

SVG
VENUE
INITIATIVE
WHITE PAPER

**RECOMMENDATIONS FOR
SPORTS VENUES:
Wireless Device Management
and Frequency Coordination**

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SECTION C: WIRELESS DEVICE MANAGEMENT AND FREQUENCY COORDINATION

PURPOSE

The purpose of this section is to be a resource of peer-reviewed best-practice guidelines for venue operators and other interested parties in the day-to-day operational deployment and management of all wireless Radio Frequency (RF) technologies commonly used in sports/entertainment venues.

CONTENTS

- C1. Basics of RF and Wireless Devices
- C2. Operational and Communication Best Practices
- C3. Technical Best Practices
- C4. Future Considerations and Technologies
- C5. References and Resources

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C1. Basics of RF and Wireless Devices

The convenience and relative ease of use of wireless devices has created an enormous amount of flexibility for broadcasters, event producers, and venues.

There can be limitations and problems in the use of these devices if they are not managed.

Most devices used for live audio- and video-production work within the same frequency bands, and, given that the number of devices is increasing, there is a need to plan and organize the available spectrum. It is common for a large sports event to have in excess of 200 individual wireless devices and an equal or greater number of frequencies in use simultaneously within the confines of an arena or stadium. Also, a great number of devices may not be directly involved in production of a show but could have an impact on the show's wireless equipment.

One rogue wireless device can ruin an event.

The following paragraphs will cover a brief definition of RF, some of the common issues that arise with multiple RF sources, and where one can find additional reference material.

For the purposes of this paper, we define RF as a modulated signal emitted by a device used to transport information. The information in an RF signal can be analog or digital and can contain audio, video, and/or data. Transmission of these signals is determined by the RF-output power, the coupling to and type of antenna used, atmospheric conditions, and physical obstructions in the intended path. Generally, production equipment that has been maintained and not intentionally modified will have the proper antenna and antenna coupling, and atmospheric conditions are usually beyond the control of the production crew. The output (transmit) power is usually fixed in most devices. Some devices have a variable output power to allow use under various applications and conditions. More problems can arise from increased power output than are solved, such as overloading the receiver, creation of noise in the signal, and additional multi-path. (In multi-path, the same signal arrives at a receive antenna at different times due to reflections off walls and obstacles. Generally, the power output of the transmitter does not need to be adjusted.)

TABLE 1: COMMON WIRELESS DEVICES USED IN U.S. SPORTS VENUES

Device Type	Frequency Bands
Two-way Radios (walkie-talkies)	462-467MHz UHF; other bands including 500 MHz, 800 and 900 MHz
Wireless Microphones	470-698MHz UHF TV; other bands including 902-928MHz, 944-952MHz
Wireless Intercoms	470-698MHz UHF TV; other bands including 900MHz and 2.4GHz. 5GHz (FHSS)
Wireless Broadcast Video Cameras	2GHz, 5.8Ghz, 6.4GHz
Wireless HDMI	2.4GHz and 5GHz
Microwave Transmitters (News ENG Trucks)	Ch 1-7, 2GHz band; Ch. 8-10, 2.5GHz band
WiFi	2.4GHz and 5GHz
Cellular DAS	2G/3G/4G; 800MHz or 1900MHz; LTE/WiMax; 700MHz, 1700-2100MHz, 2500-2700MHz
Point-of-Sale Devices	2.4GHz and 5GHz
Ticket Scanners	2.4GHz and 5GHz
RFID	433MHz-UHF, 900Mhz, 2.4GHz - 5.8GHz
Bluetooth, BLE, iBeacon	2.4GHz
Wireless Control (DMX512, Z-Wave, ZigBee, etc)	900MHz, 2.4GHz, 5GHz (FHSS)

COMMON ISSUES

Radio waves are analog: they are linear and susceptible to influence from the physical world, including other RF signals. Some of this influence is helpful, but, more often, the impact is detrimental to the proper transmission and reception of a wireless signal. The most common problems are the result of multiple signals’ influencing each other and creating a signal that a receiver cannot lock to or so distorting the signal that the information being transported cannot be recovered. Additional issues include:

- **Phase Alignment**

When two or more RF signals of the same or very close frequency are combined, intentionally or unintentionally, the phase alignment of the two signals plays an important role. The phase alignment of the signals being combined determines whether the signals add to or subtract from one another. If the signals are aligned in time, the resulting signal will add together and have an increase in signal level. However, this is rarely the case, and the misalignment degrades the signals, resulting in a drop in signal. In a worst-case situation, the signals will cancel each other enough to be unusable. Many digital systems are robust enough that they are still able to recover the information, but this is not guaranteed and risk of dropouts or lost data is still very much a possibility.

