AMCP WG/C7-WP

AERONAUTICAL MOBILE COMMUNICATION PANEL
Working Group F

SEVENTH MEETING

Bangkok
19-27 November 2001

Item 6. Future use of the 5GHz band (including MLS)

Airport Vehicle Positioning System

Presented by Shigeki Masuda
Prepared by Shuichi Tanaka & Shiro Nihei

Information Paper

SUMMARY

The attached paper provides status of the Japan's Airport Positioning System that would be one of the potential applications for 5GHz band. JCAB had informed GNSSP WG-B and AMCP WG-C of the system.

APPENDIX

AMCP WG/C3-WP25

AERONAUTICAL MOBILE COMMUNICATION PANEL
Working Group C

THIRD MEETING

Anchorage, the United States of America
15-19 October 2001

Item 6. New System to be considered/ Use of 5GHz

Airport Vehicle Positioning System

Presented by Shigeki Masuda
Prepared by Shuichi Tanaka & Shiro Nihei

Information Paper

SUMMARY

The attached paper provides status of the Japan's Airport Positioning System that would be one of the potential applications for 5GHz band.

1. Background

The frequency band 5000-5250 MHz band is allocated on an international basis to the Aeronautical Radio Navigation Service (ARNS). There are two WRC-2003 Agenda Items such as Item 1.4 and 1.6 dealing with the band.

Agenda Item 1.4 proposes considering the results of studies related to Resolution 114 (WRC-95) dealing with the 5091-5150MHz band. In order to support the future allocation requirement for the band 5091-5150 MHz, the identification of future spectrum requirements for the aeronautical system other than MLS is needed.

Agenda Item 1.6 proposes considering regulatory measures to protect feeder links for the mobile satellite service which operate in the band 5150-5250 MHz, taking into account the latest ITU-R Recommendations (for example, ITU-R S.1426, ITU-R S.427 and ITU-R M.1454) The band 5150-5250 MHz was originally allocated to the ARNS on a primary exclusive basis, however as a consequence of the later addition of other services to the band, there is little scope for safe and interference-free use of band by any ARNS systems. Therefore, the allocation of the band 5150-5250 MHz to the ARNS is likely to be deleted.

2. Discussion

Attached paper is a working paper prepared to GNSSP-WG/B in March 2001. The W.P. describes the data link system which is used for the management of mobile objects and data communications within airports. A trial system called Airport Surface ADS has been installed and tested at Chitose airport in Japan. Currently, the system is designed to use 2.4GHz ISM band, and it can be operated only for a trial basis. Therefore, the 5091-5150 MHz band is under consideration for the system.

3. Recommendation

The meeting is invited to note the information presented.

GNSSP-WG/B-WP/5

GLOBAL NAVIGATION SATELLITE SYSTEMS PANEL (GNSSP)

WORKING GROUP B

Banff, March 19th to 30th, 2001

Agenda Item 2.C): Aerodrome surface operations

Introduction of Airport Vehicle Positioning System in Japan

WORKING PAPER

(Presented by Yoshinori Kawai)
(Prepared by S. Tanaka, S. Nihei and N. Fujii (ENRI))

SUMMARY

This paper provides information of the one of the aerodrome surface operations activity with GNSS, called Airport Vehicle Positioning System installed at New Chitose airport in Japan. Its purpose is management of airport vehicles, such as fire engines and snow removing cars.

1. Background

One of the application of GNSS is the sensor of A-SMGC, therefore the vehicle management system using DGPS (RTK) is introduced to clear the performance requirement of GNSS for A-SMGC. ENRI (Electronic Navigation Research Institute) in Japan has been developing Airport Vehicle Positioning System using GNSS, and JCAB (Japan Civil Aviation Bureau) installed the trial system at New Chitose (Sapporo) airport in Hokkaido Island, where is northern part of Japan. It has been operating since May 2000. It has capability of communication with 300 mobile objects to operate ADS (Automatic Dependant Surveillance) system.

2. System Overview

ENRI has been developing the integration ADS system with various communication methods of both aircraft and vehicles on airport surface. The first of all, ENRI developed the Airport Vehicle Positioning System to manage the vehicles on the airport surface. The trial system was installed and has been operating at New Chitose airport now. The system is mainly used for the control of airport maintenance vehicles.

The system has two types of mobile object. One is the normal accuracy requirement group, which includes fire engines, runway snow friction measurement cars and airport authority utility cars, and the other is the precise accuracy requirement group, which includes snow removal cars and runway sweepers. The accuracy requirement of formers is within 1 meter using code DGPS and the requirement of latter is within 10 centimeter in order to avoid breaking the airport facility, such as runway lights and taxing lights. The latter is using RTK (Real Time Kinematic) differential GPS.

The update rates of position data of both groups are 1 Hz, and also the surveillance data of mobile objects are obtained 1 Hz at the mobile control station.

There are 6 master stations and actual moving objects are about 60 at New Chitose airport now. The system is possible to have within 15 master stations, which communicate with 100 user stations simultaneously within 1.5 km radius. The total capability of this system is that the control station can communicate with 300 mobile objects and get their positions in a second, and the mobile objects can also get the position of others.

The detail of Airport Vehicle Positioning System is described in Appendix.

3. Conclusion

This paper provides an example of GNSS application for the sensor of A-SMGC in Japan. This trial obtained good opinions by users.

The code differential and RTK differential GPS are adapted in this system. The meeting notes this activity and includes the summary of current status of performance requirements for surface operations.

Appendix

Airport Vehicle Positioning System

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1. Introduction

The Civil Aviation Bureau, the Ministry of Land, Infrastructure and Transport, is pursuing the deployment of the "Airport Coordinate Management System" which manages the positions of airports and aeronautical safety facilities using WGS-84 coordinate data based on the ICAO standards.

This system is intended to perform the centralized management of coordinates of airports by providing an electronic reference point for each airport in Japan. Studies are underway with a view to possible future application of the system to various other services within an airport such as surveying and vehicle operation management.

