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The Impact of the Application of Intelligent Technology and Equipment on the Operation of Beijing Zhangjiakou High-Speed Railway

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ABSTRACT
This paper analyzes the application of intelligent technology equipment in Beijing Zhangjiakou high-speed railway, and studies its impact on the operation of Beijing Zhangjiakou high-speed railway. By designing questionnaire survey and establishing SERVQUAL (Service Quality) model, it quantitatively analyzes the impact of intelligent technology equipment on the passenger transport service of Beijing Zhangjiakou high-speed railway, and concludes that intelligent technology equipment has greatly improved the quality of passenger transport. Through theoretical research, this paper analyzes the impact of intelligent technology equipment on high-speed railway operation organization and equipment operation and maintenance, so as to provide theoretical support for the future intelligent high-speed railway construction.

Keywords: *Beijing Zhangjiakou high-speed railway, Intelligent; SERVQUAL model, Organization of train operation, Equipment operation and maintenance.*

1. APPLICATION OF INTELLIGENT TECHNOLOGY AND EQUIPMENT IN BEIJING ZHANGJIAKOU HIGH-SPEED RAILWAY

Beijing Zhangjiakou high-speed railway applies numerous intelligent technology equipment. The following will be divided into 3 aspects, respectively summarizing the application of intelligent technology and equipment. The composition of intelligent Beijing Zhangjiakou high-speed railway as shown in Figure 1.

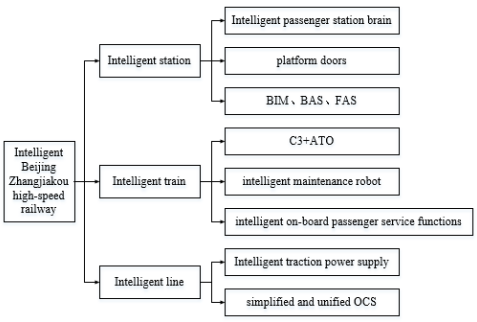

Figure 1. Composition of intelligent Beijing Zhangjiakou high-speed railway

1.1. Intelligent Station

Beijing Zhangjiakou high-speed railway is an intercity railway connecting Beijing and Zhangjiakou. Stations of the railway as shown in Figure 2. Intelligent passenger station brains are deployed at all stations along the line, equipped with platform doors, BAS(Building Automation System) and FAS(Fire Alarm System) system, so that all these stations have the advantages of efficient command, convenient travel, safety and reliability, energy conservation and environmental protection, which improves the safety of stations and facilitates modern management. In addition, BIM Technology is applied in the construction of Qinghe station, Badaling Great Wall Station and Zhangjiakou station of Beijing Zhangjiakou high-speed railway, which improves work efficiency, saves resources and reduces costs.

Figure 2. Stations of Beijing Zhangjiakou high-speed railway

1.2. Intelligent Train

The ATO(Automatic Train Operation) of Beijing Zhangjiakou high-speed railway is optimized and improved on the basis of CTCS-3 (Centralized Traffic Control System). It not only has the basic functions of CTCS-3, but also adds many functions such as train door opening protection, automatic adjustment of operation plan, real-time management of online trains, etc. The Beijing Zhangjiakou high-speed railway intelligent EMU is equipped with numerous intelligent on-board passenger service functions, mainly including carriage display, intelligent environment sensing adjustment, intelligent window, etc. In addition, the application of intelligent maintenance robot can effectively solve the problems of low quality and low efficiency. At present, the intelligent maintenance robot installed in Beijing North EMU is in the debugging stage.

1.3. Intelligent Line

The traction power supply system of Beijing Zhangjiakou high-speed railway adopts at AT(Auto Transformer) power supply mode, which provides safe, reliable, efficient and high-quality traction power supply system for railway by means of informatization, networking and automation [1]. The simplified and unified OCS(Overhead connecting structure) is applied in Chongli railway station. The simplified and unified OCS equipment is conducive to the unity of design, manufacturing, construction and operation and maintenance, and is conducive to improving the safety, reliability, availability and maintainability of the system. The high-speed railway earthquake warning system is pre-set on the Beijing Zhangjiakou high-speed railway line, which can give an earthquake alarm between seconds and tens of seconds before the earthquake has occurred and the destructive seismic wave has not arrived, and inform the running high-speed trains to slow down or stop [2].

