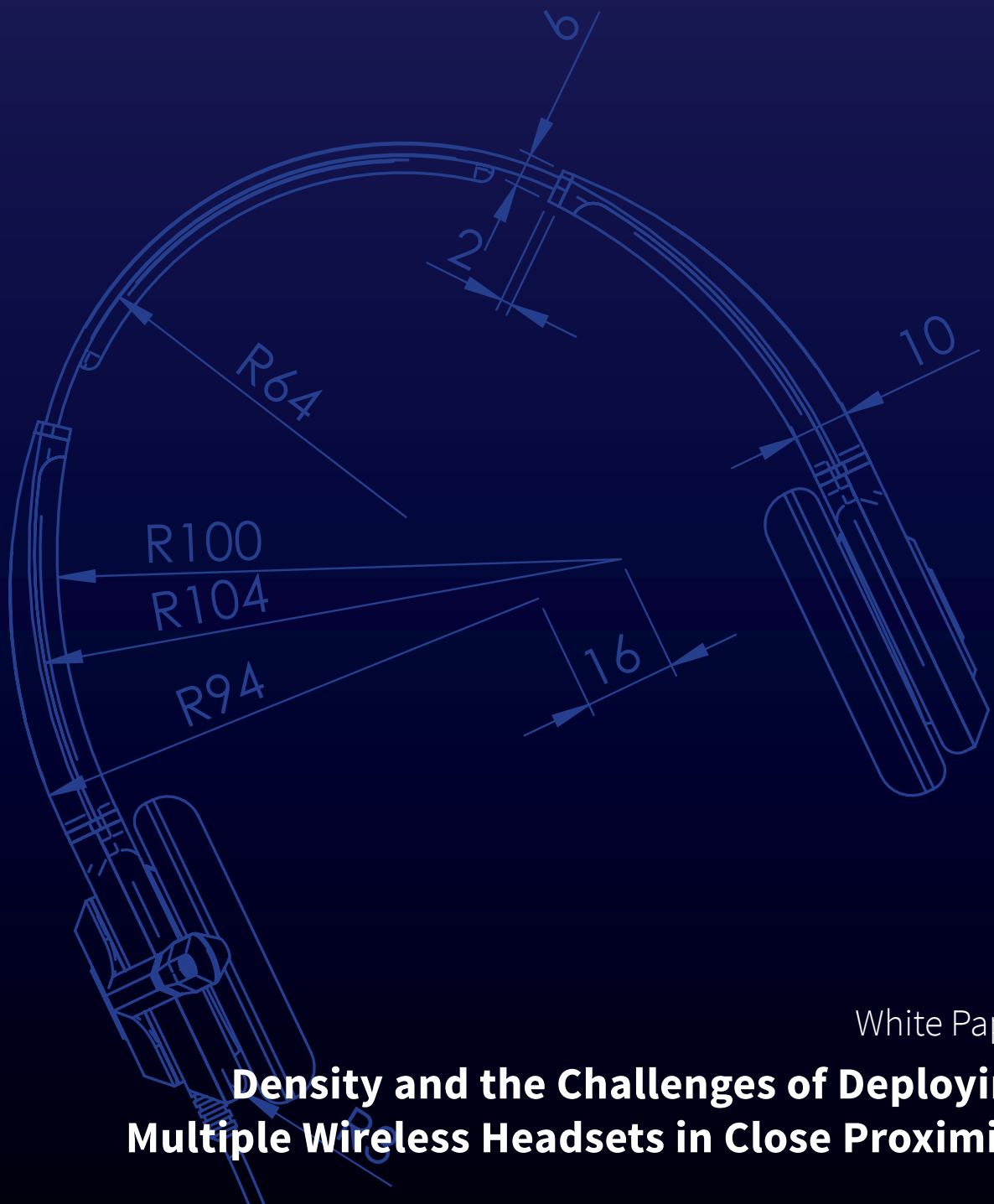


White Paper

Density and the Challenges of Deploying Multiple Wireless Headsets in Close Proximity

Contents

Introduction

Wireless headsets offer a great deal of convenience to knowledge workers in the office environment by enabling untethered communications so they can walk about hands-free in the office space without losing their audio connection.

As the number of wireless headset users in proximity to one another grows, underlying limitations in radio transmission technologies can pose challenges. Proper planning of such deployments can help a great deal in overcoming these challenges.

