# The Future Growth of IEEE 802.15.4
# Narrow Band and Ultra Wide Band Ad-Hoc Networks

**The Evolving Wireless IoT Standard**

April 20th & 21st, 2022

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# SPEAKER – CLINT POWELL

## Chair - IEEE 802.15 Work Group

Clinton C Powell (Senior Member, IEEE) is the recently elected Chair of the IEEE 802.15 Work Group.  He is also Acting Chair of the 802.15.14 Task Group and Vice-Chair of the 802.15.4ab Task Group.  Over the past 20 years he has participated (as a Chair, Vice-Chair, Technical Editor, Contributor, Reviewer) for numerous 802.15 standards.  During this time, he has also held and continues to hold numerous roles within the Connectivity Standards Alliance. More recently he has become increasingly involved in Ultra Wideband (UWB) technology including both the CCC and FiRa Consortiums.

Clint is presently a Principal Wireless Technology Consultant with Meta Platforms.  He is sought in the Emerging Wireless IoT and Smart Energy Communications Industries by chip makers, product manufacturers, end customers, and system deployers on a variety of questions, concerns, system definitions, standards clarifications, and real-world product deployment performance issues.  He has authored many internal and several conference papers and holds 36 US patents in wireless communications.

# SPEAKER – BENJAMIN A. ROLFE

## Chair - 802.15.4ab Task Group

Benjamin A. Rolfe (Senior Member, IEEE) chairs the 802.15.4ab Task Group. His industry experience spans the development of technologies for imaging systems, aerospace, wireless communication, the IoT, and energy systems. Ben has been active in the development or Ultra Wideband (UWB) technology for 2 decades. In addition to UWB, His research and development interests include wireless coexistence strategies for efficient spectrum usage, spectrum policy, and the development and application of standards. Ben is founder and principal technologist at Blind Creek Associates, Chief Technology Officer for the Ultra Wideband Alliance, is an active consultant in wireless communication and protocols, and holds officer positions in the 802.15 and 802.24 working groups in IEEE-SA.

# SPEAKER – PHIL BEECHER

## President and CEO - Wi-SUN Alliance

Phil Beecher is the President and CEO of the Wi-SUN Alliance, an industry organization which promotes standards-based interoperable wireless communications products for Smart Utility Networks, Smart City and Internet of Things applications and implements a rigorous testing and certification program to achieve its aims.

Phil has extensive experience in wireless communications protocols, standards and testing. He is a recently elected Vice Chair of the IEEE 802.15 Work Group and has held positions as chairman of IEEE 802.15 TG4d, TG4g, TG4u and TG4v (wireless standards for Smart Utility Networks for use globally), vice chairman of IEEE 802.15 TG4m (TV Whitespace), vice chairman of the Wi-Fi Alliance Smart Grid Task Group, chairman of OpenSG Edge Conformity Task Group, contributing editor to IEEE802.15.4-2006 and has held positions in the US Smart Grid Interoperability Panel (SGIP) Test and Certification Committee, Telecom Industry Association and Bluetooth SIG. He has been an active contributor in the development of communications standards and the specification of test plans for a number of Smart Utility Network standards, including Advanced Metering Infrastructure and Home Energy Management Systems.

