

Presentation Will  
Begin Shortly

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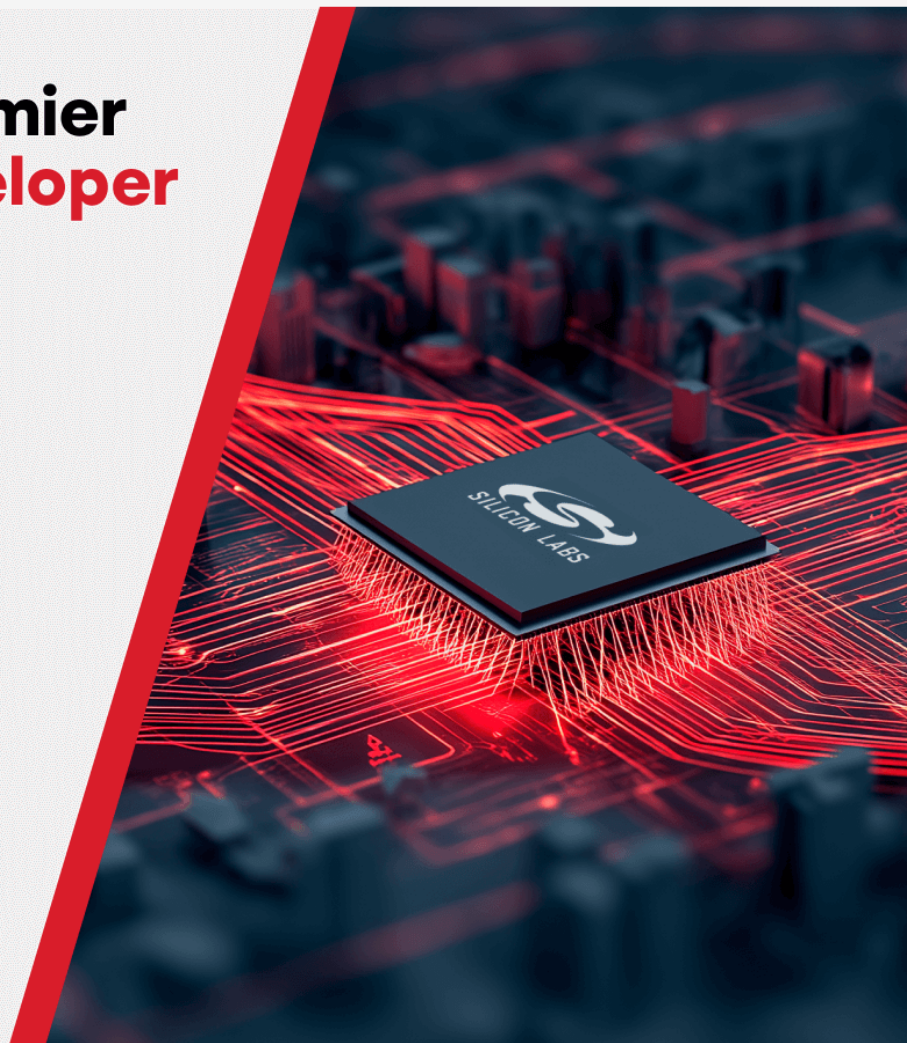
# The Premier IoT Developer Event

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# Bringing Bluetooth 6.0 Channel Sounding to Market

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2025  
tech  talks  
WEBINAR SERIES



BLUETOOTH

# Agenda

**Technology Overview**

**Channel Sounding Applications**

**Silicon Labs Offerings**

**Algorithm Performance Data**

**Developer Tools**

**Q&A**



# Why Bluetooth® Channel Sounding?

## THE CHALLENGE:

IOT applications need 'spatial' awareness to be more secure, reliable, and responsive



