Fully Automatic Operation System in Urban Rail Transit Is Applying in China

Fei Yan, Bo Liu, Yao Zhou, Chunhai Gao and Tao Tang

Abstract Fully Automatic Operation (FAO) is the highest level in the automation level of urban rail transit train operation and can reduce the security risk caused by human behavioral mistakes so as to provide more secure and efficient technical support for the urban rail transit operation. The FAO system is a complicated system and covers the whole lines and each station and train. This paper emphatically introduces development of the FAO system in domestic. FAO system will be applied to Beijing Metro Yan Fang line. Its application not only improves the automation level of technical equipment, but also comprehensively improves the technical level, the operation mode of rail transportation and the RAMS (Reliability, Availability, Maintainability and Safety) level of the whole rail transportation control equipment so as to ensure high-security, high-reliability and high automation operation under the unattended supervision situation. FAO system will be applied in several cities of the country in the near future, and it has a wide prospect of application in China.

Keywords FAO · Yanfang line · Technical support · Prospect

FAO is the highest level in the automation level of urban rail transit operation and has been widely applied in many countries such as France, Germany and Singapore, so the fully automatic operation system developed in China will go into operation in Yanfang Line in 2017. This paper has made a brief introduction for the definition, characteristics and development of the FAO system in China

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1   Introduction of Urban Rail FAO System

1.1   Concept of Urban Rail FAO System

The International Association of Public Transport (UITP) divides the grade of automation (GoA for short) of train operation into 5 grades [1, 2], Including (Fig. 1).

   The fully automatic operation (FAO) system is collectively called GoA3 and GoA4 above, which is a new generation of urban rail transit system which realizes automation during the whole train operation based on technologies such as the modern computer, communication, control and system integration. The FAO rail transportation can realize automatic awaking, driving out of the rail yard, operation in the main track according to the timetable, driving among stations, precisely train stopping, door opening and closing, departing from station, train turn-back operation, clearing of passengers after operation, train depot returning and sleep…, no intervention of driver and crew members is needed for the whole process.

1.2   Advantages of Urban Rail FAO System

Compared with the existing manned operation system widely applied, FAO can reduce the security risk caused by human behavioral mistakes. Manned operation of traditional train relies heavily on the personal response of driver, so it is hard to precisely control the human factors. However, for the metro cars with fully automatic operation, the computer program can automatically respond and make a decision at the first time during operation according to the situation happens immediately. Moreover, the train with fully automatic UTO will not be influenced due to fatigue and sudden disease of driver or other situations.
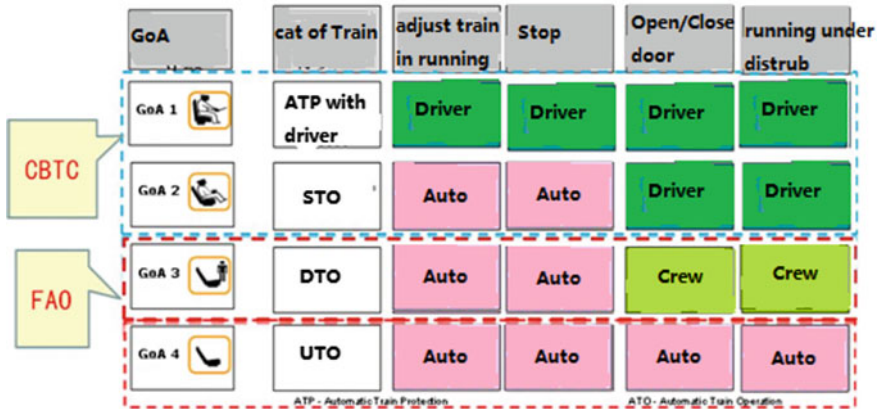
GoA	cat of Train	adjust train in running	Stop	Open/Close door	running under distrub
CBTC					
GoA 1	ATP with driver	Driver	Driver	Driver	Driver
GoA 2	STO	Auto	Auto	Driver	Driver
FAO					
GoA 3	DTO	Auto	Auto	Crew	Crew
GoA 4	UTO	Auto	Auto	Auto	Auto

ATP : Automatic Train Protection   ATO : Automatic Train Operation

Fig. 1 5 grades of automation

Fig. 2 Video monitor and emergency talking devices in FAO

The FAO system can free the driver from repetitive operation, configure crew members on the train, improve the service level for passengers and can monitor the train operation state simultaneously [3].

In addition, the FAO system can enhance the functions of video monitoring and emergency talkback on the train so as to improve the capabilities of emergency disposal and counter terrorism (Fig. 2).