He is a graduate of the University of Sussex with a degree in Electronic Engineering and holds patents in communications and networking technology.
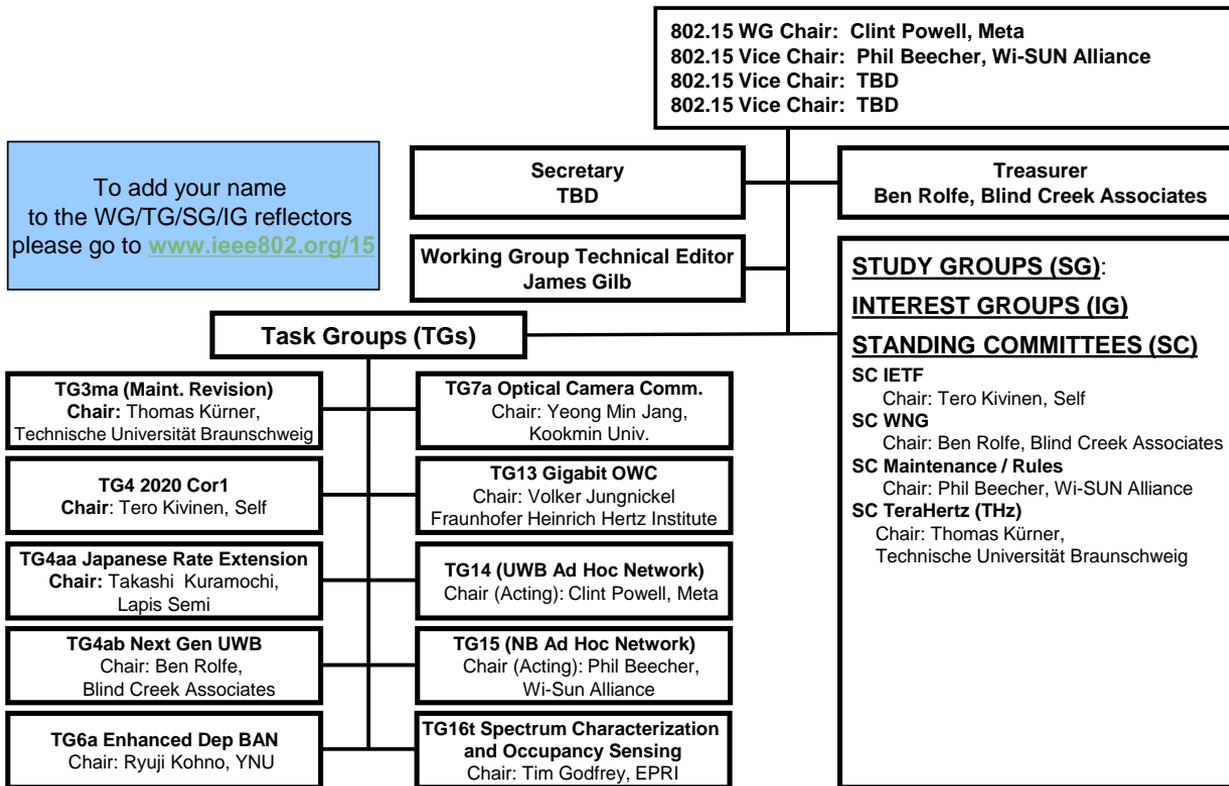
# DISCLAIMER

# IEEE 802.15 WG & 802.15.4

# IEEE 802.15 Org Chart

**802.15 WG Chair:  Clint Powell, Meta**
**802.15 Vice Chair:  Phil Beecher, Wi-SUN Alliance**
**802.15 Vice Chair:  TBD**
**802.15 Vice Chair:  TBD**

To add your name
to the WG/TG/SG/IG reflectors
please go to **www.ieee802.org/15**

**Secretary**
**TBD**

**Treasurer**
**Ben Rolfe, Blind Creek Associates**

**Working Group Technical Editor**
**James Gilb**

### Task Groups (TGs)

**TG3ma (Maint. Revision)**
**Chair:** Thomas Kürner,
Technische Universität Braunschweig

**TG4 2020 Cor1**
**Chair**: Tero Kivinen, Self

**TG4aa Japanese Rate Extension**
**Chair:** Takashi  Kuramochi,
Lapis Semi

**TG4ab Next Gen UWB**
Chair: Ben Rolfe,
Blind Creek Associates

**TG6a Enhanced Dep BAN**
Chair: Ryuji Kohno, YNU

**TG7a Optical Camera Comm.**
Chair: Yeong Min Jang,
Kookmin Univ.

**TG13 Gigabit OWC**
Chair: Volker Jungnickel
Fraunhofer Heinrich Hertz Institute

**TG14 (UWB Ad Hoc Network)**
Chair (Acting): Clint Powell, Meta

**TG15 (NB Ad Hoc Network)**
Chair (Acting): Phil Beecher,
Wi-Sun Alliance

**TG16t Spectrum Characterization**
**and Occupancy Sensing**
Chair: Tim Godfrey, EPRI

**STUDY GROUPS (SG)**:

**INTEREST GROUPS (IG)**

**STANDING COMMITTEES (SC)**
**SC IETF**
    Chair: Tero Kivinen, Self
**SC WNG**
    Chair: Ben Rolfe, Blind Creek Associates
**SC Maintenance / Rules**
    Chair: Phil Beecher, Wi-SUN Alliance
**SC TeraHertz (THz)**
    Chair: Thomas Kürner,
    Technische Universität Braunschweig