Earlier Bluetooth LE versions lack native support for precise ranging



RSSI-based ranging is noisy and unreliable in real-world use



Direction Finding needs complex antennas, adding cost & complexity



UWB is accurate but often too costly, and bulky for IoT

## THE OPPORTUNITY:

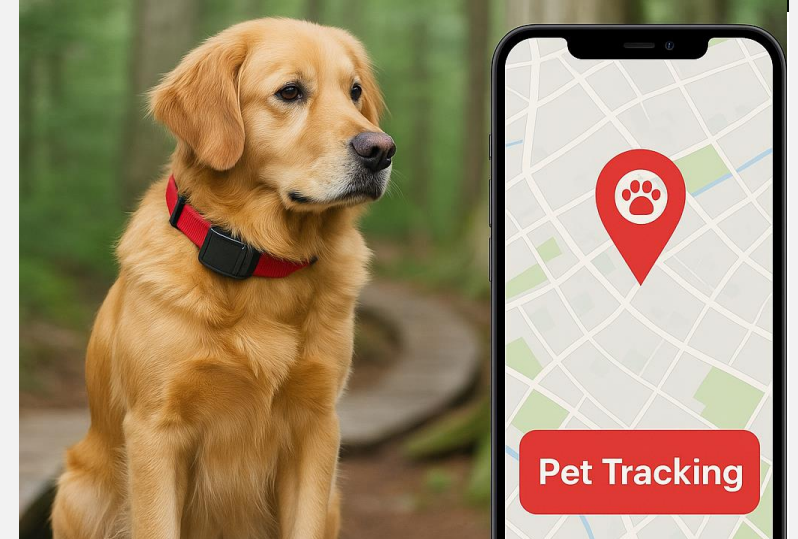
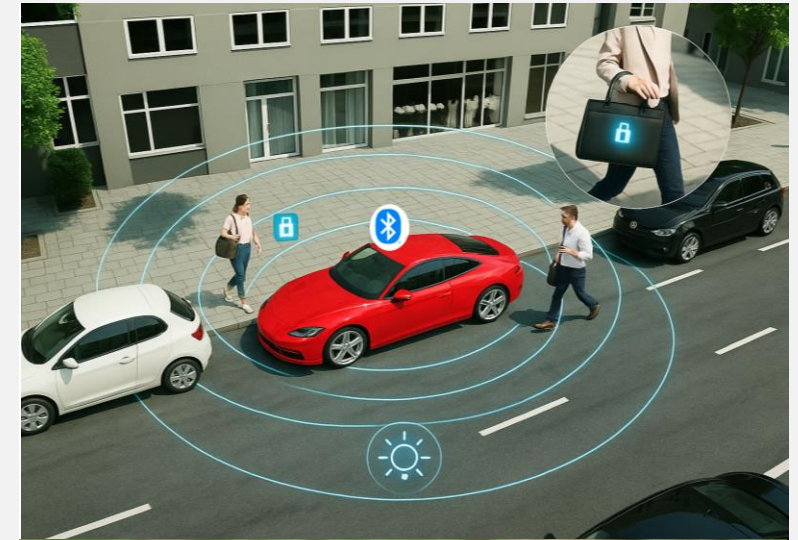
### Channel Sounding for Bluetooth

Standardized approach for accurate, secure ranging in Bluetooth 6.0

Enables sub-meter accuracy with robust performance, even in NLOS

Works with single or dual antenna setups - flexible for different form factors

More cost efficient than UWB; requires minimal external components



**Built on existing Bluetooth infrastructure, simplifying adoption and ecosystem integration**

# Bluetooth® Channel Sounding Overview

- **Measure distance between two devices using**
  - Phase-based Ranging (PBR)
  - Round Trip Time (RTT)
- **RTT and PBR operates across 2.4 GHz band**
  - Standard specifies up to 72 channels
  - Random channel hopping pattern
- **Connection-Oriented 2-way ranging with two roles**
  - Initiator: device that wishes to calculate distance from itself to another device
  - Reflector: device responding to initiator
- **Supports up to 4 antenna paths between devices**
  - 8 possible antenna combinations
- **Multiple security features included in the standard**
- **Can be combined with Angle of Arrival / Departure (AoA/AoD)**
  - Enables position estimation with single locator/tag pair

## Additional Resources

- [Webpage](#) – Learn more about Silicon Labs offerings and demos
- [Tech Talk](#) – Explore Bluetooth Channel Sounding
- [Workswith 2024](#) - Enable Accurate Distance Estimation Using Channel Sounding
- [Blog](#): Learn more about Antenna Switching with Silicon Labs Channel Sounding
- [API Spec](#): Getting Started with Silicon Labs Bluetooth Channel Sounding

