International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R SM.2257-5

(06/2019)

Spectrum management and monitoring during major events

SM Series

Spectrum management

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from http://www.itu.int/ITU-R/go/patents/en where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at http://www.itu.int/publ/R-REP/en)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	**Spectrum management**

***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2019

REPORT ITU-R SM.2257-5

Spectrum management and monitoring during major events

(2012-2013-2014-2015-2017-2019)

TABLE OF CONTENTS

Page

Page

1 Introduction

Major events like Olympics, Formula 1 races, music festivals and state visits are in the focus of the public interest. Although there is no unified definition for major events yet, they are characterized by a certain importance for one or more regions or even countries. Moreover, major events regularly require participation and coordination of various parties including governmental departments. In contrast to disasters in most cases the spectrum demands and spectrum usage of major events could be known in advance. Major events are mainly characterized by of a variety of radio applications and a substantial number of radio equipment aggregated within a limited area. The applications range from broadcasting, police, ambulance, wireless microphones and cameras to RLANs. Therefore adequate spectrum planning, licensing, spectrum monitoring, inspection of radio stations and processing of radio interferences are essential for the performance of a major event. Moreover, technical equipment limitations and last minute license applications require a rapid and in particular flexible on-site frequency management during the event.

The purpose of this Report is to provide guidance to administrations that are responsible for frequency management and enforcement activities such as spectrum management, spectrum monitoring and inspection of radio stations. Although this Report refers to major events, the basic considerations are applicable to minor regional or local special events too.

The Annexes to this Report provide practical examples of administrations' activities in spectrum management and monitoring activities during major events.

2 Information search

As there are plenty of events during a year, information from newspapers, television, Internet, calendars of events should be examined to identify events that may need special attention due to the economical or political importance of the event, the number of expected short term licenses or because of problems experienced in past events. These events should be recorded in an annual plan.

The annual plan must be handled in a flexible way and may need to be revised when new information is available. The plan should be visible to the staff, e.g. on the Intranet, so that the persons involved can duly dispose themselves.

3 General considerations

3.1 Organization team

Particularly smaller events without any on-site presence may be organized completely by a single frequency manager. The organization of major events, however, when several entities have to be coordinated, requires the nomination of a project manager who is experienced and widely recognized in the administration. He will be supported by an organization team comprising at least staff from the frequency management section and from the radio monitoring and inspection section. Lawyers, accountants and others may join the team permanently or temporarily as appropriate.

3.2 Coordination with other organizations

The following entities may be involved in the planning and performance of major events:

- organizer of the event;
- administration responsible for frequency management, monitoring and inspection;
- local authorities;
- police, ambulance, fire brigade;

- armed forces;
- other government organizations;
- security services of the organizer;
- telecommunication operators;
- broadcaster;
- press;
- participants, e.g. teams, bands;
- public authorities of neighbouring countries (e.g. for frequency coordination).

3.3 Frequency planning

The objectives of frequency planning are the settlement of spectrum demands as far as possible and the protection of other spectrum users, in particular protection of the safety services. The spectrum demand during major events like the Olympics may be much more than the frequency plan could provide on the regular channels. This problem must be solved by departing from the frequency plan.

In addition, the given frequency raster of the equipment in use may restrict the possibilities of frequency assignments.

Some channels for short term licenses may be obtained by negotiations with regular users. License holders may, for example, not require some channels during weekends. These could be used for the event.

The spectrum demand of the press is often the crucial test for the frequency management. The nomination of a host broadcaster proved to be advantageous in order to facilitate cooperation and to provide the technical and organizational basis for the press. The host broadcaster could be entrusted with the frequency coordination amongst all broadcasting companies or even with licensing for some frequency bands.

Frequency coordination with neighbouring countries may become a relevant issue if the event is located close to a border. Negotiations with the neighbouring administration may result in temporary reduced frequency reuse distances thus extending the own possibilities.

Frequency planning may become even more complex in cases of multinational events, e.g. cycle races through three countries. Broadcasters and supporters escorting the teams cannot simply change the frequencies of their equipment when crossing the border.

Anyway, the intense knowledge of the actual spectrum use is essential for successful frequency management. Hence “zero state” spectrum monitoring a few month before the event may be considered an appropriate tool in this regard.

3.4 Licensing

The procedure for applying for a short term or temporary license for a special event should be as simple as possible. In particular foreign applicants will not be familiar with the administrative procedures. It would be helpful if the application forms and the respective instructions on how to complete them were available in foreign languages too. The instructions should clearly indicate where the applicant has to send his application to and which information, e.g. frequency and power, he has to provide. Also the licensing fee should be known in advance.

The licensing staff should have a list of available frequencies including additional channels that are made available especially for the event.

If an application has to be refused the administration should explain its reasons and offer alternative frequencies or come forward with other proposals as appropriate.

3.5 Fees collection

In the various countries, fees for short term licenses may be based on different criteria, e.g. the particular radio service, duration of the license, number of equipment. Hence license fees can differ substantially from country to country.

The problems of fee collection should not be underestimated. If the applications are received sufficiently in advance of the event, the standard procedures are applicable. Procedures have to be implemented for last minute applications. Would it be acceptable not to issue a license because there is no documented evidence about the payment of fees available? The staff needs very clear regulations and management support in this regard.

The collection of fees is even more difficult if licenses have to be issued or modified on site which is sometimes unavoidable. Issuing a license and mailing the bill at a later point in time includes a high risk of losing money. If last minute licenses have to be paid in cash, two other problems emerge. First it is not sure that all applicants have enough cash with them and secondly the cash taken has to be safely stored. For this reason, some administrations will not accept cash payment. Payment by credit card is possibly the most user-friendly solution. However, this requires additional infrastructure like card readers. Where administration supports the functionality of online payment, this shall be considered as another alternative option for payment.

3.6 Labelling

Several administrations found it expedient to label previously inspected radio equipment. The event organizer could ensure that only equipment bearing a special event sticker is used at the venue. Stickers must be clearly visible and should be difficult to copy or modify. Different colours and different designs may be used to distinguish different events or locations.

3.7 Interference investigation

Cases of radio interference during major events are often of great significance and require immediate response, e.g. if the radio link between a helicopter and the TV compound on ground is interfered with. It would take too long to get a vehicle from a monitoring station. Furthermore, crowd, traffic and restricted movement would not allow proper action. Hence measurement vehicles and handheld equipment should already be at the venue. This could be complemented by fixed monitoring stations in the vicinity.

3.8 Logistics

The preparation and execution of events require qualified staff, measurement equipment and vehicles. These resources should be clearly identified. They are not available for other tasks at the same time. The necessary IT infrastructure like computers, data-base access, networking and interconnection with the office must also not be disregarded.

Accommodation of staff and vehicles is another important issue. Oftentimes staff and vehicles have to be accredited early enough in advance of the event. The secured position of monitoring vehicles and their mobility have to be discussed with the organizer. Administrative work could be done in a van, in a rented cabin or much better in an office at the venue. The availability of electricity supply and telecommunication lines is essential in all cases.

It should be taken into account that the staff may not be able to leave a certain area of the venue for a longer time, e.g. during Formula 1 races. Hence a substitute team may be needed depending on the national protection of labour regulations.

Usually it would be not efficient and sometimes even impossible to bring and depart monitoring vehicles daily during an event lasting several days. Hence staff transportation from and to a hotel

must be arranged. It is important to book hotel rooms betimes because shortly before the event it may be impossible to find any free rooms.

3.9 Radiocommunication equipment for spectrum management and monitoring staff

Some aspects of communication have already been addressed in § 3.8 on logistics. Likewise the need for communication between the frequency management team and the monitoring teams, working at their home office, walking on foot with handheld equipment or working in vehicles inside and outside the venue, has to be considered. The use of public telephone networks may be sufficient under normal conditions. However, such networks may collapse at large scale events and especially in case of disasters. Setting up an own PMR network should be considered to prevent such incidences. Important advantages of PMR networks using simple FM technology like walkie-talkies is that there is no delay due to settling times and that several users can be addressed simultaneously on the same channel.

3.10 Appearance in public

The on-site licensing and spectrum monitoring/inspection teams represent their organization anytime – at work as well as during breaks. A competent and friendly appearance is essential. This includes close cooperation and mutual information of the teams involved. Any discussions about procedures and lack of information in front of the customers and other persons are likely to cause the administration to appear in a bad light and hence have to be avoided.

For the same reason it is important to select proper clothing. The introduction of official dress may be considered so the staff can be identified immediately. A cheap solution would be a vest labelled with the administration’s name or simply “frequency management”.

4 Preparatory actions

4.1 Contacting the organizer of the event

It is useful to contact the organizer at a very early stage even in cases when no on-site presence of spectrum licensing or inspection teams during the event is intended. Experience shows that many organizers and participants are neither aware of the need of a radio license nor have sufficient understanding of interference problems. The unauthorized use of radio equipment, in particular equipment of foreign participants, may result in severe interference to broadcasting, safety and other radio services.

The first contact should be in written form. The organizer should be informed of the principles of frequency assignment and usable frequencies. Flyers and other available information material should be attached. Depending on the significance of the event, the organizer may be invited for a meeting.

The purpose of this meeting is to mutually understand the demands and problems and to have a firm basis for a decision on the further course of action. The organizer should understand the different types of licenses, e.g. permanent licenses, temporary licenses and general licenses (in many administrations called “license exempt”). The administration should obtain a general view of the number of frequency users and the spectrum required.

4.2 Plan of action

The coordination team should develop a plan of action. The plan must clearly identify dates and responsibilities. The following list illustrates possible activities that may be applicable, dependent on the relevance and size of an event. Due to the diversity of events, there is no “correct” order for the

activities. Also no general rules can be provided regarding the timing. Advance planning and first actions may start eight weeks or two years before the event.

Activities before the event

- Consulting the organizer in written form
- Counselling interview with the organizer
- Information about the radio monitoring/inspection service
- Further meetings with the organizer
- Providing information on the organizer's home page; a link to the spectrum agency would be advisable
- Providing event related information on the spectrum agency's home page
- Visit of the event location
- Drawing up a time-table
- Labelling required: yes or no?
- Assigning tasks to the spectrum monitoring/inspection service
- Fixing the manpower requirements
- Review of the situation regarding accreditation
- Fixing the location of measuring vehicles and vehicles for passenger transportation
- Organization of the power supply
- Contacting the host broadcaster regarding spectrum coordination
- Contacting security organizations (police, ambulance, etc.)
- Monitoring the spectrum (zero state)
- Allowing spectrum applications
- Handling of applications:
  - Considering applications (availability of spectrum, compatibility)
  - Spectrum coordination with neighbouring administrations
  - Approving applications
- Hotel booking
- Organizing an on-site office and office equipment
- Planning of communication (radio, telephone, Internet)
- Preparation of on-site collection of fees
- Arrangement of staff schedule
- Carry out any required coordination with a neighbouring country.

5 Activities during the event

Customers and the public are usually not familiar with the structure of an administration. Thus all colleagues should be approachable regarding all questions related to licensing, monitoring and inspection. The enquiring partner should either receive an immediate answer or be referred to a competent staff member.

Activities during the event

- Coordination of the staff involved in the event

– Processing short term applications
– Documentation of all activities including date and time
– Client counselling
– Contacting the relevant persons (event manager, companies, public authorities)
– Inspection and labelling of radio equipment; at least the frequency should be checked
– Monitoring the spectrum
– Interference investigation
– Identification and elimination of unlicensed frequency use.

6 Activities after the event

A first recapitulation of the event may be given still on-site. However, the teams probably want to leave the event as soon as possible. The activities after the meeting are compiled in the list below.

Activities after the event

– Equipment removal
– Return transport of staff
– Return of borrowed equipment
– Settlement of accounts
– Finalization of interference handling if necessary
– Initiation of legal measures (in cases of identified infringements)
– Reporting, including relevant findings, should be retained for use at later events
– Create statistics for evaluation and later use
– Final review.

The project manager should chair a debriefing meeting shortly after the event. He should use the opportunity to address the highlights and to thank his team. A review of the perceived difficulties and an analysis of unsolved problems should result in a final report that may be used for the preparation of the next major event.

7 Conclusion

Additional spectrum demand, a variety of radio applications and equipment, movement restrictions and the need for short term decisions in a flexible way are a challenge for the spectrum management at major events. Thorough planning and close cooperation with all relevant parties is essential for the success of the event. The deliberations in this Report are adaptable to smaller events.

The examples in the Annexes to this Report are intended to provide suggestions for those who are going to participate in the preparation and execution of major events.

Visiting other administrations or the exchange of information in writing well in advance of a major event could be useful.

Annex 1

Spectrum management and spectrum monitoring during the Beijing 2008 Olympic Games and the Paralympics Games

1 The importance of spectrum management and spectrum monitoring during a major event

As information technology prevails, radiocommunication applications play a more and more critical role in almost all important events, especially for an event as important as the Olympic Games. These major events strongly rely on the use of a great number of radio applications in virtually all aspects. These applications are, in many cases "mission-critical" for the major event, and sometimes not a minor mistake is allowed. Furthermore, the Olympic Games competition generally undergo during a limited time period and within a densely electronic-device-populated area or venue, which led to an extremely complex radio "environment" for these radio applications. All this brings about a number of major difficulties and high demands for the spectrum regulators and spectrum monitoring engineers to control the risks of failure of radiocommunication. This Annex introduces how the spectrum regulation and spectrum monitoring were undertaken during the Beijing 2008 Olympic Games and the Paralympics Games. It can serve as a reference for future Olympic Games and other major sport event alike.

2 Overview of the Olympic Games (some statistics)

2.1 Statistics

The following statistics gives some general information concerning the Games:

- over 11 000 athletes and from 204 countries and regions;
- over 26 000 accredited journalists and 5 900-plus un-accredited journalists from 100-plus media;
- over 70 000 employees and volunteers served the Games;
- more than 110 dignitaries (Heads of State, Member of royal families, etc.) from 50-plus countries;
- 36 sport venues and 15 Areas under Special Control (such as the headquarters of the Games' organizers).

2.2 Major radio equipment types and their frequencies during the Games

Major radiocommunication equipment used during the Games (as recommended by IOC and the past host of the Games) are listed as following text.

NOTE – The abbreviations shown in the subsections refer to Fig. A1.3.

2.2.1 Fixed microwave links (FL)

This type of equipment is used between two fixed points for the transmission of video, audio or other data.

2.2.2 Mobile micro-wave links (ML)

The terminals are located on board of vehicles, vessels or helicopters. Generally, ML is used for video transmissions, and will occupy a bandwidth of 8 MHz up to 30 MHz.

2.2.3 Satellite news gathering (SNG)

An SNG terminal must be able to be rapidly deployed, to transmit vision and associated sound or sound programme signals, to provide limited receiving capability to assist in the pointing of the antenna and to monitor (where possible) the transmitted signals, and to provide two-way communications for operation and supervision. SNG equipment is able to coexist well with other users in the Ku-band. However, interference may happen between SNG in C band and other microwave links, therefore analysis is required in this case.

2.2.4 Land mobile radio systems (LMRS)

Handheld or portable equipment for communication purposes is used with a large number of users.

2.2.5 Talk back systems (TBS)

They are used primarily for communication between the director of activities and their employees such as presenters, interviewers, cameramen, sound operators, lighting operators and engineers. TBS equipment works in the band of 403-470 MHz and 137-167 MHz in general. Since there is a great number of existing users of TBS, the frequencies for the Olympic users must be planned carefully with the assistance of radio station database.

2.2.6 Hand-held two-way radios (HR)

This is often known as walkie-talkies, being widely used by a large number of users. They share the same bands as the TBS equipment.

2.2.7 Cordless cameras (CC)

This is a type of video camera which is capable of capturing and transmitting high-quality video and audio signals within a short range (no more than 500 metres). It is either hand-held or carried by other means and is composed of transmitting circuits, battery and antenna. Typical CC equipment works between 2.0-2.7 GHz, with a bandwidth of 8 MHz up to 20 MHz.

2.2.8 Wireless microphones (WM)

Handheld or body worn professional microphones with integrated or body worn transmitter. Convenient for the interpreters and reporters, WMs were largely used during press conferences. Typical WMs occupies 120 kHz bandwidth, with a certain number exception of 180 kHz. The power of this type of equipment is very low (30-50 mW), which made it easy for the reuse of frequencies.

2.2.9 Remote control equipment

Working within the 403-470 MHz band, the telemetry and telecommand equipment was used to control the cordless cameras, vehicles, or the time and score recording equipment. Being a critical type of equipment, it worked in the most heavily used band and attentions should be paid to its coexistence with other equipment.

2.2.10 Wireless LAN (WLAN)

In total, 16 channels were made available in venues, Olympic related hotels and operational centres. Eight of these channels within the 5 150-5 350 MHz band were of a temporary nature, and they are put into use to satisfy the demand from the users.

2.2.11 In-ear monitoring system (IEMS)

An IEMS is mini receiving equipment used for the monitoring the audio communication of actors, etc. Typical WMs occupies 125 kHz bandwidth, with a certain number exception of 200 kHz. Their transmitting frequencies are within the 520-860 MHz band approximately.

2.3 Three phases for spectrum management and spectrum monitoring before and during the Games

During the Beijing 2008 Olympic Games and its preparations, the spectrum management and spectrum monitoring can be roughly divided into three phases, namely the long term preparation, just before the Games, and during the Games, each with different priorities.

2.3.1 The long-term preparation (before the end of December 2006). During this period a number of preparatory tasks were undertaken, including:

- an investigation of the potential demand for frequency resources;
- some preliminary studies of EMC analysis;
- improving and integrating spectrum monitoring facilities;
- designing of the website for frequency application;
- beginning formulating all types of work plans and procedures.

2.3.2 Just before the Games (between January 2007 and July 2008). During this period features the heaviest work load and proved to be the most critical for the success of the next phase.

- Launching of the website for frequency applications;
- Frequency planning and assignment;
- Improving the procedures for spectrum monitoring and equipment testing;
- On-site spectrum monitoring of the "background spectrum" at venues;
- Technical training;
- Practice and rehearsals (especially during the Gook Luck Beijing test events).

2.3.3 During the Games (between July 2008 and September 2008)

- Spectrum monitoring;
- Equipment testing;
- Emergencies regarding unexpected radio interference.

3 Spectrum management

3.1 Survey and analysis of the frequency demand

By correspondence or at meetings, the frequency demands of domestic and foreign users were collected, this was completed 18 months before the Games. The spectrum management team also visited their counterparts of the 2000 and the 2004 Games, in Sidney and Athens respectively. Becoming aware of the previous situations, the team estimated that the frequency demand could rise by 30% than the Athens Games.

3.2 Collecting of the frequency resource

- The un-planned bands were put into temporary use. (For example, the 5.15-5.35 GHz band was temporarily authorized to be used for WLAN during the Games.)
- Radio stations profiles were thoroughly reviewed and the unused or illegally used frequencies were taken back.
- Frequency coordination meetings were held with the broadcasting administration and some operators. (For example, a great number of frequencies were "borrowed" from the Beijing local broadcasting administration for wireless microphone equipment.)

3.3 Application of frequencies

A website dedicated to the application of frequencies for the Games was launched. It proved to be a good tool for spectrum management and the users alike. Their workload reduced thanks to the high automated processing of the applications.

FIGURE A1.1

Welcoming page of the frequency application website

For important frequency users such as Beijing Olympic Broadcasting (BOB), who applied large number of frequencies, it possible for batch process of their applications.

Repeated corrections to applications will exert heavy pressure on spectrum management. In order to reduce the number of unqualified applications and ease the pressure, it is important for the spectrum managers to have a good communication with the users of radio equipment. On the one hand, the needs of the users can be well understood, on the other, the users can be made aware of the scarcity of the frequencies and allow them to be informed of the frequencies available for application. Additionally, the spectrum managers could also advise on the type of equipment for the user, making it less likely for repeated corrections to applications.

From Fig. A1.2, it is apparent that for frequency application, the bulk of their workload appears in December 2007, 8 months prior to the Games.

FIGURE A1.2

Work load for radio frequency application

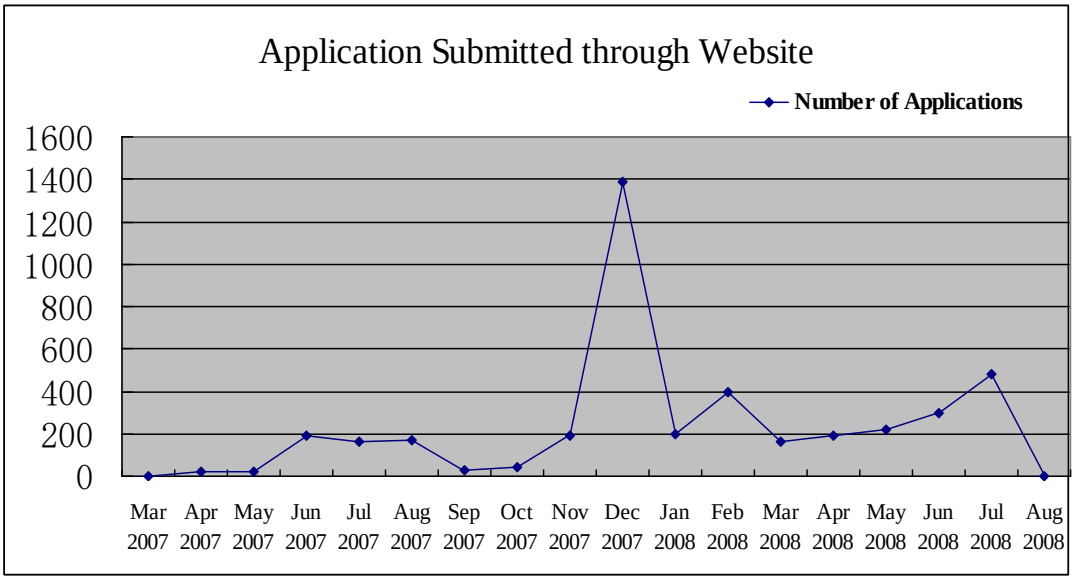
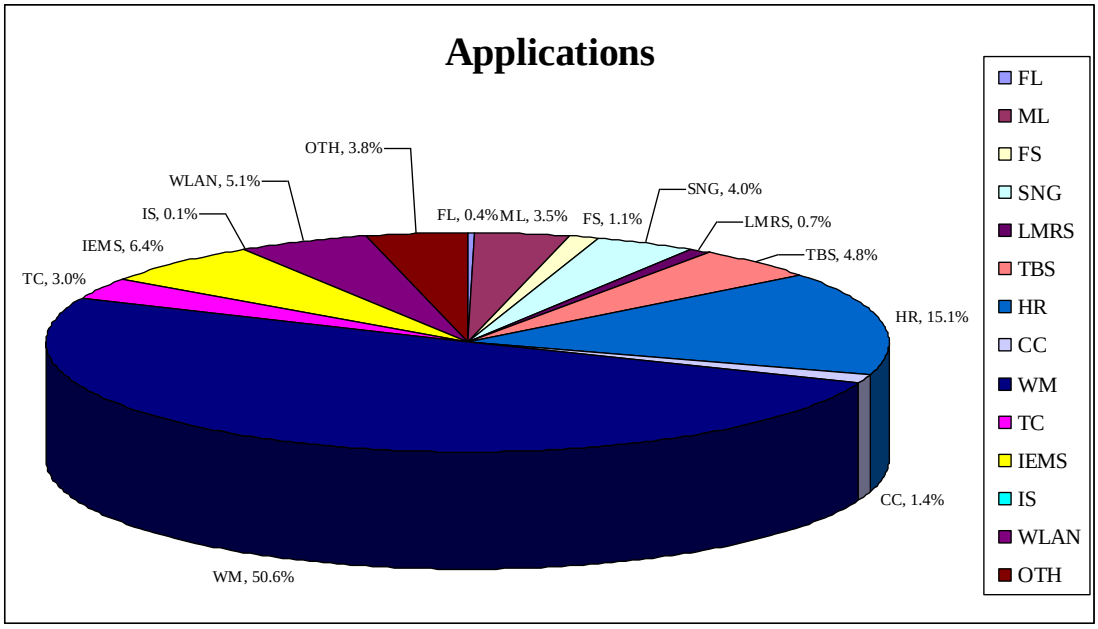


FIGURE A1.3

Radio applications used in the Games



3.4 Frequency planning and assignment

3.4.1 Considerations in frequency reuse

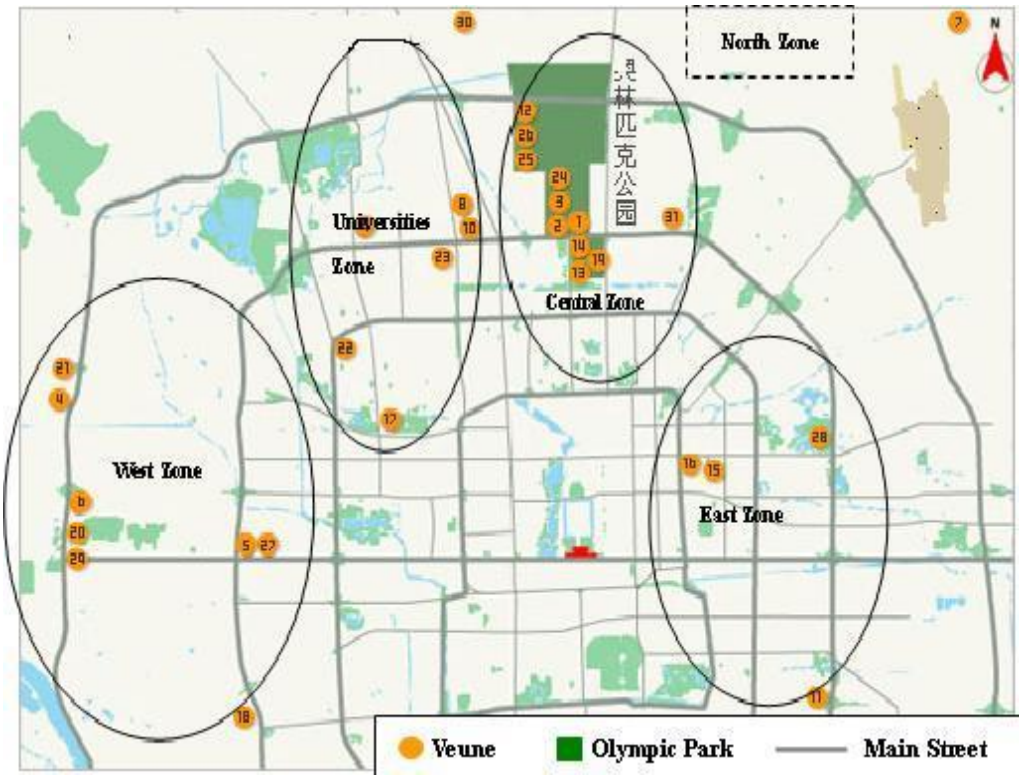
Thirty-one venues and 15 venues for non-competition purposes were divided into six zones as shown in Fig. A1.4; spatial reuse can be applied in different zones. For short-range devices, spatial reuse can even be applied in different venues.

Time reuse can be applied for equipment scheduled to be used at different periods within the same zone.

NOTE – The venues and key areas are grouped into different zones according to their location (See Fig. A1.4), and these zones include the West Zone, the Central Zone, the North Zone, the Universities Zone and the East Zone. The events which cover a large area should also be taken into considerations (for example the marathon or the road bicycle races).

FIGURE A1.4

Distributions of the venues in Beijing



The structure of the venue must be taken into consideration while planning for frequency reuse. A venue of a concrete structure can attenuate 30 dB of a signal at 400 MHz, while the National Aquatics Centre, with its ETFE membrane structure, presents little attenuation to radio waves at 400 MHz.

3.4.2 Frequency grouping

For frequency assignments, available frequencies were divided into different groups. Within the same group, there were no adjacent frequencies or a frequency which falls into the third-order inter-modulation frequency points of any other two frequencies within the group. The groups can be used when making assignments to different equipment used in the same zone of at the same period. Additionally, some "versatile" frequencies and backup frequencies were reserved for unexpected situations.