# IEEE 802.15 Standards Pipeline
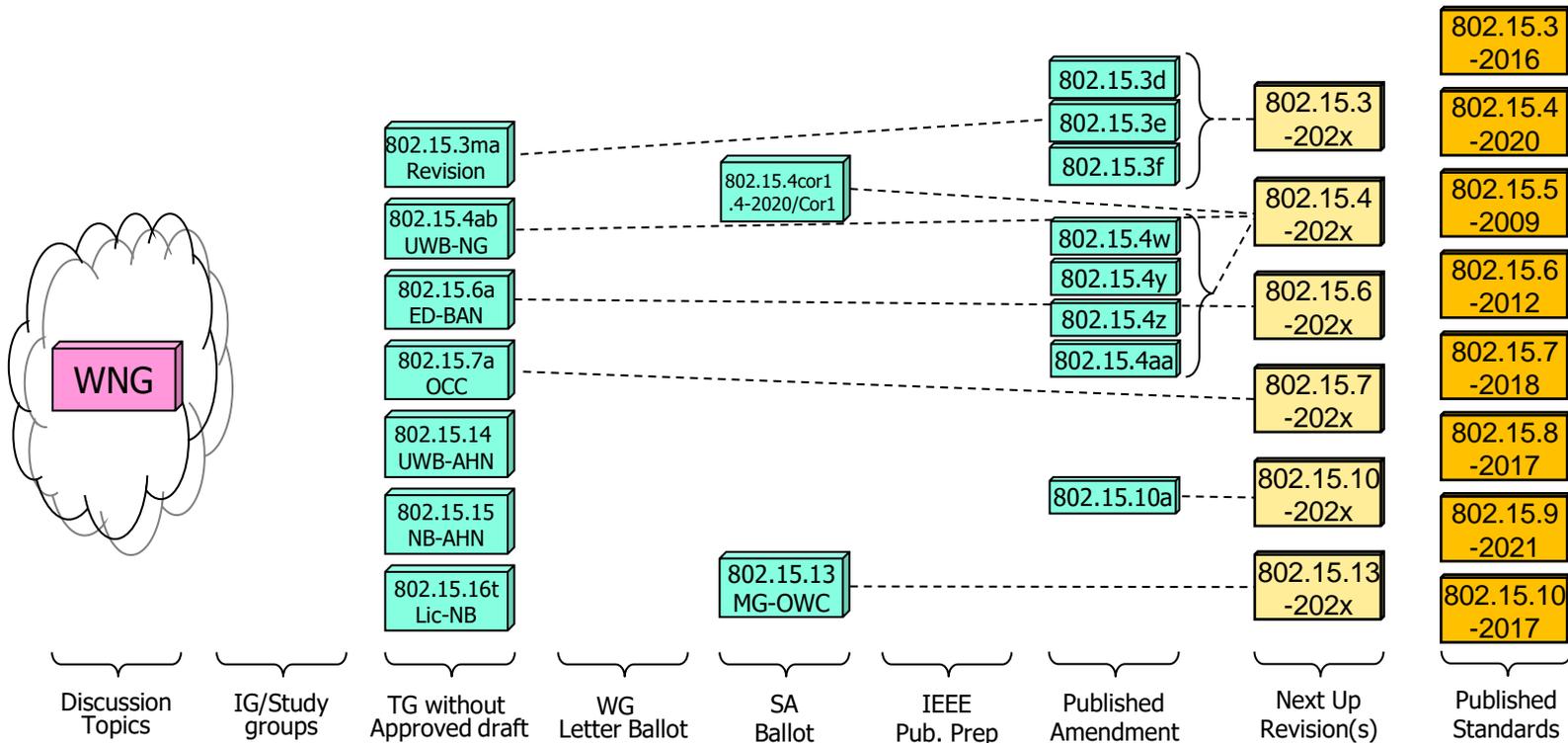
# 802.15.4 Standard

## A well-equipped toolbox

**A rich set of parts to assemble many different networks**

Multiple PHYs and a flexible, adaptable MAC

▪ Different option sets for with different application focuses

▪ Simple MAC features for directed and broadcast frame exchange

▪ Foundation for MAC layer security

▪ Flexible frame formats (containers)

