Federal Register Notice: 89 FR 12871, https://www.federalregister.gov/documents/2024/02/20/2024-03400/request-for-information-on-the-national-spectrum-research-and-development-plan, February 20, 2023.

Request for Information on the National Spectrum Research and Development Plan

Ultra Wide Band (UWB) Alliance

Comments of the

Ultra Wide Band (UWB) Alliance

on

Networking and Information Technology Research and Development (NITRD) National Coordination Office (NCO) of the National Science Foundation

Request for Information: National Spectrum Research and Development Plan (R&D Plan)

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.

1 Introduction

The Utlra Wide Band (UWB) Alliance thanks NITRD for the opportunity to provide input to the development of the National Spectrum Research and Development Plan[1].

UWB is a rapidly growing industry that is providing spectrum-efficient solutions in applications with high economic and social value. UWB is inherently a sharing technology, with low-to-no impact on other services. UWB is expanding use of available spectrum without repackaging or repurposing of spectrum. UWB is compatible with many other uses and users of spectrum. UWB is a complement to other technologies, increasing capability and capacity without increasing need for new spectrum allocations. The UWB industry has much to contribute to the future use of spectrum and so we feel is an important perspective to include in research and development of sustainable spectrum strategies, methods, and policy.

The UWB market is in the early stages of significant growth. The global UWB market is generally considered to be in the range of $1-2 billion USD as of 2024, with a CAGR (Compound Annual Growth Rate) of 17%, reaching up to $4 billion USD by 2029. Key market drivers for UWB include:

- **Consumer Electronics.** Increasing adoption of UWB in smartphones is facilitating features like secure sharing, precision location tracking for AR/VR experiences, and improved connectivity between devices**.**
- **Automotive:** UWB is used by vehicle access control systems to provide keyless entry and enhanced security. Additionally, UWB is being used to detect when a child is left unattended in a vehicle to prevent accidental heat strokes.
- **Healthcare:** UWB is used for tracking life-saving equipment in hospitals such as infusion pumps, mobile X-ray machines, and defibrillators. UWB is also being used to monitor patient vitals, track the location of staff and patients, and monitor environmental factors in sensitive areas that require precise temperature, humidity, and air quality.
- **Manufacturing:** UWB is used for real-time location tracking of materials, tools, and finished products on factory floors. It is also used for streamlining operations and improving worker safety.
- **Retail:** UWB improves inventory management and customer experience through targeted advertisements and product information based on customer location relative to products.

UWB adoption is expected to accelerate as UWB technology awareness among consumers increases, as the cost of UWB chipsets decreases, and as universally standardized protocols for UWB are developed.

It should be noted that UWB has been operating in the frequency range of 3.1 GHz to 10.6 GHz on an unlicensed basis for over 20 years. Beginning with the adoption of FCC Part 15 subpart F in 2002. In 2005, the FCC adopted rules for Wideband devices operating in the 6 GHz band via Part 15.250 with transmit power limits equivalent to subpart F.   It is often misstated that the 2020 revision of subpart E

[1] https://www.federalregister.gov/documents/2024/02/20/2024-03400/request-for-information-on-the-national-spectrum-research-and-development-plan

“opened the 6 GHz band for unlicensed operation” when in fact the band had been in use on an unlicensed basis for nearly two decades at that time. The revision to subpart E allowed substantially higher power unlicensed operation in the band. In two decades of operation under Subpart F, UWB and 15.250 Wideband rules there has been no case reported of interference with other services. The characteristics of UWB such as ultra-low transmit power are proven effective in sharing spectrum without negative impacts.

2 NSF Topics:

2.1 Recommendations on strategies for conducting spectrum research

Among essential strategies, we encourage research to enable greater diversity of use in the available spectrum. Research that expands traditional models of spectrum usage and for evaluating efficiency is needed. Traditional models of spectrum usage such as exclusive use or sharing via coordinated or non-coordinated avoidance have resulted in an unsustainable need for ever greater spectrum allocations.

