# ETC Information Guide

## ArcSystem Wireless

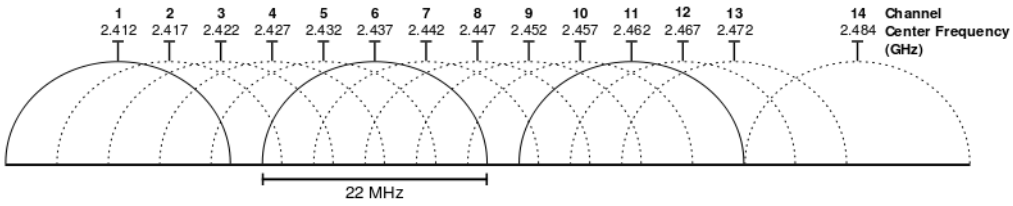
## Overview

This document describes the management of wireless systems operating in the 2.4 GHz ISM band to ensure coexistence with ArcSystem. It also details transmitter positioning suggestions and the ArcMesh System.

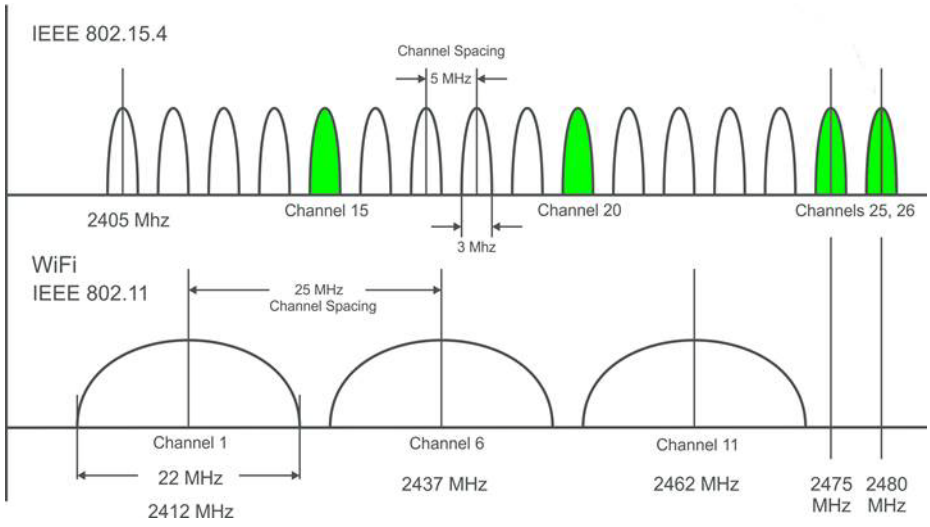
## Introduction

ArcSystem wireless nodes operate in the unlicensed 2.4 GHz ISM band using the IEE802.15.4 standard. This band is also shared with other technologies such as Wi-Fi (WLAN), Bluetooth, low power sensor networks, wireless AV transmitters, and some radio microphones.

### WLAN – 13 Channels 2.4 GHz ISM




WLAN networks are usually spread out across channels 1, 6 and 11. These are the only channels in the band that don't overlap other WLAN channels (assuming 802.11b/g 22 MHz channels). ArcSystem channels that are clear of WLANs operating on 1, 6 and 11 are channels 15, 20, 25 and 26 shown below in green. See how ArcSystem channels overlap the WLAN channels.

