



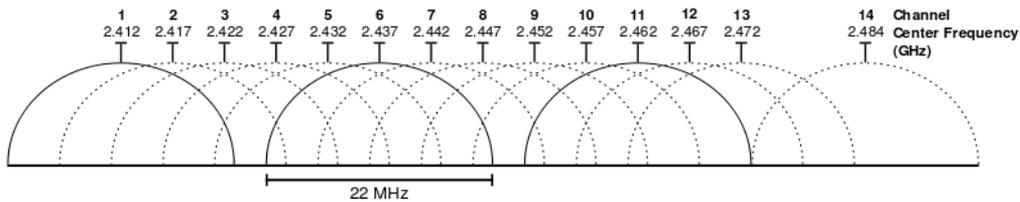
### Overview

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

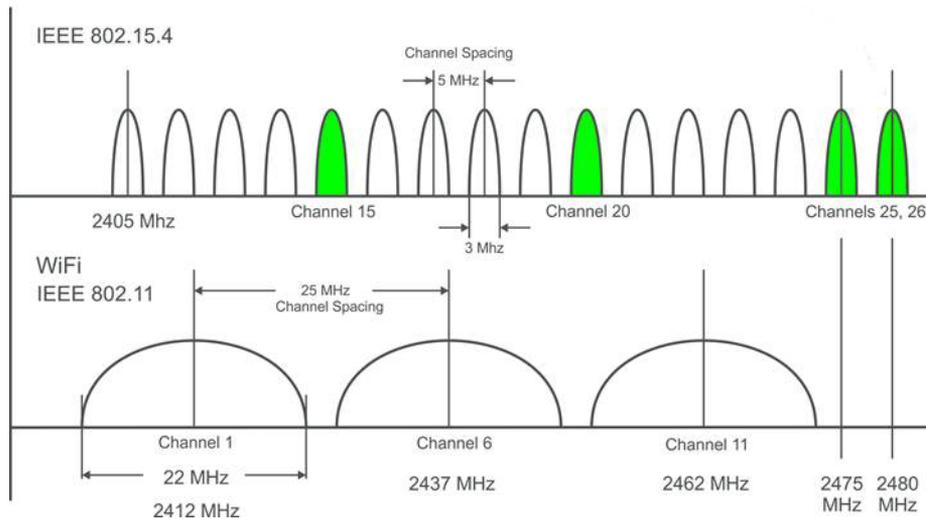
### Introduction

ArcSystem wireless nodes operate in the unlicensed 2.4GHz ISM band using the IEEE802.15.4 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 2.4ISM



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 22MHz channels). As such 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.

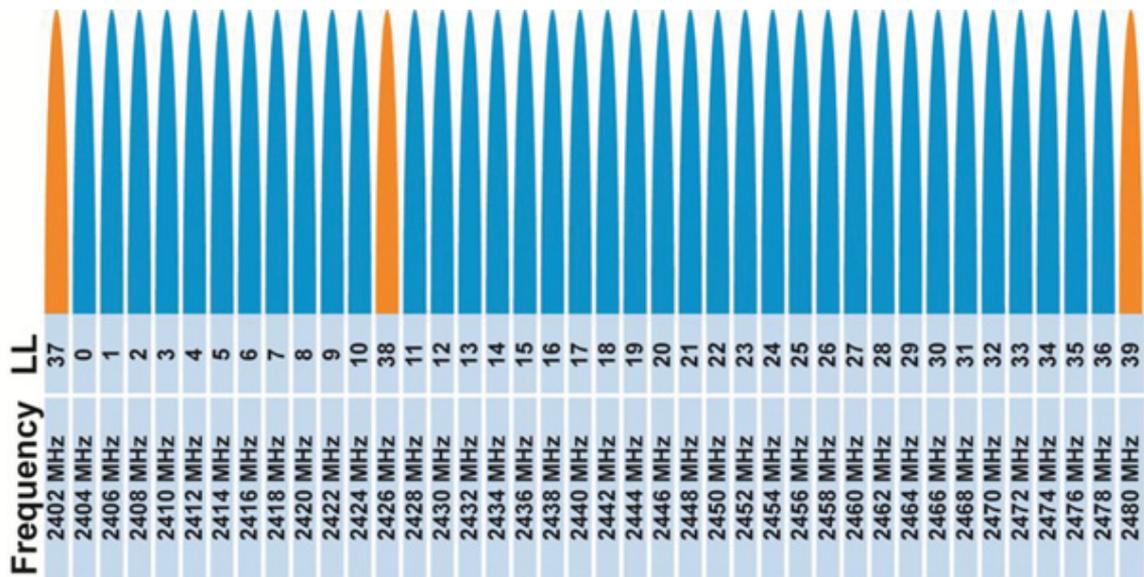


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ArcSystem can occupy the same space as a WLAN channel, however if the WLAN is very busy, this can cause latency issues with ArcSystem. This can be seen as a lag between transmitting a level, and the fixture responding. In extreme cases where the WLAN 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 10M 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 2M is recommended between the Bluetooth device and ArcSystem Gateway.

