

Operation of Radio Equipment and Coordination of Frequency Usage at the Tokyo 2020 Games

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At the Olympic and Paralympic Games Tokyo 2020 (hereinafter referred to as “Tokyo 2020 Games”), radio equipment was used for a wide variety of purposes, including worldwide broadcasting, news gathering, Games operations such as timing and judging, communication within each country’s athlete squad, and communication among staff at the Games. Planning and prior coordination of the use of radio equipment is essential when users use radio equipment. The Tokyo 2020 Organising Committee, with the cooperation of the Ministry of Internal Affairs and Communications, made frequency coordination to avoid harmful interference, and approved the bringing of radio equipment into venues. This article reviews procedures from frequency applications to the bringing of radio equipment into venues and results of radio equipment operation, and also reports on spectrum monitoring that was conducted throughout the Games.

Keywords : Olympic, Paralympic, Radio, Frequency, Spectrum monitoring, Ministry of Internal Affairs and Communications

1. Introduction

1.1 Necessity of Frequency Coordination

At the Olympic and Paralympic Games Tokyo 2020 (hereinafter referred to as “Tokyo 2020 Games”), radio equipment was used for a wide variety of purposes, including worldwide broadcasting, news gathering, Games operations such as timing and judging, communication within each country’s athlete squad, and communication among staff at the Games. The Host City Contract stipulated that Japan should be responsible for allocation, management and monitoring of spectrum required for the Tokyo 2020 Games free of charge, and we addressed it in cooperation with the Ministry of Internal Affairs and Communications (hereinafter re-

ferred to as “MIC”), the competent authority responsible for managing the radio spectrum.

Planning and prior coordination of the use of radio equipment is essential when users use radio equipment. Therefore, the Tokyo 2020 Organising Committee decided to approve the bringing of radio equipment into venues after making frequency coordination to avoid harmful interference, based on the assumption that frequencies would be used only temporarily and in limited locations.

The Tokyo 2020 Games were extremely difficult to allocate frequencies, with 55 events (33 Olympic and 22 Paralympic) taking place over a 30-day period. Many of these events were held in close proximity to each other in Tokyo, including the Odaiba and Ariake areas, making it often impossible to reuse the same frequency at different venues. In addition, the host city Tokyo is the economic epicentre of Japan, where industrial activities are concentrated and a large number of radio frequencies are used. Furthermore, its location on the Kanto Plain and facing Tokyo Bay makes it easy for

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radio waves to propagate over a wide area, and these geographical factors made it difficult to allocate frequencies. Due to this situation, unprecedented frequency allocation was required in the Tokyo 2020 Games, in particular, for wireless microphones and wireless cameras with high needs.

1.2 Operational Framework

It was anticipated that an enormous number of frequency applications would be received, and preliminary surveys were required to allocate frequencies to each venue. The scope and volume of such work could not be handled by the Organising Committee staff alone, and it also required considerable expertise.

For this reason, the Organising Committee began to outsource in 2016, to a company with know-how and operational experience, the work to receive frequency applications, notify the results, and provide user support at venues for the use of frequencies required for the Tokyo 2020 Games. It also began to outsource in 2015, to another company with know-how and operational experience, the work to collect basic data on aspects of frequency bands at each venue in order to understand frequencies available at the venue and consider the conditions of use.

2. Frequency Application and Coordination

2.1 Frequency Application

In frequency coordination, close consultation with users is essential from the viewpoint of avoiding interference between radio equipment brought in from overseas and used in Japan. In addition, since the locally available frequencies are different from overseas, it is necessary to fully inform users of the rules for using frequencies in Japan.

We published the following three basic documents from the viewpoint of making them known to users. In addition, we also published nine newsletters on the frequency application procedures and rules for the use of wireless devices such as wireless LANs.

- (1) Basic Spectrum Plan (published in November 2017)

The basic plan for the spectrum use in the Tokyo 2020 Games was drawn up based on experience of spectrum use in the past Games and state of spectrum use in Japan.

- (2) Spectrum Management Plan (published in July 2018)

The spectrum management policy in the Tokyo 2020 Games was drawn up, and specific conditions for use of the frequencies announced in the “Basic Spectrum Plan” were presented.