- **Harmonics**

Another potential problem for RF signals, harmonics are multiples of a fundamental transmitting frequency and are generated from non-linearities in electronic components (most notably, the final-output amplifier). For example, if a device is transmitting on a frequency of 300 MHz, the resulting harmonics would be 600 MHz, 900 MHz, 1200 MHz, and so on.

- **Intermodulation**

Generated when transmitting signals are combined due to close proximity of the devices. The result of two signals' combining is a signal with a frequency that is the sum and the difference of the two original fundamental frequencies and all the multiples of those new signals. These new signals, though lower in signal level, can, and often do, impact other signals for worse. Part of spectrum management is not just making sure that two operators are not on the same frequency but that these spurious signals are not going to impinge on desired signals.

- **Noise**

A third type of interference and the product of RF interference, noise can be in any number of forms, such as electromagnetic interference (EMI) from motors, lighting fixtures, or power lines or from other RF signals' creating distortions to the signal. Although this type of interference is not always avoided by spectrum management, consideration must be given to where the RF gear is set up in the venue. Noise can also be the result of interference being audible and in the form of dropouts. Analog information contained in a wireless signal can acquire buzzing, pops, crackling, or other harsh sounds. Digital signals are less susceptible to noise being generated at the output, but, instead, the audio usually drops out or is muted when the receiver cannot recover the information from the signal. In both cases, it is possible for the equipment to have adequate signal input but poor quality or loss of the recovered information.

UNIVERSAL GUIDELINES FOR THE USE OF WIRELESS SYSTEMS

Regardless of the application, size, or type of venue, there are basic universal guidelines for effective use of RF technologies. Many of these guidelines are about reducing the possibility of problems before they have a chance to manifest themselves. Additionally, planning and communication between the venue and the end users, testing, and verifying frequencies before the event help to locate problems and establish a means to resolve them.

- **Reduce the RF confusion**

While wireless devices have added flexibility and convenience to any sort of event or broadcast production, this does not make them completely indispensable. If setup time and location permit, using a cable to connect devices has advantages.

- If it can be wired, wire it.
- Troubleshooting becomes more direct and efficient.
- Well-maintained cabling and connectors provide a high degree of reliability.
- It can cost less. Generally, wireless devices are more expensive to rent, deploy, and operate.

Although using a cabled connection is still not free of problems, such as EMI and poor grounding, tried-and-true methods of running cables away from power sources/lines and using balanced cabling help minimize these issues. Additionally, the increased availability of fiber-optic systems for audio, video, and data provide additional robustness by not being susceptible to EMI and grounding problems.

- **Unused Devices**

Another common-sense step in preventing RF problems is to turn off any unused device. If a device is not needed as a main or backup, this unit should be shut down. If this unit is part of the production's usual complement of equipment, this should be communicated to the frequency coordinator in case the need to use it arises.

- **Systems that cannot be turned off in the venue**

There are some systems and devices that cannot be shut down. Some can seem unimportant: for instance, wireless control systems, such as remote controls for AV in premium suites or temperature controls for food service and HVAC. Others — such as LED scoreboard displays and new security RF systems (face recognition, bio-scanners, etc.) — that are often added to a venue over time need to be identified by the frequency coordinator. All these devices can generate unwanted noise in wireless and cabled systems, and, therefore, their frequencies and, if possible, locations should be identified and communicated.

- **Two-Way Systems**

Two-way communication systems, such as walkie-talkies or radios, are also systems that cannot be shut down and need to be listed. Multiple two-way systems are not uncommon in a venue, and, like other wireless devices, their spectrum needs to be managed and monitored to prevent conflicts and malfunctions. Some two-way applications are critical, such as emergency personnel and police. Emergency-system frequency bands are set aside by the FCC, and an increasing number of cities are implementing very robust antenna and repeater systems, so it is unlikely that common wireless-production equipment will interfere with them. Thorough communication is the key to successful coordination.

