Personal Mobile Radio : Supporting Massive Sports Event

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Abstract

At the past Olympic and Paralympic Games, a personal mobile radio system was installed and operated as a means of instantaneous voice communication for event staff. Throughout the Olympic and Paralympic Games Tokyo 2020, three personal mobile radio types, including Type 1, the first-ever business radio on a PS-LTE system basis, and Type 2, using dedicated frequencies, were deployed according to communication purpose and venue aspects. This article describes the development and operation of the unprecedented personal mobile radio system, the process of formulating a prerequisite service policy and fleet map, and the background of selecting the PS-LTE system.

Keywords : Olympic Games, Paralympics, Business radio/personal mobile radio

1. Construction of Business Radio Services

The Olympic and Paralympic Games are one of the largest sporting events in the world. The operation of the Games is carried out by staff members who specialize in around 50 areas subdivided according to their functions.

Business radio is a means of communication that plays a different role from the cell phone, which provides a function to instantaneously transmit voice messages from the sender to the pre-grouped staff members, and is a key tool for staff command and control. A business radio service that provides a smooth communication environment is indispensable for the smooth operations of games.

The development of the business radio service for the Games began in 2015 with a survey of specific past cases, etc., and then defined the high-level service requirements, taking into account the radio propagation aspects that depend on each venue's geographical layout and building structure, and the unique staffing and call timing characteristics of the Olympic and Paralympic Games. We then made progress on the selection of a radio system that could be realized at a lower cost, system design, implementation and construction, testing, selection of positions where radio equipment would be deployed, planning of maintenance and operation during the Games, conduction of test events, and staff training. This chapter introduces the main points.

Business radios are called Personal Mobile Radio (PMR) in the Olympic and Paralympic Games.

1.1 Service Requirements and System Selection

Based on the past Olympic and Paralympic Games operation records and the plans for the Olympic and Paralympic Games Tokyo 2020 (hereinafter referred to as "Tokyo 2020 Games"), conditions such as communication area, call capacity, the acceptable range of voice

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The Journal of The Institute of Electronics, Information and Communication Engineers, Vol.105, No.8, Supplement, pp.97-103, August 2022

delay, and the confidentiality were identified and defined as service requirements. A plan was formulated to provide a highly robust radio system designed and constructed to meet these requirements for the main operations at the venue (operations management, refereeing and other Games operations, medical operations, broadcasting, security, etc.), as well as for communication between leaders across the business domains.

The total number of PMR handsets provided was approximately 14,500. Three types (Type 1 to Type 3) were deployed and classified according to their configuration methods. The main reason for combining multiple Types was their suitability for each usage and cost minimization.

The three business radio types deployed for the main operations are shown below. Figure 1 shows photos of the handsets.

- Type 1 : PS-LTE system. Use a dedicated control server, relay stations, communication infrastructure and frequencies (900 MHz band). Approx. 6,300 handsets.
- Type 2 : Direct communication between devices. Use a frequency (351 MHz band) dedicated to the Tokyo 2020 Games. Approx. 2,800 handsets.
- Type 3 : IP radio. Use the infrastructure of mobile telcos and dedicated resource-occupying servers. Approx. 5,400 handsets.

An airborne radio relay system was deployed for the cycling road race apart from the above. In addition, business radio services were provided within the airport facilities on loan from specialized service providers.

(a) Type 1 PMR (b) Type 2 PMR (c) Type 3 PMR

Figure 1 PMR Handsets

PS-LTE (Public Safety LTE) is an LTE-based radio network for public use.

1.2 System Development

This section introduces the PS-LTE system (Type 1), including a selection process, the direct device-to-device communication system (Type 2), and the system for cycling road races.

1.2.1 Type 1 (PS-LTE System)

The basic service area was defined as a radius of 10 km (Figure 2) around the athletes' village, which encompasses most of the venues in Tokyo and the triathlon and marathon competition area. We selected the PS-LTE system proposed by NEC Corporation (hereinafter referred to as "NEC") that met the requirements and considered the best benefits in its operational framework.

Advantages of using the PS-LTE system included capacity management without external factors by using infrastructure and frequencies dedicated to the Games, efficient spectrum use when events and calls are concentrated simultaneously, and high flexibility in creating talk groups. Another advantage was the potential for legacy use of the equipment and operational knowledge after the Games.

