APM System Extension and Signaling System Replacement at Hong Kong International Airport

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IHI and Niigata Transys Co., Ltd. have successfully completed an APM line-extension project at Hong Kong International Airport. In addition to the 1 400 meter APM line extension and new vehicles, the signaling system was completely replaced with a new system in this project. One of the challenges was to minimize the project's impact to the daily operation of the current APM service. Another aspect of this project was that the new system required integration for four types of trains including, these supplied by another manufactures. Through this project, we had a chance to learn a lot and to build up our experience, particularly regarding the best practical methods when building APM line extensions and providing the latest technology to existing facilities.

1. Introduction

Hong Kong International Airport, one of the major hub airports in Asia, has seen ever growing quantities of passengers and cargo since it was brought into service in 1998. The number of passengers was over 70 million in 2016, reaching 68.5 million in 2015. In order to respond to this growing number of passengers, Hong Kong International Airport invested 10 billion Hong Kong dollars (approx. 150 billion yen) and launched Midfield Development project in 2011. This project covered the construction of a five-story concourse with an area of 105 000 m^2 having 20 boarding gates and the extension of the Automated People Mover (APM) system connecting the existing terminals and the concourse via underground tracks. The track layout is shown in **Fig. 1**.

2. Scope of work

This project included the following construction work:

- Track extension: Extension of 2 existing tracks, construction of 1 new track, approx. 1 400 m per track
- Signaling system replacement: Including on-board equipment for the current vehicles
- New vehicles: 5 sets of 2-car vehicle
- Modification of current vehicles: 9 vehicles
- Traction Power System
- Platform Screen Doors (for 4 platforms)
- Passenger Announcement System, Dynamic Message Sign, Intercoms

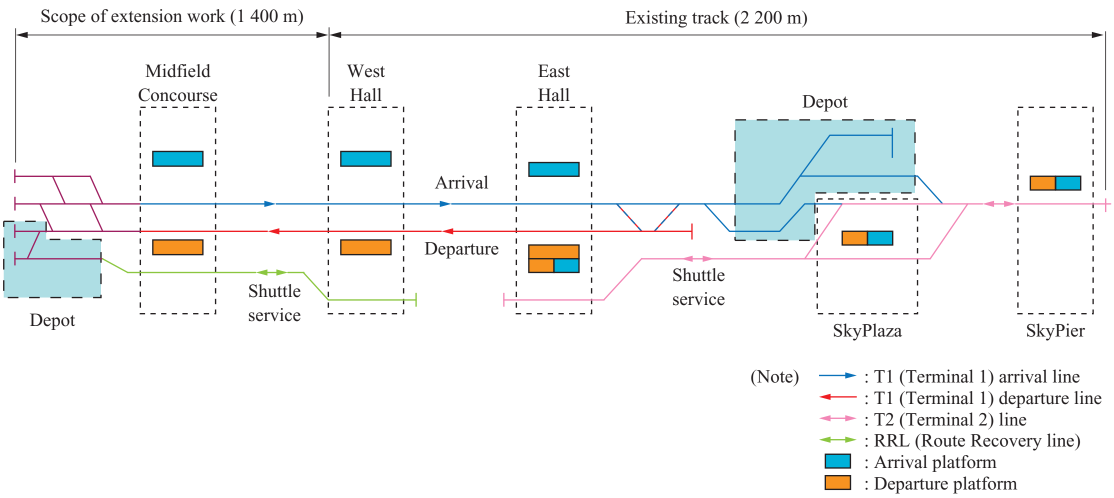

Fig. 1 APM track arrangement

3. Signaling system replacement

During the track extension work of this project, the old signaling system was replaced with a new one. The objectives of the replacement were as follows: ① improving reliability (reason: 19 years had elapsed since the old system was brought into service), ② improving operating flexibility, and ③ reducing maintenance costs.

The signaling system replacement made it possible to minimize the impact of the track extension work on service operation. The new signaling system could not be used for service operation until it was approved for operation. During the period of test and commissioning, the new signaling system was tested only during non-operational hours, and the old system continued to be used for service operation. Therefore, both the old and new signaling systems were in place during the replacement period. Since no changes were made to the old signaling system, except the addition of switches for changeover to the new system, it could be stably operated as before while the new signaling system was being installed and tested.

In the period of replacement works, some of the devices of the new and old signaling systems must be located along each track while avoiding physical interference between them. The old signaling system used a tightly coupled inductive radio system, i.e. transmitter receivers between the wayside and the on-board equipment were located close to each other. The wayside signal transmission loop cables were installed in the guideway over the entire lengths of the tracks. In addition, transponders for position reference during deceleration and stopping at stations were also installed in the guideway.

For the new signaling system, we adopted a state-of-the-art Communication-Based Train Control (CBTC) system provided by Thales. This system performs data exchange between the wayside equipment and the on-board equipment via a 2.4 GHz wireless LAN. Wayside transmitter receivers (access points) were installed on tunnel walls at intervals of 100 to 200 m. As a result, the number of devices installed in the wayside was reduced, so that the wayside equipment of both the old and new signaling systems could be laid out together.

Transmitter receivers for on-board equipment were installed corresponding to wayside transmitter receivers of the old and new systems. Under floors, in particular, three types of transmitter receivers for the old signaling system and two types of transmitter receivers for the new signaling system were installed. Since no metal was allowed to be used within a certain distance of each transmitter receiver to prevent misdetection, and the old vehicles had already been loaded with underfloor equipment, locations that accommodated the transmitter receivers of the new signaling system were limited. For this reason, locations of the new signaling system's wayside equipment and transponders installed in guideway were dependent on the layout of the underfloor equipment in the vehicles. **Figure 2** shows both signaling systems' wayside equipment and transponders installed in the guideway.