2. ANALYSIS ON THE IMPACT OF INTELLIGENT TECHNOLOGY AND EQUIPMENT ON PASSENGER TRANSPORT SERVICE OF BEIJING ZHANGJIAKOU HIGH-SPEED RAILWAY

2.1. Evaluation of High-Speed Railway Passenger Service Quality

The evaluation of high-speed railway passenger transport service quality is based on passenger perception quality. In the aspect of service quality analysis and evaluation, the concept of passenger perception service quality is not one-dimensional, passengers will evaluate service quality through multiple dimensions of perception. Different models of service quality can be created by different dimensions of service quality [3]. SERVQUAL (service quality) model is the most widely used and representative one.

2.2. SERVQUAL Model

The basic principle of SERVQUAL model to evaluate service quality is also based on the perceived gap of the service received by passengers. Through questionnaire survey or other survey methods, passengers can measure and assign values to the expected service quality and perceived service quality respectively. The difference between them can be regarded as service quality. The five dimensions of service quality include: tangibility, reliability, responsiveness, reliability and empathy.

Using SERVQUAL model to calculate service quality, first of all, according to the investigated service quality content and attributes, we need to design the SERVQUAL scale for the investigation; then we send out questionnaires to carry out the actual investigation, let customers score each evaluation index, and then get the score of service quality through comprehensive calculation. In real life, customers have different views on the importance of each attribute in service quality. Therefore, after conducting a questionnaire survey on customers, it is necessary to determine the weight of each attribute, and then make a weighted average to obtain a more reasonable SERVQUAL score. The formula is as follows:

$$SQ = \sum_{j=1}^{5} W_j \sum_{i=1}^{n} \left(P_i - E_i\right) \tag{1}$$

SQ- Perceived service quality;

P_i -The i-th factor is the score of customer feeling;

E_i -The i-th factor is the score of customer expectation;

W_j -Weight of the j-th attribute.

Finally, the average SERVQUAL score of a service product of an enterprise can be obtained by adding all the SERVQUAL scores of the returned questionnaires and dividing them by the total number of questionnaires m. the formula is as follows:

$$SQ = \frac{1}{m} \sum_{i=1}^{m} SQ_i \tag{2}$$

m- Number of customers surveyed.

According to the definition of high-speed railway passenger transport service quality and its quality

characteristics, all seven service quality characteristics of "fast, safe, punctual, economic, comfortable, convenient and civilized" are summarized and combined, modified and optimized, finally, safety, reliability, economy, convenience and comfort are identified as the five main quality attributes of high-speed railway passenger service quality evaluation.

Under each service quality attribute, the corresponding quality evaluation index should be selected. In order to make passengers feel better and score better, the quality evaluation indexes suitable for high-speed railway passenger service quality evaluation are determined as shown in Table 1.

2.3. Questionnaire on Passenger Service Quality of Beijing Zhangjiakou High-Speed Railway

For the evaluation index of passenger service quality in this questionnaire survey, this study decided to select nine indexes in two aspects: convenience of ticket ordering, convenience of entering and leaving the station, convenience of station guidance, convenience of ticket checking and boarding, comfort of station waiting, comfort of getting on and off the platform, comfort of WIFI, information service and infrastructure. Satisfaction is divided into five levels: very dissatisfied, dissatisfied, average, satisfied and very satisfied. In addition, it also includes the basic information and travel characteristics of passengers, as shown in Table 2.

2.4. Quantitative Analysis of Service Quality Evaluation Index

Based on the survey of the passenger's satisfaction with the nine service quality evaluation indicators compared with other high- peed railways, the passenger's satisfaction is divided into five levels: very dissatisfied, dissatisfied, average, satisfied and very satisfied. According to the order of very unsatisfied, unsatisfied, general, satisfied and very satisfied, the scores are given: 1, 2, 3, 4 and 5. The passenger's perceived satisfaction is assigned as shown in Table 3.

The following formula can be used to calculate the average score of the evaluation index in the questionnaire survey,

$$A_m = \frac{\sum_n Y_{nm} \times Z_n}{X} \tag{3}$$

A_m - The average score of the satisfaction questionnaire of the m index;

Y_{nm} - The number of passengers who make the n-th evaluation on the m-th index;

X - Total number of questionnaires.

According to the above formula, the average passenger perception scores of the nine passenger service quality evaluation indexes can be calculated respectively.

