-----1833 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

DL Scheme c:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 500 meters short distance road transport to Dalian Cotton Island Wharf-----Cotton Island Warf loading, on 3000-ton flat ocean barge-----242 nm near-sea shipping to Tianjin New Harbor-----Tianjin New Harbor discharging-----3128km long distance road transportation to Guangdong Zhanjiang Harbor by the combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck-----Zhanjiang Harbor loading, on 3000-ton flat ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by the combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck.

DL Scheme d:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500 meters short distance road transport to Dalian Cotton Island Wharf by 72 axes self-propelled flat trailer-----Cotton Island Warf loading, on 3000-ton flat ocean barge-----242 nm near-sea shipping to Tianjin New Harbor-----Tianjin New Harbor discharging-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 3128km long distance road transportation to Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on 3000-ton flat ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

4.3.4.2 Design of conveyance of equipments manufactured in China No.2 Sichuan Deyang Base

Comparing with those manufactured in China No.1 Dalian Base, the equipments manufactured in China No.2 Sichuan Deyang Base are much lighter. But they are still HLC with concentrated weight. Also, there are two schemes of transport route proposed for this batch of equipments. They are as follows:

DY Scheme 1:

Equipment receipt at No.2 Deyang factory-----Sichuan Leshan wharf-----Leshan wharf loading, on river boat-----Shanghai Harbor-----transshipment (from river boat to ocean vessel)-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

This scheme is a combined river and sea transportation. Except the two sections of land transportation from the reception place to the departure port and from the destination port to the delivery place (210 km between China No.2 Deyang Base and Sichuan Leshan wharf, 6982 m between Hainan Yangpu Harbor and construction site), all other process of transport is waterway transport, which includes 2404 km shipping through Yangtze river from Sichuan Leshan wharf to port of Shanghai and 1072 nm near-sea shipping from port of Shanghai to Hainan Yangpu Harbor. Total waterway distance reaches 4389 km.

There are totally 7 heavy-lifting equipments manufactured in China No.2 Deyang Base. Although the single weight of each equipment is much lighter than equipments in Dalian, they are also of concentrated weight. After safety estimation, the heaviest equipment should be 260 ton. So 300-ton heavy duty tractor, 1000-ton over-length cargo truck and 72 axes self-propelled flat trailer are all suitable to this scheme.

For the freshwater shipping from Sichuan Leshan wharf to port of Shanghai, it is proposed to use 1000-ton river barge. For the long distance ocean shipping from port of Shanghai to Yangpu Harbor, It is proposed to use 5000-ton ocean barge in this scheme.

DY Scheme 2:

Equipment received at No.2 Deyang factory-----Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on ocean vessel-----Hainan Yangpu Harbor-----Yangpu Harbor discharging-----delivery at construction site of HREC project.

This scheme consists of long distance road transportation, then a short distance ocean shipping and a short road transportation. It is proposed to apply the combination of 300-ton heavy-tractor and 3000-ton ocean barge for the means of transport in this scheme.

After the design of the means of transportation for the equipment manufactured in China No.2 Sichuan Deyang Base, the proposed logistics schemes for the transportation of heavy-lifting equipments manufactured in China No.2 Sichuan Deyang Base are summed as follows:

DY Scheme a:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 300-ton heavy duty tractor-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 300-ton heavy duty tractor.

DY Scheme b:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 1000-ton over-length cargo truck-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 1000-ton over-length cargo truck.

DY Scheme c:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 72 axes self-propelled flat trailer-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

DY Scheme d:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----long distance road transportation to Guangdong Zhanjiang Harbor by 300-ton heavy duty tractor-----Zhanjiang Harbor loading, on 3000-ton ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 300-ton heavy duty tractor.

4.3.5 Design of means of port handling

Normally, there are two models for the port handling of HLC transportation. They are lift-on, lift-off model and ro-on, ro-off model respectively. Furthermore, as per the different handling equipments used in the port handling, lift-on, lift-off model can be divided into shore crane model and floating crane model. Among these models, floating crane model can be applied in the widest situation. It can adopt different water area and port condition. Meanwhile, the cost of floating crane model is the most expensive. The use of shore crane model depends on the port infrastructures. Whether the shore cranes equipped on the loading port or discharging port has enough loading capabilities is the decisive factor of choosing this model. Ro-on, ro-of model is the most commonly used and convenient port handling model for HLC transportation. The advantage of this model is time-saving, efficient and economic. The factors affecting the choice of this model are the port's quay conditions, drafts of chosen type of vessels and the capability of adjusting the vessel's draft when doing cargo handling.

