Kansai International Airport : automated guideway system

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Abstract

The Kansai International Airport passenger transportation system is a short-distance unmanned transport system (hereafter referred to as the AGT system: Automated Guideway Transportation system) which commenced operation in September 1994, at the same time as the airport opened. This paper deals with the overall configuration and functions of the AGT system, and configuration, method, content of information transmissions and method of preparing train control information of the traffic control devices, the station ATO cab equipment, ATC/TD ground-based equipment, ATC/TD cab equipment, and train shed equipment.

1. Introduction

The AGT system is designed to transfer international passengers safely, pleasantly and quickly by unmanned train between the main terminal building and the North and South Wings (approx. 680m) of Kansai International Airport which is located off the coast of Osaka. The AGT system eliminates the need for passengers arriving and departing on international flights to walk long distances and enables them to transfer between the main terminal building and the wings in less than 5 minutes, including waiting time. Efficient operation is ensured by switching between operation at regular intervals and demanding by passengers. This paper deals with the configuration and function of the AGT system, and with the content of the information transmissions, and the method and preparation of train control information.

2. Outline of the Automatic Driving System

2.1 Outline of the System

(1) Characteristics of the system

Although from the point of view of the equipment this is a single system, from the point of view of the system it is a double system with double installation of single lines , thus ensuring operation of each system in the event of failure or malfunction.

(2) Characteristics of the tracks and trains

Points are provided on the main line for use when the train is entering or leaving the repair shed. In addition, by introducing a branch system where turnout wheels are provided on the cabs to enable the trains to cross, the points are not used during unmanned operation.

The trains are of single fixed composition and oncoming trains pass at the double-track section.

The turnout wheels catch on the guide plates fitted along the traveling route, making the train run in the specified direction.

(3) Unmanned operation system

Unmanned operation is carried out by means of cab equipment which receives departure signals and position signals from the position loops installed along the route. To ensure safety, unmanned operation is based on ATC signals and the emergency brake on the train is activated when overspeed is detected.

Additional functions supporting unmanned operation include announcements to passengers at boarding and alighting points announcements on the train, safety monitors, and intercoms for communication with passengers.

Configuration of the system is shown in Fig.1.

The ground-based equipment consists of an operation control device, ATC/TD wayside equipment, vehicle radio fixed station device (hereafter referred to as an IR device), automatic broadcasting device and CCTV control device.

The cab equipment consists of station ATO cab equipment, ATC/TD cab equipment, vehicle radio cab equipment, an ATC/ATO control device, cab automatic broadcasting device and cab CCTV device.

(4) Modes of operation

There are two modes of operation, fixed interval operation where the shuttle runs between the boarding/alighting points in the main terminal building and the North and South Wings at 2 - 6 minute intervals, and demand operation where the passenger summons the shuttle, and setting can be switched from one mode to the other.

(5) Unmanned operation section and manual operation section

Unmanned operation takes place on the main line, while the shuttle is moved between the repair shed and the main line by manual operation. When the

shuttle leaves the shed, it is transferred to the main line where it is switched over to automatic operation. When the shuttle is moved to the shed, it is switched over from automatic operation to manual operation on the main line.

2.2 Traffic control device

To ensure smooth operation of the unmanned train, multiple unit control is carried out of the ATC/TD wayside equipment, communication equipment and indication board. Centralized control, monitoring and recording are also carried out, including train operation control, automatic driving control, condition monitoring, broadcasting device, indicating device, operation recording, etc.

The equipment is not divided into a PRC device, station ATO control device and interlocking device; instead, the functions are integrated into the traffic control device.

(1) Outline of functions

Operation of the train is based on the control mode and operation mode which are entered in the traffic control device in advance by selecting the setting on the dispatcher console.

The traffic control device enters the train number from the station ATO cab equipment and the train location information from the ATC/TD wayside equipment, tracks the train on the basis of this information and indicates operation on the dispatcher console.

Safe, smooth unmanned operation is ensured by departure control, door control, fixed stop position control, guidance indication control, broadcasting device control and train protection control.

(2) Configuration of equipment

The traffic control device consists of the ATO control rack, interface relay rack, ATO transmitter/receiver rack, dispatcher console and recording device.

(3) Man-machine communication function

Dispatcher console setting/selection and indications are shown below.

a. Control mode setting/selection

The modes of operation for the train are classified into schedule mode, demand mode and maintenance mode and setting is carried out by the person in command.

* In schedule mode automatic driving is carried out at designated regular intervals.

* In demand mode the train runs in response to pressing of the demand button on the platform.