More effective use of spectrum must include true sharing techniques, not just focused on traditional models of sharing that depend on coordinated or non-coordinated avoidance of simultaneous occupancy. Studies should include consideration of methods and technologies that can enable simultaneous use through positive coexistence. UWB is an example of technology that presents a different sharing model than higher power radios and supports simultaneous use by a large number of devices and compatibility with a diversity of other technologies. Any study of future sharing should include UWB and ultra-low power techniques.

Consideration of diversity of use and deeper sharing techniques requires new methods for evaluating coexistence performance. Collaborative measurement-based studies can be an effective method identifying potential areas of incompatibility. The approach should aggregate a mix of technologies and stakeholders with different spectrum usage needs.

Sharing information and creating collaborative opportunities such as shared test beds can reduce duplication of effort while also ensuring diversity of views. As part of an R&D investment strategy, making resources for simulation and measurement-based testing available to a wide range of stakeholders will enable greater collaboration. Making resources available to smaller yet innovative entities and individuals enables contribution on a larger scale.

2.2 Recommended Priority areas for spectrum R&D

Methods to expand sharing of spectrum through positive coexistence should be a priority area for spectrum research and development. Research beyond traditional usage models is needed to achieve sustainable growth. Real coexistence of different services, technologies and users will enable more users and new capabilities without new dedicated spectrum allocations.

NITRD identifies dynamic spectrum sharing as an important area of research and development. There are various degrees of dynamic in the context of spectrum usage. Database driven models for coordinated spectrum access such as Automated Frequency Coordination (AFC) and Spectrum Access Systems used by Citizens Broadband Radio Service (CBRS) are examples of slowly changing conditions:

the information that is the basis for access decisions changes slowly. These models assume access to a central or distributed database, usually via the public internet. For a great number of applications this is not available. This limits the usefulness of this kind of access for many applications: examples include power-constrained sensor networks in industrial settings, or even metro-area IoT which do not need or cannot have gateways to external networks.

These methods follow the temporal and spatial separation model of mutual avoidance. “Sharing” in this context means exclusive use for some time period and area. Traditional methods such as listening before talk are more dynamic, making decisions based on a snapshot of channel conditions, but typically with small amounts of information with which to inform the condition e.g. instantaneous energy level. These methods are still focused on exclusive use for some time period.

We suggest alternative dynamic sharing methods that utilize active situational awareness of spectrum usage coupled with coexistence methods that enable simultaneous use. Research areas should include passive techniques to reduce impact area (e.g. extremely low transmit power). Research should also include active techniques that intelligently assess real-time and predictive trends to greatly augment coexistence and thus sharing. Combined with other positive coexistence techniques we can challenge the assumptions that limit overall capacity.

Refining methods for measuring spectrum efficiency is a priority. Diversity of use is an important metric in evaluating spectrum utilization efficiency. Evaluation of efficiency should include methods for evaluating coexistence impacts and compatibility metrics. The capacity to support many users and different uses simultaneously is an important metric of efficiency.

Coexistence studies should include methods to control and reduce impact footprint. Some examples to explore include improving algorithms for transmit power control, link adaptation, spatial containment via smart(er) antennas (e.g. beam steering) and other antenna techniques that reduce impact area.

Current practice for many services is to configure transmitters based on achieving a certain link margin under the worst-case conditions expected. The result is that much of the time they are transmitting at much higher power than needed for a given link. This practice greatly decreases the capacity of a frequency band. This in turn drives demand for larger spectrum allocations. Developing more appropriate “use only what you need” methods will increase overall capacity. The vast number of variables that affect radio performance in real-world situations makes dynamic optimization a complex problem. This also makes it a rich area of research, with the potential for major gains.

Another important area of research is in reducing the energy consumed by wireless systems. Even small improvements become significant when multiplied by the many billions of consumer devices in use. Areas of research include efficiencies at the semiconductor process level as well as at the protocol levels. Advances in device efficiency will provide future gains, while protocol improvements yield benefits more immediately and in ways that can be applied to already deployed physical devices.

An important priority is to make more information available via measurement-based studies. Measurement based studies (testing) using a variety of technologies and services, including UWB, should have as primary goals:

- Include a mix of multiple technologies and systems
- Include methods for evaluating coexistence performance

- Identifying areas of potential incompatibility
- Evaluate methods for achieving compatible uses
- Include study of real-world conditions

Research should include more complete characterization of real-world conditions, so that the assumptions used in both lab-based testing and simulations can be improved. The complexities of real-world RF conditions create significant challenges for which new, innovative methods are needed.