For the HREC project, in order to achieve the most economic and efficient process of port handling, all ports' handling work are proposed to use ro-on, ro-off model except in Leshan Wharf and for the transshipment in port of Shanghai. In Leshan Wharf, there equipped gantry cranes of sufficient loading capability and for the transshipment in Shanghai port, choosing a floating crane is the most efficient method.

4.3.6 Design of the overall project

After all the above process, the final result is that there are both four schemes proposed for the equipments manufactured in China No.1 Dalian Base and China No.2 Sichuan Deyang Base and two schemes proposed for the equipments manufactured in other places. The summary details are shown as below:

Schemes designed for equipments manufactured in China No.1 Dalian Base:

DL Scheme a:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 500 meters short distance road transport to Dalian Cotton Island Wharf-----Cotton Island Warf loading, on 5000-ton flat ocean barge-----1833 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck.

DL Scheme b:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500 meters short distance road transport to Dalian Cotton Island Wharf by 72 axes self-propelled flat trailer-----Cotton Island Warf loading, on 5000-ton flat ocean barge-----1833 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

DL Scheme c:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 500 meters short distance road transport to Dalian Cotton Island Wharf-----Cotton Island Warf loading, on 3000-ton flat ocean barge-----242 nm near-sea shipping to Tianjin New Harbor-----Tianjin New Harbor discharging-----3128km long distance road transportation to Guangdong Zhanjiang Harbor by the combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck-----Zhanjiang Harbor loading, on 3000-ton flat ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by the combination of 500-ton heavy duty trailer and 1000-ton over-length cargo truck.

DL Scheme d:

Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500 meters short distance road transport to Dalian Cotton Island Wharf by 72 axes self-propelled flat trailer-----Cotton Island Warf loading, on 3000-ton flat ocean barge-----242 nm near-sea shipping to Tianjin New Harbor-----Tianjin New Harbor discharging-----500-ton heavy-duty trailer for hydrogenation refining reactor (449 tons), 1000-ton over-length cargo truck for another 5 equipments, 3128km long distance road transportation to Guangdong Zhanjiang Harbor-----Zhanjiang Harbor loading, on 3000-ton flat ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

Schemes designed for equipments manufactured in China No.2 Sichuan Deyang Base:

DY Scheme a:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 300-ton heavy duty tractor-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 300-ton heavy duty tractor.

DY Scheme b:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 1000-ton over-length cargo truck-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 1000-ton over-length cargo truck.

DY Scheme c:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 72 axes self-propelled flat trailer-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer.

DY Scheme d:

Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----long distance road transportation to Guangdong Zhanjiang Harbor by 300-ton heavy duty tractor-----Zhanjiang Harbor loading, on 3000-ton ocean barge-----166nm shipping across Qiongzhou Strait to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 300-ton heavy duty tractor.

Schemes designed for equipments manufactured in other places:

OP Scheme 1:

Establish an assembly center in Zhanjiang to co-ordinate the railway transport operation.

For the factories who have their leased railway lines, it is proposed that the equipments shall be loaded on the freight train at the leased railway lines and then transported to Guangdong Zhanjiang. For those who don't have a leased railway line, it is proposed that the equipments shall be loaded on the trucks at their factories then transported to local railway freight station and transfer to freight train for the further transportation to Zhanjiang.

Equipments discharged in Zhanjiang should be loaded on trucks and road transported to port of Haian in Guangdong Province, then ferry to Haikou New Harbor and finally delivered at construction site of HREC project.

OP Scheme 2:

Equipments manufactured in Lanzhou, Shenyang, Fushun, Harbin, Xian, Beijing, Wuxi, Nanjing, Shanghai, Guangdong shall be transported by the manufacturers' leased railway line or from the local freight railway station directly to Haikou South Railway Station, crossing Qiongzhou Strait through Guangdong-Hainan Railway and then transfer to road transportation, delivery at construction site of HREC project.

According to the above 10 schemes, 32 different logistics projects are concluded for heavy-lifting equipments supply of HREC Engineering Project by means of combining schemes designed for a certain manufacturing place with those for another manufacturing place. Figure 5 will guide you to understand it more clearly.

