

Influencing factors analysis of mega-cities subway last train extended hours of operation during holidays

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Abstract:With the size and layout of national mega-cities railway network gradually improving, during the holiday season,the intensification of supply and demand which is between the normalization of the railway network operator service last train at night time and the residents travel time is increasingly intensifying.The feasibility of exploration and study on subway extended hours of operation during holidays has practical significance.Based on current supply and demand of existing transport capacity, domestic large cities such as Beijing, Shanghai, Guangzhou, Shenzhen and other metro operators have made the relevant delay operation plans.But this kind of decision which was not based on the experience doesn't form normal delay operating system and programs.In this paper, according to the background of domestic delay operations, summarize the factors of delay operations which include passenger demand characteristics,maintenance ,cost and so on, propose the corresponding solutions, in order to provide a reference and guidance for mega-cities subway extended hours of operation during holidays .

Keywords:holidays;subway;delay operations;influencing factors

I. INTRODUCTION

With the economy and population of mega-city rapidly growing,during the holiday, people's travel frequency and intensity is increasing, especially the number of residents who go outside for entertainment, shopping, visiting friends and other purposes is rising.Subway is one of the significant ways to relieve the ground traffic pressure , the subway train operations can not meet the demand of the passengers at the end of the night. Therefore, the problem of delay operations during the holiday is to be solved urgently.

Whether the last train of subway meet passengers' needs or not is one of the indicators to measure the subway service level.As the passenger flow at night during holiday is higher than daily flow which leads that the last train of subway can't meet passengers' needs and service levels decline naturally.In order to study such problems, the domestic metropolitan cities such as Beijing, Shanghai, Guangzhou and Shenzhen have already explored and tried to extend the operating time at the last train.They have made some adjustment measures concerning delay operations during the holiday, and hope to improve the situation of the residents' travel at night, to meet the needs of residents travel at night as soon as possible.However, they are only based on experience, they determine upon the existing subway capacity and supply, develop delay operation of the program, lead to lack of appropriate theoretical decision-making support.It's difficult to form a relatively complete delay operation system and normalization^[1] operational plan.Therefore, this paper is based on these backgrounds, it summarizes the influencing factors of delay operation from the aspects of passenger demand, maintenance at night, cost efficiency and so on. Finally, the paper provides the countermeasures for the delay operation of the last train in metropolis.

II. ANALYSIS OF DOMESTIC MEGA-CITIES SUBWAY DELAY OPERATIONS

In order to understand the status of the last train operation of the domestic subway, the author conducts a special research on representative metropolises in China, such as Beijing, Shanghai, Guangzhou and Shenzhen.

Table1 research on domestic mega-cities delay operations

City	Normal time of last subway train	Concerning holidays	Extended time and program	Minimum departure interval	Formulate method
Beijing	23:00	National Day, Labor Day	Extend 30-60minutes during National Day;Extend 35minutes	2minutes	Empirical decision- making

			during Labor Day		
Shanghai	23: 49	National Day	Extend 30-45minutes	2minutes and 44seconds	Empirical decision- making
Guangzhou	23:30	National Day, Spring Festival and so on	The first day of National Day and Spring Festival,New Year's Eve extend 1hour;The second day of Spring Festival extend 2hour	3minutes	Empirical decision- making
Shenzhen	23:00	New Year's Day,National Day, Labor Day,Christmas Eve,The first day and second day of Spring Festival	Extend 1 hour during Major holidays	2minutes and 45seconds	Empirical decision- making
Shenzhen(MTR)	23:00	Weekends and Major holidays	Extend 1 hour	3minutes and 30seconds	Empirical decision- making

According to research and analysis above,it shows that:The four mega-cities have extended their last subway train service hours during the holidays, while Beijing and Shanghai have been extended for a short time, and Guangzhou and Shenzhen are longer.These cities also made a distinction in extending operating time during different holidays , targeted to do the delay operation adjustment to meet the needs of passengers at night travel as soon as possible.At the same time, it can be seen from the table that delay operation plans are based on empirical decision-making, and there is no normalized delay operation program^[1].

III. INFLUENCING FACTORS ANALYSIS OF SUBWAY LAST TRAIN EXTENDED HOURS OF OPERATION

3.1 Passenger demand analysis of subway last train extended hours of operation during the holidays

3.1.1 Passenger demand characteristics analysis of subway delay operation

The paper refers to the research of delay operation of the day before the National Day of Shanghai in 2013,the main research and analysis include the passengers' personal characteristics of the last subway train , purpose, origin and destination (OD), travel frequency, expectation of extended hours of delay operations ,demand of service time and level and so on.