3.4.3 Frequency bands for typical radio communication equipment used in the Games

TABLE A1.1

Typical radio communication equipment used in the Games and their frequency bands

Application	Frequency range	Bandwidth per channel
Two-way radios including LMRS/TBS/HRS	137-174 MHz/403-470 MHz/800 MHz	12.5 kHz/25 kHz
Public mobile communication GSM/CDMA/TD-SCDMA	900 MHz/1 800 MHz/ 800 MHz/2 000 MHz	200 kHz/1.25 MHz/ 1.6 MHz
WLAN	2.4 GHz/5.1 GHz/5.8 GHz	22 MHz
Wireless microphones	500-806 MHz	125 kHz
Wireless cameras and mobile microwave equipment	1 920-2 700 MHz/3 200-3 700 MHz	10 MHz/20 MHz
Time and score	3 MHz band/2 400-2 475 MHz	
Satellite and fixed microwave equipment	C-band or Ku-band	

4 Spectrum monitoring

4.1 Objectives and tasks at different phases

− Preparation period

  Frequency occupancy measurements were undertaken to have a basis for drawing up the frequency plan.

− Just before the Games

  Monitoring of the assigned frequencies were undertaken to ensure an interference-free spectrum. In case of interference to the assigned frequency, the investigation and location will be conducted to locate the source and eliminate the interference.

− During the Games

  Assigned frequencies were under close monitoring with an aim to protect the radiocommunication.

4.2 Configurations of monitoring stations

The terrestrial fixed monitoring network is composed of one control center and nine fixed monitoring stations. This monitoring network is used in preliminary analysis as to which part in the city the signal under test originates.

Monitoring facilities within zones: all the Olympic venues were divided into eleven monitoring zones, each zone was equipped with one or two monitoring vehicle and spectrum monitoring can be undertaken.

Portable monitoring equipment can be very useful because most radio equipment was used inside venues. Due to its low transmitting power, there is a significant difference of the spectrum status between the interior and the exterior. Therefore, it is important to have portable monitoring equipment deployed inside venues.

In addition to terrestrial spectrum monitoring, it is also the responsibility of the spectrum monitoring organization to conduct monitoring of satellites' emissions, which is critical for broadcasting or transmitting the event to other parts of the world. During the Beijing Olympic Games, the satellites carrying emissions related to the Games were closely monitored. In case of interference or failure of satellite transmission, the automatic monitoring system will send warning messages to monitoring engineers, who will immediately react. In addition, two monitoring vehicles dedicated for the SHF band were used for monitoring of the satellite uplinks or other emissions falling into this band.

4.3 Monitoring network

All the fixed monitoring stations and mobile stations are networked, which made it possible for the monitoring officers to have an overall view of the spectrum at different locations. At the same time, the direction-finding results can be processed to yield locations of stations under test.

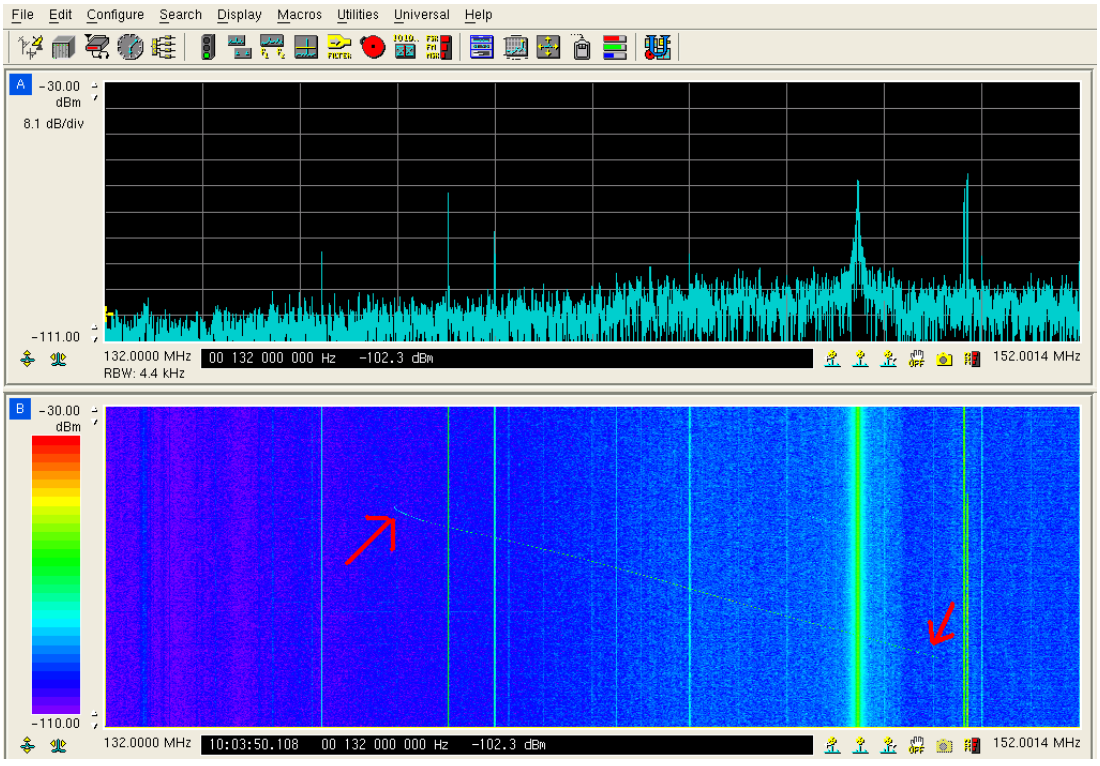
4.4 Case studies of interference resolution

Case One: A case study of new technologies in spectrum monitoring-real-time wideband spectrum analysis

Limited by its tuning or sweeping time, the super-heterodyne receiver or spectrum analyser is sometimes unable to analyse frequency agile signals or burst signals within a wide frequency range. These signals could pose significant interference to radio applications. However, thanks to the FFT technology in wideband, real-time analysis, it is possible to conduct real-time monitoring of the up to hundreds of Megahertz of spectrum, burst or agile interference can be easily detected.

FIGURE A1.5

The use of real-time spectrum analysis to detect frequency agile signals



As is shown in Fig. A1.5, traditional spectrum analyser was unable to detect a sweeping, frequency modulation signal (upper part of the Figure). While at the same time, the real-time analyser recorded its trace in its waterfall mode (lower part of the Figure).

Case Two: Radio interference caused by ISM equipment

During the Good-Luck Beijing testing event (an overall rehearsal prior to the Games) in February, 2008, radio interference with the WLAN system in the Nation Aquatics Center (NAC) was found. The interference caused high failures rates and unusually low speed access for the WLAN users. By direction finding, the interferer was identified to be the "Dual-channel microwave oven" which leaked at 2 458 MHz with a power of −50 dBm to −70 dBm in the NAC. This kind of giant microwave ovens was used to prepare food for the staff working for the Games. In addition the interference is partly because of the special membrane structure of the NAC outside layer. This membrane structure attenuates very little of the radio waves.

FIGURE A1.6

Interior of the "Dual-channel microwave oven"

In China, the 2 400-2 500 MHz band is "designated for industrial, scientific and medical (ISM) applications. Radiocommunication services operating within these bands must accept harmful interference which may be caused by these applications." However, considering its importance to the Games, WLAN should be protected. Therefore, a compromise solution was reached to install shielding facilities around the oven and the WLAN quality of service was much improved.

5 Equipment testing

5.1 Purpose

The purpose of equipment testing is to verify whether the users' equipment complies with the technical parameters in the frequency license granted by the spectrum managers.

5.2 Testing teams and testing sites

Four fixed testing sites and three mobile testing sites were available for the media and the players. The three fixed sites were located at the IBC, the MPC and the OLV (the International Broadcast Center, the Main Press Center and the Olympic village). Such equipment as spectrum analysers, communication testing sets, GTEM chambers and label printers were available at these sites.

5.3 Workload

For equipment testing, the peak of its workload appears between four to two weeks prior to the competition.

5.4 Parameters to be tested

The parameters for mandatory tests include frequency, power, bandwidth and spurious transmissions.

5.5 Sample ratio to the equipment under test

TABLE A1.2

Sample ratio and technical standards of the equipment under test

Equipment	Sample ratio
Fixed or mobile link	5-10%
Satellite news gathering or fixed satellite	5-10%
LMRS/TBS/HR	10-20%
Cordless camera	10-20%
Wireless microphone	5-10%
WLAN	10-20%

5.6 Others

Potential interference may be produced by devices for non-communication purposes. For instance, UPS power may interfere with the timing and scoring systems working under 30 MHz, and microwave ovens may interfere with WLAN equipment. It is of essential importance for the spectrum regulators and monitoring organizations to have a good communication with the other event organizers, for example, the security staff should be notified to try not to use radio jammers. It is equally important to address problems in advance as much as possible. This is because that during the event, there will not be much time left for trouble-shooting and the access of the spectrum regulating and monitoring staff are quite limited.

6 Conclusions

6.1 Spectrum management

− The demand for spectrum resources during a major event is expected to be greater and greater. It is very likely that this demand during the next Olympic Games would exceed that of the Beijing Games.

− Except for a small number of important application (the time and score recording applications and those applications for the opening and closing ceremonies for example), sharing use of the spectrum among multiple applications is becoming an obvious solution. Therefore, sharing criteria and standards should be a very important subject to study.

6.2 Spectrum monitoring

− The configuration, distribution and coverage of monitoring facilities are critical for the investigation and location of interference. For example, a monitoring system in the VHF/UHF band should be installed as high as possible to improve its coverage.

− The advancement of digital technology renders it possible to perform real-time wideband monitoring and in-depth off-line analysis.

6.3 Equipment testing

– Frequency and bandwidth are important parameters for equipment tests and verifications. Power is another important one, but because it is difficult for some types of equipment with integrated antenna, it is a good practice to roughly estimate the e.i.r.p. by calculation the free space loss.

6.4 Spectrum management and monitoring within venues

– For the spectrum managers and monitoring engineers within venues, it is critical to get the most accurate and up-to-date information of the use of radio equipment in terms of its place, time and user.

6.5 Information systems

– To have an accurate radio station database and equipment database will lay a solid foundation for radio management and monitoring.

– It is essential to network fixed monitoring stations, equipment testing sites, monitoring vehicles, etc., which significantly improves the efficiency and response time.

Annex 2

Spectrum management and spectrum monitoring during 2016 Rio de Janeiro Olympic and Paralympic Games

1 Planning and general coordination

Host city nomination and Olympic Act (Federal Law Nr. 10,035)

In October 2009, Rio de Janeiro, capital of Rio de Janeiro state in Brazil, was nominated as host city of the Olympic and Paralympic Games of 2016.

When the city submitted its bid to host the 2016 Games, the Brazilian government made a commitment to the International Olympic Committee (IOC) to guarantee the spectrum needed for the Games, in accordance with item 16.9 of the Candidature File, as described below:

"…

16.9 – Frequency Reservation and Services - Free to Games clients

The Federal Government, through the Ministry of Communications and ANATEL, guaranteed to review legislation, regulations and decrees, or approve new legislation or regulations, as necessary, to ensure that no fee will be charged to athletes, the IOC, the Rio 2016 Organising Committee, NOCs, NPCs, IFs, the press, members of Rights-Holding Broadcasters or Olympic partners, for frequency allocation reservation and services in the period beginning one month before the Opening Ceremony of the Olympic Games and ending one week after the Closing Ceremony of the Paralympic Games, further undertaking to do so quickly and efficiently.

…"

The guarantee is provided for in article 13 of the Olympic Act, approved by de Brazilian Federal Law 12,035 of October 1st, 2009, which states: *"**Article 13.** The availability of the entire radiofrequency spectrum to organise Rio 2016 Games is legally assured, guaranteeing their assignment, management and control during the period from 5 July to 25 September 2016."*.

Additionally, the Law defined that all frequency assignments for entities classified as "Olympic Family" would not be charged, leading to a very complex frequency management scenario due to low incentives to efficient use of licensed spectrum (free of charge).

After the host city nomination, the preparation roadmap was designed in 2011 with the creation of a working group in Anatel, responsible to advising its board of directors on the management of the telecommunication infrastructure for the major international events from 2011 to 2016. The multidisciplinary approach required that the group included staff of all major areas of Anatel and external participants from public and private sectors, including the Ministry of Communications, the Olympic Public Authority (APO) and Rio 2016 Organizing Committee.

International benchmarking and previous experiences

Some years before the Olympics, Anatel performed benchmarking studies with telecommunication regulatory bodies in countries of previous Olympic host cities, making technical visits and debriefing meetings with regulatory authorities of China (Beijing 2008), United Kingdom (London 2012) and Russia (Sochi 2014)[1]. The most relevant study was related to London 2012, when Anatel could send a delegation to follow Ofcom field enforcement spectrum control operations in a shadow mission. Anatel spectrum enforcement agents worked together with Ofcom teams, having a deeper understanding about challenges and practices, especially on Olympic native processes.

Furthermore, Anatel internal preparation framework for the Rio 2016 took high advantage on the fact that it occurred in a sequence of several major events held in Brazil in the previous years. Thus, many projects already deployed for those previous events, such as renewal of spectrum licensing system and purchase of new spectrum monitoring equipment, were already deployed and were very useful during Rio 2016.

Spectrum Management and Spectrum Control Plans for Rio2016

In 2013 a high level spectrum management plan was established between Anatel, Ministry of Communications, the Olympic Public Authority and Rio 2016 Organizing Committee. The plan included basic definitions, general spectrum management operations framework, a high level band plan and complimentary aspects. It also defined communication strategy and target dates for spectrum licensing milestones.

In October 2014, going into deeper operational details for Games Time period, a Spectrum Control Plan was established between Anatel and Rio 2016, defining the governance, infrastructure, working procedures, workflows, service level agreement, spectrum monitoring equipment, harmful interference resolution, test and tagging, services priorization, risks management, human resources, communications plan and further.

Rio 2016 Spectrum Management Plan

http://www.anatel.gov.br/Portal/verificaDocumentos/documento.asp?numeroPublicacao=317630&pub=original&filtro=1&documentoPath=317630.pdf

[1] Further important references were taken from Report ITU-R SM.2257-3 (*Spectrum Management and Monitoring during Major Events*).

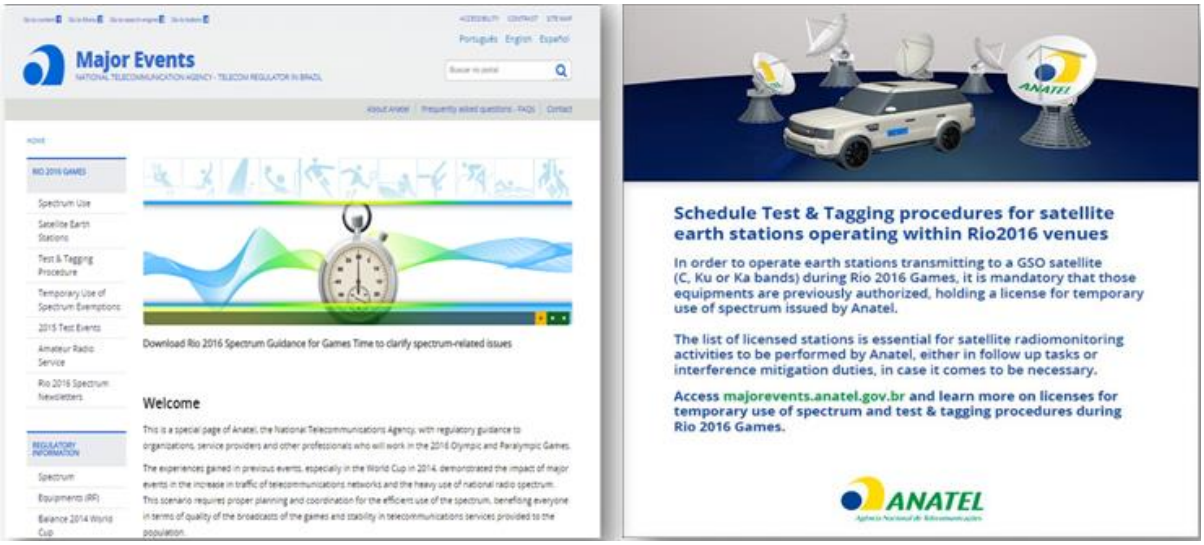
Communication

In order to disclose fast and more comprehensive information to spectrum stakeholders, orientations related to spectrum procedures, target dates, temporary spectrum licensing guidance and further spectrum enforcement aspects were posted on both Anatel and Rio2016 websites. Anatel updated one special webpage developed in 3 languages used for previous international events (e.g. FIFA World Cup).

The most dense communication strategy was developed through internal Rio 2016 rights holding broadcasting communication mailings. It included Rio 2016 website, meetings with the event main stakeholders and the development of Spectrum Newsletters.

However, after noticing relevant delays on the submission of spectrum licensing applications by some stakeholders (e.g. satellite earth stations operations), specific and intensive communication campaigns were made to stimulate stakeholders to initiate licensing procedures as soon as possible, leading to extremely positive results as many spectrum licensing applications started immediately after this specific communication effort.

Anatel special website with spectrum regulatory guidance on spectrum management for Rio2016



152 countries that accessed Anatel website for Rio2016 from August 2014 until September 2016 (blue color)

More details:

– Anatel special website for major events

– http://www.anatel.gov.br/grandeseventos/en/

– Rio 2016 Spectrum Newsletters

– http://www.anatel.gov.br/grandeseventos/en/rio-2016-spectrum-newsletters

2 Anatel positions and human resources

The event took place in 34 Competition Venues, grouped into 4 Clusters spread over different regions of Rio de Janeiro city and five football stadiums at other cities. It was a great challenge to have simultaneous activities in several Venues in a single city. At any given moment any spectrum demand could be driven to Anatel, such as licensing request, test and tagging scheduling, radio interference or non-authorized spectrum users complaints. The response and resolution times followed a high level SLA, so huge staff was needed.

Staff distribution

The staff distribution by working process during Rio2016 operations were:

- Test and Tagging of RF equipment – 102 people
- Spectrum Incident Management – 66 people
- Centralized Spectrum Monitoring – 10 people
    - Satellite (5) and Terrestrial (5)
- Technology Operations Center – 14 people
    - Incidents Resolution (9) and Spectrum Licensing (5)
- Integrated Command and Control Center (CICC) – 3 people
- Drive and Walk Test – 6 people

The roles of Anatel teams including the teams in Technology Operations Center (TOC), Integrated Command and Control Center (CICC), Spectrum Monitoring Center, Test and Tagging and Spectrum Incident Management rooms at the Venues will be detailed in the following items.

It shall be remarked an important involvement of other departments of Anatel in the preparations phase, years before the event, such as IT, Procurement, Public Attorneys, Communications, International Affairs and Human Resources.

3 Coordination functions (TOC, CICC)

Technology Operations Center (TOC)

The Technology Operations Center (TOC) of Rio2016 was the main coordination centre for all technology services for Rio2016, including IT, IP networks, time and score, printing services, wireless networks and spectrum management. A service desk call centre was responsible to receive calls and register the spectrum ticket requests from the Olympic family in the TOC. The service desk was a sort of technology customer relationship management for Rio2016 Olympic family. After classification, the spectrum tickets were sent to be treated by the spectrum team, which first analysed and depending on the topic, submitted to the responsible team and correlated Venue. Anatel had three positions in the TOC, being two for incidents resolution and one for licensing.

Integrated Command and Control Center (CICC)

Olympic Games are always very intense in terms of security processes. The many public security organizations involved in Rio2016 event were coordinated from Rio de Janeiro Command and Control Center (CICC), a sort of security operations centre of Rio de Janeiro metropolitan government. Since spectrum was a critical resource, not only for the organization and transmission of the event but especially for security operations, Anatel was part of the public security task force, having a permanent position in CICC. Many efforts involving spectrum used for military operations had involvement from Anatel staff, especially in interference resolution cases, allowing for fast communication with huge spectrum users such as Navy, Army and Air Force.

4 Spectrum temporary licensing

In order to protect regular authorized systems and help coordination necessary to achieve the goals of the Rio 2016 Spectrum Management Plan, all devices using radiofrequencies, such as wireless cameras and microphones, walkie-talkies, access points, Satellite News Gathering stations (SNGs), among others, even if they are regularly exempt form licensing (short range devices), needed to be authorized in advance for them to be used in Games venues.

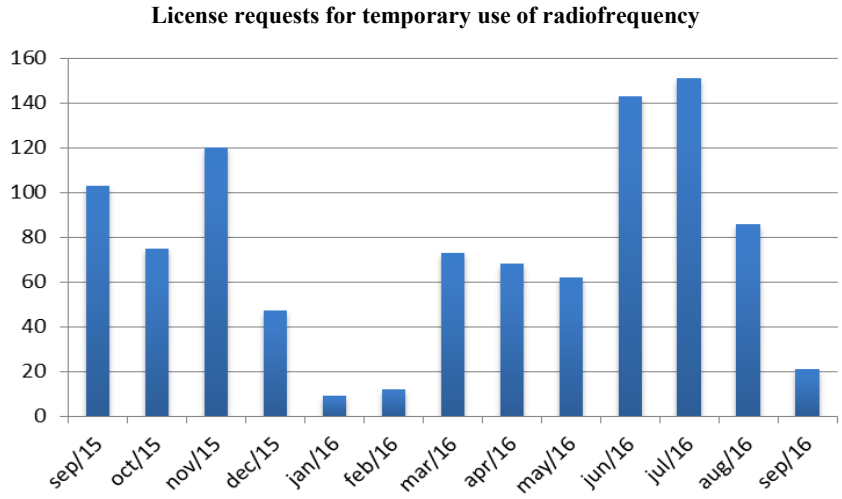
Only personal devices were excluded, such as mobile phones, key chains, devices using Bluetooth technology, tablets, notebooks, wireless keyboards and wireless mice. Entry into Games venues was only permitted for properly authorized and tagged equipment.

Authorizations for the temporary use of spectrum by members of the Olympic and Paralympic Family were issued by Anatel on behalf of Rio 2016.

For Olympic and Paralympic Games, Anatel issued 970 temporary licenses which included more than 35,000 frequencies to be used by 90,000 radiocommunication stations.

One interesting comparison in terms of events dimensions, for World Cup 2014, Anatel issued 319 temporary licenses which included 7,146 frequencies to be used by 19,110 radiocommunication stations.

The graph below shows figures of license requests for Rio 2016 by each month. In a recurrent behaviour from World Cup 2014 and other major events, there was a high concentration of license requests between June and August of 2016, close to and during the event. Thus, it was very important to have licensing staff as part of TOC's team and available to issue licenses during the event in order to deal with doubts or late requests.



5 Testing and Tagging of RF equipment (T&T)

This preventive process successfully implemented in previous events, including FIFA World Cup 2014, was also applied, in a major scale, in Rio 2016.

As in previous events, T&T of radiocommunication equipment in Rio 2016 consisted in conducting previous technical measurements, license verification and labelling of those RF transmitter equipment that would operate in the venues.

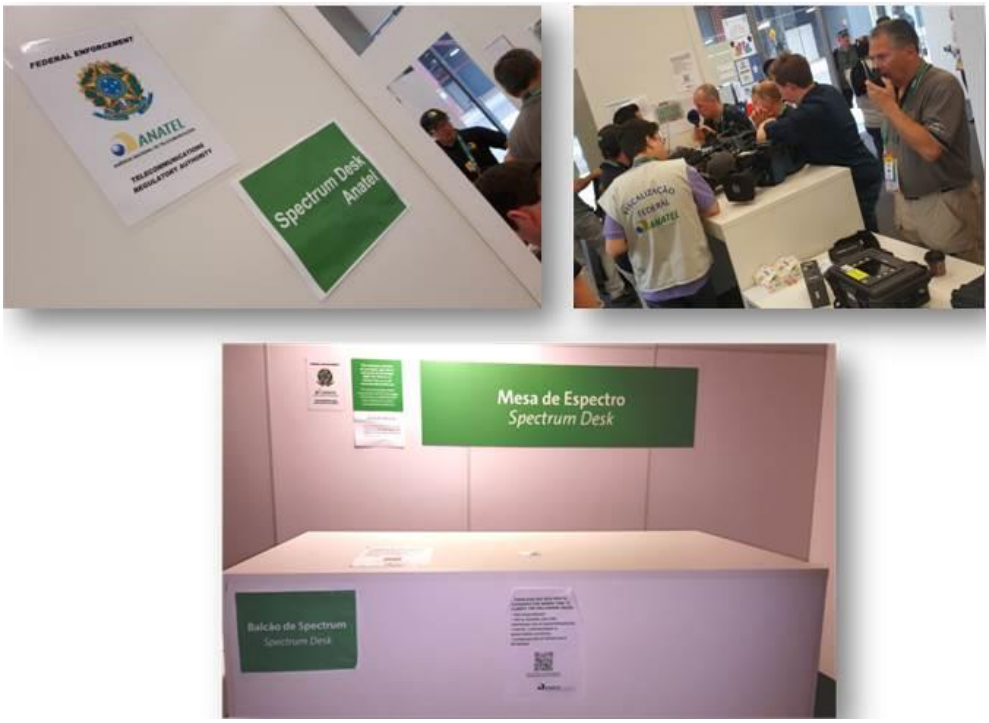
As it is done before the operation, it can detect non conformities and allow the adoption of corrective measures before the interference occurs. At each Cluster and mainly at the International Broadcast

Center (IBC), Anatel had offices where T&T and other spectrum management activities were conducted.

Considering the previous major events in Brazil, the pasts Olympics and the number of equipment expected to be used, Rio 2016 Committee and some major broadcasters had their equipment tagged prior to the opening of the Spectrum Desks in the venues. Anatel's team went to their warehouses to perform the tests, being able to test large amounts of equipment and facilitating logistics to these players. Almost 16,000 pieces of equipment were tagged this way.

The Spectrum Desks in the venues were opened on July 22nd, two weeks before the opening ceremony. There were Desks in seven competition venues, four in non-competition venues and one in each football stadium. It was important to have one Spectrum Desk in a venue (the Uniform and Accreditation Centre) which didn't require accreditation. It was attended mainly by users who didn't have accreditation to other venues with Spectrum Desk and it was the third Desk which tagged more equipment, behind IBC and Main Press Center (MPC).

Anatel Spectrum Desks in the International Broadcast Center (IBC) and Main Press Center (MPC)



A total of 29,600[2] equipment were tagged for Olympic and Paralympic games, the great majority, as expected, in the week prior to the opening ceremony and in the first days of the Olympic Games. There was low demand the week before and during Paralympic Games because the authorizations were given to the whole period, so almost all equipment used in Paralympics were already tagged.

The following steps are parts of the T&T procedure:

- Equipment users take all RF equipment expected to operate inside the venues, along with their authorization for temporary use of spectrum, to one of the Spectrum Desks.

[2] The number of equipment tagged does not match the licensed number because: 1. Users did not take all the licensed equipment to Rio (low incentives to efficient use); 2. Some licensed equipment were not used inside venues.

- Anatel staff verifies if the frequency, bandwidth and other technical parameters are in accordance with the license.
  - If the equipment is approved, it receives a label corresponding to the cluster or group of venues where it would operate. For those equipment authorized to be used in all venues, a white label ("ALL") was used.
  - If the equipment is not set in according to the license, it receives a red "DO NOT USE" label.

The red label was used in 450 equipment. The users of these equipment could apply for a license or reconfigure them (depending of the reason for disproval) in order to obtain the needed entrance label.

Examples of tags, tagged RF equipment and mobile radios tagged with "Do not use" red tags

Managing the tests and tags was only possible because of the use of a software, developed by Anatel specifically to assist during the games. The application allowed for quick search for licenses by number, user, frequency or venue, and register contact and equipment information and details of the use of equipment and label. It also had a special form to register satellite earth stations and could be filled using mobile phone browsers.

6 Spectrum monitoring (Terrestrial and Satellite)

Previous monitoring

Different spectrum monitoring activities were performed for preventive purposes. Previous spectrum monitoring operations took place several months before Rio 2016, in many Venues.

