Airport MCA Radio Systems in Times of Disaster and Future Prospects

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1. Introduction

Airport MCA, "Multi Channel Access", radio system is a communication system for ground services at airport. It is provided by dedicated base station equipment and frequencies. Its features include high radio wave use efficiency, flexible group call settings, and reliability in times of disaster. When the Great East Japan Earthquake hit Narita International Airport in 2011 and a typhoon damaged Kansai International Airport in 2018, the MCA radio systems in these airports remained in operation, contributing to disaster response efforts in the respective airports.

Currently, the use of public safety radio systems known as TETRA is growing globally. Airport MCA radio systems in Japan are also being replaced with TETRA.

This report outlines the airport MCA radio system and describes its features at the times of disaster as well as the status of deployment of TETRA up to now. It also discusses the latest trends and the issues and future prospects of airport radio systems in disaster situations.

2. Airport MCA Radio Systems

2.1. Background

Before 1990, airport radio communication systems were deployed by individual companies and organizations and had problems such as interference and low radio wave use efficiency. In 1985, efforts began to develop and standardize radio systems utilizing multiple radio channels and, in 1990, analog MCA systems were introduced to the airports in Narita, Haneda, Naha, and Kansai. Starting in 2004, they were upgraded to digital systems one after another. Over the next 10-plus years, these systems served as the radio communication infrastructure at five airports (the above-mentioned four airports and Chubu Airport), supporting the business communication of domestic and foreign airlines, airport-related companies, affiliated organizations, etc.

In the meantime, a new public safety radio system, TETRA, was increasingly accepted as an international standard and began to be deployed in airports and other facilities mainly in Europe. In Japan, discussions also took place to consider deploying TETRA as the successor to the airport MCA radio system. Since Narita International Airport introduced the new system for the first time in 2016, Naha, Haneda, and Chubu Airports have replaced their systems with TETRA.

2.2. Airport MCA radio in times of disaster

When the Great East Japan Earthquake occurred on March 11, 2011, PSTN and mobile phone calls were made impossible or difficult in a vast region of eastern Japan, including Narita International Airport because of failures of communication equipment and congestion of phone traffic. By contrast, the airport MCA radio systems remained in operation without being affected by these circumstances.

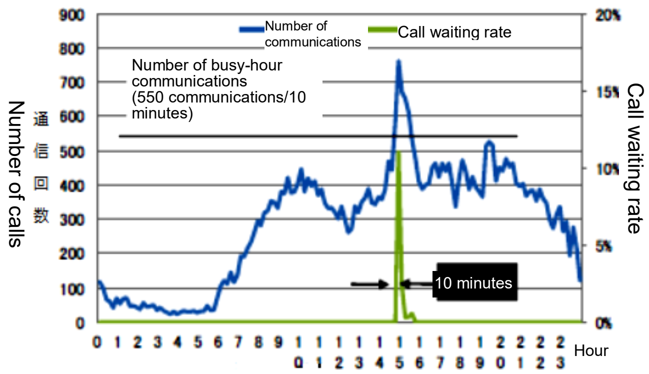

Figure 1 Number of calls and call waiting rate at the time of the Great East Japan Earthquake

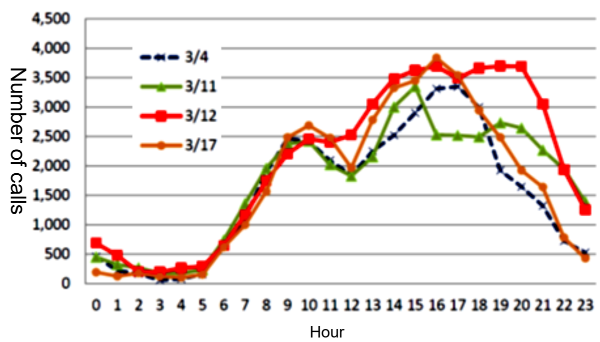

Figure 2 Number of calls made before, on, and after the day of the earthquake

Figure 1 shows the number of calls and call waiting rate for the MCA system at Narita International Airport on March 11, 2011. During the 10-minute period immediately after the earthquake occurred at 14:46, more than 750 calls were made, which was 1.4 times as many as the regular busy hour. This raised the call waiting rate (the ratio of calls waiting to be connected after the pressing of PTT) to around 10% temporarily, although it dropped to the normal level soon. When compared to the number of calls made before and after the day of the earthquake in Figure 2, the number of calls decreased immediately after the earthquake of March 11 as the airport was closed. On the following days, however, the number returned to the normal level as flight services resumed. At the time, the MCA system of Narita International Airport served approx. 3,500 wireless terminals over a total of 97 communication channels. It was operated efficiently to handle high volumes of traffic during the disaster.

