

PAPER • OPEN ACCESS

Design of Outbound and Inbound Integrated Transportation Organization Scheme for China Railway Express

To cite this article: Wenqian Liu and Xiaoning Zhu 2019 *J. Phys.: Conf. Ser.* **1176** 052013

View the [article online](#) for updates and enhancements.

You may also like

- [The Heliospheric Current Sheet in the Inner Heliosphere Observed by the Parker Solar Probe](#)
Adam Szabo, Davin Larson, Phyllis Whittlesey et al.
- [Looking down: a model for visual route following in flying insects](#)
J Stankiewicz and B Webb
- [MHD Inertial and Energy-containing Range Turbulence Anisotropy in the Young Solar Wind](#)
Laxman Adhikari, Gary P. Zank, Lingling Zhao et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Design of Outbound and Inbound Integrated Transportation Organization Scheme for China Railway Express

Wenqian Liu, Xiaoning Zhu*

School of Traffic and Transportation, Beijing Jiaotong University, Beijing China

*Corresponding author e-mail: xnzhu@bjtu.edu.cn

Abstract. At present, with the support of national policies, China railway express have maintained the momentum of rapid development, but there are still problems such as the imbalance in the number of outbound and inbound trains, and the long detention time of railway port stations. First of all, this paper analyzes the current situation and transportation organization mode of China railway express, then an outbound and inbound integrated transportation organization model was established with taking into account many factors such as transshipping capacity, storage yard capacity, facility capacity etc., in order to minimize the total container-hour in railway port station.

1. Introduction

The China railway express, which has fixed train number and route, refers to the international container rail line running between China and Europe as well as countries along the "One Belt And One Road". The first line of China railway express started on March 19, 2011, marking the official operation of the international railway freight transport corridor. Since then, China railway express has maintained a rapid development momentum.

China has built three major international channels: western channel, central channel and eastern channel. The western channel, which mainly transports goods from the central and western regions of China, is the channel with the largest volume and highest benefit of the three channels at present. The central channel mainly transports goods from central China and North China. It enters and exits from the Erlianhot port station, passes through Mongolia, meets the western channel in Moscow, Russia, and finally reaches Europe. The eastern channel mainly transports goods from the southeastern coastal areas of China, the three northeastern provinces, etc. It enters and exits from the Manchuria port station, then meets the central channel in Ulan-Ude, Eastern Siberia.

At present, nearly 40 cities in China have opened China railway express lines, with the terminus covering more than 30 cities in more than 10 European countries. By the end of 2017, there were 61 lines designed for China railway express. The total number of China railway express running in 2017 was 3,673, with an average of more than 10 trains each day, which even exceeded the cumulative total of all running China railway express trains from 2011 to 2016.

With the continuous implementation and promotion of "One Belt And One Road" initiative, China railway express, as an important carrier and focus point, have maintained the trend of rapid development. Relevant scholars from various countries have gradually joined in the research of China railway express. This paper summarizes the research level of similar subjects at home and abroad from the related research of China railway express and the research of coordination operation mode between different transport systems.



(1) Research on China railway express

At present, the domestic and international research on China railway express is still in the early stage of research. The research mainly elaborates on the development status of the trains, cargo, operating entities and transportation organization modes^[1]. Besides, the main problems in the development of China railway express are proposed, and the development suggestions and measures for the integration of China railway express are given in a timely and steadily manner^[2]; Or put forward how to correctly understand this new mode of transport, point out the status and role of China railway express in China's foreign trade transport, applicable areas and suitable goods^[3]; Or study the optimal transportation route from the economic point of view such as transportation cost^[4]. To sum up, relevant researches at home and abroad mainly discuss methods and measures to improve transport efficiency and reduce transport cost, and there are relatively few researches on quantitative analysis using mathematical models and actual data.

(2) Research on coordination operation mode between different transportation systems

At present, domestic and foreign scholars have done many works for intermodal transportation organization^[5], terminal operations organization^[6] and transportation path planning^[7], mainly focusing on the feasibility and necessity of the container rail-water transportation.