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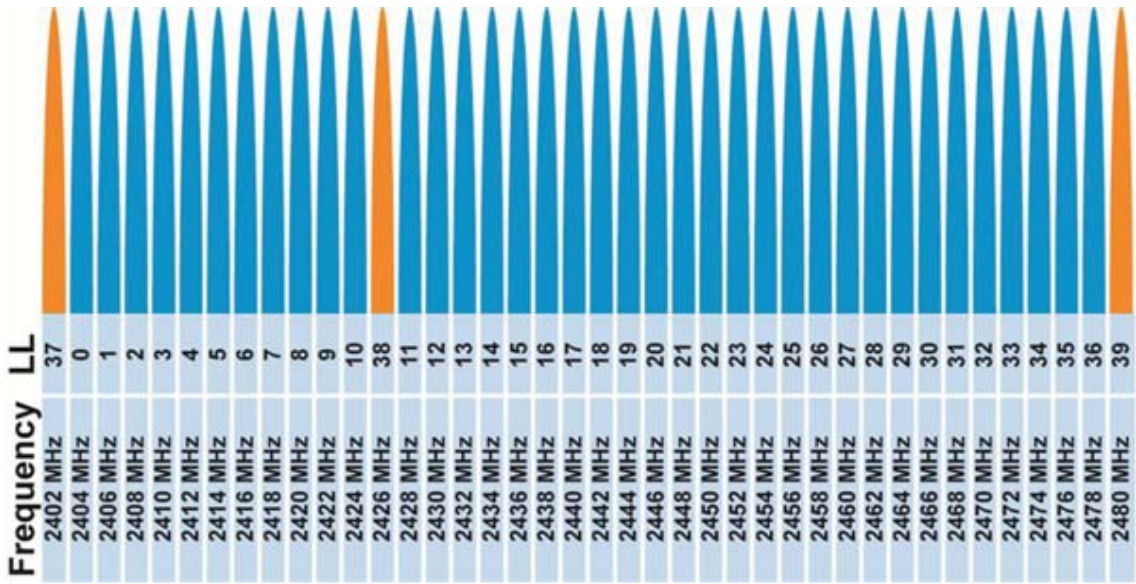
ArcSystem can occupy the same frequencies as a WLAN channel, however if the WLAN is very busy, this can cause latency issues with ArcSystem. This can be seen as a lag between transmitting a level and the fixture responding. In extreme cases where the WLAN AP is close to the ArcSystem node, this can stop it functioning altogether.

For co-channel operation, a physical separation between the WLAN AP and ArcSystem Gateway of 10 m (33 ft) is recommended.

### Bluetooth LE – 40 Channels 2.4ISM




Bluetooth interference is less of an issue for ArcSystem. The packet retry mechanism employed by the underlying 802.15.4 transport ensures re-transmission of packets corrupted by Bluetooth interference. Bluetooth may interfere with the first transmission attempt, but will usually have hopped to a different part of the spectrum for the retry.

To achieve satisfactory performance in the presence of Bluetooth interference, a physical separation of 2 m (6.5 ft) is recommended between the Bluetooth device and ArcSystem TX1 Wireless Transmitter.

### Line 6 Radio Microphones – 14 channels 2.4ISM

Line 6 wireless microphones and belt-pack transmitters operate across 12 or 14 channels in the 2.4 GHz ISM band.These channel numbers are not the same as WLAN or ArcSystem channels. The microphones can be operated in two modes, RF1 and RF2.

RF1 Mode - The transmitter sends encoded audio on 4 separate carrier frequencies spread out over the spectrum. This allows the signal to be received even when interference from other systems is present on some of these frequencies. When operating 12 transmitters in this mode, pretty much all of the spectrum is utilized. All other systems operating in the 2.4 GHz spectrum will suffer including WLAN.

RF2 Mode – The transmitter sends encoded audio on 2 separate carrier frequencies spread out over the spectrum. RF2 mode was introduced to allow WLAN to be used at the same time as the microphones.

| Line 6 Digital Wireless Transmission Frequencies By Channel | | | | | | | |
|---|---|---|---|---|---|---|---|
| **RF2 Mode** | | | **RF1 Mode** | | | | |
| **Channel** | F0 | F1 | F0 | F1 | F2 | F3 | F4 |
| **1** | 2425 | 2475 | 2402 | 2433 | 2448 | 2463 | na |
| **2** | 2422 | 2472 | 2404 | 2423 | 2453 | 2470 | na |
| **3** | 2402 | 2450 | 2406 | 2435 | 2457 | 2477 | na |
| **4** | 2447 | 2478 | 2407 | 2425 | 2443 | 2465 | na |
| **5** | 2428 | 2453 | 2408 | 2437 | 2449 | 2472 | na |
| **6** | 2430 | 2461 | 2410 | 2427 | 2454 | 2478 | na |
| **7** | 2433 | 2467 | 2412 | 2439 | 2459 | 2466 | na |
| **8** | 2436 | 2469 | 2414 | 2429 | 2451 | 2474 | na |
| **9** | 2413 | 2456 | 2415 | 2440 | 2445 | 2471 | 2426 |
| **10** | 2416 | 2458 | 2417 | 2430 | 2455 | 2468 | na |
| **11** | 2407 | 2464 | 2419 | 2441 | 2476 | 2476 | na |
| **12** | 2405 | 2439 | 2421 | 2431 | 2447 | 2464 | 2475 |
| **13** | 2419 | 2444 | na | na | na | na | na |
| **14** | 2410 | 2442 | na | na | na | na | na |