* In maintenance mode operation is stopped.

b. Each monitor information displayed on the screen during operation

The items indicated on the CRT screen are shown below.

- The operation condition at the present time and when a new setting is

made are displayed. The contents of the display are as shown below.
* Control mode/operation mode
* Designated train name
* Interval between services
* Train location
* Composition number & train name

· Conditions at the boarding/alighting points are displayed. The contents of the display are shown below.
* Demand for train
* Doors open/Doors closed
* Abnormal message
* Emergency stop
* Start command received

c. Remote control of the train or site from the dispatcher console is as follows.

· If an abnormality occurs when the doors are closing, etc., the train is prevented from departing.

· In the event of passengers being trapped in the train while in demand mode, etc., the doors are forcibly opened.

· In the event of the partition door between departing and arriving passengers being opened, etc., the door is forcibly closed.

· In the event of shuttle personnel needing to board the train between stations in an emergency, the emergency brake is activated.

· In the event of shuttle personnel boarding the train between stations in an emergency, feeding of both the land side and air side lines (two single lines are named each as land side and air side) is stopped.

· The train stopped between stations is restarted.

· The emergency brake is released .

· The train is restarted as far as the station home position if it has stopped before reaching the station.

· The lights are lit or extinguished.

· The air conditioning is turned ON/OFF .

· The partition door signal is erased when the partition door has been opened or closed and operation is completed.

· Local operation of the electric points to enable the train to travel between the shed and the main line is approved when entering or leaving the shed.

(4) Warning function

The items and contents of the failure or abnormality warnings are shown below.

a. Failure or abnormality of the rolling stock

b. Emergency warning

In the event of an emergency involving the rolling stock, an audible and visual warning is given.

c. Abnormality of the electric points
The point is in the normal position during unmanned operation, and if it is moved to another position, an audible and visual warning is given. If the point is in a position other than the normal position when changing from maintenance mode to another mode, an audible and visual warning is given.
d. Door opening abnormal
e. Door closing abnormal
f. Local operation
If operation of the platform doors provided at each boarding/alighting point is set on local operation, an audible and visual warning is given.
g. Platform door failure
h. Equipment failure
If trouble arises in the traffic control device, ATC/TD wayside equipment or IR device located in the equipment room, an audible and visual warning is given.
i. MCCB failure (Distribution board breaker is tripped)
(5) Main ATO control functions
a. With regard to route control, provided that the train is approaching the control point (entering the double-track section) or control timing (a fixed time prior to departure when the train is stopped at a boarding/alighting point) has been reached, the operation mode and route control conditions are checked and if all the conditions are satisfied, the aspect is control output.
The route is controlled as follows. Signal waves f1, f2 (L direction) and f3, f4 (R direction) are sent by the cab equipment to the ground-based equipment as TD signals corresponding to the direction in which the train is traveling. The ground-based equipment receives the signal waves from the cab, identifies the direction in which the train is traveling and determines the direction of the branch section to be cleared according to that direction.
The trains controlled by signal waves f1 and f2 are identified as 'A' (land side) and 'C' (air side), and those controlled by f3 and f4 are identified as 'B' (land side) and 'D' (air side).
b. With regard to traffic control, sector codes are drawn up for each operation according to the control mode and operation mode on the dispatcher console. Control of the timing of control mode changeover and departure control is also carried out.
① Drawing up of sector codes
② Detection of timing of operation mode changeover
③ Simultaneous start limit when 4 trains are running inside the wing
c. With regard to departure control, when in schedule mode, departure is based on the service interval set on the dispatcher console. The various start conditions are checked and the departure control information is sent to the station ATO cab equipment. When in demand mode, starting is controlled according to demand (pressing of the demand button by passenger).