▪ Multiple channel access schemes
  · Random access with listen before talk (CSMA-CA)
  · Random access via Aloha
  · Time-based access (multiple schemes)

▪ Many options to support various needs
  · Low power operation
  · High precision ranging
  · Control oriented communications

# 802.15.4 Standard

A foundation for many diverse uses



**Vast flexibility and adaptability for applications such as:**

- Home Energy management
  - Moderate data rates
  - Low latency
  - Small mesh networks

- Field area network support
  - Need for low to moderate data rates (1kbit/sec to 2.4 Mbit/sec)
  - Networks may be very large with mesh topologies scaling to thousands of nodes with multiple border routers

- UWB for precision location and communication
  - Peer to peer ranging: one to a few with no infrastructure gateways or need for infrastructure (fixed) devices
  - Infrastructure based (TDOA): Network of fixed anchors and mobile tags (phones or other devices)
  - 850 kbit/sec to ~50 Mbit/sec
  - May combine ranging with data delivery

# 802.15.4 and Ad-Hoc Networks

**802.15.4 Supports many network topologies to address many applications**
**An Ad-Hoc network can be many things**

▪ Network Scale - from a few devices to many thousands

▪ May not be infrastructure based

▪ May be formed without a single control point

▪ Supports peer-to-peer communication

· May support single hop peer-wise communication (e.g. Phone to Phone)

· May support multi-hop peer to one or more peers (mesh)

▪ May be formed dynamically and change rapidly

▪ May be relatively static once formed

There are many different scales and types of Ad-Hoc network and many uses

… including RC Helicopter control on Mars

# 802.15.4 Standard - NB & UWB at the Next Level

Large Consortium Adoption

**802.15.4 PHY and MAC components are used as the underlying communications technology by many industry consortia including:**

1. **CCC**
2. **CSA**
3. **ETSI TG28**
4. **ETSI TG34**
5. **FiRa**
6. **IEEE 1901.1+2**
7. **IETF: 6lo**
8. **IETF: 6tisch**
9. **IETF: Roll**

10. **ISA100**
11. **ISO/IEC JTC1/ SC31/WG4**
12. **JUTA**
13. **Omlox**
14. **Thread Group**
15. **TIA TR-51**
16. **UWB Alliance**
17. **WIA**
18. **Wi-SUN Alliance**

# Growth of 802.15.4 NB Ad-Hoc Networks

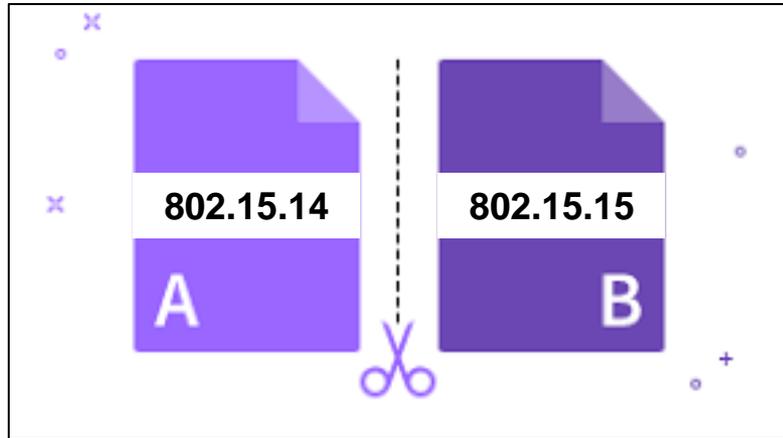Hundreds of Millions (to Billions) of Deployed 802.15.4 NB Devices