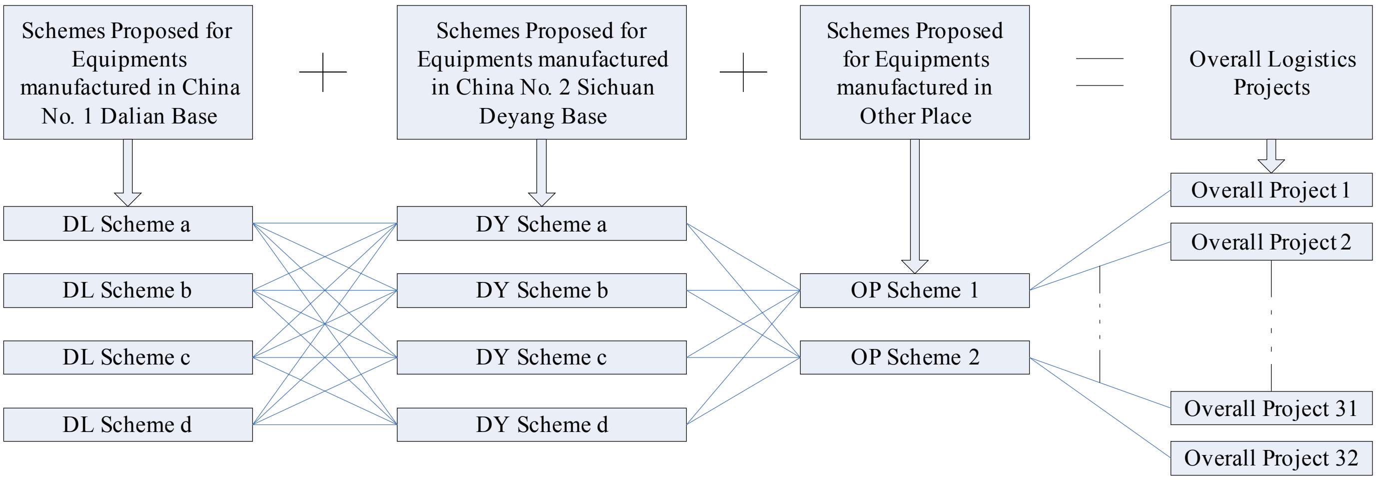

Figure 5 – The process of forming overall logistics projects

4.3.7 Evaluation and selection of heavy-lifting equipments supply logistics projects designed for HREC engineering project

4.3.7.1 The initial selection of logistics projects

This section applies the method of questionnaire in order to evaluate each of the 32 different logistics projects and make an initial selection among all the proposed projects.

The participants of this questionnaire are all experts and engineers in the project logistics field of China. Among them, three important persons should be mentioned here. They are chief engineer of the project logistics department of Pan Company, chief designer of heavy-lifting department of Shanghai Port Container Co. Ltd. and chief engineer of HREC Engineering Project. All ten copies of the questionnaire papers are carefully and seriously finished. The questionnaire survey is meaningful to the selection and very successful.

The questionnaire includes eleven evaluation factors concerning three aspects of rationality of the logistics project, economic of the logistics project and integral harmony of the logistics project. Every evaluation factor was graded by the experts according to the 1～10 grading standard. As is shown in table 19, the meaning and specification of 11 evaluation factors are important.

Table 19 – Specifications of 1 ~ 10 grading standard for the questionnaire

Rationality Evaluation of the Project		
No.	Evaluation Factors	Specifications
1	Rationality of the Choice of Routes	Evaluating the degree of the feasibility of transport route and transport links.
2	Rationality of the Choice of transshipment and cargo loading & discharging ports	Evaluating the handling capability of the chosen HLC port for equipments loading, discharging and transshipment.
3	Rationality of the Choice of Conveyance	Evaluating the degree of the demand satisfying of the chosen conveyance and the elasticity of conveyance’s speed
4	Rationality of the Choice of port handling methods	Evaluating the feasibility and the degree of demand satisfying of the chosen handling equipments.

Economic Evaluation of the Project		
No.	Evaluation Factors	Specifications
1	Economical Efficiency of the Choice of Routes	Evaluating the effect of the choice of route and distance on the overall logistics project's cost.
2	Economical Efficiency of the Choice of Conveyance	Evaluating the effect of the choice of conveyance on the overall logistics project's cost.
3	Economical Efficiency of the Choice of port handling methods	Evaluating the effect of the choice of port handling method on the overall logistics project's cost.
4	Economical Efficiency of the Combination of schemes in a logistics project	Evaluating the effect of the combination of schemes on the overall logistics project's cost.
Integral Harmony Evaluation of the Project		
No.	Evaluation Factors	Specifications
1	Harmony between the Choice of Conveyance and Routes	Evaluating the degree of matching between the choice of conveyance and route.
2	Harmony between port handling methods and Conveyance	Evaluating the degree of matching between the choice of port handling methods and Conveyance.
3	Harmony between Logistics Project and Construction Project	Evaluating the degree of matching between Logistics Project and Construction Project.

As a result, three logistics projects which got the highest marks were chosen for the further selection. They are as follows:

Overall project 11: the combination of DL Scheme b, DY Scheme c and OP Scheme 1. This project got the point of 93. For the convenience of the explanation, it is called "Project A" in the further selection process.

Overall project 17: the combination of DL Scheme c, DY Scheme a and OP Scheme 1. This project got the point of 88. For the convenience of the explanation, it is called "Project B" in the further selection process.