Since this was the first full-scale introduction of PS-LTE radio system in the history of the summer Olympic and Paralympic Games, the adoption of this system was decided after extensive feasibility verification and risk assessment. For example, the system was tested under the loads expected during the Games. While system components, such as base stations and handsets, were evaluated for actual past operation in addition to procurement risks. Furthermore, the Tokyo 2020 Organising Committee received a report from a radio expert with whom the Tokyo 2020 Organising Committee signed a consulting contract on the PS-LTE technology that no risks that could affect the Games had become evident in light of the unique requirements of the Games. Moreover, it was confirmed that the readiness for legacy use was positive.

We assumed the system went along with technical requirements, including frequencies, provided that the Ministry of Internal Affairs and Communications (MIC) consulted the Information and Communications Council on the technical requirements for upgrading 900 MHz band independent mobile communication systems (Con-

Figure 2 Type 1 Service Area (10 km Radius Around the Athletes' Village)

sultation No. 2041 dated September 27, 2017), and set up relevant regulations after a recommendation was issued.

1.2.2 Type 2 (Direct Device-to-Device Communication System)

We developed a system with enhanced call confidentiality based on the digital simplex radio system. Dedicated frequencies were allocated for Tokyo 2020 Games.

We did communication tests at all venues, clarifying available service areas considering test results, the staff's roaming range and timing of use. We created combination frequency reuse patterns to operate the system through efficient resource management.

1.2.3 Radio System for Cycling Road Race

The cycling road race course started at Musashinonomori Park (Tokyo), passed through Kanagawa and Yamanashi, and finished at Fuji Speedway (Shizuoka). Around 240 km race route (men) included areas along mountain valleys and at the foot of Mt. The main race convoy, where athletes and support vehicles ahead of and behind them are included, stretches for about 20 km, moving from the starting point to the finish line at high speed. Radio communications essential to the competition, such as those for race status announcements, judging and rescuing, must allow simultaneous conversations within the convoy and at the race headquarters set up in a location separate from the race course.

An IP communication system using the infrastructure of a cell phone operator was considered due to the wide service area required. However, a risk peculiar to the IP communication system became apparent : a significant voice delay in some low-field areas in mountainous areas. Since the speed of athletes there could be as high as 90 km/h, the risk of voice delay was judged to be significant, and this system was applied only to usages where the delay effect was minimal.

For the conversation system where a delay is unacceptable, a radio relay system, which was used in past Olympic Games, was loaded on an aircraft to provide wide-area coverage. An analog system was used to ensure continuity of communication, and the aircraft circled at around 3 km altitude during the Games to ensure coverage. Before the Games, an aircraft with a radio relay system was operated, and vehicles with actual radio equipment installed ran on the ground to test coverage.

1.3 Selection of Positions for Deploying PMR Handset

In addition to accurately defining the technical specifications, the key to smooth communication is to ensure that the overall quantity of handsets is appropriately controlled and deployed to staff positions that require radio communication. The Technology Service Bureau coordinated the deployment and quantity of handsets and provided technical support.

1.3.1 Service Policy

We created a service policy that prescribes a deployment principle for coordination of deployment. The service policy to sort out requests was defined to limit usage, narrow down staff positions, and facilitate understanding of deployed handset types. The main items of the service policy are as follows :

(1) Coordination of Usage and Deployment Targets

- Deployment targets must be staff positions that indispensably need group talks or those that need to continue conversations, even when voice communication with a cell phone is difficult due to congestion or other reasons. Furthermore, it is limited to cases where there are no other alternatives such as cell phone, email, IT tools or verbal communication.
- All PMR provided must be defined in the fleet map*.

* This means the fleet map described in section 1.3.2 must be coordinated and agreed on.

- This does not apply to usage that requires a voice delay of 200 ms or less.

(2) Type Assignment

① Principle of Type Allocation within Type 1 Service Area

- Type 1 : All talkgroups (except when Type 3 allocation is applicable).
- Type 3 : Talkgroups that need to communicate outside the Type 1 service area.

② Principle of Type Allocation outside Type 1 Service Area

- Type 2 : Talkgroups for operation management, competition management, time and scoring, rescuing and OBS, or talk groups that require a voice delay of less than 300 ms.
- Type 3 : Talkgroups Type 2 is not allocated. (including talkgroups that need to communicate with places exceeding Type 2 propagation distance)

1.3.2 Fleet Map

In the Olympic and Paralympic Games, a document describing the composition of talkgroups, radio types, availability of accessories, distribution and collection dates, etc., for PMR is called a "fleet map", which will be created to manage the system of conversation. We created over 100 fleet maps for each venue and event at the Tokyo 2020 Games. Creating fleet maps is a critical task, as it is an effort to determine which staff positions will be equipped with handsets. It also has the aspect of deciding on an operational framework.