- **Field Area Networks for Smart Energy & Smart Cities**

- **Home Energy Management**

- **Industrial Controls**

- **Consumer Entertainment**

- **Smart Home Control**

- **Wireless Gaming Controls**

- **Smart Agriculture**

# 802.15.4 NB Ad-Hoc Networks → 802.15.15

IEEE 802.15 TG15 - Goals

## 802.15.4



802.15.14 | 802.15.15

A | B

1) Identify functionality from IEEE 802.15.4-2020 which is currently in use or intended for use in wireless ad hoc networks:
   a. in derived standards
   b. in specifications adopted by industry consortia

2) To create a new standard that references, in a structured way, only the relevant functionality from IEEE 802.15.4-2020.

# 802.15.4 UWB Ad-Hoc Networks

## Capabilities

**802.15.4 UWB (802.15.4z) being used widely**
**You've probably got it in your phone!**

Unique capabilities of Impulse Radio Ultra Wideband (IR-UWB) Provides precision ranging and location services as well as low impact data communications (good coexistence).

- Very short duration impulse signal (~1ns) provides precise measure of time of arrival -> enables precise ranging (few cm)
- IR-UWB provides exceptional coexistence with other IR-UWB and other radios
  - Short impulse with a lot of space in between
  - Multiple transmissions does not mean collisions (failure)
  - Very low power (thousands of times lower than typical radio) means no impact on other radios
- Can also support sensing

