Ultra Wide Band (UWB) Alliance

Ref: OIA Docket No. 24-30

Comments to WRC-27 Advisory Committee Draft Recommendations

<u>About the UWB Alliance</u>

The Ultra Wide Band (UWB) Alliance is a global not-for-profit organization that works to collectively establish ultra-wideband (UWB) technology as an open-standards industry. A coalition made up of vendors that either design, manufacture, or sell products that use ultra-wideband technology, the UWB Alliance aims to promote and protect the current allocation of bandwidth as well as promote the continuing globalization of the technology. As part of our mission, we advocate UWB technology and use cases to promote verticals showing the value of UWB for IoT and Industry 4.0 and to build a global ecosystem across the complete UWB value chain, from the silicon to the service. In addition, the Alliance is promoting and assuring interoperability through its work with Standards Development Organizations such as the IEEE and ETSI and then working with members to define upper layers and testing to assure compliance. For more information, please visit us at www.UWBAlliance.org.

Comments to WRC-27 Advisory Committee Draft Recommendations
Agenda Item 1.7

The Ultra Wide Band Alliance (UWBA) thanks the WRC27 Advisory Committee for providing the opportunity to comment on the WRC-27 Advisory Committee Draft Recommendations. The following comments are regarding agenda item 1.7, but some could also apply to many of the other frequency bands within the recommendations.

Regarding Agenda item 1.7

This agenda item specifies recommendations "to studies on sharing and compatibility and develop technical conditions for the use of International Mobile Telecommunications (IMT) in the frequency bands 4 400-4 800 MHz, 7 125-8 400 MHz (or parts thereof), and 14.8-15.35 GHz taking into account existing primary services operating in these, and adjacent, frequency bands, in accordance with Resolution 256 (WRC-23)."

The draft U.S. views are provided specifically as they apply to the frequency band between 7.125 – 8.4 GHz. The two alternatives are:

- Alternative 1: The United States supports the sharing and compatibility studies called for in Resolution 256 (WRC-23), with a view to ensure the protection of services to which the frequency bands are allocated on a primary basis, including in adjacent bands, as appropriate. Based on these studies, the United States supports appropriate action at WRC-27.

- Alternative 2: The United States supports the sharing and compatibility studies called for in Resolution 256 (WRC-23), with a view to ensure the protection of services to which the frequency bands are allocated on a primary basis, including in adjacent bands, as appropriate. The United States supports appropriate action at WRC-27 where studies demonstrate coexistence mechanisms can be employed to safeguard incumbent operations and can ensure that such an identification to IMT would not impose additional regulatory or technical constraints on those incumbent services.

Within the confines of discussing these two alternatives, the Ultra Wide Band Alliance supports Alternative 2. There are many incumbents, both licensed and unlicensed, that need to be considered in any sharing and compatibility studies. These incumbents include older licensed technologies that would be costly to replace such as fixed station data links as well as newer technologies such as UWB which has been deployed in millions of consumer devices such as virtually every smartphone, millions of new automotive key fobs, and tracking tags such as AirTags.

Methodologies for spectrum sharing

There are three primary methods of sharing spectrum: frequency diversity, spatial diversity, and time diversity.

Frequency diversity sharing is commonly an all or nothing approach to spectrum sharing, (i.e., the technology has full unencumbered use of the band). This is the most common method of spectrum sharing and is already planned to be considered in the studies.

The case for Time Diversity spectrum sharing

Time diversity can share a band using diverse technologies within the same frequency and same area of coverage. All the systems in the proposed studies use packets of data that are broken into separate secure transmissions. Therefore, an approach using time diversity should be a part of the proposed studies. It allows various technologies to share the same frequency and thus provide maximum sharing plus coexistence within a single frequency band.

Duty cycle limits are a method to provide this time diversity. It would be a means for IMT (at reasonable power levels), wireless LANs, Bluetooth as well as UWB to all coexist within the 7.125 - 8.4 GHz band. Methodologies for determining the presence of dissimilar transmissions should be explored.