2 Components and Technical Features of FAO System

2.1 FAO System Components

The FAO system is a complicated system which is composed of the central monitoring system, the station subsystem, the on-board controller and the train-ground communication network and covers the whole line and each station and trains [4–6]. In addition, it is also a system with high reliability, high safety and high automation and can operate continuously for the whole day. The system structure is shown as the following figure.

The strengthened central monitoring system is in charge of monitoring, controlling and maintaining the whole line equipment such as driving, trains, electromechanical device and power supply units and conducting emergency disposal under emergency or accidental situations; the station subsystem is in charge of train management within the area, access handling, station monitoring, track-side location layout, zone occupation, turnouts and annunciator; the on-board controller realizes the functions such as train safety protection, automatic operation, passenger response and train monitoring; and the train-ground communication network realizes the two-way wireless train-ground communication with high-capacity and comprehensive load bearing [7].

2.2 Technical Features of FAO System

The FAO system not only improves the automation level of technical equipment, but also comprehensively improves technical level and the operation mode of rail transportation. Meanwhile, it improves the RAMS grade of the whole rail transportation control equipment so as to ensure high-safety, high-reliability and high-automation operation under the unattended supervision [8]. However, the FAO system shall solve the following technical problems:

1. Improve the whole automation level through multi-discipline deep integration.

Take the train traffic control as the core, deeply integrate signals with multiple systems such as trains, electric power, electromechanical and communication, realize multi-discipline automatic linkage under normal and fault conditions and improve the whole automation level of the rail transportation operation system. The Integrated supervision and control platform is shown as the following Fig. 3.

2. Improve the reliability of system through the comprehensive and sufficient redundancy configuration.

Signals enhance the redundancy configuration based on the existing equipment redundancy. For example, the train enhances dual-network redundancy control and increase interface redundancy configuration with signals and PIS (Passenger Information System).

3. Improve the overall security through enhancing the protection of passengers and operation staff.

Enhance the protection function for passengers, protect the train on-off and interior safety of passengers, enhance the protection function of operation staff and increase each system linkage function under the emergency situation, such as the linkage of ventilation, driving, power supply, videos and broadcast under the fire situation.

Fig. 3 Multi-equipment multi-domain deep integration and cooperation in FAO
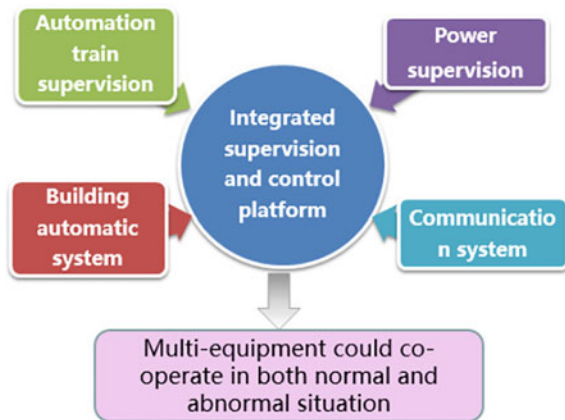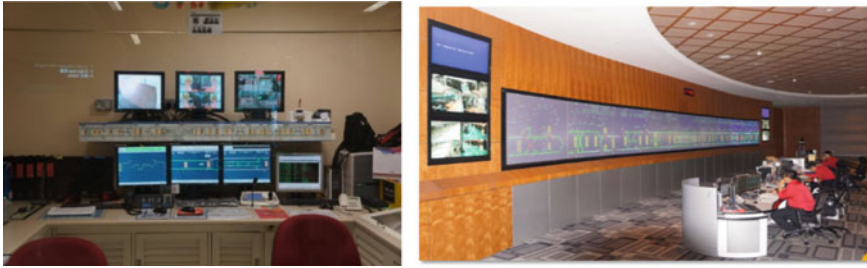
Fig. 4 FAO use enhanced control center functions

4. Improve the emergency treatment capability through rich central control functions.

The FAO system will weaken the station functions, enhance the control function of center, realize comprehensive monitoring of the train FAO, conduct detailed monitoring and maintenance dispatching of each equipment system and provide the remote service facing passengers. The control center newly increases the functions of train dispatching and passenger dispatching so as to realize the functions of train remote control, state monitoring and passenger service [9] (Fig. 4).

5. Reduce the maintenance cost of system equipment through the maintenance comprehensive dispatching system based on big data.

According to the modern operation demands, set up a metro operation maintenance dispatching command platform based on big data by adoption of the thought "Network+", taking the user as the core, with co-construction of all disciplines and based on the data method. Therefore, the system fault rate and the maintenance cost can be reduced [10].