The reports of spectrum monitoring (ex: Spectrum occupancy) helped getting a wider picture about the situation of several relevant frequency bands that would be heavily used in the event. Information was used either for licensing purposes and further Anatel enforcement actions, such as geolocation of non-authorized users nearby the Olympic venues that could affect the event months later.

Spectrum monitoring centralized teams (terrestrial and satellite) – Games time

Anatel created a centralized spectrum remote monitoring centre in its branch unit at Rio de Janeiro Office, which was in charge of providing support to field spectrum incident resolution, testing & tagging and TOC teams. Two spectrum monitoring teams were allocated at the centre, one for terrestrial spectrum and another for satellite spectrum monitoring. From the room, both teams were

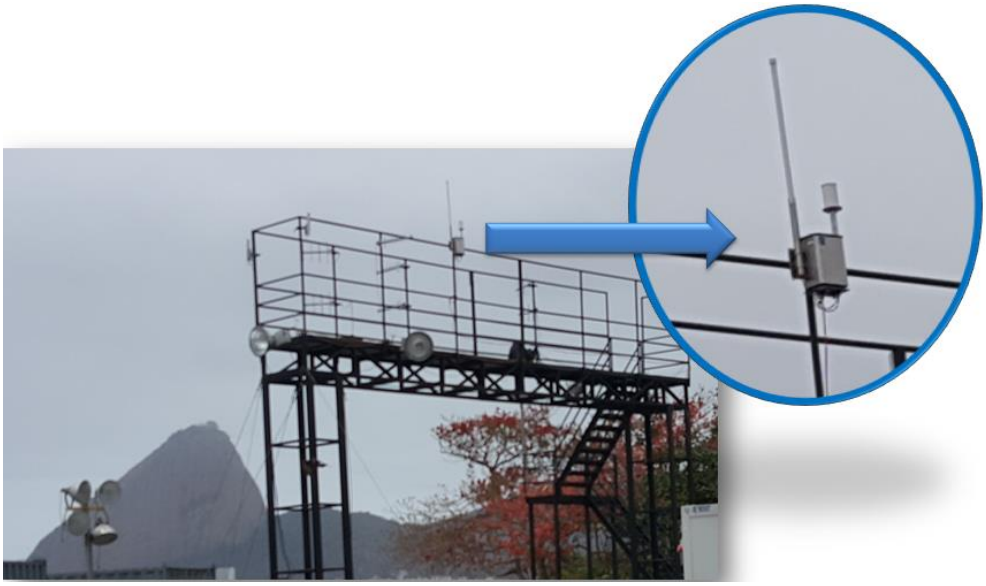
able to remotely access Anatel´s spectrum monitoring network, including satellite radiomonitoring station and all the 34 spectrum monitoring sensors in Rio de Janeiro city.

As an example, during an interference incident resolution activity inside one Olympic Venue, the TOC team and spectrum incident field teams could be informed, in real time, by the centralized spectrum monitoring room, about the status, characteristics of the interference and possible locations of the source. The centralized monitoring network was a very positive asset for Anatel operations during the event.

Terrestrial spectrum monitoring network

In order to provide better spectrum monitoring services and fast response during interference resolutions in all Venues, it was deployed a network of several RF sensors with remote access in the Rio de Janeiro metropolitan area. The sensors provided functions for spectrum analysis and geolocation of RF sources. The system is able to monitor spectrum from VHF/UHF/SHF bands, and was able to perform geolocation using TDOA.

Anatel's RF sensor at Marina da Gloria (Olympic Sailing)



The RF sensors metropolitan network topology was implemented according to the map bellow using 34 RF sensors. The idea was to cover all Rio2016 venues and surroundings, in a way to facilitate TDOA triangulation, for better geolocation processing results of RF sources.

RF sensors metropolitan network and competition Clusters in Rio de Janeiro city

Anatel RF sensors at Barra Olympic Park venues (green)

One of the greatest challenges was the deployment in time for the games. The installation of the sensors depended on the clearance of competition venues structure, and the previous delivery of space, power and connectivity.

Local Spectrum Monitoring (Venue Technology Office)

At many venues, Anatel allocated a dedicated interference resolution team. The Rio2016 Organizing Committee provided Anatel some positions in technology offices distributed in all Clusters, where further portable spectrum analysis equipment were also available for ready response in case of spectrum incidents. Monitoring activities as a support for interference resolution were also done in a Venue level. In case some spectrum incident occurred in a venue, Anatel could provide local (and fast) response.

Satellite Radiomonitoring (MSAT)

Anatel performed continuous satellite radiomonitoring activities in C and Ku bands of geostationary satellites during the whole period of the event. Anatel´s satellite radiomonitoring earth station (EMSAT) was used to monitor the downlink spectrum of satellites, and perform earth station geolocation operations during the event, including interfering or potentially irregular earth stations.

A set of satellite “Olympic carriers” was defined as the main target of MSAT operations. The carriers’ database was composed by RF signals that were able to be monitored with EMSAT, including those assigned in a temporary basis by Anatel Rio2016 spectrum licensing process, and those informed by satellite operators as being related to the transmission, organization and security of the event.

Anatel Satellite Radiomonitoring Facility (EMSAT)

Satellite radiomonitoring was mainly focused in satellite transponders with carriers used for live feeds transmitted from the competition *Venues* (e.g. SNGs) to receptions at the Satellite Farm in IBC (Olympic Park), and also satellite distribution carriers from IBC uplinks. By making continuous monitoring of satellite downlink, Anatel was able to analyse a bigger picture, having complementary information from different sources about the scenario and spectrum conditions.

The coordinated actions with TOC, T&T, CICC, spectrum incident field teams, and also the terrestrial monitoring team that could remotely access RF sensors to monitor terrestrial C-Band emissions at Satellite Farm, allowed Anatel to provide much faster response to spectrum incident tickets that occurred involving satellite networks during the event.

IMT – Mobile networks coverage (drive test)

In order to evaluate mobile network performance in main competition Venues and further main sites, Anatel conducted drive (and walk) tests, with mobile network benchmarking platforms. The goal was to identify any non-conformity to the regulatory requirements, and to act proactively with mobile operators in order to mitigate possible network coverage gaps.

7 Spectrum incidents resolution

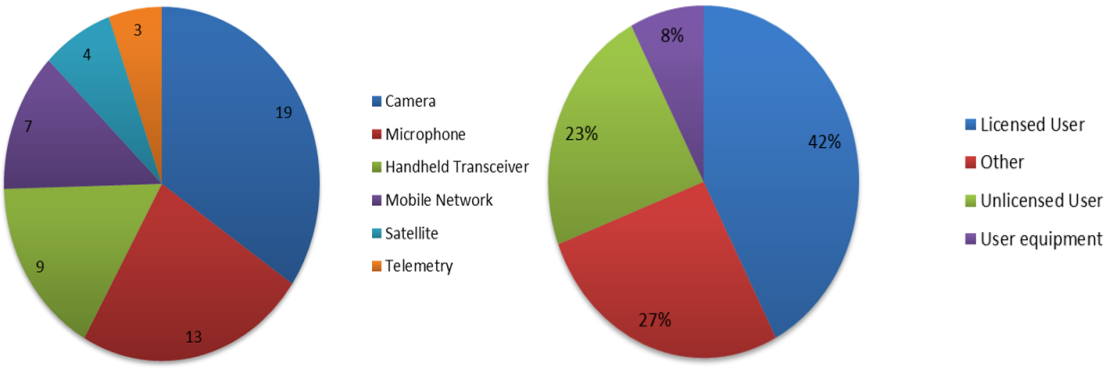
One of the operational processes defined in spectrum management plan for Rio2016 was the spectrum incident resolution. After receiving an interference complaint through a Rio2016 spectrum incident ticket, Anatel team in Rio2016 TOC was responsible to coordinate actions for its resolution, according to SLA previously defined in the Spectrum Control Plan.

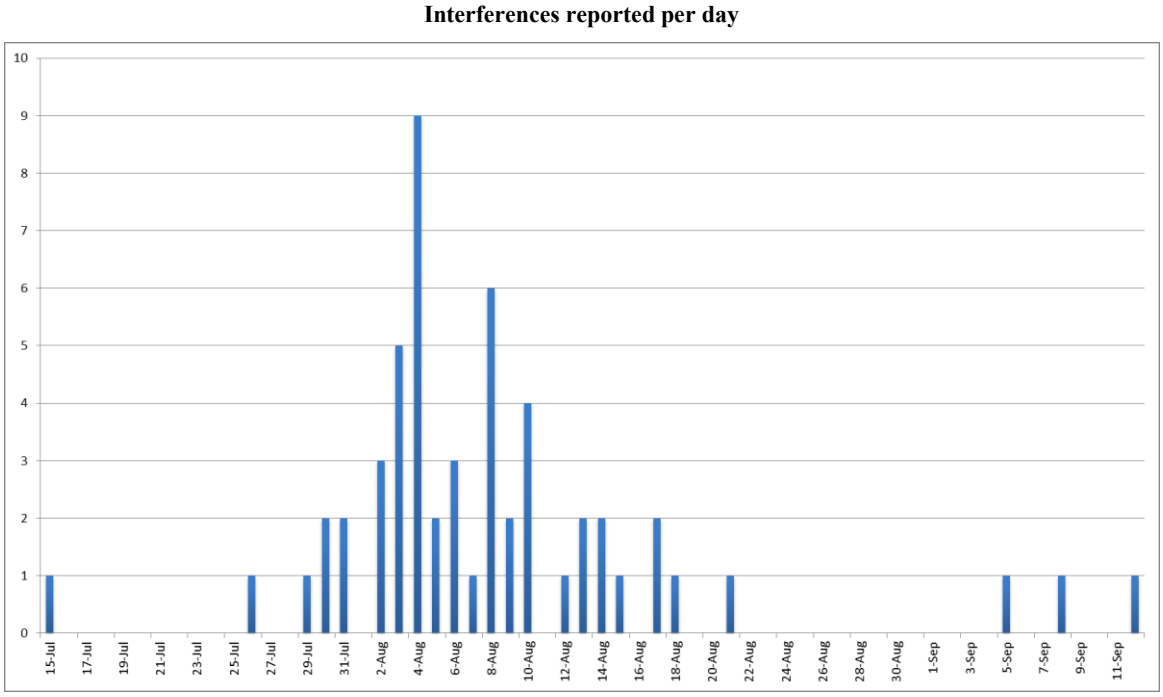
Depending on the characteristics of the radiocommunication service affected, terrestrial or satellite, and depending on the Venue where the interfered station was located, tickets were immediately directed to the appropriate field team and also to the centralized spectrum monitoring team.

During Rio 2016, a total of 55 interferences were reported or identified, only three during the Paralympic Games. Out of these, 26 were confirmed as interference and were solved by direct action of Anatel enforcement agents. Only three of them involved telemetry systems and in one case (women's aquatic marathon) it led to loss of partial time information of athletes, though not affecting the final results. The interference was solved for the related competitions that took place the following days (men's aquatic marathon and triathlon). Additionally, four cases involved satellite frequencies or earth stations.

The Ceremonies were a major concern because of the heavy and concentrated use of the spectrum. Fortunately, and thanks to hard work from licensing and monitoring teams, there were no tickets opened during these events.

Interferences by equipment type and cause of confirmed interferences





It can be seen that interferences report occurred manly in the days prior and after the opening ceremony, because that's when users are arriving to the venues and testing their equipment. Just as a comparison, the World Cup 2014 had 62 interferences in sixty four games.

8 Lessons learnt and conclusion

Spectrum management in major events such as Olympic and Paralympic Games is extremely challenging and requires a very specific and flexible approach from the national telecom regulator. At the same time, each day it gets more attention from several stakeholders, as a crucial resource for major international events. The increasing number of frequency assignments verified from previous events indicates this trend.

Anatel advanced planning framework for several events running from 2011 to 2016 in Brazil was a key element for the success, contributing in a relevant manner to the success of Rio 2016 Olympic and Paralympic Games and further international events occurred in Brazil.

Some important lessons:

– Planning
  – Allocating dedicated budget for spectrum management in order to make possible the purchase of spectrum management software, monitoring equipment, and the procurement of further services, was fundamental for the success of spectrum management operations in Rio 2016, executed by Anatel.
  – Establishing spectrum management and control plans in advance, involving both Anatel and Rio 2016 Organizing Committee, allowed clear definition of roles, and good planning and execution in time for the event.
  – It is important, to allow flexible and agile solutions, to work closely with the events organizing committee and main spectrum stakeholders and to establish a joint working group with regular meetings.
  – It is important to keep disclosure of information by Anatel own communication channels as well, not only depending on the events organization internal mailing communications. Active promotion of new information posted on the site is also required to attract

readership. That was done directly to specialized media sites every time a new rule was issued or updated regarding major events. If there are other governmental bodies that may help to spread information or that are directly affected by the regulator's actions, it is important to establish communication with those actors. In Brazil's case, Anatel's role was published on the Federal Government Official Site for Rio 2016 Games and important updates were shared with their team. The specific cases of diplomatic missions and international bodies, dealt by the Foreign Office (Brazilian Ministry of External Relations), required that basic guidelines were published on Anatel´s website.

– Spectrum Management
  – Frequency management was very difficult due to low incentives to efficient use of licensed spectrum, since it was made available free of charge. A large number of frequencies requested were not used, something made clear by the difference in the number of requested licenses and tagged equipment. A different approaches should be studied in order to promote better spectrum allocation for such event.
– Test and Tagging (T&T) of RF equipment
  – T&T is an excellent preventive process for events. Previous T&T, including satellite earth stations, is extremely important to have a previous contact with stakeholders and prevent operational failures (e.g. misconfigurations) and non-conformities, reducing the number of radiointerferences and impacts in games time.
  – Developing an online system for managing the testing and tagging process was very positive. Because of the high number of RF equipment in use, and the need to constantly check equipment according to authorization acts.
  – Providing solid information and training of security teams in order to better control the entrance and usage of only tested and tagged RF equipment could be improved.
  – T&T had to be used to complement data from satellite earth stations which were not acquired through licensing process (e.g. polarization). These data were necessary for radiomonitoring purposes. The best approach should be increasing the data fields from licensing, removing this additional task to test and tagging.
  – A relevant feature that could not be implemented in time, but might have helped reducing T&T demand bottlenecks, was a T&T agenda, allowing spectrum users to be able to schedule according to a T&T time plan.
– Human Resources (HR)
  – To have staff present at each Cluster and several competition or non-competition venues, including Technology Operations Center, Spectrum Monitoring Center and Command and Control Integrated Centers. A very spread operation with continuous communication allowed a better coordination of actions and more complete information collection to build solutions to many problems happened, such as interference incidents.
  – The HR timesheet control is something critical considering the size of the staff involved with the operation. It is important to have dedicated team to provide guidance and control of working hours in order to prevent costs with overtime;
  – Accreditation for allowing technical staff to access events services area and competition venues is fundamental for test and tagging and interference resolution. Due to a complex accreditation procedure, it is important to assure that the team is assigned with correct and enough access as necessary for doings its job.
– Monitoring & Incident Management
  – Reliable IP network infrastructure and continuous supervision of remote connectivity to RF sensors is critical. In case RF interference happens, there is no time to troubleshoot

connectivity problems to the sensors because geolocation must be performed as soon as possible. In case of the Olympics, with an RF sensor network with many elements (34 sensors), there must be ways to keep constant verifications to RF sensors connectivity;

– The ticket system should be available to Anatel staff in the venues. It would facilitate the communication of detailed information on the tickets by the interference solution personnel. If the demand was higher, communication between TOC and field teams could have been a constraint.

– Test events are important opportunities for allowing staff to get used to the event infrastructure, process, logistics, and also serves as an opportunity to install and test equipment in the places that will be used during the games time.

Annex 3

Spectrum management and spectrum monitoring during the 2005APEC Summit meeting I 2010 G20 Seoul Summit in the Republic of Korea

1 Introduction

Major events such as Olympics, summit meeting and world cup games are in the focus of the public interest and also take too much time to prepare. During the event a lot of radio applications and equipment are used within the arena and therefore there is great potential of radio interference or noise. The applications range from broadcasting and communication, police, wireless microphone, and so on. Therefore systematic spectrum planning, licensing, spectrum monitoring, inspecting and eliminating interference are very important to host the event successfully.

The purpose of this report is to provide information to administrations by sharing the general experience of the KCC (Korean Communication Commission) in some cases of activities especially in the field of licensing, spectrum monitoring and interference eliminating.

2 Overview of activities during the major event

2.1 General tasks of preparatory group to host the major event

The preparatory group usually carries out the following tasks to make the major event successfully. First, the group establishes an annual plan with investigating domestic and international events, and has a close relation with relevant organizations by contacting regularly. Just before the event, it is very important to measure radio environment around the arena and eliminate interference resource. During the event, the group monitors authorized frequency band for the purpose of security, police, broadcasting and so on. After the event, the group discusses the result and finds a solution of the problem.

2.2 Before the event

The preparatory group performs radio environment measurement and spectrum monitoring around the arena to prevent radio interference before the event is started.

When radio interference or unwanted signal is detected, the group eliminates it promptly on-site. Especially in case that the signal is not reached to spectrum monitoring vehicle, the group moves to the location and investigates the cause.

Also, spectrum monitoring is more strengthened at the fixed site for searching violations of radio regulation and illegal radio stations. It focuses on certain frequency band which is used in the arena. If an illegal radio signal is captured then the group notifies to CS team.

CS (Customer Satisfaction) team

CS team, which belongs to KCC, consists of some staffs and monitoring vehicle.

When users cannot operate their radio stations normally because of interference or electromagnetic wave, CS team deals with these inconveniences in ten days and protects radio environment.

CS team can usually carry out two main tasks. One is “notifying arrival time of customer” and the other is “One-stop radio service”. “Notifying arrival time” is a service to inform the customer when CS team actually goes on-site to solve the problem. “One-stop radio service” is a complaint handling. Once the staffs receive a complaint from a customer by the phone or the internet, CS team removes the interference resource and then notifies the result to the customer.

2.3 During the event

Once the event is started, CS team (They are members of preparatory group.) performs spectrum monitoring and direction finding with monitoring vehicle.

The team is made up of four staff who operate a monitoring vehicle. The team also has portable equipment to investigate radio interference and eliminate it.

Also, the team carries out spectrum monitoring. It is to find out violations and radio interferences in monitoring vehicle with radio quality measurement system and monitoring equipment. This measurement system automatically scans and searches authorized frequency band.

2.4 After the event

After the event, the preparatory group reports the results of their activities to KCC. Considering this report, relevant officials establish a solution and take improvement of measures if it is necessary.

3 Cases of spectrum management and radio monitoring during the major event

3.1 2005APEC summit meeting

3.1.1 Overview

KCC temporarily configured the preparatory group to support for the operation of wire and wireless networks and good communication services during the APEC summit. The group performed activities of radio monitoring and interference eliminating by ten operators who were deployed daily around the meeting area during the event.

3.1.2 Spectrum management

The group received spectrum application from APEC preparatory Office in advance and licensed radio stations for broadcasting company and VIP guard considering the frequency, power and the using places.

Only radio stations for emergency communications and small equipment (wireless microphones, intercoms and walkie-talkies) were licensed on site during the event. All other applications were licensed prior to the event.

3.1.3 Spectrum monitoring

The CS team performed spectrum monitoring to find out violation against the radio regulation and legal frequency use. Fixed monitoring stations were used for monitoring the authorized radio frequency around meeting areas. In case of spectrum monitoring in a blind spot or the interference eliminating immediately, the monitoring vehicle was deployed around the meeting area for 24-hour.

3.1.4 Cases of violations and actions

In case of violations, there are two possible ways of actions:

– Certain delegation's frequency was overlapped with police communication and they asked the delegation to stop using the frequency band.

– Some wireless equipment malfunctioned because of radio interference by telecom company's wireless network device. So the network device was replaced with wire network device.

3.2 Satellite radio monitoring during the 2010 G20 Seoul Summit

3.2.1 Overview

During international events such as G20 Seoul Summit, international communication demands, especially satellite communications, may increase significantly. Therefore it is necessary to support stable satellite communication during the event. In this context, Korean Satellite Radio Monitoring Center (SRMC) performs several activities for protecting satellite network. The SRMC, which has responsibilities on protecting Korean satellites networks from interferences of earth and space stations, monitors satellite signals into the Korean peninsula by using fixed and mobile equipment during the G20 Summit.

3.2.2 Satellite radio monitoring

Especially intensive monitoring on the four Korean geostationary satellites (KOREASAT-3, KOREASAT-5, HANBYUL, CHEOLIAN) were held before and after the event, from 8 to 12 November. Two operators were deployed at the operating room of the SRMC and other two men operate the monitoring vehicle.

Considerations for monitoring

– The intensive monitoring should be performed in consecutive order on each satellite, bands for broadcasting and communication have priority.

– The interference handling has a higher priority than others during the G20 Summit.

– Mobile satellite radio monitoring vehicles should be deployed around at the venue.

– The monitoring report should be separately recorded and managed.

Measurement parameters

– Orbital position, polarization and mean frequency.

– The maximum equivalent isotropically radiated power (e.i.r.p.) of a station in the fixed or mobile shall not exceed +55 dBW (see No. 21.3 of the Radio Regulations).

– +47 dBW in any direction within 0.5 of the geostationary satellite orbit shall not exceed (see No. 21.4 of the Radio Regulations).

– Occupied bandwidth, power flux-density (pfd) and e.i.r.p.

Unusual result was not found during the event.

4 Conclusion

During major events, broadcasting and communication demands may increase significantly. Therefore, it is essential to support seamless communication for hosting the event successfully. To make this possible frequency planning, authorizing, monitoring, dealing with the interference and establishing a cooperative relation with all relevant parties are very important.

This Report regarding some cases may be helpful to administrations.

Annex 4

Spectrum management and spectrum monitoring during the FIFA Soccer World Cup 2006 in Germany

1 Introduction

In accordance with the provisions of the German government, the president of the German Bundesnetzagentur (BnetzA, Federal Network Agency), the responsible authority for frequency management and monitoring issues, set highest priority for the support of the FIFA world soccer championship 2006 that took place from 9 June to 9 July 2006 in Germany.

Although the spectrum was already heavily occupied around the 12 venues, frequencies had to be assigned for broadcasters, security staff, the organizer and others at public-viewing locations, training locations, hotels of the teams, etc., in several towns.

The main tasks of the Federal Network Agency were:

– to provide sufficient frequencies for the additional frequency users during the event;
– to ensure for an interference-free usability of the security relevant frequencies (police, fire brigade, ambulance, aeronautical service and military); and
– to solve interference problems with other radio services rapidly.

2 Organisation and cooperation

On July 6, 2000: FIFA decided that the event will take place in Germany. A first contact between the Federal Network Agency and the organisation committee was established. The contacts reoccurred from 2002 until the games on a regular basis. Regarding frequency management there was a close contact to the host broadcaster which was a foreign company. At an early stage the Federal Network Agency set up a task group comprising of staff from all departments of the Agency involved.

3 Distribution of information

Early information of the radio users is essential for an interference-free operation. The Federal Network Agency’s homepage was supplemented accordingly in order to answer the following questions:

– What are the conditions for the use of frequencies?

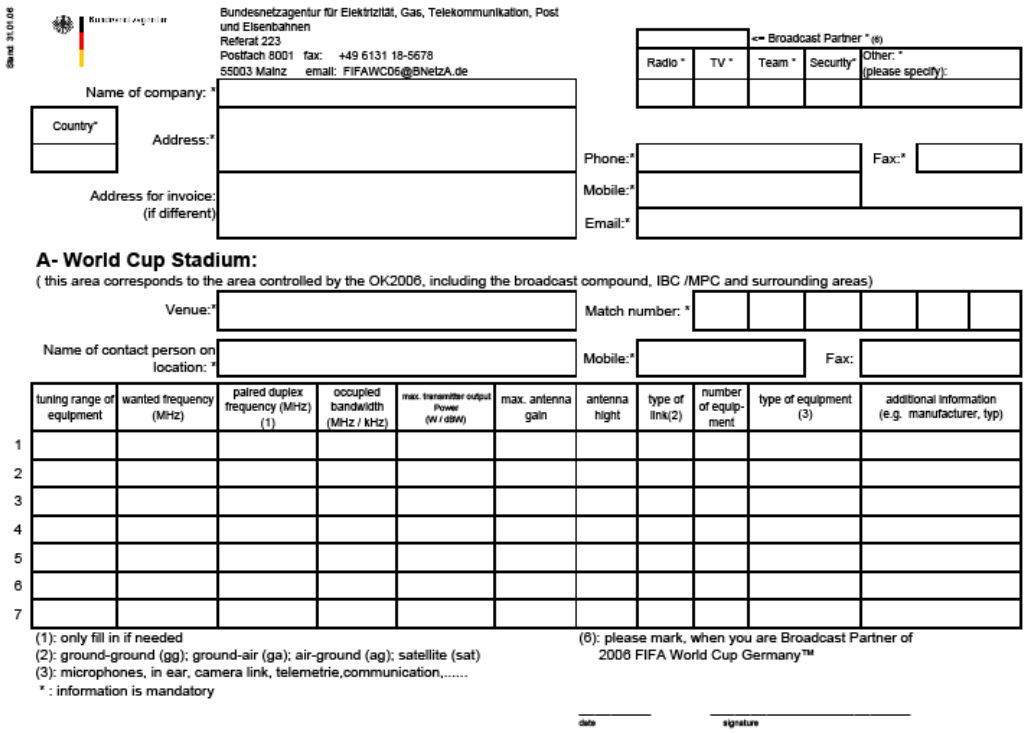
– Who can be asked?
– Who provides licenses?
– What has to be noted?

The information on the homepage contained

– the general description of the relevant procedures including terms (time limits) and contact points;
– the red list of frequencies which cannot be used;
– the green list of generally licensed frequencies; and
– special application forms ensuring the provision of all relevant information.

FIGURE A4.1

Special application form on the occasion of the FIFA Soccer World Cup 2006



Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen
Referat 223
Postfach 8001 fax: +49 6131 18-5678
55003 Mainz email: FIFAWC06@BNetzA.de

Stand: 31.01.06

<= Broadcast Partner * (6)

Radio *	TV *	Team *	Security*	Other: * (please specify):

Name of company: *

Country*

Address:*

Address for invoice: (if different)

Phone:*

Mobile:*

Fax:*

Email:*

A- World Cup Stadium:

(this area corresponds to the area controlled by the OK2006, including the broadcast compound, IBC /MPC and surrounding areas)

Venue:*

Match number: *

Name of contact person on location: *

Mobile:*

Fax:

	tuning range of equipment	wanted frequency (MHz)	paired duplex frequency (MHz) (1)	occupied bandwidth (MHz / kHz)	max. transmitter output Power (W / dBW)	max. antenna gain	antenna hight	type of link(2)	number of equip-ment	type of equipment (3)	additional information (e.g. manufacturer, typ)
1											
2											
3											
4											
5											
6											
7											

(1): only fill in if needed
(2): ground-ground (gg); ground-air (ga); air-ground (ag); satellite (sat)
(3): microphones, in ear, camera link, telemetrie,communication,.....
* : information is mandatory

(6): please mark, when you are Broadcast Partner of 2006 FIFA World Cup Germany™

date

signature

FIGURE A4.2

Green list and red list of frequencies

Bundesnetzagentur

2006 FIFA World Cup Germany

(Green List; date: 31/01/2006)

Frequency usage is possible without any separate frequency assignment for the following frequencies / in the following frequency bands if the given parameters are not exceeded:

MHz	MHz	Channel bandwidth (kHz)	Power (mW ERP)	Radio application	
32,47500 -	32,62500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
32,77500 -	32,92500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
33,87500 -	34,02500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
34,17500 -	34,32500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
34,47500 -	34,62500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
34,77500 -	34,92500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
35,07500 -	35,22500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
35,37500 -	35,52500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
35,67500 -	35,82500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
35,91500 -	35,99500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
36,62000 -	36,78000	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
36,87500 -	37,18000	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
37,67500 -	38,12500	50	10	Wireless microphones	Official Gazette 07/04 Order No 08
40,66000 -	40,70000		10	Wireless microphones	Official Gazette 25/03 Order No 71
433,05000 -	434,79000		10	Low power equipment in the ISM frequency bands	Official Gazette 25/03 Order No 71

Bundesnetzagentur

2006 FIFA World Cup Germany

(Red List, date: 04/10/2005)

Frequency assignments are **not possible** in the following frequency bands:

(MHz)	(MHz)	(MHz)	(MHz)
84,55 -	144,00	467,40 -	468,30
146,37 -	146,95	876,00 -	880,00
156,80 -	157,45	890,00 -	915,00
165,00 -	165,70	921,00 -	925,00
166,45 -	167,20	935,00 -	960,00
167,56 -	169,38	960,00 -	1260,00
169,80 -	170,30	1340,00 -	1350,00
171,00 -	171,80	1452,00 -	1480,00
172,15 -	174,00	1725,10 -	1780,50
223,00 -	395,00	1820,00 -	1875,50
419,72 -	419,80	1900,00 -	1980,00
429,72 -	429,80	2019,70 -	2024,70
443,59 -	445,00	2110,00 -	2170,00
448,60 -	450,00	2351,00 -	2381,00
457,40 -	458,30	2655,00 -	2900,00

In all other frequency bands case-by-case examinations are required.
(Exception: general assignments; please see frq-list-BNetzA-green.pdf)

The host broadcaster organized World Broadcaster Meetings in December 2005 and April 2006. The network agency used these meetings to explain the 600 delegates the procedures. Many questions could be answered and problems were picked up at an early stage.