# Bluetooth® Channel Sounding Comparison

	RSSI	UWB	Angle of Arrival	Channel Sounding
Localization metric	Resolve distance estimation from transmitter signal strength	Resolve distance between two points using high-resolution time-of-flight (ToF)	Resolve direction vector between two points	Resolve distance between two points using time of flight and phase-based ranging
Antenna requirements	Single antenna	Often complex hardware	Multi-antenna required by spec	Single or dual antenna
Connectivity	Connection-oriented and connectionless	Connectionless	Connection-oriented and connectionless	Connection-oriented
Performance metrics	+/- 5 m, high susceptibility to multipath interference	High accuracy (~10–30 cm)	+/- 3 degrees accuracy – azimuth +/- 5 degrees accuracy – elevation	+/- .3 m < 5m with PBR +/- 0.5 m > 5m with PBR
Solution advantages	Ubiquitous support for RSSI measurements in existing Bluetooth LE products	<ul style="list-style-type: none"> <li>• High Precision</li> <li>• Low Latency</li> </ul>	<ul style="list-style-type: none"> <li>• Scalable solution for real time position tracking</li> <li>• Supports 5-10 year battery life</li> </ul>	<ul style="list-style-type: none"> <li>• Small form factor with flexible antenna design</li> <li>• Feature-add for security by proximity</li> </ul>
Solution disadvantages	Highly susceptible to RF noise and multipath	Expensive and complex integration	<ul style="list-style-type: none"> <li>• Needs complex antenna setup and calibration</li> </ul>	Scalability

# Bluetooth® Channel Sounding - Target Markets & Use Cases



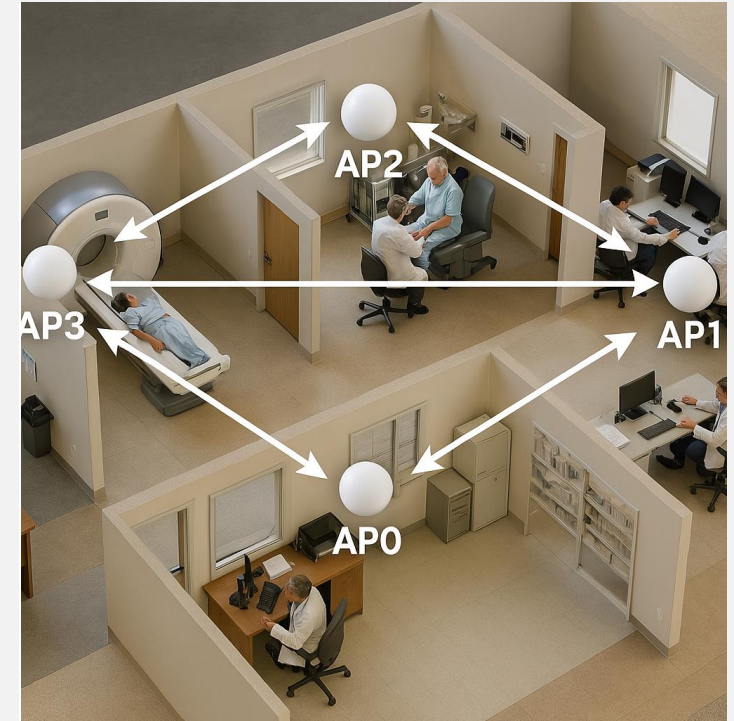
## PROXIMITY AWARENESS

**Door locks**  
**Keyless entry**  
**Building access systems**  
**Geofencing - security alerts**



## LOCALIZATION

**Indoor asset management -  
hospitals, warehouses**  
**Pet tracking**  
**Item finding - wallet, keys**



## AUTOMAPPING

**Solar Trackers**  
**Luminaires, Access Points**  
**Accurate Mapping for Battery  
Storage**



# BG24: Optimized for Battery Powered, Channel Sounding-enabled IoT Devices



- 5x5 QFN40 (26 GPIO), AEC-Q100
- 6x6 QFN48 (32 GPIO), AEC-Q100
- 3.1x3.0 WLCSP42

## DIFFERENTIATED FEATURES

- **Ultra small form-factor**
  - 3.1 x 3.0 WLCSP package
- **+20 dBm output power**
  - Eliminates need for external power amplify
- **AI/ML accelerator**
  - Accelerates inferencing while reducing power consumption
- **Secure Vault High**
  - Protects data and device from local and remote attacks
- **20-bit ADC**
  - 16-bit ENOB for advance sensing
- **Improved Coexistence**
  - Ideal for gateways and hubs
- **PLFRCO**
  - Eliminates need for 32 KHz xtal