Output power 10 mW

2 Bands per channel RF2 Mode

4 Bands per channel RF1 Mode

### ArcSystem TX1 Wireless Transmitter Positioning and Transmission

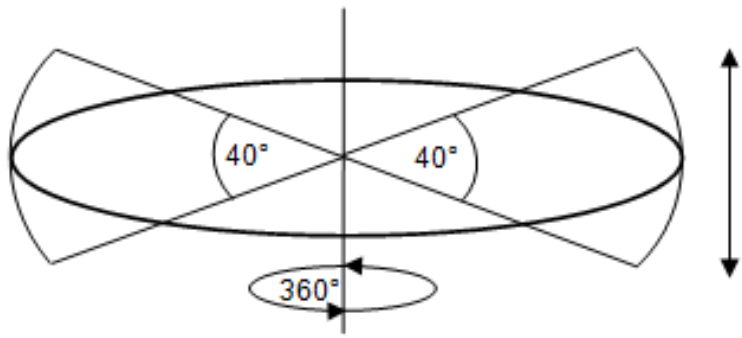
To establish a stable system, the positioning of the TX1 transmitter can make a considerable difference. Fixtures within the system will not necessarily connect directly to the transmitter; instead, fixtures can connect to each other to establish a connection. This is known as meshing.

As a result, fixtures outside the broadcast range can still establish a connection. The system becomes more reliable as more fixtures are introduced to the network. In smaller installations where only a few fixtures are used, positioning of the transmitter becomes more important. As there are fewer fixtures to establish a network, the transmission range will drop because fewer fixtures are connecting to each other. To ensure the strongest possible signal levels you will also need to consider the type of antenna used and its orientation in relation to the fixtures.

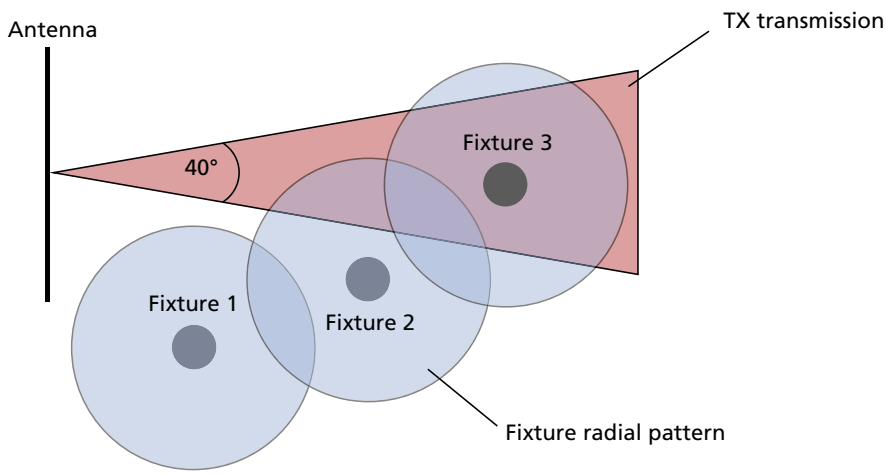
*For example:.*

The ArcSystem TX1 transmitter is supplied with a 5 dB antenna with a typical radiation pattern as shown.

With the antenna pointing directly up, as indicated to the right, you will have 360° coverage in the X plane and 40° coverage in the Y plane; thus achieving a disc shape coverage.