Additionally, media and production crews can bring portable two-way systems that can cause problems with each other. Simply communicating the frequencies and channels that each system has and working with the frequency coordinator to plan for their use can prevent conflicts. We will address methods for acquiring this information in Section C2.

- **WiFi/DAS**

Another RF system that has become as ubiquitous as wireless microphones is WiFi. Many venues are increasing their capacity to provide “public” WiFi for the fans attending an event as well as back-of-house operations. Knowledge of these networks is helpful in planning and setting up any additional temporary networks or making use of available bandwidth in a venue. Many production crews prefer to operate on their own WiFi network or even MiFi networks rather than a public one. The frequency coordinator would need to be made aware of intended use and location of access points and should have and share information for the production companies about areas of high WiFi-device use, such as point-of-sale and ticket-scanning devices and the wireless networks contained in the venue.

- There is also a number of wireless intercom systems from multiple

manufacturers in this spectrum as well as other production-control devices that are non-WiFi. These devices may use Frequency Hopping Spread Spectrum (FHSS) technology, which allows superior performance within the 2.4-GHz WiFi and 900-MHz bands. These FHSS systems may have an impact on the general WiFi system of the venue so it is important to provide frequency coordination.

- Cellphone distributed antenna systems (DASs) will also need to be identified and documented, especially any temporary or portable Cell on Wheels (CoW) systems that wireless and cellphone providers add for large events.

TESTING

Finally, an “all-hands” test should be done before air/event time. This would require all wireless users to switch on their transmitters and receivers at the same time and test for interference. Each user should be monitoring their equipment through the entire path to ensure that there are no dropouts or other objectionable artifacts. If possible, the frequency coordinator should take this time to electronically sweep the venue looking for potential problems and helping to resolve any conflicts.

RESOURCES

A number of resources are available for both event producers and end users to help manage spectrum and prevent common problems. Many markets have AV companies that offer frequency-coordination services. Additionally, the Society of Broadcast Engineers (SBE) maintains a list of frequency coordinators throughout the U.S. Manufacturers also provide a great deal of support both from a customer-service standpoint and with educational materials on their Websites. Either of these options would be a good place to start planning or reviewing an RF plan. There are also software tools available for the frequency coordinator. These vary in completeness; some are free, others are for purchase. Books and other publications can also be obtained from the SBE and the National Association of Broadcasters (NAB). Helpful resources are listed in Section C5.

C2. Operational and Communication Best Practices

Communication is the best tool to prevent problems in using wireless devices. The most important best practice is **assigning a designated frequency coordinator** for your venue, someone from the venue or designated by the league or client who will maintain the frequency database, communicate with end users, and help resolve conflicts. The purpose of the frequency coordinator is to coordinate every wireless device in a venue to ensure that everyone has a space to operate in. This person is there not as an enforcer but rather as a resource for all parties. Each customer/production company involved in an event should also designate a contact person to work with the frequency coordinator and be responsible for the RF systems. News and media personnel using wireless gear should also be in contact with the coordinator.

OPERATIONAL INFORMATION: GATHERING AND SHARING

What information needs to be gathered? The short answer is everything. Although this is a great deal of information to collect from any venue, most of the information will not change very frequently and can be documented once and carried over from event to event.

- **In-House Venue Devices**

First and foremost, you will want to know exactly what device type, frequencies, bandwidth, and locations your venue is using. A solid starting point would be to contact venue operations, vendors, and the primary tenants and simply ask what wireless devices they use and for what. The venue's technical-operations staff should be able to assist with any installed wireless AV systems. The operating frequencies will likely need to be researched, but, again, most of this information will not need to be updated very frequently. All wireless control systems and devices should be included in the survey, not just microphones and camera systems. The RF channels for all the local TV stations — UHF and VHF, Class A and low power — should also be listed.

Once this is documented, an RF sweep of the facility should be performed to find/verify and document the actual RF signals within the building. This sweep should be done outside as well as inside the building, where applicable. This sweep will provide a picture of the strength of signals outside the venue as well as a measure of what signals and their respective strengths are getting inside the building. These signals could be over-the-air TV, two-way systems, even 4G/LTE from a nearby cellular site. The sweep should be as broad as possible to get as complete a picture of potential sources of interference. There is also the possibility of broadcast auxiliary signals (typically, microwave transmissions) in the 2 GHz range entering the building and impacting wireless camera systems. In an enclosed arena, there is little chance of most signals getting into the building, but it's not impossible. A little extra time spent uncovering all possible problems could be beneficial one day. Several companies can provide this service, and most local SBE chapters have a designated area frequency coordinator or members who are contractors that can perform a RF sweep. A list of these resources can be found in Section C5.