Overall project 18: the combination of DL Scheme c, DY Scheme b and OP Scheme 1. This project got the point of 91. For the convenience of the explanation, it is called "Project C" in the further selection process.

For the detailed contents and results of this questionnaire, please refer to Appendix 1.

4.3.7.2 Final selection of the logistics project

This section applies the AHP method to select the optimistic logistics project among the three selective projects A, B and C. After the enquiry of the experts and engineers in the project logistics field in China, I got the scales for each factors and compared the alternatives and criteria in pairs with respect to each element of the next higher level as for certain attribute and conduct the level unit rank and overall rank. The process of conducting the level unit rank and overall rank is done by the Microsoft EXCEL. The detailed information about the AHP model and the calculation process is in Appendix 2.

As per the calculation, the final result of the project selection is calculated out. According to the overall rank, "Project A" got the highest, which means "Project A" is the optimal logistics project for HREC engineering project.

As a result, after the initial selection by questionnaire method and the final selection by

AHP method, the optimal logistics project of HREC engineering project is deduced to the following details:

The optimal logistics project of HREC engineering project is: (1) For Dalian base: Equipment receipt on heavy duty vehicles at No.1 Dalian factory-----500 meters short distance road transport to Dalian Cotton Island Wharf by 72 axes self-propelled flat trailer-----Cotton Island Warf loading, on 5000-ton flat ocean barge-----1833 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer. (2) For Sichuan Deyang base: Equipment receipt on heavy duty vehicles at No.2 Deyang factory-----210 km road transportation to Sichuan Leshan wharf by 72 axes self-propelled flat trailer-----Leshan wharf loading, on 1000-ton river barge-----2404 km freshwater shipping to port of Shanghai along Yangtze river by 1000-ton river barge-----transshipment (from 1000-ton river barge to 5000-ton ocean barge)-----1072 nm near-sea shipping to Hainan Yangpu Harbor-----Yangpu Harbor discharging-----6982m road transport to construction site of HREC project for delivery by 72 axes self-propelled flat trailer. (3) For other places: Establish an assembly center in Zhanjiang to co-ordinate the railway transport operation. For the factories who have their leased railway lines, I proposed that the equipments shall be loaded on the freight train at the leased railway lines and then transported to Guangdong Zhanjiang. For those who don't have a leased railway line, I proposed that the equipments shall be loaded on the trucks at their factories then transported to local railway freight station and transfer to freight train for the further transportation to Zhanjiang. Equipments discharged in Zhanjiang should be loaded on trucks and road transported to port of Haian in Guangdong Province, then ferry to Haikou New Harbor and finally delivered at construction site of HREC engineering project.

Chapter 5 Conclusion

This research paper is a sufficient investigation, research and understanding of the designing method of logistics project for national large-scale engineering construction. With a deep research on the Pan Company's heavy-lifting logistics services, conveyance equipments, technical advantages, transport networks and other resources, the paper applies the method of expert questionnaire and AHP analysis to the design and selection of the heavy-lifting equipments supply logistics project for HREC.

This paper briefly introduces the HLC logistics service of Pan Company, the outstanding achievements of the HLC logistics service and the competitive advantages of Pan Company in the HLC transport field.

A method for designing the equipments supply logistics project for large-scale petrochemical engineering project is established in this research paper. With sufficient research on the international and domestic project logistics, expert questionnaire and AHP are applied in the designing method of heavy-lifting equipments logistics project. The paper works out the systematic and effective designing process for heavy-lifting equipments logistics project and decision criteria for the evaluation and selection of the project. The study chooses eight decisive criteria from three aspects affecting the harmony, utility and feasibility of the logistics project and established a hierarchical analysis model for heavy-lifting equipments supply project selection of LPP. It also introduced the application of EXCEL for the calculation of AHP model. The new and effective designing method would be helpful to some Chinese heavy-lifting equipments supply logistics service operators.

Furthermore, the paper also applies the systematic designing method established in Chapter 3 to a real case --- HREC engineering project. With the help of the experts and engineers in the project logistics field, according to the systematic designing method, the study proposed 32 alternative logistics projects for the HREC project in this chapter. With the initial selection by expert questionnaire and final selection by AHP model, the paper concluded an optimal logistics project for the HREC engineering project.

The purpose of this research paper is to establish a systematic method of designing the logistic project for large-scale petrochemical construction project for Pan Company and the selection model by evaluation of the project with AHP. I hope it would have some significance and give reference to the HLC transport operators and large-scale petrochemical construction project logistics service providers.