## DEVICE SPECIFICATIONS

- **High Performance Radio**
  - Up to +19.5 dBm TX
  - -97.6 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
  - Up to 78 MHz
  - 1536kB Flash, 256kB RAM
- **Low Power**
  - 49.1  $\mu$ A/MHz (CoreMark)
  - 5.0 mA TX @ 0 dBm
  - 5.1 mA RX (802.15.4)
  - 4.4 mA RX (BLE 1 Mbps)
  - 1.3  $\mu$ A EM2 sleep
- **Multiple protocol support**
  - Bluetooth 6.0 (1M/2M/LR), Bluetooth mesh, Proprietary 2.4 GHz



# BG24L: Channel Sounding Optimized, High-Performance & Low-Cost AI/ML Wireless SoC



- **5x5 QFN40 (26 GPIO)**

## DIFFERENTIATED FEATURES

- **Supports Bluetooth 6.0**
  - Channel Sounding optimized BLE SoC
  - Single-connection two-way ranging
  - Ideal Solution for Channel Sounding tags
- **Lowest Power RF**
  - Increases battery life
- **PLFRCO**
  - Eliminates need for 32 KHz XTAL and lowers overall system cost
- **16-bit ADC**
  - Up to 14-bit ENOB for better analog sensing
- **AI/ML accelerator**
  - Accelerates inferencing while reducing power consumption
- **Secure Vault Mid**
  - Protects data and device from local and remote attacks
- **Improved Coexistence**
  - Ideal for gateways and hubs

## DEVICE SPECIFICATIONS

- **High Performance Radio**
  - Up to +10 dBm TX
  - -97.6 dBm RX @ BLE 1 Mbps
- **Efficient ARM® Cortex®-M33**
  - Up to 78 MHz
  - 768kB Flash, 96kB RAM
- **Low Power**
  - 49.1 µA/MHz (CoreMark)
  - 5.0 mA TX @ 0 dBm
  - 5.1 mA RX (802.15.4)
  - 4.4 mA RX (BLE 1 Mbps)
  - 1.3 µA EM2 (16kB RAM retention)
- **Wide Operating Range**
  - 1.71 to 3.8 volts
  - +125°C operating temperature
- **Multiple protocol support**
  - Bluetooth 6.0 (1M/2M/LR), Bluetooth mesh, Proprietary 2.4 GHz

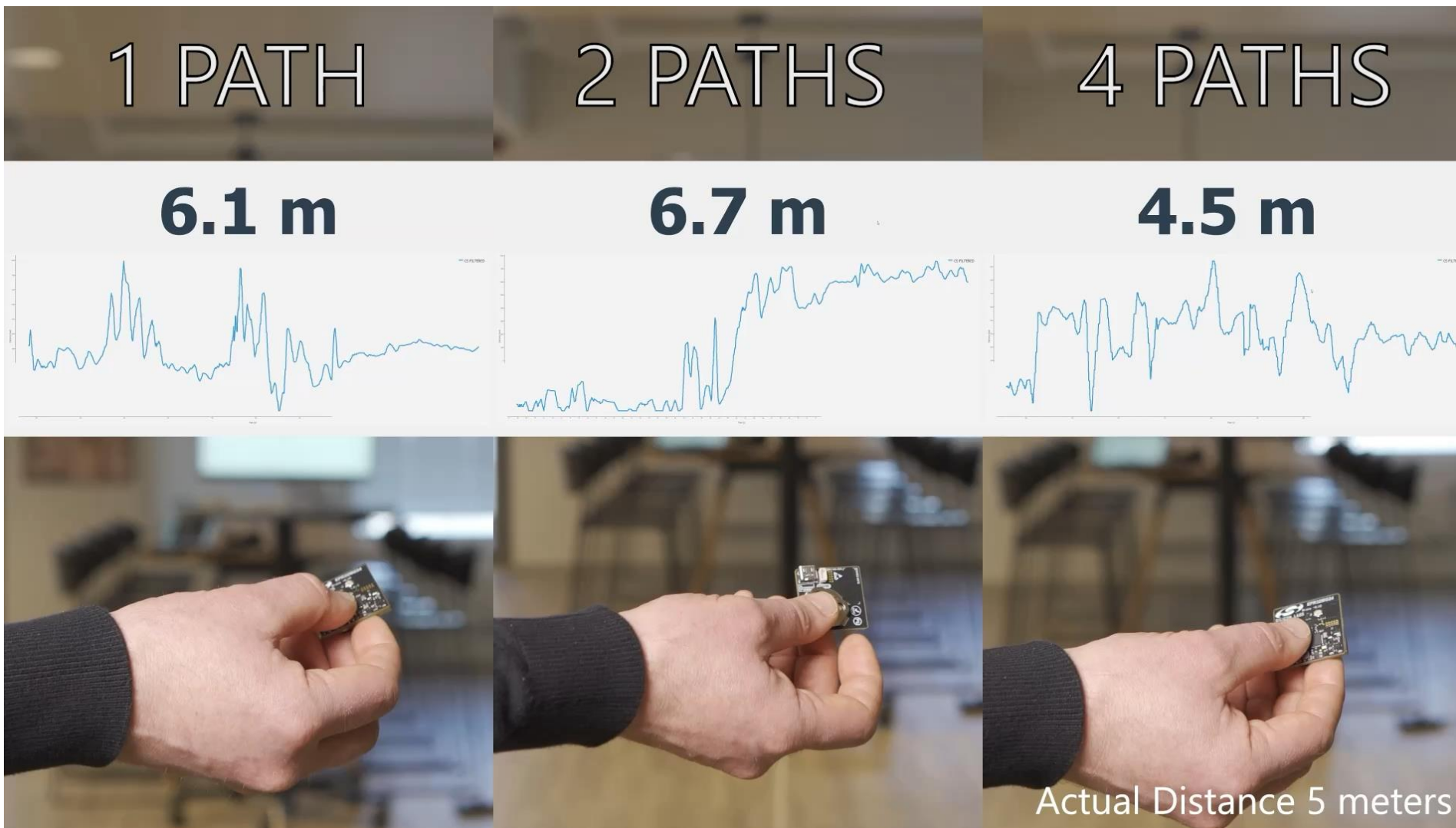
# Bluetooth® Channel Sounding Dual Antenna Development Kit