For the purpose of studying one of the possible applications of the Airport Coordinate Management System's electronic reference point, a prototype of the "Airport Vehicle Positioning System" which can be used for the management of mobile objects and data communication within an airport, has been built and installed in New Chitose Airport.

2. Overview of System

Figure-1 shows the concept of the Airport Surface ADS (Automatic Dependent Surveillance) System. The ADS system which is intended to keep mobile objects (such as aircraft and vehicles) on the airport surface under surveillance, accurately measures the positions of mobile objects using differential GPS (DGPS) or the like, then transmits the measured position data to the control tower and other locations through radio data links (data communications), and further displays the transmitted data on the airport surface map for the surveillance purpose. Based on these features, the ADS system can be applied to the purposes of collision prevention, traffic route instructions, etc.

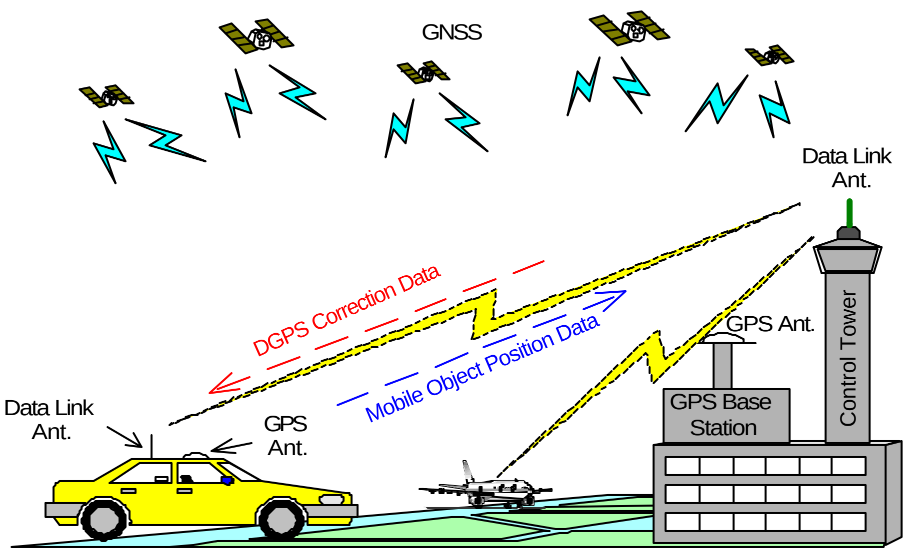


Figure-1 Concept of the Airport Surface ADS System

To implement a system intended for such purposes on the airport surface, a precision positioning technology (such as DGPS) and high-speed high-capacity data links are required to display the positions of a mixture of mobile objects consisting of many aircraft and vehicles at an update rate of once per second or so. However, it is difficult to handle aircraft and vehicles through the same data links, due to various restrictions.

To avoid this problem, the Electronic Navigation Research Institute (ENRI) is conducting research on an integrated ADS system which can handle mixed mobile objects using different respective communication media and methods but can keep such mixed mobile objects under surveillance on the same screen. So far, prototyping and testing of an airport surface ADS system intended mainly for surveillance of vehicles have been conducted, which have proven that surveillance of mobile objects within an airport can effectively be performed.

Figure-2 shows the example configuration of an integrated ADS system.

Figure-3 shows the basic configuration of a prototype of an Airport Vehicle Positioning System that has been built for operation evaluation experiments at New Chitose Airport on the basis of experimental airport surface ADS systems developed up to now.

This prototype system has a feature which can keep the entire airport surface under surveillance using high-speed SS (spread spectrum) communication technology which employs 1 Mbps DPSK convolvers, a polling protocol within radio cells, and technology to handle entry/withdrawal from radio cells. Specification of the radio data link are shown in Table-1.