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

Line 6 wireless microphones and belt-pack transmitters operate across 12 or 14 channels in the 2.4GHz 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 2.4GHz 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 10mW

2 Bands per channel RF2 Mode

4 Bands per channel RF1 Mode

### Transmitter Positioning and Transmission

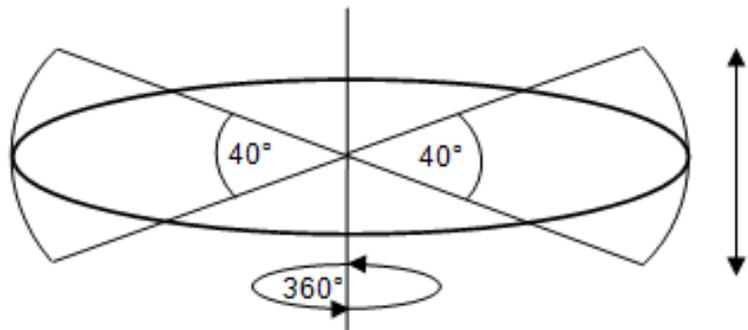
To establish a stable system the positioning of the transmitter can make a considerable difference. Fixtures within the system will not necessarily connect directly to the transmitter; instead fixtures can connect to each other to establish a connection. This is known as meshing.

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.

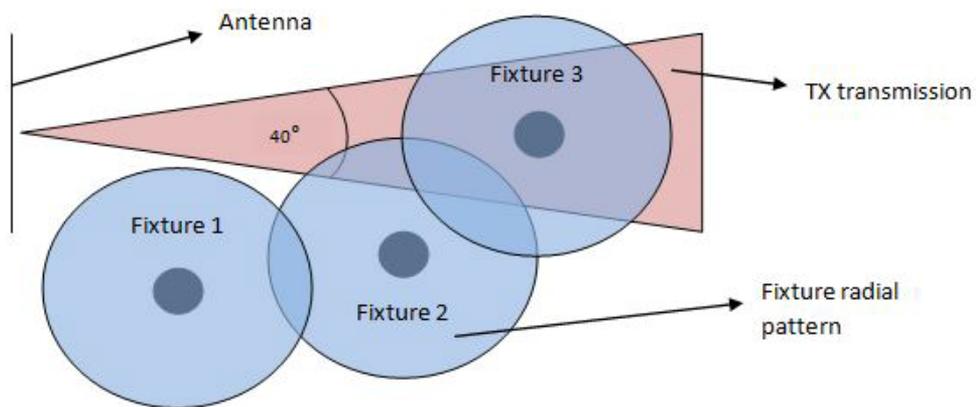
**For example:**

The GDS TX1 transmitter is supplied with a 5db antenna with a typical radiation pattern as shown