4 Confederations Cup 2005

The Confederations Cup 2005 provided an important test scenario for the FIFA Soccer World Cup 2006. In June 2005 the following issues could be tested in 5 stadiums:

– English knowledge of the staff;

– Data exchange between the BnetzA's central project team in Mainz and the stadiums via remote access service (RAS);

– Cooperation between the central project team and the local teams;

– Technical equipment;

– Accreditation;

– Service schedule;

– Cooperation with the police;

– Clothing (spectrum management and monitoring).

5 Project team and local teams

For the overall coordination a central project team of up to 8 staff members was installed in the head office of the BnetzA in Mainz.

Local teams consisting of frequency managers and radio monitoring staff equipped with vehicles and handheld devices were set up in all 12 venues. They were in charge of the stadium, public viewing sites, team hotels, training areas, etc.

An additional team was responsible for the International Media Centre (IMC or IBC) in Munich, hosting offices and studios of more than 70 broadcasters.

Training courses were organized for the teams to refresh their English knowledge. As described in § 2, the project team and the local teams could test their operational readiness at the FIFA Confederations Cup 2005. This resulted in a repeated modification of the procedures and in the solution of remaining problems.

6 Licensing

There are differences between the frequency utilisation at the 12 stadiums and at other places like hotels and public viewing locations. The latter show lower frequency occupation but for longer periods of time compared to the other locations.

The frequency usage at the stadiums is concentrated from a few hours before the game and 2 hours after the game. Only the host broadcaster and a few other broadcasters are allowed to produce TV pictures from the stadiums. There was an increased frequency usage at the end of the contest.

All requests for frequencies had to be sent to the project office which had a special fax number and email address. The requests were checked for completeness and plausibility. Ambiguities were discussed with the applicant. The requests were recorded in a central data base and made available for the 12 local teams.

The requests were further processed by the local teams. They checked the availability of the frequencies, looked for alternatives if there were problems, assigned the frequency, produced the relevant documents including the assessment of fee and sent them to the applicants.

The teams made the following experience:

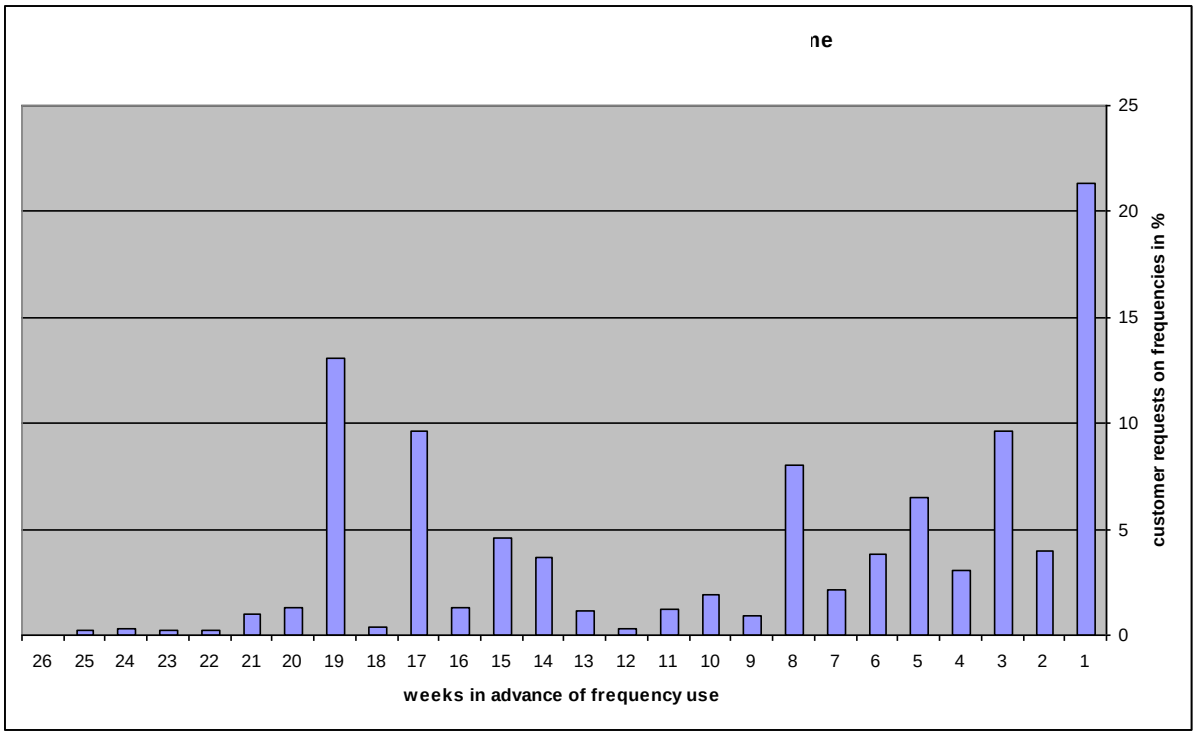
– The majority of requests for frequency assignments could be handled in due time before the event.
– In case of substitute radio equipment there was sometimes the need to assign new frequencies. This resulted in substantially increasing workload immediately before the event at the time of testing and initial operation of the radio equipment.
– A few frequency users only had not at all applied for a license.
– This was due to the good preparation and information by the Federal Network Agency, the OK 2006 and the 2 World Broadcaster Meetings.

Also the use of generally licensed (or license free) equipment needed sometimes careful attention. Several remote controlled cameras using ISM frequencies or other frequencies designated for SRDs were operated by different photo reporters. This resulted in complaints about the unintentional release of cameras. Troubleshooting was done by the host broadcaster who assigned the radio channels to the photo reporters during their morning briefing.

For the World-Cup in 2006 the German administration received over 10 000 requests of frequency assignment. Figure A4.3 shows the chronological distribution of incoming requests for frequency assignment for a single event, e.g. one of the games of the World Cup 2006.

FIGURE A4.3

Number of requests for over time



The Figure shows a time line in weeks at the horizontal axis. At the vertical axis the frequency requests in % can be seen. The intersection point at the bottom right corner marks the date of the event.

One of the most important facts that can be analysed is that about 21% of all requests occur only one week prior an event (e.g. a single game of the World Cup 2006). Even 4% of the requests occur on the day of the event itself (this actually cannot be seen, due to the grouping of this statistical elaboration). For example staff of broadcasting companies bring equipment like cordless microphones with them on the day of the event, contact the administration staff from face to face, that in this case has to give on-the-spot support.

The Figure shows other peaks at the weeks 17 and 19 prior to an event. Such peaks can be explained by two different facts. On the one hand the process of “How to request a frequency” is declared to the broadcasting companies at large conferences. Driven by this knowledge the requests are nearly given at the same time. On the other hand major events are often hosted by one “Host Broadcaster”. Frequency requests of this broadcaster are naturally of high numbers.

7 Staff and accreditation

The office at the International Media Centre in Munich was opened 4 weeks before the games. It was available seven days a week until 8 p.m.

An information booth of the BnetzA with a total of six staff was available two days before the first game in all stadiums.

FIGURE 4.4

Information booth of the bnetza

The stadiums and the International Broadcasting Centre (IBC) were divided in several zones. As radio waves do not respect them it is essential that the agency's staff can access as many as possible locations.

The OK 2006 issued 2-part identification badges. The first part identified the colleagues individually. The second part referred to a location. Up to seven zone badges were issued for each of the 12 stadiums and the IBC.

The zone badges were turned over from one colleague to the next according to the work schedule. Two colleagues of the project office in Mainz received an accreditation for all sites.

8 The International Media Centre (IMC or IBC)

The following pictures may give an impression of the size of the international media centre.

FIGURE A4.5

The International Media Centre






9 Spectrum monitoring tasks

The following tasks had to be carried out:

– Initial frequency survey;
– Inspection of the frequency users and their equipment in the TV-compound;
– Inspection of other frequency users in the stadiums (security staff, catering, etc.);
– Interference investigation;
– Monitoring of the spectrum, identification of unlicensed emissions.

9.1 Spectrum monitoring before the event

An initial spectrum survey (band scan and channel occupancy measurements) between 148 MHz and 3.5 GHz revealed unused frequencies which could be assigned for the event and assisted in the search of unlicensed users.

The measurements were limited to the 12 stadiums and the IBC. No measurements were carried out at training areas, hotels, etc.

– Experience shows that measurements should have been done at the fan festival in Berlin, too.

9.2 Spectrum monitoring during the event

The spectrum was permanently monitored by remote controlled stations during the championship in order to identify unauthorized emissions.

Mobile measurement equipment was available at the days of the event in the vicinity of the stadiums.

One mobile unit was permanently present at the IBC.

Handheld equipment was available in the stadium.

Occasionally monitoring vehicles were also deployed at public viewing locations, etc.

10 The fan park

Figure 4.6 shows the fan park outside the Munich stadium. Here are also a lot of possible sources of interference like large scale video displays and radio equipment.

FIGURE A4.6

The fan park

11 Interference investigation and problems

The following conclusions can be drawn from the event:

– When using so much equipment in a small area, interferences cannot be avoided completely.

– User equipment is installed and decomposed several times per year. This may result in faulty RF shielding and spurious emissions.

– The main problems were:

  • EMC problems from video screens;

  • intermodulation because of insufficient spatial decoupling;

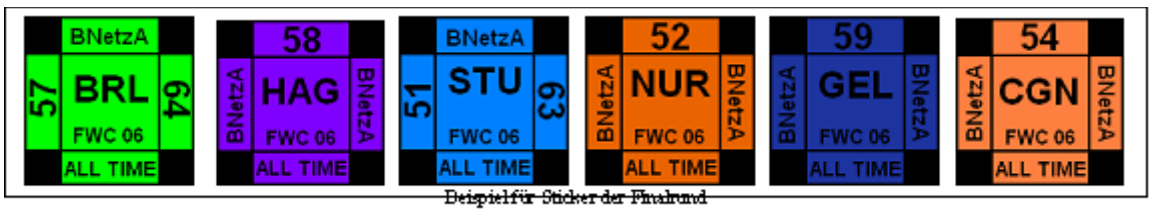
  • faulty programming of radio equipment.

12 Labelling

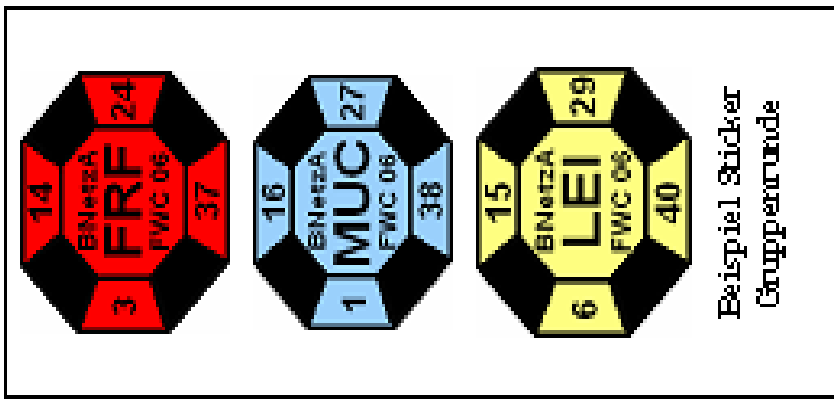
All users were informed about equipment inspection well in advance. All tested equipment was labelled. The labels were valid for up to four matches and could be devaluated for single matches. Figure A4.7 shows some examples.

FIGURE A4.7

Examples for labelling of radio equipment



Beispielfür Sticker der Finalrund



13 Some interesting figures

For the preparation of similar events it may be useful to see the following figures.

– 200 colleagues were accredited;
– Some 10000 frequencies requested;
– 6 500 thereof designated for the use at the 12 stadiums;
– 85% of the requests were accepted;
– 1 000 short term licenses for 150 applicants were issued;
– 84 interference reports before and after the games;
– 12 interference reports during the games;
– 60 cases of interference were solved;
– More than 6 000 stickers were issued.

14 Conclusion

The amount of electronic equipment in general and radio equipment in particular in a limited area provided a challenging situation for the frequency management and the radio monitoring service. Thorough planning of the event at a very early stage and participation and information of all stakeholders resulted in a successful event with a limited number of interference problems.

Annex 5

Spectrum management and spectrum monitoring during the Formula One (F1) racing at UAE

1 Introduction

The Formula-1 is one of the major international events held at UAE and organized by Abu Dhabi Motorsports Management (ADMM) at Yas Abu Dhabi. The event has been held successfully since 2009 once each year.

The event requires efficient spectrum management for allocation of more than 600 frequencies to be used at the same venue for various wireless services and applications that are required by the ADMM and Formula 1 teams. Spectrum authorizations applications were including walkie-talkie, telemetry, security, radio microphones, data units, wireless cameras, broadcasting, etc. More than 12 500 wireless apparatus was imported to the UAE exclusively for the F1 event.

2 The Telecommunications Regulatory Authority (TRA) involvement

The TRA being the sole regulatory authority to manage the radio spectrum and monitoring was on board from the planning of the event. The TRA signed a MoU with the event management committee also responsible for security aspects. As per the MoU the TRA will provide support for:

- frequency management, assignments and coordination;
- minimize interference and illegal usage;
- security and safety for communication during the event.

To meet its obligations, the TRA constituted a team from following sections/department:

- spectrum monitoring section;
- spectrum allocation section;
- broadcasting spectrum section;
- finance.

The major responsibilities included frequency assignments and monitoring for interference free spectrum. The challenge was to:

- conduct RF surveys before and during the event to find the noise floor and clean spectrum;
- assign more than 600 frequencies in VHF, UHF and SHF, for the event to be used within a small area simultaneously;
- monitor spectrum usage and detect and resolve any harmful interference within a very short response time;
- issue on site authorizations, invoices settlement and equipment authorizations;
- handling custom clearance approvals for the imported equipment.

3 Preparation activities before the event

The major activities before the event are summarized as follows:

- internal coordination within TRA departments to form a team for the event;
- establishment of team and project plan;

- identification of monitoring assets required during the event;
- analysing the frequency requirements based on discussions with the event organizers on the type of wireless equipment that will be used;
- detailed meeting with the event organizers for preparing the guidance documents to the users of the wireless equipment informing them about the procedures and requirements;
- pre-assignment site survey (spectrum occupancy measurements);
- meetings with public safety organizations to coordinate their frequency requirements;
- coordination for type approval and custom clearance of wireless equipment;
- details on establishment of site office for spectrum authorization, monitoring, spectrum fees invoicing and payments with facilities and access requirements;
- detailed spectrum planning on available frequency channels in the area after validation of monitoring results;
- site visits to identify the locations for positioning monitoring equipment.

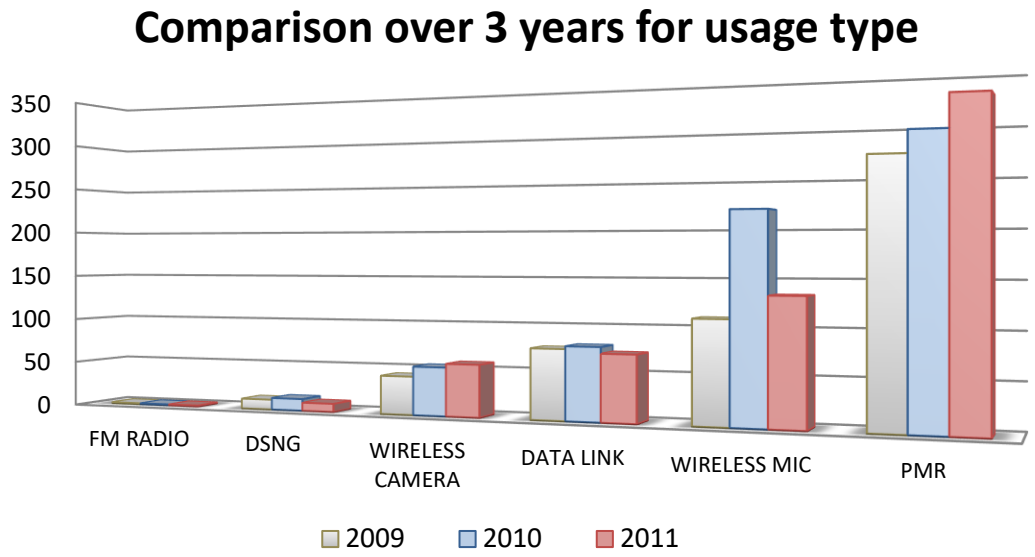
4 Spectrum authorizations and usage

Table A5.1 provides details on the number of assignments made for the different types of wireless equipment used at the 2011 event.

TABLE A5.1

Application	No. of frequency assignments
Wireless camera	57
Data link	72
Digital satellite news gathering	9
Private mobile radio	329
Wireless MIC	134
FM broadcasting station	1
TOTAL	**602**

The following Figure shows the variations in the number of assignments for different types of wireless equipment from 2009 to 2011.



5 Challenges of spectrum management

Table A5.1 shows that the major challenges in assignment were related to private mobile radio, wireless microphones and wireless cameras.

5.1 Challenges on PMR assignments

The private mobile radio assignments are manageable within a given area. It is possible to accommodate a large number of assignments by authorizing the required power levels and balancing the assignments in both VHF and UHF bands. The actual challenge is that majority of the teams participating in the Formula One circuit have pre-programmed equipment which they are using at different venues around the world. The programmed frequencies are sometimes not readily available with the team coordinators responsible for logistics arrangements and the actual requests with specific frequencies are received at a short notice. This challenge is generally greater for the first year of the event and is then decreasing subsequently as the database of previous events is available.

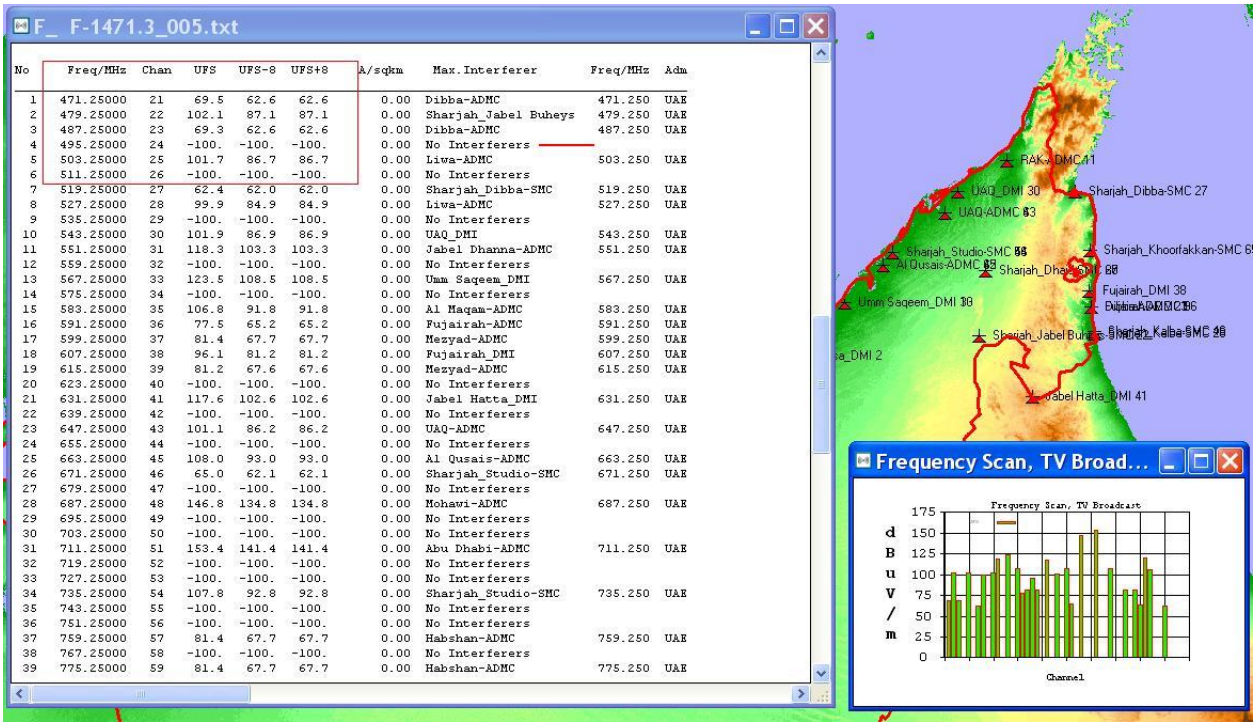
5.2 Challenges on wireless microphone assignments

The majority of wireless microphones and other PMSE equipment work in the UHF band where either the band is allocated to broadcasting (analogue or digital) and mobile. The challenge is when majority of the applications for wireless microphones are received in the 470-790 MHz range. This band is still used for analogue television. The following steps are then taken to undertake spectrum planning:

5.2.1 Spectrum planning

Computer aided techniques of spectrum planning are used to identify the available spectrum. The software provides a list of TV channels with Usable Filed Strength value for each channel arranged in ascending order (Fig. A5.1). The channels having lower usable field strength value can be used for wireless microphones.

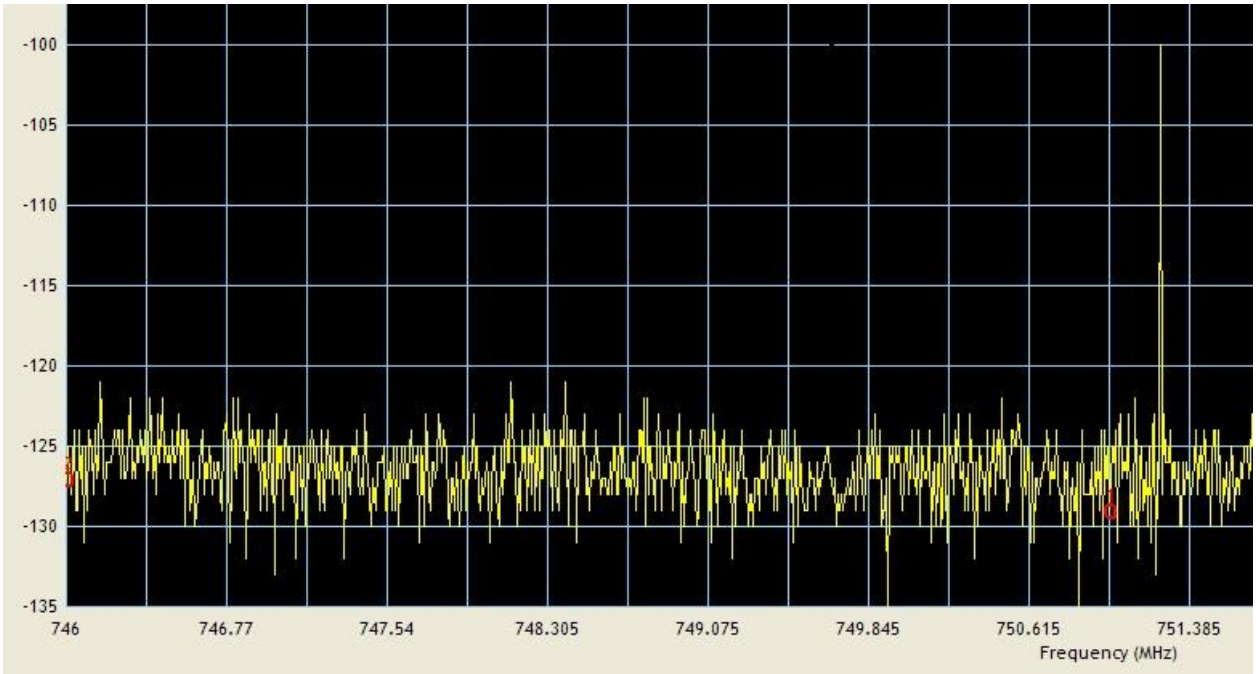
FIGURE A5.1



5.2.2 Spectrum monitoring

On site spectrum monitoring surveys are then conducted for different times of the day to ascertain exact measurements on the ground (Fig. A5.2) and to compare the prediction result with the actual situation. This helps in validating the availability of spectrum. This is required as in the Gulf region the ducting affect sometimes results in field strength values different from the predicted values.

FIGURE A5.2



5.2.3 Frequency assignment

For making assignments, the applicant provides the details of the equipment along with preferred frequencies. Most of the wireless microphones manufacturers provide frequency sheets (Fig. A5.3) containing preferred frequencies to avoid inter-modulation.

FIGURE A5.3

Channel	Bank 1	Bank 2	Bank 3
1	718,000	718,000	718,500
2	718,875	718,400	719,375
3	721,875	719,000	722,375
4	723,250	719,800	723,750
5	730,375	721,000	730,875
6	732,750	722,600	733,250
7	741,000	724,800	741,500
8	756,375	728,000	756,875
9	762,250	730,400	762,750
10	766,375	735,200	766,875
11	772,625	739,200	773,125

If this sheet is not available then the inter-modulation can be calculated using software (Fig. A5.4) before assigning frequencies to an applicant:

FIGURE A5.4

6 Challenges of spectrum monitoring

The spectrum monitoring challenges during the event are:

- short reaction time;
- availability and positioning of on-site monitoring equipment;
- detection of the source of harmful interference, especially when majority of the wireless equipment is positioned in close proximity;
- temporary installations create radiation leakage issues from connectors causing harmful interference;
- coordination with different entities and designated focal points;
- spectrum enforcement.

7 Overall lessons from spectrum management and monitoring at events

The following are the summarized lessons learnt:

- prior planning for spectrum availability, requirements and project;
- communicate and coordinate with all stakeholders;
- publish the procedures and guidelines for wireless equipment import;
- publish the spectrum authorization procedures and regulations;
- on-site support for the complete spectrum management and monitoring;
- flexibility and contingency planning for changing requirements of spectrum use;
- details on project team communication, procedures and methods.

Annex 6

Spectrum management and spectrum monitoring during the final tournament of the UEFA EURO-2012 football championship in Ukraine

1 Introduction

The European football championship, which is organized by the Union of European Football Associations (UEFA) once every four years, is one of the major international events for the football community in Europe.

According to the UEFA decision, the final tournament of the European football championship EURO-2012 took place in four cities of the Ukraine (Kyiv, Donetsk, Kharkiv and Lviv), and in four cities of Poland from 8 June till 1 July 2012.

In respect to spectrum management issues, the football championships are characterized by a substantial number of different radio equipment within a limited area – inside and outside of the stadiums area.

In order to facilitate temporary import and operation of radio equipment before, during and after EURO-2012, the National Commission for Regulation of Communication of Ukraine adopted Decision Nr. 689 of 01.12.2011 “On approval of the Procedure for issuing permissions for import

and operation of radio equipment to foreign users during EURO-2012". In accordance with this Decision:

– it covered foreign users and their equipment intended to be used for EURO-2012 purposes before, during and after the event (up to 31.08.2012 – two additional months after the closing of the championship);
– no permission was required in order to temporarily import radio equipment into the territory of the Ukraine;
– spectrum management and spectrum monitoring during the EURO-2012 had to be fulfilled by the Ukrainian State Centre of Radio Frequencies (UCRF);
– the deadline for applications was set to 15 April 2012 (less than 2 months before the event).