Based on this, this paper studies the optimization of the integrated transport organization of the China railway express under the background of different railway track gauge in railway port station. It is innovative and the research results can expand the research breadth and depth in the relevant research fields of China railway express.

2. Influencing factors

2.1. Equipment and facilities

The rapid development of China railway express depends on the construction and improvement of facilities and equipment. If the yard size of the port station and the container handling and transfer equipment cannot meet the development requirements of China railway express, it will have a significant impact on the seamless connection of the port station.

With the accelerating development of the Central European trains, there are some problems of insufficient operation capacity of the port stations, such as the number of lines and the limited length, etc., which are difficult to meet the increasing traffic volume, so that the queues of trains are at the port stations. The detention time is prolonged, which seriously affects the operational efficiency of the port station. In addition, the China railway express schedule is not tightly connected at the port station. It needs to wait for empty vehicles. The utilization rate of empty vehicles is not high, and the container turnover rate is slow, which makes transportation efficiency low.

2.2. Volume of containers

The number of containers of China railway express is closely related to the local economic development and transportation construction in the area where the goods are gathered. However, before studying the seamless connection of China railway express at the port station and the optimization of integrated transport organization, it is necessary to estimate the volume of containers. If the volume is expected to be less than the actual demand, sufficient transport services cannot be provided, resulting in the detention of trains at the port station, affecting the integrated transport organization. When the predicted value is greater than the actual demand, the station operation ability is not effectively utilized.

Due to the relative independence between the different lines of China railway express and the disorderly competition, the information is not interoperable, which may cause only a small number of trains to arrive at a certain period of the port station, or a soaring number of trains arrive at a certain time to cause congestion. This characteristic has a significant impact on the reliability of the integrated transport organization of the China railway station, when the train arrives at the port station in a short time, it puts higher requirements on the facilities and equipment capabilities of the port station. It may cause long-term detention of the yard container and affect the economic efficiency of the train. When

the trains arriving at the port station in a period are few, the capacity of the port station is not fully utilized.

2.3. Operation plan

The origin and destination of China railway express lines are known, and the operation routes are fixed. At present, the supply of goods from the starting places is relatively stable, and the operating frequency of each line of China railway express is basically unchanged. The operation plan also includes information such as the type and number of vehicles and the number of containers transported on each train. At present, the China railway express adopts the assembly mode of fixed-time at the departure station. In the place where there is sufficient supply of goods, the train can reach the formation of full axle.

3. Outbound and inbound integrated transportation organization model

3.1. Problem description

China railway express are currently facing two major problems, one is the imbalance in the number of outbound and inbound trains, and the other is the long detention time of railway port stations. The economic benefits and timeliness should be considered to achieve the optimization of outbound and inbound container distribution organization, which depend on the reasonable division of the equipment and the coordination between the operation procedures. Therefore, an outbound and inbound integrated transportation organization model was established with taking into account many factors in order to minimize the total container-hour in railway port station as well as to speed up transshipping efficiency of containers.

In the study of this paper, the transport organization mode of inbound China railway express is divided into direct and assembled modes as shown in the following figure 1.