Compiling the data on the RF systems existing in the venue is the next step. This can be done in any number of ways as long as the information is accessible and editable. A basic spreadsheet would fit this application nicely; an example can be seen in Table 2.

Table 2: FREQUENCY COORDINATION DOCUMENT EXAMPLE

				Event Date:	27-Jul-2013
Orlando Market FULL POWER DTV STATIONS					
Amway Center - Wireless A/V systems - ON only as needed for show or event					
Amway Center - Building Systems - Always ON and transmitting					
CALL SIGN	BLOCK	FREQ. MHz		SERVICE/USE	
WOPX - ORL		671.001	>	START OF UHF CHNL 48	<
		671.700		Shure UHF-R Microphone Bowl System	
		677.000	>	END OF UHF CHNL 48	<
WVEN - ORL		677.001	>	START OF UHF CHNL 49	<
		678.100		Shure UHF-R Microphone Bowl System	
		680.2750		UR24D/SM58 Dual Handheld Wireless System	Wireless AV
		681.5000		UR24D/SM58 Dual Handheld Wireless System	Wireless AV
		682.7250		UR24D/SM58 Dual Handheld Wireless System	Wireless AV
	BL 26 (691.1)	683.000	>	END OF UHF CHNL 49	<
		683.001	>	START OF UHF CHNL 50	<
	BL 27 (691.2)	689.000	>	END OF UHF CHNL 50	<
WHLV - ORL		689.001	>	START OF UHF CHNL 51	<
		695.000	>	END OF UHF CHNL 51	<
	BL 27 (716.7)				
		2425.0000		Wireless Thermostat Controller System	Building
		2450.0000		Wireless Thermostat Controller System	Building
		2475.0000		Wireless Thermostat Controller System	Building
		5470.000	>		<
		5725.000	>		<
		6425.000	>	START OF MOBILE ONLY BAND	<
		6437.5000		Link Wireless Camera system 1	Wireless AV
		6512.500	>	Link Wireless Camera system 2	Wireless AV <

Regardless of the format used for the RF database, there should be information on type of device, operating frequency, and the user information. A logical format that can be easily distributed and/or communicated to users and updated as changes are made on event day should be implemented. Ideally, the majority of the user information will be known well before the event. The frequency coordinator should establish a means of receiving information from the users (usually via an e-mail address) and set a deadline so the information for that event can be entered into the database.

This baseline database of all the permanently installed RF equipment and spectrum

use should be actively maintained for distribution to productions that will use all areas of the venue and handle their own coordination, such as a concert tour.

- **Client- or Production-Provided Devices**

The frequency coordinator should establish a means of receiving the following information from each venue client, ideally two to four weeks in advance of the event: device type, frequency, and user for each wireless device the client plans to use. One method is to provide an e-mail address for submitting device info and set a deadline so that the information for that event can be entered into the database.

Each venue should outline its RF policies to all users and clearly identify the frequency coordinator for the event. Although every venue and show will have unique needs and operational personnel, the basic need for information regarding equipment, responsible parties, testing, and compliance with the RF policies should be clearly outlined. The frequency coordinator is there to help and should not have to be the police, so the cooperation of all users is needed for the execution of a successful event.

Procedures for testing and checking can vary from location to location and event to event, but there should be some sort of pre-event check-in between the users and the frequency coordinator. This check-in can be as the users enter the venue, typically through the media-credentialing entrance or a designated meeting at the operating point. The location is not as important as the need to verify that the equipment being used is accounted for and is set up per the frequency plan.

Like the equipment check-in, a test of the RF equipment can vary from place to place, but there should be a time set aside to have all equipment from all users powered on.

HOW CAN THE INFORMATION BE GATHERED AND SHARED?