# 802.15.4 UWB Ad-Hoc Networks
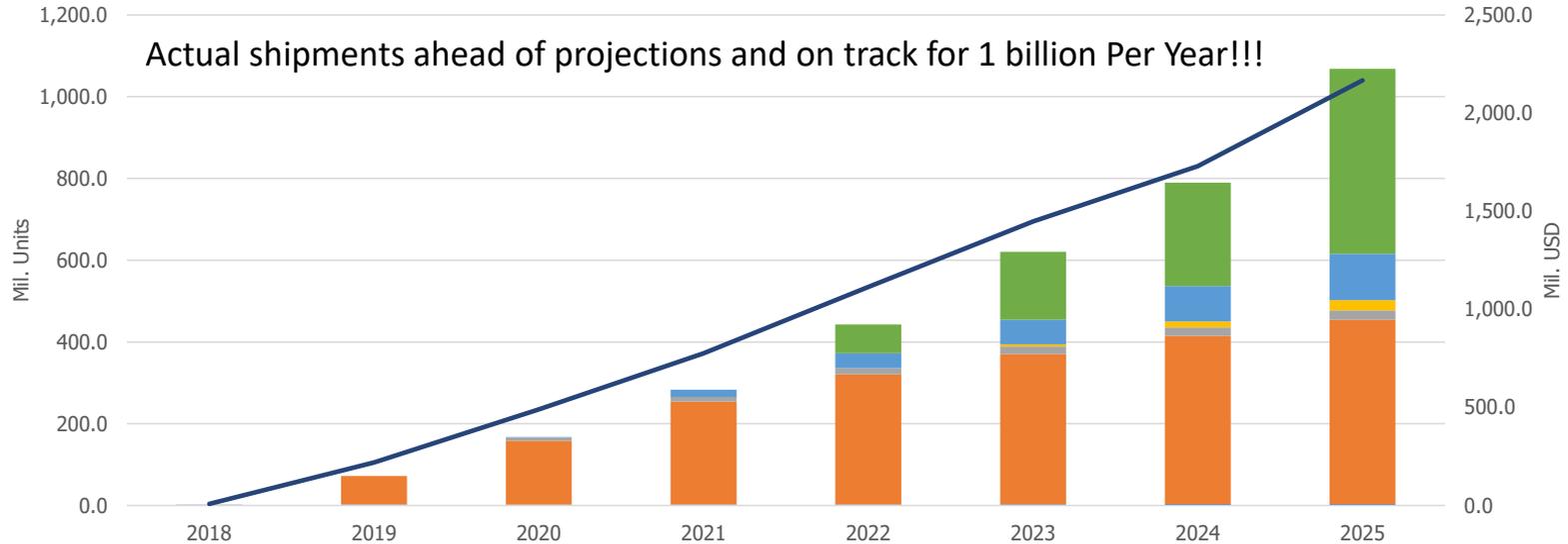
## Industry Adoption

**Support for multiple industries**

- Manufacturing
  - Locating and Tracking assets and people
- Automotive
  - Secure entry
  - Occupancy detection ("no child left behind")
- Security, Public Safety, and Convenience
  - Secure entry
  - Presence detection
  - Personnel location and tracking
- Healthcare
  - Locating patients, personnel and equipment
  - Contact tracing (infectious disease control)
- Consumer
  - Locating and finding things
  - Enhancing Virtual Reality and Augmented Reality
  - Secure access to vehicles & buildings from your phone

High-Resolution Contact Tracing

Next Generation Passive Keyless Entry

Find "My Stuff" Applications

AR & VR Positional Awareness and Communication

Secure Payment Solutions

RTLS for Healthcare

# Growth of 802.15.4 UWB Ad-Hoc Networks

**FOUNDATIONAL TECHNOLOGIES**

Explosive Growth of 802.15.4 UWB continues



Actual shipments ahead of projections and on track for 1 billion Per Year!!!

**Based on TSR 2020 UWB Market Report. UWB Smartphone Accessories for Smartphones will drive a 1:1 chip ratio with Smartphones by 2025, producing an estimated total $2.3B of Chip Revenue Annually**

Legend: Industrial RTLS · Smartphone (ASP) · Consumer Tag · Consumer Wearable · Automotive Access · Others Including Smartphone Accessories · Total UWB Chip Revenue

# 802.15.4 UWB Ad-Hoc Networks → 802.15.14



IEEE 802.15 TG14 - Goals

**802.15.4**
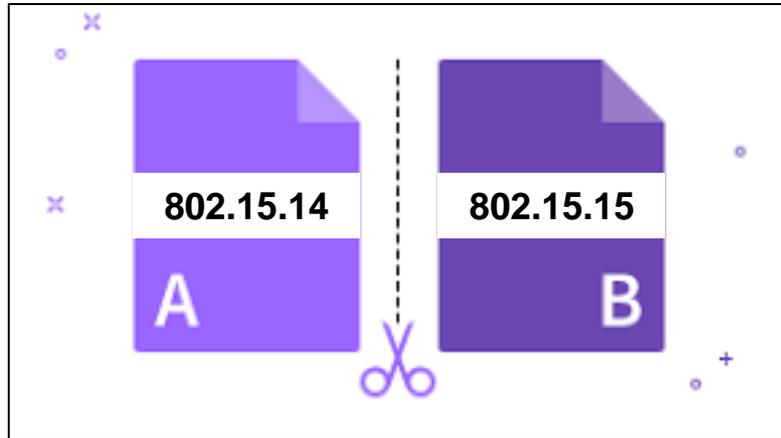
1) Identify functionality from IEEE 802.15.4-2020 which is currently in use or intended for use in impulse radio ultra wideband wireless ad hoc networks:
   a. in derived standards
   b. in specifications adopted by industry consortia

2) To create a new standard that references, in a structured way, only the relevant functionality from IEEE 802.15.4-2020.

