Study on the Construction of Emergency Logistics and Integrated Transport System Based on “Scenario-Response” Mode

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Abstract. Through describing the meanings and characteristics of emergency logistics and integrated transport, as well as the relationship between the two, a multi-objective, multi-stage mathematical optimization model based on “scenario-response” mode is proposed in this article. When factors such as time, cost and accident rate are taken into account, the optimization of integrated transport at different stages of public emergencies is solved and analyzed using the improved Dijkstra algorithm. The results show that this algorithm avoids the limitations of traditional multi-objective optimization methods, and can effectively resolve the multi-objective and multi-stage integrated transport in the optimization of emergency logistics.

Keywords: scenario-response; emergency logistics; integrated transport; public emergencies

1 Introduction

China has vast and complex geographical conditions, and the ecological environment is very fragile. In recent years, public emergencies have become more frequent and shown chain characteristics, the impact of which is getting more and more serious. Due to the comprehensive requirement of timeliness, security and economy, the emergency processing of public emergencies has become a complex systems engineering. And the capacity and performance of emergency logistics transport will impact the effectiveness of the entire emergency rescue operation directly.

As early as in the 1990s, the United States has begun to invest a lot of capital in the construction and improvement of the warning defense system for public emergencies, in which the Metropolitan Medical Response System (MMRS) is an important part. Britain, France and Italy have established the warning defense system for public emergencies one after another. The emergency logistics system of China has been tested from the outbreak of SARS in 2003, the snowstorm in South China and the Wenchuan earthquake in 2008, and the earthquake occurred in
Lushan County, Ya'an City, Sichuan Province, in the morning of April 20, 2013, reflecting that the emergency relief supplies reserves and emergency distribution system of China are not perfect. With the emergency treatment and experience summary of a series of public emergencies, emergency logistics has become one of the focus of the current academia at home and abroad. The aspects of the emergency logistics: Kembali-Cook and his team[1], based on the issue of Somali refugees rescue, proposed the supply process of the relief supplies logistics management needs firstly in 1984; Ardekani and others[2], who committed to the rescue and reconstruction efforts after the Mexico City earthquake, analyzed the situation of the road transport network and the status of the road transport network after the disaster, and pointed out the problems which are faced by the transport of relief supplies in the field of the management process; Fiedrich[3] researched the model of multiple locations affection distribution and transportation resources optimization after the earthquake, which sets the Minimum-time, resources, limited quantity and quality of the case, the minimum number of deaths as a target; Linet[4], who detailed description of the constraints of the transportation of emergency supplies, including the condition of the number of vehicles, materials supply etc, designed the mode of the emergency supplies of Transportation Planning, which is mainly to solve the problem of time-varying dynamic transport of commodity. The aspects of the comprehensive transportation: Suleyman Tufekci and Wallam A. Wallace[5], as the authority of emergency management experts, pointed out that the nature of the emergency management is a complex multi-objective optimization problem, it is mainly to solve the utilization of the compromise resource in the case of limited emergency resources; Haghani and OH[6] researched the material dispatching of emergency disaster relief, established the deterministic network flow model of the multi-varieties of materials, the multi-mode of transport and the Time-window based on the Time-space Network, and proposed two inspired-algorithm; Nierat[7] determined the market scope of road transport and rail transport and its influencing factors, which are as a prerequisite in order to minimize shipping costs; Ozdamar and his team[8] studied the problem of the deterministic dynamic transportation, which is based on the time-dependent in the natural disaster emergency logistics plan, established the integrated optimization model of the problem of the vehicle routing under the flow problem of the multi-cycle and multi-species and the problem of the multi-mode of transport, as well as pointed out a kinds of iterative algorithm based on the relaxation of the Lagrange. The aspects of the mode on “Scenario-Response”: Sheu JB[9] researched the classification and demand of the unconventional emergency supplies in the paper, including the method of classification, the standards, and the demand for emergency supplies-level; Kalashnikov D V, Ma Y, Mehrotra S, et al[10], Han Q, Venkatasubramanian N[11] and Raschid L, Knoblock C, Naumann F[12], Xinxin Jia[16] summarized the objectives of the emergency management system, the specific content of the emergency management system, the scope of the emergency management system, and pointed out the model of the emergency supplies vehicle scheduling of the multi-demand, multi-point and multi-modal transport.
2 Emergency logistics integrated transport system

Emergency logistics is a special logistics activity to supply emergency safeguard to meet the demand for supplies, personnel and funds in all kinds of unexpected events, the purpose of which is to provide emergency supplies in major natural disasters, sudden public health incidents and public safety events, in pursuit of the maximization of the time benefits and the minimization of the losses caused by the disasters[17]. As a special case of the general logistics activities, emergency logistics exhibits the features of burst, uncertainty, weak economy and unconventional.

