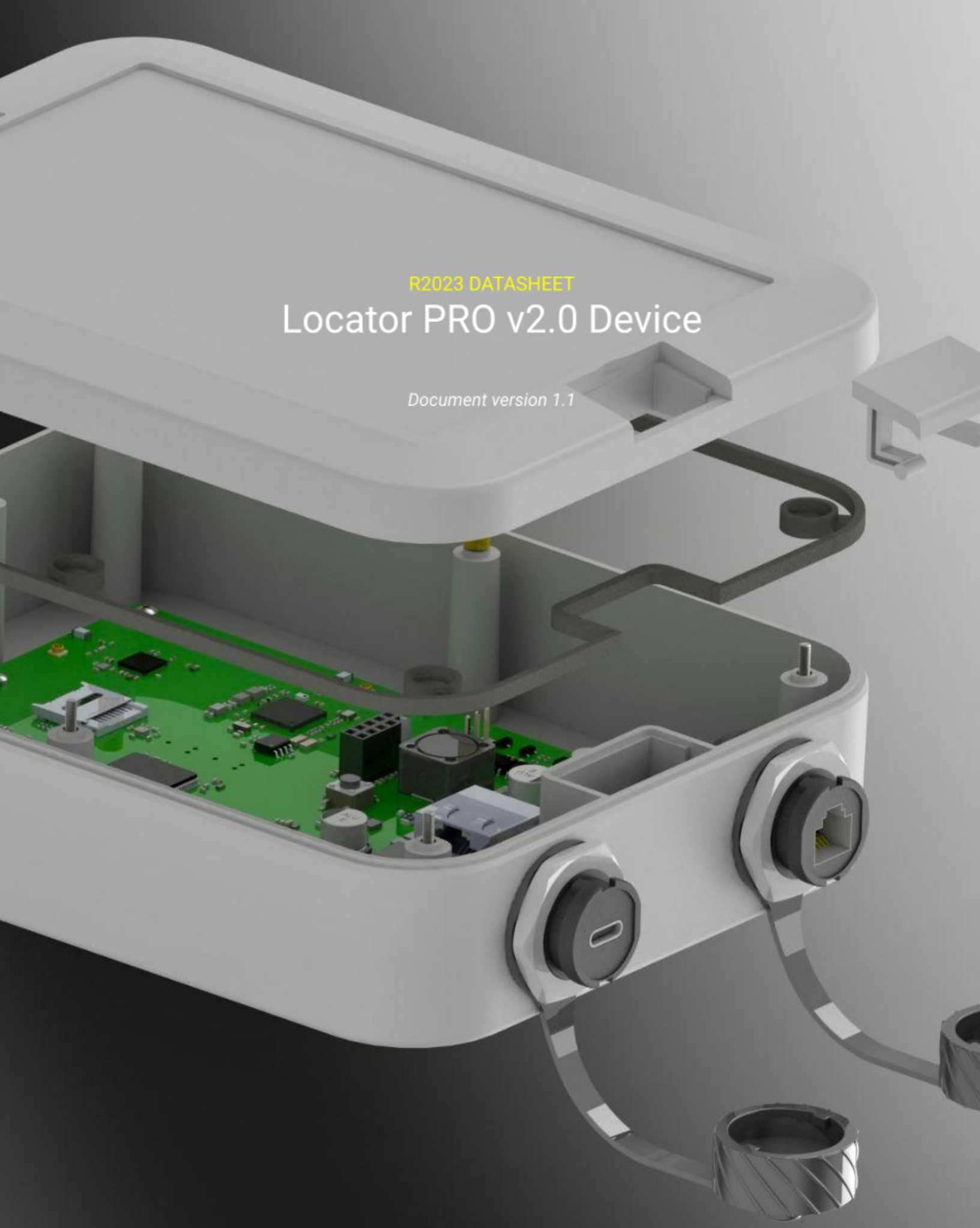
R2023 DATASHEET

Locator PRO v2.0 Device

Document version 1.1



DOCUMENT REVISIONS

Version	Date	Author	Comments
v1.0	2022-08-01	Oleg Puzanov	Draft version
v1.1	2023-01-24	Oleg Puzanov	Updated BLE GATT parameters and MQTT messages.