# 802.15.4 Extended UWB Functionality → 802.15.4ab

IEEE 802.15 TG4ab - Goals
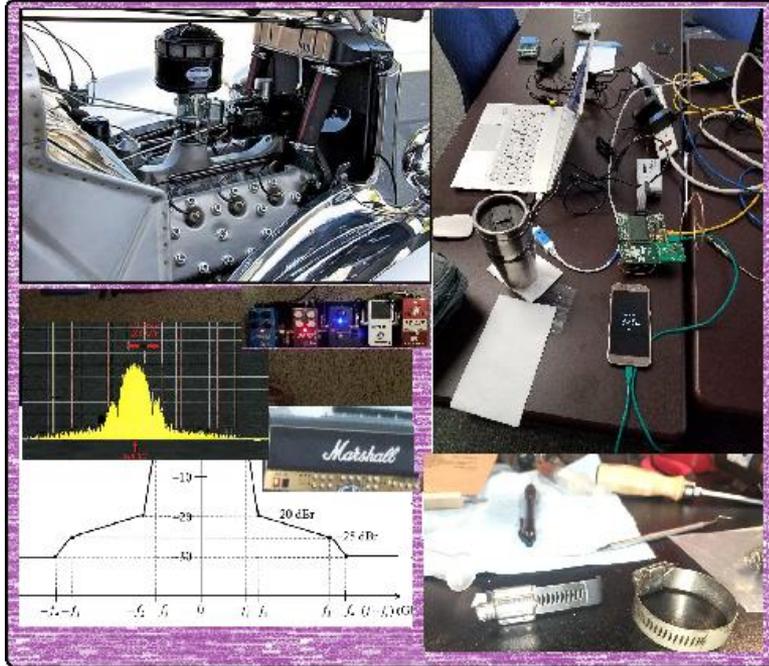


Enhance the Ultra Wideband (UWB) physical layers (PHYs) medium access control (MAC), and associated ranging techniques while retaining backward compatibility with enhanced ranging capable devices (ERDEVs)

# Near Term 802.15.4 UWB Needs

Enhancements being targeted in IEEE 802.15 TG4ab

- Additional coding
- Preamble and modulation schemes to support:
  - Improved ink budget
  - Reduced air-time relative to IEEE Std 802.15.4 UWB
- Additional channels and operating frequencies
- Interference mitigation techniques to support:
  - Greater device density
  - Higher traffic use cases relative to the IEEE Std 802.15.4 UWB
- Improvements to accuracy, precision and reliability and interoperability for high-integrity ranging

- Schemes to reduce complexity and power consumption
- Definitions for tightly coupled hybrid operation with narrowband signaling to assist UWB
- Enhanced native discovery and connection setup mechanisms
- Sensing capabilities to support
  - Presence detection
  - Environment mapping
- Mechanisms supporting:
  - Low-power low-latency streaming
  - High data-rate streaming allowing at least 50 Mb/s of throughput

Safeguards so that the high throughput data use cases do not cause significant disruption to low duty-cycle ranging use cases

# 802.15.4 is Evolving for Future Growth

## 802.15.4ab - NG UWB

**Purpose**

Extending UWB functionality, features, and capabilities of 802.15.4

## 802.15.14 - UWB AHN

**Purpose**

Provide an underlying communications standard for UWB Ad-Hoc Networks specific technologies, making it easier for users to understand what needs to be implemented from 802.15.4 and what is not relevant to UWB usage

## 802.15.15 - NB AHN

**Purpose**

Provide an underlying communications standard for NB Ad-Hoc Networks specific technologies, making it easier for users to understand what needs to be implemented from 802.15.4 and what is not relevant to NB usage

# THANK YOU

Clint Powell: Chair - IEEE 802.15 WG, cpowell@ieee.org

Phil Beecher: President and CEO of the Wi-SUN Alliance, pbeecher@wi-sun.org

Ben Rolfe: Chair - 802.15.4ab Task Group, ben@blindcreek.com

LinkedIn: Clint Powell, Phil Beecher, Ben Rolfe

# ADDITIONAL RESOURCES

IEEE 802.15 (WSN) WG - Homepage
https://ieee802.org/15/index.html

IEEE 802.15 (WSN) WG - March 2022 Mtg. Mins.
https://mentor.ieee.org/802.15/dcn/22/15-22-0137-02-0000-802-15-wg-cac-mins-march-2022-virtual-plenary.docx

IEEE 802.15 (WSN) WG - March 2022 Closing Report
https://mentor.ieee.org/802.15/dcn/22/15-22-0203-00-0000-mar-2022-closing-report-for-802-15.pptx

IEEE 802.15 (WSN) WG - May 2022 Mtg. Graphic
https://mentor.ieee.org/802.15/documents?is_dcn=201&is_year=2022

IEEE 802 - May 2022 Wireless Interim Session Registration
https://touchpoint.eventsair.com/2022-may-ieee-802-wireless-interim-session