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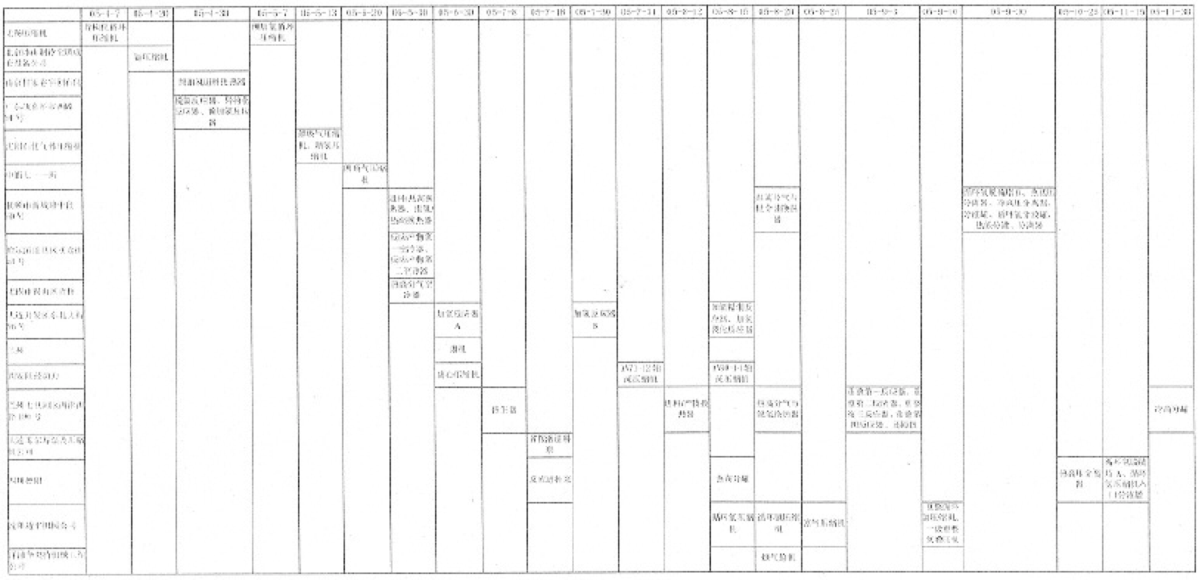
Appendix 1 Delivery timetable of the equipments supply for HREC engineering project



Appendix 2 Experts questionnaire

Evaluation Factors	P1	P2	P3	P4	P5
Rationality Evaluation of the Project					
Rationality of the Choice of Routes	9	8	6	7	8
Rationality of the Choice of transshipment and cargo loading & discharging ports	7	6	7	8	7
Rationality of the Choice of Conveyance	6	8	8	6	8
Rationality of the Choice of port handling methods	8	8	8	8	8
Total Points	30	30	29	29	31
Economic Evaluation of the Project					
Economical Efficiency of the Choice of Routes	7	7	6	8	7
Economical Efficiency of the Choice of Conveyance	8	6	7	6	6
Economical Efficiency of the Choice of port handling methods	9	9	9	9	9
Economical Efficiency of the Combination of schemes in a logistics project	9	7	7	7	8
Total Points	33	29	29	30	30
Integral Harmony Evaluation of the Project					
Harmony between the Choice of Conveyance and Routes	9	8	7	9	7
Harmony between port handling methods and Conveyance	6	6	8	7	8
Harmony between Logistics Project and Construction Project	7	6	8	8	7
Total Points	22	20	23	24	22
Totals	85	79	81	83	83

P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25
6	8	9	8	9	9	9	8	8	8	9	9	8	8	9	7	8	8	8	9
7	6	6	7	8	9	5	6	7	8	8	8	6	8	8	8	8	8	8	7
6	7	6	8	6	8	7	7	6	7	7	8	9	9	6	7	7	8	6	8
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
27	29	29	31	31	34	29	29	29	31	32	33	31	33	31	30	31	32	30	32

8	6	7	7	7	9	6	6	7	7	8	8	8	6	7	7	9	8	9	6
7	7	8	6	6	8	7	8	8	8	6	9	8	7	6	9	6	6	8	9
9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
7	6	6	8	7	7	8	6	7	9	8	8	9	7	7	7	6	7	5	7
31	27	30	30	29	33	30	29	31	33	31	34	34	29	29	32	30	30	31	31

7	6	7	7	8	8	8	7	8	8	8	7	9	6	6	9	5	5	7	6
8	7	5	7	7	9	7	8	8	7	8	6	8	7	7	8	9	6	9	7
8	6	6	8	6	9	7	7	7	8	8	8	9	6	7	7	7	5	9	7
23	19	18	22	21	26	22	22	23	23	24	21	26	19	20	24	21	16	25	20