This white paper aims to explain the factors that determine how densely headsets can be deployed in one area, common wireless headset technologies and their limitations, as well as some recommendations that should help our customers in planning their large wireless headset deployments.

DECT (Digital Enhanced Cordless Telecommunications)

DECT wireless technology enjoys a dedicated frequency spectrum which implies that other wireless transmission in the vicinity, e.g., Wi-Fi or Bluetooth devices cannot affect or interfere with it in any way. Since each conversation requires a dedicated channel in that limited DECT frequency band with time sharing slots, as the number of users and simultaneous conversations grow, available channels can all get consumed creating a density challenge. And as the number of users and conversations grow further, audio distortion may also be experienced.

Bluetooth

Unlike DECT, Bluetooth wireless technology does not have a dedicated frequency spectrum and may be impacted by other wireless technologies such as Wi-Fi Access Points that also operate in the 2.4 GHz spectrum. Interference by other sources can reduce the number of available Bluetooth channels (conversations).

General Concepts of Density

Several factors can influence wireless headset technology selection, deployment, and performance.

User density: When multiple wireless headsets operate near each other, they share the radio spectrum. It is important to understand how many wireless headsets can be used near each other without experiencing interference, and how you can maximize the number of wireless headsets that can be deployed. The key factor, user density, defines the number of users who can talk on wireless links simultaneously, and depends on wireless headset technology in use.

Coexistence with other wireless technologies. In a busy office, wireless headsets may need to contend with other transmitting devices. While different systems coexist best when each has its own frequency band, sadly, this isn't always possible. On 2.4 GHz ISM band, Bluetooth and Wi-Fi share the same radio spectrum. As a result, it is important to understand how many and what kind of wireless devices are in use, as well as how interaction between them affects operation.

The building and environment. No two offices are alike. Some utilise an open plan, while others are divided by several rooms and walls. Building layout and materials affect how far wireless headset signals will reach, which in turn influences range and density. Concrete and metal construction block wireless signals, reducing the potential for interference while limiting range. On the other hand, large windows or a central atrium will allow signals to travel further, allowing greater range while potentially increasing the density issue. Understanding how building design affects wireless performance is key to maximising wireless headset deployment density and audio quality.

Factors that affect user density

When deploying wireless headsets, the following factors must be fully understood:

1. **The number of users with wireless headsets in a given area:** The most important factor in density calculations is the number of users with wireless headsets in a given area. All wireless communication technologies have their limits regarding the usage of the frequency band for that technology.

2. **Type of wireless headset technologies being deployed:** Wireless headsets deployed can be all DECT, all Bluetooth or a mix of both technologies. Regardless of number of users or utilization rate, Bluetooth and DECT headset will never interfere with each other since they operate in different frequencies. However, other wireless transmissions such as Wi-Fi 2.4 GHz can interfere with Bluetooth.

3. **Utilisation rate of wireless headsets:** Just as important as the number of wireless headsets deployed is the utilisation rate. For instance, if headsets are used only 50% of the time, then the number of headsets may approximately be doubled. Although, the relationship is not linear so if the users only use their headsets 10% of the time, that does not mean that 10 times as many headsets may be deployed.

4. **Building layout and furniture:** Headset density can be multiplied by the number of deployment areas if the areas are properly separated and isolated from one another. For instance, a concrete wall provides far better isolation of signals than doors and windows do. Even in a single deployment area, the more separation among users the higher densities can be achieved. This separation can be achieved by deploying more furniture, cubicle walls and other objects. Open office environment with sparse furniture are most susceptible to interference among user headsets and therefore yield the lowest density.

JPL Recommendations

1. **Choose the right version of the JPL-Element-X500 DECT product:** In order to accommodate different density requirements by our customers, the JPL-Element-X500 is offered in two modes; one with standard range and density, and the other with lower range but higher than normal density. In a given deployment, if users do not have to roam around too far from the base, the low-range version of this product would be the recommended choice as it can provide higher density.

2. **Mix 'em up:** It is important to keep in mind that DECT and Bluetooth use completely different frequencies and will therefore never interfere with each other. This means that user density can be doubled by simply deploying DECT headsets for one half of the users and Bluetooth for the other half.

3. **Site survey:** It is important to survey all the areas where wireless headsets are to be deployed and to look for separation among deployment areas and amongst individual users. Proper site planning can greatly improve user density.

4. **Corded option:** Consider using JPL corded headsets for environments that are highly dense and have very high utilisation rates.