- (3) Spectrum Monitoring Plan (published in September 2018)

From the perspective of ensuring a secure and reliable spectrum use environment free of interference and jamming, the plan for spectrum monitoring in the Tokyo 2020 Games was presented.

At the Tokyo 2020 Games, we constructed a portal site to accept frequency applications from users and started accepting applications in February 2019. Initially, we set up three application periods including the Games times. However, we eventually set up four application periods in response to the one-year postponement of the Games decided in March 2020, and sequentially gave responses as to whether the allocation was possible or not.

In the past Games, there were many applications for wireless microphones and other equipment, making it difficult to coordinate frequencies. For this reason, we made efforts to repeatedly inform applicants so that they would not submit excessive applications. For example, there were many cases where applicants with a large number of applications were asked to reduce the number of applications, or where applicants that made a request with ambiguous plan of use, such as using the same frequency at all venues, were asked to clarify venues and withdrew their applications at some venues.

Excluding such applications withdrawn by applicants, the number of applications we received by the end of the Games was approximately 85,000, the largest in the history of the Games, of which approximately 1,100 were received during the Games times.

2.2 Allocation and Notification of Results

The Organising Committee, as the licensee, received frequency allocation from the MIC for radio equipment requiring a radio station license, such as wireless microphones and wireless cameras, and decided to allow them to be brought into venues, provided that they passed the test (MIC inspection) at the venues and have the prescribed tag affixed.

The Organising Committee also decided that it would

allocate frequencies for wireless LAN and other wireless devices that did not require a radio station license.

(1) Frequency Coordination Method

The MIC examined spectrum sharing between radio equipment used in the Games and local radio stations, while the Organising Committee examined spectrum sharing and operational coordination among radio equipment used in the Games and between venues.

It was conceivable that as many as or more than the numbers of frequencies in the past Games would be used in the Tokyo 2020 Games. In order to allocate frequencies so that wireless devices used at the same venue and those used at different venues would not interfere with each other, the Organising Committee worked from FY2017 to FY2019 on a frequency allocation plan. We studied the allocation of frequencies considering interference with a primary carrier and third-order intermodulation for wireless microphones and wireless cameras, spectrum sharing, operational coordination, and calculation of a required separation distance.

Based on these results, we first conducted a simulation to determine whether the frequencies applied for the Rio de Janeiro 2016 Games could be allocated for the Tokyo 2020 Games, and were able to identify the radio equipment and frequency bands where more efficient use of frequencies was assumed to be necessary.

(2) Frequency Allocation and Notification of Results

The number of applications approved by the end of the Games was the largest in the history of the Games (approximately 64,000), of which approximately 1,000 applications were received and approved during the Games times. Applicants were notified of approval or denial for each application.

The Olympic Broadcasting Services (OBS), which filmed the Games and broadcast footage to rights-holding broadcasters worldwide, needed to be allocated necessary frequencies with the highest priority. We received more applications from OBS than at any past Games, requiring a wider bandwidth to meet the demand for higher definition images (transition from high definition to 4K/8K), including the use of wireless cameras utilizing advanced technologies such as Ultra High Definition (UHD) and High Dynamic Range (HDR) for higher value-added Games production.

Comparing the number of approvals for high-defini-

tion wireless cameras (bandwidth > 10 MHz), 214 applications were received for the Tokyo 2020 Games compared to 48 for the Rio de Janeiro 2016 Games. Around May 2021, when specific plans for the use of broadcasting equipment were clarified and transportation began, requests for frequency changes due to the changes of equipment came in rapid succession, requiring considerable operations to coordinate with the MIC and local licensees as need arises.

In addition to the aforementioned restrictions on the frequencies that could be allocated and the increasing trend of bandwidth per application, the number of applications was the largest in the history of the Games, making the frequency allocation process extremely difficult. As a result of repeated coordination with local licensees such as Telcos and broadcasters through the MIC until just before the Games, we were finally able to approve all frequencies that were essential for the operation of the Games. All in all, it was a difficult task that could not have been accomplished without the cooperation of the local licensees and other parties concerned.