## ■ xG24 Channel Sounding Development Kit

- Available since March 2025
- Development Kit with two PCB antennas
  - Antenna diversity offers increased robustness and accuracy
- Intra-event antenna switching for optimal non-line of sight performance
- Includes IMU sensor to detect movement & wake-up the tag
- Small form factor
  - Ideal for size-constrained applications like key fobs
- AEC-Q100 Compliant
- SoC/NCP Sample Apps
  - Initiator and Reflector examples supported
- Ranging Library
  - Process IQ samples, post-filtering, and compute distance using configurable algorithm

# Antenna Diversity – What does it bring?



# Silicon Labs Channel Sounding Algorithm

## ■ Algorithm Features

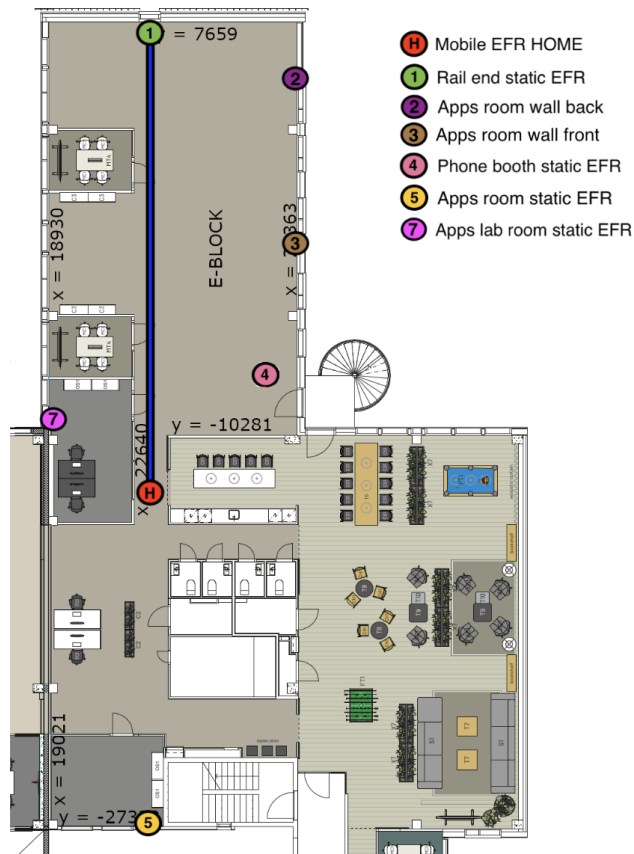
- Supports Multiple Channel Sounding Ranging Modes
  - PBR, RTT, PBR with RTT as sub mode
- Antenna Switching
  - Built-in support for antenna diversity
  - Supports 1, 2 and 4 antenna paths
- Supported Algorithm modes
  - Static mode – Delivers the highest accuracy with high measurement latency; optimized for ranging between stationary devices
  - Real Time Basic – Provides high accuracy with increased computational and measurement latency; supports tracking at speeds up to 1 m/s
  - Real Time Fast – Balances moderate accuracy and range with low latency; supports tracking at speeds up to 2.1 m/s, additionally produces velocity metric
- Configurable Channel Selection (72, 37, or 20 Channels)
  - Selectable based on accuracy needs and power constraints