d. Trains are tracked by means of the train detection information entered through the ATC/TD wayside equipment, and the train number, starting direction and fixed stop information entered through the station ATO cab equipment, and the results are displayed on the CRT screen.
e. To verify the name of the train for selection of the turnout wheels, the name is input from the train and its rationality is checked.
f. To stop the train at the fixed stop position, a position signal is sent to the cab by the T1 and T2 loops installed along the traveling route. The direction is selected on the cab side.
g. To enable the train to transit the intermediate station, the sector code is sent to the station ATO cab equipment when the train departs the terminal station and the position signal for stopping at the intermediate station is erased on the train side.
h. To verify the fixed stop position, arrival of the train at the fixed point is detected by the D loop. When it has been verified that the train has stopped, a stop signal is sent to the wayside equipment via the D loop.
i. To protect the train, the emergency stop on each lane is activated when the following conditions occur.
① When the emergency door cover on the train is opened
② When the emergency stop button on the station platform or the emergency stop button on the dispatcher console is pressed
j. To control the train doors and platform doors, information relating to opening the doors according to the fixed stop position of the train based on the sector code, and information relating to closing the doors at the fixed time prior to departure is sent to the platform doors and station ATO cab equipment.
The door open control is suppressed if the partition door in the cab is opened.
It is released by operation from the dispatcher console.
If the door is opened or closed from the dispatcher console, the respective information is transmitted.
k. With regard to switching the departure direction, when it has been verified that the train doors and platform doors have opened after the train has stopped at the station, information for switching the departure direction is sent to the cab.
An answer back check is carried out by the traffic control device and if there is any abnormality, the alarm on the dispatcher console sounds.
l. To monitor the train, information relating to the state of the vehicle is input at regular periods from the train and from the vehicle radio device which transmits data, and the train is constantly monitored for irregularities.
m. When operating in demand mode, the train starts to operate when the demand button on the station platform is pressed.
n. When the train is entering or leaving the repair shed, the electric points on the shed line can be operated locally from the shed operation panel by

pressing the shed operation approval button on the dispatcher console.
o. The guide indicator provided on each station platform displays the service intervals when in schedule mode and CALL or OPERATION SUSPENDED when in demand mode, according to the control mode and operating mode information sent from the traffic control device.
p. The images from the cameras are changed by CCTV contral device according to the control information from the traffic control device and are displayed on the platform CCTV monitors. The traffic control device changes the images on the platform CCTV monitors from the passenger arrival platform to the passenger departure platform at a set time after arrival.
(6) Information transmission
As the receipt and transmission of information between the train, equipment room and central command room is essential to automatic driving, the transmission system shown below is provided.
a. The station ATO transmission system (using D, T1 and T2 loops) is used for route control, start control and fixed stop position control.
b. The vehicle radio transmission system (using the ATO/IR loop) is used for communicating with the trains and for data transmission with the vehicle.

2.3 Station ATO cab equipment
(1) Outline
The station ATO cab equipment is positioned as part of the cab equipment of the ATO control device. It carries out communication with the traffic control device and receives and transmits information for automatic running and for control of the equipment on the vehicle and wayside. It also sends position detection information for fixed stop position control to the ATO control device when in automatic driving mode. In addition to the functions of the ATO, there is also a speed check function as a backup to the ATC device. If overspeed is detected at the speed checkpoint, the emergency brake is applied.
(2) Merits
This device applies ME technology and has the following functions using 16-bit micro-computer.
a. Loop transmission between the wayside equipment and the cab
An induction-type communication system by close connection of the train antenna and wayside loop coil is employed. The communication protocol uses HDLC to ensure reliable, high quality, high speed transmission.
b. Improved security and maintainability are assured by concentrating the warning indications on the panel and by monitoring movement.
(3) Configuration
The station ATO cab equipment consists of a station ATO transmitter/receiver, station ATO antenna, connecting cable, etc.
(4) Functions

a. Transmission of information between the wayside equipment and the cab
① Serial transmission between the traffic control equipment and the station ATO cab equipment
② Serial transmission with the ATO control equipment
③ Input and output of control information and indication information from and to on-board equipment such as the ATC/TD cab equipment, door close circuit, automatic cab broadcasting equipment and vehicle radio cab equipment.
b. Position detection for automatic driving
The device receives position information from the wayside loop and the position is detected by the ATO control equipment on passing the twisting point of loop . The ATO control equipment corrects the position on the basis of the position information and carries out fixed stop position control.
c. Composition number
The vehicle composition number can be set by the composition number setting switch (2 figures) provided on the panel.
d. Operation indication
Monitoring of the position information, abnormality of the control parts, normal transmission, normal processing, and overspeed are indicated by the lighting up or flashing of the LED indicators.
e. Speed check
This device receives speed check information from the wayside loops for checking speed and measures the traverse time between the two twisting points provided on the loops to check the speed of the train. If the results of the speed check show that the train is traveling over the prescribed speed, the emergency brake is applied.

