1 Overview

This reference manual provides users with detailed feature descriptions and in-depth settings guidance for the CUWB Manager. For detail on individual settings, page descriptions, and general CUWB Manager information see the CUWB Manager Manual

> This CUWB Manager Reference Guide is only for v5.1 CUWB Manager Version. The v5.1 CUWB Manager Version and Reference Guide is compatible with 300 series devices and is not compatible with older databases or legacy Ciholas hardware. Legacy documentation is available in our legacy area.

1.1 Background

Successful operation and tuning of any CUWB system takes careful setup and planning. This document dives into detail regarding a few common top level features. It may be helpful to have these other documents available:

Document	Description
Quick Start Guide	Brief walkthrough for installation and setup.
CUWB Manager Manual	Detailed descriptions of settings, web-interface pages, and system-level information.
System Architecture Overview	Overview of the CUWB System architecture and integration concepts.
Deployment Considerations	Detailed overview of system-level considerations necessary to operate a UWB RTLS.
Installation Guide	Detailed instructions for installing CUWB Hardware.

2 API Control

The CUWB Manager includes a comprehensive Application Program Interface (API) that enables user programs to interact directly with CUWB Configurations and CUWBNets. Developers can build custom tools and automation for tasks such as adding or removing Tags, adjusting beacon rates, or monitoring system performance.

For details, see API and API commands.

3 CUWBNet Search

Devices discover available CUWBNets using a feature called CUWBNet Search. During this process, devices scan multiple RF setting sets to locate CUWBNets. Tags can participate in more than one CUWBNet on different RF settings. However, tags cannot simultaneously participate in multiple CUWBNets. This feature is only active when a device is not currently participating in a CUWBNet.

> CUWBNet Search can impact battery life when devices are not participating in a running CUWBNet. Scanning additional RF search settings consumes more power, which reduces battery life.

3.1 CUWBNet Search Default Behavior

This feature utilizes RF agility to search for available CUWBNets. By default, tags have the following RF search setting sets:

- Default Channel A: Channel 5 PRF64 Preamble Code 11[1]
- Default Channel B: Channel 9 PRF64 Preamble Code 11
- Recovery Channel: Channel 9 PRF64 Preamble Code 11

1. Only available in select regulatory jurisdictions.

For every programmed default or additional RF setting set, the tag will use the following pattern to search for CUWBNets:

Time Between Searches	Search Duration	Total Search Count
5 s	100 ms	20
10 s	100 ms	20
40 s	100 ms	20
80 s	100 ms	20
160 s	100 ms	20
320 s	100 ms	20
640 s	100 ms	20

Once a device hits the 640 second period, the device will remain in that state until it finds a CUWBNet that it can join or battery power runs low. This provides a balance between conserving battery life and being able to quickly rejoin CUWBNets.

3.1.1 Recovery Channel

The Recovery Channel is unique and devices will search every 640 seconds on the Recovery Channel Settings. This occurs regardless of whether the device is using the default behavior or the Wake-on-Shake feature.

3.2 CUWBNet Search & Wake-on-Shake Search Behavior

The above default behavior is impacted by using the Wake-on-Shake feature:

Time Between Searches	Search Duration	Notes
5 s	100 ms	While in motion
640 s	100 ms	After being stopped for preconfigured timeout
640 s	100 ms	Recovery Channel Search

See the Wake-on-Shake CUWBNet Search feature for additional details.

3.3 CUWBNet Search Disabled Behavior

This feature cannot be disabled. Tags and anchors always will search for a CUWBNet.

> Devices that are in ship mode will not search for CUWBNets.

3.4 Adjusting Settings for CUWBNet Search

The default CUWBNet Search settings are pre-programmed and cannot be adjusted by the user via the CUWB Manager.

4 Filtering

Filtering is a mathematical process applied to the output position data that makes the data more precise, at the cost of latency. The CUWB System allows for users to configure position data filtering, which is applied to the position data on the User Stream.

Filtering can be configured in the CUWB Manager UI or via `position_smoothing_mode` in the System Setting Keys. Users can set the `Smoothing Factor`, which defines the number of positions used in the filter. The equivalent settings key is `position_smoothing`.

4.1 Supported Algorithms

Currently, the CUWB Manager supports three different filtering algorithms: a simple average, a weighted average, and a Kalman filter.

4.1.1 Simple Average

The simple average is the moving average of the position data over the last number of positions determined by the smoothing factor. Dropped beacons, or positions that are unable to be calculated are not included in the output. The simple average filter is sufficient for most users to increase system precision and eliminate outliers.

The simple average filter is a windowed average and will continue to deliver output location data at the nominal tag beacon rate.

4.1.2 Weighted Average

The weighted average is an average of the last number of positions determined by the smoothing factor, weighing each position based on its quality. Dropped beacons, or positions that are unable to be calculated are not included in the output.

The weighted average filter is a windowed average and will continue to deliver output location data at the nominal tag beacon rate.

4.1.3 Simple Kalman Filter [Expert Only]

The Kalman filter is recommended for expert users only. Contact Ciholas for support on Kalman filter configuration.

5 Firmware Updates

5.1 Tags

Tags support firmware updates via one of two possible bootloading methods: Over-the-Air (OTA) and Wired.

5.1.1 OTA Bootloading

OTA bootloading utilizes the CUWB Manager and UWB communications to send packets to tags for bootloading. OTA bootloading is the default method for bootloading tags.

> OTA is the default bootloading method, but if a device is plugged into a powered USB hub, the bootloader will swap to the CUWB USB Driver instead of using OTA.

Setting Up OTA Bootloading

The CUWB Manager is used for OTA bootloading, and devices must be part of a CUWBNet.

1. Setup CUWB Configuration with devices that need to be updated. Devices must be participating in the associated CUWBNet to be updated.
2. Install and Confirm firmware images for devices are installed on the machine. See Software Downloads for firmware installation location.
3. Enable Automatic updates via the CUWB Manager `Configuration -> General` tab.
4. Start the CUWBNet.
5. Wait for devices to start and finish updating, by monitoring the `Status -> Devices` tab.
6. Stop the CUWBNet.
7. Disable Automatic updates via the CUWB Manager `Configuration -> General` tab once all devices are updated. This helps prevent unwanted updates if using a mix of firmware on devices.

> For customers using a set production CUWBNet, an additional isolated (via RF separation or physically isolated) CUWBNet can be set up to safely manage updates without impacting the production CUWBNet.

OTA Success

When the OTA is successful, the tag will automatically reboot, rejoin the CUWBNet, and the reported version string will update.

OTA Failure

Should the OTA process fail, check the following:

- The devices have sufficient battery life
- The Image being sent is compatible with the devices
- The Image being sent isn’t corrupted

If the issue persists, plug the device in and use the CUWB USB Driver to recover the device.

5.1.2 Wired Bootloading

Wired bootloading utilizes the CUWB USB Driver and serial communications to send packets to the tags for bootloading.

Setting up Wired Bootloading

1. Install the CUWB USB Driver on the Host PC running the CUWB Manager.
2. Plug devices in to the Host PC either via single USB-C cable or via a powered USB-C hub.
3. Run the command `sudo cuwb-usb-interface-daemon lo` on the command line.
4. Follow the steps in the Setting Up OTA Bootloading section above to perform the update.

Wired Bootloading Success

When wired bootloading is successful, the tag will automatically reboot and join the CUWBNet. The reported version string will update.

> Wired bootloading does not need to be done in the same space as the active CUWBNet.

Wired Bootloading Failure

If the wired bootloading fails, verify the following:

- The Image is compatible with the devices.
- The Image isn't corrupted.

If issues persist, plug the device in and use the CUWB USB Driver to recover the device.

Contact Ciholas and provide a copy of the image being loaded onto devices.

5.2 Anchors

Updating Anchor firmware is similar to updating Tag firmware; however, Anchor bootloading is performed exclusively over a wired Ethernet connection.

5.2.1 Setting up Wired Bootloading

Anchor wired bootloading uses the CUWB Manager and requires devices to be part of the CUWBNet.

1. Setup a CUWB Configuration with devices that need to be updated. Devices must be participating in the associated CUWBNet.
2. Install and Confirm firmware images for devices are installed on the machine. See Software Downloads for firmware installation location.
3. Enable Automatic updates via the CUWB Manager `Configuration -> General` tab.
4. Start the CUWBNet.
5. Wait for devices to start and finish updating, by monitoring the `Status -> Devices` tab.
6. Stop the CUWBNet.
7. Disable Automatic updates via the CUWB Manager `Configuration -> General` tab once all devices are updated. This helps prevent unwanted updates if using a mix of firmware on devices.

> For customers using a set production CUWBNet, an additional isolated (via RF or physically) CUWBNet can be set up just for bootloading

5.2.2 Anchor Bootloading Success

When bootloading is successful, the anchor will reboot and automatically rejoin the CUWBNet. If using chained power, downstream power and communications to anchors are maintained. The reported version string will update.

5.2.3 Anchor Bootloading Failure

If the wired bootloading process fails, verify the following:

- The Image is compatible with the devices.
- The Image isn’t corrupted.

Contact Ciholas and provide a copy of the image being loaded onto devices.

6 LED Control

The LEDs on CUWB devices can be configured in a variety of ways. There are two main parameters of the LEDs: LED Pattern and LED Brightness.

6.1 LED Pattern

The LED Pattern dropdown in the `Configuration -> General` tab of the CUWB Manager sets the device LED pattern when participating in that particular CUWBNet. This can be set to `Role` or `Device`. This setting is also available as a system setting key: led_mode.

- When set to `Role`, all devices will follow the defined LED pattern for their assigned role.
- When set to `Device`, all devices will follow the pre-defined firmware behaviors listed in the respective device datasheets.

6.1.1 Pattern Priorities

The LED Pattern will follow this priority order:

1. Error Codes
2. LED Identification
3. Charging Behaviors (if applicable)
4. Role Mode
5. Device Mode (Firmware)

This priority list is independent from the Brightness priorities.

6.2 LED Brightness

The LED Brightness sets the intensity of the LEDs. This is based on an intensity percentage, with 0% being `Off` and 100% being `On`. This can be set on a per role basis in the CUWB Configuration on the `Configuration -> Schedules` tab or by the LED Intensity persistent property.

> Device firmware defaults the LED Brightness to `On` or 100% intensity.