The case for Spatial Diversity spectrum sharing

Spatial diversity sharing utilizes zones of coverage that are again full utilization of a band, but now with in a specific area. It is inherent in this model that smaller areas of coverage translate to a higher density of users sharing the overall area of coverage.

As wireless systems also follow a version of Moore’s Law, smaller areas of coverage using Transmission Power Control (TPC) are the natural evolution of wireless networking. The detection of 40 or more Wi-Fi networks with different SSIDs’ within an urban office or home is evidence that Access Points (APs’) defaulting to run at full power are wasting valuable spectrum. New methodologies of TDC and regulation should be studied.

What is UWB?

All radio-based technologies like to trace their lineage back to Gugliemo Marconi, but UWB can legitimately lay claim to that distinction as Marconi’s spark gap transceiver from 1896 was impulse radio (IR) UWB technology. Long before technologies like Wi-Fi[1], Bluetooth[2], near-field communication (NFC), and Global Positioning Satellite (GPS), UWB was used in military applications for precision training applications.

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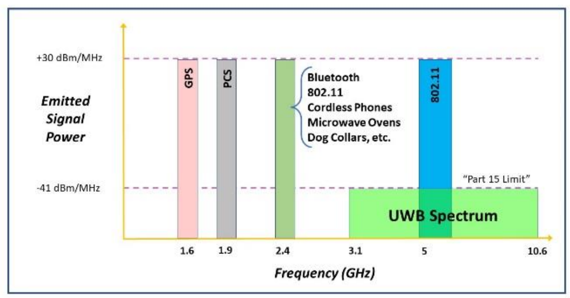
[1] Wi-Fi is a registered trademark of the Wi-Fi Alliance.
[2] Bluetooth is a registered trademark of Bluetooth SIG, Inc.

While important UWB applications began to deploy as soon as the rules allowed, the focus was largely on industrial and military uses including precision tool tracking, sports tracking, and military war games training. The mid-2000s witnessed a growing interest in the use of UWB technology in consumer applications, initially for high-throughput data communications and later for location tracking. A major boost in popularity occurred in 2019 with the publication of a global standard (i.e., IEEE Std 802.15.4z) designed for consumer applications. Now it is built into many consumer products including virtually every smartphone and many vehicles. Standards such as IEEE 802.15.4 continue to evolve, accelerating UWB adoption across many new industries.

UWB is a digital wireless technology that behaves differently than other methods of wireless communication. UWB emits short pulse signals rather than continuous wave signals, which enables applications to locate and sense objects with extremely high precision. UWB can also transmit massive quantities of data quickly, which can improve consumer audio, VR, and AR experiences.



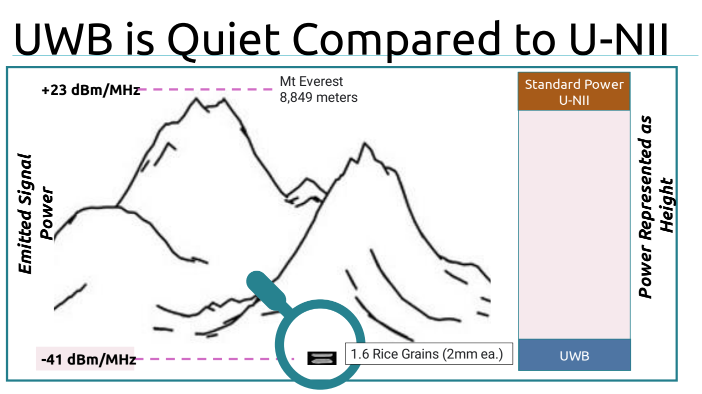
UWB uses a wide bandwidth, typically about 500 MHz or larger. Although the frequencies in which UWB are allowed to operate vary by country, the most common allowed frequencies are between 6 and 9 GHz.