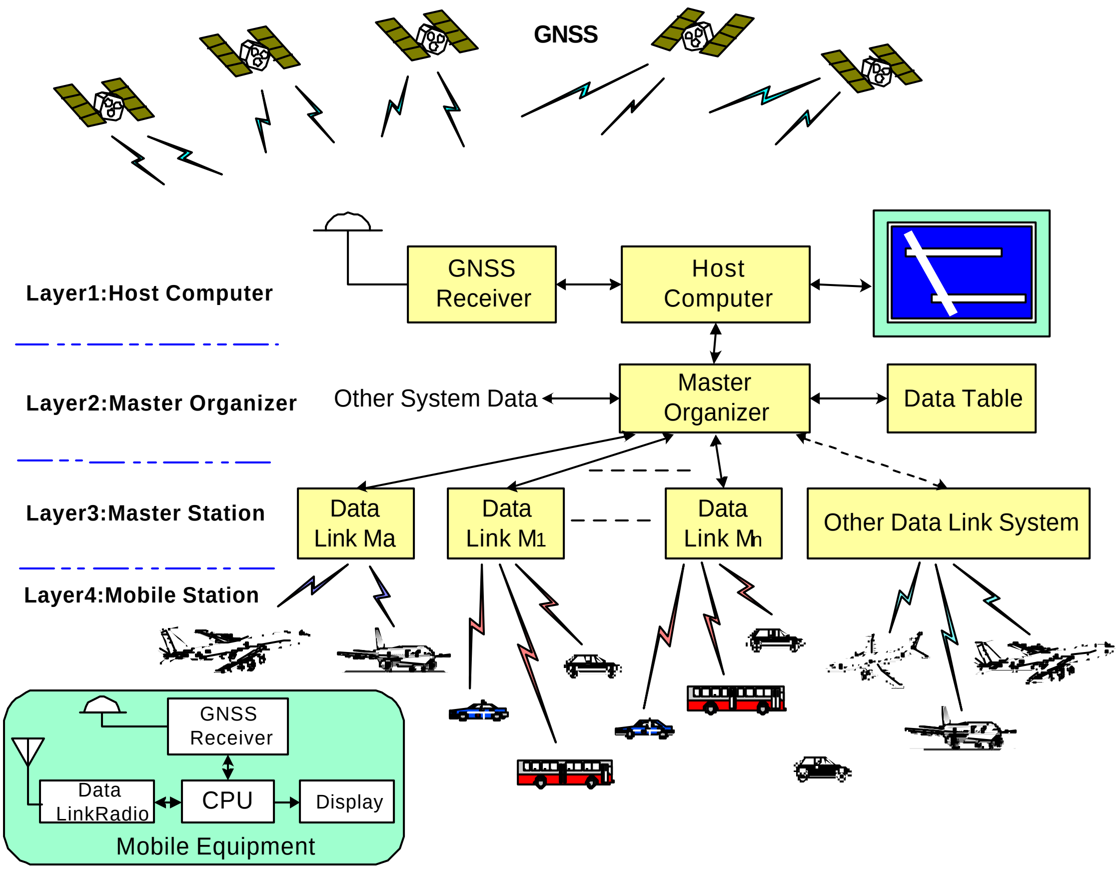


Figure-2 Example Configuration of Integrated ADS System

Each master station can handle a maximum of 100 mobile objects (either vehicles or aircraft) within the associated radio cell. The number of master stations can be increased to a maximum of 15 stations in one system, but one system can only keep maximum of 300mobile objects (either vehicles or aircraft) under surveillance. Each radio cell has a radio service area of approx. 1 km in radius, and is connected to the master organizer in the base station through an optical fiber cable LAN. The master organizer exchanges control messages with master stations, and executes sequential switching control of service times of the master stations to form cellular communication areas with no interference.

Table-1 Specifications of SS Radio Data Link

Radio Frequency	2.4GHz ISM (Industrial, Scientific and Medical) Band
Modulation Method	Direct Sequence Modulation
Spread Bandwidth	26MHz or less
Antenna Power	10mW/MHz or less
Data Transmission Rate	1Mbps
Data Link Method	Polling Method
Data Modulation Method	DPSK Modulation
Demodulation Method	Matched Filtering Demodulation by DPSK Convolver

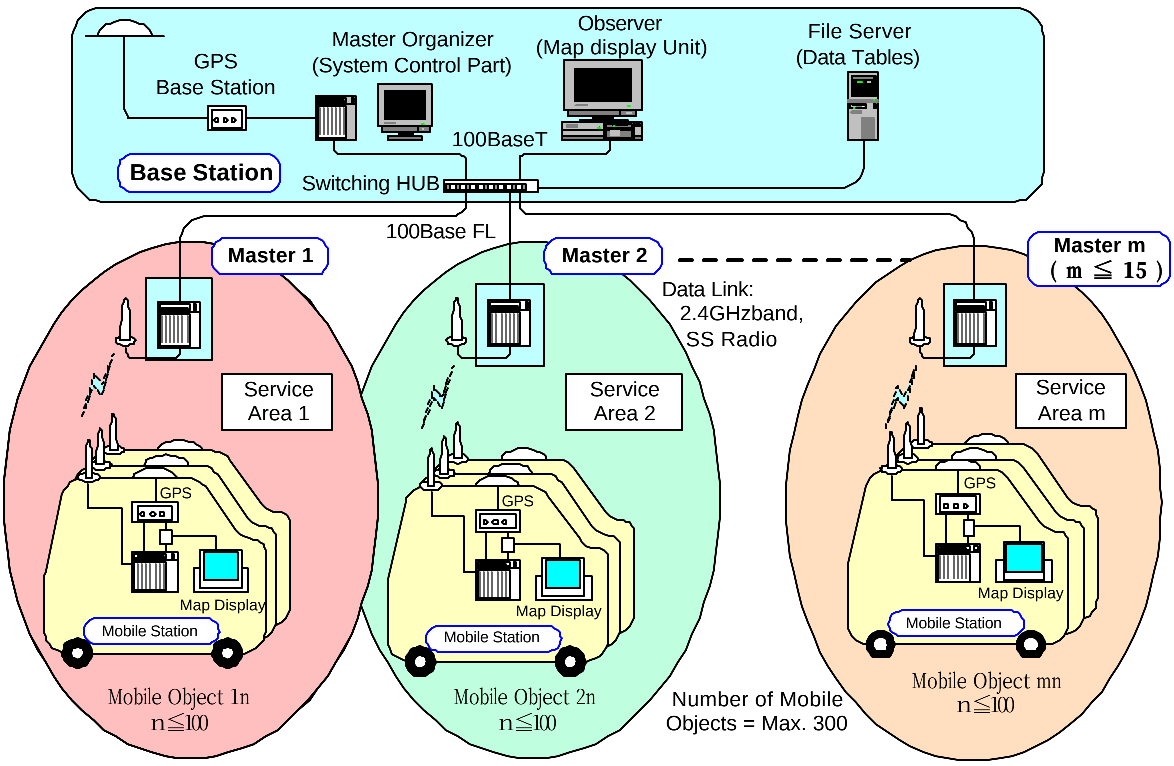


Figure-3 Basic Configuration of the Airport Vehicle Positioning System

3. Configuration of Prototype System

This prototype system is equipped with user stations in addition to the basic configuration as shown in Figure-3, so that the same features as the base station may be available in the individual divisions of the airport administration office.

This prototype system not only implements real-time data communications between the administration office and the vehicles used for various activities within the airport, to display their positions on a map, but also enables the exchange of simple messages and transmission of data between the administration office and such vehicles.

3.1 Base Station Equipment

Figure-4 shows the external appearance of the base equipment installed in New Chitose Airport Administration Office.

The GPS station distributes the GPS correction information output from the electronic reference point, to the individual master stations.

The correction information to be distributed includes RTCM SC-104 types 1 and 3 information for DGPS, and CMR (Compact Measurement Record) types 0, 1 and 2 information for RTK (Real Time Kinematic) GPS.