On September 9, 2019, the Tokyo metropolitan area, primarily Chiba Prefecture, was struck by Typhoon No. 15, leaving as many as 13,000 people stranded at Narita International Airport. At the time, mobile phone users in Chiba Prefecture had difficulty in getting connections, while the airport MCA radio system continued operation without being affected.

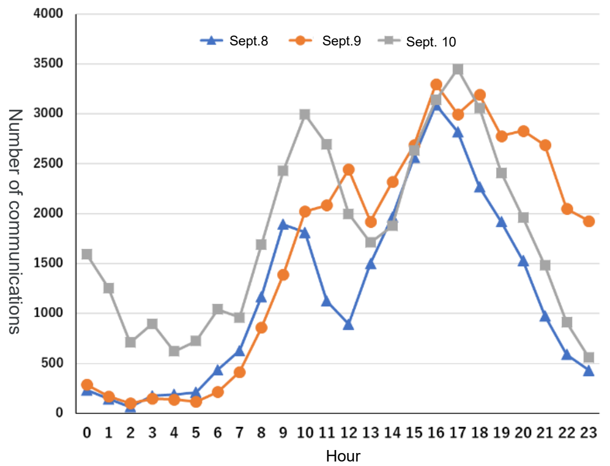

Figure 3 Number of calls made via the MCA system of Narita International Airport before, on, and after September 9

Figure 3 shows changes in MCA traffic at Narita International Airport before, on, and after September 9. Then, the staff in the airport needed to deal with the stranded passengers, the number of calls increased during the evening hours from the evening of the 9th until flight services resumed on the 10th. However, calls were not concentrated to any specific time zone, and the quality of communication was not affected by any problems.

When Typhoon No. 21 passed the Kinki region of Japan in September 2018, a tanker collided with the connecting bridge of Kansai International Airport, damaging the communication cable between the airport and the mainland and thus shutting down the lines connecting mobile operators' base stations to the core networks. This accident made the mobile phone service unavailable inside Kansai Airport while, in contrast, the MCA radio system of the airport remained in operation without being affected.

The airport MCA radio system utilizes a dedicated frequency. It is designed based on the radio wave environment of the airports and the style of work. It is also operated in a manner best suited to airport facilities. These ensure high reliability and availability, making the system vital communication infrastructure to support communication in case of a disaster or other unexpected event.

3. Deployment of TETRA in Airports

3.1. About TETRA

TETRA is the name of the digital mobile communication system (1) for public safety that the ETSI (European Telecommunications Standards Institute) standardized in 1994. In 2014, the ARIB (Association of Radio Industries and Businesses) developed a standard for Japanese airports as "Airport Digital Mobile Telecommunication System TYPE 2" STD-T114(2).

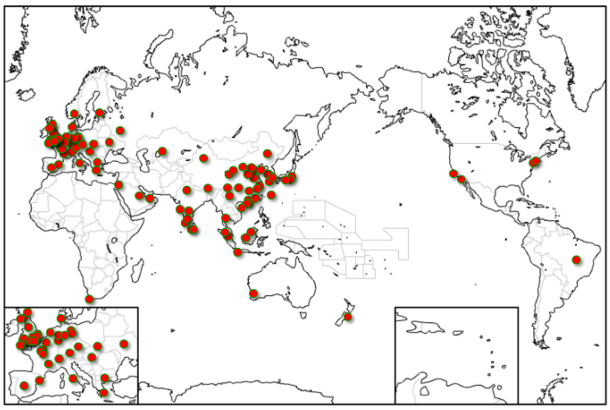

Figure 4 Airports TETRA is deployed (as of July 2018; according to our own research)

TETRA has been deployed mainly in Europe and Asia as common radio communication infrastructure primarily for mission-critical fields such as police, fire departments, transportation, military, and plants. It is used in more than 80 airports around the world (Figure 4). In Japan, roughly 20 local governments, in addition to airports, have adopted TETRA for their disaster prevention wireless system.