81	75	77	83	81	93	81	80	83	87	87	88	91	81	80	86	82	78	86	83

P26	P27	P28	P29	P30	P31	P32
9	9	7	8	9	8	8
7	8	8	8	7	8	9
6	8	7	8	8	7	7
8	8	8	8	8	8	8
30	33	30	32	32	31	32
7	9	7	7	7	7	9
6	7	9	7	7	9	7
9	9	9	9	9	9	9
7	6	7	5	7	7	7
29	31	32	28	30	32	32
6	6	7	9	9	7	7
7	9	7	6	6	9	9
5	7	7	7	7	7	7
18	22	21	22	22	23	23
77	86	83	82	84	86	87

Remarks:

Project 1	=	DL Scheme a	+	DY Scheme a	+	OP Scheme 1	
Project 2	=	DL Scheme a	+	DY Scheme b	+	OP Scheme 1	
Project 3	=	DL Scheme a	+	DY Scheme c	+	OP Scheme 1	
Project 4	=	DL Scheme a	+	DY Scheme d	+	OP Scheme 1	
Project 5	=	DL Scheme a	+	DY Scheme a	+	OP Scheme 2	
Project 6	=	DL Scheme a	+	DY Scheme b	+	OP Scheme 2	
Project 7	=	DL Scheme a	+	DY Scheme c	+	OP Scheme 2	
Project 8	=	DL Scheme a	+	DY Scheme d	+	OP Scheme 2	
Project 9	=	DL Scheme b	+	DY Scheme a	+	OP Scheme 1	
Project 10	=	DL Scheme b	+	DY Scheme b	+	OP Scheme 1	
Project 11	=	DL Scheme b	+	DY Scheme c	+	OP Scheme 1	93
Project 12	=	DL Scheme b	+	DY Scheme d	+	OP Scheme 1	
Project 13	=	DL Scheme b	+	DY Scheme a	+	OP Scheme 2	
Project 14	=	DL Scheme b	+	DY Scheme b	+	OP Scheme 2	
Project 15	=	DL Scheme b	+	DY Scheme c	+	OP Scheme 2	
Project 16	=	DL Scheme b	+	DY Scheme d	+	OP Scheme 2	
Project 17	=	DL Scheme c	+	DY Scheme a	+	OP Scheme 1	88
Project 18	=	DL Scheme c	+	DY Scheme b	+	OP Scheme 1	91
Project 19	=	DL Scheme c	+	DY Scheme c	+	OP Scheme 1	
Project 20	=	DL Scheme c	+	DY Scheme d	+	OP Scheme 1	
Project 21	=	DL Scheme c	+	DY Scheme a	+	OP Scheme 2	
Project 22	=	DL Scheme c	+	DY Scheme b	+	OP Scheme 2	
Project 23	=	DL Scheme c	+	DY Scheme c	+	OP Scheme 2	
Project 24	=	DL Scheme c	+	DY Scheme d	+	OP Scheme 2	
Project 25	=	DL Scheme d	+	DY Scheme a	+	OP Scheme 1	
Project 26	=	DL Scheme d	+	DY Scheme b	+	OP Scheme 1	
Project 27	=	DL Scheme d	+	DY Scheme c	+	OP Scheme 1	
Project 28	=	DL Scheme d	+	DY Scheme d	+	OP Scheme 1	
Project 29	=	DL Scheme d	+	DY Scheme a	+	OP Scheme 2	
Project 30	=	DL Scheme d	+	DY Scheme b	+	OP Scheme 2	
Project 31	=	DL Scheme d	+	DY Scheme c	+	OP Scheme 2	
Project 32	=	DL Scheme d	+	DY Scheme d	+	OP Scheme 2	

Evaluation Standards:

Rationality Evaluation of the Project

Point Ranges / Evaluation Factors	Rationality of the Choice of Routes	Rationality of the Choice of transshipment and cargo loading &
1～3	Low feasibility of route, awkward choice of transport link.	Low heavy-lifting cargo port handling capability
4～6	Medium feasibility of route, suitable choice of transport link .	Medium heavy-lifting cargo port handling capability
7～9	High feasibility of route, good choice of transport link.	High heavy-lifting cargo port handling capability
10	Very high feasibility of route, perfect choice of transport link.	Very high heavy-lifting cargo port handling capability

Rationality of the Choice of Conveyance	Rationality of the Choice of port handling methods
Just meet the transport demand, low elasticity of conveyance speed.	Low feasibility, handling equipments just meet the demand.
Meet the transport demand well, medium elasticity of conveyance speed.	Meduim feasibility, handling equipments meet the demand well.
Meet the transport demand very well, high elasticity of conveyance speed.	High feasibility, handling equipments meet the demand very well.
Meet the transport demand perfectly, very high elasticity of conveyance speed.	Very high feasibility, handling equipments meet the demand perfectly.