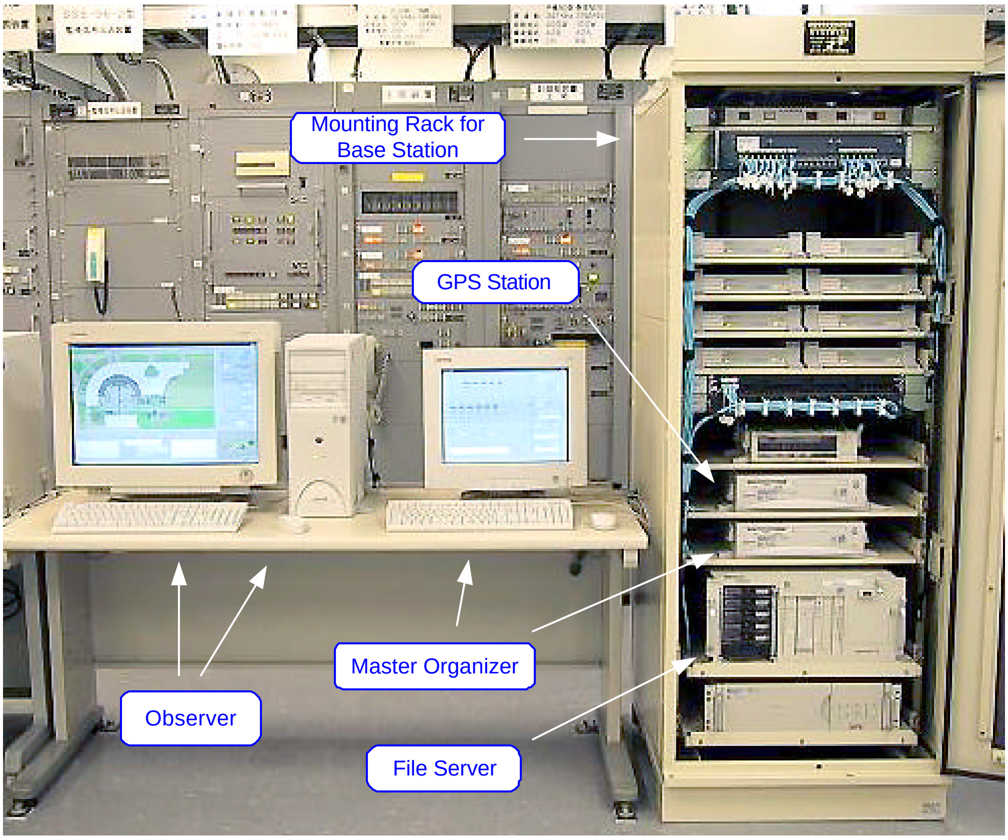


Figure-4 Base Station Equipment

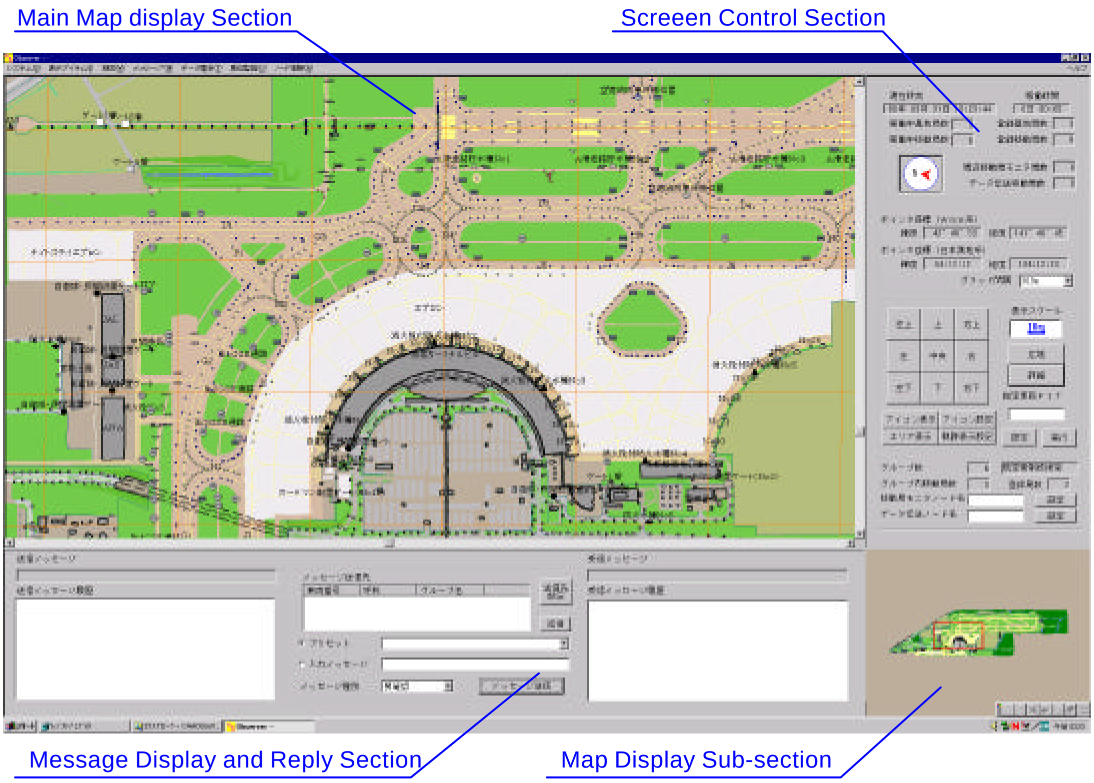


Figure-5 Example of Observer Display

The file server executes the centralized management of various data relating to the base station, master stations and mobile stations, positioning data of the mobile stations collected via the individual master stations, and other data.