6.2.1 Brightness Priorities

The LED Brightness will follow this priority order:

1. CUWB Configuration Setting
2. Persistent Property
3. Device Firmware

This priority list is independent from the Pattern priorities.

6.3 Pattern & Brightness Interaction

> Error Codes and LED Identification will always be at 100% intensity (or `On`) regardless of the Brightness setting. These two LED functions cannot be disabled.

> If a device is using role mode, it will flash the role pattern at the LED Brightness setting. By default, that would be at 100% intensity. However, if a user additionally configures devices to use 0% intensity (aka Off), the role pattern will flash at 0% intensity and not be visible.

6.4 LED Functions

- **Error Codes:** Device error codes will vary. Each device datasheet includes an LED error code table detailing the applicable codes. Datasheets can be found under the `Products` sidebar.
- **LED Identification:** The CUWB Manager can send out special identification commands to help identify devices in the environment. Options include setting a solid color, a flashing color, or using the serial number flash pattern. Additional details can be found in the LED Identification section of the CUWB Manager.
- **Device Charging:** For devices that support battery charging, the LED indicates the battery's charge state while charging. See device datasheets for specific charging LED patterns and timing.
- **Role Indication:** Devices operating in `Role` mode will flash their LEDs in the Role Mode Pattern.
- **Device Indication:** Devices operating `Device` mode will enable their LEDs in their respective device modes. The device mode pattern is detailed in the corresponding device datasheet.

7 Logging

7.1 Available Logs

Logs are located on the Host PC at `/var/log/cuwb/network`. These are also referred to as text logs to differentiate them from “CDP Logs”.

The following text logs are available from the CUWB Manager in the `Log` tab:

- `cuwb-manager.log` - logs UI related errors and issues
- `cuwb-websocket.log` - logs errors and issues between the backend and CUWB Engine
- `<name_of_CUWBNet>.log` - logs errors and issues for the CUWBNet.

> When requesting support, logs are helpful to send for debugging if available.

CDP logs can be captured using CDP Logging. Users can use CDP logs to record and replay CUWB activities as if it was from a live system.

7.2 Log Summary Tab

The Log Summary tab, in the CUWB Manager, provides a shortened list of log messages to the user. The log tab utilizes de-spamming to minimize repeated entries. See the Log Tab for additional details.

7.3 Common Log Messages

> In the examples below, all serial numbers would be replaced with serial numbers from the running CUWBNet.

7.3.1 Device Joining CUWBNet

```
Sent commands to 01:0B:00B7 for it to join the CUWBNet
```

This message occurs when a device first announces its presence to the CUWBNet. It indicates that the CUWB Engine has received the announce packet from the device and is sending commands to the device so it can participate in the CUWBNet.

7.3.2 No Unconfigured Slots

```
No available slots to assign unconfigured tags (0 total slots): 01:12:0001 01:12:0002 01:12:0003
```

> This message only appears when using MultiTime mode.

This message indicates the presence of CUWB devices, within UWB range, that are not configured to participate in the current CUWBNet and that there are insufficient `Unconfigured Tag` slots for them to participate.

The amount of `Unconfigured Tags` can be increased or decreased in the `Configuration -> Schedules` tab of the CUWB Manager under Tag Count.

7.3.3 Ignoring CUWB Engine

```
Telling nodes to ignore this CUWB Engine: 01:12:0001 01:12:0002 01:12:0003
```

This message indicates the presence of CUWB devices, within UWB range, that cannot participate in the CUWBNet. These devices are being sent Ignore Commands from this CUWBNet. This allows devices to search for other CUWBNets in the area instead of continuing to try to join this particular CUWBNet.

7.3.4 Planar Anchors

```
The anchors are all bound to a single plane, and that plane intersects the position bounding zone,
which can lead to poor tracking.
```

This message indicates an issue with the Bounding Box, which can be configured on the `Configuration -> General` tab in the CUWB Manager. This indicates that the anchors are on a single geometric plane and that this plane falls within the bounding box limits.

> If all anchors are installed directly on a flat ceiling, then they are all on the same plane.

When this occurs, the anchors cannot resolve which side of the plane any given tag is on. This can lead to odd behaviors when tracking.

There are two methods to resolve this issue:

1. Adjust the bounding box setting so the plane of the anchors is **not** included within the boundaries of the bounding box. This can be done by manually adjusting the bounding box values or the `Use Anchor Bounds` button in the `Bounding Box` section.

   > If the anchors are mounted on the ceiling at a height of 3.5 meters, set the bounding box Z value to 3 meters.

2. Install additional anchors that are not on the same plane as the original set.

   > If all the anchors are on the ceiling, anchors could be added along the floor or at an additional ceiling height.

7.3.5 Host Control

Initializing

```
Initializing the host...
```

This is one of the first messages logged when a CUWBNet is started. It indicates that the CUWBNet is in the initialization phase prior to the beginning of UWB activity.

Shutting Down

```
Host shutting down...
```

This is one of the last messages logged when a CUWBNet is stopped. It indicates that the CUWB Engine is removing CUWB devices from the CUWBNet to allow for safe termination of the CUWB Engine.

7.3.6 Alien Nodes

```
Marking the following devices belonging to CUWB Engine FE:00:0002 as
Alien Nodes: 01:1200A, 01:12:000B, 01:12:000C
```

This message occurs when a second CUWBNet is started on the same LAN that an existing CUWBNet is using for the Anchor CDP Stream. This message indicates that the two CUWBNets detected each other, enabling coordination of CUWB devices, so any CUWB devices in range will join the correct CUWBNet.

7.3.7 MultiTime Seeder Messages

> These messages only appear when using MultiTime mode.

```
Waiting for Anchor Discovery on Ethernet (discovered X of Y, initial candidates: 0)
```

This message occurs when the CUWBNet cannot communicate over Ethernet with any Anchors configured in the `Initial Seeder` role. In the above example, X is the count of Anchors discovered over Ethernet and Y is the total number of Anchors enabled in the CUWB Configuration.

Verify the following:

- The initial seeder is powered on.
- The initial seeder is connected to the same LAN as the CUWB Manager.
- The CUWB Manager interface is configured correctly for the Anchor Stream.

```
No initial seeder was configured. Promoting all seeders to initial seeder now.
```

This message occurs when the CUWBNet is configured for MultiTime mode without any Anchors configured for the `Initial Seeder` role. At least one `Initial Seeder` is required for MultiTime mode. The CUWBNet will automatically promote all Anchors configured as `Seeders` to the `Initial Seeder` role, meaning that any `Seeder` Anchors may be selected as the `Initial Seeder`.

7.3.8 Tag Rate Too High

```
WARNING: Tag 01:12:0074 is configured to transmit at 10Hz,
but that tag is only capable of transmitting at 1 Hz
```

This message indicates that the specified tag is configured for a faster Role than the Tag's Max Tag Rate will allow. The Tag will still participate in the CUWBNet and it occupy one slot for its configured Role, but it will only transmit at its maximum supported rate.

> If the Tag is limited to a 1 Hz maximum tag rate but is configured for a 10 Hz Role, it will transmit only at 1 Hz while still occupying one 10 Hz slot in the CUWBNet.

8 Performance Tuning

This section outlines different performance metrics that users can adjust to better tune the CUWB RTLS system to their application.

8.1 Strategies For Increasing Tag Battery Life

The following sections outline strategies to increase Tag battery life, either by reducing UWB transactions or through other means. When optimizing a CUWBNet for Tag battery life, reducing the number of UWB transactions will always be the most impactful change. The biggest source of power consumption for Tags is UWB activity. With regard to UWB activity, receptions consume more power than transmissions, making reduction of receptions particularly effective.

Users should carefully consider system latency and accuracy requirements when making changes to improve battery life. Changes that improve battery life often come at a cost in performance, ie., lower-beacon rates.

8.1.1 Use MultiTime instead of MultiRange

MultiTime mode inherently has lower power than MultiRange mode for a given Tag beacon rate, and thus will improve Tag battery life. See ADP001 - CUWB Operational Modes for a thorough comparison of MultiTime and MultiRange modes.

The power savings from using MultiTime depends heavily on the system configuration (command window divisor and beacon rate), with diminishing returns at lower beacon rates. MultiTime can decrease Tag power consumption by a factor of roughly 4 to 5 when using a beacon rate of 10Hz or more. Multitime can decrease Tag power consumption by a factor of roughly 1.5 to 2 when using a beacon rate of 1Hz or less.

8.1.2 Increase the Command Window Divisor

> The option to increase the Command Window Divisor is only available when using MultiTime operational mode.

Increasing the command window divisor (see the command_window_divisor Settings Key in the CUWB Manager Manual) will decrease the number of command windows a Tag listens to.

> A Tag, with a default command window rate of 10 Hz and a divisor of 10, will only listen to every tenth command window (for an effective command listen rate of 1 Hz).

Listening to fewer command windows decreases power consumption, but has the trade-off of increasing latency in command delivery. Commands sent through the CUWB Manager or user apps will thus take longer to be delivered to the Tag. This also slows down CUWBNet shutdown, requiring the CUWB Engine to command devices to leave the network at a slower rate.

In MultiTime mode, the Tag power consumption is driven primarily by a combination of the total number of UWB transmissions (beacons) and UWB receptions (command windows) in a given time period. The runtime will scale roughly proportional to the total rate of transmissions and receptions. Note that there are diminishing returns as the rates are made lower.

> Consider a Tag that beacons at 100 Hz and listens to command windows at 100 Hz (200 UWB operations per second). By decreasing the beacon rate to 10 Hz and decreasing the command listen rate to 10 Hz (increasing the command window divisor to 10), the number of UWB operations will be cut by a factor of 10, to a total 20 UWB operations per second. As a result, the Tag power consumption will roughly be divided by 10.

8.1.3 Reduce the Tag Beacon Rate

In both MultiTime and MultiRange mode, using a lower beacon rate will increase battery life, with the trade-off of decreasing locates per second. See the Battery Life Examples section of the PT301 Datasheet for a sample listing of Tag battery life based on different channels and beacon rates.

In MultiRange mode, Tag power consumption decreases roughly proportionally to the beacon rate decrease. Note that there are diminishing returns as the beacon rate gets lower and lower.