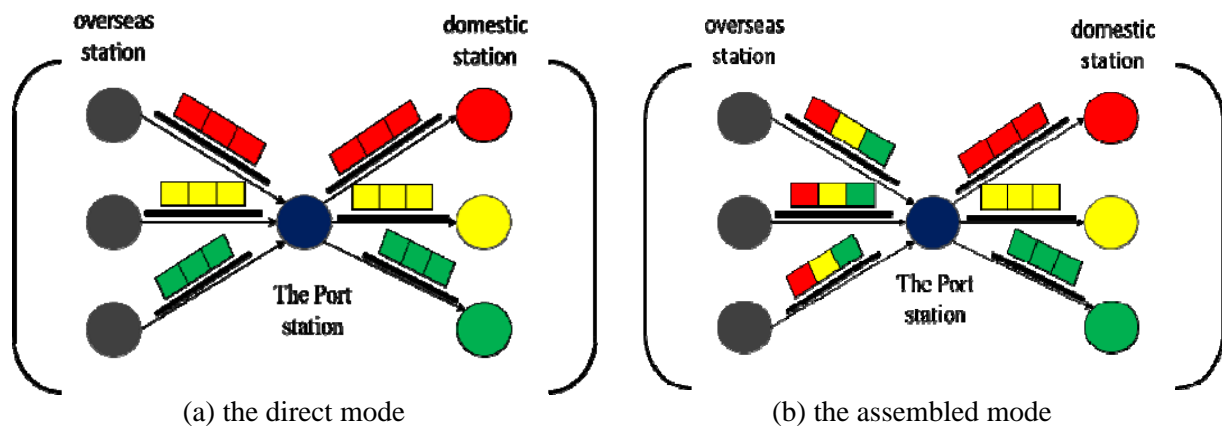


Figure 1. Illustration of the direct and assembled modes

3.2. Basic assumptions

There are many factors involved in the integrated transport organization process of China railway express, which requires high coordination in time and space. In order to rationally express the influence of key factors on the connection process and ensure the scientificity of the model, the following assumptions are made:

Assumption 1. The transportation organization of China railway express has periodic characteristics. The departure time and frequency of trains are basically fixed. So a period is taken as the time range of optimization research.

Assumption 2. In a certain period of time, the arrival time of China railway express trains is known. The amounts of containers and their destinations are certain because the information of containers on the trains will be released to the railway port station in advance.

Assumption 3. There would be enough empty vehicles in the railway port station.

3.3. Objective function

The capacity of the integrated transportation organization of China railway express can be described by total container-hours staying in railway port station (from unloading to loading). The shorter time for the containers staying in the railway port station, contributes to the faster container transshipping. A schematic diagram of calculation on total container-hours in railway port station is shown as figure 2.

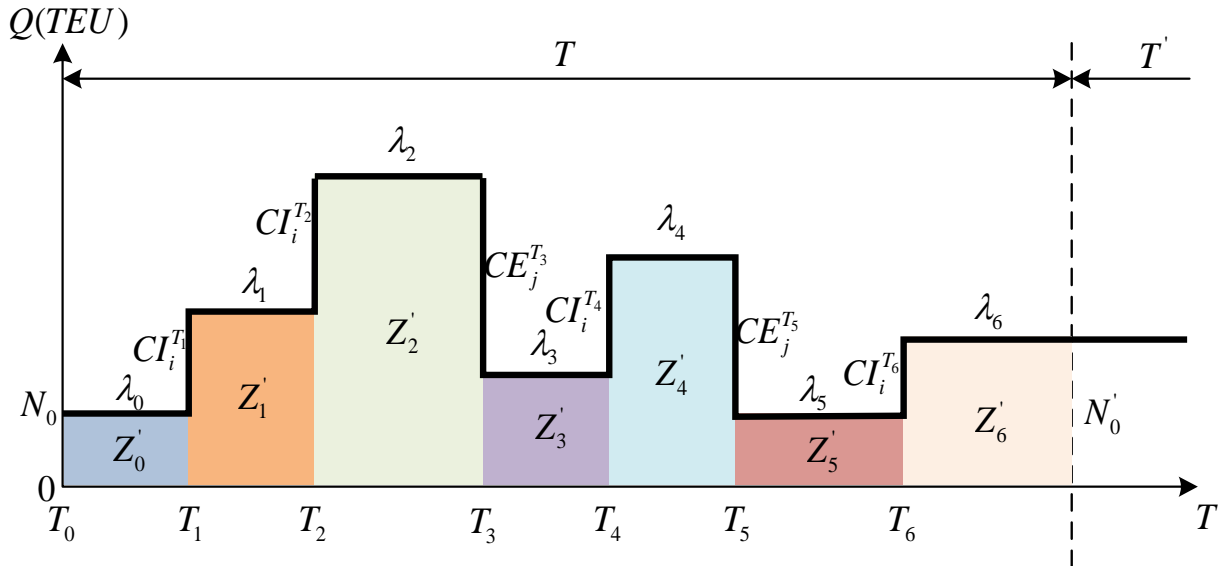


Figure 2. Schematic diagram of calculation on total container-hour in railway port station