2.4 ATC/TD wayside equipment
(1) Outline
The ATC equipment produces an ATC signal suited to the speed stages shown in Table 1 to maintain safety of automatic train operation based on the signal aspect conditions from the traffic control equipment and sends it to the ATC/TD loop which transmits it to the ATC/TD cab equipment.
The TD equipment detects the train by continuously receiving TD signals from the cab by means of the ATC/TD loop. The ATC/TD loop is used by both the ATC equipment and the TD equipment and is integral with the equipment.
The equipment uses the PWD-ATC/TD system proven by monorails and new means of transport.
(2) Merits
a. Since the induction loop and cab antenna can be used by both the ATC and TD, the signal safety equipment is simple.
b. A high level of safety is assured as the trains can be detected by cab signals at both the front and rear of the train.

c. Safety has been improved by changing the TD signal according to the set position of the cab turnout wheel.
d. The PWM system is used to produce and amplify the ATC signals and TD signals. In addition to enhanced compactness and reliability by digitalization of the whole circuit, electric power amplification efficiency has been improved and electric power consumption reduced.
e. Safety and maintainability have been improved by concentrating the failure detection functions in the loop and by comprehensive monitoring of movement.
(3) Configuration
The ATC/TD wayside equipment consists of an ATC/TD transmitter/receiver rack, relay rack, matching transformer rack and ATC/TD matching transformers.

TABLE 1 SIGNAL CLASSIFICATION AND ACTION

SIGNAL CLASSIFICATION	ACTION			
	SIGNAL ASPECT	SPEED LIMIT	APPLICATION	BRAKE CLASSIFICATION
SIGNAL 37	37	37km/h	MAX. SPEED LIMIT	NORMAL FULL BRAKE
SIGNAL 22	22	22km/h	CROSSING SPEED LIMIT	NORMAL FULL BRAKE
SIGNAL P01	P01	37→0km/h	END OVERRUN PROTECTION	EMERGENCY BRAKE
SIGNAL P02	P02	37→0km/h	CROSSING OVERRUN PROTECTION	EMERGENCY BRAKE
SIGNAL P03	P03	22→0km/h	CROSSING OVERRUN PROTECTION	EMERGENCY BRAKE
SIGNAL 01	01	0km/h	NORMAL STOP	NORMAL FULL BRAKE
NO SIGNAL	02	0km/h	EMERGENCY STOP	EMERGENCY BRAKE

(4) ATC function in automatic driving
The ATC functions as a backup when the automatic driving functions are being operated by the traffic control device and contributes to assuring driving security.
a. Speed control and interval control
The ATC sends speed limit information according to the preceding train and route conditions to the cab equipment.

b. End overrun protection when stopping at the station
The ATC provides protection against end overrun as a backup to automatic fixed stop position control.
c. Crossing overrun protection
The ATC provides protection against crossing overrun if the rear of the train does not exit the contact limit when trains are crossing on the double-track section.

2.5 ATC/TD cab equipment
As Kansai International Airport is a severe environment for signal systems such as radio communications when aircraft are taking off and landing, special consideration has had to be given to noise resistance. The TD device uses a PWM-type AMP with reduced electric power consumption. The ATC device uses the SDP (Signal Digital Processing) system which is recognized for its compactness and high reliability, and performance has been further enhanced by use of the DSP (Digital Signal Processor) for signal wave selection. The cab devised front car on the terminal side (M3) acts as a signal amplifier and relays the signal to the ATC receiver on the driving cabin of the front car on the wing side (M1).
(1) Configuration
The equipment is divided into blocks according to function and is constructed for easy maintenance. The rolling stock is structurally fixed into those which run on loop 4T and those which run on loop 5T. As with the signals sent from the TD, the vehicles which run on loop 4T are "f1" on the terminal side and "f2" on the wing side, and those which run on loop 5T are "f3" on the terminal side and "f4" on the wing side.
(2) Operation
a. The ATC provided on the M1 and M3 driving cabins operates as follows.
① When the train is traveling towards the terminal side
The ATC amplitude parts on the terminal side and the ATC receiving parts on the wing side are in operation and the TD transmission parts on both driving cabins are in operation.
An f1 or f3 signal is sent from the TD transmission parts on the terminal side and an f2 or f4 signal is sent from the wing side.
② When the train is traveling towards the wing side
The ATC receiving parts on the wing side are in operation and the TD transmission parts on both driving cabins are in operation. An f2 or f4 signal is sent from the TD transmission parts on the wing side and an f1 or f3 signal is sent from the TD transmission parts on the terminal side.
b. TD operation
The CHR is the relay which checks that an f1 (f3) or f2 (f4) signal has been sent from the ATC/TD antenna and it is the receiving relay of the CHR circuit. The f1 (f3) and f2 (f4) signal is the signal which notifies the wayside equipment of the presence of a train. If the f1 (f3) or f2 (f4) signal is broken

and the CHR relay is released, the emergency brake is applied immediately. The CHR contact condition is sent to the other driving cabin and the CHPR operates. When the CHPR is operating, the TD signal that is sent from the antenna becomes an amplitude modulation wave and when the CHPR is released, it becomes an unmodulated wave (hereafter referred to as a continuous wave). In other words, when the CHR relay is released, the TD device conveys the abnormality of the cab equipment to the wayside equipment by turning the TD signal of the other driving cabin from an amplitude modulation wave into a continuous wave.