The first version of the fleet map was defined in January 2017 after interviews with the functional areas (FAs) involved. At that time, specific plans for venue operations and the number of operators at each FA were not yet determined. The optimization of operational methods and the number of deployed PMR were not examined, so this version was a provisional list of requests for more than 30,000 handsets.

Since then, based on the proven talkgroup structure and budget constraints, the talkgroups and their usages were carefully examined, and adjustments were made with each FAs repeatedly. By the end of June 2021, when the final version for the Games was formulated, countless minor updates and eight major version upgrades had been implemented. The process of coordination and agreement was very strenuous. We were able to enhance mutual understanding and reach

an agreement through repeated discussions on subjects such as explanations of service policies, talkgroup compositions used in the past Games, and explanations of the characteristics of radio communications.

The most common gap in the coordination was due to the demand to switch freely between many talkgroups and to join multiple talkgroups with the idea of using a system like a cell phone. This demand came from users who were not accustomed to the differences between radios and cell phones and those who had experience with radios and event management but were accustomed to a form in which one person had a specific authority and could join all the talkgroups involved. From the standpoint of close examination of the number of handsets, we must avoid deploying excess handsets and avoid a situation in which it was unclear who was calling in which talkgroup. Furthermore, it was necessary to create an environment in which each person could always focus on the talkgroup for which they were responsible for communicating without delay across the segmented business functions unique to the Olympic and Paralympic Games. Hence, such a demand was unacceptable. As a measure, the roles of liaisons (bridges) between talkgroups were carefully examined, and only those positions in charge of liaison were allowed to belong to each talkgroup with a limit of two in principle, thereby establishing a contact framework.

Continued communication with venue management staff regarding the fleet map helped prevent operational problems during the Games. On the other hand, some international federations could not establish a clear line of communication with the competition management departments in advance, and some events had to request changes to the fleet map during the Games times. However, these were few in total and did not cause significant problems.

1.4 Business Structure

The Tokyo 2020 Organising Committee had four staff members (Note 1) in the Technology Services Bureau in charge of developing requirements for the Games, designing the talkgroups conducting a thorough review and user consulting to create fleet maps, operational design, quality evaluation, and coordination with users and related domestic organizations.

In the fall of 2016, we signed a basic outsourcing contract with NEC covering the provision of equipment, operation and user support during the test events and Games, and maintenance and monitoring of systems. Since then, we have developed the service through collaboration based on the above responsibilities.

For the radio system for the cycling road race, the Tokyo 2020 Organising Committee established the requirements, and the provision of equipment and aircraft operations was outsourced to a company with a proven track record.

The operation framework specialized for the Games is described below.

2. Operation of PMR Service

This section introduces the test events and operations during the Games.

2.1 Test Events

In the test events held sequentially from the summer of 2019, we provided the PMR service for a total of 18 events, including cycling road races, sailing and athletics, to evaluate fleet maps and gain operational experience. In all the events conducted, handsets were deployed based on the fleet map for the actual competition. Conversation traffic was analyzed in detail to determine if the deployment was excessive or insufficient, if there were any system malfunctions or dead zones, and if users were using the system appropriately.

Experience of the test events was very useful in improving their problem-finding and solving skills, in addition to improving their management skills. In addition, operating the fleet map based on the assumption of the actual Games led to a common understanding with the users, and discussions on fleet map coordination have become much richer since then.

The most challenging part of the test events was user education. There were many more users than expected who thought that radios could be used as cell phones or who, although they said they had experience in handling radios at events, actually had only experience with IP radios and had no experience of direct device-to-device communication methods. As a result, many users did not understand that a dead zone was generated in shadows, etc., and used the system inappropriately, leading to complaints that they could not speak. The user manual was revised and expanded to include tips and other information on frequently occurring problems and measures, and explanations were repeatedly provided to

(Note 1) As of March 2021

users until the Games.

2.2 Technology Rehearsal

In June 2021, a technology rehearsal (training to solve problems (scenarios) that may occur during the Games) was conducted. The Tokyo 2020 Organising Committee staff members, who would be in charge of operations during the Games, also participated. This opportunity was used to gain knowledge of the processes necessary for problem-solving (including determining the necessity of escalation), the ability to respond in English, and the procedures for changing the fleet map.

2.3 During the Games Times

(1) Staff Positions

Figure 3 shows the composition of staff members at the Technology Operations Centre (TOC) and the venues during the Games. TOC had a Radio Duty Manager in charge of overall radio operations, PMR Provider Expert, PMR Operations Manager and PMR Analyst (one, two, and two persons, respectively) under the Radio Duty Manager to provide support for the PMR services across all venues. A Venue Radio Manager was assigned to each venue to oversee radio operations at the venues, and a PMR Engineer (one person) was assigned under the Venue Radio Manager to support the PMR services at the venues. More than 300 NEC staff took care of the staff positions, except for the Radio Duty Manager. In principle, the TOC worked 24 hours a day, seven days a week during the Olympic Games, and 19 hours a day during the Paralympic Games, excluding late nights. In venues, support was provided during the Games and for several hours around the Games times.