> Decreasing the beacon rate from 100 Hz to 10 Hz will decrease the average power consumption of the Tag by a factor of roughly 10.

In MultiTime mode, the Tag power consumption is dictated by a combination of the beacon rate and the command window listen rate. See the previous section Increase the Command Window Divisor for more details.

> For MultiTime mode, increasing the command window divisor will generally save more power than reducing the Tag beacon rate.

8.1.4 Decrease the number of Anchor response slots

> The option to decrease the Number of Anchor Response Slots is only available when using MultiRange operational mode.

In MultiRange mode, a Tag must listen to multiple responses from Anchors for every Tag beacon it sends. The number of responses to each beacon (known as “Anchor responses”) is set by the mr_num_anchors settings key in the CUWB Manager. By default, the number of Anchor responses is set to eight. Reducing the number of Anchor responses will significantly reduce Tag power consumption on MultiRange CUWBNets. CUWBNets with fewer than eight Anchors can reduce the number of Anchor responses to match the number of Anchors with no drawback. CUWBNets of eight Anchors or more will have less precision in the location algorithm when reducing the number of Anchor responses.

See the Ranging Beacon - MultiRange section of ADP001 - CUWB Operational Modes for more information on two-way ranging.

Tag power consumption scales with the number of anchor responses, although it is not a linear function. As a rule of thumb, cutting the number of anchor responses in half will reduce the power consumption by a factor of roughly 1.5 to 2.

> Reducing 8 anchor responses to 4 will divide Tag power consumption by roughly 1.5.

8.1.5 Use Wake-on-Shake

Tag battery life can be further optimized by using the Wake-on-Shake feature, with the lowest average power coming from a combination of both CUWBNet Leave and CUWBNet Search Wake-on-Shake. Using CUWBNet Leave will cause Tags that are not moved for a configurable time period to stop participating in a CUWBNet. Using CUWBNet Search will cause motionless Tags to enter a sleep mode and only occasionally search for a CUWBNet (until they are moved).

Tag power consumption is highly variable depending on CUWB Configuration parameters (such as Tag beacon rate, command window divisor, etc.), but generally speaking, searching for a CUWBNet with Wake-on-Shake CUWBNet Search enabled consumes less power than on-CUWBNet behavior.

> As of a rule of thumb, if the Tag beacon rate is 1 Hz or higher, then off-CUWBNet behavior will most likely consume less power than on-CUWBNet behavior

Enabling CUWBNet leave has the trade-off of requiring Tags to be in continuous motion to remain participating in the CUWBNet, which is not suitable for all applications.

Tag power savings are highly dependent on the CUWBNet configuration and use case.

> Consider a scenario where Tags are attached to workers during a workday and thus are in motion for 8 hours per day, on a MultiTime CUWBNet, at a beacon rate of 10 Hz. The Tags will consume much less power during the 16 hours they are stationary and off-CUWBNet. In this case, the long-term average power consumption will decrease by a factor of roughly 2, doubling the Tag battery life.

8.1.6 Use Channel 5 instead of Channel 9

> This tuning option is only available for regions that allow the use of UWB Channel 5.

Using channel 5 will typically give a 10 to 15% increase in Tag battery life when compared to channel 9. See the RF Settings section of the CUWB Manager Feature Reference for more details on this feature.

8.1.7 Disable Tag LEDs

Disabling the Tag LEDs will reduce power consumption. This feature should be used with caution as disabling the LEDs makes it impossible to tell from looking at a Tag if the Tag is participating in the CUWBNet or if the battery has died.

The LEDs consume a constant amount of average power that does not change with other settings such as beacon rate. Disabling the LED has a much greater effect when the beacon rate is low.

> Disabling the LED will reduce power consumption by roughly a factor of 2 or 3 for a Tag with a 0.1 Hz beacon rate. By comparison, disabling the LED will only reduce the power consumption by roughly 1 to 2% for a Tag with a beacon rate of 100Hz.

9 Persistent Properties

> Persistent property modification is for expert users only. These properties will override device default settings and can lead to adverse RTLS behavior.

Persistent properties are settings that are stored, and persist, locally on the tag and anchor hardware. Persistent properties allow users to change device behavior that is specific to the hardware. Many of the available persistent properties impact behaviors that cannot be controlled by a CUWBNet, like off-network search, because no CUWBNet is running.

> Firmware updates do not overwrite persistent properties.

9.1 Setting a Persistent Property

Persistent properties are set in the `Device Manager` tab. See Persistent Property Configuration for instructions.

> Devices must be hard reset for persistent property changes to take effect.

> CUWBNets must be running to set a persistent property. Devices need to be participating in the CUWBNet or devices need to use a wired connection.

9.2 RF Agility & Search Expert Settings

Expert users can configure devices to use one custom search / RF agility channel via persistent properties. The custom channel setting replaces the Default Channel settings.

When persistent properties are used, devices search for CUWBNets using the persistent property configuration and the recovery channel when not participating in a CUWBNet.

To modify the persistent property, use the Device Manager. See 0x0064 Search Parameter in the Persistent Properties Appendix for details on setting options.

9.3 Wake-on-Shake Search Expert Settings

The Search Motion threshold and Timeout for Wake-on-Shake CUWBNet Search can be configured via persistent properties. This feature can also be disabled via persistent property updates. The persistent property is described in 0x40b0 Wake-On-Shake in the Persistent Properties Appendix.

9.4 LED Intensity Settings

The LED Intensity persistent property allows the LED intensity state to be retained while a device is **not** participating in a CUWBNet. The Intensity can be set to either `On` (100%) or `Off` (0%). The persistent property is described in 0x4083 LED Intensity in the Persistent Properties Appendix.

> Turning off the LEDs may cause confusion about devices being functional. Use with caution.

9.5 RF Power Control Settings

The TX Power Adjustment persistent property allows the TX Power Adjustment settings to be retained even when a device is **not** participating in a CUWBNet. The TX Power Reduction can be set to any value between 0-25.5 dB and the LNA can be set to either `Enabled`, `Disabled`, or `Device's Setting`. The persistent property is described in 0x40b2 Tx Power Adjustment in the Persistent Properties Appendix.

10 Radio Frequency (RF) Agility

Tags and Anchors support Radio Frequency (RF) Agility, which allows them to switch between predefined RF settings. RF Agility allows users to operate multiple overlapping UWB networks or change UWB frequency to avoid interference with other systems.

RF settings consist of three components: UWB Channel, Pulse Repetition Frequency (PRF) and Preamble Code.

The following combinations are supported on Series 300 hardware:

UWB Channel	PRF	Preamble Codes
5	16	3 or 4
5	64	9, 10, 11 or 12
9	16	3 or 4
9	64	9, 10, 11 or 12

> Not all RF settings are available to all users. Countries have varying regulations and requirements for use. Verify local regulatory requirements prior to use.

10.1 RF Agility Enabled Behavior

By default, this feature is enabled on devices and is configured as follows:

- Default Channel A: Channel 5 PRF64 Preamble Code 11[1]
- Default Channel B: Channel 9 PRF64 Preamble Code 11
- Recovery Channel: Channel 9 PRF64 Preamble Code 11

1. Available only in select regulatory jurisdictions.

RF agility uses the timing patterns defined in CUWBNet Search.

10.1.1 When a CUWBNet is running:

Devices will discover and attempt to participate in the first CUWBNet they hear on their default channels or on the recovery channel.

- **If a Tag is configured for multiple CUWBNets**, then it will join whichever CUWBNet it hears first.
- **If a Tag is only configured for one CUWBNet but is in range of multiple CUWBNets**, the Tag will be pushed to the CUWBNet it is configured for, even if it initially hears a different CUWBNet first.
- Anchors can only be configured for one running CUWBNet at a time. When Anchors are participating in a CUWBNet, they will use the RF settings defined in the CUWB Configuration under RF Settings.

> Large systems that use multiple Host PCs to run multiple CUWBNets require all Host PCs to be on the same Anchor Network. See Networking Guide for additional information on Network Configuration.

10.1.2 When a CUWBNet isn't running:

The Recovery Channel allows devices to be recovered if their RF settings have been modified in the device's persistent properties. Devices listen on the Recovery Channel periodically (once every 640 seconds). Devices will either attempt to join a new CUWBNet or continue searching if no active CUWBNets are present.

> Devices search RF setting sets in the following order: Default A ->Default B -> Recovery.

Additionally, devices that support Wake-on-Shake Search will follow the CUWBNet search behavior described in the Wake-on-Shake section. Wake-on-Shake Search is enabled by default on supported devices.

> If Wake-on-Shake Search is disabled, the Tags will revert to the CUWBNet Search Default Behavior.

10.2 RF Agility Disabled Behavior

RF Agility cannot be disabled; the Recovery Channel search settings are always enabled and cannot be removed.

10.3 Adjusting Settings for RF Agility

RF Agility parameters for Anchors are modified via the RF settings in the drop down menu on the `Configuration -> General` tab.

By Default, Tags can only join the CUWBNet if the CUWBNet's RF Setting matches one of the RF agility default channels or the recovery channel. Tag RF Settings can be modified by setting persistent properties, as described in 0x0064 Search Parameter of the persistent properties appendix.

> CUWBNets must be stopped before the CUWBNet RF settings can be modified.

Expert users can configure devices to use a single custom search / RF agility channel via persistent properties if the Default Channel settings are not desired. The custom channel setting will replace the Default A and Default B channel settings.

> CUWBNets must be running to set a persistent property on a device or the device must be connected via a wired connection.

11 Radio Frequency (RF) Power Control

> Transmission power settings are for expert users only.

A combination of a CUWB Device's transmission (TX) power and the receiving device's receive (RX) sensitivity determine the range at which a packet can be received. Users with dense installations or complex radio frequency (RF) environments may choose to reduce the effective range between devices. Range reduction reduces the computational load on the Host PC, while lowering the TX power can also help prevent environmental reflections of the RF signal.

The RF Power control settings allow users to modify default device settings by reducing TX power and adjusting RX sensitivity through control of the Low Noise Amplifier (LNA).

> The preconfigured maximum TX power is controlled by regulatory requirements based on jurisdiction. Devices cannot exceed these preconfigured maximum power levels.

11.1 Transmission Power Reduction

CUWB Devices are configured to use the maximum TX power permitted for the jurisdiction in which they are operated. The power reduction setting allows the user to configure an offset, which will reduce the TX power. Applying the offset reduces the effective communication range between CUWB devices.