The master organizer acts as a data link operation control station, and has the following functions:

(1) Display of operation conditions of individual nodes.
(2) Start/stop control of master stations.
(3) Control of service times of master stations.
(4) Instruction to reset master stations.
(5) Instruction to mobile stations to enter/leave the service area of a master station.
(6) Supervision of abnormal conditions in the system.
(7) Instruction to set various parameters.
(8) Other display functions, user interface functions, etc.

The observer has not only the mobile station monitoring functions but also the message distribution control functions and other functions, based on the grouped management where the vehicles are grouped according to the divisions they belong to. In the message function, any message of 40 bytes or less, or a preset message selected from 10 preset messages can be sent to all the mobile stations. To enable surveillance of the surrounding mobile objects on the map displayed on a mobile object, information about the positions of the surrounding vehicles can be downloaded to a specific mobile station in a group (grouped for each user station) for display purposes. The information to be downloaded can include only a maximum of 30 positions of the surrounding vehicles in the order of proximity from the vehicle in question, due to limitations concerning the communication capacity. In addition, there is a function for data transmission between a mobile station and a user station, which allows data communication via a PC's serial port. This function may possibly be used for data transmission from a snow and ice survey vehicle (which measures friction coefficients of runways and taxiways in winter), for transmission of inspection data for radio facilities and for other data.

Figure-5 shows an example of the observer screen displayed on a 24-inch wide-diagonal monitor (resolution: 1920 x 1200). The screen consists of a main map display section, a map display sub-section which indicates the position of the area displayed in the main section, a screen control section, and a message display and reply section.

A digital map (electronic map) with a discrimination accuracy of approx. 30 cm has been created for this prototype system. In this electronic map, data concerning the following items are stored respectively in an associated database in a hierarchical structure, so that the data selected may be retrieved and displayed:

(1) Airport basic facilities.
(2) Airport accessory facilities.
(3) Aeronautical safety facilities/air traffic control facilities.
(4) Aviation weather facilities, etc.

3.2 User Station Equipment

In this prototype system, multiple user stations have been installed. Each user station has similar functions to the observer in the base station equipment. These functions include surveillance of mobile stations, mobile station management based on management of vehicle information databases, message distribution control based on grouped vehicles management, etc.

A user station has been installed at each of the following five locations: Air Traffic Control Technical Official MDP (Maintenance Data Processing) Room, Air Traffic Control Information Official Room, Air Traffic Control Managing Official Room, Five Brigade Building (Airport Safety and Disaster Prevention Division), and Snow Removal Center (Civil and Architectural Engineering and Construction Division).

3.3 Master Station Equipment

The master station, which executes radio data communications with the mobile stations located within its service area, has no display part nor user interface, and therefore its operation is controlled from the base station equipment.

The unit body is a cabinet with external dimensions of 600 mm W x 250 mm D x 900 mm H, which contains a radio set part, a UPS (uninterrupted power supply), an optical media converter, a thermoregulator, a heater, etc. The internal temperature is kept between 0 degree, Celsius and 50 degree, Celsius by the thermoregulator.

Figure-6 shows the locations of master stations. A master station is installed at each of the following six locations: ILS/GS-01R (M1), the rooftop of the Fire Brigade Building (M2), ILS/GS-19R (M3), the rooftop of the Airport Administration Office Building (M4), the ITV pole located before JAL Cargo (M5), and the luminary pole at No.55 spot in the apron for night stays on the Air Self-Defense Force side (M6).

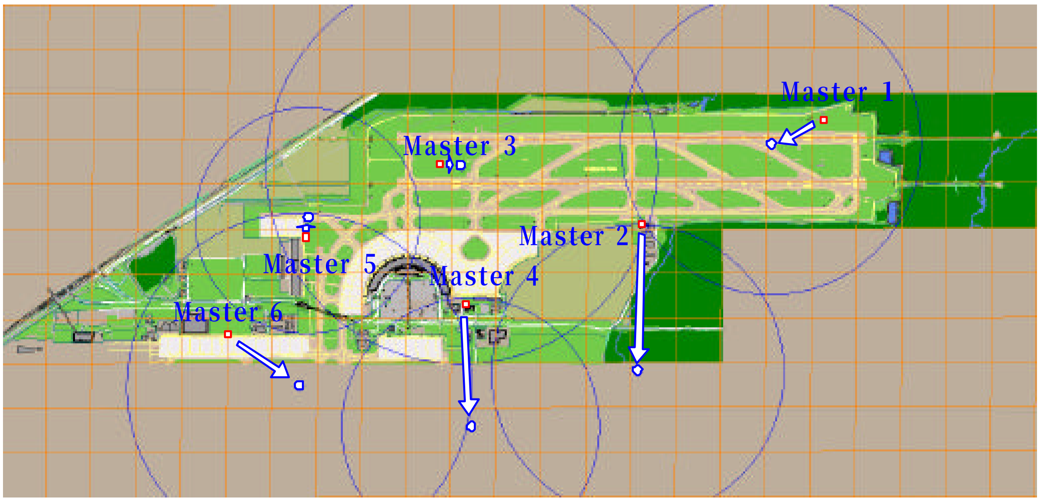


Figure-6 Locations of Master Station

Used as the center location of each master station is an assumed location that has been suitably offset so that the radio cell switching operation may be executed more efficiently, except when such an offset is restricted due to the physical conditions at the place of installation. Red locations in Figure-5 indicate the actual installation locations of the master stations, and dark blue locations indicate the respective offset assumed locations. Circles centered on the master stations indicate the associated service areas.

Figure-7 shows the external appearance of a master station (M1) installed on a steel tower for antennas at ILS/GS-01R.