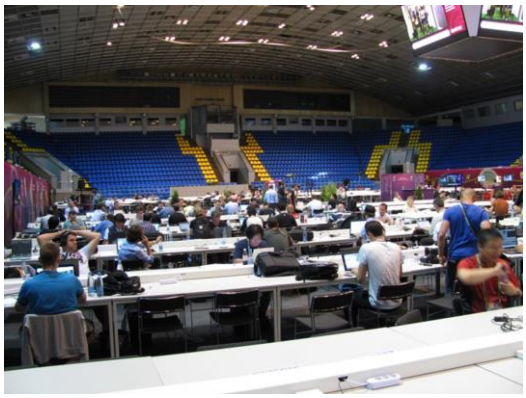
2 Specific tasks at a stage of long-term preparation to EURO-2012

The UCRF started its preparation for EURO-2012 at the end of 2009. During the preparatory period the following tasks were undertaken:

– the preliminary information on required spectrum, potential frequency users and radio technologies was collected from UEFA and hosting countries of previous championships;
– an application procedure for temporary permissions on import and operation of radio equipment was simplified;
– initial spectrum occupancy measurements were made (verification of existing use, elimination of illegal use, checking the availability of frequencies);
– EMC analysis and frequency planning were made to meet an estimated spectrum demand and protect existing local frequency users;
– the stadium areas to be controlled were defined (stadiums, media centres, compounds, fan-zones, etc.) as well as required spectrum monitoring manpower and technical facilities;
– a dedicated UCRF web-page devoted to EURO-2012 was developed and implemented;
– a special e-mail address was created for receiving the applications and queries from the spectrum users;
– consultations with Polish Frequency Authority (UKE) and UEFA were carried out;
– the labelling procedure was agreed with UEFA;
– a hot-line for potential frequency users was created;
– the information about frequency usage and authorization in Ukraine was provided to broadcasters at UEFA meetings for broadcasters and by other occasions.

FIGURE A6.1

Media centre (left) and Broadcasting Compound (right) in Kyiv during EURO-2012




Report SM.2257-06.1

3 Frequency management before the event

The main task of the frequency planning process before and during the championship EURO-2012 was to provide the necessary spectrum resources for all potential frequency users, giving special attention to priority users, specified by the organizer of the event.

During the preparation period and in the course of EURO-2012 the Ukrainian State Centre of Radio Frequencies received 3 773 applications for assigning frequencies from 83 foreign companies and issued 3 569 permissions for radio equipment, particularly for:

– 1 163 portable radio stations;
– 920 TETRA terminals;
– 229 UHF base stations;
– 1 199 wireless radio microphones;
– 134 SNG stations;
– 69 wireless video cameras.

Only 45% of applications were submitted prior to the official deadline.

The most popular frequency bands requested by frequency users are the following:

– 2 430-2 480 MHz, 2 200-2 290 MHz – wireless video cameras (2 260-2 290 MHz – wireless video cameras, installed on helicopters);
– 174-216 MHz, 470-862 MHz – wireless radio microphones;
– 416-430 MHz – TETRA;
– L, C, K, Ku, Ka bands – SNG.

4 Technical check and labelling of radio equipment

In order to prevent the usage of unauthorized radio equipment at stadiums, media centres and broadcasting compounds, the technical check and labelling of equipment was organized in media centres and broadcasting compounds in accordance with the following schedule:

– 15, 10 and 5 days before the first match – local services' equipment (police, ambulance, fire-fighting, security, etc.);
– 2 days before any match – other equipment.

FIGURE A6.2

Technical check and labelling of radio equipment in the stadium area

Report SM.2257-06.2

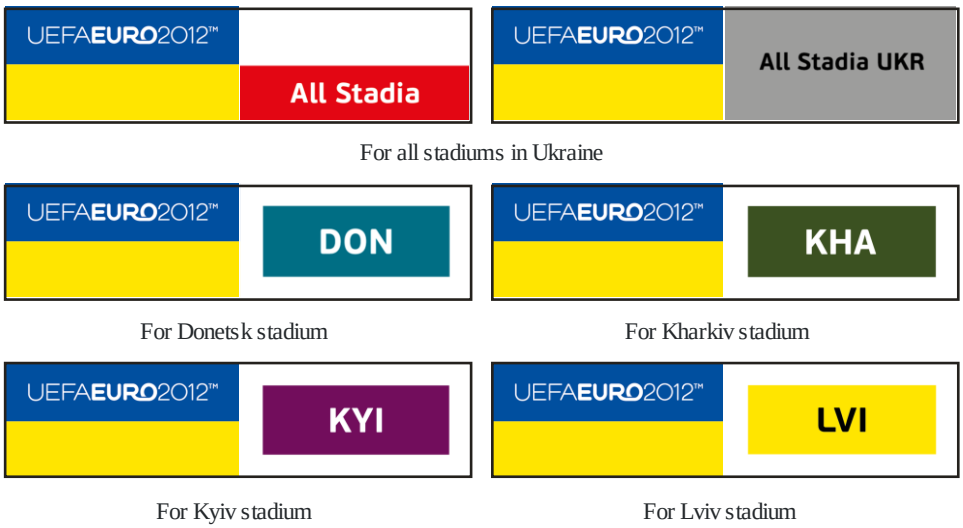
Radio equipment to be labelled shall meet the following conditions:

– UCRF permission for operation of radio equipment (requiring authorization) shall be presented on request;

– Technical characteristics shall be in compliance with authorized ones.

FIGURE A6.3

Stickers, used in Ukraine



Report SM.2257-06.3

5 Spectrum monitoring of terrestrial services before and during the EURO-2012

The main task of the UCRF spectrum monitoring team before and during the EURO-2012 was to provide the interference-free operation of radio equipment.

During the month before the EURO-2012 tournament the UCRF spectrum monitoring teams in four hosting cities carried out non-stop daily spectrum monitoring to detect interference sources that could cause harmful influence to legally operated radio equipment during the EURO-2012 matches.

For providing the spectrum monitoring inside and outside of stadiums in four hosting cities just before and during matches temporary local spectrum monitoring sub-systems, consisting of two fixed monitoring stations and 3 to 6 mobile monitoring stations, were deployed. It was actively used starting from two days before the match and ending after finishing the match.

The local spectrum monitoring subsystem in Kyiv consisted of (Fig. A6.4):

1) two fixed monitoring stations:
   - direction finder for the frequency band 30 MHz-3 GHz, located on the top of the roof of high-rise building at the distance about 500 m from stadium;
   - compact monitoring system, located at the distance about 500 meters from stadium;
2) two mobile monitoring stations equipped with direction finders, receiver, spectrum analyser and directional antennas, which were located near the stadium;
3) four mobile monitoring stations equipped with direction finders, which operated in their zones on distance about 3 km around the stadium;
4) pedestrian monitoring crews equipped with portable receivers and spectrum analysers which operated outside of stadium area;
5) pedestrian monitoring crew for monitoring of SNG stations emission;
6) fixed monitoring unit equipped with receiver and located in stadium area.

At four stadiums the UCRF spectrum monitoring system was ensured by using:

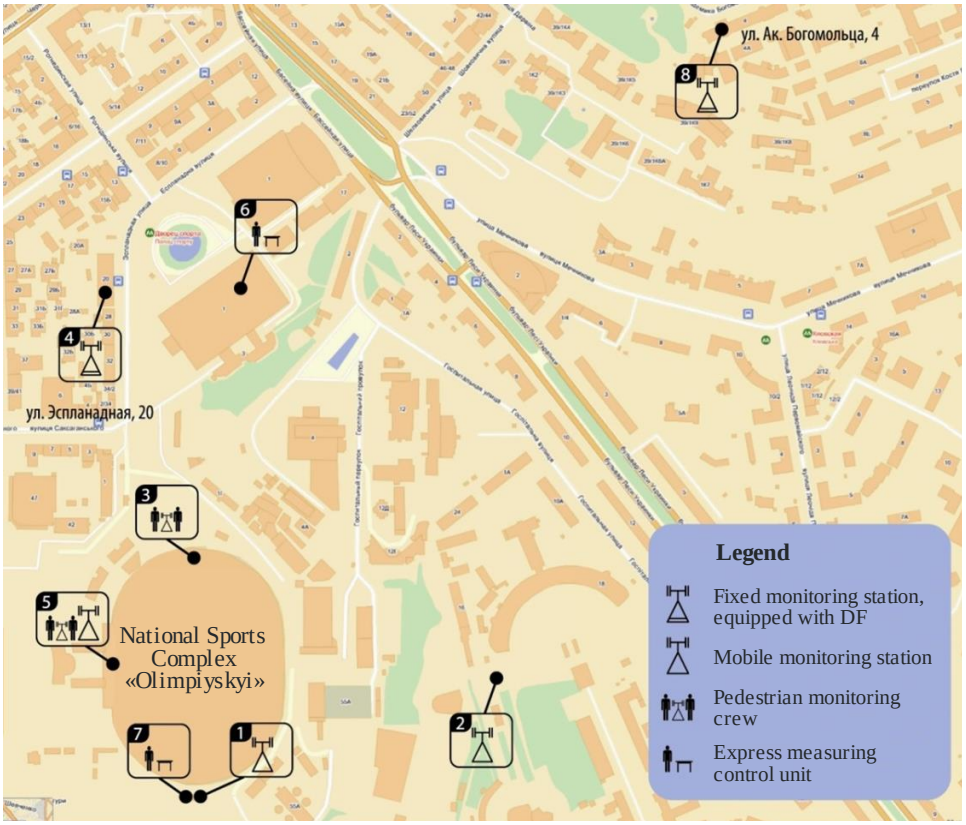
- 8 fixed monitoring stations equipped with direction finders;
- 18 mobile monitoring stations with and without direction finders;
- 13 pedestrian monitoring crews, equipped with portable monitoring receivers, portable spectrum analysers and directional antennas;
- compact monitoring system (small fixed station).

During the spectrum monitoring, special attention was paid to frequency bands used by public safety services (416-430 MHz) and broadcasting companies (450-483 MHz, 2 140-2 570 MHz).

In order to eliminate the interference, at the first stage UCRF spectrum monitoring teams detected the interference sources location. At the next stage the information about interference sources was sent to the UEFA technical department. The final elimination of interference was carried out in close cooperation with the UEFA technical department, the interference source operator and the legal operator when needed.

FIGURE A6.4

Local spectrum monitoring subsystem topology in Kyiv



1 - Mobile monitoring station MMS-01UA (located in broadcasting compound NSK «Olimpiyskyi»)
2 - Mobile monitoring station MMS-02UA
3 - Pedestrian monitoring crew (located into NSK «Olimpiyskyi»)
4 - Fixed monitoring station UMS100 (located on the top of the roof of high-rise building)
5 - Fixed monitoring control unit
6 - Express monitoring control unit (monitoring check-in, located into Palace Spotru)
7 - Express measuring control unit (located into NSK «Olimpiyskyi»)
8 - Fixed direction finder (located on the top of the roof of high-rise building)

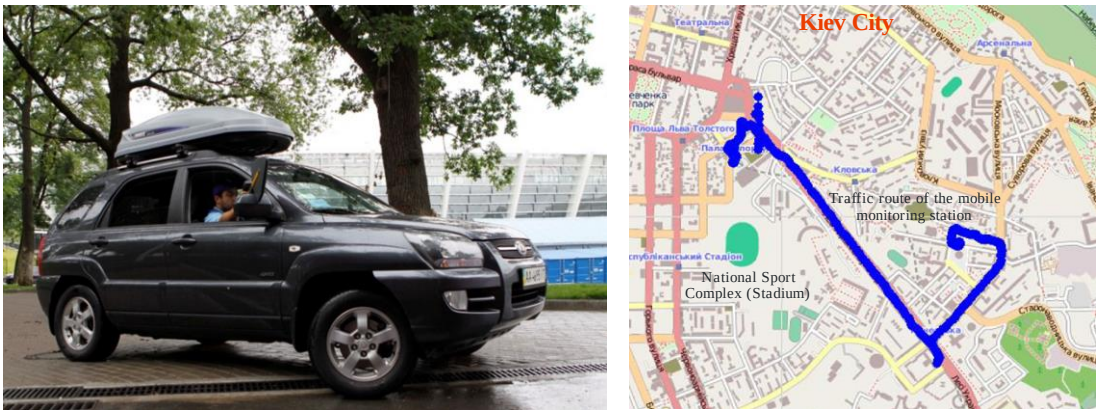
MMS-01 MMS-02 UMS-100 AIK-S

Report SM.2257-06.4

Before and during the tournament, the UCRF spectrum monitoring service carried out monitoring of approximately nine thousand radio stations in four hosting cities. On the match days, two mobile monitoring stations carried out the spectrum monitoring around the stadium areas and adjacent territory in each hosting city for detecting potential unwanted emission sources (Fig. A6.5).

FIGURE A6.5

Mobile crew carries out spectrum monitoring in Kyiv and its traffic route on the match day



Report SM.2257-06.5

Continuous monitoring of the spectrum environment around the stadium areas, media centres and broadcasting compounds was carried out by pedestrian mobile crews, equipped with portable spectrum analysers and directional antennas (Fig. A6.6).

FIGURE A6.6

Monitoring of the spectrum environment in the stadiums and surrounding territory by pedestrian mobile crews

Report SM.2257-06.6

Fifteen radio monitoring engineers were involved in carrying out the spectrum monitoring in Kyiv, in other hosting cities spectrum monitoring was carried out by five to eight engineers. The total number of engineers in four cities of Ukraine was equal to thirty-five people.

During the preparation period of EURO-2012, UCRF's spectrum monitoring departments in four cities of the Ukraine detected and eliminated 87 interference sources on assigned frequencies.

The main reasons of the appearance of interference were:

– Improper frequency tuning of transmitters and its operation mode.

– Illegal operation (without permission or with permission to operate in other hosting cities).

– The use of damaged or unshielded cables.

The total area covered by the spectrum monitoring team in Kyiv, achieved approximately 11 km^2. The time required for detection and elimination of radio interference sources during the event varied from twenty minutes to two hours.

6 Spectrum monitoring of the satellite transponder emissions and geolocation of earth stations during the EURO-2012

During the EURO-2012 tournament matches of the 11th, 13th, 15th and 19th of June 2012 the UCRF carried out spectrum monitoring of the 57 satellite transponder emissions of 12 satellite networks in *C*- and *Ku*-bands. As the result of spectrum monitoring, 28 operating earth stations were recorded. Spectrum monitoring analysis data are presented in Table A6.1. Spectrum monitoring of the satellite transponders emissions was carried out using the UCRF satellite monitoring station (Fig. A6.7).

TABLE A6.1

Match day	June, 2012			
	11th	***13th***	***15th***	***19th***
Number of authorized frequencies to be controlled	59	59	59	59
Number of frequencies used in fact	46	32	50	50
Number of frequencies used without violation of permission	10	6	13	13

FIGURE A6.7

UCRF satellite monitoring station antenna system

Report SM.2257-06.7

The measurement of SNG-station emission parameters was carried out using the UCRF satellite monitoring station, special-purposed measuring stations and portable spectrum analysers (Fig. A6.8). As a result of spectrum monitoring, 42 violations of frequency use were detected and requested to be eliminated by frequency users.

FIGURE A6.8

Measuring laboratory for the frequency band from 3 to 40 GHz (left picture) and measurement of SNG-station emission parameters using portable spectrum analyser (right picture)

Report SM.2257-06.8

7 Spectrum utilization just before and during the EURO-2012 in Kyiv

For the measuring of spectrum utilization in Kyiv, the fixed monitoring station, compact monitoring system and portable back pack monitoring equipment were used. The portable back pack monitoring equipment was installed both in the broadcasting compound to control the stadium area during the matches and in the mobile monitoring station to control the stadium adjacent areas a few hours before the matches.

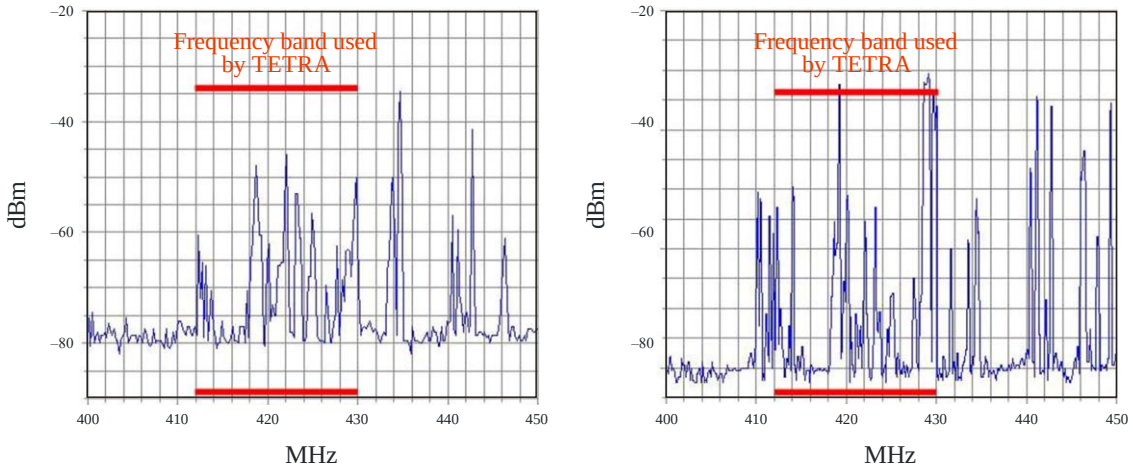
The measurement of spectrum utilization was carried out in the frequency band from 150 to 2 500 MHz.

The average signal values in the frequency band 1 800-2 100 MHz during the period from eight hours before the match to the beginning of the match increased approximately by 15 dB: from −70 dBm to –55 dBm.

The frequency band from 410 to 430 MHz was used by TETRA base stations and user terminals. Figure A6.9 shows the peak signal values spectrograms in the frequency band 400-450 MHz, the central part of which is occupied by TETRA emissions, measured 8 to 6 hours before the match (spectrum utilization level achieved about 80%) and measured during the match hours (spectrum utilization level was equal to 100% practically).

FIGURE A6.9

Spectrograms of peak signal values in the frequency band 400-450 MHz, measured 8 to 6 hours before the match (left picture) and during the match hours (right picture)

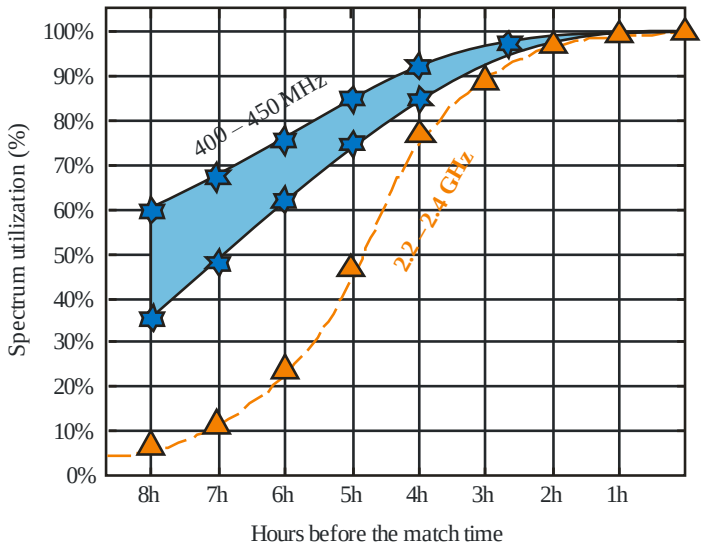


Report SM.2257-06.9

The changing of the spectrum utilization level during the period of measurements is displayed in Fig. A6.10.

FIGURE A6.10

Spectrum utilization changing diagram in the frequency bands 400-450 MHz and 2.2-2.4 GHz



Report SM.2257-6.10

Annex 7

Spectrum management at XXVII World-Wide Summer Universiade in Kazan city, the Russian Federation, July 2013

1 Introduction

July 6th to 17th, 2013, Kazan city, the Russian Federation, hosted XXVII World-Wide Summer Universiade where 351 medal events in 27 sports were held to more than twelve thousand participants from 160 countries, which was a record for all student games. For the Universiade, 64 sports facilities were involved, 33 of them were directly used for competitions. More than 20 000 law enforcement officers ensured law and order. More than 150 000 guests visited the Universiade, three Russian and thirteen international broadcasters provided live transmissions. More than thirty television commentators, two hundred cameras and fifteen mobile television stations worked on a daily basis.

The purpose of this Annex is to show the main organizational and technical aspects of spectrum management and monitoring activities during the preparation and holding of XXVII World-Wide Summer Universiade in Kazan city which are described in detail in references [1] and [2].

2 Preparation activities

As the first step of the spectrum management activities organization during the preparation to the Universiade 2013 was the development in 2010 by the National communication administration of the "Plan of Measures on Management of the Radio-Frequency Spectrum during Preparation and Carrying out of XXVII World-Wide Summer University Games of 2013 in Kazan City". According to this document, the concept and the particular spectrum management plan have been developed, the specialized Automated Spectrum Management and Monitoring System for Universiade 2013 (referred to below as the "Universiade 2013 System") was launched, regulations of interaction with other departments are developed. The Control Centre has been created in which experts of the radio-frequency service from Privolzhsky and Central administrative regions of the Russian Federation were involved.

Before the beginning of the Universiade 2013 in Kazan city, the training of the personnel of the Control Centre, including English language courses, was carried out; three training camps have been organized. During these camps, the following issues were worked out: spectrum monitoring planning and operations, job setup to the personnel by means of the automated spectrum management system and supervising of their performance, checking of communication channel conditions, etc.

All sports objects and the Universiade Village have been provided by telecommunications, the possibility of the organization of videoconferences was provided and 1 629 points of wireless Internet connection were established. Besides, for operative interactions with emergency services, the TETRA radio communication network has been developed. During preparation and carrying out of competitions, about 3 000 portable user's terminals were used in the TETRA network. As concerns the safety and order measures, more than 4 000 video cameras have been installed which provided registration of various events in a real time mode.

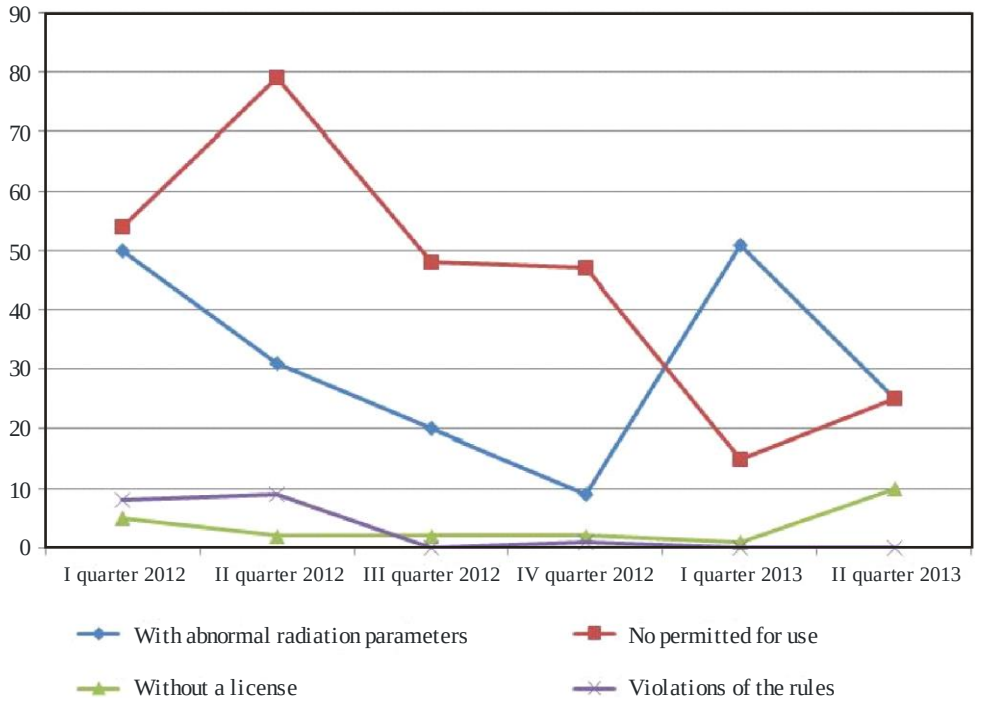
At the main objects (venue locations) of the Universiade 2013 the estimation of the electromagnetic environment has been carried out in advance. In total, during the preparation of the Universiade 2013, 3 526 spectrum monitoring actions have been carried out. A number of emission sources – potential sources of interferences – was revealed and operative measures for their suppression were taken.

The analysis of spectrum monitoring results has shown that during 2012 and the first half of 2013 at the Universiade 2013 territory, there was a decrease in the total number of spectrum use violations, see Fig. A7.1.

Since the beginning of the preparations for the Universiade 2013, the total number of radio transmitters in the region has increased by 42%.

FIGURE A7.1

Dynamics of violations during the preparation of the Universiade 2013



Report SM.2257-7.01

3 Universiade 2013 System

The Universiade 2013 System provided automated registration and licensing of radio transmitters, checking their electromagnetic compatibility, detecting and localization of unauthorized emission sources and sources of interference as well as the management of the personnel.

The Universiade 2013 System was designed based on ITU-R Recommendations and solutions presented in reference [3]. The essential components of the system include radio monitoring equipment, client-server software, as well as an engineering and technical infrastructure.

Radio monitoring equipment included the following units shown in Fig. A7.2:

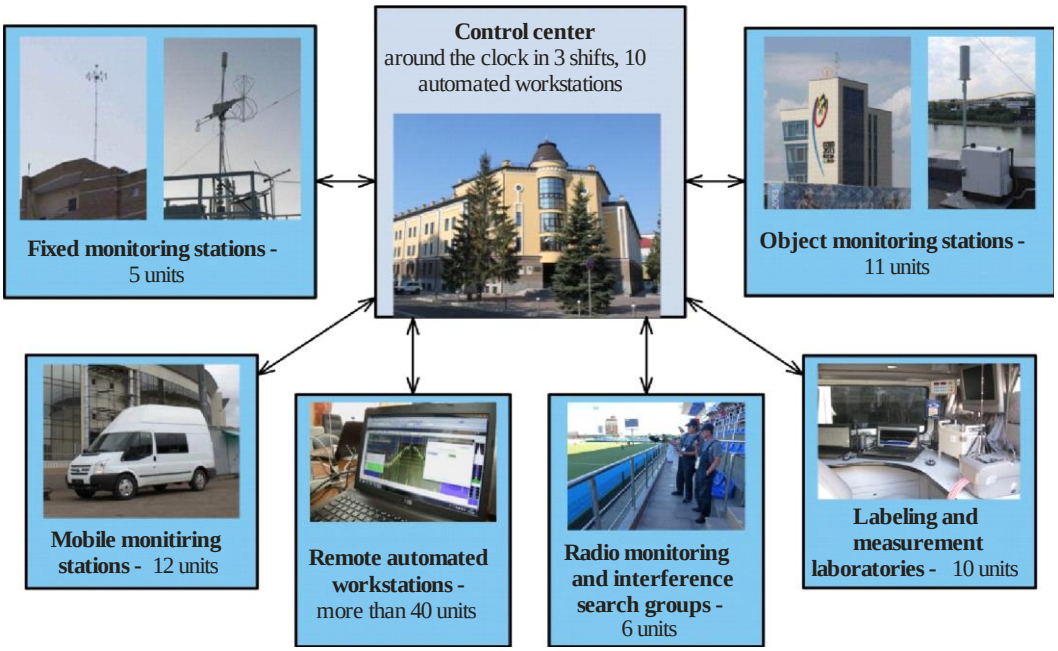
– unattended fixed radio monitoring stations;
– unattended fixed temporary “object” radio monitoring stations (positioned at the venue locations);
– mobile radio monitoring stations;
– portable radio monitoring equipment which was used by radio monitoring and interference search groups;
– labelling and measurement laboratories.