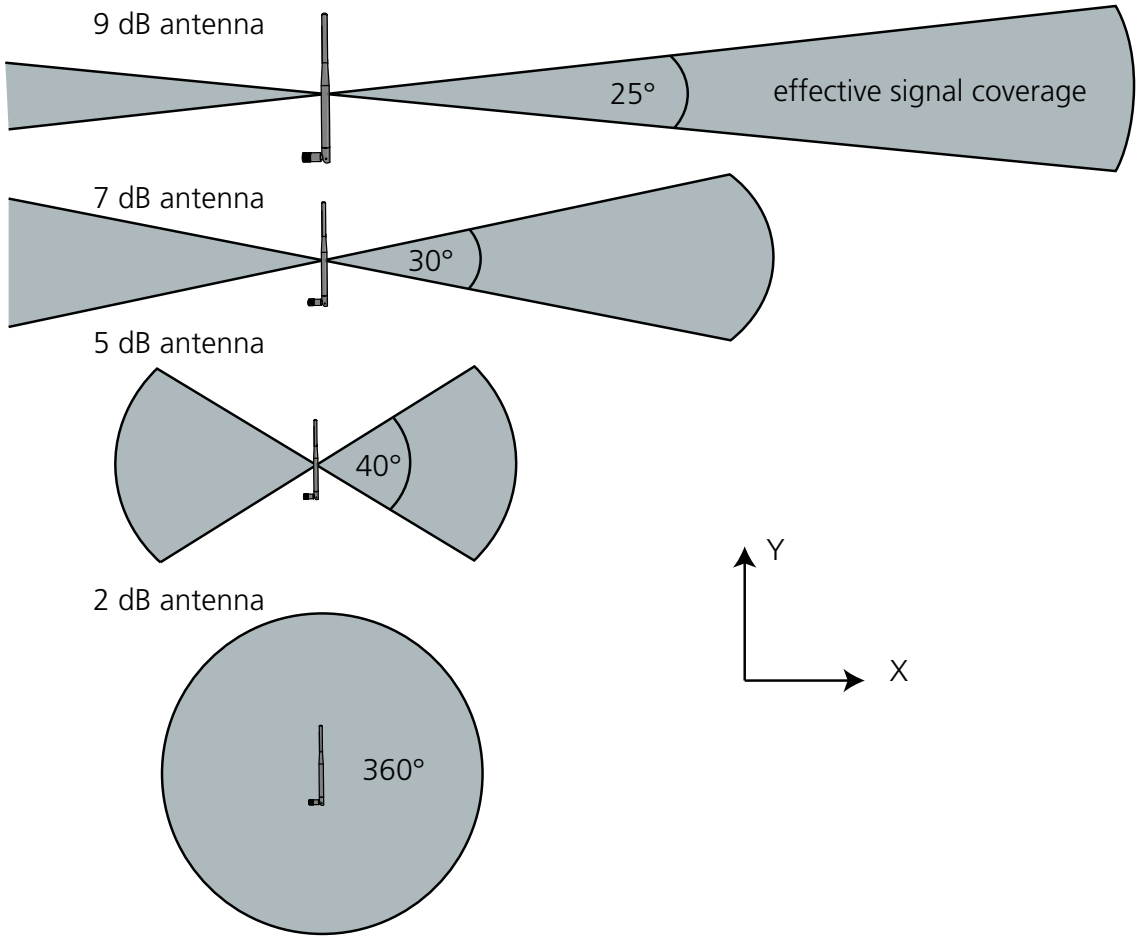



Fixtures within this coverage will be able to communicate directly to the transmitter.




A fixture's radial pattern is 360° in all directions, radiating from the button antenna. The illustration above shows how the fixtures' radiation patterns could overlap. As you can see, 2 fixtures are within the transmission path of the transmitter. These could talk directly to the transmitter (TX). However, fixture 1 is outside the transmission coverage of the transmitter, and therefore would need to talk through fixture 2.

If a fixture is outside the broadcast ranges of the transmitter and all other fixtures, it will not receive a signal. Positioning the transmitter within the same plane as the fixtures will lower the risk of this occurrence. In some cases it may not be possible to achieve this ideal and it may be necessary to explore other antenna options. Below are a few examples of antenna types.




As the antenna gain increases, radiation in the Y-Plane becomes narrower. The coverage in the X-Plane will increase. A higher gain antenna will not increase signal power; it will only alter the radial pattern of the transmission, just like a reflector in a flashlight focuses the light from the lamp into a beam.