It can be seen from the table 4 that among the nine evaluation indexes related to the impact of intelligent technology and equipment, the scores are all over 3 points, and the percentage of improvement is more than 25% compared with 3 points, which indicates that the application of intelligent technology and equipment can obviously improve the perception of

Table 1. High speed railway service quality evaluation scale

Quality of service attributes	Components		Related facilities or technologies
Safety	1	Safety of taking high-speed rail	Platform doors, BAS, FAS, C3+ATO, earthquake warning system, intelligent EMU
	2	Public order at stations and carriages	
	3	Catering and food hygiene	
Reliability	4	Punctuality of train arrival and departure	Intelligent passenger station brains, C3+ATO
	5	Is the station name broadcast timely	
	6	Timeliness and reliability of staff response	
Economy	7	Is the fare reasonable	E-ticket, intelligent EMU
	8	Catering service quality	
	9	Whether the commodity price is reasonable	
Convenience	10	Convenience of ordering tickets	Intelligent passenger station, E-ticket, intelligent ticketing organization, automatic face recognition,
	11	Convenience of security check	
	12	Convenience of walking in the station	
	13	Convenience of ticket checking and boarding	
Comfort	14	Comfort of alighting and boarding	Intelligent EMU, intelligent platform doors, intelligent passenger station
	15	Comfort of station waiting	
	16	Infrastructure	
	17	Network service(WIFI)	
	18	Information service	

specific passengers on the evaluation indexes.

2.5. Service Quality Calculation Based on SERVQUAL Model

Using the calculation method of SERVQUAL model for reference, we can calculate the customer perceived quality score of intelligent equipment. The results are as shown in Table 5.

This study only studies the convenience and comfort of intelligent technology equipment in passenger service, a total of 9 quality evaluation indicators. Therefore, in the SERVQUAL calculation, the safety, reliability and economy are regarded as unchanged.

In terms of weight, refer to the determination value of SERVQUAL model case in the textbook "high speed railway passenger service". The SERVQUA score of a single passenger taking Beijing Zhangjiakou high-speed railway based on other high-speed railway is as follow:

$$SQ=(92.25+73.1)/134=1.23$$

Which means, with the application of intelligent equipment, the average SERVQUAL score of Beijing Zhangjiakou high-speed railway is 1.23 higher than that of other high-speed railways. It can be seen that the application of intelligent technology and equipment has greatly improved the passenger transport quality of Beijing Zhangjiakou high-speed railway compared with other high-speed railway.

3. ANALYSIS OF THE IMPACT OF INTELLIGENT EQUIPMENT ON HIGH-SPEED RAILWAY OPERATION ORGANIZATIO

The influence of the application of high-speed railway intelligent technology equipment on the operation organization of high-speed railway can be divided into two aspects, one is the influence on the operation process, the other is the influence on the railway carrying capacity.

3.1. Influence of High-Speed Railway Intelligent Technology Equipment on Operation Process

The intelligent CTC system has an internal operation model consistent with the actual train operation. The system can use the model and comprehensively consider various information to realize intelligent adjustment of operation plan. Through data mining, statistics and other methods, it can count the relevant train operation data to provide theoretical basis and decision support for train operation, adjustment and emergency disposal. The intelligent CTC system establishes the station track adjustment model, which can obtain the information

Table 2. Survey contents of basic passenger information and travel characteristics

Essential information	Gender	Male, female
	Age	Under 20 years old, 21-35 years old, 36-50 years old, 51 years old and above
Travel characteristics	Travel purpose	Go home, work, travel, experience intelligent high-speed rail, etc
	Travel frequency(one year, Beijing Zhangjiakou high-speed railway)	Once, twice, three times or more
	Travel frequency(one year, other high-speed railways)	Less than 10 times, 10-30 times, 30 times and more

Table 3. Distribution table of the number of passengers with various index evaluation scores

Evaluating indicator Satisfaction		1	2	3	4	5
Convenience	Ticket booking X_1	2	6	46	50	30
	Accessing to stations X_2	0	1	9	59	65
	Guidance X_3	0	1	23	70	40
	Security/Ticket checking and boarding trains X_4	0	0	10	70	54
Comfort	Waiting in station X_5	0	2	25	61	46
	Boarding and alighting X_6	0	0	23	60	51
	Service facilities on train X_7	0	1	15	74	44
	Internet service(WIFI) X_8	1	6	42	51	34
	Information service X_9	0	1	27	64	42

of the actual track occupation, equipment operation status, train plan and passenger flow from the database, and calculate the adjusted track according to the model. Track intelligent adjustment can not only reduce the labor intensity of dispatchers and duty officers, but also effectively prevent passengers from getting on the wrong train and reduce the interference of passenger flow to station operation.