JPL Density Guidance

In considering how many wireless headsets can be used in a limited environment, a range of elements need to be considered. The most critical are:

1. The number of concurrent headset users.
2. The building layout and design
3. The wireless technology being used (DECT or Bluetooth)

DECT and Bluetooth systems have completely different operating frequencies, and neither will cause the other interference.

Guidance for DECT

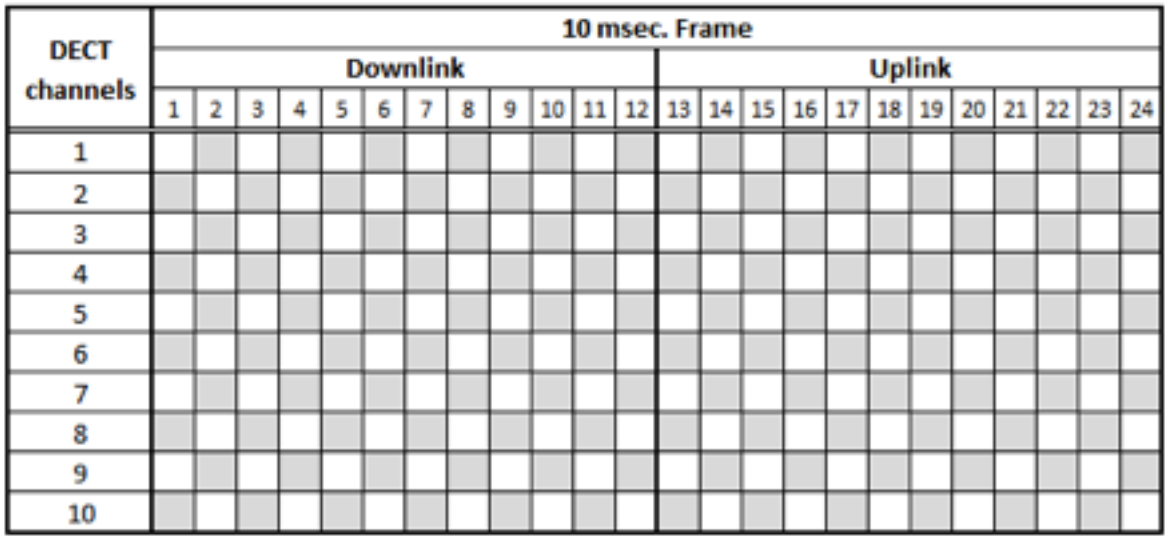
There are many interrelated factors in play when determining DECT density. It is for that reason that JPL strongly recommends a site survey for customers interested in deploying more than 40 DECT headsets. As a general guidance, 40 DECTs can normally be deployed without any problems. In typical office settings, where users are not on the phone for more than 30~40% of their time, and depending on the environment, it is possible to deploy significantly more but a site survey is required to make specific recommendations. As you will read below, the above density numbers can be doubled by using the low-range version of the JPL-Element-X500 DECT headset.

For DECT, there are several different versions. The typical DECT is designed for Europe and the DECT 6.0 standard is made for the United States. The following table shows the differences.

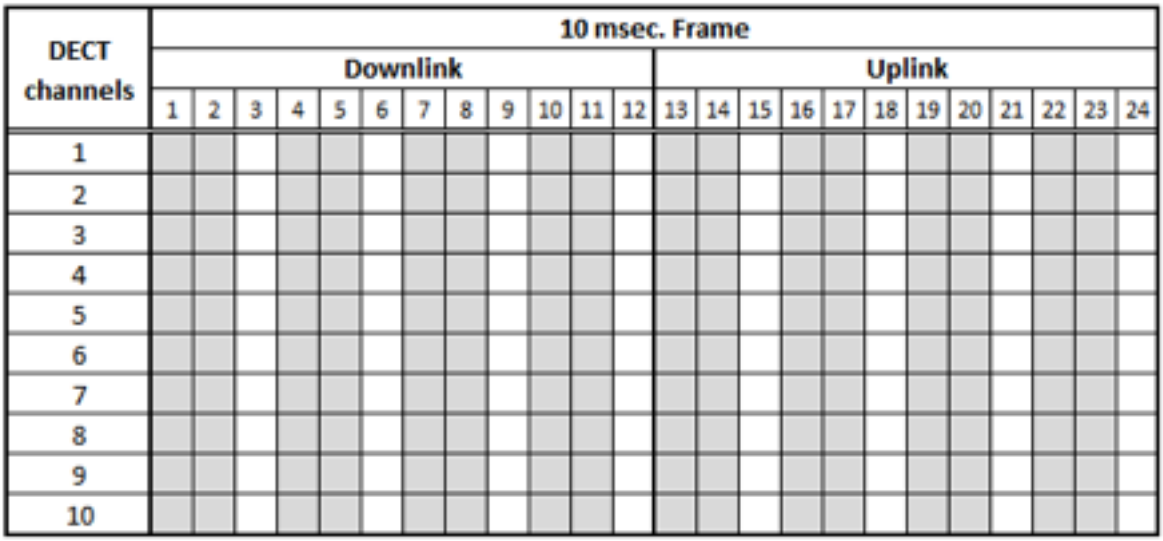
Type	RF Channel	Frequency	Max. Peak Power	Avg. Power
European DECT	10	1880 - 1900 MHz	240 mW	10 mW
DECT 6.0	5	1920 - 1930 MHz	125 mW	4 mW