TABLE OF CONTENTS

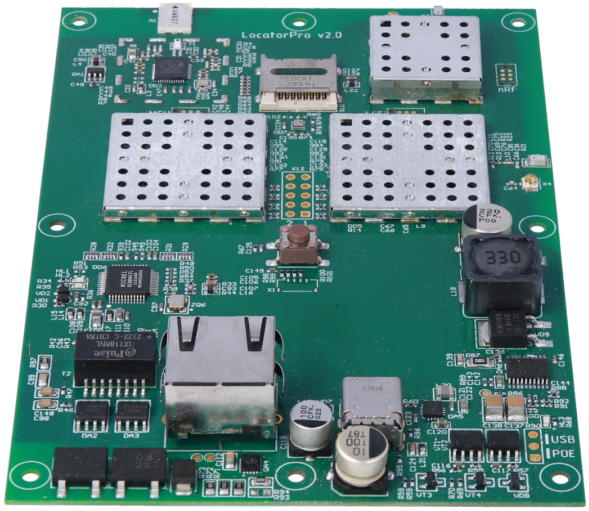
1. Overview

Locator PRO is a feature-rich anchor and gateway device for industrial RTLS networks. It was designed and developed for both indoor and outdoor installations in industrial environments, such as metallurgical factories and warehouses.

The device is compliant with IP67 requirements and includes all typical interfaces and connectors, which are needed for enterprise-grade installations at your locations - for example: 802.3at-af PoE, WLAN and USB interfaces.

Locator PRO: Default Enclosure

Locator PRO: PCB



Special configurations, such as the Sealed Mode (see Chapter 6.4), enable fully wireless installations without any cables for power supply or network connectivity. Some other configurations, such as the custom Wi-Fi Mesh network, enable installations in challenging areas without Ethernet or Wi-Fi coverage.

Several RTLS technologies are supported in both hardware and software of Locator PRO devices:

- UWB for 1D-3D RTLS scenarios based on TWR and our custom algorithm with 5-10 cm accuracy. Maximum range for UWB TWR is 70-80 meters for the case of SMD chip antenna, which is a default option.
- Custom UWB TDoA algorithm for highly scalable and low-power 2D RTLS scenarios, which need 50-60 cm accuracy for RTLS. Maximum range for UWB TDoA is 70-80 meters for the case of SMD chip antenna, which is a default option.
- Tunnel UWB/BLE RTLS algorithms, which were developed specifically for underground mines (see Chapter 7.5).
- BLE zoning based on RSSI and Kalman filtering - suitable for room-level tracking scenarios.
- Height tracking based on the embedded barometer - suitable for floor/level detection with less RTLS anchors.
- Sensor telemetry for RTLS tags over UWB or BLE payloads - accelerometer, gyroscope, temperature (see Chapter 7.8).

Industry-specific RTLS features, such as Collision Avoidance and Proximity Detection Subsystem, have been developed in software (see Chapter 7.7). Android HMI is available for vehicle-based installations of Locator PRO devices. Please also check Tag PRO devices on the Leantegra website for vehicle-based RTLS installations.

The payload format for UWB and BLE protocols of Locator Pro has been customized to include non-RTLS data from other Leantegra devices, such as UWB wristbands or mining equipment (e.g. Smart Lamp IPX-RTLS). For example: barometer data, accelerometer, gyroscope, HRM for wristbands, temperature sensors, methane sensors etc.

Multiple configuration parameters are available via BLE GATT and MQTT protocols, as well as OTA firmware upgrade via LAN or WLAN connection (see Chapter 8).