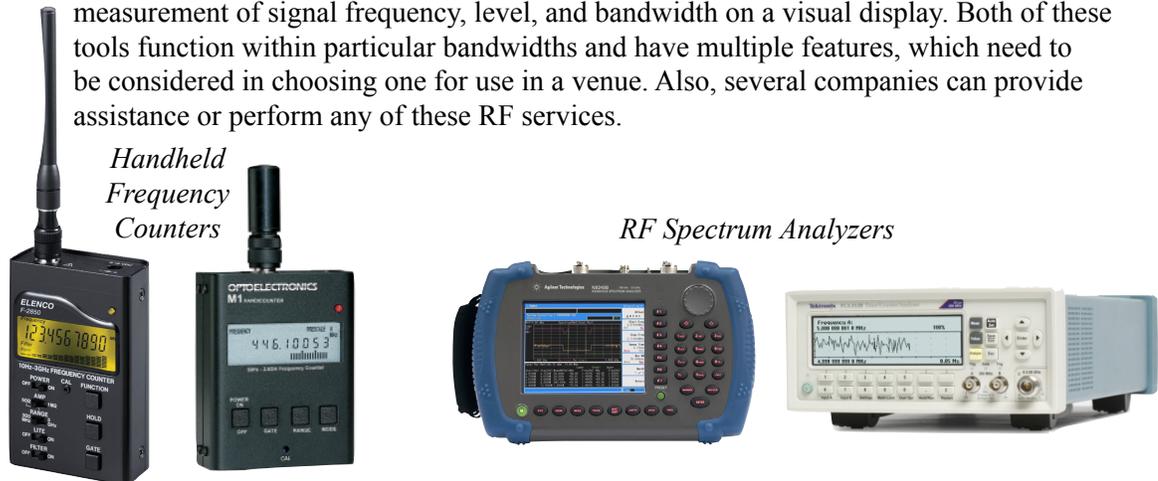
Asking questions is the first step in gathering the RF information. Many venues have multiple vendors working in the building both day-to-day and on event days. Most of these vendors are not concerned with the technical operation of any wireless devices that they use. Therefore, a series of questions will aid in digging down to the needed information. These can include:

- Do you use any wireless devices like WiFi, remote controls, or POS scanners?
- Who would use these?
- When are these units in use?
- Can these units be turned off?
- Do you have any paperwork or manuals for them. And, if you do, may I see them?

For event day, arrangements should be made to collect information on all wireless equipment coming into the venue. This would include the event production crew(s), broadcasters, media covering the event, and anyone using a wireless device. Collecting this information in advance of the event, primarily through the media-credentialing process, will aid in creating the frequency plan for event day and will make testing, changes, and additions easier. An e-mail address specifically for frequency coordination would be useful for

collecting the information that users provide. Some coordinators send out a form or list of questions with their requests; others may rely on event coordinators and show producers to get the information or to pass along the request and contact information. As users are setting up and during test time, a handheld frequency counter and/or spectrum analyzer would be useful.

These devices will enable the frequency coordinator to verify that everyone is on frequency and, by using a directional antenna, to track down interfering or uncoordinated signals. The frequency counter will detect and display the RF signal's frequency. In some frequency counters, the sensitivity can be set to give a more near-field pickup of the signals. This can help in measuring a specific device's output frequency. A spectrum analyzer enables measurement of signal frequency, level, and bandwidth on a visual display. Both of these tools function within particular bandwidths and have multiple features, which need to be considered in choosing one for use in a venue. Also, several companies can provide assistance or perform any of these RF services.



*Handheld
Frequency
Counters*

RF Spectrum Analyzers

WHO SHOULD GATHER AND SHARE THE INFORMATION AND ENFORCE THE PROTOCOLS?

The gathering and distribution of the information is the primary function of the frequency coordinator. This is the person who will maintain the frequency database, coordinate the RF plan, check the equipment, and address problems. Since the coordinator is usually the one working with the end users or their designated contacts to resolve problems, the coordinator is usually the person communicating the RF plan. The amount of information distributed to the end users can vary based on the user's need; the volume of information may make it impractical to distribute the whole database. Communication is vital to the coordination process, so it is usually better to provide too much rather than not enough information.

For frequency coordination to work and be a benefit to all parties involved, the coordinator needs to be aware of all wireless devices. There should be methods of communication both before and during the event to report the equipment being used and the frequencies that these devices operate. If a device has not been cleared for use during an event, that unit should not be deployed and certainly should not be powered on. Since there is the possibility that no two devices — even the same make and model — operate exactly the same, backup units should be reported just like main units even if they operate on the same frequency.