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



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

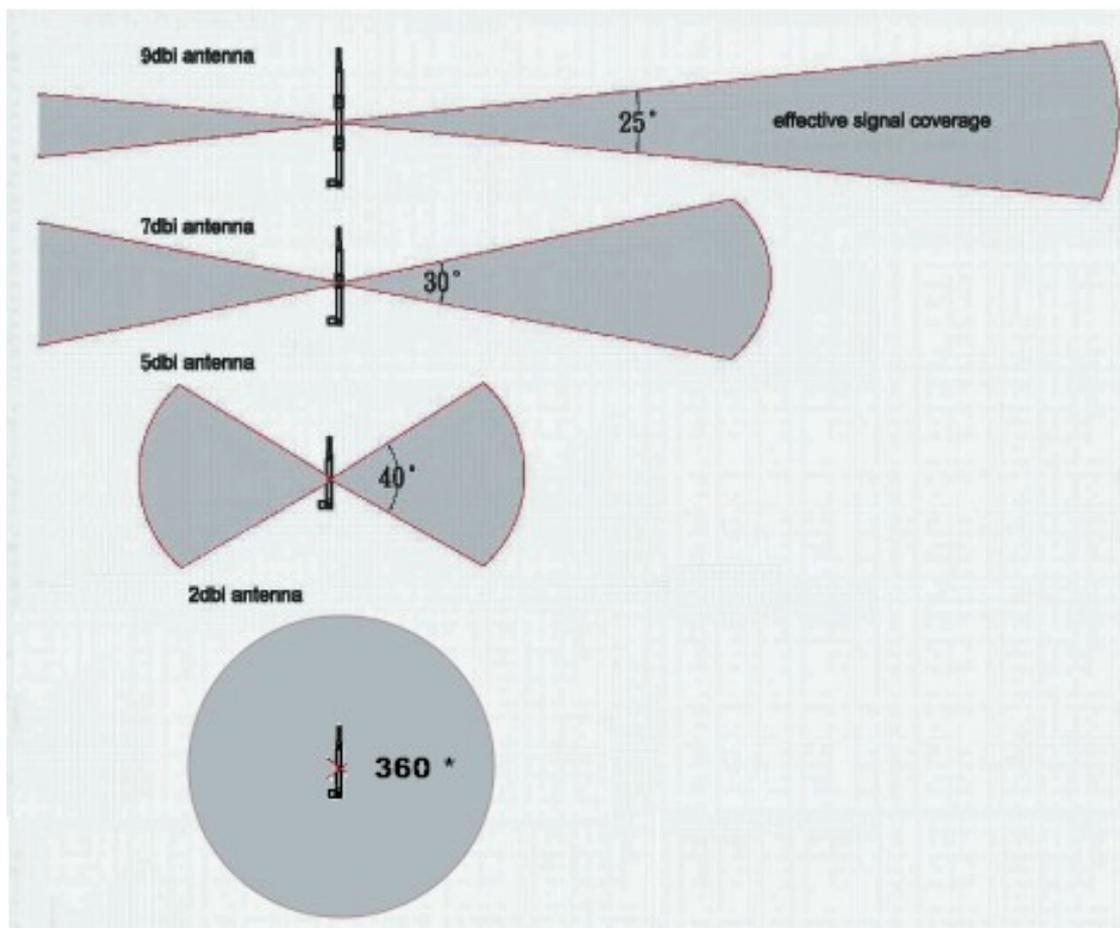


The Fixtures radial pattern is 360° in all directions radiating from the button antenna. The illustration above shows how the fixtures transceivers could overlap. As you can see, 2 fixtures are within the transmission path of the transmitter. These could talk directly to the TX, however fixture 1 is outside the transmission coverage therefore would need to talk through fixture 2.

If a fixture is outside the broadcast range of the transmitter and another fixture 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, in which case other antenna options may need to be explored. 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 torch 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 TX1 Wireless Gateway, 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 it as a stepping stone will become detached from the network and will need to find a new connection.

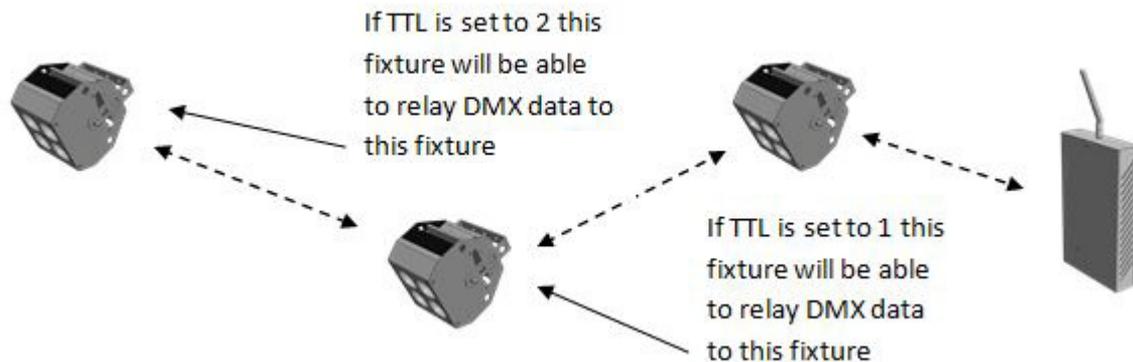
None of the self-healing mechanisms require any setup or human interaction, it is completely autonomous.

### **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.

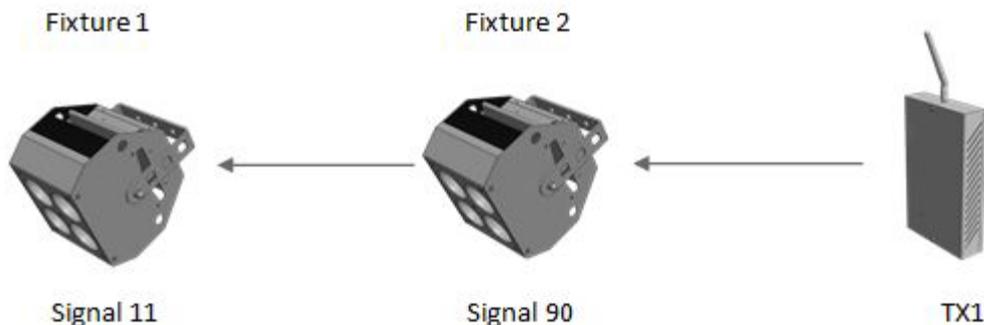
The structure of the building and structures within it may make reliable connection to some fixtures difficult. Thick concrete walls and metal rigging and ducts may shelter particular fixtures from getting good enough signals. In the event were this may be the case the systems Re-Broadcast functions 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 DMX Gateway. This will increase signal levels of those fixtures that have very low signal. To use Re-Broadcast effectively follow these best practices.