4. Modification of the old vehicles

The airport planned to operate four types of vehicles on the extended lines — new vehicles manufactured by Niigata Transys Co., Ltd. (NTS), and the three types of old vehicles. Some of the old vehicles were delivered by NTS in 2005, and the remainder were non-NTS vehicles.

On the old vehicles, devices of signaling system have been installed. Those vehicles were modified to add the new signaling system. The modification work included the installation of controllers, which could be likened to the brains of the system, as well as the installation of velocity and position detection sensors serving as sensory organs and the modification of cables serving as the nervous system connecting the controllers and the on-board equipment of the non-signaling system (e.g., propulsion/brake controllers, door operating unit).

During the vehicle modification work, we had to deal with the lack of space for installing devices and cables. Due to their intrinsically compact design, the vehicles lacked empty spaces. Also we had to leave the old signaling system as it was. Therefore when installing new on-board controllers on the old vehicles, we removed some of the seats and then installed their housings. In order to install additional cables that could not be installed in the existing underfloor cable duct, we installed additional cable duct in the ceilings. Because of these cables, terminal blocks also had to be added, and they were located taking ease of future maintenance into account to the maximum extent possible. **Figure 3** provides a photograph of the vehicle modification

Fig. 2 Trackside equipment for new and old signaling systems

Fig. 3 Vehicle interior during modification work

work.

Before starting the modification work, we carefully checked the old vehicles and their drawings. However, during the modification of the old non-NTS vehicles, in particular, we encountered several problems that we had anticipated from the beginning. For example, we found that existing cables were inconsistent with their drawings as a result of modification to add equipment conducted by a contractor, not the vendor of the vehicle. It was found during function test in a course of investigation for a problem.

With the awareness of the risk that aged cables and connectors of the old vehicles would pose problems such as broken conductive wires and short-circuits, we took extra care (avoiding modification of the existing cables to the maximum extent possible, etc.) during the modification of the old vehicles to prevent the occurrence of problems. **Figure 4** shows a vehicle compartment upon completion of the modification work.

5. Securing test time — separate track test

In extension work, like the work we completed in Hong Kong International Airport, all work that might affect service operation on the existing lines are performed during non-operational hours. In Hong Kong International Airport, because of daily maintenance work after service operation and confirmation run before the beginning of service operation in the next day, we had no more than about 3 hours a night to do our work. Actually, due to the necessity of switchover from the old signaling system to the new signaling system to perform our test and commissioning, the time we could spend on testing was limited to about 2.5 hours per night. Securing time for running tests was a major challenge.

Fig. 4 Vehicle interior after finish modification work

On the other hand, there was possibility to work on the new line and the extensions of the existing lines without having to worry about interfering with the service operation. In order to secure as much time as possible for running tests, we planned to perform some items of the test and commissioning only on the new line or the extensions of the existing lines wherever possible. New vehicles underwent a running test on the new line, in principle. **Figure 5** shows a photograph of new vehicle delivery work. **Figure 6** is a photograph of a vehicle undergoing a running test.

For the extension of the existing lines, we took a special measure called Separate Track Test, in which a running test was conducted only on the extensions. This measure divided each track into three areas: an operating area, a test area, and an isolation area located between the operating and test areas to prevent the vehicle running in the operating area from entering the test area and vice versa. Track end buffers that had been installed since before the track extension work at the end of operation area were left unremoved, and the traction power feeder line in the isolation area was de-energized. At the end of test area, temporary track end was also added to the track database of the new signaling system. In addition, additional temporary stations (stop positions)

Fig. 5 Delivery of a new vehicle

Fig. 6 Test runs

were provided within the test area to eliminate the inconvenience during tests for Automatic Train Operation due to the lack of stations — there was only one station in the extension area.

During the separate track test, we checked the track database of the signaling system and the interface between the signaling system and vehicles. By adopting a separate track test free of time constraints, we were able to reduce the total work period.

6. Stages of the project

APM track extension work, including the job we completed, are preceded by civil engineering work in the extension areas. In this project, on-site work for the APM system was started after the completion of tunnel construction. We started our work from the construction of running surface and the installation of guide rails before installing wayside equipment, including the signaling system.

In parallel with these tasks, we modified the old vehicles and installed wayside equipment in the operating areas. Basic interface test and functional test were performed with these modified vehicles and wayside equipment that had been installed.

The new vehicles were fabricated at the Niigata Works of NTS and then upon completion of the guide rail installation work, they were delivered to the newly constructed depots in the extension areas.

During the periods of the extension work and the separate track test mentioned above, the tracks in the operating areas were physically isolated from the tracks in the extension areas. It was therefore impossible to transfer vehicles between operating and extension areas. Whereas only old vehicles were allowed to run in operating areas, only new vehicles were allowed to run in test areas of extension areas. A running test requiring all vehicles to run the entire lengths of all lines was started after completion of the separate track test.

Fig. 7 Overview of the airport island

A track extension project is completed through many complicated stages, as described above. We were able to successfully complete this project by formulating an appropriate general plan and carefully coordinating work before proceeding to each stage.

7. Conclusion

The Midfield Concourse and the APM system were partially brought into service at the end of 2015 and into full service in March 2016. **Figure 7** shows a general view of the airport island.

Operators of a lot of airports around the world are planning to extend their APM systems. We will continue to cooperate with Niigata Transys Co., Ltd. to provide smooth system extensions taking advantage of the experience gained from this project.