The transmit power for devices can be reduced to an effective 0 dB output level. At this setting, devices continue to transmit but at an extremely low power level. This does not turn the device off or stop transmissions.

11.2 LNA Control

The Low Noise Amplifier (LNA) on a CUWB device is enabled for packet receptions and disabled for packet transmissions by default. The LNA amplifies incoming UWB radio signals, allowing for better reception and longer ranges. Similar to transmit power control, disabling the LNA reduces the reception strength of the incoming signal and effectively limits the range of CUWB device communications.

11.3 Adjusting Settings for RF Power Control

> Users can opt to use one or both of the RF Power control settings.

RF Power Control parameters for all devices participating in a CUWBnet are managed via the Power Setting section in the `Configuration -> General` tab of the CUWB Manager. This section is only visible when Expert settings are enabled.

Settings can also be modified at the role and device level using the settings keys `tx_power_reduction` and `lna_mode`. These settings keys follow the Settings Key Priority scheme.

When devices are not participating in a CUWBNet, they will use predefined transmit settings and LNA behavior. To adjust off network behavior, the Tx Power Adjustment Persistent Property (0x40b2) can be configured using the Device Manager.

12 Settings Keys

Settings Keys are special expert user options in the CUWB Manager that enable unique features or specialized settings. These can be added to any configuration when operating in expert mode. There are three types of Settings Keys:

- **Device** - Settings Keys applied on a per device basis.
- **Role** - Settings Keys applied on a per role basis.
- **System** - Settings Keys applied at the system configuration basis.

Some Role and System Settings Keys duplicate functionality of the CUWB Manager UI. These cases are noted in their respective entries within the Settings Keys Appendix.

12.1 Priority

When a device is participating in a CUWBNet:

The devices will follow this priority order for settings, where lower numbers indicate higher priority:

1. Device Settings Keys
2. Role Settings Keys
3. System Settings Keys
4. Persistent Properties
5. Firmware

When a device is not participating in a CUWBNet:

The devices will follow this reduced priority order for settings:

1. Persistent Properties
2. Firmware

13 System Ownership Negotiation

The CUWB Engine includes a System Ownership Negotiator to help resolve issues that may arise from overlapping communications. Communication overlap may occur when multiple CUWBNets operate in close or overlapping proximity within a facility.

> If multiple adjacent CUWBNets are used, it is recommended to minimize the amount of UWB communication overlap whenever possible or to use different RF settings for adjacent CUWBNets.

13.1 CUWBNet ID Overlap

CUWBNet Instance IDs must be unique. The System Ownership Negotiator prevents a second CUWBNet from starting if it detects that the CUWBNet is using the same Instance ID as another CUWBNet that is already running.

13.2 Device Participation

When running two CUWBNets, it is possible for a device only configured for CUWBNet B to first be detected by CUWBNet A. Should this occur, the System Ownership Negotiator for CUWBNet B communicates to CUWBNet A that the device it currently has marked as an unconfigured tag is configured for CUWBNet B. CUWBNet A then releases the device so it can join CUWBNet B.

14 Troubleshooting

14.1 Common Issues

The following sections describe common issues that users encounter into while using the CUWB RTLS.

14.1.1 Interface mismatches

If all anchors have Ethernet connectivity but only the initial seeder has UWB connectivity, this may indicate an Interface mismatch or a cable connection issue with the initial seeder.

This could be due to one of the following:

- A loose cable connection on the Initial Seeder.
- The Anchor Stream Network Interface not being configured properly.

Verify the following:

- The initial seeder is properly installed and securely connected.
- The Anchor Stream Network Interface is properly specified in the Ethernet settings.

14.1.2 PoE+ Switch Overloading

If anchors intermittently lose power (LEDs shut off or Anchors reset) and the CUWB Manager status is inconsistently showing green and red status for anchors, the PoE+ switch port may be overloaded.

Verify the following:

- The PoE+ Switch is correctly configured properly for power delivery and link budget.
- Anchor chains do not exceed 12 units in length.

14.1.3 Invalid UDP Interface Specified

If the CUWB Manager reports an invalid UDP interfaces error, verify that all network interfaces specified are valid interfaces on the Host PC. See Interface Example for instructions on checking Host PC interfaces.

14.1.4 CUWB Viewer Connectivity

If the CUWB Manager shows device connectivity but the CUWB Viewer does not display any devices, the issue is likely an Ethernet configuration mismatch between the User Stream and CUWB Viewer.

Verify the CUWB Viewer is on the same subnet as the CUWB Manager's User Stream Interface and the Viewer is connected to the correct CUWBNet.

14.1.5 Tag Unable to Join CUWBNet

If a Tag is unable to join the CUWBNet, but the Tag RF settings match the CUWBNet RF settings, verify:

- The assigned Role for the Tag has the Tag Count set.
- The Tag Count is large enough to support all units using that Role. The following text log message will be displayed in the log:

```
Unable to schedule {SERIAL_NUMBER} (Role = {ROLE_NAME}).
Check that the Tag Count is high enough to make room for this device in this Role.
```

14.1.6 Finding Devices

Accurately recording serial numbers during installation is strongly encouraged but can be error-prone. Common errors include: mistyping the serial number, writing down the serial number incorrectly during installation, and failing to record the serial number entirely.

In case of serial number errors, Ciholas recommends the following during debugging:

1. Run the CUWBNet with devices in 'Role' mode for LED patterns, then walk around the tracking area. Any anchor that isn't configured for the CUWBNet will use the UNCONFIGURED LED pattern.
2. Using the LED identification, assign a few devices different colors, either solid or flashing, to identify them visually. Verify that the LED color matches the expected serial number and installation location.
3. Using Serial number flash, set devices to flash their serial numbers via LED color patterns. This provides a visual method to confirm the devices serial number against installation records.

14.1.7 Hz Rounding Causing Schedule issues

The basic unit of the CUWB schedule is the Tick, with 975,000 Ticks occurring each second. Device rates within the CUWB schedule can be configured in Hz or Ticks. The formula for converting between the two options is as follows: T = 975000 / H, where T is the period in Ticks and H is the repeat rate in Hz.

The Hz option is provided for user convenience, and for most situations, specifying rates in Hz is sufficient. However, in some advanced configurations, using Hz can introduce rounding errors leading to significant fragmentation of the schedule. This fragmentation may result in reduced capacity, or in extreme cases, a completely invalid schedule.

Example:

In a configuration where the Seeder Rate is 8.00 Hz and Tag Rate of 16.00 Hz, configuring these rates in Hz will lead to schedule fragmentation. This is because 16.00 Hz = 975000 / 16 = 60937.5 Ticks. Fractional Ticks are not supported, so the value will be rounded to 60938 Ticks. Likewise, 8.00 Hz = 975000 / 8 = 121875 Ticks. 121875 is not evenly divisible by 60938, so using these 2 rates in the same configuration will result in an invalid schedule.

To resolve this, the CUWB Configuration can be set with a Seeder Rate of 121876 Ticks and a Tag Rate of 60938 Ticks. These rates still round to 8.00 Hz and 16.00 Hz respectively, but now they are evenly divisible, and will produce a valid schedule.

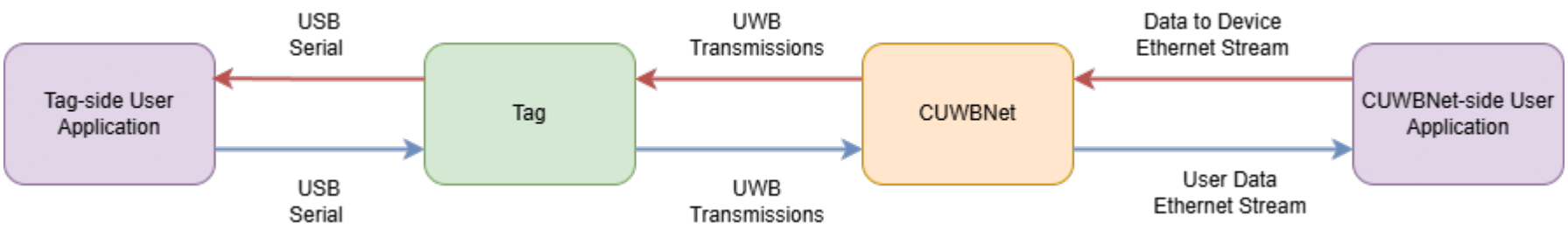
15 User Data

> User Data is for expert users only.

The CUWB System User Data feature enables data transport between a Tag and end-user application. Users are able to define their own custom packets for User Data.

> One way to think about User Data is as a shipping package. The CUWB System acts like a shipping company, transporting the package from one destination to another without concern for its contents. It is the user's responsibility to package the data correctly using appropriate packet definitions to ensure efficient and reliable delivery.

User data is bidirectional. Data can be sent Tag-to-CUWBNet or CUWBNet-to-Tag:



For Tag-to-CUWBNet User Data, shown in blue, the CUWBNet is configured to allow Tags to send additional data (User Data) along with normal Tag beacons. The Tags are configured to send the data over time, intentionally fragmenting packets to reduce the airtime required. The CUWBNet collects and reassembles the fragmented data, then emits a CDP Data Item on the User Stream with the original packet contents.

For CUWBNet-to-Tag User Data, shown in red, the CUWBNet receives User Data from an application and transmits the data to the Tag during a scheduled 'Command Window'. The Tag receives the data and sends it over USB to the Tag-side application. CUWBNet-to-Tag User Data is not fragmented like Tag-to-CUWBNet, which limits overall packet size.

> User Data requires UWB airtime for transmission and will reduce overall system capacity.

15.1 User Data Considerations

Some applications of User Data are more suitable than others due to the limited airtime available for UWB transmissions. This section contains a few considerations for users that plan on implementing User Data in their CUWB System.

15.1.1 Event Driven Data

Users should avoid sending repeated or periodic User Data messages from the CUWBNet-to-Tag. Instead, an event-driven approach is recommended, where data is transmitted only when a status change occurs. Since over-the-airtime is limited, asynchronous updates are generally more efficient than fixed-rate transmissions.

> It is significantly more efficient to send status updates on button press and release events as opposed to a periodic User Data report that consistently indicates the current button state.