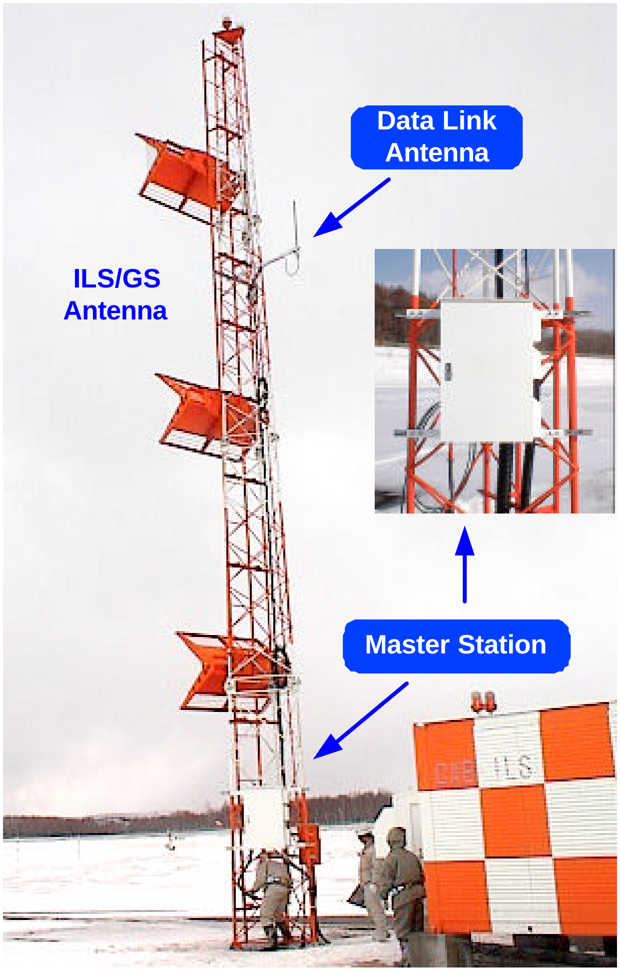


Figure-7 Master Station Installation

3.4 Mobile Station Equipment

The GPS correction information sent from the electronic reference point includes the information for both RTK and DGPS. Making effective use of this fact, three types of mobile stations are utilized in this prototype system: Type-1 using a DGPS receiver, Type-2 using a RTK GPS receiver, and Type-3 using a RTK GPS receiver (this type is intended for use in simplified surveying activities). 28 Type-1 mobile stations, 24 Type-2 mobile stations, and one Type-3 mobile station have been manufactured.

Mobile stations of Type-1 and Type-2 use the same digital map (electronic map) as the observer to display the position of the vehicles in which they are mounted. In addition, these types of mobile stations have a function to exchange messages with the base station, user stations and other mobile stations.

(1) Type-1 Mobile Station

This type of mobile station uses a DGPS receiver board with a positioning accuracy of approx. 1 m (2 drms), and is mounted on a utility service vehicle, fire engine, or such. The CPU motherboard, the radio set board for the data link and the GPS board are compatible with half-size ISA buses, and contained in a unit body cabinet with external dimensions of 125 mm W x 245 mm D x 237mm H. Figure-8 shows the external appearance of the Type-1 mobile station.

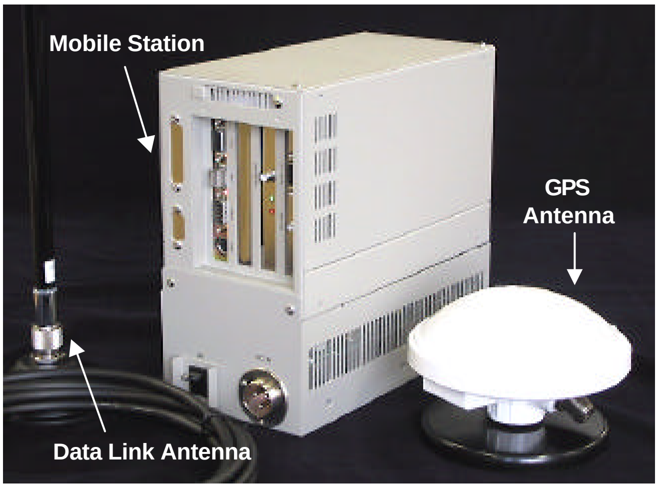
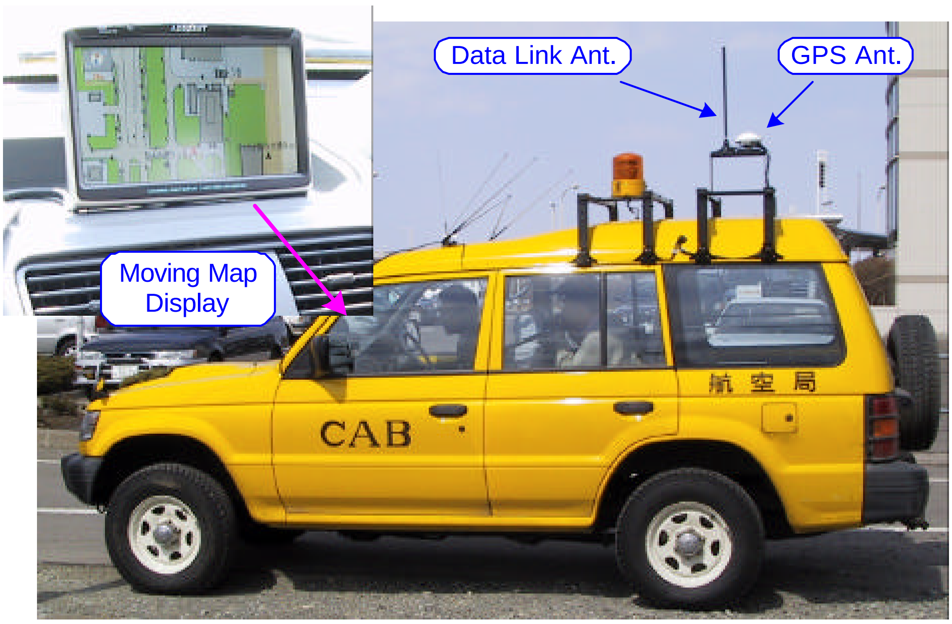


Figure-8 Type-1 Mobile Station Equipment

Used, as the moving map monitor is a 7-inch wide-diagonal LCD monitor intended for use in a car-mounted navigation system. Figure-9 shows an example of the mounting on a Civil Aviation Bureau’s utility service vehicle.