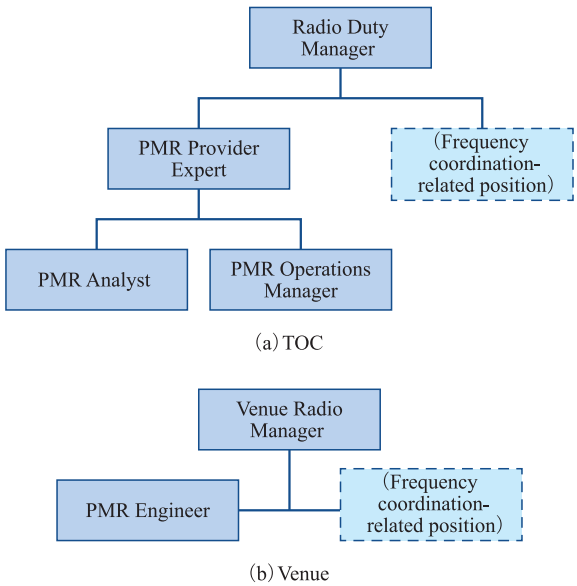

Figure 3 Positions Related to PMR

(2) Distribution and Collection of Equipment to Users

Equipment (including accessories) was delivered to users by a representative of the FAs, who distributed and collected all the equipment used by the FAs. The organization providing the equipment was defined and agreed upon in advance, and users managed the equipment, including recharging, while they had the equipment in possession.

(3) Change Requests, Incidents, etc.

The main request for change during the Games was to change the fleet map due to staffing modifications that occurred during the Games. Fleet map changes were handled promptly and with the utmost care during the Games. Minor requests, such as a change of users within the same talkgroup, were handled by on-site maintenance staff. However, complex requests, such as creating a new talkgroup or changing the composition of a talkgroup, required a report to TOC and a decision by the Radio Duty Manager. These change flows were defined in advance and announced to users, and support staff was trained to handle them on a case-by-case basis.

Major incidents included two base station equipment failures during the Games. However, redundant equipment helped the service not to be interrupted, and the equipment was quickly replaced and restored to normal operation.

3. Conclusion

The Tokyo 2020 Games operated the unprecedented PMR service. In addition to knowledge of radio propagation, knowledge of IP communications and, above all, knowledge of the Games management and competition-specific requirements, and open-minded communication with relevant people, were extremely important for completing the service.

Finally, we take this opportunity to thank the IOC TEC members and express our appreciation to sports federations, event organizers and venue owners for their cooperation in observing the events from the planning phase of the Games. We also would like to express our

gratitude to NEC and all other operators, the Ministry of Internal Affairs and Communications and other related organizations for their cooperation in the operation of the personal mobile radio.

(Received February 28, 2022 ; Revised March 17, 2022)

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He joined the Ministry of Posts and Telecommunications (now the Ministry of Internal Affairs and Communications) in 2000 and primarily focused on ICT development in developing countries. He moved to Tokyo Organising Committee for the Olympic and Paralympic Games in 2018, working for Technology Service Bureau as Senior Project Director for Frequency Coordination. He served as Radio Duty Manager at the TOC at the Games times.

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He graduated from the University of Electro-Communications in 1998 and completed the master's course at the University of Electro-Communications in 2000. From 2015 to 2021, he was in charge of Head of PMR services at the Technology Service Bureau of the Tokyo 2020 Organising Committee and was in charge of Radio Duty Manager at TOC at Games time.

KONISHI Hirohito

He graduated from Hosei University in 2003 and has been a member of the Technology Service Bureau of the Tokyo 2020 Organising Committee since 2017. He is mainly in charge of overseeing the construction of the PMR system and developing the fleet map. During the Games, he will be engaged in managing radio and frequency operations at the TOC as Radio Duty Manager.

KATSUYAMA Sakae

He graduated from Nagoya University in 1994 with a bachelor's degree in engineering and information technology, completed the first half of a doctoral course at the same university in 1996 and joined NEC in the same year. He has been engaged in the design, development, and maintenance of defense communication networks since then. He has been engaged in the maintenance of the business radio service for the Tokyo 2020 Games. Currently manager of the Urban Infrastructure Solutions Division 1 of NEC Corporation.