Economic Evaluation of the Project

Point Ranges / Evaluation Factors	Economical Efficiency of the Choice of Routes	Economical Efficiency of the Choice of Conveyance	Economical Efficiency of the Choice of port handling methods	Economical Efficiency of the Combination of schemes in a logistics project
1～3	The choice of route and distance leads to a relative high cost	The choice of conveyance leads to a relative high cost	The choice of port handling method leads to a relative high cost	The combination of schemes increases the cost.
4～6	The choice of route and distance leads to a relative medium cost	The choice of conveyance leads to a relative medium cost	The choice of port handling method leads to a relative medium cost	The combination of schemes has little effect on the cost.
7～9	The choice of route and distance leads to a relative low cost	The choice of conveyance leads to a relative low cost	The choice of port handling method leads to a relative low cost	The combination of schemes decreases the cost.
10	The choice of route and distance leads to a relative very low cost	The choice of conveyance leads to a relative very low cost	The choice of port handling method leads to a relative very low cost	The combination of schemes decreases the cost dramatically.

Integral Harmony Evaluation of the Project

Point Ranges \ Evaluation Factors	Harmony between the Choice of Conveyance and Routes	Harmony between port handling methods and Conveyance	Harmony between Logistics Project and Construction Project
1～3	Little matching between the choice of conveyance and route.	Little matching between the choice of port handling methods and Conveyance.	Little matching between Logistics Project and Construction Project.
4～6	Moderate matching between the choice of conveyance and route.	Moderate matching between the choice of port handling methods and Conveyance.	Moderate matching between Logistics Project and Construction Project.
7～9	Good matching between the choice of conveyance and route.	Good matching between the choice of port handling methods and Conveyance.	Good matching between Logistics Project and Construction Project.
10	Perfect matching between the choice of conveyance and route.	Perfect matching between the choice of port handling methods and Conveyance.	Perfect matching between Logistics Project and Construction Projecte.

Appendix 3 AHP model calculation process by EXCEL

Optimal logistics project	Harmony between logistics project and engineering project	Harmony with communication and transport	Transport distance	Transport time	Transport capacity	Transport costs	Harmony among schemes	Operability of logistics project
Harmony between logistics project and engineering project	1	5	3	7	6	6	0.3333333	0.25
Harmony with communication and transport	0.20	1	0.3333333	5	3	3	0.2	0.14285714
Transport distance	0.33333333	3	1	6	3	4	6	0.2
Transport time	0.14285714	0.2	0.1666667	1	0.33333333	0.25	0.1428571	0.125
Transport capacity	0.16666667	0.3333333	0.3333333	3	1	0.5	0.2	0.16666667
Transport costs	0.16666667	0.25	0.25	4	2	1	0.2	0.16666667
Harmony among schemes	3	5	0.1666667	7	5	5	1	0.5
Operability of logistics project	4	7	5	8	6	6	2	1

	Standardization of columes							
	0.11099366	0.2295333	0.2926829	0.1707317	0.2278481	0.23301	0.0330813	0.09799347
	0.02219873	0.0459067	0.0325203	0.1219512	0.11392405	0.116505	0.0198488	0.05599627
	0.03699789	0.13772	0.097561	0.1463415	0.11392405	0.15534	0.5954631	0.07839477
	0.01585624	0.0091813	0.0162602	0.0243902	0.01265823	0.009709	0.0141777	0.04899673
	0.01849894	0.0153022	0.0325203	0.0731707	0.03797468	0.019417	0.0198488	0.06532898
	0.01849894	0.0114767	0.0243902	0.097561	0.07594937	0.038835	0.0198488	0.06532898
	0.33298097	0.2295333	0.0162602	0.1707317	0.18987342	0.194175	0.0992439	0.19598693
	0.44397463	0.3213466	0.4878049	0.195122	0.2278481	0.23301	0.1984877	0.39197387
	Average value of standardized columes							
	0.17448427	0.0661064	0.1702178	0.0189037	0.03525777	0.043986	0.1785981	0.31244593
	Maximum eigenvalue							
	1.7611025							
	0.57034721							
	1.95591603							
	0.17273977		9.6019528					
	0.3096112							
	0.36607202							
	1.74572041							
	3.30810521							
	Consistency inspection							
Consistency indicator			0.2288504					
Average consistency random indicator			0.1623052					

Harmony between logistics project and engineering project	A	B	C
A	1	6	8
B	0.166666667	1	4
C	0.125	0.25	1
	Standardization of columes		
	0.774193548	0.827586207	0.615384615
	0.129032258	0.137931034	0.307692308
	0.096774194	0.034482759	0.076923077
	Average value of standardized columes		
	0.73905479	0.191551867	0.069393343
	Maximum eigenvalue		
	0.814504245		
	0.197433679	3.139919494	
	0.069887719		
	Consistency indicator		0.069959747
	Average consistency random indicator		0.120620253