2.3 Electric Field Strength Survey

In the frequency coordination, it is necessary to grasp the frequencies that can be used at each venue and to consider the conditions of use. For this purpose, the Organising Committee measured and collected, from 2015, the shielding loss caused by structures at a venue and the latent (incoming) electric field arriving at a venue, for the purpose of collecting basic data on the frequency band characteristics of each venue, targeting venues that had already been constructed and could be surveyed.

The measured data on the shielding loss was used to calculate the frequency reuse distance to enable the utmost reuse at contiguous venues. The latent electric field measurement data was also used to check whether there were non-negligible noise components at individual frequency points. It should be noted that the latent electric field could be affected by various factors such as urban noise, unique noise sources in and around the venue, etc., and might change after the measurement.

2.4 Individual Issues

2.4.1 Broadcasting of Outside Races

OBS used the same dedicated radio equipment that had been used in the past Games for broadcasting outside races, and the Organising Committee made the

necessary frequency coordination for this. The outside races covered were cycling (road race, time trial), marathon, race walk, and triathlon (race walk was only for the Olympics).

Although the number of wireless devices used varied depending on the competition, the maximum number of devices used was six motorbikes, one RF vehicle, and three helicopters, and the coverage were transmitted by two fixed-wing aircraft to receiving points located at the International Broadcasting Centre, Fuji Speedway, and Sapporo. The live coverage aired for rights-holding broadcasters worldwide.

In addition, the live coverage of the opening and closing ceremonies, sailing, athletics, football and cycling (mountain bike) were transmitted by up to three helicopters to the International Broadcasting Centre and receiving points set up inside and outside the venues, and aired for rights-holding broadcasters worldwide (football only at the Yokohama International Stadium).

Since wireless cameras required a particularly wide bandwidth, there were many local radio stations that needed to be considered for spectrum sharing. We did a study of spectrum sharing, operational coordination and the condition of spectrum use at venues from 2018, with the cooperation of local licensees, RF vendors, academic experts and other parties. During the study, we asked OBS to provide us with information necessary for the study, such as detailed specifications of radio equipment and the roaming range. After the study in Japan was completed, preliminary RF tests were conducted several times by OBS. The Organising Committee was present during the tests and confirmed that there were no problems by having local licensees check the impact on their radio stations in real time.

2.4.2 Wireless LAN

In the past Games, the frequencies of wireless LANs,

which in principle had not required a radio station license, were not always well managed, often causing problems for those involved in competition management, broadcasting, and media use.

For this reason, the Tokyo 2020 Games should, in principle, manage the frequencies in the 2.4 GHz and 5 GHz bands used for wireless LANs according to the following policy. In addition, we decided not to approve frequency applications submitted during the Games times as we anticipated difficulty in the frequency coordination.

- (1) Of the 5 GHz band, channels 52 to 64 and 100 to 124 are allocated to access points brought in by users, etc., and other frequencies are allocated to the Games network, etc. (Figure 1).
- (2) Frequencies are designated and approved on the condition that power is kept to a minimum and interference is tolerated. However, radio equipment of OMEGA, responsible for timing, International Federations and OBS is protected.
- (3) Access points are approved only at venues or at specific places in a venue (e.g., private offices).
- (4) Mobile Wi-Fi routers, wireless cameras and still cameras (master units) are not approved. If a user need the bringing into venue, the Organising Committee attaches a “DO NOT USE” tag on the condition of pledging not to use it.

3. Activities at Venues

3.1 Spectrum Desks

Spectrum Desks were set up at 23 venues for users to have their wireless devices tested and tagged (Figure 2). At six of these sites in Tokyo, including the Olympic Stadium and the International Broadcasting Centre, tests were conducted every day from two weeks before