3 Application of FAO System in China

China's construction on the FAO rail transportation system has just begun. Currently, there are only 2 FAO lines which are respectively Beijing Airport Express and Shanghai Metro Line 10. Beijing Airport Express went into operation in July 2008 and had the UTO function in March 2012, the total length is 28.1 km, with the maximum running speed of 100 km/h, and the control system adopts the Urbalis CBTC UTO system of ALSTHOM LTD. Shanghai Metro Line 10 (Phase I), the first large-volume rail transportation line by adoption of UTO level in domestic, went into operation in November 2010, the total length is 36.2 km, with the maximum running speed of 80 km/h, and the control system adopts Urbalis CBTC UTO system of CASCO Signal Ltd. In order to ensure the traffic safety, one steward is respectively configured on both lines during actual operation,

Fig. 5 FAO lines in China

when the UTO system operates normally, the steward is responsible for monitoring the operation state of train; and when a fault occurs, the steward can conduct emergency treatment in time and manipulate the train to run. At present, this kind of system is continuously planed and adopted by various cities such as Beijing, Shanghai, Chongqing, Shenzhen and Qingdao (Fig. 5).

China have completed the development, equipment development and test procedure of the FAO system, and the engineering implementation of Beijing Metro Yanfang Line is being carried out at present.

Operation analysis and design of Beijing Subway Yanfang Line is jointly completed by the construction unit and Beijing Jiaotong University. The whole operation process of ATO system were analyzed from the angle of system, and the Operation Scenario of ATO system is compiled. In combination with the Operation Scenario of ATO system, the personnel organization structure and post responsibilities of ATO system control center, rail yard and station were analyzed, and the management rules and emergency disposal rules under GOA3 and GOA4 were formulated. The control center dispatching responsibilities were combed according to the operation scenario of Yanfang Line. Based on the analysis results of dispatching load, the configuration scheme of control center dispatchers and professional equipment of the dispatching console is designed, and the site layout plan and console design scheme were designed.

Operation control equipment of Beijing Subway Yanfang Line is developed by Beijing TCT. The system realizes automatic execution or center manual execution of remote sleep awake through the sleep awake module. Realize the LTE-based large-capacity vehicle-ground communication technology, realize CBTC signal system, PIS, CCTV, emergency text and train real-time status by setting different priorities. Realize highly reliable on-board automatic train operation control, and improve reliability through head and tail BTM redundancy, head and tail speed measurement redundancy and red-blue dual net vehicle-ground communication redundancy; improve fault tolerance through contraposition isolation of the car door and platform door and platform jumping benchmarking; improve recoverability thorough remote fault isolation and remote fault reset. The system can realize unmanned automatic turn-back after the train arrives at the turn-back station, and the accuracy rate of automatic turn-back is over 99.99%; the probability for the train
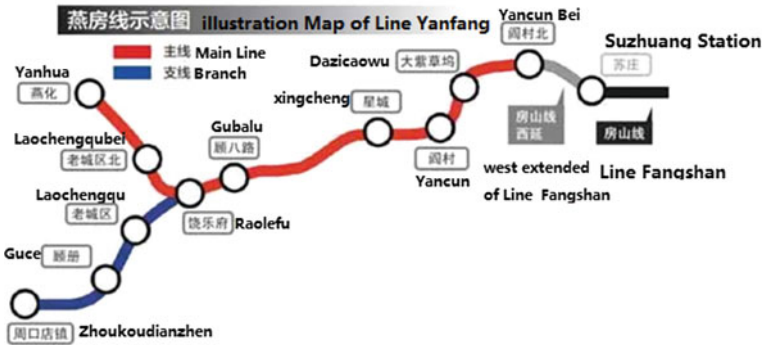
Fig. 6 Illustration map of line Yanfang

to park within ±0.3 m parking accuracy range is over 99.99%; the probability for the train to park within ±0.5 m parking accuracy range is over 99.9998%.

The Beijing Metro Yanfang Line with FAO will go into operation in 2017 (Fig. 6).

4   Conclusion

FAO is the highest level in the automation level of urban rail transit train operation and can reduce the security risk caused by human behavioral mistakes so as to provide more secure and efficient technical support for the urban rail transit operation. It not only improves the automation level of technical equipment, but also comprehensively improves the technical level, the operation mode of rail transportation and the RAMS level of the whole rail transportation control equipment so as to ensure high-security, high-reliability and high automation operation under the unattended supervision situation.

Although FAO system has been widely applied in the world urban rail transit, its construction in China has just begun. The FAO system developed in China will go into operation, and FAO system will be applied in several cities of the country in the near future. It is obvious that the FAO system has a wide prospect of application in China.

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