DECT has 24 time slots for each RF channel and 12 time slots can be used for receiving and the other 12 time slots are reserved for transmission. With limited technology, adjacent time slot can't be used. So, one of the double slots can be used. With this physical limitation, the maximum density can be calculated as follows;

European DECT with Narrowband



European DECT with Wideband



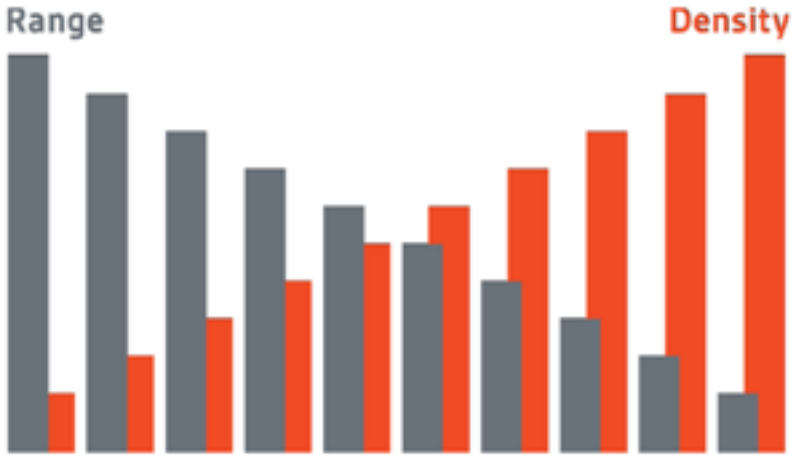
With simple calculations, the narrowband European DECT can have 6 x 10 = 60 users and wideband European DECT can have 4 x 10 = 40 users. The DECT is designed on TDMA (Time Division Multiple Access). So, all DECT base stations are not time synchronized. By this reason, some offices may have much more densities and some offices may have less densities.

DECT headset avoid interference by selecting the best available channels at the start of a call and changing channels automatically when encountering interference. Interference occurs when two headsets in close proximity operate on the same channel. This can occur when a user moves closer to another user on the same channel, or in dense installation with workers seated close together and all channels in use. Interference manifests as pops, clicks, or blanks noticeable to headset users.

Each headset and base continuously monitors the channels and maintains a map of channel versus signal strength. When interference is encountered, the headset consults the channel map and changes to the best available channel.

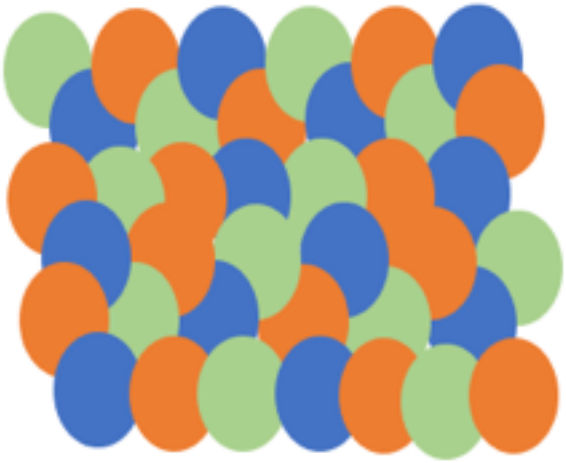
The ability to move around is an important factor for deciding to go wireless. The distance you can travel is commonly called the range. In a simple system with a small number of users, range primarily is a function of the strength of the radio transmitter and the effects of objects that block the transmitted signal.