Figure-10 shows the tracks of fire engines night test run.



Figre-9 Mounting on the CAB Utility Service Vehicle

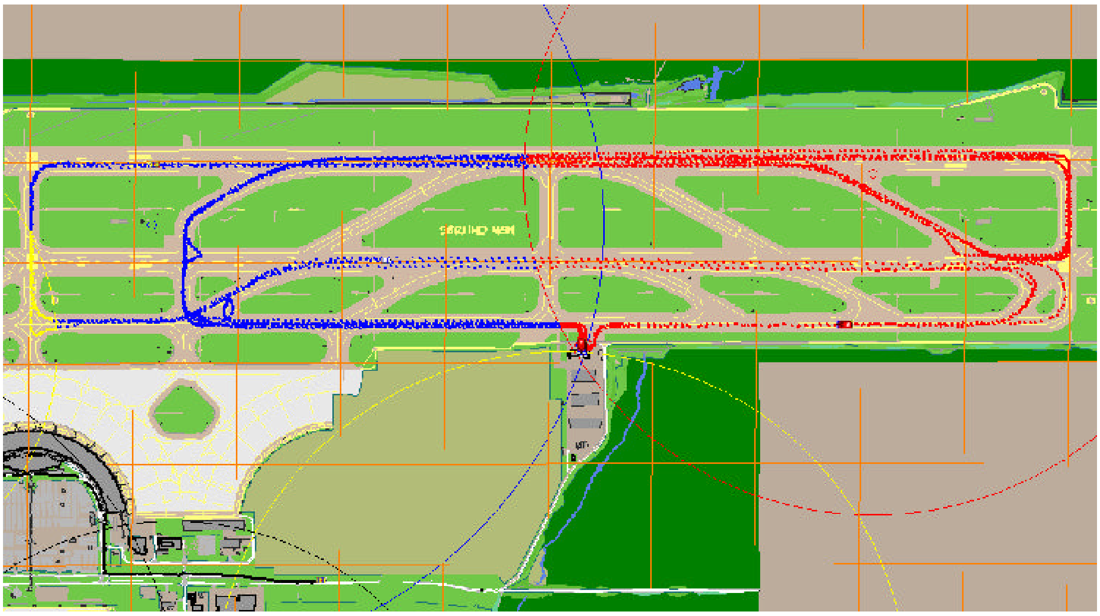


Figure-10 Tracks of Fire Engine Night Test Run

(2) Type-2 Mobile Station

This type of mobile station uses a RTK GPS receiver board with a positioning accuracy of approx. 2 cm (2 drms), and is mounted principally on a snow removing vehicle. The GPS board used in Type-2 is of Euro-card size and is a little larger than the boards for half-size ISA buses. Therefore this board is installed on the top of the unit body, resulting in a height increase of approx. 50 mm when compared with Type-1.

In the Type-2 mobile station, a touch screen type 12-inch SVGA LCD monitor (resolution: 800 x 600) is employed as a map monitor, to provide a high resolution appropriate to the positioning accuracy.

Figure-11 shows an operating scene of snow removing vehicles (snowplows) mounting a Type-2 mobile station. Figure-12 shows an example of the Type-2 mobile station display.

Using this system enables accurate verification of the self-position of the vehicle within the airport even when

Figure-11 Snow Removing Operation

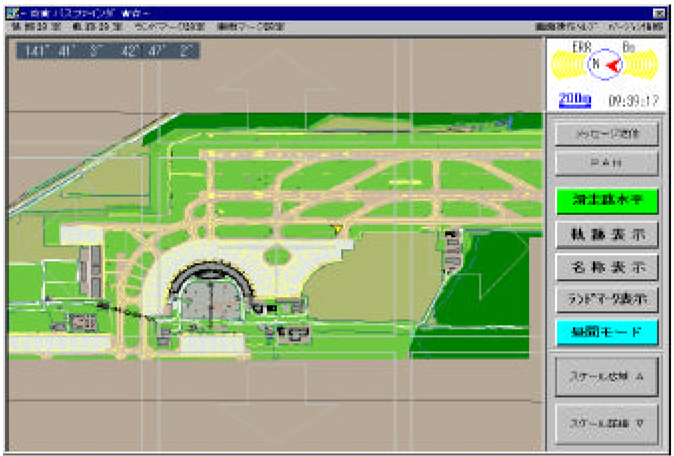


Figure-12 Type-2 Mobile Station Moving Map there is an accumulation of snow. It also enables monitoring of the snow removal activities at the base station and user station and the sending of appropriate operational instructions, etc. as necessary.

Figure-13 and 14 show the typical tracks of snow removing vehicles.