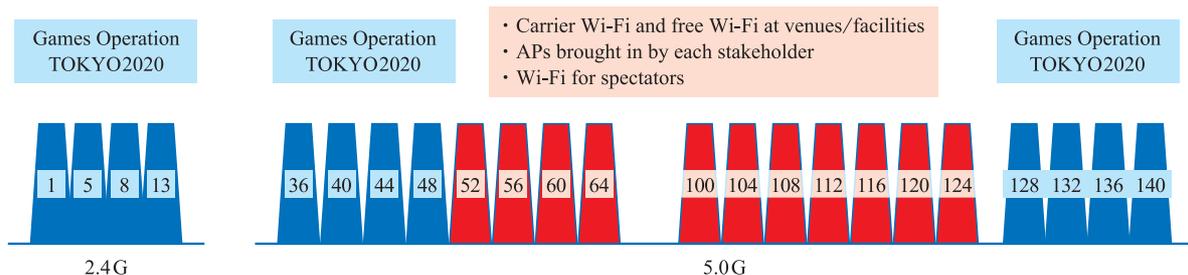


Figure 1 Frequency Plan for Wireless LAN Blue-coloured quadrangles denote frequencies allocated to the Games network, etc., and red-coloured quadrangles denote frequencies allocated to the access points, etc., brought in by users.



Figure 2 Sample Tags Attached to Wireless Devices The tag on the left was attached to wireless devices that passed the test, and the tag on the right was attached to wireless devices whose use was banned in venues.

the Games until the closing ceremony of the Paralympic Games. Users that came to nearby venues were guided in testing at the six sites. In addition, tests were carried out at 17 venues far from these six sites only during the competition period. The venues where tests were conducted, the service hours and other information were described in the “Guide for the Use of Wireless Devices” published in July 2021 to build users’ awareness.

Since there were many venues where wireless devices were used from the user’s point of view, Spectrum Desks were allocated and adjusted with user convenience, the cost of setting up and operating the sites, and the mitigation of the burden on site staffs (in other words, testing efficiency) in mind.

In the past Games, Spectrum Desks were set up in the security perimeters of venues (an area where only people and vehicles related to the Games are allowed to enter), but this meant that wireless devices were brought into the venues and then inspected. For this reason, the Tokyo 2020 Games placed emphasis on “not allowing untagged wireless devices to be brought into venues” and, in principle, set up the Spectrum Desks outside the security perimeters of venues, except in cases where the conditions of venues made it unavoidable.

3.2 Test Schedule Adjustment and Notification

In order to have users who completed the frequency coordination and were notified of approval receive tests of their radio equipment both inside and outside venues in a planned manner, the test schedule was adjusted by sequentially confirming the desired test dates and locations with each user starting in February 2021. At that time, we also confirmed contact details in Japan during the Games times so that we could respond to any changes in the reserved test dates and times.

Users who had completed booking for their test were sent a provisional approval letter and asked to bring it

with their wireless devices to the reserved Spectrum Desk on the test day.

In order to prevent infection with COVID-19, in principle, all users were required to make an appointment to have their wireless devices inspected. In cases where wireless devices could not be brought into the Spectrum Desk due to reasons such as a large number of the devices and the devices being already installed at venues, testing & tagging staff visited a place of the user’s choice to conduct the test.

3.3 Restrictions on Bringing Wireless Devices into the Venue

During the lockdown period (when people and vehicles are restricted from entering the venue), the venue must be free of wireless devices that were not approved by the Organising Committee.

From this perspective, as rules for bringing in wireless devices, it was decided to stipulate that untagged wireless devices would not be allowed to be brought in, and that A “DO NOT USE” tag must be labelled if staff at the Games brought in a mobile Wi-Fi router without an application, and to distribute a reminder document.

To inform the general users that untagged wireless devices, except for some wireless devices such as cell phones, could not be brought into the venues, this was stated in the “Guide for the Use of Wireless Devices” published on the Organising Committee website and posted at various locations at the venues. In addition, the Tokyo 2020 Ticket Purchase and Use Agreement specified wireless devices other than cell phones as restricted items, and also specified the use of mobile Wi-Fi routers in the venue as prohibited activities.

If an untagged wireless device was found at the baggage checkpoint, it was directed to the Spectrum Desk or a “DO NOT USE” tag was attached.

In addition, the following measures were requested to the Security Bureau of Tokyo 2020 Organising Committee and implemented during screening at the baggage checkpoint upon entry to the venue.