Using DECT headsets inside buildings changes the way radio signals propagate and affects the usable range of wireless headsets. Signal strength can no longer be modelled according to a neat mathematical equation. Many objects in typical office environments can reduce the range of radio signals. Walls, furniture, and people attenuate the radio signal and reduce the range of a wireless headset.

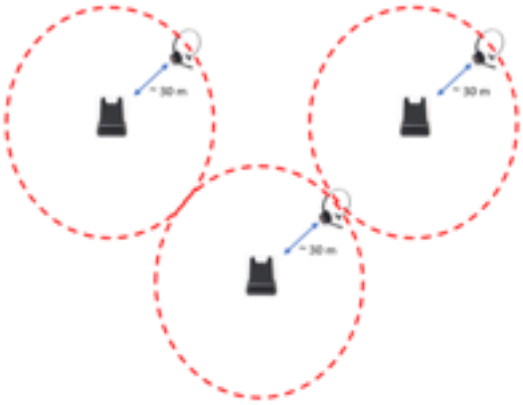


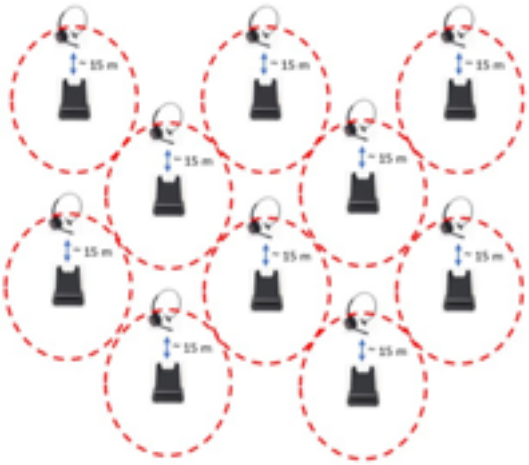
The recommended distance is 2~4 meter/7~13 ft between base stations even if the number of headsets is low.
When base stations are deployed very close, interference will occur.

For high density requirement, the customised base station and headset can be deployed. The base station always transmits a signal even when there is no call connection, because the headset should be synchronised to base station to match time slot. The low radio transmission version has 12 dBm lower radio transmitting power. A typical DECT base station can cover up to 50 meters indoor range. The low radio transmitting base station can only cover up to 20 meters. With reduced cell coverage, the density can be increased.



Normally, the 40 DECTs can be used in a typical office. However, if the lower radio transmitting DECTs are deployed in the same space, more than 80 DECTs can be used.





Guidance for Bluetooth

For the JPL Bluetooth headset, 8 users with 100% headset utilisation can be deployed in a 15m x 20m office space. As a rule of thumb, as deployment space doubles, the Bluetooth headset density can be increased by a factor of 1.5. Also, as with DECT, with lower utilisation rates, higher densities can be achieved.

To deal with possible interference from WiFI Access Points:

1. Deploy 5 GHz WiFi Access Points instead as they will not interfere with Bluetooth operation
2. Limit the number of 2.4 GHz WiFi Access Points to two in the same area.

Bluetooth is an open wireless technology standard that has been adapted for voice communication. While Bluetooth headsets are commonly used to connect with mobile phones, they can also connect to computers through a JPL USB Bluetooth dongle and to Bluetooth enabled desk-phones. While the most common Bluetooth implementation allows communication up to 10 meters, the Bluetooth standard also supports classes of operation that can communicate up to 100 meters.

Class	Transmit Power	Distance (Meter)
Class 1	100 mW	100 m
Class 2	2.5 mW	10 m
Class 3	1 mW	1 m
Class 4	0.5 mW	~0.5 m

Bluetooth devices operate on the 2.4GHz Instruments, Scientific and Medical (ISM) band. This radio band is shared with other technologies, including Wi-Fi access points, cordless phones, amateur radios, garage door openers and more. Because different technologies share the same radio frequencies there is potential for conflict between devises. More specifically, Bluetooth operates on the 2,402 MHz to 2,480 MHz frequencies. This band is divided into seventy-nine 1MHz channels. In operation, a Bluetooth headset hops among the 79 channels 1,600 times per second in a pseudo-random sequence known only to the transmitter and receiver. From Bluetooth 4.0, the physical channel is 40 with FH (Frequency Hopping).