### Environmental Implications and Network Stabilization

ArcMesh is an auto-forming, self-healing wireless mesh network. If a fixture is out of range of the ArcSystem TX1 Wireless Transmitter, it will relay data to its closest neighbor in an attempt to contact the transmitter. This part of the system requires no setup from the user.

The auto-forming network dynamically changes depending on the RF environment. It can also take a small amount of time to establish the network after initial power on.

As the network becomes larger (in terms of number of devices), the time it takes for the network to form increases. This is because once a connection is formed between two fixtures, another fixture may 'join in' and present a better route than the first connection. The first connection will then be lost and the fixtures will search for a better route. Once the network has formed and self-adjusted, the network will then be stable.

Environmental factors will have an impact on the network. For example, in a theatre auditorium the introduction of large pieces of scenery will have an effect on the wireless network. This may cause devices to drop off the network, search for an alternate and stronger route, and then re-connect. This process is known as self-healing.

Self-healing also comes into action if, for some reason, a fixture loses its mains power connection. Any devices that were using the fixture as a stepping stone will become detached from the network and will need to find a new connection.

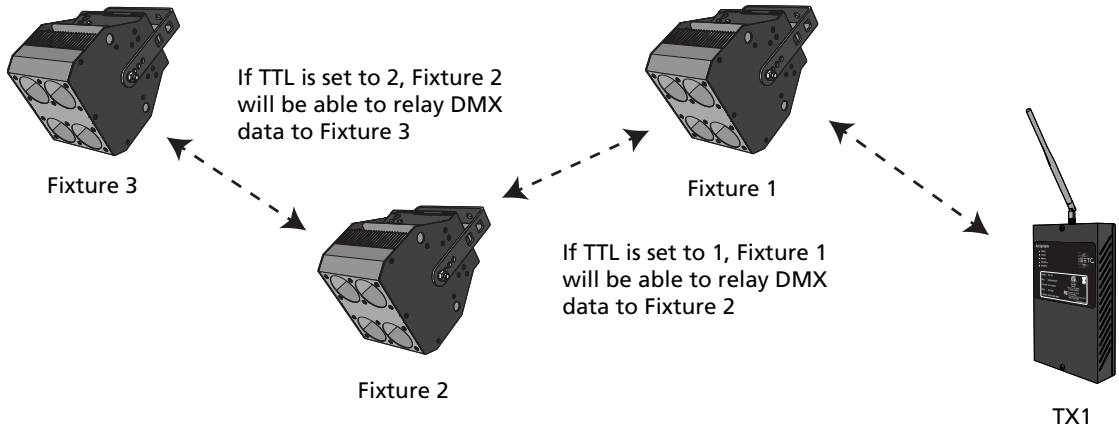
None of the self-healing mechanisms require any setup or human interaction. They are completely autonomous.

### Abnormally Low Signal Levels

In some cases, the ArcMesh self-healing nature will not always accomplish satisfactory connection to some fixtures. The main factors that will contribute to this issue are as follows.

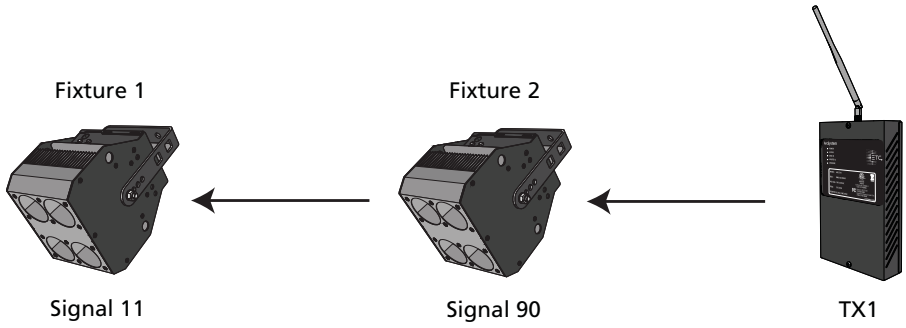
The structure of the building and structures within it may make reliable connection to some fixtures difficult. Thick concrete walls and metal rigging and ducts may shelter particular fixtures from getting good enough signals. In this case, the system’s Re-Broadcast functions can help.