- (1) Prohibit untagged wireless devices.
- (2) Attach a tag prohibiting the use of mobile Wi-Fi routers brought in by staff at the Games.
- (3) Distribute reminder documents.

3.4 Spectrum Monitoring

Given the strict frequency usage requirements for the

Tokyo 2020 Games, we requested spectrum monitoring from the MIC and conducted the spectrum monitoring both inside and outside the venues in preparation for the unexpected occurrence of interference. The following is an overview of the activities conducted by the Organising Committee and the MIC.

(1) Roles of Organising Committee and MIC

Since the Organising Committee was the licensee of all radio equipment used in the Games, the Organising Committee was responsible for stopping transmission from the interference source, and the MIC was responsible for identifying the interference source.

Several MIC and Organising Committee staff members were assigned to each venue for the spectrum monitoring within venues. The MIC staff members were in charge of overall spectrum monitoring technology, while the Organising Committee staff members were in charge of user management as representatives of radio users.

(2) Spectrum Monitoring Activities

The spectrum monitoring staff worked in the spectrum monitoring room and proactively walked around the venue to check for the use of unapproved frequencies. Since it was known from the past Games that eyeing untagged wireless devices was effective in preventing interference, staff members commissioned by the Organising Committee also proactively roving around the venues and took measures such as stopping the use of such devices or having them apply for frequencies as soon as they were found.

The Tokyo 2020 Games also included full-scale monitoring of wireless LANs, which had not been done in the past Games. Specifically, unapproved access points and mobile Wi-Fi routers were probed and shut down.

For the monitoring of wireless LANs, we used Wi-Fi analysers specialized for monitoring wireless LANs. In addition to frequency information, related information such as SSIDs and MAC addresses could also be acquired, allowing detailed investigation of the use of Wi-Fi frequencies not applied for in the place and the impact on SSIDs used by the Organising Committee and competitions.

3.5 Test Event, Technology Rehearsal

(1) Test Event

In order to verify operations and gain experience at

the venues specified in the manual, radio staff were deployed to 27 of the test events conducted from 2019, including the modern pentathlon, sailing, and athletics, which required tests of radio equipment and spectrum monitoring. Since OMEGA planned to use many of the radio devices at the Games, we used the opportunity of the test events to test and tag, eliminating the need for tests during the Games times.

Since there were many cases in which the specifications of approved radio equipment did not match those actually brought to the Games, we took such cases into account and improved the testing procedures by making them more flexible and simplified. In addition, we attempted to monitor wireless LAN using multiple methods, which was expected to be difficult, and reflected the results in the methods and procedures for monitoring activities during the Games.

(2) Technology Rehearsal

Twelve staff members that would work at venues during the Games times were assigned to 11 venues for the technology rehearsal held in June 2021. Based on 30 scenarios (problems that could be anticipated during the Games and the procedures for solving them) prepared in advance, we verified whether the problems were handled well.

The foreign users who played the role of a wireless device user commented that more proactive communication was needed to understand user requests, and that the staff members should be more familiar with the IT service management system to manage the status of problems that might occur. After the technology rehearsal, all staff members that would work at venues were encouraged to share findings and lessons learned.

3.6 Personnel Regime during the Games Times

During the Games times, three positions (three people) were assigned to the Technology Operation Centre (TOC) and two to four positions (two to six people) were assigned to each venue to be in charge of frequency coordination, testing & tagging and spectrum monitoring, and they were supervised by the Radio Duty Manager (Figure 3). The positions other than the Radio Duty Manager were assigned to approximately 370 personnel from the contractor. In principle, the TOC worked round-the-clock shifts during the Olympic Games and 19-hour shifts during the Paralympic Games, while the venues were staffed for several hours before and after competition time.