## ■ Key Benefits

- Licensing cost free
  - Eliminates third-party royalties, simplifying BOM cost structure
- Optimized HW-SW Co-Design
  - Tight coupling between silicon & firmware ensures seamless performance & efficiency
- Single-Vendor Lifecycle Support
  - Unified hardware & software ownership streamlines debugging, validation, and updates



# Algorithm Performance Test Setup



Node Pairs		Distance (in m)	Obstacles
	H & 1	20	Line-of-Sight
	H & 4	7.9	Walls, Kitchen
	1 & 4	14.84	Cubicles, Luminaires
	1 & 5	33.9	Walls, Glass door



# Algorithm Performance Data<sup>1</sup>

Algorithm Mode	LOS 90 <sup>th</sup> Pct. Absolute Error (in m)	LOS 95 <sup>th</sup> Pct. Absolute Error (in m)	NLOS 90 <sup>th</sup> Pct. Absolute Error (in m)	NLOS 95 <sup>th</sup> Pct. Absolute Error (in m)	Computation time (in ms)
STATIC_HIGH_ACCURACY	0.5	0.6	1.7	2.7	20000 <sup>2</sup>
REAL_TIME_BASIC	0.5	0.6	1.9	4.2	188
REAL_TIME_FAST	0.4	0.5	4.0	5.3	20

- 1. CS mode – PBR, CS channels – 72, number of antenna paths – 4
- 2. ~100 CS Procedures used to produce single distance estimate