Harmony with communication and transport	A	B	C
A	1	6	7
B	0.166666667	1	4
C	0.142857143	0.25	1
	Standardization of columes		
	0.763636364	0.827586207	0.583333333
	0.127272727	0.137931034	0.333333333
	0.109090909	0.034482759	0.083333333
	Average value of standardized columes		
	0.724851968	0.199512365	0.075635667
	Maximum eigenvalue		
	0.817125276		
	0.207621231	3.177449215	
	0.07635468		
	Consistency indicator		0.088724607
	Average consistency random indicator		0.152973461

Transport distance	A	B	C
A	1	6	8
B	0.166666667	1	3
C	0.125	0.333333333	1
	Standardization of columes		
	0.774193548	0.818181818	0.666666667
	0.129032258	0.136363636	0.25
	0.096774194	0.045454545	0.083333333
	Average value of standardized columes		
	0.753014011	0.171798631	0.075187357
	Maximum eigenvalue		
	0.795101553		
	0.17428768	3.074894548	
	0.075526773		
	Consistency indicator		0.037447274
	Average consistency random indicator		0.064564265

Transport time	A	B	C
A	1	4	7
B	0.25	1	5
C	0.142857143	0.2	1
	Standardization of columes		
	0.717948718	0.769230769	0.538461538
	0.179487179	0.192307692	0.384615385
	0.102564103	0.038461538	0.076923077
	Average value of standardized columes		
	0.675213675	0.252136752	0.072649573
	Maximum eigenvalue		
	0.730769231		
	0.261396011	3.126284558	
	0.073178673		
	Consistency indicator		0.063142279
	Average consistency random indicator		0.108865998

Transport capacity	A	B	C
A	1	3	8
B	0.333333333	1	4
C	0.125	0.25	1
	Standardization of columes		
	0.685714286	0.705882353	0.615384615
	0.228571429	0.235294118	0.307692308
	0.085714286	0.058823529	0.076923077
	Average value of standardized columes		
	0.668993751	0.257185951	0.073820297
	Maximum eigenvalue		
	0.677037995		
	0.258488353	3.018353275	
	0.073913668		
	Consistency indicator		0.009176638
	Average consistency random indicator		0.015821789

Transport costs	A	B	C
A	1	4	7
B	0.25	1	5
C	0.142857143	0.2	1
	Standardization of columes		
	0.717948718	0.769230769	0.538461538
	0.179487179	0.192307692	0.384615385
	0.102564103	0.038461538	0.076923077
	Average value of standardized columes		
	0.675213675	0.252136752	0.072649573
	Maximum eigenvalue		
	0.730769231		
	0.261396011	3.126284558	
	0.073178673		
	Consistency indicator		0.063142279
	Average consistency random indicator		0.108865998

Harmony among schemes	A	B	C
A	1	7	7
B	0.142857143	1	3
C	0.142857143	0.333333333	1
	Standardization of columes		
	0.777777778	0.84	0.636363636
	0.111111111	0.12	0.272727273
	0.111111111	0.04	0.090909091
	Average value of standardized columes		
	0.751380471	0.167946128	0.080673401
	Maximum eigenvalue		
	0.830572391		
	0.172435466	3.140287804	
	0.081331837		
	Consistency indicator		0.070143902
	Average consistency random indicator		0.120937762

Operability of logistics project	A	B	C
A	1	5	8
B	0.2	1	5
C	0.125	0.2	1
	Standardization of colunes		
	0.754716981	0.806451613	0.571428571
	0.150943396	0.161290323	0.357142857
	0.094339623	0.032258065	0.071428571
	Average value of standardized colunes		
	0.710865722	0.223125525	0.066008753
	Maximum eigenvalue		
	0.784854457		
	0.231780811	3.150275804	
	0.066497358		
	Consistency indicator		0.075137902
	Average consistency random indicator		0.129548107

Project	Harmony between logistics project and engineering project	Harmony with communication and transport	Transport distance	Transport time	Transport capacity	Transport costs	Harmony among schemes	Operability of logistics project	**Rank**
	0.1744843	0.0661064	0.17021776	0.01890367	0.0352578	0.043986	0.178598	0.31244593	
A	0.7390548	0.724852	0.75301401	0.67521368	0.6689938	0.675214	0.75138	0.71086572	0.7274
B	0.1915519	0.1995124	0.17179863	0.25213675	0.257186	0.252137	0.167946	0.22312553	0.2005
C	0.0693933	0.0756357	0.07518736	0.07264957	0.0738203	0.07265	0.080673	0.06600875	0.0721
	Ultimate selection		A						
		Consistency indicator		0.06474498					
Average consistency random indicator				0.58					
		Overall consistncy		0.11162928					