We strongly support the concept of aggregation research that mix multiple technologies, both measurement-based and via simulations. Studies that aggregate multiple technologies such as UWB, Wi-Fi, mobile and Bluetooth must include participation of experts from each of these areas. This is an important step in identifying potential compatible and incompatible use and informing development of effective techniques to increase compatibility. Additionally, such studies can be used to evaluate other performance characteristics, for example effects of (and on) ambient noise floor, receiver performance, channel access algorithms and link adaptation techniques.

We encourage research into effective means to improve receiver performance. Such research can benefit both commercial and government users. There are widely varying ideas as to what performance metrics are meaningful. This suggests a priority area of research is to evaluate metrics and find those that correlate well to specific goals. The record suggests “easy” metrics such as receiver sensitivity are insufficient. Development of more useful metrics for performance are needed to enable research into methods to improve performance. Studies should promote technology transfer so that established techniques in one area can feed innovation in another. For example, receiver design methods used in UWB systems enable link margin at extremely low transmit power; such techniques may benefit developers of other systems in achieving performance targets at lower transmit power.

The UWB Alliance strongly endorses the concept of a national test bed that is made available openly. There are many technical challenges to implementing such a test bed, including enabling remote participation, which is essential to include the widest range of researchers and stakeholders. A priority is reducing the financial thresholds for participation. This will enable participation by small entities and individuals without the extensive resources of large companies. Technological innovation often comes from small entities such as start-ups and incubators that typically have very limited financial resources.

The national test bed must include a wide range of technologies, including UWB. UWB is playing a critical role in expanding capabilities for consumer devices and increasing non-interfering use of existing spectrum allocations. Compared to other commodity wireless technologies, UWB is at an earlier stage of evolution and on a steep innovation curve.

In addition to a physical testbed, the national testbed should include simulation models and access that is not geographically dependent. Simulation based testbeds should provide access to all researchers irrespective of entity size. A virtual testbed or set of testbeds creates a level playing field in which all can contribute and learn. Openness is essential so that the models and methods used by any group are available to, and understood by, others. This provides the greatest opportunity validation and repeatability of study results by multiple peers and peer groups. Openness also increases credibility, confidence and applicability of results.

2.3 Recommendations on grand challenge problems for spectrum R&D.

One of the greatest challenges is changing traditional thinking. The current mindset in wireless systems is to think of different technologies and systems as competing for the same uses, users and resources. This leads to an "I can do it all with one radio" mindset limiting the ability to optimize spectrum usage. This mindset is obsolete and results in huge inefficiencies that waste spectrum resources and drive the unsustainable need for ever more spectrum allocations.

To achieve optimal solutions, the wide array of available technologies must be considered. Better matching of the radio to the application needs will result in greater efficiencies. Enabling synergies will increase performance, capabilities, and capacity. Better understanding through research demonstrating the advantages of "using the right tool for each part of the job" can expand awareness of the many possibilities for improvement. The "right tool" solution drives innovation in multiple technologies.

The UWB industry is an example of how a more inclusive mindset is leading to more efficient solutions: UWB can work efficiently in situations where other technologies do not, or do not work as efficiently or effectively. When paired with traditional wireless such as Bluetooth and Wi-Fi, the combined solution offers capabilities not achievable alone, and improves efficient use of the spectrum. A specific example is use of UWB in nearby sharing applications, where the precise range and angle of arrival information provided by the UWB radio identifies the correct peer quickly with minimal communication. This in turn reduces the overhead for discovering and connecting, reducing use of the band. While the value of synergies has been shown, developers have only scratched the surface of what is possible. The "one size fits all" mindset continues to be a challenge and limitation.

The simple goal is to expand diversity of use for a given band without repackaging, repurposing, or new spectrum allocations. A clear metric is: are we preserving the usability of existing allocations while expanding uses, or are we driving a need for ever more spectrum allocations?