3.2. Migration to TETRA

While the deterioration of old MCA system became an issue, discussions on the next system began in earnest in 2013. TETRA as well as the U.S. standard APCO-P25 were compared and considered. As a result, TETRA was adopted as it featured high scalability and had a proven track record in European nations similar to Japan in size. First, Narita International Airport upgraded its system to TETRA.

Figure 5 TETRA radio base station at Narita International Airport

During the system migration at Narita International Airport, the new system was assigned the same frequency band as the existing system, 400 MHz, and two base stations were set up. The airport operated the old and new systems in parallel temporarily, thus avoiding the suspension of the radio service and giving users time to get accustomed to the new terminals. The migration was complete in October 2016 (Figure 5).

After that, Naha Airport replaced its MCA system with TETRA in July 2017 and added antennas and other equipment when it expanded terminal facilities in 2019. The airport is now planning to scale up the system in response to an increase in the number of flights, the start of operation of the second runway, the relocation of the control tower, etc. In April 2019, Haneda Airport also migrated to TETRA.

In 2019, Chubu Centrair International Airport also completed its migration to TETRA. The airport officials had been considering the next system as the time drew near to upgrade the previous MCA system installed when the airport was opened. In considering the next system, they made disaster control a major priority, with the typhoon damage suffered by Kansai International Airport in mind. They chose TETRA from the perspective of system reliability. Design, construction, and relevant procedures began in June 2018, and equipment installation was complete in April 2019. After a three-month period of the parallel operation of the old and new systems, the changeover from the old system was complete on July 1 of the same year. In September, relay amplifiers were installed to ensure sufficient radio field strength in the newly built second terminal and the exhibit hall "FLIGHT OF DREAMS."

3.3. System configuration and the reliability

Figure 6 shows the current system configuration of TETRA deployed in the airports.

Base stations are installed in Narita, Naha, Chubu, and Haneda, with those of Naha and Chubu connected to the controller in Narita via dedicated lines.

While each airport provides the necessary area coverage through the use of base stations and antennas, a radius of approx. 5 kilometers is actually covered mainly with outdoor antennas, making it possible to make calls even in related facilities around the airport.

Figure 7 shows the results of radio wave measurements conducted in and around Chubu Centrair International Airport. The system not only covers the entire island on which the airport is located but also provides sufficient radio signal strength to

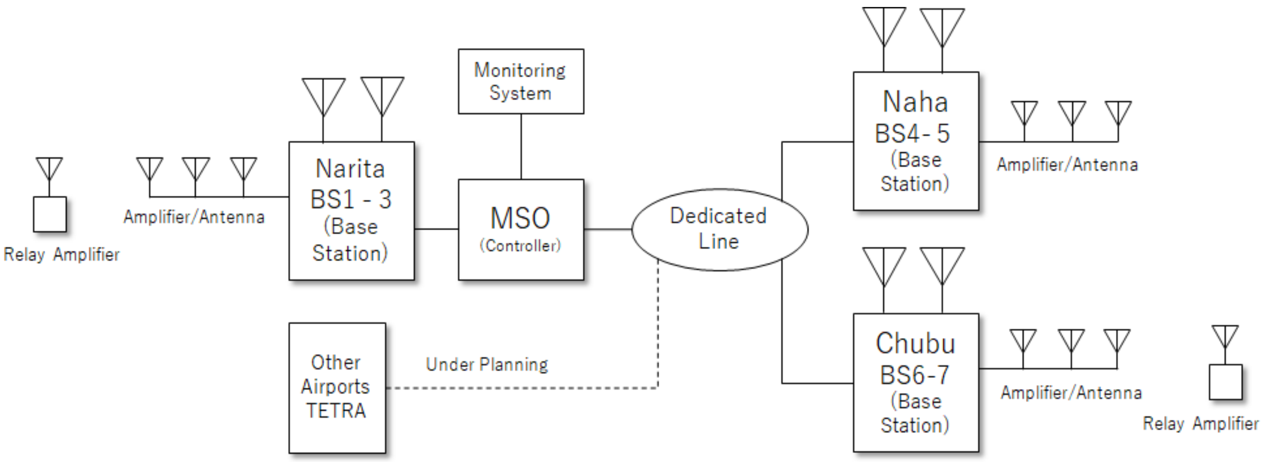

Figure 6 TETRA system configuration

communicate even in Tokoname City on the opposite shore except in weak signal areas (black spots) such as behind buildings. This suggests that the system can contribute to the sharing of information between the local government and the airport in future disaster situations.