The Universiade 2013 System provided flexible control of the equipment. Tasks can be assigned from the Control Centre, automated workstations of radio monitoring stations or in other agencies, e.g. in Universiade Directorate. Encryption was used to ensure security of the data that circulate within the system including its local networks.

Engineering and technical infrastructure contained engineering installations, equipped premises of Control Centre, communication lines and data transmission nodes, service radio communication system, data transmission equipment, server equipment, etc.

FIGURE A7.2

Components of the Universiade 2013 System



Report SM.2257-02

The Control Centre contained a set of central database server equipment, employee automated workstations, video wall, video conferencing equipment, subsystem of communication and data transmission.

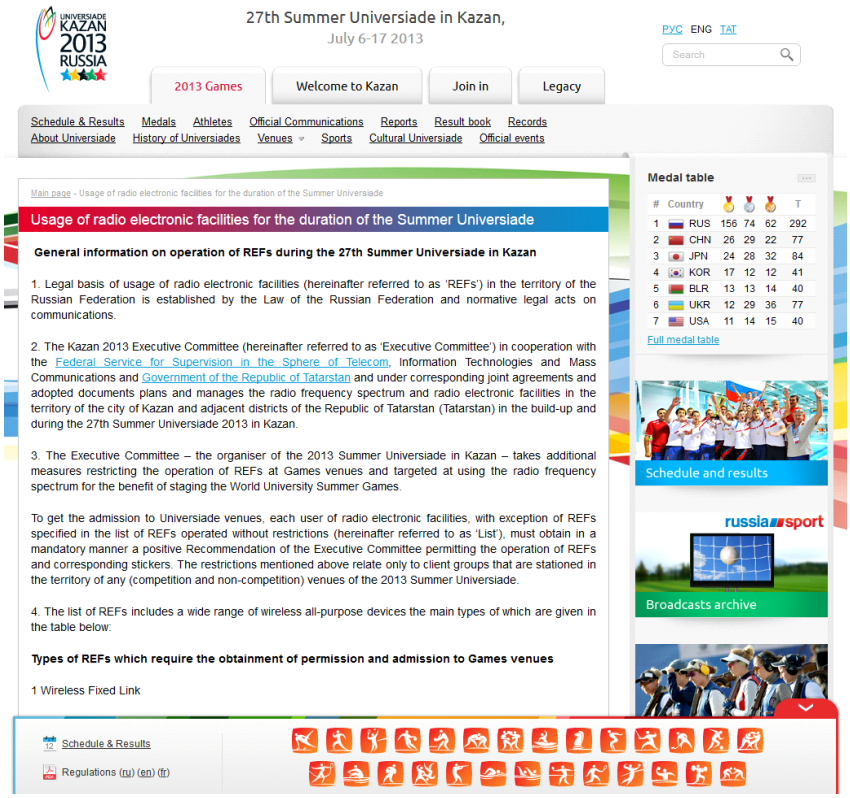
Communication and data transmission subsystem provided data exchange within the Control Centre and with external nodes. Control Centre also included a server that managed the operation of service radio communication network deployed on the basis of MOTOTRBO digital communication platform. Service radio communication network had three repeaters, which provided radio communications in all areas of the city and forty-eight subscriber's stations.

4 Licensing and fee collection

The application service was designed for automated processing of applications for radio transmitter use. Authorized users submit applications by special form to the official Universiade 2013 information portal as shown in Fig. A7.3.

FIGURE A7.3

Screen of the official Universiade 2013 information portal

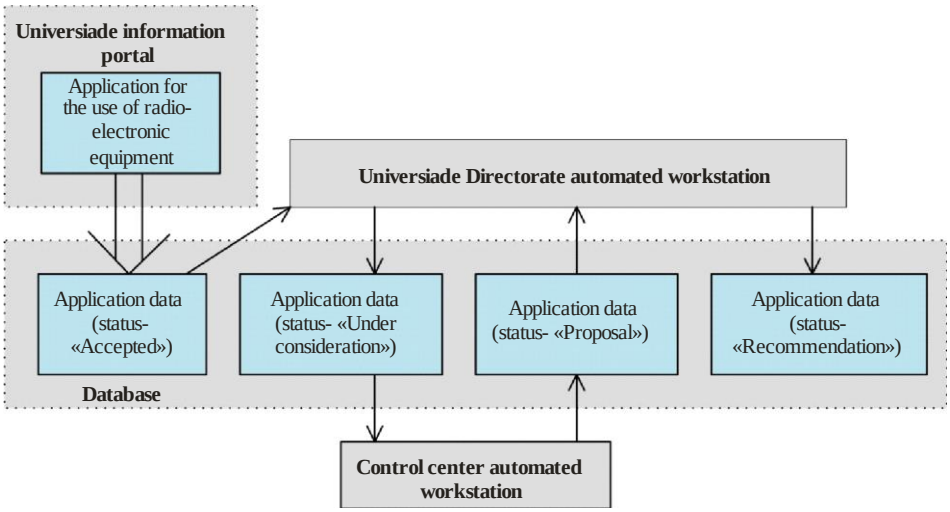


Report SM.2257-3.03

The applications were automatically submitted to the Universiade 2013 System database. Application processing steps are shown in Fig. A7.4.

FIGURE A7.4

Processing of radio transmitter usage applications



Report SM.2257-3.04

In the case of a positive decision on the application, "Recommendations on Radio transmitter Use Conditions" were generated which presented frequency assignments and other conditions concerning radio transmitter use.

Fee collection was performed in accordance with the actual national fee collection system taking into account short operational periods of some radio transmitters.

5 Testing and labelling of radio equipment

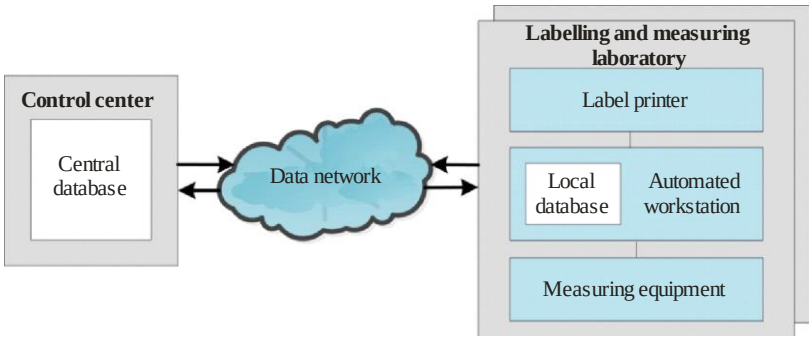
The testing and labelling process was used for technical verification of radio transmitter parameters for compliance with "Recommendations on Radio transmitter Use Conditions" and after testing, the radio transmitters were labelled with a coloured sticker. Testing included checking that actual emission characteristics (frequency, bandwidth and level) complied with the issued recommendations. A decision to label was taken in automatic mode based on measurement results. Testing and labelling were carried out by measurement laboratories that were deployed on the basis of fixed and mobile stations. Local laboratory databases were automatically synchronized with the central Universiade 2013 System database via data exchange networks, as shown in Fig. 7.5, and measurement laboratory operations were conducted both when the communication channels operated and when they failed.

The testing and labelling algorithm given in Figs A7.6 and A7.7 demonstrates checking parameters of the mobile television station by measurement laboratory personnel.

If a positive decision was taken on test results then a marking label was printed and the status of frequency assignments in the database was changed to "Effective". The label contained an index of the Universiade venue locations or a group of venue locations where it was permitted to use the transmitter, the period of use and the transmitter identifier in the database. An example of the label is given in Fig. A7.8. The labels were pasted to radio transmitters and they permitted clear identification of them. Labels were used as seals, i.e. if one tried to remove or to unglue the label then it was destroyed.

FIGURE A7.5

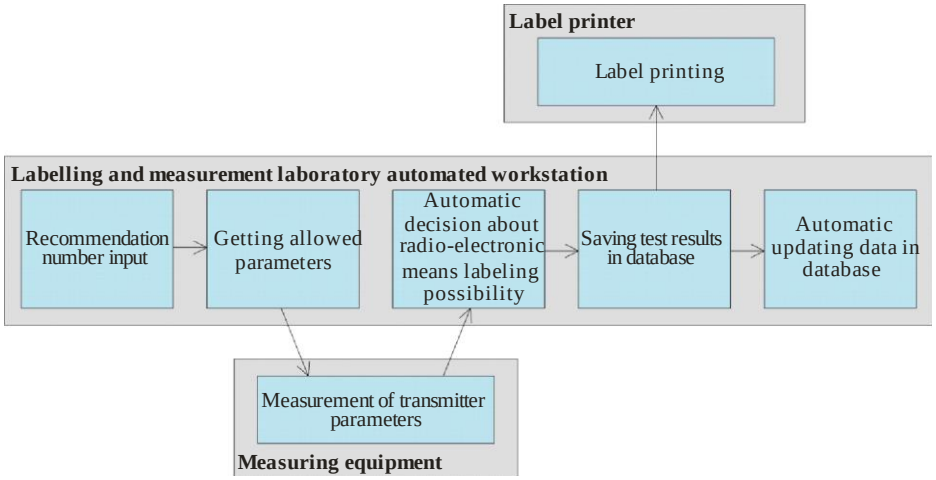
Interaction between labelling and measurement laboratories and Control Centre database



Report SM.2257-3.05

FIGURE A7.6

Radio transmitter testing and labelling algorithm



Report SM.2257-7.06

FIGURE A7.7

Verification of mobile television station parameters

Report SM.2257-7.07

FIGURE A7.8

An example of an identification label

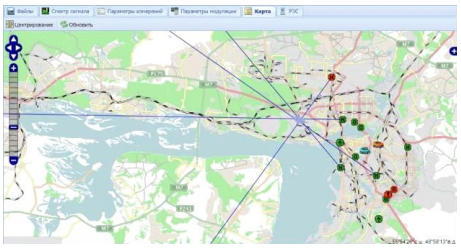
Report SM.2257-7.08

6 Planned and online operation monitoring

The planned operation mode provided automatic solution of radio monitoring tasks based on an agreed schedule, including measurement of emission parameters, localization of emission sources, detecting of new sources, monitoring emission parameters of the registered radio transmitters and their comparison with specifications, measuring of frequency and frequency band occupancy, etc. The use of a flexible radio monitoring events system that implemented spectral and temporal masks was of particular importance. This made possible operating of monitoring equipment in the automatic mode to detect interference and detect deviations of radio transmitters' emission parameters. Options for displaying the results of tasks execution by the Universiade 2013 System interface are given in Figs A7.9 and A7.10.

FIGURE A7.9

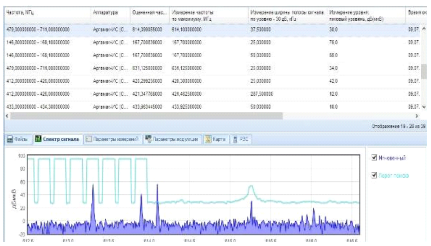
Display of direction finding results on the map



Report SM.2257-7.09

FIGURE A7.10

Detection of a signal based on radio monitoring event (the signal level is higher than the mask)



Report SM.2257-7.10

Online mode was used when it was required to take the necessary decisions in complex cases of interference source search and for immediate localization of emission sources. In fact, all fixed radio monitoring equipment during the Universiade 2013 executed tasks automatically, using radio monitoring events. If an event occurred, such as the appearance of a signal with a level higher than the spectral mask, then the Control Centre operator received a message and he switched to online mode for detailed analysis of what happened in order to estimate the degree of hazard of the event and to take the necessary decision on further action.

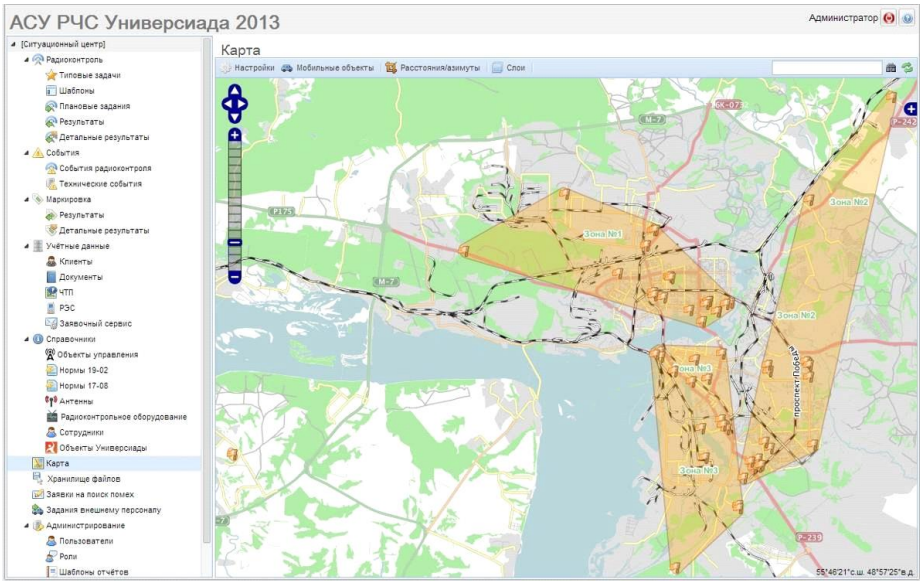
Assignment of tasks for the external personnel was necessary for management of the operation of mobile monitoring stations, radio monitoring and interference search groups and measurement laboratories. The Universiade 2013 System assigned targeted tasks to the crews, monitored their execution and saved the results. The tasks were assigned both based on a plan, for example, according to the schedule of sports events for the next day, and off-plan, for example, tasks for interference search if they were detected, or tasks related to received applications.

7 Use of radio monitoring equipment before and during Universiade 2013

When the Universiade 2013 System was deployed, it was supposed that the radio electronic environment in Kazan city during Universiade preparations and execution would demonstrate a significant increase in the number of operating radio transmitters, and that most of the emission sources would operate in the upper part of the VHF frequency band, in all UHF bands and also in the lower part of the SHF band. A substantial part of the emission sources were expected to have low emission power and, consequently, a small area of the electromagnetic availability. They could be located inside sports facilities and use a broadband modulation and packet data communications. Other factors that were taken into account were a large number of competitive, training and other Universiade venue locations (the number of venue locations were more than 60) scattered throughout the city and beyond it, where electromagnetic compatibility of operating radio transmitters should be provided and interferences prevented (see Fig. A7.11). Further experience obtained before and during Universiade 2013 completely confirmed the correctness of these assumptions.

FIGURE A7.11

Universiade 2013 "objects" (venues) and radio monitoring zones

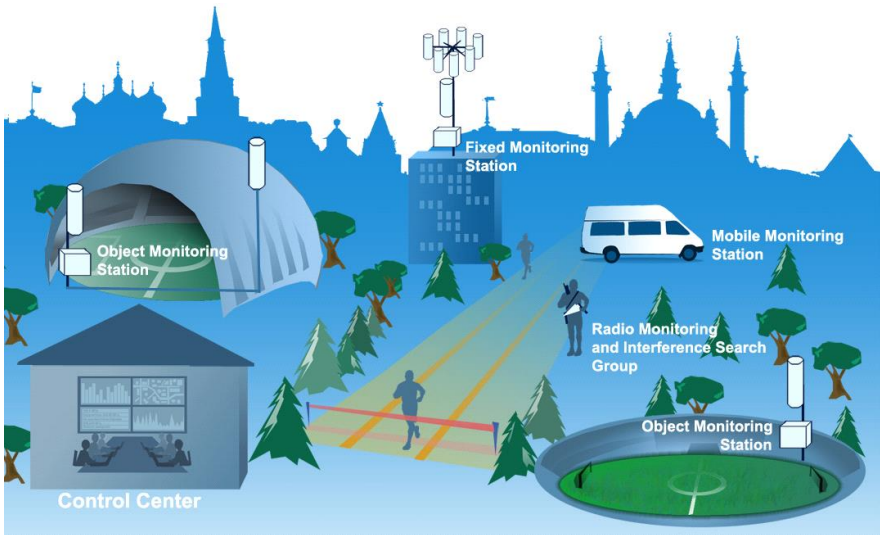


Report SM.2257-7.11

During the Universiade 2013, two types of fixed monitoring equipment were used: fixed monitoring stations with antennas located on roofs of tall buildings and object monitoring stations installed directly at Universiade venue locations. There were also mobile monitoring stations and portable radio monitoring equipment which were used to equip radio monitoring and interference search groups. The features of radio monitoring equipment use are explained in Fig. A7.12.

FIGURE A7.12

Illustration showing deployment of monitoring equipment

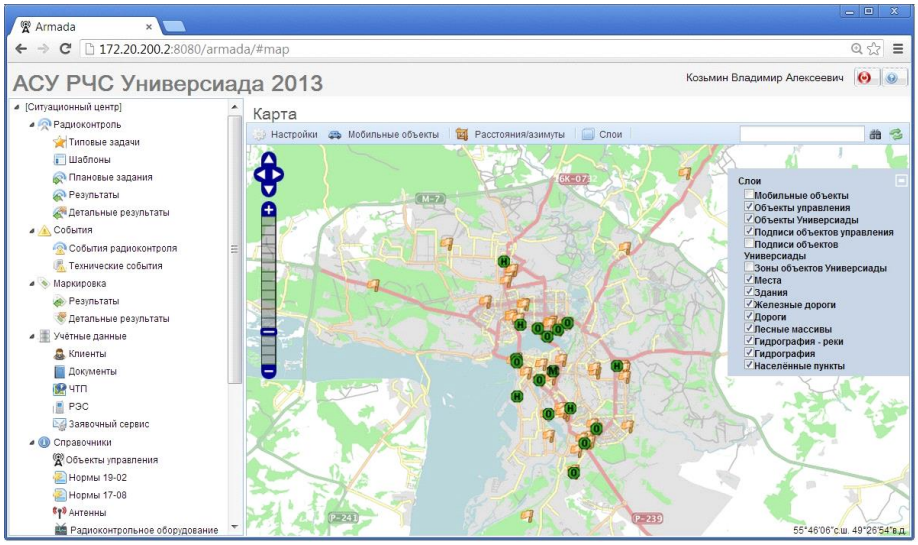


Report SM.2257-7.12

Figure A7.13 shows the location of fixed radio monitoring equipment when the Universiade 2013 was prepared and held.

FIGURE A7.13

Location of fixed radio monitoring equipment in Kazan city



Report SM.2257-7.13

The fixed monitoring stations contained fixed direction finders with 3 GHz upper operating frequency, as it was expected that emission sources operating at higher frequencies, would have a short range or use directional antennas for transmission, and that makes fixed direction finders ineffective. The lowest frequency of fixed direction finders was 1.5 MHz, which permitted direction finding of emissions in and around the event area in the HF frequency band.

Besides the fixed direction finders, three fixed monitoring stations included measuring receivers which provided spectral analysis of radio emissions and measurements of their operating parameters, as well as an analysis of signal parameters specific to GSM, UMTS, LTE, CDMA, TETRA, DECT, Wi-Fi and DVB T/T2/H systems. Example of antenna siting is presented in Fig. A7.14.

FIGURE A7.14

Measuring antenna system (left) and direction finding antenna system (right) on a roof of a building

Report SM.2257-7.14

FIGURE A7.15

Object monitoring station located on the roof of Rowing Sports Center

Report SM.2257-7.15

Temporary “Object” monitoring stations were installed directly in the most important sports venues/facilities and provided round-the-clock monitoring of short range radio-electronic equipment used in the venue locations. The highest operating frequency of object monitoring stations was 8 GHz. Figure A7.15 shows an example of an object monitoring station placement in the Rowing Sports Centre.

Monitoring station equipment was remotely controlled from the Control Centre, and if required it was controlled from mobile monitoring stations or by radio monitoring and interference search groups. The control was provided via wired communication channel that was backed up by 3G wireless channel, as well as by a radio channel for transmission of alarm messages based on the deployed service radio network MOTOTRBO.

Mobile monitoring stations provided direction finding from 1.5 to 8 000 MHz. For the measurement of radio emissions up to 43 GHz, handheld equipment and manually rotated portable directional antennas were used. The operator’s workstation is shown in Fig. A7.16. In order to extend radio monitoring and amplitude direction finding ranges up to 43 GHz, as well as for mobile monitoring station operation as a labelling and measurement laboratory, the station had spectrum analysers integrated with the Universiade 2013 System.

Data exchange between mobile monitoring stations and the Universiade 2013 System was provided via a 3G modem wireless channel. Also, during the preparatory period all main competition venue locations were equipped with special places for providing wired connection of mobile monitoring stations to the Internet. A wired connection over Ethernet cable was used in parkings near such sites.

FIGURE A7.16

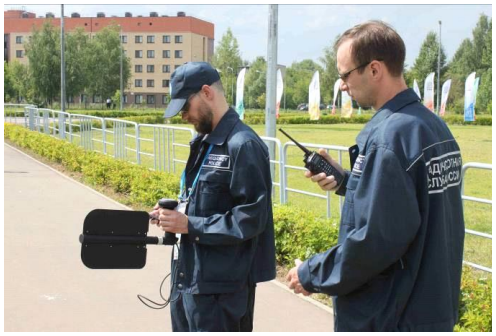
Operator’s workstation of mobile monitoring stations

Report SM.2257-7.16

Handheld direction finders with a set of directional antennas with operational frequency ranges from 0.3 to 18 000 MHz, as well as portable measuring receivers were used as portable monitoring equipment. Figure A7.17 illustrates a radio monitoring and interference search group activity at TULPAR stadium during a rugby match.

FIGURE A7.17

Radio monitoring and interference search group is searching for the interference source



Report SM.2257-7.17

8 Organization of the radio monitoring process during preparation for and during Universiade 2013

Measures used to manage spectrum up to and during Universiade 2013 were divided into three control levels, namely city, zone and object levels[3].

City level used a network of five remotely controlled fixed monitoring stations; it provided direction finding, localization and measurement of radio emission parameters.

Zonal level consists of twelve mobile monitoring stations. It provided direction finding, localization and measurement of radio emission parameters, including low-power sources. Location of Universiade sport facilities (orange flags) and the borders of three radio monitoring zones (the fourth zone included a shooting range located outside of the city) are shown in Fig. A7.11. There were simultaneously up to two mobile monitoring stations crews and also a few radio monitoring and interference search groups with portable equipment in each zone. The position and tracks of mobile monitoring stations were displayed on electronic maps.

In order to provide a site (local) level of radio monitoring, eleven object monitoring stations and radio monitoring and interference search groups were used; these groups were equipped by portable radio monitoring facilities that made it possible to search and localize interference sources in the most hard-to-reach places.

9 Staff management

The Universiade 2013 System personnel management function was integrated into Operational control centre which combined the Control Centre staff and the external personnel (labelling and measurement laboratories, mobile monitoring stations and radio monitoring and interference search groups).

Ten operator’s automated workstations were deployed at the Control Centre. They were used to manage fixed, object and mobile monitoring stations, radio monitoring and interference search groups, special transport and service radio communication system.

---

[3] See references [1] and [2].

More than 40 remote automated workstations were deployed outside the Control Centre for the external personnel, Universiade Directorate, as well as in the participating security service agencies.

10 Activities after the Universiade 2013

At the end of the Universiade 2013, object monitoring stations concentration in the city became excessive, therefore most of object monitoring stations were moved to other locations for use as stations for measuring radio emission parameters. However, some of them were left in Kazan city to strengthen the local permanent radio monitoring network.

11 Some interesting figures

With the help of the application service subsystem, leading up to and during the Universiade 2013, 285 applications for radio transmitters use were received, 39 of them were rejected. Ten labelling and measurement laboratories (two fixed and eight mobile ones) were deployed. In total, 8 368 radio transmitters were tested and labelled, including 6 714 of the land mobile service, 1 364 short-range devices, 20 of the fixed satellite service, 266 of the fixed service and 4 of the radio location service.

During the Universiade 2013 employees of the radio-frequency service detected 207 violations of frequency use, particularly: operation of radio microphones, so-called “radio ear” devices, wireless access points, earth satellite stations, and also mobile radio transmitters of opening ceremony organizers. The pictures of a few violating devices which were revealed as a result of operations at Universiade objects are presented in Figs A7.18 and A7.19.

12 Conclusion

Universiade 2013 System provided effective remote control of geographically remote fixed, mobile and portable radio monitoring means, testing and labelling of radio transmitters, interaction with external information structures when the Universiade 2013 in Kazan city was prepared and held. The system enabled effective personnel management, coordinated task assignment, control of their execution and taking necessary decisions in real time.

FIGURE A7.18

Wireless access station in Rowing Sports Center

Report SM.2257-7.18

FIGURE A7.19

Earth satellite communication station in AkBure Sports Center

Report SM.2257-7.19

Annex 8

Spectrum management activities performed in Brazil for the FIFA Soccer World Cup 2014

1 Introduction

This Annex summarizes general results of spectrum management activities performed in Brazil for the FIFA Soccer World Cup 2014. This major event had the participation of 32 national teams in 64 matches in 12 different locations in Brazil, from 12 June to 13 July 2014.

The information provided herein includes relevant activities with a focus on the preparatory and operational steps performed by the regulatory body in Brazil, the Agência Nacional de Telecomunicações (Anatel). A key element for the success was a highly anticipated preparation framework, strong project management, associated with a state of the art national spectrum management infrastructure.

Relevant experiences might be useful references for further large scale events in the region, including:

– **Preparation framework** (working group, study of past events, webpage with regulatory information in foreign languages).

– **Spectrum regulation and licensing procedures** (regulatory adjustments, licensing for temporary use of spectrum - frequency assignment).

– **Field operations** (testing and tagging[4], monitoring, enforcement, integration with Public Protection and National Security Forces, IMT mobile networks performance monitoring).

2 Preparations framework

2.1 Working Group

International large scale sporting events generally attract worldwide attention and are responsible for significant increase in telecommunications networks traffic. It also reflects into an intensive use of the radiofrequency spectrum, which is a key element for the success on the delivery of sound, images and detailed information to the whole world.

---

[4] Also known as “check and labelling”.

With such needs, it has been increasingly common that the interested parties of such event, including organization committees, media organizations and society in general, require a strong commitment of local authorities towards the availability of such communication resources in order to decide if and where to organize the event.

In order to answer for governmental commitments to the event, Anatel was in charge of developing important actions directly related to wireless transmissions and the provision of telecommunications services by national operators.

A past experience with Rio 2007 Pan-American Games indicated that a consistent preparatory roadmap should be anticipated in order to minimize negative impacts during several major events that would be held in Brazil between 2011 and 2016, including the FIFA Soccer World Cup 2014 and Rio 2016 Olympic and Paralympic Games. In this context, Anatel established in 2011 a working group comprised of executives of several departments in areas that would have relevant impact over Anatel roles in the events.

This working group encompassed a broad scope of activities needed for addressing the spectrum management activities for a major event, including spectrum regulation, licensing and enforcement teams, other departments such as human resources, finances, communications, international affairs, procurement and IT. The group was responsible for developing several projects and advising Anatel Board of Directors on those actions related to the major international events.

A very important goal on this process was the update of Anatel's spectrum management facilities. Several projects, with guaranteed budget, have deployed the necessary systems and equipment, including new spectrum management planning and licensing platform, fixed and mobile spectrum monitoring stations, satellite monitoring facility, high performance spectrum analysers, mobile network benchmarking analysers and several portable equipment.

2.2 Study of past events

As an initial step, international case studies were developed in order to create a better understanding on the involvement of regulatory bodies on previous editions of FIFA Soccer World Cups and Olympic Games. Anatel made several technical visits and debriefing meetings were held with regulatory authorities, manufactures and operators of South Africa (World Cup 2010), China (Beijing 2008 Summer Olympic Games), UK (London 2012 Summer Olympic Games) and Russia (Sochi 2014 Winter Olympic Games). Further important references were the ITU-R Recommendations and Reports and the interaction with the Ukrainian spectrum monitoring body taking into account experiences with Euro 2012 event.