Tag-to-CUWBNet communications require enough airtime padding for UWB messages on each transmission. This makes the Tag-to-CUWBnet message more tolerant to periodic status, or non-event driven User Data messages. Whether User Data is actually provided for a given transmission doesn't impact the amount of time allocated for the Tag transmission.

15.1.2 Manage Latency

User Data latency requirements are application-dependent and can be controlled through careful CUWBNet setup and configuration. For applications where latency is not critical, e.g. battery capacity or temperature reporting, the default settings may be sufficient to provide reasonable latency.

> Slow beacon rates like 1 Hz deliver User Data once per second, which is typically fast enough for battery capacity or temperature reporting.

However, in applications that are sensitive to latency, e.g. fast button press events, the configured Tag rate determines the latency of the Tag-to-CUWBNet User Data.

> If a Tag is assigned a Role with a 10 Hz beacon rate, then the highest expected latency would be 100 milliseconds. The average expected latency would be 50 milliseconds.

Increasing the Tag beacon rate on the CUWBNet reduces the available airtime for User Data transmissions. In some cases, using multiple Roles with different beacon rates may be warranted. Tag-to-CUWBNet User Data latency and the intended number of Tags on the CUWBNet must be balanced against the available system airtime.

As with Tag-to-CUWBNet User Data latency, User Data from CUWBNet-toTag can be sensitive to latency. The `command_window_period` can be increased to reduce latency of User Data from CUWBNet-to-Tag.

15.1.3 Protocol Considerations

Avoid ACKs

Data acknowledgments (ACKs) are commonly used in communication protocols to ensure that data has been received by the target. However, ACKs are not recommended when sending User Data CUWBNet-to-Tag. Multiple Tags can send data to a CUWBNet rapidly creating a condition where the CUWBNet must acknowledge more messages than it has airtime to respond.

ACKs are generally unnecessary for Tag-to-CUWBNet communications. Only a single Anchor is required to receive User Data from a Tag, and in a typical CUWB RTLS deployment, a Tag transmission can be received by multiple Anchors. Thus, Tag-to-CUWBNet User Data is highly reliable.

> Position calculation requires multiple Anchors to receive a Tag's transmission to compute a valid location. As a result, Anchor density must be sufficiently high to generate good location data for the Tag. Thus, there will naturally be multiple Anchors within range of the Tag to receive the User Data packets. Only one Anchor is required to receive the User Data.

An effective alternative solution to ACKs is to duplicate User Data where reliability is a concern.

Use Sequence Numbers and Data Types

It is recommended to include a sequence number within the packet payload. Sequence numbers enable detection of missing User Data packets and can help identify and remove duplicate data.

Including data type identifiers is also useful when multiple kinds of User Data are transmitted within the same CUWB System, allowing applications to distinguish between different payload formats or message types.

Checksums

Users should not require a checksum on their user data, as the CUWB System already implements packet-based cyclic redundancy checks (CRCs).

15.2 From Tag-to-CUWBNet

The Tag firmware is capable of receiving User Data via USB serial communications from a user application or additional hardware. The Tag then forwards the data to the CUWBNet as part of its UWB Beacon Packet. Upon receipt, the CUWBNet sends the data to the User Stream packaged in a User Data CDP packet for consumption by external applications.

15.2.1 Tag User Data Configuration

The Tag Role assigned to a Tag contains all of its User Data configuration options. The CUWBNet has three required Role parameters to support receiving User Data from a Tag:

Parameter	Description
User Data Rate	Value in either Hertz or Ticks. Rate for Tag to send User Data.
User Data Size	Value in Bytes. Expected size of the User Data. Size exclusive of overhead.
Payload Overhead Size	Value in Bytes. Recommended value of 5 bytes. The overhead is a buffer space within the beacon to account for user supplied data that does not arrive with the exact same timing as the beacon rate transmission

The `User Data Size` and `User Data Rate` are used to compute the number of bytes to allocate to the Tag's User Data transmission.

The User Data Size is limited to a maximum of 117 bytes per Tag Beacon Packet. The User Data protocol has an additional two bytes of overhead to handle over-the-air packet fragmentation and an additional two bytes per User Data Item type being delivered, leaving users with up to 115 bytes to customize. This results in a maximum of 1150 bytes per second of throughput for User Data from Tag to User Application, assuming the packet is only using one User Data Item type.

> A Tag running at 100 Hz is configured to send 10 bytes of User Data at 10 Hz. The Tag will add one additional byte to every 100 Hz beacon plus the overhead.

> It is up to the user application(s) to deliver data no faster than the rate configured in the CUWB Manager. Data delivered faster than the configured rate will cause the data to be delayed and/or lost.

> When using User Data, it is recommended to always have a few bytes of payload overhead to act as a buffer to account for user-supplied data that does not arrive with the same timing as the beacon rate transmission. An overhead payload value of 5 bytes is recommended for most applications.

15.2.2 Setting up the Tags to deliver user data

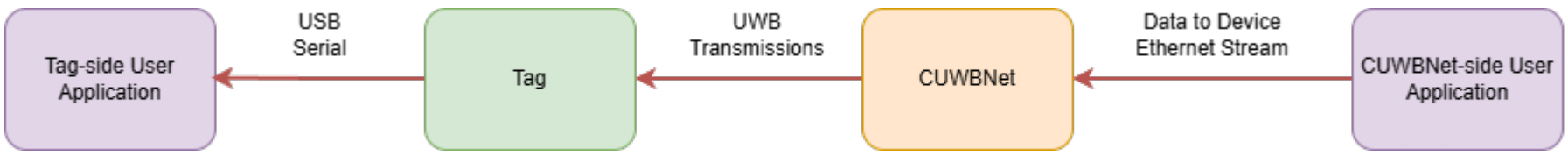
1. Select the CUWBNet.
2. Enable Expert Mode if not already enabled.
3. Navigate to the `Schedules` tab under `Configuration`.
4. Choose which Tag Role will be modified to allow User Data.
5. Enter the `User Data Size` in bytes.
6. Enter the `User Data Rate` in Hertz.
7. Enter the `Payload Overhead Size` in bytes.
8. Click the Save icon to save the changes.
9. Repeat for additional Roles as needed.

The Tag must receive data over the USB serial connection from the user application. The Tag-side application should transmit a Ciholas Serial Protocol (CSP) packet of type UDP CDP (0x0101) that contains a data portion consisting of a CDP Deliver User Data V1 packet (0x010C). This packet includes a placeholder serial number (all Fs) for the desired recipient and a payload that is defined by the User application.

Upon reassembly of the data, the CUWBNet will emit a CDP packet with a User Defined V2 (0x0148) format over the User Stream. The serial number of the CDP packet header will be the serial number of the CUWBNet. The User Defined V2 data item will contain the serial number of the transmitting tag. See Ciholas Serial Protocol (CSP) and Ciholas Data Protocol (CDP) for complete packet definitions.

15.3 From CUWBNet-to-Tag

The CUWBNet can receive User Data via Ethernet CDP packets from the Data-to-Device Stream. These packets are then delivered to a Tag over UWB transmissions. Upon receipt, the Tag forwards the packets to user-connected applications using CSP packets over the USB serial connection.



UWB transmissions containing User Data from the CUWBNet occur during the UWB Command Window. The Command Window is not just used for delivering User Data to Tags. It is used for the transmission of all commands sent to all wireless devices on the CUWBNet. There are numerous internal commands that need to be sent to Tags in order to keep normal CUWBNet operations running.

15.3.1 CUWBNet User Data Configuration

The following CUWBNet must be configured for CUWBNet-to-Tag User Data:

Parameter	Description
Command Window Period	Ticks between consecutive command windows. Governs the rate at which user data can be delivered to Tags. By default, the period will follow the CUWBNet Seeder Rate.
Max User Data Payload Size	Size in bytes. Number of bytes transmitted in a maximally sized command packet. Inclusive of CUWBNet Command bytes and User Data. Note, packets larger than 350 bytes can result in significantly reduced UWB ranges.
Data to Device Ethernet Stream	This Ethernet stream is required to be configured for sending User Data to Tags.

> It is recommended to pad the Command Window Rate with the assumption that 20% of all Command Windows will be utilized for CUWBNet operation, which would leave at most 80% for the delivery of User Data.

> To determine the maximum payload size, determine how many bytes of data per second will be sent to devices. Multiply this value by 1.25 and divide by the command window period in Hertz. This results in the Max User Data Payload Size - which includes the CUWBNet operation commands and User Data commands.

> All configuration options that modify the Command Window are applied globally to all devices on the CUWBNet.