Figure 7 Radio wave signal strength and around Chubu Centrair International Airport

Moreover, efforts are underway to improve the radio wave environment to prevent dead zones from forming in airport buildings and other locations. In Narita, about 50 amplifiers and about 100 indoor antennas have been installed (Figure 8) and leaky coaxial cables are used in some tunnels to complement the radio field strength. Also, antenna facilities are added as needed to deal with dead zones that form as buildings are expanded and renovated.

Figure 8 Indoor amplifier and antenna

One base station of TETRA has multiple transmitting and receiving parts, which are all made redundant along with the control part. The receiving antenna features a triple-diversity for enhanced receiving sensitivity. Four channels are supported per radio wave and, excluding control channels, a total of 89 communication channels on 23 radio waves are currently provided in Narita. Highly reliable dedicated lines are used to connect the base stations. Even if the base stations are isolated, their radio relay function is maintained, thus allowing wireless terminals inside the airport to continue to communicate.

At Narita International Airport, the electric power to the base stations is supplied from the power supply in the NTT Building and, at the other airports, uninterruptible power supply (UPS) systems in the respective airport buildings are used. Since a UPS is installed individually at every location where a base station resides, the base station can continue its operation for as many as two hours even if the power supply in the building fails. Furthermore, adjusting the number of radio waves according to traffic enables the base station operation to continue for up to five hours.

Figure 9 Mobile base station of TETRA system

In addition, a mobile base station is deployed in anticipation of a risk that both the commercial power and the UPS system in the building may become unavailable for an extended period of time (Figure 9). When operated in or near the airport, this mobile base station provides seven channels on two radio waves for emergency use.

The provided wireless terminals for TETRA are robust and waterproof and capable of noise suppression. They can also communicate directly with one another, bypassing the base station.

4. Trends of Airport Radio Systems

Narrowband business radio systems, including TETRA, have proven highly reliable in life-threatening emergencies. Diverse wireless terminals are also available for use in specific usage scenes. Therefore, these systems are being increasingly deployed in mission-critical fields. For example, Guarulhos International Airport of São Paulo, Brazil, was plagued by interference and information leaks because airport-related companies choose radio systems independently, and it also had concerns about information sharing in case of a disaster. The airport officials solved all these problems by deploying TETRA as a common radio system for the entire airport [3].

On the other hand, advances in mobile broadband technology have prompted 3GPP and other organizations to discuss ways to apply its convenience to the field of public safety, and standardization efforts are underway.

In fact, PS-LTE (Public Safety LTE) systems to which dedicated frequencies are assigned are coming into wider use as common radio communication infrastructure for police, fire department, and other emergency organizations in the U.S., the U.K., and South Korea [4]. Discussions are ongoing in Japan as well on the integration of public safety radio systems using PS-LTE [5].

Figure 10 Private LTE base station in Charles de Gaulle Airport of Paris

At the airports in Paris, Vienna, Helsinki, and other European cities, LTE-based demo experiments of video communication are being conducted using vehicle-mounted cameras and tablets (Figure 10). In each of these cases, reliability and security are ensured by a private LTE system, instead of the public network, and such a system can be expected to be useful in grasping damaged status and sharing the information via video in a disaster situation. At international conferences on critical radio communication, discussions are held about the interworking technology that takes advantage of the features of both the stable narrowband and the new broadband communication [6] and the application of 5G technology to critical communication [7] among other topics.

5. Challenges for Disaster Situations

5.1. Issues associated with the style of use

There are two types of users of radio wave in airports (one used by humans is assumed here): 1) general visitors who come to the airport for such purposes as to go on travel or send off passengers and 2) airport workers. General visitors mostly use public networks provided by telecom carriers via mobile phones, smartphones, or other devices. While the later type of users - airport workers - mainly rely on MCA and other business radio systems. In recent years, even airport workers, they have come to use public network-based services including Push to talk on cellular, “PoC”, smartphones, and tablets.