During London 2012 Paralympic Games, Anatel sent a delegation to follow Ofcom field spectrum control operations during the event. This practical experience was very important to provide a deeper understanding about challenges and good practices on spectrum use, interference mitigation and enforcement activities. Such exchange, if possible, is highly recommended to allow a better harmonization of practices on the international level, in consistency with the event scope.

The information received by international cooperation, along with previous experiences of past events in Brazil such as Rio 2007 Pan, Rio+20 diplomatic conference on climate change and FIFA Soccer Confederations Cup 2013, created a fundamental knowledge basis for Anatel preparations.

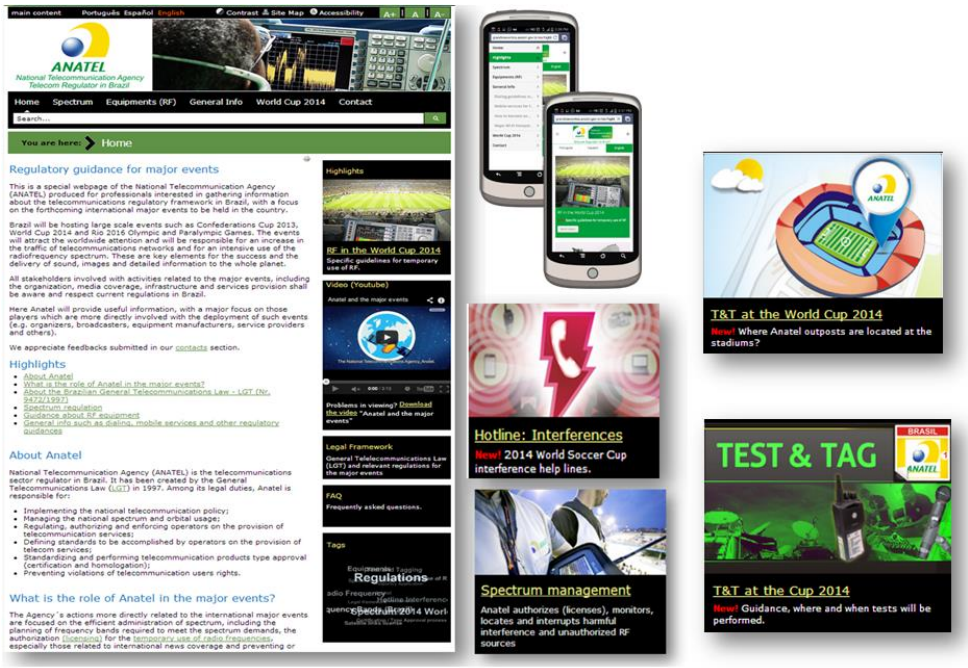
2.3 Webpage with regulatory information in foreign languages

Anatel external communication strategy followed two pillars. The first was communication to the general public, professionals and organizations involved in activities directly related to the event. The second was the communication with the committees and other organizations, public or private, directly involved on the event execution.

Communication to the general public, professionals and organizations involved in activities directly related to the event was mainly established through the Internet. More than two years before the World Cup 2014, Anatel launched a webpage[5] in Portuguese, English and Spanish with regulatory guidance for telecom activities related to major events. Some of the topics of the page included spectrum regulations, licensing procedures for temporary use of radiofrequency, telecom equipment certification process, testing and tagging of radiocommunication equipment for operating during special events in Brazil, hotline for interference mitigation during the World Cup 2014.

The following pictures show the website layout and features of the page including mobile version, banners and an animation video presenting Anatel and explaining relevant regulatory issues focusing on spectrum management challenges and regulatory procedures. The webpage will be available until 2016, after Rio 2016 Olympic and Paralympic Games.

Anatel webpage for the major events (Portuguese/English/Spanish)



The second pillar was the construction of relevant external partnerships with other federal government bodies, specialized channels and the event's organizers as well. This interaction was fundamental to allow information achieving relevant target stakeholders, with reasonable time in advance, making them aware of national regulatory requirements, processes and spectrum management procedures related to the event. Additional special communication campaigns such as "testing and tagging", "interference hotline" and "geolocation of Anatel desks at stadiums and International Broadcast Center – IBC" were promoted with those partners.

5 http://grandeseventos.anatel.gov.br/en/.

Examples of special communication campaigns developed to the World Cup 2014

3 Spectrum regulation and licensing procedures

3.1 Regulatory adjustments

The very unusual nature and scale of a global major event demands special treatment for specific points under the national regulatory framework. This requires regulatory adjustments allowing a more flexible and agile approach. In this regard, Anatel issued specific regulatory Acts for the World Cup, including:

– The maximum length period for temporary authorizations (licenses) related to the World Cup 2014 was extended to 120 days;

– Usage of transmitting earth station linked to a satellite without the needed authorization to operate within the Brazilian territory;

– "Automatic Camera Trigger" type devices operating in radio frequency bands between 340 MHz and 354 MHz and between 433.44 MHz and 434.42 MHz have been exempt from licensing and testing & tagging procedures;

– Update on the regulation for temporary use of radiofrequency.

3.2 Licensing for temporary use of spectrum (frequency assignment)

In order to meet the high demand of radio frequencies for temporary basis operations in major events, it is necessary to develop a well-designed spectrum management plan in advance.

Taking into account experiences from previous events, it was understood that a very well-planned and efficient licensing system should be designed in order to allow a better spectrum planning and a faster processing of several frequency licensing applications in a short time.

In 2014, Anatel launched a new spectrum licensing system capable of making automatic coverage calculations and interference probability assessment along with frequency assignments already under operation, reaching a higher efficiency on the licensing process.

In order to authorize RF temporary operations during the World Cup, Anatel issued 319 temporary licenses which included 7 146 frequencies to be used by 19 110 radiocommunication stations.

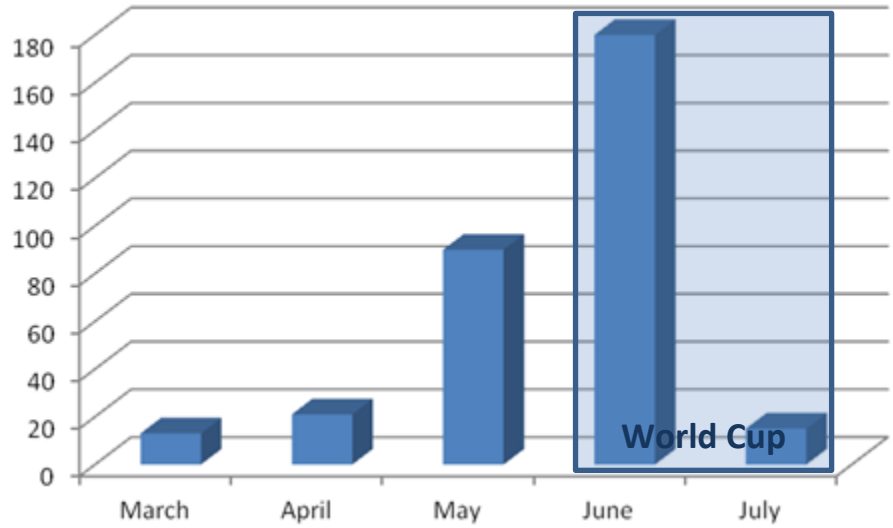
One interesting comparison in terms of events dimensions, for FIFA Confederations Cup 2013, Anatel issued around 127 temporary licenses which included 1 319 frequencies to be used by 3 648 radiocommunication stations.

Almost all radiocommunication equipment, including several short range devices operating at unlicensed bands, should pass through Anatel temporary radiofrequency licensing procedures. These included Satellite News Gathering stations (SNGs), portable radios, wireless cameras and microphones and further RF devices associated to Electronic News Gathering (ENG) and security systems. This broad scope was established in order to enable the frequency coordination of all radio devices, including the ones usually exempt but which, in such a RF cluttered environment, might cause interference to other services and devices.

Besides ENG, other relevant stakeholders of radio frequencies were the diplomatic delegations, international organizations and foreign military aircrafts and ships. The graph below shows figures over licenses issued in relation to the World Cup 2014 by each month. One important remark is the high concentration of licenses between May and June 2014, near and during the event. This is a common behaviour in large scale events.

Another important decision was to keep licensing staff available to issue licenses during the event in order to deal with doubts or late requests. About 23 IT support personnel was also kept in standby to ensure the full availability of all systems and fast recovery in case of unexpected failure of any support system.

Licenses for temporary use of radio frequency issued by Anatel for the World Cup 2014



4 Field operations (testing & tagging, monitoring and enforcement)

The field operations were carried on by means of a national coordination team, 14 local coordinators and 303 enforcement and monitoring technicians divided among activities such as radio monitoring of fixed mobile and satellite networks, testing and tagging and on-site enforcement.

In order to guide Anatel field efforts, an enforcement action plan was drafted, including documents later designated as Operational, Communication and Contingency Plans.

The Operational Plan for all enforcement activities was designed to ensure that the telecommunications infrastructure in the stadiums and host cities met the requirements officially defined by the Agency and publicized to stakeholders.

The Communication Plan was designed to ensure the proper collection, production, storage, destination and final dissemination of information about the activities performed.

The Contingency Plan identified possible scenarios that could jeopardize the fulfilment of Anatel's tasks during the World Cup, so that it was possible to act in a coordinated manner to mitigate the undesirable effects of each occurrence.

4.1 Testing and tagging of radiocommunication equipment (T&T)

One major innovation in Brazil for preventing interferences at the venues was the full use of "Testing and Tagging (T&T)" procedure. Such task was partially applied on previous events and performed for the first time in Brazil at FIFA Soccer Confederations Cup 2013, taking into consideration the experience of spectrum regulators in previous World Cups (2006, 2010), Euro 2012 and Olympic and Paralympic Games (2008, 2012).

The T&T of radiocommunication equipment consists in conducting previous technical measurements, license verification and labeling on those RF transmitter equipment that would operate in the venues. As it is done before the operation, it can detect non conformities and allow the adoption of corrective measures before the interference occurs. At each Stadium and at the International Broadcast Center (IBC), Anatel had an office provided by the event organization where T&T and other spectrum management activities were conducted.

Anatel Offices conducting T&T procedures and other spectrum management activities

For the World Cup 2014, the T&T procedure officially started on the venues on June 7th, five days before the opening match at São Paulo Stadium, and also five days before every first match at remaining stadiums. After that, T&T procedures started two days before every match (all stadiums). This relatively short period was considered enough for this specific event taking into consideration the size of each location, number of locations (12) and, due to this fact, the amount of teams working in parallel. Also the schedule on each location, with at least two days of rest between matches, allowed newcomers to a specific location to run through the T&T process on a first come first served basis. Other events might need more sophisticated procedures and scheduling.

The procedures were conducted until the final match in Rio de Janeiro, July 13th 2014. In general, the T&T procedure consisted in the following steps:

– After receiving the license for temporary use of radio-frequency, spectrum users should present to Anatel Agents all RF equipment expected to operate inside the venues. They should bring the RF equipment to Anatel desks to perform testing and tagging.

– Anatel agents conducted tests and verified if the frequency, bandwidth and other technical parameters were according to the license.

– After the test, the RF equipment was tagged with a specific label. Depending on the result of the test, a different label was used according to the following criteria:

  • RF equipment that did not meet Anatel criteria for Testing and Tagging, or could not operate in accordance with license parameters, received a red label, indicating "Do Not Use".

- RF equipment approved, received a label corresponding to the stadiums where it would operate (e.g. each stadium had a label with different colour and city name abbreviation). They were also segmented into first phase and second phase (finals) on those cities with more than four matches, excluding the IBC. For those equipment authorized to be used in all venues and all tournament phases, a white label ("ALL") was used.
- Main stakeholders had test and tagging with higher anticipation, around 10 days before the matches.

A total number of 17 325[6] radiocommunication equipment have been through the T&T procedures.

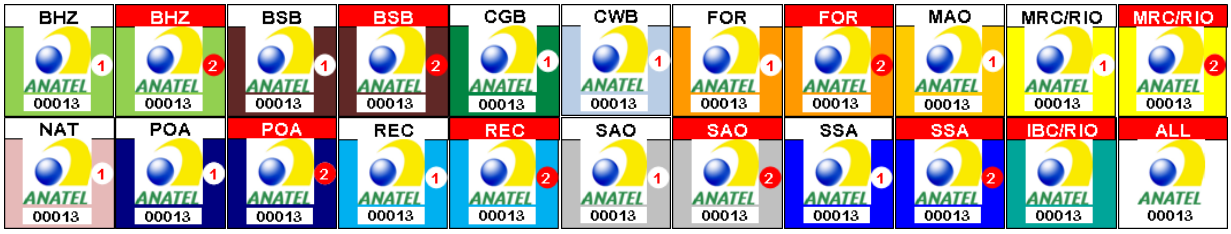
– 16 219 received the approved label with the colour corresponding to the city to which they were able to operate, including those cases where RF equipment received white label ("ALL"), being able to operate in all host cities.

– 1 106 received the red label, meaning that they did not have authorization for temporary use of radio frequency or were not configured to operate according to the license[7].

According to expectations, the T&T procedure was capable of avoiding the use of several equipment wrongly configured to operate at frequencies to which they were not authorized, preventing a high number of harmful interferences.

More than 200 probable interferences were avoided, mostly by short range devices that in other circumstances and events studied, were exempt of license. Therefore, local coordination was especially necessary for these equipment and the prevention strategy was considered highly successful.

Labels used at each stadium on the first and second phases and IBC during World Cup 2014



The high level of success of the T&T procedure was translated into relevant interference prevention indicators. Due to this result, the T&T procedures are already planned to be implemented on other major events in Brazil, especially at Rio 2016 Olympic and Paralympic Games.

---

6 The number of equipment submitted to T&T procedures does not (exactly) match the quantity of licensed equipment. In specific cases, RF equipment were not required to be submitted to T&T procedures, especially those operating outside stadiums (Fan Fests, hotels, etc.).

7 In few cases the equipment was re-configured correctly and submitted again for authorization, with success on the second try. In most cases the equipment could not be reconfigured properly or it was reconfigured on the spot and as such it did not receive the red tag.

4.2 Enforcement team identification and preparation

One of the main issues that may affect the performance of teams involved in enforcement activities during a major event, especially the effectivity in solving interference cases is the ability to access and interact with the people interfered and the ones causing the interference.

Communication becomes essential in this front. Besides the already discussed communication strategies, they included the following:

– use of banners for identification of the spectrum desk and/or test and tagging locations;

– use of an uniform for clear identification of field teams;

– foreign language proficiency of teams assigned to solve interferences and might need to approach non Portuguese speaking individuals.

4.3 Measurement instruments used

Several new equipment was specifically acquired to aid the activities during the FIFA World Cup 2014 and constitute an important legacy for the national spectrum management infrastructure.

The spectrum monitoring infrastructure used in each host city consisted of:

– at least three fixed spectrum monitoring sensors located on the top of the roof of high-rise building at the distance from 1 to 5 km of the main event sites;

– at least one direction finder and one spectrum monitoring sensor within the stadium;

– a pedestrian monitoring crew equipped with portable receivers, spectrum analysers and directional antennas within the stadium with additional support of up to three other similar crews with limited access to stadium area;

– car mounted direction finder and monitoring unit located in stadium area with additional support of up to two other similar units;

– additional monitoring sensors and equipment used on other areas of interest that might be adversely affected by the event, especially airports, team training sites and IBC;

– 24 mobile network benchmarking platforms for drive-test with capabilities test four operators each and additionally two walk-test backpacks;

– a satellite monitoring station, capable of radio monitoring and geolocation of earth emitters in C and Ku bands in use during the event.

4.4 Spectrum monitoring and interference solving activities

In order to identify irregular emissions and potential interferences, three types of pro-active monitoring activities were performed, especially at the event's relevant locations and frequency bands. These types may be named: preparatory, pre-event and during the event monitoring phases.

Preparatory monitoring activity was done using fixed, mobile or portable stations during the three months before the event started. The goal was to obtain field information about real spectrum conditions in relevant frequency bands and take pre-emptive measures. It was an opportunity to verify the existence and suppress the emissions of any unauthorized spectrum users, and to verify if licensed radiocommunications stations were meeting technical and regulatory requirements, operating according to their licenses.

Pre-event monitoring was performed in the week before the event kick off. It involved a review of the information generated during the preparatory monitoring, but this time it included also temporary licensees to be operating specifically during the event.

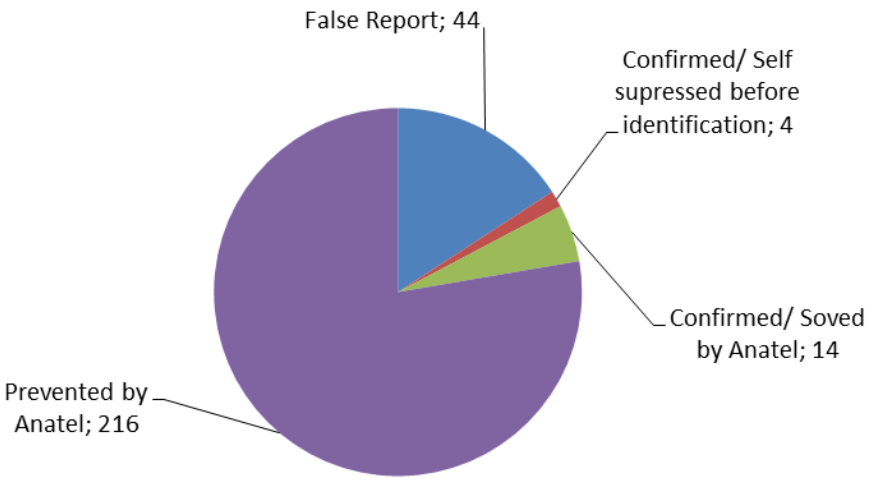
Monitoring during the event was performed a few hours preceding and during the event. The goal was to quickly identify and find potentially irregular interfering emissions that appeared during the event, in order to assist in solving harmful interferences, even before they were reported.

Anatel Spectrum monitoring stations installed at the 2014 World Cup stadiums

Additionally to proactive monitoring and to Anatel traditional communications channels, spectrum users during the hole event period could file interference reports directly to Anatel staff at each stadium Spectrum Control Offices, at IBC or by phone call (interference hotline).

The following graphs presents a brief description of the activities performed in relation to the interference cases during the FIFA World Cup 2014:

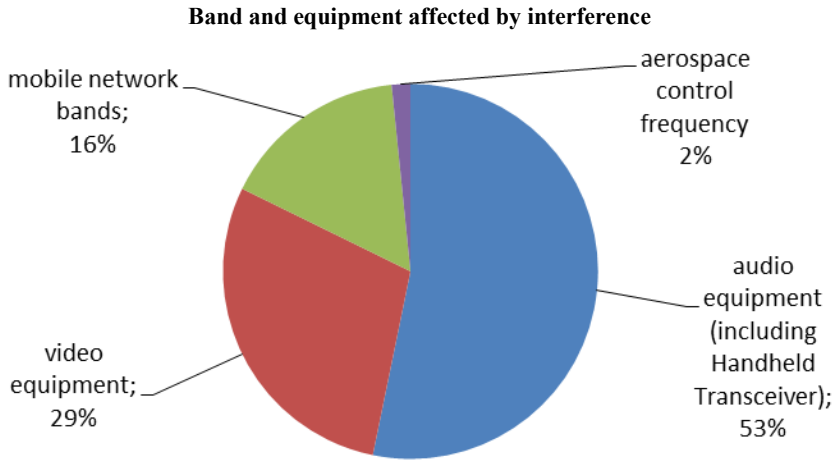
Interference events during World Cup 2014



From the above graph, a first highlight is that through procedures such as test and tagging and enforcement activities on entrances and other main event areas a total of 216 possible sources of interference such as wrongly configured and non-authorized emitters could be detected and corrected, before interference was caused or a complaint was filed.

A total of 62 interference cases were identified (or reported) as related to the event and evaluated by Anatel. From these, only 18 were effectively interference cases (29%), the remaining 44 cases were closed as problems associated with equipment installation, configuration or operation. Fourteen cases were solved by direct action of Anatel enforcement agents, and the remaining interference cases ceased during the investigations. Thirty of the reported interferences involved the host broadcaster or local organizing committee.

The following graph presents the distribution of the interference cases detected in accordance with the band and equipment affected.



In proportion to the number of matches, the number of interferences during the World Cup 2014 was lower than in Confederations Cup 2013, when 36 cases were reported in a total of 16 matches. These figures reflected the improvement of preventive actions, such as T&T and pro-active monitoring activities.

As for satellite networks, transmissions remained free of interferences and no formal complaints were reported to Anatel throughout the whole event. The preventive approach of the work of the field staff conducted along with satellite operators was also an important factor that contributed to the success of satellite operations.

4.5 Integration with public protection and national security forces

During the event, Anatel agents were present at the National Integrated Command and Control Centre (CICCN) in Brasilia and Regional Integrated Command and Control Centres (CICCR) deployed in the 12 host cities, in order to support the Public Security Forces on telecommunications issues and receive assistance to identify unauthorized emissions that could affect the event or endanger its safety. In this context, Anatel's support was required for the identification and apprehension of Unmanned Aerial Vehicles (UAVs), also known as drones, which were operating without license or telecommunication equipment certification (type approval).

Additionally, there were negotiations with other agencies, especially the Ministry of Foreign Affairs in order to inform official foreign delegations about the restrictions on the use of Radio Frequency Signal Blocker (known as jammers), which are forbidden in Brazil except within prison premises.

4.6 IMT – Mobile networks performance monitoring

In order to evaluate mobile network performance in the 12 (twelve) host cities, from May 2014 Anatel conducted weekly drive tests, with mobile network benchmarking platforms.

The goal was to identify any non-conformity to the regulatory requirements, especially the ones established specifically for the games, which included coverage and quality of services obligations. Such preemptive actions allowed Anatel to act proactively with mobile operators in order to mitigate these non-conformities, preventing future problems and low quality on the provision of mobile service during the event.

The measurement routes were designed to reach areas of large concentration of people in those cities, including the soccer stadiums surroundings, regions with large number of hotels, airports, bus stations and Fan Fests locations.

During the World Cup matches, walk-tests were also conducted with the use of portable mobile network benchmarking platforms and smartphones. The average download and upload rates along with call completion rate were analysed. These tests were performed at the stadium 2 (two) hours before and during each match. Additionally, with the objective of enforcing mobile service performance, the day after each match mobile operators provided Anatel with the radio air interface indicators of the match day.

Anatel was also able to remotely access mobile operators' network performance systems, having a graphical view of traffic and processing indicators of network elements and telephone traffic. Network failure alarms and performance were collected before and during the event, especially over the group of Base Stations that covered the event host cities, segmented in regular reports issued by relevant areas groups (Ex: Stadium and main transportation ways). With such, the relevant information about the communication network could be made readily available to the authorities that might be called to respond in the event of a crisis.

The traffic channel allocation during the games were mostly above 90% of the installed capacity, reaching 100% in several cases, with drop rates in voice and data, and call block rates below 5% during most of the matches.

After data analysis, it was noticed a visible general improvement on voice channel and data connections indicators during the World Cup 2014 when compared with what was achieved in Confederations Cup 2013, when similar procedure was adopted. The traffic volume registered during the World Cup 2014, at stadiums and relevant surrounding areas was much higher, being around 12.2 million voice calls, and 704 million data connections.

According to data provided by national mobile operators, considering only the traffic related to the World Cup 2014 stadiums, the total volume included 4.4 million voice calls, 48.5 million data connections (0.55 MB average each connection) and a total volume of 26.7 TB data traffic.

5 Lessons learned

Considering success and problems encountered during the event a few key aspects stand as relevant for future activities related to major events.

– Partnership with event organization is essential. Great effort should be made to guarantee the full cooperation of the organization responsible for the event in order to minimize problems related to credentials and entry pass to event areas and also to ensure the availability of working areas for activities such as test and tagging, including, if possible, areas outside restricted zones so any interested party can have access to the spectrum management teams.

– On-line information availability in different languages is fundamental to allow international organizations to understand, in advance, the national regulatory framework including any specific procedures for temporary RF licensing.

– Transparent and clear communication to all stakeholders is essential to the success.

– An efficient temporary assignment procedure is critical and applications should be made a few months in advance. Even so, it must be considered that applications might come in the last minute and during the event. This procedure includes the allocation of frequency channels in quantity compatible with the expected need since reallocations during the event are almost impossible.

– Structure planning procedures, including tactical, strategic and operational plans should be used and done long in advance in order to allow a comprehensive integration of all efforts, including the communication, selection and training of teams, specification, purchase, training and field use of new equipment and software.

– When needed, new equipment should be made available to field teams as much in advance as possible in order to allow the technicians to acquire experience by the use of the new equipment in different real situations. Training only might not allow users to incorporate a full understanding of all capabilities made available by the new equipment and with such take full benefit of its use.

– Portability to the equipment is essential considering the restrictions to the use of cars in event areas for security reasons. Great care should be taken with this characteristic in case of new procurements.

– The quality of tag stickers used in testing and tagging procedures might become an issue since it may significantly vary from one manufacturer to another.

– Attention should be taken to all areas affected by the event that will demand the use of spectrum. This may include several sites outside the main event areas, for example, studios and media centres outside IBC, training sites, airports. These locations may experience an increase in interferences and teams should be ready to answer these cases.

– Information to field teams and automated reporting tools are essential to allow fast access to important information associated with the event, including access to equipment database and reports from different locations.

6 Conclusion

Anatel planning framework for the FIFA Soccer World Cup 2014 was a key element for the successful spectrum management and mobile networks quality monitoring activities during the event, allowing the development of several projects, especially those related to investments in renewing the national spectrum management infrastructure.

The engagement and high commitment of internal and external stakeholders, including governmental bodies, foreign regulators, event's organizing committee, national and international operators along with spectrum users was essential for the success of the event, anticipating the high demands and possible solutions.

Considering the challenging goals established, it can be generally affirmed that spectrum management and telecommunication services provision by national operators were satisfactory during the World Cup 2014 and positively contributed to the success on the organization and transmission of the event.

References

[1] D. Alexeev, A. Ashikhmin, S. Kobelev, V. Kozmin, A. Rembovskiy, D. Sysoev, L. Tsarev. Features and Application of Automated Spectrum Management System at 27-th Summer Universiade in Kazan City//Electrosvyaz, 2014 – No. 4 – pp. 9-16 (in Russian). (The manuscript of the article translated into English is available at the web-site: http://www.ircos.ru/en/articles.html).

[2] http://rspectr.com/article/radiokontrol/kazan

[3] A. Rembovsky, A. Ashikhmin, V. Kozmin, S. Smolskiy. Radio Monitoring. Problems, Methods, and Equipment. Volume 43 in the Science and Technology series. ISBN 978-0-387-98099-7, Springer Dordrecht Heidelberg London New York, 2009 – p. 530.

Annex 9

Spectrum management and spectrum monitoring during 2018 PyeongChang Winter Olympic and Paralympic Games

1 Introduction

The PyeongChang 2018 Olympic and Paralympic Winter Games (hereinafter referred to as "PyeongChang 2018") needed the use of tens of thousands of wireless devices for the operation, timing and scoring, broadcasting production and transmission of this Winter Games. Details of both events and hosting cities located in the east-north area of Korea are summarized in Table 1.

TABLE 1

Details of the PyeongChang 2018 Olympic and Paralympic Winter Games

	PyeongChang 2018 Olympic	PyeongChang 2018 Paralympic
Period	From 9 February to 25 February 2018	From 9 March to 18 March 2018
Event Item	102 items in 7 sports (15 disciplines)	80 items in 6 sports
Venues	5 regions (PyeongChang, YongPyong, Bokwang, JeongSeon, GangNeung), 13 Arenas	3 regions (PyeongChang, JeongSeon, GangNeung), 13 Arenas
Nations & Athletes	92 Nations, 2922 Athletes	49 Nations, 569 Athletes

In addition, the PyeongChang 2018 has witnessed the usage of 5G technology for the first time during the Winter Games.

Most of the outdoor snow events were held in the county of PyeongChang which was centre of the PyeongChang Organizing Committee for the 2018 Olympic and Paralympic Winter Games (POCOG), the Alpine skiing were held in the county of JeongSeon. The indoor ice events were held in the city of GangNeung.