Integrated transport is, in the conditions of market economy, taking sustainable development as a precondition, to allocate resources comprehensively and arrange the transport structure rationally in accordance with the economic characteristics of highways, waterways, railways, aviation and pipelines, forming an integrated transport system of divide-and-cooperate, organic combination, rational layout and effective docking, to maximize the comparative advantages and combination efficiency of the various transport modes[18]. Compared to the single-mode and one-way traditional transportation, integrated transport system exhibits the features of relevance, effectiveness, simplicity, full process, versatility, interoperability etc.

3 “Scenario-Response” mode

Facing the dynamic emergency response management of the public emergencies, when scenario evolution and "scenario-response" mode are considered, in pursuit of the maximization of the time benefits and the minimization of the losses caused by the disasters, the emergency supplies needed for all types of public emergencies should be organized, implemented and controlled through effective integrated transport plan. The whole process of the public emergencies can be divided into several key stages including initial scenario, middle scenario and end scenario according to the time sequence; the end scenario of the previous stage is often the initial scenario of the next stage. To sum up, the whole process of scenario evolution can be shown in figure 1:
the occurrence of public emergencies

- event
- time
- location
- weather
- traffic
- Potential secondary disasters
- others

Potential secondary disasters
occurrence time
duration
Latitude and longitude
Administrative region
Live weather
Recent weather
path
Transport mode
status
reason
type
harmdegree
analysis

the scenario of stage S

Scenario reasoning

- the understanding of current scenario
- The deduction of the future scenario
- The detection of the future scenario

The generation of emergency decision-making scenario

the design and evaluation of the alternative emergency decision-making programs

feasible

The implementation of the program

YES

end scenario

NO

Fig. 1. procedure chart of the scenario evolution

(4) Determine the shortest path
As shown in Table 3, the shortest cost path is M=121. The path R=O-A3-B3-B1-C1-C2-D means that air transport is adopted from node O to node
A and from node A to node B, highway transport is adopted from node B to node C, and railway transport is adopted from node C to node D. The shortest time path is \( T=21 \), and the path \( R=O-A3-B3-C3-D \) means air transport is selected from node A to node D. The shortest accident rate path is \( P=1.15 \). The path \( R=O-A2-B2-C2-C3-D \) means that railway transport is adopted from node O to node A, highway transport is adopted from node A to node B and from node B to node C, and air transport is adopted from node C to node D.

4 Conclusions

In summary, emergency logistics exhibits the characteristics of suddenness or non-normal, the randomness and afterwards electivity of logistics demands, the imbalance of flow, the urgency of time constraints and social welfare etc. When public emergencies occurs, in pursuit of the maximization of the time benefits and the minimization of the losses caused by the disasters, the selection of transport mode based on “scenario-response” should be the optimized decision-making mode to protect people's life and property safety as much as possible. In the transport of emergency logistics, reasonable transport mode should be selected according to different requirements on goods transport under different scenarios of public emergencies. Aiming at the transportation problem in emergency logistics, an integrated transport model of multi-object and multi-stage based on the "scenario-response" mode is proposed in this work. The results of numerical example show that this model and algorithm can effectively resolve the multi-object and multi-stage transportation problem in emergency logistics systems under the "scenario-response" mode.

Acknowledgments. This work is supported by the Humanities Social Sciences Programming Project of the Ministry of Education of China No. 10YJA630126, 12YJC630200, 12YJC630100 and the State Social Science Fund Project No. 11CJY067 and the Natural Science Foundation of Gansu Province, China. No. 1107RJYA070, 1208RJZA164.

References