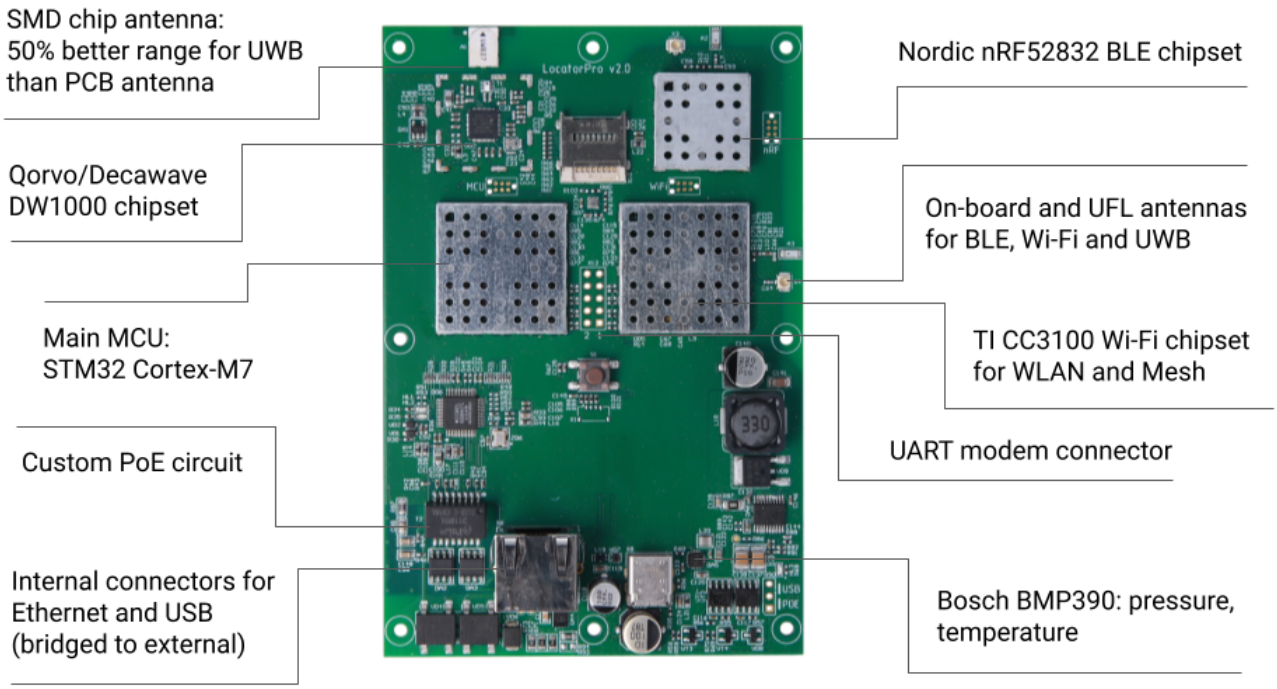
Locator PRO devices are natively supported by Leantegra RTLS Server and CVO Portal software. Lower-level protocol integrations with Locator PRO are possible via MQTT or BLE GATT.

The firmware of Locator PRO is based on the FreeRTOS operating system and can be customized with extra device drivers or network protocols upon request.

Important - at this stage Locator PRO devices do not have ATEX certifications and shouldn't be installed in coal mines or other locations, where ATEX Zone 0-2 certificates are required. If you need ATEX-certified UWB or BLE devices, then please check some other devices on the Leantegra website.

2. Key Characteristics

2.1. PCB Components



- **Main MCU:** low-power STM32 Cortex-M7
- **BLE chipset and antenna:** Nordic nRF52832, SMD chip antenna and UFL connector for the external antenna
- **UWB chipset and antenna:** Qorvo/Decawave DW1000, SMD chip antenna or UFL-connected antenna for longer range
- **Wi-Fi chipset and antenna:** Texas Instruments CC3100 - 2.4 GHz only, SMD chip antenna and UFL connector for the external antenna
- **PoE:** ON Semiconductor 802.3at-af module with our custom PoE circuit
- **Ethernet:** Microchip Ethernet RMII PHY module
- **Barometer:** Bosch BMP390
- **USB:** Amphenol USB 3.2 module
- **Front panel (can be removed):** status LED for Ethernet and Wi-Fi connectivity, “Reset” button
- **Connectors:**
    - Protected USB Type-C connector
    - Protected Ethernet RJ45 connector
    - Internal UART connector for modems or sensors
    - Internal microSD card slot
    - Internal pins for the front panel connector
    - UFL connectors for the external BLE and UWB antennas

2.2. Antenna Characteristics

Radiation patterns and electrical characteristics for the antennas are available in the corresponding datasheets:

- Datasheet for UWB antenna
- Datasheet for BLE antenna
- Datasheet for Wi-Fi antenna

Please consider that it's possible to use the on-board UFL connector for the external Wi-Fi and UWB antennas. This option is available separately for Locator Pro orders.