15.3.2 Setting up the CUWBNet to deliver user data

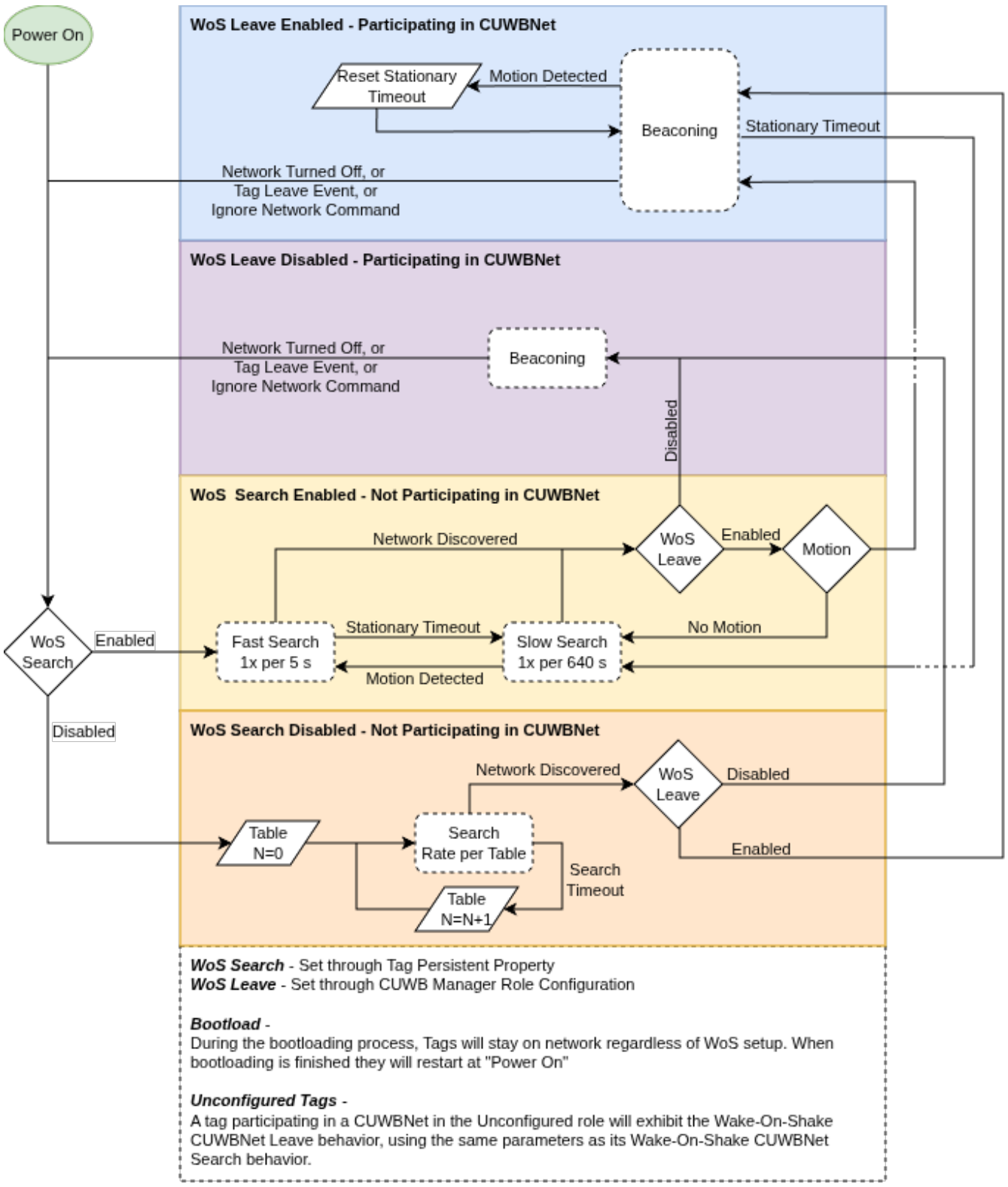
1. Select the CUWBNet.
2. Stop the CUWBNet if active.
3. Navigate to the `General` tab under `Configuration`.
4. In the System Settings section, add the following keys:
    i. Add `max_user_data_payload_size` followed by the size in bytes. Click the `Add` button.
5. If the Seeder Rate for the CUWBNet is inappropriate for the Command Window Period:
    i. Add a System Settings key: `command_window_period` followed by the rate in ticks if Seeder Rate is not adequate. Click the `Add` button.
6. Under the Optional Ethernet Setting section, add an Ethernet setting for the `Data to Device` stream, followed by the IP, Port, Interface. Click the `Add` button.
7. Restart the CUWBNet.

The User Application will then need to send data in a Deliver User Data V1 (0x010C) CDP data item to the CUWBNet over the Data to Device Stream. This packet consists of the serial number for the desired recipient and a payload that is defined by the User application.

This data is delivered over UWB transmissions to the Tag, which then emits User Defined V2 (0x0148) CDP data items in a CSP packet sent over their serial connection. If connected to a PC running the cuwb-usb-interface, these data items will be converted back to CDP and emitted on the *User Data* Channel, which uses localhost (127.0.0.1) as the IP and 7999 as the port.

16 Wake-on-Shake

Wake-on-Shake (WoS), for CUWB devices, is a combination of two different settings: Wake-on-Shake CUWBNet Search and Wake-on-Shake CUWBNet Leave. Below is a flow chart outlining the various state interactions.



Search Pattern Table for N[1]:

N	Time Between Searches	Search Duration	Total Search Count
0	5 s	100 ms	20
1	10 s	100 ms	20
2	40 s	100 ms	20
3	80 s	100 ms	20
4	160 s	100 ms	20
5	320 s	100 ms	20
6	640 s	100 ms	20

1. This search pattern is the same pattern that devices use when searching for a CUWBNet without WoS features enabled. See CUWBNet Search Default Behavior for non-WoS search behaviors

16.1 Wake-on-Shake CUWBNet Search

Tags support Wake-on-Shake CUWBNet Search, which allows a tag to enter a low power sleep mode between searches for CUWBNets. This feature enables tags to quickly rejoin a CUWBNet when they are no longer participating in a CUWBNet. After a tag is motionless for a preconfigured amount of time, the tag will enter a sleep mode and periodically wake to search for a CUWBNet.

16.1.1 Wake-on-Shake CUWBNet Search Enabled Behavior

By default, this feature is enabled on tags with the following settings:

Motion & Timeout Threshold

Parameter	Default	Description
Search Motion Threshold[1]	125 m*g*	Minimum amount of movement default
Search Motion Timeout Threshold	300 s	Device timeout if not moving

1. Motion is given in milligravities.

Devices are preconfigured to wake from a reasonable movement. They will then search for CUWBNets until there are 300 consecutive seconds of no movement.

Search Timing

Time Between Searches	Search Duration	Notes
5 s	100 ms	While in motion, see motion threshold
640 s	100 ms	For Default Channels, after not moving for preconfigured timeout
640 s	100 ms	For Recovery Channel

16.1.2 Wake-on-Shake CUWBNet Search Disabled Behavior

Wake-on-Shake CUWBNet Search may be disabled, by setting either the Search Threshold or Search Timeout to zero. If disabled, the tag will utilize the default CUWBNet Search behavior.

16.1.3 Powered Devices & Wake-on-Shake Search

This feature can be used while a tag is powered via USB. The following are the powered settings:

Time Between Searches	Search Duration	Notes
5 s	100 ms	For both default and recovery channels

The Tags use a faster search pattern while powered. This is due to not needing to conserve as much power while being charged.

16.1.4 Adjusting Settings for Wake-on-Shake CUWBNet Search

Users can only configure the motion threshold and stationary timeout settings, which are configured via persistent properties. This feature can also be disabled by setting the persistent property. The persistent property is described in 0x40b0 Wake-on-Shake Search in the Persistent Properties Appendix.

16.2 Wake-on-Shake CUWBNet Leave

This feature allows a tag to leave the CUWBNet immediately if the tag does not move for a set period of time. This allows tags to save battery life when stationary.

By default, this feature is disabled on the tags.

16.2.1 Wake-on-Shake Leave Enabled Behavior

If the tag does not experience movement greater than the motion threshold for a set period of time, the tag will immediately leave the CUWBNet.

Settings options:

Parameter	Recommended Value	Description
Leave Motion Threshold	125	Minimum amount of movement in milligravities, configurable from 125 m*g* to 16000 m*g*
Leave Timeout Period	30	Time in seconds, configurable from 1 to 65534

> Setting the timeout period or motion threshold to 0 will disable the feature.

The leave motion threshold and timeout period is set and sent to devices via the CUWB Manager.

16.2.2 Wake-on-Shake Leave Disabled Behavior

This feature is disabled by default. When the feature is disabled, the tag will not leave the CUWBNet due to a motion threshold or timeout period caused by lack of movement

16.2.3 Powered Devices & Wake-on-Shake Leave

This feature can be used while a tag is powered via USB; however the behavior is modified. The tag will timeout after the set timeout period and will announce every 5 seconds. It will not join the CUWBNet until it is in motion or given a tag role without Wake-on-Shake CUWBNet Leave parameters. Additionally, Wake-on-Shake search is disabled while the tag is powered by USB when this feature is enabled.

16.2.4 Adjusting Settings for Wake-on-Shake CUWBNet Leave

Tags can be enabled with this feature via the CUWB Manager. To modify the settings, use the System Settings keys in the CUWB Manager. The setting keys are described in wake_on_shake_timeout and wake_on_shake_threshold respectively in the Settings Key Appendix.

17 Revision

Version	Date	Change Description
5.1.0	2026-05-01	Document restructure; Adding TX Power Control Feature, Position Delivery, and User Data Support
5.0.1	2025-11-14	Correcting document description in Background
5.0.0	2025-10-31	Initial Release

18 APPENDIX A : Persistent Properties

This appendix outlines the currently available persistent properties that can be set through the CUWB Manager UI.

18.1 0x0064 Search Parameter

The Search Parameter persistent property is available via dropdown menu in the Device Manager. The following options are available:

Property Options	Default Value	Description
rf_channel	5	This is the channel that will be used in UWB communications. Valid values are 5 or 9
rf_prf	64	This is an enum that specifies which PRF will be used in UWB communications. Valid values are 16 or 64
rf_preamble_code	11	This is the Preamble Code that will be used in UWB communications. Supported values differ based on PRF. When PRF is 16, then the supported Preamble Codes are 3 and 4. When PRF is 64, then the supported Preamble Codes are 9, 10, 11, and 12.

> Available channel settings vary depending on regulatory jurisdiction.

18.1.1 Search Parameter UI Messages

Property Not Set

For devices that do not contain the search parameter persistent property, the following message will be posted to the Device Manager UI:

> Device 12:34:5678 does not have a Search Parameter set.

This means that the device will use the default channel search and RF agility settings.

Property Set

For devices that have the search parameter persistent property, the following message will be posted to the Device Manager UI:

> Device 12:34:5678's Search Parameter is set for Channel 5, PRF16, and Preamble Code 4.

18.2 0x4083 LED Intensity

The LED Intensity persistent property is available via dropdown menu in the Device Manager. The dropdown menu offers `On` or `Off` options, which correlate to the following LED intensities:

Property	Value	Description
led_intensity	100	Device LEDs are `On`
led_intensity	0	Device LEDs are `Off`

> If manually entering the setting, the property value must be given as an intensity percentage, either `100` for On or `0` for Off.

18.2.1 LED UI Messages

Property Not Set

For devices that do not contain the LED Intensity persistent property, the following message will be posted to the Device Manager UI:

> Device 12:34:5678 does not have a custom LED set.

This means that when a device is not participating in a CUWBNet, it will follow the default firmware LED settings, and when it is participating in a CUWBNet, it will follow the LED settings specified in the CUWB Configuration.

Property Set

For devices that do have the LED intensity persistent property, one of the following messages will be posted to the Device Manager UI:

> Device 12:34:5678's LED is ON.

> Device 12:34:5678's LED is OFF.