3.2. Influence of Intelligent Equipment on Railway Carrying Capacity

The influence of intelligent equipment on railway carrying capacity is mainly reflected in the compression of station interval, so as to improve the railway carrying capacity. Through the case study on ATO and manual test of Chaoyang Station to Xinmin North station section of Beijing Shenyang Passenger Dedicated Line [4], it has found that compared with manual driving mode, ATO mode has more accurate train control, and ATO mode has shorter departure interval than manual driving mode.

4. ANALYSIS ON THE INFLUENCE OF INTELLIGENT EQUIPMENT ON HIGH-SPEED RAILWAY EQUIPMENT OPERATION AND MAINTENANCE

Algorithmic IT Operations (AIOps) refers to the operation and maintenance methods that automatically learn and summarize rules from massive relative data and make decisions through artificial intelligence

Table 4. Evaluation score table of passenger indicators

Evaluating indicator	Score of Beijing Zhangjiakou high-speed railway	Higher value than other high-speed railways	Percentage of increase
Ticket booking X_1	3.75	0.75	25.0%
Accessing to stations X_2	4.40	1.40	46.7%
Guidance X_3	4.11	1.11	37.0%
Security/Ticket checking and boarding trains X_4	4.33	1.33	44.3%
Waiting in station X_5	4.13	1.13	37.7%
Boarding and alighting X_6	4.21	1.21	40.3%
Service facilities on train X_7	4.20	1.20	40.0%
Internet service(WIFI) X_8	3.83	0.83	27.7%
Information service X_9	4.10	1.10	36.7%

Table 5. SERVQUAL model calculation table

Quality Attribute (Wj)	Index（Xi）	Expected value $\sum_{i=1}^{134} E_i$	Experience value $\sum_{i=1}^{134} P_i$	$\sum_{i=1}^{134}(P_i - E_i)$	$\sum_{j=1}^{5} W_j \sum_{i=1}^{134}(P_i - E_i)$
Convenience (0.15)	Ticket booking X_1	402	502	100	92.25
	Accessing to stations X_2	402	590	188	
	Guidance X_3	402	551	149	
	Security/Ticket checking and boarding trains X_4	402	580	178	
	total			615	
Comfort (0.10)	Waiting in station X_5	402	553	151	73.1
	Boarding and alighting X_6	402	564	162	
	Service facilities on train X_7	402	562	160	
	Internet service(WIFI) X_8	402	513	111	
	Information service X_9	402	549	147	
	total			731	

algorithms such as machine learning. The impact of the application of intelligent equipment on the operation and maintenance of high-speed railway equipment is as follows:

(1) Equipment monitoring. Using intelligent equipment for equipment detection can shorten the maintenance time, reduce the labor intensity of operators, and improve the detection quality and efficiency [5].

(2) Information management. The equipment information management platform is the basis of the intelligent operation and maintenance system. Relying on this platform to realize the intelligent management of equipment maintenance management, data storage analysis, construction management and other production links, which eliminates the fragmentation of operation and maintenance management information [6].

(3) Data analysis. By using big data technology to analyze various indicators, we can grasp the health and quality of each system of high-speed trains, formulate reasonable maintenance strategies, reduce the maintenance cost of the whole life cycle as far as possible under the premise of ensuring safety and reliability.

5. CONCLUSION

This paper briefly describes the application of intelligent technology equipment in Beijing Zhangjiakou high-speed railway. Through the design of questionnaire and SERVQUAL model based service quality calculation, this paper focuses on the analysis of the impact of intelligent technology equipment on the passenger transport service of Beijing Zhangjiakou high-speed railway. The results show that the application of intelligent technology equipment can improve the perception of specific passengers on the evaluation index, and greatly improve the passenger transport quality of Beijing Zhangjiakou high-speed railway. In the process of traffic organization, the application of intelligent technology and equipment can realize the reasonable allocation of transportation resources, eliminate potential safety hazards in advance, and greatly improve the service level. It can also reduce the station interval time and improve the railway carrying capacity. In terms of equipment operation and maintenance, the use of intelligent technology equipment can improve the operation and maintenance efficiency and reduce the learning cost and construction cost.

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