When a disaster hits an airport, general visitors simultaneously use their mobile phones and other devices to check the safety of their family members or flight and other transportation information. This causes temporal and spatial concentration of traffic, resulting in congestion degrading the quality of communication. Failures of telecom carriers' equipment also have a direct impact to them. In such circumstances, PoC, smartphones, and other devices used for business compete against general visitors for limited telecommunication resources. In fact, it became difficult to get PoC connections at the typhoon-damaged Kansai and Narita Airports and the earthquake-hit Shinchitose Airport.

By contrast, business radio systems that use dedicated equipment and frequencies, such as airport MCA radio systems, allow reliability measures to be taken as appropriate for the purpose of use. Even during a disaster, these systems can continue to operate unless their equipment, power supply, and other hardware components are affected. On top of that, the use of the system does not impact the communication of general visitors.

5.2. Requirements for airport radio systems

The functions that an airport is required to fulfill in a time of disaster such as an earthquake or typhoon include providing information to people in airport, guiding them to safety, and achieving rapid recovery to serve as a base for rescue, transportation of goods, etc.[8] In order to meet these needs, the airport radio system in particular must satisfy the following requirements.

(a) To ensure reliable communication and sharing of information related to rescue and recovery among airport officials, the system must not be affected by the failure or congestion of the public network.

(b) Even if no channels are available due to heavy traffic, priority interrupts and simultaneous broadcasts must be possible in an emergency.

(c) The system must be installed in a secure, earthquake-resistant, and flood-proof environment with an uninterruptible power supply system.
(d) An integrated radio system must be shared to enable communication and information sharing among different companies and organizations operating in the airport in the event of a disaster.
(e) In case of a large-scale disaster, the affected airport and nearby airports serve as rescue bases and work together in many ways [(9)]. Therefore, the system must be expandable to a network that enables inter-airport communication in a disaster situation.

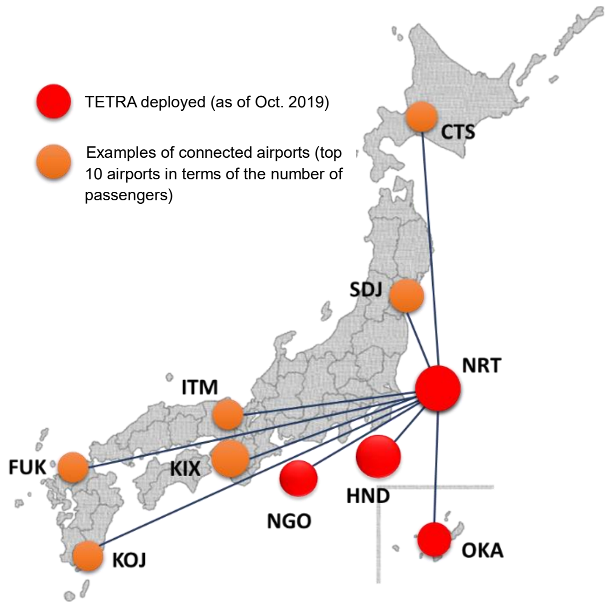

Figure 11 Concept of the inter-airport network

5.3. Future actions

The airports that already have TETRA in operation satisfy the requirements of (a) to (c) above from the functional perspective. As for the integration and sharing of airport radio systems by each airport (d) and how to operate the priority interrupt and other functions across multiple organizations (b), they meet the requirements to different degrees.

With regard to the inter-airport communication requirement of (e), three airports can currently communicate with one another via dedicated lines that control the TETRA base stations. This inter-airport network will expand as more airports deploy TETRA in the future. Also, communication between TETRA and smartphones is made possible, albeit in a complementary fashion, by leveraging the function to communicate with the public network.

Our next steps will be to increase the use of TETRA systems, enhance their convenience through the use of private LTE, 5G, and other technologies, and propose ways to operate these systems in assumed disaster situations. Currently, different companies and organizations use different business radio systems at most airports. We are going to work on technology for connecting different systems as well and build a nationwide inter-airport network. Figure 11 shows the concept of this network.

6. Conclusion

Airport radio systems are vital communication infrastructure used not only for daily work but also to ensure the safety of passengers and workers in the event of a disaster. We will continue our ongoing efforts to maintain the communication environment that enables reliable communication even in times of disaster and ensure its stable operation. By building an inter-airport network for the future and applying new technologies such as LTE and 5G, we hope to contribute to further improving the disaster prevention capabilities of Japanese airports.

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