18.3 0x40b0 Wake-On-Shake CUWBNet Search Configuration

The Wake-on-Shake CUWBNet Search persistent property is available via dropdown menu in the Device Manager. The following options are available:

18.3.1 Wake-on-Shake Search Threshold

Property	Value	Type	Description
threshold_mg[1]	x	uInt16	Threshold of movement in m*g*, up to 16000 m*g*
threshold_mg[1]	125	uInt16	Recommended Value - Threshold of movement in m*g*
threshold_mg[1]	0	uInt16	Disables Wake-on-Shake search

1. Motion is given in milligravities.

18.3.2 Wake-on-Shake Search Timeout

Property	Value	Type	Description
stationary_timeout_s	x	uInt16	Stationary timeout in sec, up to 65534 seconds
stationary_timeout_s	300	uInt16	Recommended Value - Stationary timeout in seconds
stationary_timeout_s	0	uInt16	Disables Wake-on-Shake search

It is recommended to keep the stationary timeout to less than 600 seconds.

18.3.3 Wake-on-Shake Search UI Messages

Property Not Set

For devices that do not have the Wake-on-Shake CUWBNet Search Configuration persistent property, the following message will be posted to the Device Manager UI:

Device 12:34:5678 does not have a custom Wake On Shake set.

This means the device will follow the default Wake-on-Shake CUWBNet Search Settings. The recommended values in the tables above match the default Wake-on-Shake CUWBNet Search Settings.

Property Set

For devices that do have the property set but not disabled, the following message will be posted to the Device Manager UI:

Device 12:34:5678 is configured to timeout 30 seconds with wake threshold of 200 m*g*.

For devices that do have the property set and disabled, the following message will be posted to the Device Manager UI:

Device 12:34:5678's Wake on Shake is disabled.

18.4 0x40b2 TX Power Adjustment

18.4.1 TX Power Reduction

Property	Value	Description
tx_power_reduction	x	Value to subtract from the transmission power in tenths of decibels, up to 25.5 dB
tx_power_reduction	0	Recommended Value - Do not reduce default transmission power

18.4.2 LNA Mode

Property	Value	Description
lna_mode	enabled	The device will use their LNA
lna_mode	disabled	The device will not use their LNA
lna_mode	device_setting	Recommended Value - The LNA is enabled by default unless configured otherwise through persistent properties.

18.4.3 TX Power Adjustment UI Messages

Property Not Set

For devices that do not have the property set, the following message will be posted to the Device Manager UI:

> Device 12:34:5678 is not using any power adjustments.

Property Set

For devices that have the property set, the following message will be posted to the Device Manager UI:

> Device 12:34:5678 has its TX Power Reduced by 10 dB and its LNA enabled.

19 APPENDIX B : License Terms and Conditions

1 General Terms and Conditions of Purchase/Service

These General Terms of Purchase/Service are a legal Agreement between you and Ciholas, Inc. (“Ciholas”), and govern your use of all Ciholas services and products, which include, but are not limited to, CUWB.io, Ciholas.com, and all Ciholas Products, Software, and Hardware. If you are accessing and/or using any of the Ciholas services and products on behalf of your employer or as an agent of a third party, your employer or third party is bound to these terms.

Please read these General Terms carefully. Your use of these services and products indicates that you have read, understand, and agree to be bound by the terms herein. Any attempt to set up, use, or install these products constitutes your assent to all the terms of this Agreement. If you disagree with this or any of our other policies, please do not install or use our services and products, and see our return policies for instructions regarding our 60-day Money-Back Guarantee. Written approval is not a prerequisite to the validity and enforceability of this Agreement. Ciholas reserves the right to amend and/or update these terms from time to time. Such modifications to this Agreement will be posted to the website and bundled with software revisions.

This Agreement constitutes the entire and exclusive Agreement between Licensor and Licensee regarding Ciholas services and products, unless modified and agreed to in writing by both parties. We may terminate or suspend access to our services and products at any time, without prior notice or liability, for any reason whatsoever, and without limitation if you breach the General Terms. All provisions of the General Terms shall survive termination, including, without limitation, ownership provisions, warranty disclaimers, indemnity, and limitations of liability. If any provision of this Agreement is deemed invalid or unenforceable, the remaining provisions shall remain in full force and effect.

Any customized services and products will be governed under a separate Customization Agreement.

2 Definitions

For purposes of this Agreement, the following terms shall have the following meanings, unless the context clearly requires otherwise:

“Agreement” means this General Terms of Purchase/Service Agreement and Technology License, any exhibits or appendices attached hereto, and any documents incorporated by reference.

“Buyer” means a person or entity that purchases or contracts to purchase products, services, or property from Ciholas.

“Ciholas” means Ciholas, Inc. including any entity controlled by Ciholas, Inc.

“End-User” means the person or entity that receives and uses Ciholas services and/or products.

“Firmware” means a code segment compiled into binary machine code that is embedded inside a device.

“Hardware” means the physical components of the Ciholas UWB Systems, such as anchors, tags, and supporting equipment.

“Indemnitee” includes, but is not limited to, all End-Users, Buyers, and/or Licensees.

“License Configuration” means a particular configuration or setting provided with Ciholas services and/or products for the purposes of meeting regulatory requirements, or ensuring performance to specification.

“Licensee” means any individual or entity who purchases or uses Ciholas services and/or products covered by this Agreement.

“Licensor” means Ciholas, Inc. including any entity controlled by Ciholas, Inc.

“Our” means Ciholas, Inc. including any entity controlled by Ciholas, Inc.

“Personal Identifiable Information (PII)” means any identifying information unique to you that is made available to Ciholas when you browse our sites, create accounts on our sites, purchase and use our services and products, and/or contact us through our support phone number /email.

“Products” means any goods and/or services provided by Ciholas that are covered under this Agreement.

“Services” means services ancillary to the support and operation of Ciholas Products, Software, Firmware, or Hardware.

“Software” means programs or sets of instructions, including associated source code, object code, documentation, and data, which enable End-Users to perform specific operations or series of operations.

“Technology License” means the License granted to the Licensee for the use of Ciholas services and products through this Agreement.

“We” means Ciholas, Inc. including any entity controlled by Ciholas, Inc.

“You” means the person or entity entering into this Agreement with Ciholas.

3 Technology License

Subject to the terms and conditions of this Agreement, Ciholas grants to you, the Licensee, a limited, non-exclusive, license to use CUWB Software and CUWB Hardware containing Ciholas' Intellectual Property and patent-protected technologies. Ciholas remains the owner of all titles, rights, and interests in the CUWB Software, CUWB Hardware, and other Ciholas products.

Unless expressly stated otherwise, all Software constitutes original code and is subject to the License. Any use of the Software must be in compliance with the License. You acknowledge that the Software and the underlying ideas or concepts of the services and/or products are valuable intellectual property, and you agree not to, except as expressly authorized and only to the extent applicable by statutory law, attempt (or permit others to attempt) to decipher, decompile, disassemble, modify, or otherwise reverse engineer, or attempt to reconstruct or discover any original code, underlying ideas, algorithms, interoperability of the services, products, and Software by any means. Ciholas services, products, and Software are meant to be used in conjunction with one another and any attempt to circumvent this is a violation of this License.

It is a violation of this Agreement to alter any of the Ciholas products to change their designated capability with the intent, or resulting effect, of circumventing the license configuration. Any unauthorized modification violates the terms of service and may make the products illegal in certain jurisdictions (see Government, Regulation, Jurisdiction, and Export Control below).

You must never use Ciholas services and products in any way where the failure of said services and products could cause possible harm, injury, or death to you or others.

The Licensor may amend the License at any time and will post such modifications on our website. Changes are effective upon posting. The Licensee's continued use of the Software after such posting constitutes acceptance.

4 Support

Under this Agreement, Ciholas is under no obligation to provide support for any product or service (such as, but not limited to, technical support, maintenance, upgrades, modifications, or new releases) unless otherwise specified by an additional Agreement.

5 Indemnification

Notwithstanding any other Agreements with Ciholas, the user shall indemnify, defend, and hold harmless the Licensor, its employees, successors, and heirs against any claim, liability, cost, damage, deficiency, loss, expense, or obligation of any kind or nature (including, without limitation, reasonable attorney's fees and other costs and expenses of litigation) incurred by or imposed upon the indemnitees, or any one of them, in connection with any claims, suits, actions, demands, or judgments (including, but not limited to, actions in the form of tort, warranty, or strict liability) arising from the use of Ciholas software and products.

6 Force Majeure

Ciholas shall not be liable or responsible to you for any failure or delay in fulfilling or performing any term of this Agreement, when and to the extent that, such failure or delay is caused by or results from acts beyond Ciholas' reasonable control, including, but not limited to, acts of nature, natural disasters, war, terrorism, labor disputes, supply chain disruptions, power outages, or governmental restrictions.

7 Government Regulation, Jurisdiction, and Export Control

Ciholas products are subject to governmental regulations and laws that may vary by state and country. By purchasing Ciholas products, you agree you will not ship, transfer, or export said products in any manner prohibited by law. You also warrant and agree that you are not located in, under the control of, or a national or resident of any of the countries defined by the Office of Foreign Assets Control, which include, but may not be limited to, Cuba, Iran, North Korea, and Syria. In addition to embargoes, other countries and/or regions may face restrictions under various U.S. export control regulations or be the target of sanctions governed by the Export Administration Act of 1979 (EAA), as amended, any successor legislation, the Export Administration Regulations (EAR), and the International Traffic in Arms

Regulations (ITAR). You will comply in all respects with the export and reexport restrictions applicable to Ciholas products and will otherwise comply with the EAA, EAR, ITAR, and other United States laws and regulations in effect from time to time.

In addition to export regulations, the United States and other countries have laws and regulations governing the use of radio frequency (RF) devices. In the United States, such regulation is under Title III of the Communications Act of 1934, as amended, and regulated by the Federal Communications Commission (FCC). The FCC oversees all non-Federal uses of the radio frequency spectrum, while other regulatory bodies oversee RF devices in other countries' jurisdictions. You agree that you will only use Ciholas products in the jurisdiction for which they were certified and will not exceed the products' operational and use limitations as stated in the product manual. All Ciholas products are labeled as to their specific jurisdictional certification in accordance with the laws of that jurisdiction.