2.6 Shed operation panel

The shed operation panels are located in the train sheds at the North and South Wings for operation by the person in command in the central command room or the person in charge of the shed when vehicles are entering or leaving the shed.

3. Conclusion

This report has focused on traffic control of the passenger transport system of Kansai International Airport. In conclusion we would like to express our sincere thanks to everyone at Kansai International Airport Company for their assistance and cooperation and to all those involved in the preparation of this report.

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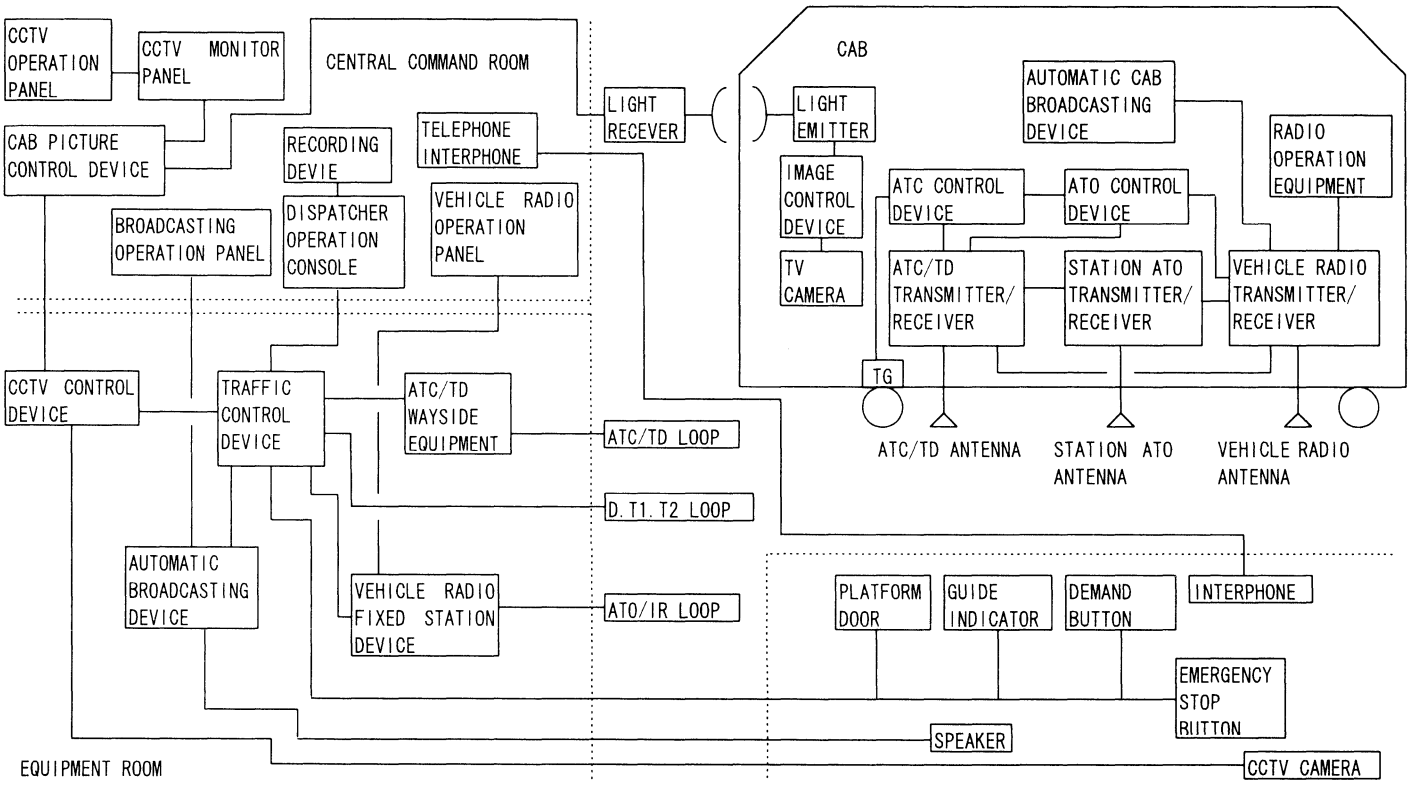

Figure 1 AGT SYSTEM CONFIGURATION DRAWING