The POCOG, the Ministry of Science and ICT (MSIT), the National Radio Research Agency (RRA) and the Central Radio Management Service (CRMS) formed the Spectrum Management Steering Committee (SMSC) in 2013 to devise a Spectrum Management Plan. The plan was an essential resource to guarantee the Quality of Service (QoS) of communications and broadcasting for tens of thousands wireless devices used in the Games. The spectrum policies were set by the Korean government. In addition, the Spectrum Management Plan of previous Games including London 2012, Sochi 2014 and Rio 2016 were taken into account in developing the Spectrum Management Plan for PyeongChang 2018.

Spectrum management and monitoring activities for the Games were started in 2017 which ensured appropriate allocation of spectrum and elimination of harmful interference.

2 Scope of Spectrum Management Plan

The scope of spectrum management plan of Korean government submitted to the International Olympic Committee (IOC) in 2010 included the followings;

1) Spectrum allocation; 2) spectrum usage approval; 3) compliance testing (testing & tagging); 4) monitoring and enforcement of interferences.

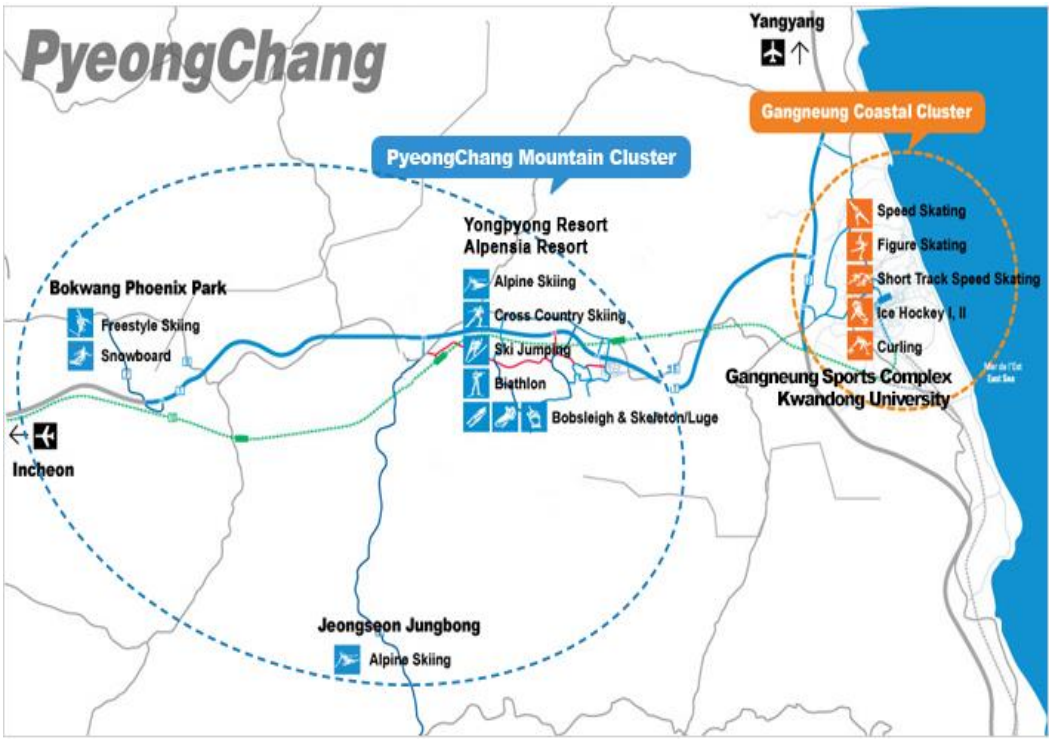
Spectrum management during the Games had the following objectives:

1) Determine available spectrum and establish spectrum usage plan
2) Secure a computerized system to apply for frequency use
3) Control access of wireless equipment to locations where the Games were held through compliance test (testing & tagging)
4) Guarantee the effective management of harmful interferences to ensure that users have high-quality of spectrum usage
5) Approve and guarantee the spectrum usage in compliance with prevailing legislation and regulations
6) Guarantee the disclosure of up-to-date information about spectrum management

Figure A9-1 shows the areas of spectrum usage in the Games. The areas were divided into mainly two Clusters, which were the PyeongChang Mountain Cluster and the GangNeung Coastal Cluster. These clusters had both competition venues and non-competition venues such as the International Broadcasting Centre (IBC) and supporting facilities for the Games

FIGURE A9-1

Areas of spectrum usage for the 2018 PyeongChang Games



3 Organization and Activities for Spectrum Management & Monitoring

The main organizers of SMSC for the PyeongChang 2018 Winter Games were the MSIT, RRA and CRMS. To devise and execute the spectrum management plan, SMSC had to carry out in advance the following activities:

1) Get in contact with major spectrum users (Olympic Broadcasting Services and Right Holding Broadcasters) in advance, giving them the due prioritization.

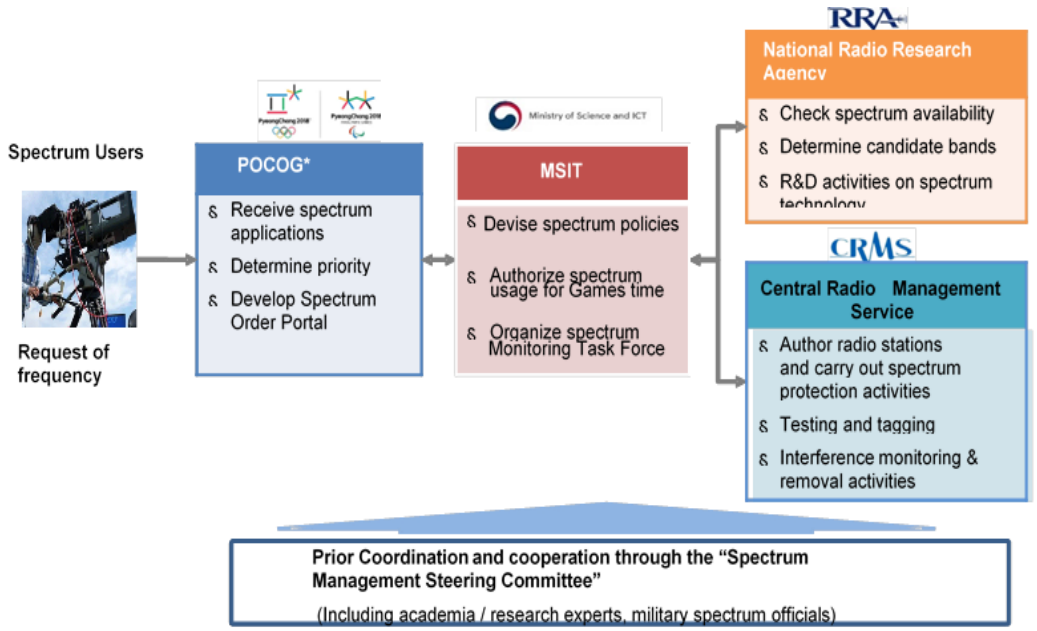
2) Provide spectrum users with POCOG spectrum manager's contact information to facilitate communication. Carry out promotional activities, such as sending out newsletters and guidelines, in advance to reduce the number of late applications.

3) Notify users of spectrum guidelines in advance to prevent the illegal use of spectrum.

Figure A9-2 shows the basic roles and responsibilities of each organization within the SMSC.

FIGURE A9-2

Roles of SMSC in spectrum management and structure of operations



4 Process to request for spectrum usage and approval

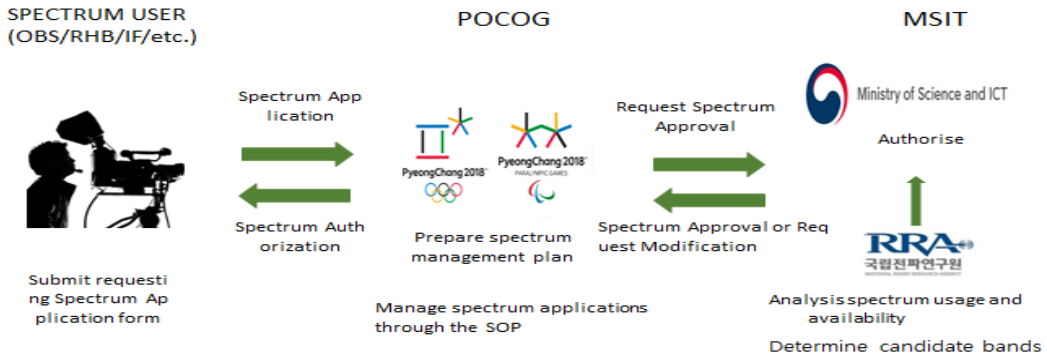
Spectrum demand management was done using the Spectrum Order Portal (SOP) developed by POCOG. All applications were analysed by POCOG and given due prioritisation before being submitted to the MSIT for approval.

POCOG has conducted a thorough analysis of requests and optimized the spectrum application process with the MSIT and other main organization to prevent the request of unnecessary spectrum. For example, analysis was conducted to see if spectrum was requested in unnecessary locations or if users requested backup spectrum.

Figure 3 shows the process of spectrum request, authorization and approval.

FIGURE A9-3

Process of spectrum request, authorization & approval



Although the radio equipment of domestic Olympic participants such as domestic broadcasters and athletic association should apply for frequency according to the above process as well, however a permission to use the radio equipment in accordance with the radio regulations in Korea must be obtained in advance.

5 Spectrum Order Portal (SOP)

The Spectrum Order Portal (SOP) was used for managing the spectrum demand from applicants through the form of spectrum order as shown in Fig. A9-4.

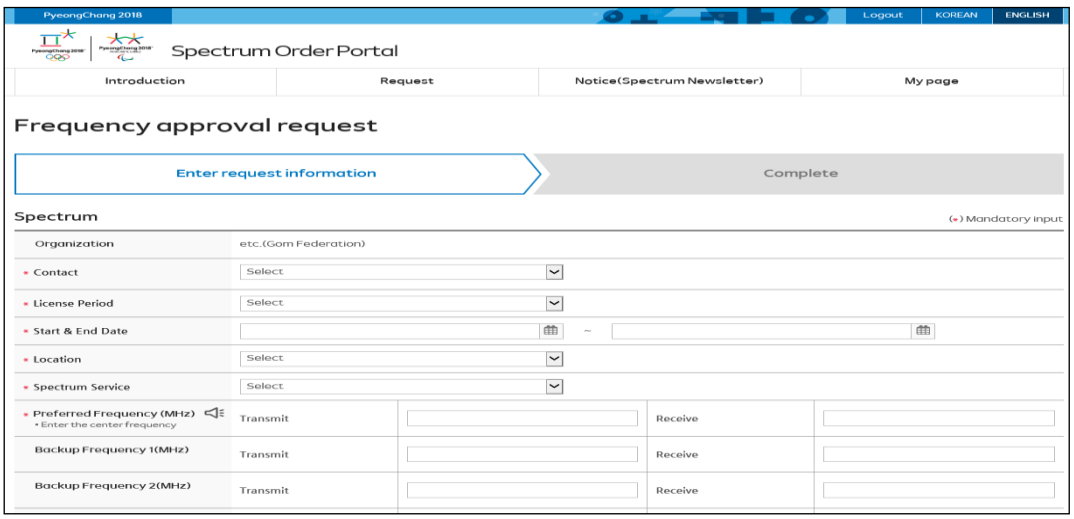
Spectrum users access the SOP to submit and manage their spectrum application as well as the status updates. A Spectrum Application User Guide, which was a detailed explanation on how to apply for spectrum, supported the usage of the SOP.

For the effective usage of spectrum, spectrum users can also cancel any spectrum no longer required during the Games through the SOP or at any nearby on site spectrum management office.

The SOP included in the spectrum application form the following items: usage periods including start and end dates, location of the spectrum usage, technical characteristics of the equipment, desired frequency bands and other information requested in the regulations.

FIGURE A9-4

Spectrum Order Portal



6 Spectrum Application Methods for Spectrum Users

Two methods were available to request for spectrum by Olympic members. The first was through the SOP if a few frequency ranges were requested. However, for many frequency ranges, an Excel spreadsheet form was published on the official web site of the Games together with the Spectrum Management Plan. Applicable users had to contact the POCOG beforehand to make sure they are intended to use the excel spreadsheet form.

Spectrum users could submit applications to the POCOG through SOP for spectrum usage. Some spectrum users who were unable to submit their applications in time or requested for the allocation of a different frequency could receive on-site help from the Spectrum Monitoring and Enforcement Team that had members from all the relevant government organizations. However, the frequency assignment was not guaranteed for users who were not able to submit their application in advance.

To obtain the official frequency authorization from POCOG, spectrum users received a "Temporary Frequency Usage Approval" document which was based on the MSIT's frequency authorization.

7 Compliance for Testing & Tagging

Before the start of the PyeongChang 2018 Winter Games, the CRMS verified the conformity of frequency parameters, compliance testing and tagging wireless devices. Users that require the use of wireless equipment before the start of the Games must specify the period of usage on their spectrum application and must have their equipment tested & tagged in advance. Users who applied for frequencies for the Games had to bring all their wireless devices to the POCOG for testing and tagging.

POCOG supported testing & tagging for users who had more than 30 pieces of equipment. For equipment that could not be brought to the POCOG, such as broadcasting equipment inside the TV compound, POCOG went to the user's location for testing & tagging directly. Moreover, POCOG announced and demanded all users to ensure that all their wireless devices were correctly configured before bringing them to Korea.

If a wireless device failed compliance test and the irregularity could not be rectified, POCOG would attach to it, a "Use Not Permitted" tag. The spectrum users were responsible for configuring any wireless devices found to require frequency reprogramming during compliance testing.

After testing compliance, the devices were tagged with a distinct colour associated with each venue cluster, indicating that its transportation and operation were authorised. Security teams were instructed to hand over any person operating untagged wireless device or operating devices with tags allocated for another cluster to the POCOG. The unauthorised equipment was confiscated by POCOG and CRMS.

8 Candidate Frequency Ranges for the PyeongChang 2018 Winter Games

The POCOG defined a list of candidate frequency ranges for the Games based on the Korean spectrum policies through collaboration with RRA and MSIT as indicated in Table A9-2.

TABLE A9-2

Candidate frequency ranges for device

Device	Frequency Ranges (MHz)	Allocation Purpose in Korea	Allocation Availability
Wireless Cameras	5 250-5 350		Available
	5 470-5 725	Small drones	Available
	5 725-5 850		Limited Availability
	6 400-7 300		Limited Availability
Mobile Microwave Links	5 925-7 000		Limited Availability
	10 300-10 450		Limited Availability
Fixed Microwave Links	17 700-17 740		Available
	19 260-19 300		Available
Handheld Radio, Walkie-Talkie	136-174		Limited Availability
	310-328.6		Limited Availability
	403-698	TV Broadcasting	Limited Availability
Wireless Intercom or Talkback	2 400-2 483.5		Available
Telemetry & Telecommand	216-328.6		Limited Availability
	406.1-470		Limited Availability
	2 400-2 483.5		Limited Availability
Wireless Microphones	470-698	TV Broadcasting	Limited Availability
	740-752		Available
	917-940		Limited Availability
	2 025-2 065		Limited Availability
IEM & IFB (In Ear Monitor & Interruptible Feed Back)	72-76		Limited Availability
	137-216		Limited Availability
	470-698	TV Broadcasting	Limited Availability
	894-904		Limited Availability
Permanent & Transportable Earth Station	12 750-14 500		Limited Availability
	24 650-30 000		Limited Availability
Wireless LAN (Wi-Fi)	2 400-2 483.5		Available
	5 150-5 250		Limited Availability
	5 250-5 350		Available
	5 470-5 650		Available
	5 725-5 825		Available

Allocation availability indicated as “Available” signifies that the frequency may be used for the planned application, shared with existing services, but there is a possibility of interference.

9 Spectrum Reuse Locations

In order to manage the limited amount of radio spectrum resources effectively, POCOG reused the same spectrum in different regions according to the characteristics of the frequency and wireless

devices. POCOG divided the locations for spectrum reuse according to the output power of the wireless devices. POCOG and MIST divided locations per zone for devices with output power of five watts or less and divided locations per venue for devices with output power of 0.1 watt or less.

Taking geographical characteristics into consideration, the spectrum reused zones for devices with output power of 5 watts or less were divided into the following four zones:

1) Alpensia Zone, 2) Jeongseon Zone, 3) Bokwang Zone, 4) Gangneung Zone

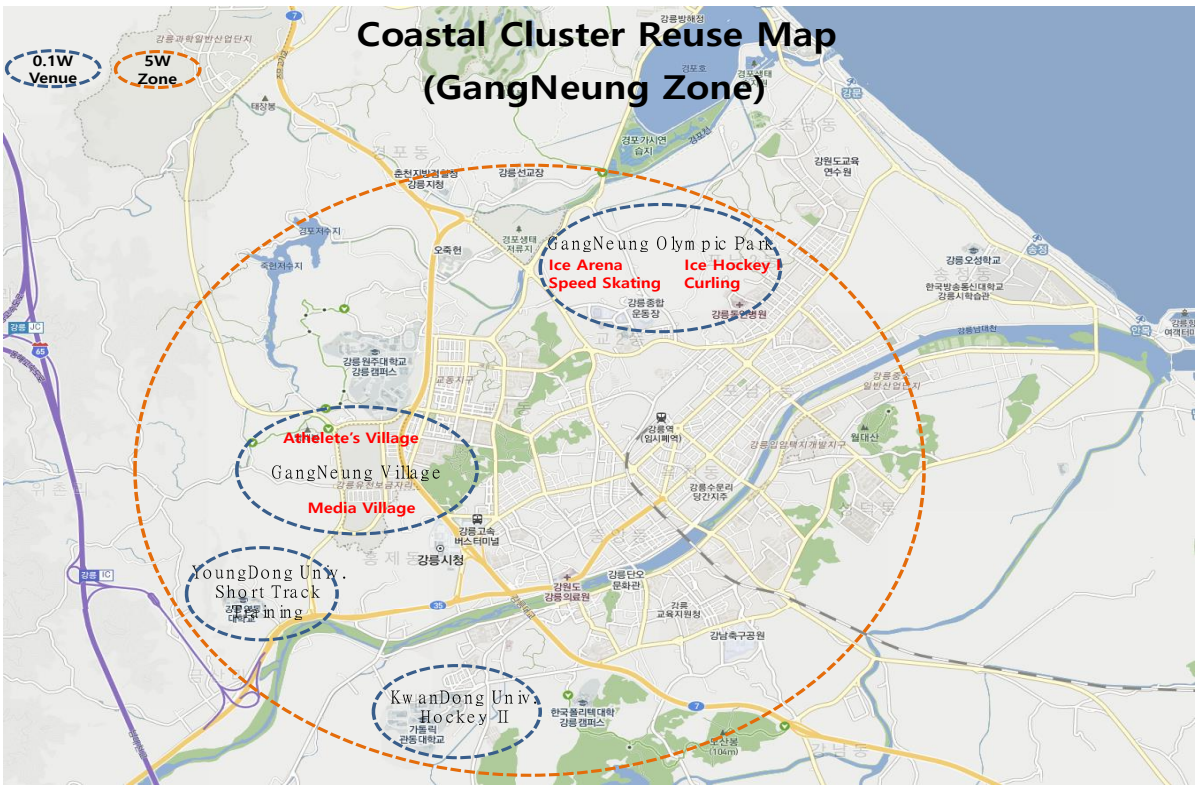
Figure A9-5 shows the spectrum reuse zones in the PyeongChang Mountain Cluster and GangNeung Coastal Cluster

FIGURE A9-5

Total map for spectrum reuse locations

Alpensia Zone for Centre of Mountain Cluster

Coastal Cluster



10 Result for spectrum usage and monitoring

Pre-approval and on-site approval of Radio frequencies in the PyeongChang 2018 Winter Games is summarized in Table A9-3.

TABLE A9-3

Results of pre-approval and on-site approval

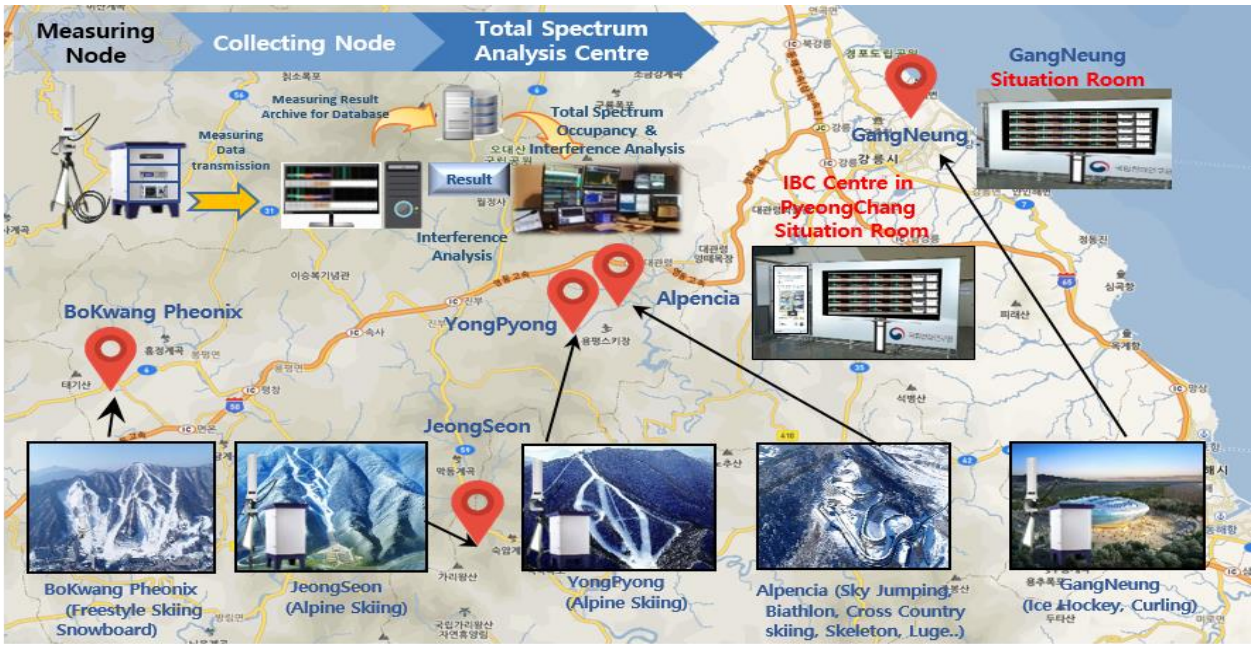
	Pre-Approval (~ Jan 2018)	On-site Approval			Total
		Winter Olympic	Winter Paralympic	Sum	
Number of frequency assignments	10,311	556	110	666	10,977

The spectrum management followed a process for pre-analysis and pre-approval to authorize a frequency through a specific system called “Radio frequency Diagnostics and Environment Monitoring System (hereinafter referred to as "RDEM")” from 2016 to 2017.

The RDEM measured the radio environment before and after the Games. The configuration of the RDEM is shown in Fig. A9-6.

FIGURE A9-6

RDEM Configurations



The RDEM configured three systems and measured 20 sites, which were located at mountain area (mountain cluster), sea area (costal cluster), and rural cluster in the Games. Figure A9-7 shows the result of real time spectrum usage at four different sites in the Games.

FIGURE A9-7

Result of real time spectrum usage

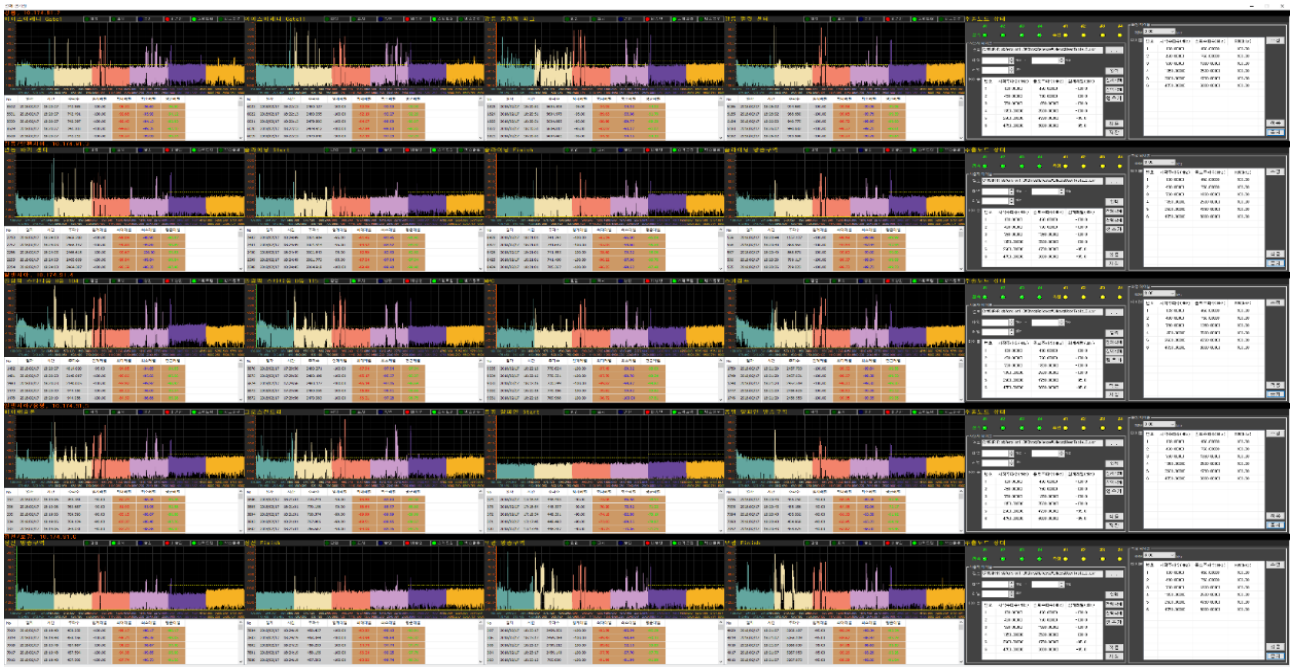


Figure A9-8 shows the spectrum monitoring activities.

FIGURE A9-8

Spectrum monitoring activities

In order to perform on-site spectrum management, monitoring and enforcement activities, a team was formed mainly by the MSIT, RRA and CRMS. The team constantly monitored the spectrum usage in order to identify any harmful interference and illegal spectrum usage to protect the frequencies allocated for the PyeongChang Winter Games that ultimately supported Korea to host a successful Olympics.

Radio frequency direction finding vehicles were stationed outside the venues in order to quickly locate and eradicate sources of interference. For the indoor venues not accessible by vehicles, mobile monitoring system installed with cutting edge radio frequency sensors was used to analyse real-time frequency usage.

The management process for interference incidents was as follows:

1) Notify to the POCOG as soon as interference is detected.
2) Request users with equipment causing interference to turn it off.
3) Negotiate the use of an alternative frequency (determine the frequency re-configuration functionality of user's equipment).
4) Request alternative frequency from RRA.

The Spectrum Monitoring and Enforcement Team attached a "Do not use (device)" tag to any untagged device and prohibited it from being used as indicated in Fig. A9-9.

FIGURE A9-9

"Do not use (device)" Tag

The result of activity for the "Spectrum Monitoring and Enforcement Team (SMET) was as follows:

1) Total number of interference elimination for 2018 PyeongChang Winter Games: 43 cases.
   - GangNeung Zone: 18 cases
   - PyeongChang (YongPyong) Zone: 18 cases
   - BoKwang Zone: 6 cases
   - JeongSun Zone: 1 cases
2) Number of cases of detection, finding, and elimination of unauthorized wireless equipment: 8 cases
   - GangNeung Zone: 3 cases
   - PyeongChang Zone: 1 cases
   - BoKwang Zone: 3 cases
   - JeongSun Zone: 1 cases

Reference

[1] "Radio frequency Spectrum management plan" for the PyeongChang 2018 Winter Olympic and Paralympic Games, PyeongChang Organizing Committee for the 2018 Olympic and Paralympic Winter Games (POCOG), April 2017.