7.4 Governing Law

This Agreement will be governed by the laws of the State of Indiana, USA. Parties agree to attempt, in good faith, to resolve and settle any dispute arising out of this Agreement through negotiation between officially authorized representatives of each party. If the dispute is not resolved through negotiation, any litigation arising from the use of Ciholas services and/or products must be brought and resolved in the State of Indiana, USA.

8 60-Day Money-Back Guarantee

All standard Ciholas products not covered by another agreement have a 60-day Money-Back Guarantee. If for any reason the performance of any product is not acceptable, the product may be returned to Ciholas for a refund. Please note: bulk orders are not eligible for the money-back guarantee and cannot be canceled once the order is processed.

Shipping costs and any taxes and/or duties are not refundable and there is a 20% restocking fee for all returns under this policy. To be eligible for a refund, a customer must include an RMA# (see our return process) and dated proof of purchase with the item for return. The cost of the return shipment, including all taxes and duties, is at the buyer's expense. Any product returned not in resalable condition will not be refunded.

9 Limited Warranty

Ciholas warrants that all Ciholas manufactured products, excluding software, will be free from any defect in materials or workmanship for a period of one year. Warranty begins on the date that an item is shipped from Ciholas to the buyer. The warranty is non-transferable and is extended only to the original buyers of this product when the product is used for the purpose for which it was intended. The one-year warranty covers only defects arising under normal use and does not include malfunctions or failures resulting from misuse, abuse, neglect, alteration, improper installation, acts of nature, tampering, or any repairs attempted by anyone other than Ciholas. During the one-year warranty period, the customer's sole and exclusive remedy will be, at Ciholas' sole discretion, the repair or replacement of the defective product, or refund of the purchase amount of the product. Ciholas reserves the right to substitute functionally equivalent new or serviceable used parts.

To be entitled to the rights provided by the one-year warranty, the customer must do the following:

1. Contact Ciholas Technical Support at returns@ciholas.com or 1-844-595-TECH (8324).
2. Provide in email/phone call, all model number(s), serial number(s), and proof of purchase for all items affected.
3. If return/exchange is necessary, customer will be given a Returned Material Authorization (RMA) # to include with their return.
4. The customer must then ship the item(s), at their expense (including all duties and taxes), to the address provided in the RMA authorization.
5. Once a product arrives at Ciholas, return shipment of repaired or replaced product(s) or a refund will be sent to the customer. The method of return shipment is at Ciholas' discretion and expense, except for applicable duties and taxes, which are the responsibility of the buyer.

9.1 Product Warranty Exclusions

Ciholas does not warrant or guarantee, and is not responsible for the following:

1. Defects, failures, damages, or performance limitations caused in whole or in part by: (A) power failures and surges; fires; floods; acts of nature; excessive temperatures; corrosive environments; accidents; actions by third parties; or

other events outside of Ciholas' control; or (B) customer abuse; mishandling; misuse; negligence; improper storage, servicing, installation, or operation; or unauthorized attempts to repair or alter equipment in any way.

2. Performance of the equipment when used in combination with equipment not purchased, specified, or approved by Ciholas.
3. Consumable goods used with, or required by, Ciholas products.
4. Alterations and/or modifications to any Ciholas equipment without Ciholas' written authorization. Such action unconditionally VOIDS the Ciholas Agreement and Warranty.
5. Installation of any software code, other than that provided and licensed by Ciholas. Any such installation onto any Ciholas product voids the one-year warranty, unless a written exemption is provided to the customer by Ciholas.

9.2 Disclaimer of Warranty

CIHOLAS SERVICES, PRODUCTS, AND ALL INFORMATION, CONTENT, MATERIALS, (INCLUDING SOFTWARE AND HARDWARE), AS WELL AS OTHER SERVICES MADE AVAILABLE THROUGH CIHOLAS, ARE PROVIDED ON AN "AS IS" AND "AS AVAILABLE" BASIS, UNLESS OTHERWISE SPECIFIED IN WRITING. CIHOLAS SERVICES INCLUDE ALL CIHOLAS OWNED AND OPERATED DOMAINS, INCLUDING, BUT NOT LIMITED TO, CIHOLAS.COM, CIHOLAS SHOP, CUWB.IO, AND ALL CIHOLAS PRODUCTS, SOFTWARE, AND HARDWARE. THE USE OF CIHOLAS SERVICES AND PRODUCTS IS AT THE USER'S SOLE RISK.

EXCEPT AS EXPRESSLY PROVIDED IN THE CIHOLAS WARRANTY POLICY STATEMENT, CIHOLAS HEREBY EXPRESSLY DISCLAIMS ALL REPRESENTATIONS, CONDITIONS, AND WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF TITLE, MERCHANTABILITY, NON-INFRINGEMENT, AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL CIHOLAS BE LIABLE TO THE USER OR ANY OTHER PARTY FOR ANY DIRECT, INDIRECT, GENERAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL, EXEMPLARY, OR OTHER INJURIES AND/OR DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE CIHOLAS SERVICES AND PRODUCTS (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF INFORMATION, BREACH OR ANY OTHER PECUNIARY LOSS), OR FROM ANY BREACH OF WARRANTY. NOTWITHSTANDING ANYTHING TO THE CONTRARY CONTAINED IN THIS DISCLAIMER OF WARRANTY, IN NO CASE SHALL THE MAXIMUM AGGREGATE LIABILITY OF CIHOLAS TO THE USER EXCEED THE TOTAL AMOUNT OF THE ACTUAL FEES PAID BY THE USER TO CIHOLAS.

CIHOLAS IS NOT LIABLE FOR ANY CONDUCT OF ANY USER OF CIHOLAS SERVICES AND PRODUCTS, NOR FOR ANY APPLICATION OR USE OF CIHOLAS SERVICES AND PRODUCTS IN AN ILLEGAL MANNER, TO COMMIT AN ILLEGAL ACT, OR IN A JURISDICTION IN WHICH IT IS ILLEGAL OR UNAUTHORIZED TO USE THESE SERVICES AND PRODUCTS. IT IS THE RESPONSIBILITY OF THE USER OF CIHOLAS SERVICES AND PRODUCTS TO ESTABLISH THE LEGALITY OF ITS USE IN THE USER'S JURISDICTION.

10 Ciholas Standard Privacy Policy

Ciholas is committed to protecting your personal information and your right to privacy. If you have any questions or concerns about our policy or our practices with regards to your personal information, please notify Ciholas at info@ciholas.com.

The following is to inform you of our policies for collecting, using, and disclosing your Personal Identifiable Information (PII) made available to Ciholas when you browse our sites, create accounts on our sites, purchase and use our services and products, and/or contact us through our support email. By using any of our services and products, you agree to the collection and use of your PII in accordance with this and other policies contained in this Agreement.

10.1 Personal Identifiable Information Collected

In the CUWB.IO Shop, we collect personal information that you voluntarily provide to Ciholas when creating an account, posting messages, or otherwise contacting us. The PII that we collect depends on the context of your interactions with Ciholas and the choices you make regarding the information you provide. The PII you share is up to you and is not required for browsing any of our sites. However, if you want to create an account, purchase an item in our shop, and/or call/email our support staff, you may be asked for PII. The PII collected is encrypted using secure socket layer technology (SSL).

The PII we collect could include the following:

Name and Contact Data – First and last name, email address, postal address, phone number, and other similar contact data.

Credentials – Passwords and similar security information used for authentication and account access.

Payment Data – All payment data collected through the website is by a third-party payment processor (TPPP). Ciholas DOES NOT have access to any of the payment information that you provide to the TPPP. None of the TPPPs use any of your data for anything other than processing your payment and have their own privacy policies, which are as strict as or stricter than, those contained in this privacy policy. Ciholas and all Ciholas TPPPs use SSL/TLS encryption for securing data. All Ciholas TPPPs are PCI DSS compliant for payment processing standards.

10.2 Information Usage

We use your PII for the purposes listed above and to keep our site safe and secure (for example fraud monitoring and prevention) and to enforce our terms, conditions, and policies for our legitimate business purposes.

We may disclose your information where we are legally required to do so to comply with applicable law, judicial proceedings, court order, or legal process, such as in response to a court order or a subpoena.

We will not share, sell, rent, or trade any of your PII with any third parties.

10.3 Duration of PII Storage

We keep your information for only as long as necessary to fulfill the purposes outlined in this privacy policy unless otherwise required by law.

10.4 Keeping PII Safe

We have implemented appropriate technical and organizational security measures designed to protect the security of any personal information we process. However, given that the internet is not 100% secure, transmission of personal information to and from our sites is at your own risk. Only access our services, products, and sites within a secure environment.

10.5 Unique Privacy Rights

Based on the laws of some countries and states, you may have the right to request access to the PII we collect from you, change that information, or delete it in some circumstances. For more information on how to do that, please contact Ciholas at info@ciholas.com.

If you are visiting our sites from outside of the United States, please be aware that you are sending information (including PII) to the United States where our servers are located. That information may then be transferred within the United States or back out of the United States to other countries outside of your country of residence, depending on the type of information and how it is stored by us. These countries, including the United States, may not have data protection law as comprehensive or protective as those in your country of residence; however, our collection, storage, and use of your PII will at all times continue to be governed by this Privacy Policy.

10.6 Non-PII Information Automatically Collected

We automatically collect certain information through web analytics when you visit, use, or navigate any of our sites. This information does not reveal your specific identity, but may include device and usage information, such as your computer's Internet Protocol (IP) address, browser type, browser version, operating system, referring URLs, country, location, the pages of our sites that you visit, the time and date of your visit, the time spent on those pages, and other similar statistics. This information is primarily needed to maintain the security and operation of our sites and for our internal analytics and reporting purposes.

We collect this information using cookies. Cookies are small pieces of text stored on a user's computer. They can be accessed by the web server or the client computer, allowing the server to deliver information tailored to the user. Most web browsers are set to accept cookies by default. We use cookies to keep track of items stored in your shopping basket, to conduct research and diagnostics to improve our content, services, and products, to prevent fraudulent activity, and to improve security.

If you prefer, you may choose to set your browser to remove and reject cookies. This could affect the availability of certain features, services, or products on our sites. Most browsers allow you to turn off cookie collection in their Tools/ Settings button under a Privacy tab.

These Terms of Service were last modified on 2025-11-11.

[**End of Agreement**]