The Benefits of UWB

The unique technical characteristics of UWB make it beneficial for many applications and use cases. While multiple technologies play in in the radio frequency eco-system, UWB does certain things extremely well and its worth enumerating:

#1: UWB is designed for sharing and coexistence

One of the unique advantages of UWB technology is its ability to coexist with other wireless technologies without interfering. The reason UWB technology can coexist with other wireless technologies is that it is virtually undetectable. Its transmission power is extremely low relative to other wireless technologies. UWB signals operate at levels below the unintentional radiation limits of other wireless technologies, and thus operate in the general ambient RF noise level, making UWB invisible to other devices. In real-world and lab tests, conducted to measure UWB transmissions and their impact on other wireless technologies, UWB



consistently has been shown to not create interference.

A common question raised by some is whether the wide bandwidth emissions of UWB will interfere with the narrower bandwidth of other RF systems. The entire wide bandwidth of a UWB signal is required to be limited to operation below the unintentional radiation limits of all other RF technologies and emitters. With all UWB signals operating at or below the ambient RF noise floor level, it is clear why there have been no reports of device interference despite the long history of UWB operation.

A study conducted by the UWB Alliance with an independent 3rd party in 2023 showed no measurable impact on Wi-Fi 6E access points[3]. Up to 8 UWB devices simultaneously operated near Wi-Fi 6E access points and routers, and no changes to up or downlink throughputs were detected.

Despite having millions of devices in operation for over twenty years, there has never been a claim of interference attributed to a UWB device.

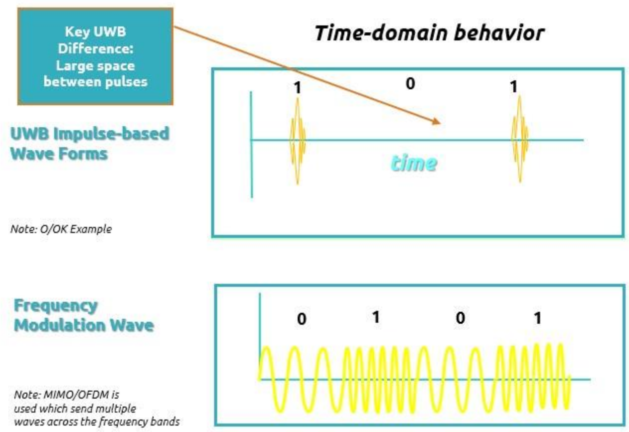
However, UWB devices can be overwhelmed by devices transmitting at extremely high-power levels. IMT transmissions are even more powerful than U-NII (e.g., Wi-Fi) transmissions. IMT base stations can transmit at 3,280 watts (+65 dBm) per MHz under part 27 limits. This is 44.2 billion times more powerful than a UWB transmission. These comparisons show how large the differences are when comparing linear power spectral density instead of dBm/MHz, (i.e., dBm is a logarithmic scale that makes orders of magnitude look small).

While UWB is proven to coexist with other technologies operating at higher power levels, such an extreme difference as this will be disruptive to the substantial number of deployed UWB devices.

#2: UWB is fundamentally different

While UWB, Wi-Fi and Bluetooth are all wireless radio frequency (RF) communication technologies, UWB is quite different from other RF technologies. UWB operates within a much wider frequency range and operates by sending exceedingly short ultra-low power pulses. This makes it making it especially resistant to multi-path and self-interference, two areas that limit the performance of the other traditional carrier-based RF technologies. It is designed for use cases that require high precision location awareness, fast data transfer, and extremely lower latency.

[3] Ultra-Wideband (UWB) Aggregation and Co-existence of Wi-Fi 6E Operating in the Presence of UWB https://uwballiance.org/wp-content/uploads/2023/05/UWBA-Interference-Testing-Report-April-2023-corrected-final.pdf



UWB has vastly different physical properties that make it more suitable for some uses compared to other RF technologies. It is widely used for secure real-time distance and location determination because the very short-duration pulses enable exceedingly accurate measurement of range (distance) instantaneously. Due to an extremely low duty cycle (the UWB pulse is typically not present 98% of the time) and extremely low transmit power, interference potential is negligible to non-existent. This has enabled millions of UWB devices to operate concurrently with other RF technologies for years without a single interference claim.