Table 2 structure and content of survey table

Structure	Content
Passengers'personal information	Mainly in age, occupation and so on
Passengers' main travel purposes	Work, go to school, shopping, entertainment, go home, visit friends and so on
Passengers' origin and destination (OD)	Urban to urbanOD ; Urban to suburban OD;Suburban to Urban OD
Passengers' travel frequency	Collect statistics online

The time period of passengers' last train on the subway	Research as close as possible to the last subway train
Passengers' evaluation of the last train on the subway	demand of service time and level and so on

According to the design survey form above, to analyze the passengers' demand of the last train on the subway during the holidays.

Based on the research statistics, it shows that in the age distribution, 19-40 years between the young and middle-aged demand for delay operations is most, the top three destinations for the last subway train are "entertainment/go home", "shopping/go home" and "work /go to school/home". Therefore, the service radius of the future railway network delay operations should focus on the CBD business area, CBD leisure and entertainment area, large adult education and training institutions and other areas. In the last subway train frequency distribution, the proportion of the frequency which is more than 2 times accounts more than 50 percent, indicating that passengers on the last subway train demand is large enough.

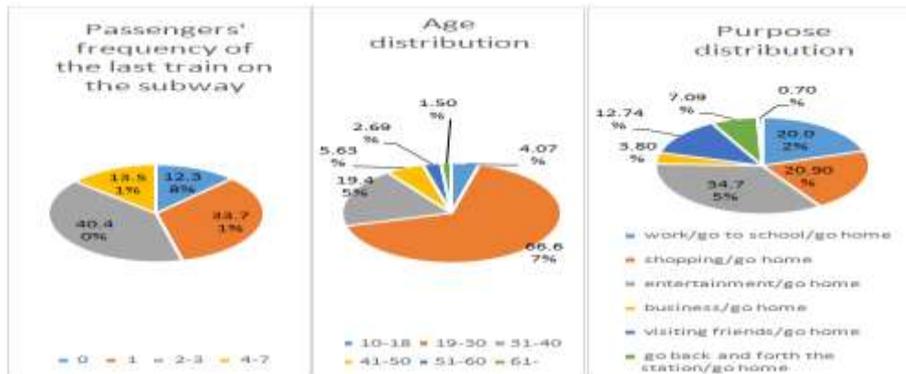


Chart 1 frequency, age and purpose distribution chart

3.2 Impacts of delayed operation on night maintenance

3.2.1 Use of operation diagram:

Train operation diagram is the comprehensive plan and basis of train operation^[2], the delay operation of the holidays during the night will have an impact on normal maintenance.

There are difficulties in the shunting operation of trains inside the subway garage: After the trains are out of service during the holidays, the density of back trains to the subway garage is relatively high, it brings difficulties that completing the shunting and maintenance of the train after the test line operation. Delay operations will cause the early trains demand can not be met, it will result in more prominent contradictions on the day which is after the end of the holidays as well.

It can not meet heavy load demand of trains during the holidays: Extending operation time will shorten the day inspection work time at night, there is no sufficient time to deal with the day-to-day inspection of the major train temporary repair failure, it also can not meet the heavy load demand of trains during the holidays.

Maintenance capacity is not balanced: Due to the shortened maintenance time after the extension of the operating time, if the number of trains which are back to the subway garage is not commensurate with the maintenance capacity, the maintenance capability will not be balanced.

3.2.2 The allocation of the maintenance personnel:

The deficiency of the allocation of the maintenance personnel: In accordance with normal operation, the maintenance personnel is deficient, extending time of operation will lead to more lack of staff.

There are difficulties for OCC stationed personnel to be engaged in daily inspection: The main line OCC staff who are back to the subway garage still need to complete part of the vehicle daily inspection work, it is difficult to ensure that OCC staff can return to their original positions timely the next day and it can not ensure their good working condition either.

3.2.3 Train gas brake test items:

Train air brake is when the train electric braking force is insufficient or it's broken, the train needs to supplement the air train brake^[3]. In order to ensure the safety of the train braking system, all trains need to conduct a daily air brake test, in other words: a fixed time point of the train control panel will appear the request for air brake test tips, without air brake test, the train may be forced to stop on their own, so it is necessary to conduct the test. Once conduct the delayed operation, part of the train braking tests need to be adjusted, and it causes that train delays back to the subway garage.