Each fixture has the ability to Re-broadcast signal to others near it. To be able to use this function the TTL (Time to Live) settings inside the Transmitter Gateway need to be utilized. The Transmitter has a default TTL of 2. TTL is the number of fixtures in a hopping depth that repeat DMX data. For example, if TTL is set to 1, every fixture that is wirelessly connected to the transmitter will repeat the DMX level data. If TTL is set to 2, every fixture that is connected one hop deeper in the tree will repeat the data.




However, a fixture will only repeat the DMX if the "Broadcast DMX Data" setting is enabled in the fixture settings.

Allowing re-broadcast allows you to relay signal in particular areas of installation that are unable to receive a signal directly from the TX1 Transmitter. This will increase signal levels of fixtures that have very low signal. To use Re-Broadcast effectively follow these best practices.




**Note:** *Fixture 1 has a low signal of 11. As a rule, we recommend that fixtures with a signal of 30 and below need attention. If fixtures are at this level they may hang or drop off the network altogether.*

To improve the fixture's signal start by selecting a fixture with good signal half way between the TX1 and the problem fixture. In the above diagram, you would enable the "Re-Broadcast DMX Data" option for Fixture 2.

You will then start to see the signal levels increase. If the signal levels are still not above 30 select another fixture between the first re-broadcasting fixture and the problem fixture. Signal levels should start to rise above 30. You may need to experiment with this with different fixtures to get the best result.

**Note:** *Be careful while using the Re-broadcast function. Only use it if you have to and try to limit the number of fixtures re-broadcasting. If too many fixtures are re-broadcasting, traffic in the network can rise and cause the network to slow down or collapse altogether.*

### Wi-Fi Surveys and Dealing with Interference

ETC always recommends a full wireless site survey prior to installing any wireless equipment. This will ensure correct placement of transmitters and reliable operation of the system.

In the event that interference is causing issues with the ArcSystem lighting, you are likely to see the following symptoms:

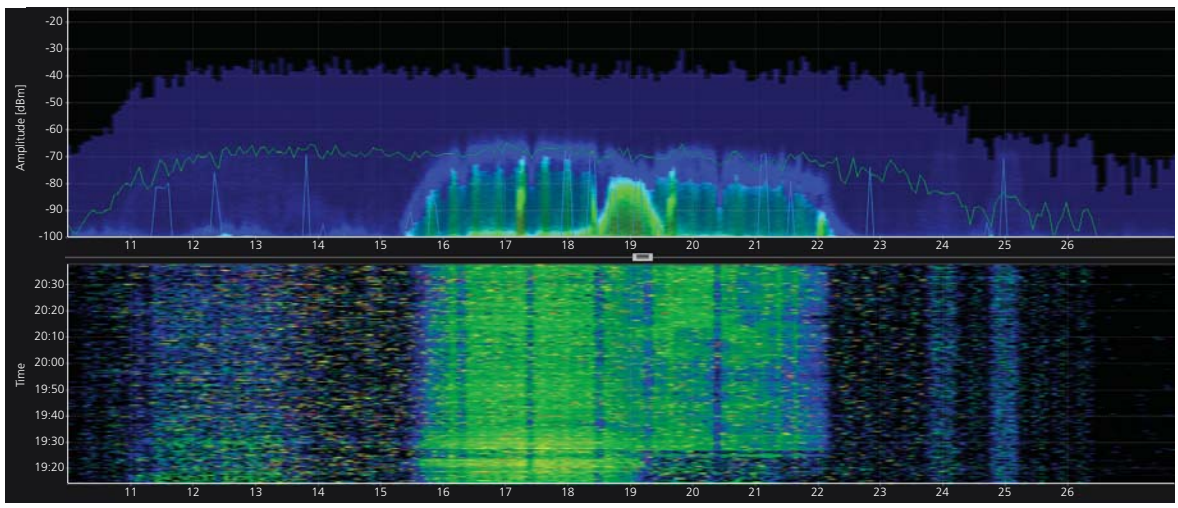
- Slow response from some fixtures in the system
- Fixtures not responding while fading
- Sections of fixtures locking on or off
- Delayed scene recall

In some cases, the symptoms above may seem random, and won't be isolated to particular fixtures. However, if the interfering access point is near a fixture, you will likely see that fixture experiencing the symptoms more than others.