A UWB transmission emits far less power than the power transmitted by Bluetooth or Wi-Fi. This difference can range from 10's of thousands to millions. Not only is the amount of energy put "into the air" by UWB much lower, but the time during which energy is in the air is much less. The UWB signal comprises a series of pulses instead of a continuous signal. The continuous waves of other RF technologies are susceptible to wave physics that include additive, subtractive, fading, and distortion of the waves, which can diminish the quality of received signals.

Like UWB, Bluetooth is used in applications that require wireless data exchange over short distances. However, being a continuous wave carrier-based technology Bluetooth is subject to limitations in device density and performance. Although it is popular and convenient for consumer-grade electronics, it is extremely difficult to obtain full quality audio and impossible to obtain the high-precision location performance provided by UWB. Professional broadcast/theatrical communications or precision asset management is not possible due to the significantly lower bandwidth. Latency measures and audio quality have recently improved for Bluetooth but are far from accomplishing the sub 3 ms latency that is possible with UWB.

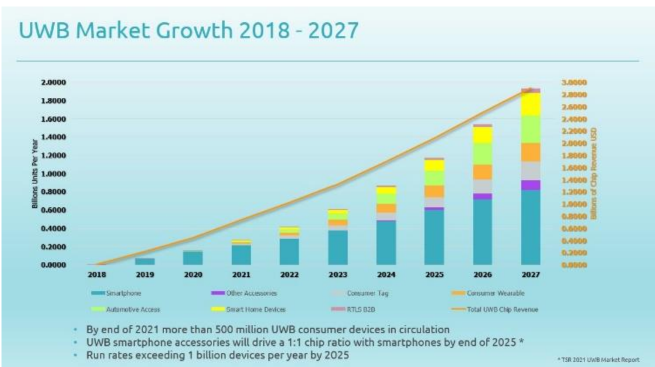
Wi-Fi, on the other hand, is a high-data-rate wireless technology used primarily for connecting devices to the Internet through wireless routers. Wi-Fi, like Bluetooth, is also a continuous wave technology subject to device density, performance, and self-interference issues. Of course, Wi-Fi has its advantages, especially regarding performance over longer or less line of sight applications. If one were to visualize the best RF technology for various uses in a home, Wi-Fi is designed to cover a "whole house" (or even outside the house or garage). In contrast, Bluetooth and UWB are more applicable to shorter range "whole room" approaches.

#3: UWB applications are growing exponentially

UWB technology has a wide range of applications that continue to expand. These include asset tracking, indoor positioning, automotive radar systems, smart home devices, and even healthcare applications, such as vital sign monitoring.

UWB is also excellent for a multitude of consumer entertainment applications that require low latency, low power, and high data rates. For example, low latency, high polling rate gaming devices, high-definition audio headsets, and wireless speakers.

Now existing in most high-end smartphones, the availability of UWB is spurring innovation to develop new applications that previously were not possible. A similar wave of innovation began in 2004 when Bluetooth was widely available in mobile phones. The same is now happening with UWB. AirTags and SmartTags are examples of how smartphones leverage UWB for tracking and finding objects, but this is just the beginning.



Because of its low energy consumption, accuracy, and lack of interference with other types of RF, UWB is also an excellent 'supporting technology' when used in conjunction with other methods to enhance performance. For example, AirTags and SmartTags use Bluetooth for detecting nearby objects and use UWB for determining the precise location of objects. The advent of more advanced chip technology is upon us, and major chip manufacturers have recognized the unique value UWB adds to their device offerings. Manufacturers now offer chips that utilize UWB right alongside Wi-Fi and Bluetooth. Each RF technology has its own unique advantages, and a complete wireless device is one that is designed to maximize the advantages of each. With the integration into multi-radio chipsets, UWB is now no more limited than Wi-Fi or Bluetooth.