**Note:** *Fixture 1 has a low signal of 11 by 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 fixtures signal start by selecting a fixture with good signal half way between the TX 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 amount of fixtures re-broadcasting. If too many are re-broadcasting then traffic in the network can rise to an extent where the network will slow down or collapse altogether.*

### WI-FI Surveys and Dealing with Interference

GDS always recommend 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.

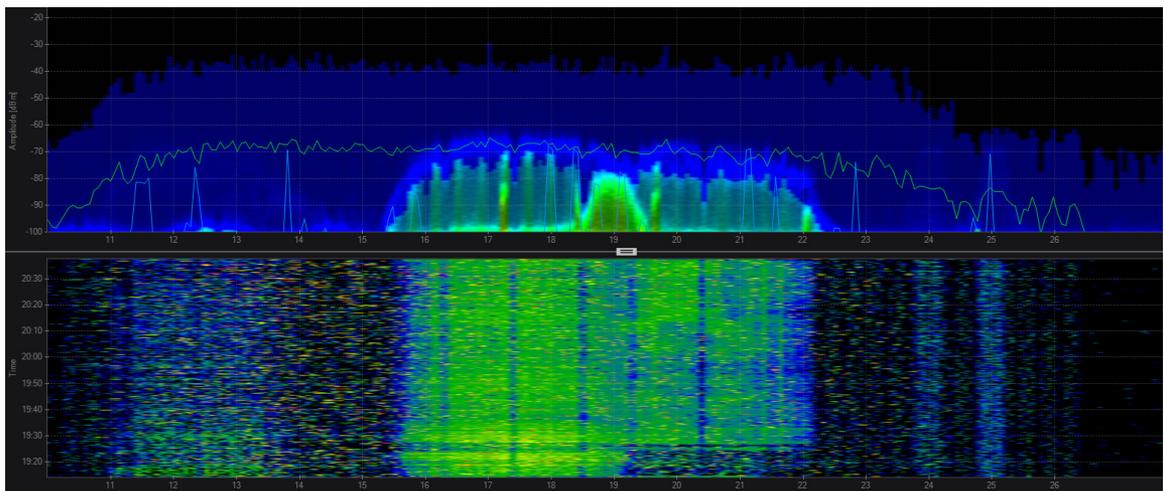
- Slow response from some fixtures in the system
- Fixtures not responding while fading
- Sections of fixtures locking on or off
- Delayed scene recall

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.

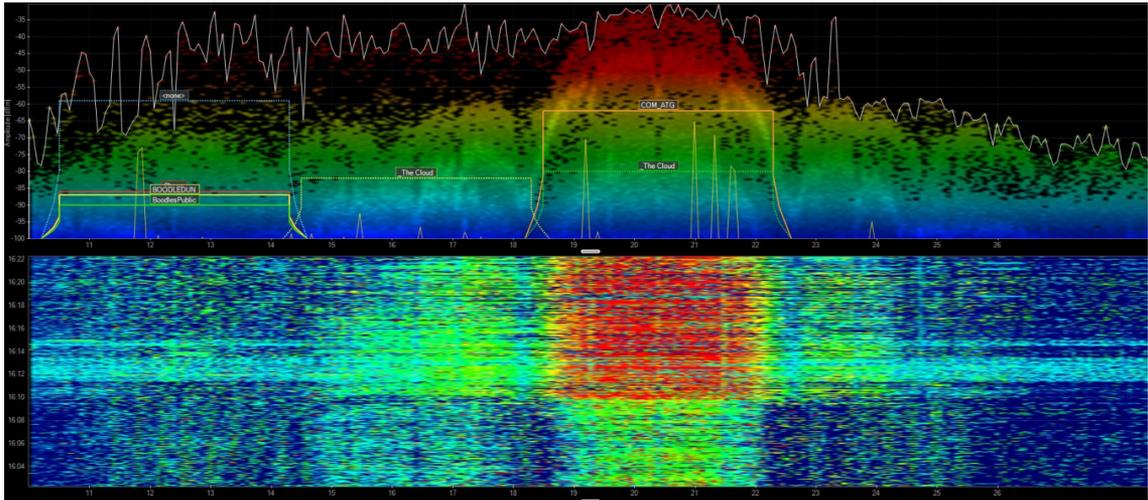
Interference will occur when Wi-Fi equipment occupies the same radio space as ArcSystem and has high signal strength. The Symptoms will become more predominant when large amounts of information are passed through the interfering access points.

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 utilisation of this space which is causing the interference with ArcSystem.

Moving the ArcSystem transmitter that was originally operating on channel 24 to channel 26 which is 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. GDS recommend 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

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