3.2.4 Reduced construction time for main line:

With the expansion of the subway network scale, construction tasks and intensity will be increased^[4]. Construction time is relatively tight in the circumstances, to extend the operating time is bound to lead to shortening the construction time for the main line at night^[4].

3.3 Additional costs of subway delay operation

Cost benefit analysis:

Direct cost-effectiveness: The additional operating costs include staff costs, train traction power and lighting power consumption, equipment depreciation and other aspects. While staff costs include drivers, station staff, facilities and equipment maintenance personnel overtime pay and traffic Fees, etc.^{[5][6]}. According to the operation plan of Shanghai subway line1 and line2 delay operation on September 30 of 2013, extending one hour of additional operating costs include four aspects :traffic organization, passenger organization, the maintenance of facilities and equipment, traction power and lighting power consumption.

Indirect cost-effectiveness: Although the direct cost-effectiveness of delay operation is low, it is difficult to balance the incremental cost of delay operation from the ticketing revenue. However, the characteristics of passenger flow shows that passengers go outside for entertainment, sightseeing, and other external transport hub ,the main purposes of their travel are flexible. Therefore, the delay operation of future subway network will bring a larger passenger flow improvement and efficiency improvement of space, it's more significant and convenient for long-distance travel passengers to provide delay operation services for time, cost and energy savings , and the indirect overall economic benefits will be much higher than the direct economic benefits of the rail transit system on its own. In addition, extending the subway operating time during the holidays has played a significant role in improving subway service levels, enhancing corporate image, passenger satisfaction and loyalty, creating a harmonious festive atmosphere and promoting the normal activities of the festival , its huge social benefits can not be ignored. In summary, from the economic point of view, extension of the subway operating time is feasible in the future.

IV. THE COUNTERMEASURES OF SUBWAY DELAY OPERATION

Based on the decision-making basis for delay operations and mechanisms, night maintenance ,cost and other aspects , put forward the following solutions:

4.1 Delay operation mechanism:

For the demand analysis of passenger on the last subway delay operation during the holidays, the subway management department should be based on scientific basis and research mechanism, delay operations are supposed to conducted in the Spring Festival, National Day and some other major holidays , and services and regional of delay program should be based on passengers' origin and destination(OD).

4.2 Night maintenance of delay operation :

According to the influence of the use of operation diagram, delay operations should be carried out from the first day of the holidays to the day before the last day of the holidays , and pay attention to balance the number of train back to ensure the normal operation of the early train the next day.

According to the influence of delay operation to the allocation of the maintenance personnel and unbalanced maintenance capacity, make some suggestions like that the increase the number of daily inspection operations personnel appropriately, do a good job and staff matching analysis.

And make the use of balanced maintenance. Disperse the original maintenance time and maintenance tasks to different period or lower level of the repair process, make the entire maintenance work dispersed and balanced ,to balance the various levels of repair time^[7], and adjust working time of OCC reasonably.

According to the influence of delay operation to train gas brake test, future delay operations need to update the software for the involved trains through the supplier, postpone the test time node to the end of the operating time and provide it to the operating company in the form of a technical description ,the driver should conduct the correct operation to ensure that the train can continue to run normally on the main line until the end of the day.

Arrange the maintenance work time reasonably: Extending the operating time will lead to shortening the construction time for the main line at night, the part of the existing subway line construction time has been more tensed, in this circumstance, the future delay operations requires that the operating company should not only make full use of time and improve the efficiency of the completion of the repair process vehicle test line to accomplish the test task, but also should add the important parts of the train attachments appropriately (Such as traction modules, auxiliary modules, air compressors and other large spare parts), in order to reduce the wasting time which is caused by spare parts turnover^[8].

4.3 Optimization of delay operation cost :

When it comes to the new cost of the delay operation, in the direct costs, the number of personnel is essentially increasing, but we can optimize the schedule of the staff in the delay operation, make a reasonable schedule to ensure that the staff can work normally and form the rationalization, as much as possible to improve efficiency and reduce the new costs indirectly.

V. CONCLUSION

In this paper, according to the background of domestic mega-cities delay operations like Beijing, Shanghai, Guangzhou and Shenzhen subway, based on the delay operation and research data of Shanghai in 2013, to analyze the travel characteristics of the passenger group in delay operation. The influencing factors of delay operation are analyzed in detail, and corresponding delay operation measures are proposed for each of these influencing factors. Based on this, it evaluates the feasibility of the subway delay operation in the future, which provides a reference for the delay operation of metro in metropolis.

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