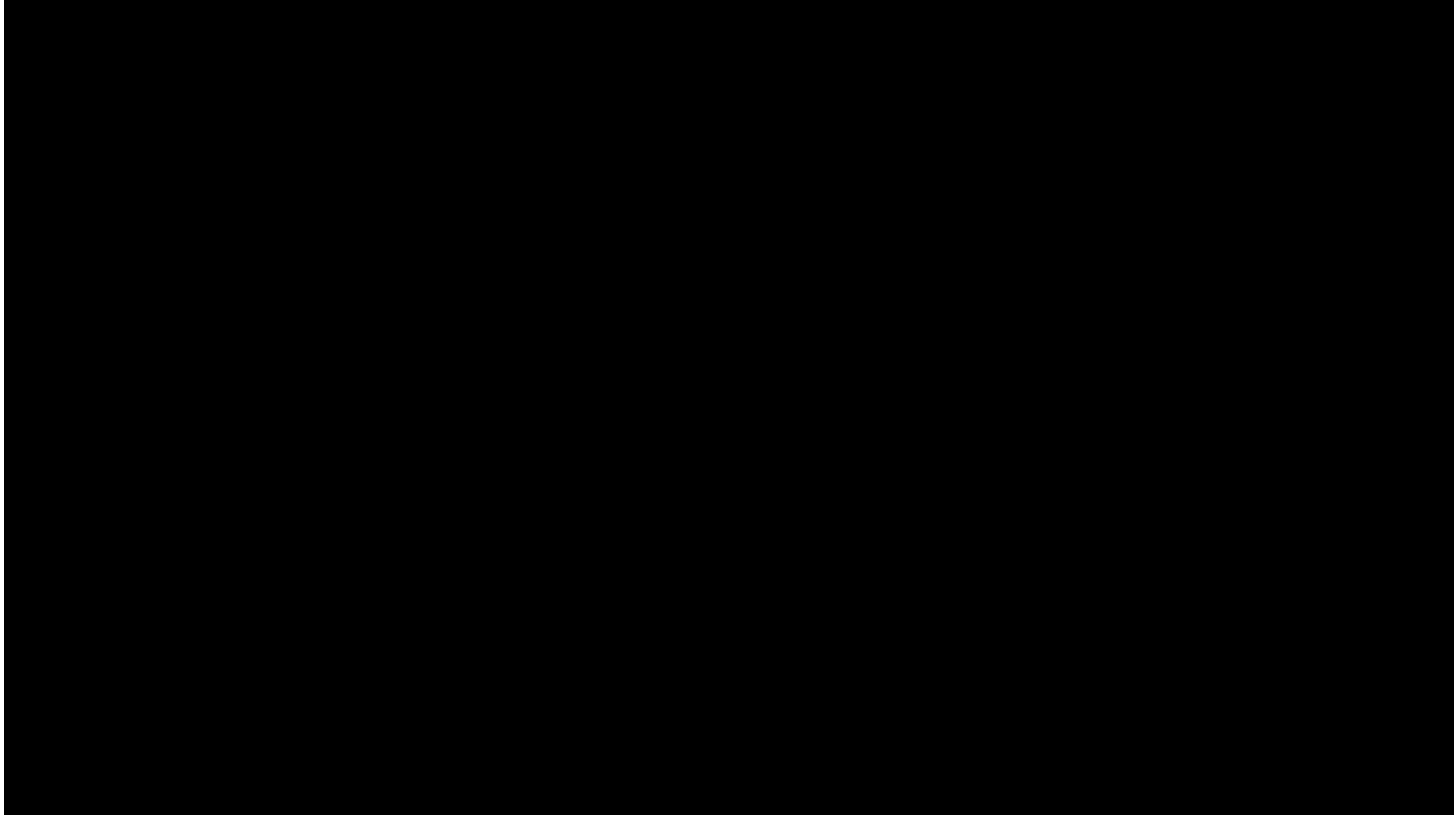
*Fit For Purpose Algorithm Modes*

# Energy Consumption Profile – Reflector

Reference Board	Number of Antenna Paths (NAP)	Number of Channels	Mean Current Consumption (mA)	Mean Energy Consumption (nAh)
BRD2606A	4	72	~2.2	~191.0
		37	~1.2	~111.0
		20	~0.9	~75.4
	2	72	~1.7	~146.0
		37	~1.0	~91.0
		20	~0.8	~65.0
	1	72	~1.5	~122.8
		37	~1.0	~79.0
		20	~0.7	~58.0

*Antenna Diversity Increases Total Energy Per Measurement*

# Algorithm Performance





# Visualizer Tool



## Visualizer Tool displays real-time CS data

- CS configuration
  - Channel map selection
  - Antenna path configuration
  - Algorithm mode selection
- CS data visualization
  - RSSI based distance for comparison
  - Raw distance estimate and likelihood
  - Filtered distance estimate
  - IQ data visualization
- Interfaces with CS enabled EVKs

# Silicon Labs Bluetooth® Channel Sounding Offering



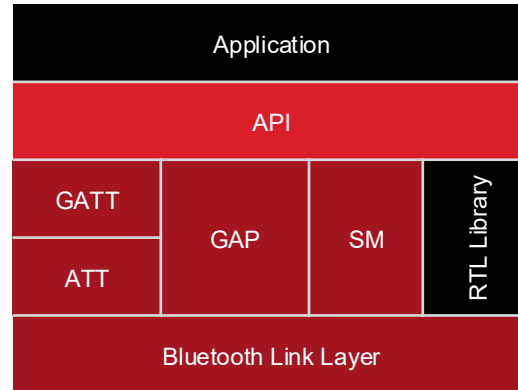
## ICS & DEVELOPMENT KITS

Channel Sounding Supported by **B/MG24**

Kits:

**xG24-RB4198A** single antenna kit

**xG24-DK2606A** dual antenna kit

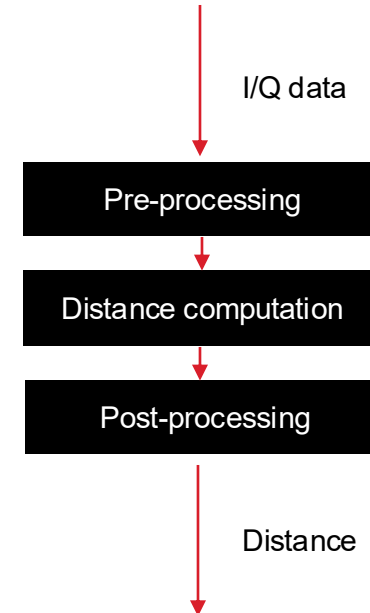


## BLUETOOTH 6.0 STACK

In-house developed stack, supported and maintained stack

Bluetooth 6.0 qualified

PBR & RTT Modes



## RTL LIBRARY

Computes distance from raw I/Q data

Developed and supported by Silicon Labs

New features added based on market needs

No 3<sup>rd</sup> party license fees



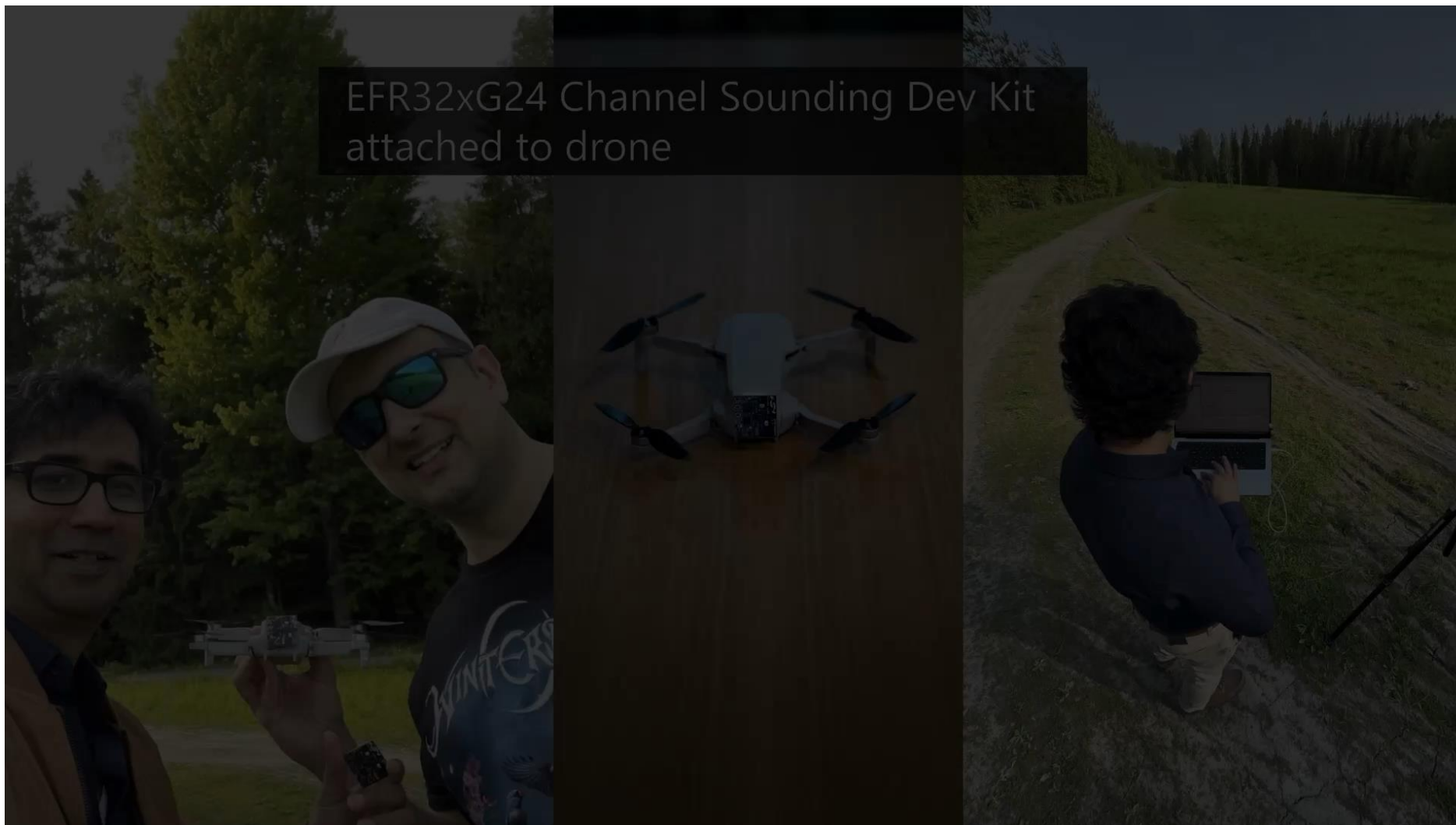
## SDK & TOOLS

Initiator & Reflector examples

Real-time visualization tool for Bluetooth Channel Sounding

Energy Profiler etc.

EFR32xG24 Channel Sounding Dev Kit  
attached to drone





# Thank you



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