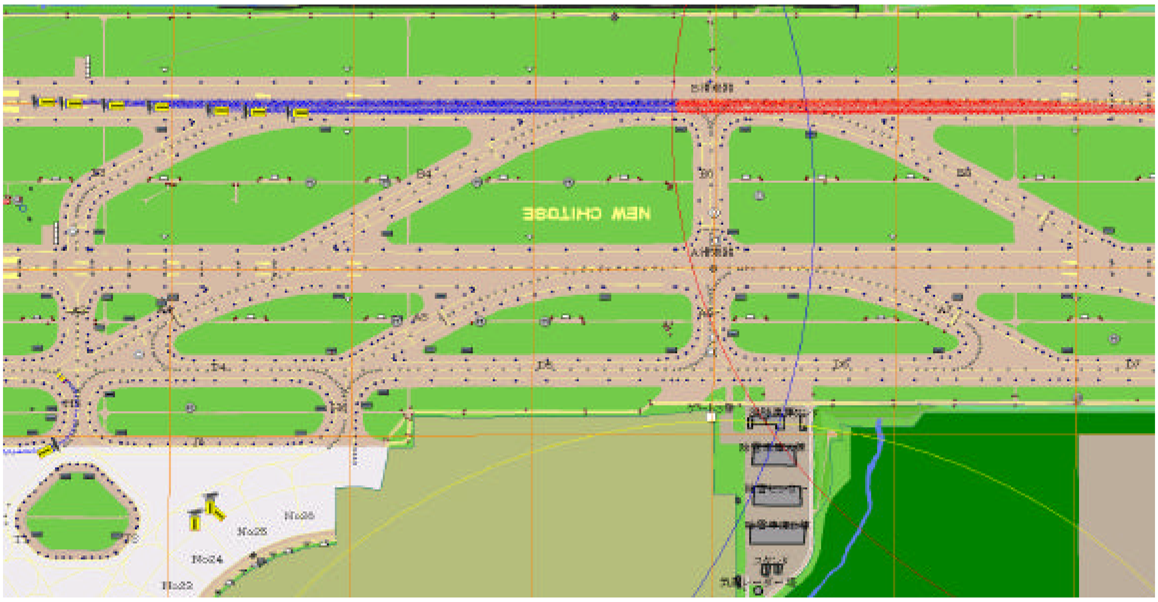


Figure-13 Tracks of Snow Removing Vehicles (Runway)

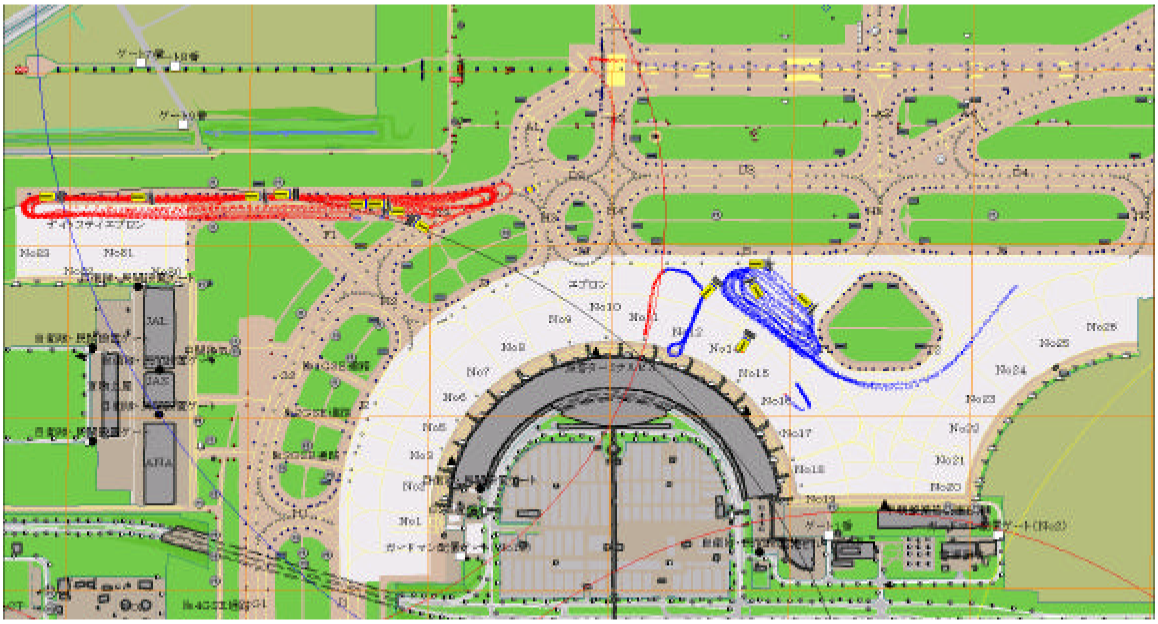


Figure-14 Tracks of Snow Removing Vehicles (Apron and Taxiway)

(3) Type-3 Mobile Station

This type of mobile station is a portable mobile station that uses a RTK GPS receiver with a positioning accuracy of approx. 2 cm (2 drms), as in the case of the Type-2 mobile station. Type-3 is intended for use in simplified surveying activities within the airport.

4. Conclusion

As one of the possible uses of the electronic reference point data in the Airdrome Coordinate Management System, a prototype of the "Airport Vehicle Positioning System" which is capable of management of mobile objects and also capable of data communications within an airport, has been built and installed in New Chitose Airport.

The following effects are expected from the operation of this prototype system:
Positions of mobile objects can be kept under surveillance at the base station, even when visibility is low.

- Self-positions within the airport can accurately be confirmed by mobile stations mounted on mobile objects, even when visibility is low.
- An alarm/warning can remotely be sent to a vehicle in an off-limits area.
- Instructions on an optimum traveling route to a destination, or the guidance thereto can appropriately be given.
- Airport operation activities (such as snow removal, etc.) can be conducted more efficiently. In addition, the progress of such activities can be monitored at the user stations.
- A "follow me" vehicle running in front of an aircraft for the guidance thereof can accurately confirm its self-position even when visibility is poor (for example, when there is an accumulation of snow).
- The positions of falling objects, damaged portions in runways and aviation lighting fixtures can accurately be confirmed to give instructions on required activities.

Activation and basic operation tests of this prototype system were conducted at New Chitose Airport in May. Thereafter, system performance evaluation tests are planned both in normal seasons and at times of snow accumulation in winter. In addition, yearlong operation evaluations are intended using Civil Aviation Bureau vehicles. Such operation evaluations concern the system's operating conditions, functions, ease of maintenance, operability, and serviceability and adaptability to failures.

In closing, we would like to express our appreciation for their kind cooperation in the implementation of this study to everyone concerned in the Tokyo Aviation Administration, the New Chitose Airport Administration Office and the Iwanuma Branch of the Electronic Navigation Research Institute.