According to the figure 2, the number of containers in the yard increases or decreases as the train arrives or leaves at time T_x ($x = 1, 2, \dots, n$), $CI_i^{T_x}$ and $CE_j^{T_x}$ respectively represent the number of containers from the arriving train and the leaving train at T_x ; N_0 represents the number of containers remaining in the yard at the end of the last period which is also the beginning of this period T_0 . Thus it can be seen that the area ($Z = \sum_k Z'_k$) enclosed by coordinates and folds represents the total container-hour in railway port station. Therefore, the expression of the objective function can also be described from the figure 2 above.

3.4. Model constraints

Several operational constraints and bounds are illustrated as following to ensure the feasibility and the quality of integrated transportation organization.

(1) Fixed-axle constraint. In order to guarantee the economic benefits of the China railway express, the fixed-axle (fixed-length) constraint of the train must be satisfied, which requires the number of vehicle bottoms (flat cars) above a threshold.

(2) Yard storage capacity constraint. The number of containers in the storage yard is constantly changing with the arrival of the inbound trains or departure of the returning trains, but cannot exceed the maximum storage capacity of the yard.

(3) Time interval constraint. Within a certain period, the interval time of arrival and departure between any two adjacent trains shall not be less than the minimum time required to complete the required work

(4) Transshipping capacity constraint. In addition to the necessary procedures, the operation process of inbound and outbound trains of China railway express at the port station mainly includes handling operation, transshipment and changing operation to meet the break-of-gauge.

(5) Containers balance constraint. The total number of containers loaded on returning train shall not exceed the total number of containers left in the storage yard during the previous planning cycle and the number of containers unloaded from the inbound trains.

4. Conclusion

The outbound and inbound integrated transportation organization of China railway express is a complex system problem. In this paper, an outbound and inbound integrated transportation organization model was established with taking into account many factors to solve the problem of long detention time of trains at the port stations.

The research on China railway express is a long-term process, which needs to keep pace with the development of economic and adapt to the cutting-edge demand of China railway express in operation practice.

Acknowledgments

This work was supported by the National Key R&D Program of China [grant number 2018YFB1201403].

References

- [1] Wang Yangkun. Status, Problems and Suggestions on Development of Sino-Europe Block Trains [J]. Comprehensive Transportation, S1(2015):70-75+89.
- [2] Liu Jingsong. The Game Behind the Subsidies of China Railway Express [J]. New silk road horizon, 11(2015):38-41.
- [3] Wang Jiao'e, Jing Yue, Wang Chengjin. Study on Better Organization of China-Europe Express Train. Bulletin of the Chinese Academy of Sciences, 32(2017):370-376.
- [4] Fu Xinping, Zhang Yixuan, Wan Honghu. Study on Economy Optimization of China-Europe Block Train Corridor in Central West of China [J]. Rail Way Transport and Economy, 4(2017):26-30.
- [5] Fan Yingxiu, Liu Yongbin. Study on the Equipment and Transportation of Container Highway-Rail Multimodal Transportation [J]. Storage Transportation & Preservation of Commodities, 3(2017):7-9, 6.
- [6] Liu Yong. Optimization Model and Method on Distribution Organization of Railway Container based on Rail-water Intermodal Transportation [D]: Beijing Jiaotong University, 2016.
- [7] Luis Couto Maia. A Rail Network Optimization Model Designed for Freight Traffic[J]. Computer-based Modelling and Optimization in Transportation, 2014, 262: 209-222.