#4: UWB is used across almost every electronics segment

UWB is increasingly being used in a wide range of industries for different applications all of which benefit from UWB's unique technical characteristics:

- **Audio:** Broadcast and entertainment professionals are switching to UWB to deliver the full audio bandwidth with low latency needed to meet audio performance requirements.
- **Automotive:** Secure keyless entry systems in cars, detection of children and pets left behind in cars, advanced driver-assistance systems for object avoidance

  Commercial: Secure hands-free building access, indoor navigation assistance, and automatic adjustment of lighting, heating, and ventilation to save energy and create a more comfortable environment
- **Healthcare:** Tracking medical equipment, staff, and patients within hospitals, monitoring patient vitals

- **Industrial and Manufacturing:** Tracking assets, personnel, and equipment for workflow optimization and safety
- **Internet of Things (IOT):** Communication and data transfer in IoT devices
- **Robotics**: Accurate positioning and localization, improving the efficiency of robotic systems
- **Search and Rescue:** Detect and locate people trapped in debris following natural and human-caused disasters

UWB Use Cases (Grouped by volume)

High Volume	Medium Volume	Lower volume
"Point and shoot" to initiate broadband	Smart Industrial Automation and Control	Sports monitoring and tracking
Keyless entry: Vehicles, Home and Office	Contactless vital sign and fall detection	Tank level
AR/VR	Vehicle and personnel proximity (safety)	Body Area Network
Wide dynamic range low latency audio	Robotic consumer device	GPR (Ground Penetrating Radar)
Child left behind in vehicle safety seat	RTLS Industrial asset tracking tag	
Secure payment systems	Social distancing/contact tracing	
Phone "find it" apps: tag, peripheral devices	Building material analysis device	

The versatility of UWB, with its ability to provide high data rates and precise location information in short-range communication, makes it suitable for a wide range of industries beyond consumer electronics. Its applications continue to expand as technology advances, cost comes down, and new use cases emerge.

#5: UWB is an established standard technology

UWB has been around for over two decades and has been used in various applications, including military and industrial uses, long before it gained attention in consumer devices. The establishment of standards has played a crucial role in promoting the adoption of UWB technology since 2007. Standards provide a common framework ensuring interoperability, reliability, and compatibility among UWB devices. In 2019 UWB was first used in mobile phones, spurring further awareness of the technology in consumer applications and accelerating other innovative uses across industries.

Standards, technical specifications, and certification programs have played a pivotal role in shaping the UWB landscape, facilitating its integration into various industries, and ensuring a consistent and reliable experience for users worldwide. Standardization efforts continue to evolve as technology advances, contributing to the ongoing success and expansion of UWB applications.

- **IEEE 802.15.4** is an industry standards group that specifies UWB physical (PHY) and medium access control (MAC) layers. Task Group 4ab is currently expanding the usefulness of the 802.15.4 technical standard for a wider variety of UWB applications.
- **ETSI ERM TGUWB** is the industry body that requests changes to UWB regulations in Europe and drafts the Harmonized Standards on which product compliance testing is based.
- **AES SC-02-02-B** is a task group within the Audio Engineering Society (AES) that is defining a new standard for UWB audio.

- **Omlox/PROFIBUS** is a standard that enables manufacturing applications to use location data from multiple wireless location technologies and manufacturers, including UWB, through standardized APIs.
- **Connected Car Consortium (CCC)** Digital Key standard allows mobile devices to authenticate and share digital keys that leverage UWB securely for the automotive industry.
- **The Connectivity Standards Alliance** is defining an open standardized communication protocol to enable interoperability between mobile devices, wearables, and access control readers that use multiple RF technologies including UWB.
- **FiRa** defines UWB test specifications for ranging applications and provides a UWB product certification program.

#6: UWB is far more than just short-range communication

Although there are numerous highly effective short-range UWB solutions on the market, UWB is also an important technology for critical safety and positioning applications at both short and longer distances. Child presence detection in vehicles, secure access control, and smart home applications are examples of UWB applications that utilize short-range use of the technology. In contrast, important critical applications such as search and rescue operations, autonomous vehicles, and outdoor positioning systems employ additional infrastructure or technical methods that allow longer-range use of UWB technology.