One critical protocol that will need to be developed by venue operations and communicated as part of the RF Plan for each event is the order of priority for device issues and RF-policy enforcement. A pecking order, a food-chain of sorts, should be established as a general guideline so that venue operators, clients, and device users know what to expect and where they stand in identifying and resolving non-compliance issues with others on a particular venue/show.

Different people, not just the frequency coordinator, can handle enforcement of the designated protocols. The primary need for enforcement is to make sure that no uncoordinated or unauthorized frequencies are used and/or causing interference with other devices. This can be handled by asking unauthorized users to shut down or by even collecting the antennas of the offending radios or confiscating the radios themselves until the event is over. Some venues may prefer to have their staff involved in enforcement of the rules; other locations may stay hands off and let the frequency coordinator or the show take care of it. The most important guideline for enforcement is that, to make enforcement effective, there must be full cooperation and consistency from the venue management, the team/tenant management, and the show producers. If there isn't a full buy-in from the management, inconsistent enforcement occurs, and some users will proceed with little regard for or knowledge of problems they may be creating.

Since the goal of frequency coordination is to help with the success of the event for all parties, consistency, cooperation, and tact will be the best tools for enforcing the rules.

If there is a problem, the situation should be reported to the frequency coordinator immediately. Since the source of RF interference can be difficult to locate, the user may be asked to move to a new frequency in order to expedite a solution. A clear RF Plan and Protocols will help expedite and facilitate a fair resolution. Users should not scan for new frequencies or resolve the problem by themselves. This can create a ripple effect that causes more problems than are solved. If a backup device has been set up and switching to this device has been coordinated, powering off the main unit would allow the coordinator to sweep for the interference and work with the users to resolve the problem.

C3. Technical Best Practices

The general rule of thumb for antenna placement is to place them higher than the transmitter. Although this is generally a good practice, many of today's transmitting and receiving antenna combinations work best when the components are in the same plane of use. There can be practical limitations with this, such as proximity to fans. Most venues will not let the antenna system block spectator line of sight, and the operator certainly doesn't need fans adjusting their antennas during the broadcast. The frequency coordinator, the user, and the venue should work together to find a location that optimizes height and line of sight for the transmitters and receivers and allows the fans to enjoy the show without an obstructed view.

Many systems use diversity antenna systems to receive the signal(s), and the distance to place these antennas comes into question:

- One-half or one-quarter of a wavelength is generally considered the ideal distance between antennas. A VHF wavelength is about 5 ft. A UHF wavelength is about 2 ft.
- It is possible to have the antennas too close together. When the two are very close, they start interacting with one another in the near-field and act as a single antenna. This will create intermodulation and phase artifacts at the receiver and can degrade performance.
- An approximation of a half wavelength between antennas should be fine for most applications.
- Wireless devices work best when there is a clear line of sight between the transmitter and the receiver. Any object between the transmit antenna and

the receive antenna will reflect and absorb the RF energy to some degree. This interference can cause any number of problems with clear reception of the signal and can create problems for other users. Attention to potential obstructions should be considered when placing antennas. Essentially, if the receive antennas cannot be seen from the transmit point, the signal cannot “see” the antenna either.

- Locations will need to be reviewed and agreed to by both the users and the venue to ensure that the antenna is not placed in an undesirable or view-obstructing location.
- Cabling from the antennas to the receiver should be minimal, and, for multiple antennas, the cables should be equal in length.

C4. Future Considerations and Technologies

The most immediate concern for wireless users is the upcoming broadcast-television–spectrum repack. The broadcast-spectrum repack will not only limit the spectrum available for wireless production equipment but may also require new equipment capable of operating at tighter RF requirements. All of this will almost certainly increase the need for RF coordination and planning. This spectrum repack is part of the National Broadband Plan laid out by the federal government in 2010 as roadmap for providing broadband data service to as much of the country as possible.