2.4 Recommendations on spectrum R&D accelerators

As noted, sharing of information and resources is an effective way to accelerate research. We endorse NSF efforts to create means to share data, test resources, and ideas in ways that include small entities and individual developers. The idea of shared testbeds, both physical and virtual (simulations), is a powerful means to accelerate R&D by providing deeper understanding of the characteristics of technologies, environments, and the resulting trade-off decisions that will lead to better development.

We strongly support sharing of testbeds and research infrastructure, with related support for collaboration. Collaboration among a wide range of researchers and practitioners is extremely valuable.

Benchmarks and competitions have limited value in promoting innovation. Challenges include selecting meaningful criteria for benchmarks and selecting "winners". Collaboration is a much more effective path to discovery.

2.5 Recommendations on near-term Federal activities to make progress towards anything identified in responses 1–4.

We recommend prioritizing true co-existence over more limited sharing. Sharing is most often defined in a way that results in temporary exclusive use of a given frequency range and/or area. This can greatly improve utilization over static allocations; however, it limits the number of uses available in that temporary period. A priority goal should be to stimulate innovations in coexistence that allow true simultaneous use by many devices operating in the same space and time. Investing in coexistence research and development leads to sustainable approaches to spectrum usage growth.

Near term actions can include policy measures that place priority on coexistence, that preserve useability of allocated spectrum based on positive coexistence capabilities. Requests for exclusive access to spectrum already being shared should be discouraged until and unless it can be shown:

a) Compatibility with current users sharing effectively is preserved
b) Technologies employed are up to the best operating performance standards
c) Operational strategies and coexistence techniques are used to minimize the need for more spectrum or more power.

Increasing transmit power and thus impact area is potentially disruptive and limits overall spectrum capacity. The "ever more" approach is unsustainable and alternatives should be given priority.

2.6 Recommendations on a process to refine and enhance the R&D plan on an ongoing basis.

To refine and enhance the R&D plan, include many stakeholders in regular review and revision of the plan. To effectively improve, metrics for evaluating performance of the plan are needed. Meaningful metrics that relate goals to progress are challenging but form the foundation of improvement. Given the vast diversity of spectrum users and uses, inclusion of the widest possible set of perspectives is essential. Lowering the barriers for participation, in terms of time or financial resources, is critical.

Organized reviews using virtual meeting tools can be useful, but finding suitable meeting times can be difficult. Non-real time review methods can be more easily used by more participants. Leveraging both on-line and off-line review is necessary.

Sharing of research and development resources will not only facilitate progress in more research areas by more researchers, but it can also provide feedback on which resources are most valuable. Likewise sharing research methods can provide feedback on what works.

2.7 Terminology and definitions relevant for spectrum R&D.

Several terms are used frequently but with varying meanings. Clarification with respect to R&D planning would facilitate clear communication.

Low power: This term is used in the context of both radio transmit power and energy consumption of the devices. We recommend "power" be in the plan context to mean *energy emitted* (transmitted) by the device or system.

Low energy: We recommend this term “energy” be used in the context of energy consumed. What constitutes “low” is challenging to quantify.

Very low power: Confusion exists over what “very low” means. In the UWB industry this means at or below regulatory limits defined in FCC part 15 subpart F and 15.250, while recently amended FCC regulations in subpart E define “very low” to be much higher than this. For consideration moving forward we recommend VLP as used in FCC U-NII regulations and introduce “Extremely low power”.

Extremely low power: we recommend this term for power substantially below “very low” as used in FCC subpart E, corresponding to typical UWB limits.

Dynamic: This term is problematic in that there are many levels of dynamic in discussing wireless systems. This can mean both active and passive adaptation. It is often used to mean “not static” (anything other than exclusive, licensed access). We suggest that resolving to a set of context-specific meanings is not trivial and that additional terms may need to be defined to clarify each type of “dynamic” meant in a specific context.

Coexistence: Coexistence is the ability of multiple systems to share spectrum in the same time and space. There can be levels of coexistence. Broadly, positive coexistence is the ability to operate without disruption of either system; negative coexistence is when one or more systems are disrupted.

Sharing: The most common use is broadly inclusive of any allocation that is not fixed and exclusive.