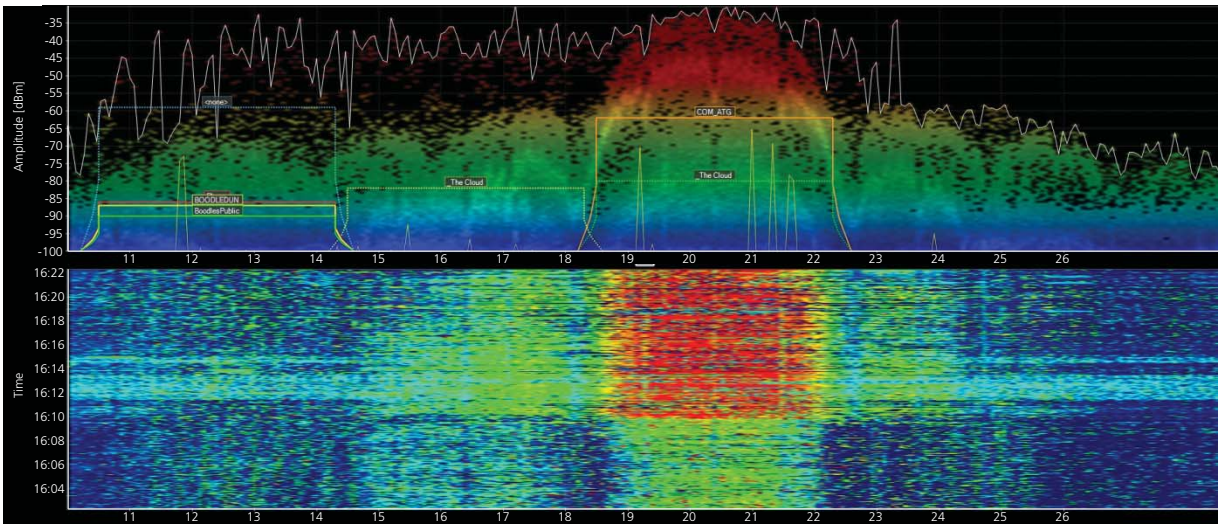
Interference will occur when Wi-Fi equipment occupies the same radio space as ArcSystem and has high signal strength. The symptoms will become more predominant when large amounts of information are passed through the interfering access points.

To reduce the chance of interference from other wireless technologies affecting ArcSystem operation, it's important to ensure that the wireless space is correctly managed. To do this it is important to know what channel ArcSystem is on and what Wi-Fi equipment you have in the building. Wi-Fi surveying is a good tool to highlight this information.

Equipment such as Wi-Spy can be used to scan the Wi-Fi space. See below for a few examples.




The diagram above shows a venue with two ArcSystem transmitters operating on channels 24 and 25, and heavy WLAN activity. In this instance there are no overlapping transmissions between WLAN and ArcSystem and the space around them is clear. We would expect no interference at this site.




The venue which produced the scan above was experiencing fixtures hanging. This is due to the over lapping of AP transmissions in the same space as ArcSystem sitting on channel 24. As you can see there is a large amount of utilization of this space which is causing the interference with ArcSystem.

Moving the ArcSystem transmitter that was originally operating on channel 24 to channel 26, the last channel on the right side of the spectrum, solved the problem. This is because that area of the spectrum was clear of almost all Wi-Fi interference.

It is important to ensure correct management of the wireless space to ensure you have a trouble-free installation. ETC recommends fixing WLAN access point channels so they are always in a known radio space. If this is not possible, reliable operation cannot be guaranteed, as the WLAN AP will change channels at some point, and will operate in the same radio space as the ArcSystem installation.

## References


- EE Times: ZigBee RF4CE Coexistence with Common 2.4-GHz ISM-band Consumer Electronics (http://www.eetimes.com/document.asp?doc_id=1276468)
- Digi-Key: Shaping the Wireless Future with Low Energy Applications and Systems (https://www.digikey.com/en/articles/techzone/2013/jun/shaping-the-wireless-future-with-low-energy-applications-and-systems)