Some UWB systems can communicate across distances exceeding 100 meters. It seems counterintuitive that a UWB radio can communicate at the same distance as other technologies, (e.g., Bluetooth) using as little as 1/10th of the power consumption. The result of spreading energy over a wide bandwidth, the nature of UWB signals, and other factors such as coherent coding make this possible. The precision with which the time of flight can be determined remains extremely high even at distances over 100m with some implementations.

#7: UWB uses power extremely efficiently

UWB is used in power-constrained applications including car key fobs, mobile phones, tracking devices, RTLS infrastructures, and smart watches. The brief pulses of typical UWB transmissions allow for months or even years of use on a typical coin cell battery. In contrast to traditional wireless transmitters that constantly emit radio waves to carry the information, the duty cycle of UWB transmitters is exceptionally low since they transmit extremely short pulses (several nanoseconds) and stay silent for a relatively long time. Those with prior radar experience often assume power consumption levels much higher than what can be achieved with UWB. Power consumption on par with less feature-rich sensing modalities like Passive Infrared Sensors (PIRs) for certain applications is unimaginable to most customers familiar with, for example, mmWave radar.

Continuous transmission, used with both Wi-Fi and Bluetooth, consumes power at a higher rate than non-continuous transmissions used by UWB. This is the case with Bluetooth using GFSK in which a frequency wave is constantly modulated. Similarly, modern Wi-Fi uses OFDM-based modulation that combines several waves on various frequencies. Both technologies use far more power than needed to accomplish the same communication.

Energy consumption also applies to wireless receivers. Many wireless technologies typically require receivers with complex equalizers to mitigate channel impairments or clean receiver chains to deal with overly complex modulation schemes (e.g., 1024 QAM). The complex structure of such receivers requires higher power consumption than UWB receivers.

#8: UWB is inherently more secure

UWB is inherently secure even though it operates over a broad frequency range. UWB can easily be designed with robust security features taking advantage of the latest encryption methods, making it more secure than other wireless technologies. There are two UWB technical characteristics that uniquely enhance UWB security:

1. UWB is a pulse technology with an extremely short pulse duration. This prevents an attacker from decoding and modifying the transmitted signal, and
2. UWB signals are difficult to detect, due to the pulsed nature and extremely low power, operating below the ambient RF noise floor.

The unique capabilities of UWB make it particularly useful for enhancing security in some applications. Dedicated standards such as IEEE 802.15.4z have been developed and are commonly implemented to make UWB more robust and secure.

Security benefits have led to wide adoption of UWB for secure access to vehicles, buildings and even payments. New payment capabilities integrated into smart phones and watches are using UWB. Unlike payments that use Near Field Communication (NFC) and RFID, UWB does not require tapping your smartphone or watch on a screen. Payments made using UWB offer higher accuracy, robust security, and faster transactions speeds. Enhanced security via UWB is possible due to its very precise distance measurements, which can identify and differentiate between intended users and imposters.

Conclusion

UWB is a critical component of the total wireless industry. It must be included in the studies of sharing and compatibility being pursued as part of the Nation Spectrum Strategy and WRC-27. Ignoring its existence poses a grave threat to all the millions of devices that are currently deployed throughout the global wireless environment.

About the UWB Alliance

The Ultra Wide Band (UWB) Alliance is a global not-for-profit organization that works to collectively establish ultra-wideband (UWB) technology as an open-standards industry. A coalition made up of vendors that either design, manufacture, or sell products that use ultra-wideband technology, the UWB Alliance aims to promote and protect the current allocation of bandwidth as well as promote the continuing globalization of the technology. As part of our mission, we advocate UWB technology and use cases to promote verticals showing the value of UWB for IoT and Industry 4.0 and to build a global ecosystem across the complete UWB value chain, from the silicon to the service. In addition, the Alliance is promoting and assuring interoperability through its work with Standards Development Organizations such as the IEEE and ETSI and then working with members to define upper layers and testing to assure compliance. For more information, please visit us at www.UWBAlliance.org.