The spectrum available for wireless devices is currently at a premium for some events, and the spectrum repack will reduce the white spaces between TV signals in the 600 MHz range. Currently, the FCC has allotted two 6-MHz TV channels in each market for wireless use; under the new plan, this will be reduced to a single channel and will need to be shared with other White Space devices. Additionally, a plan for a guard band between television broadcasters and the wireless-data providers may be made available for wireless use. Under the FCC rules, venues are eligible for licensing of their wireless gear, and this can greatly assist in coordination of frequencies between venues and local and regional media and broadcasters.

New technologies may be needed to accommodate the tighter spectrum spacing and ever increasing number of wireless devices. Tighter RF filters, advanced digital modulation, and smart antennas might be some of the new technologies implemented in new wireless production equipment. Some of the new microphone systems are being designed to operate on the channels available in a specific geographical area, and, should there be a conflicting signal, these units can search for a new frequency within those available channels.

Since the final TV-channel–allocation plan has not been set and the timeline for the channel repack has not been finalized, planning for these changes can be difficult. However, since there could be a sizable investment in new equipment, monitoring these changes would be advisable.

Some highlights from the FCC’s Notice of Proposed Rule Making (FCC 14-145) regarding wireless microphones from the September 30, 2014, public meeting.

The Commission proposes:

- To allow unlicensed wireless microphones to operate in the TV spectrum on

channels 2-51, excluding channel 37 in all locations. ... Since the number of TV channels that will be available for unlicensed wireless microphones will be reduced after the incentive auction, the Commission also proposes to add an advisory in the rules indicating that the highest channel available for wireless microphones will be determined by the outcome of the incentive auction and will be modified consistent with the auction results.

- To permit wireless microphones to operate with a power level to the antenna of up to 50 mW in both the VHF and UHF TV bands.
- To allow unlicensed wireless microphones to operate in certain segments of the guard bands and duplex gap. Specifically, to allow unlicensed wireless microphones to operate in the same 6-MHz portion of the duplex gap as White Space devices.
- That unlicensed wireless microphones operating in the guard bands and duplex gap operate with a maximum conducted power output of 20 mW to the antenna. This is less than the 50-mW power level proposed for unlicensed wireless microphones in the TV bands.
- The Spectrum Act states that the Commission may permit unlicensed use of the guard bands and stipulates that (a) unlicensed use shall rely on a database or subsequent methodology as determined by the Commission and (b) the Commission may not permit any use of a guard band that the Commission determines would cause harmful interference to licensed services. The Commission's Part 15 rules already require that unlicensed devices not cause harmful interference to and must accept interference from authorized users.

The FCC has made a point to address the rules for the operation of wireless microphones. This could have the advantage of giving users a clearly defined set of operating guidelines. Even in their current vague state, these new rules and any that are forthcoming highlight the need for venues to have an RF-use plan and at least a minimum of event-day frequency coordination.

C5. References and Resources

Full FCC 14-145 Document

http://transition.fcc.gov/Daily_Releases/Daily_Business/2014/db0930/FCC-14-145A1.pdf

Society of Broadcast Engineers, Frequency Coordination Resources

http://www.sbe.org/sections/freq_local.php

Examples of Frequency Coordination Forms/Questionnaires

<http://freq.professionalwireless.com/lib-2013.aspx>

Useful Tools in Collecting Over-the-Air-TV Information

<http://www.antennaweb.org>

SOFTWARE TOOLS

Shure Wireless Workbench

<http://www.shure.com/americas/products/software/wireless-workbench>

Professional Wireless IAS (Intermodulation Analysis System)

<http://www.professionalwireless.com/ias>

MANUFACTURER WEBSITES AND TOOLS

Cisco

<http://www.cisco.com/c/en/us/td/docs/wireless/technology/wlc/82463-wlc-config-best-practice.pdf>

Shure

<http://www.shure.com/americas/support/tools>

Professional Wireless

<http://www.professionalwireless.com/faqs>

Sennheiser

<http://en-us.sennheiser.com/support>

**VARIOUS ARTICLES ON FCC REGULATIONS CONCERNING SPECTRUM
REALLOCATION AND VENUES**

<http://reboot.fcc.gov/reform/systems/spectrum-dashboard>

<http://www.commlawblog.com/tags/wireless-microphones/>

<http://www.fohonline.com/current-issue/74-tech-feature/10836-fcc-reallocation-update-is-there-a-frequency-in-your-future.html>

<http://www.fohonline.com/current-issue/75-company-411/11175-the-fccs-part-74-license.html>