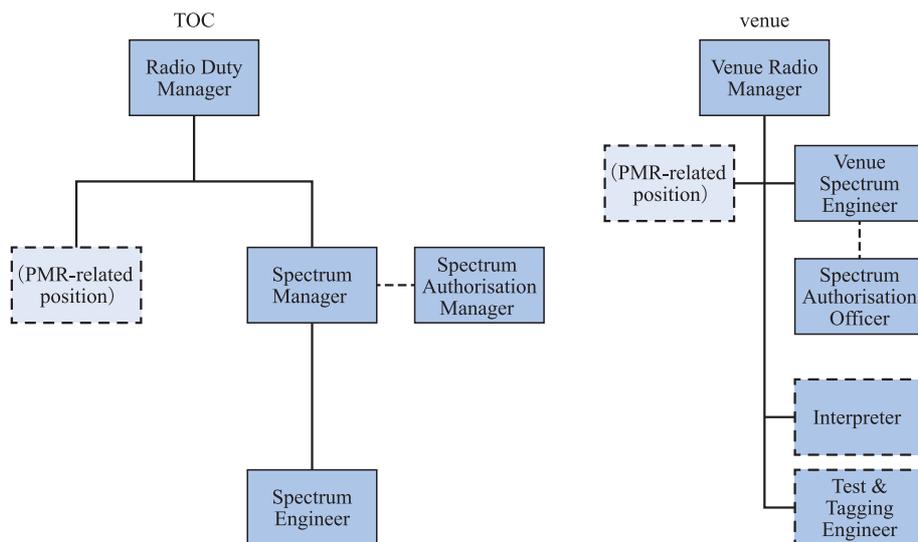


Figure 3 Positions Related to Frequency Coordination Interpreter and Test & Tagging Engineer were not assigned at some of the venues.

3.7 Incidents that Occurred during the Games

The number of incidents (problems such as interference that occurred and were registered in the IT service management system) during the Games was 16, excluding wireless LAN-related incidents, which numbered 12 (all for the Olympic and none for the Paralympic). For each of these incidents, a severity level (defining the decision-making process, time allowed for resolution, etc.) was determined and addressed.

As an example, there was a report of interference with the rugby referee radio (wireless microphone) at the Tokyo Stadium (resolved by changing the frequency). There were also cases of interference between wireless devices for the Games at multiple venues (resolved by changing the frequency), and a case in which the use of an unapproved mobile Wi-Fi router affected the wireless LAN for the Games operations (resolved by shutting down the mobile Wi-Fi router in question).

There were 63 and 177 interference incidents during Rio de Janeiro 2016 and London 2012, respectively. Even taking into account the fact that some of on-site issues were not registered as incidents because they were detected and handled before becoming incidents, the number of incidents during the Tokyo 2020 Games was extremely small (Table 1). This is the result of the following unique efforts in Japan, which have kept the number of incidents to a lower level than in the past Games.

Table 1 Comparison of the Number of Incidents with Past Games

	All Incidents	Wireless LAN-related incidents
London 2012 Games	177	—
Rio de Janeiro 2016 Games	63	9
Tokyo 2020 Games	16	4

※ The number of wireless LAN-related incidents at London 2012 Games is unknown.

- (1) A frequency allocation system and procedures in Japan that were managed in a very strict manner, even internationally.
- (2) Detailed prior coordination and deliberation with the MIC and local licensees, including Telcos and broadcasters, in order to meet the unique requirements of the Games, which required use of a large amount of frequencies in a short period of time.
- (3) Planning for construction of the Spectrum Desks and the strict equipment inspection and labelling regime to prevent unapproved radio equipment from being brought into the venue.
- (4) Thorough spectrum monitoring system during the Games and requests for cooperation from staff at the Games.

4. Conclusion

The Tokyo 2020 Games, which was the second Tokyo Games following the 1964 Games, were forced to operate a very large scale multi-sport event in a bubble system under difficulties amid COVID-19. In addition, compared to the past Games, it can be said that a wide variety of radio equipment was brought into the Tokyo 2020 Games.

It was a great challenge to use the largest number of radio equipment brought into Japan in the history of the Games without affecting local radio stations. I believe that I was able to fulfil my mission to support the Games from the aspect of radio communications and lead them to success. I would like to thank the MIC for their tremendous support and cooperation in the use of frequencies at the Tokyo 2020 Games, as well as Telcos,

broadcasters, and all other local licensees for their understanding and cooperation in the frequency coordination. Last but not least, I would like to take this opportunity to express my gratitude and appreciation again.

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