2.3. Electrical and Environmental

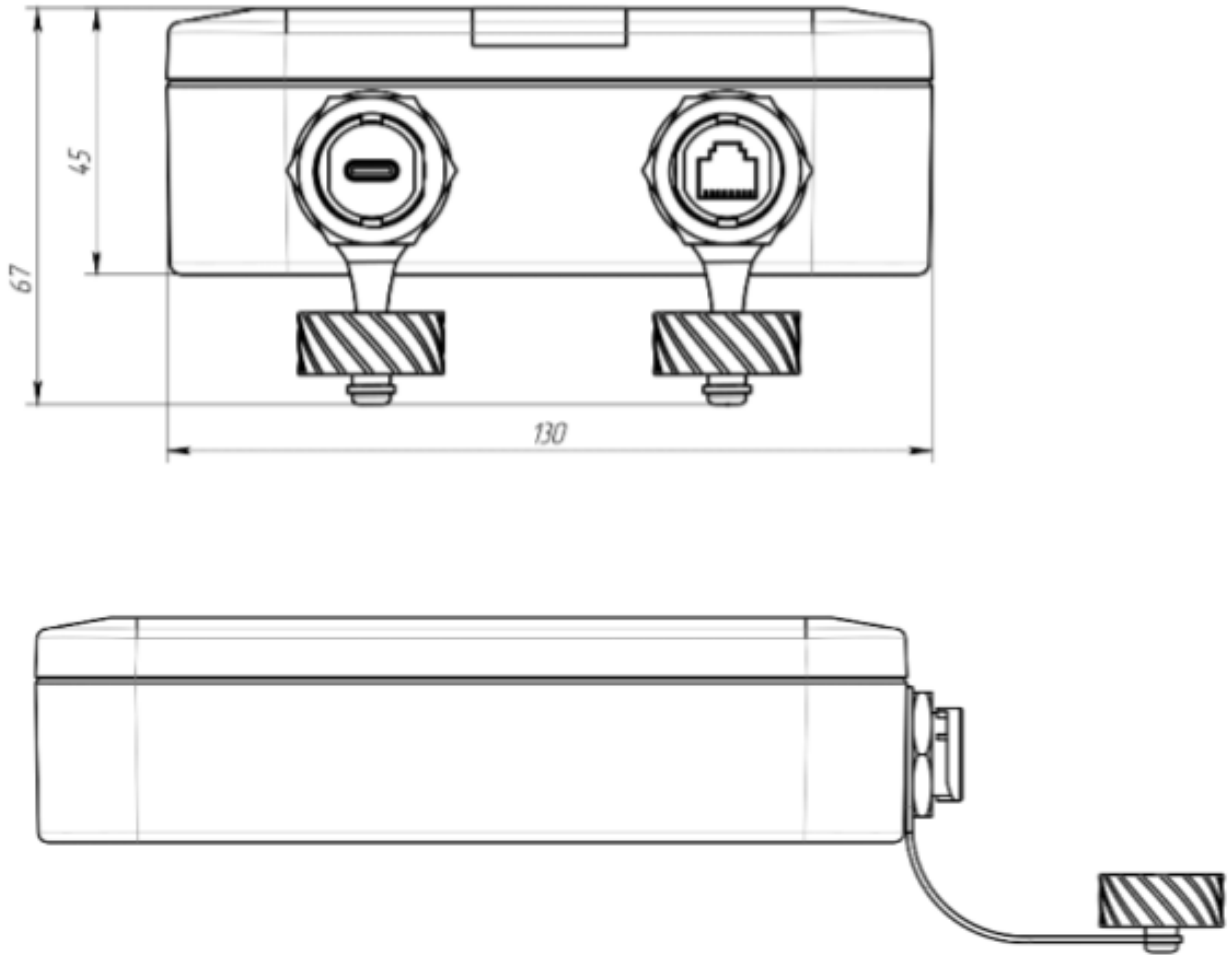
- Enclosure IP compliance: IP67 - without front panel, IP66 - with front panel.
- Temperature range with the default enclosure: -20 °C … + 60 °C
- PCB temperature range: -40 °C … +85 °C
- Power supply and consumption:
    - Average 3-4 Watts with both UWB and BLE working.
    - USB Type-C connector: 5V, 1A
    - Ethernet PoE connector: standard 802.3af or 802.3at power supply from PoE switches or injectors.

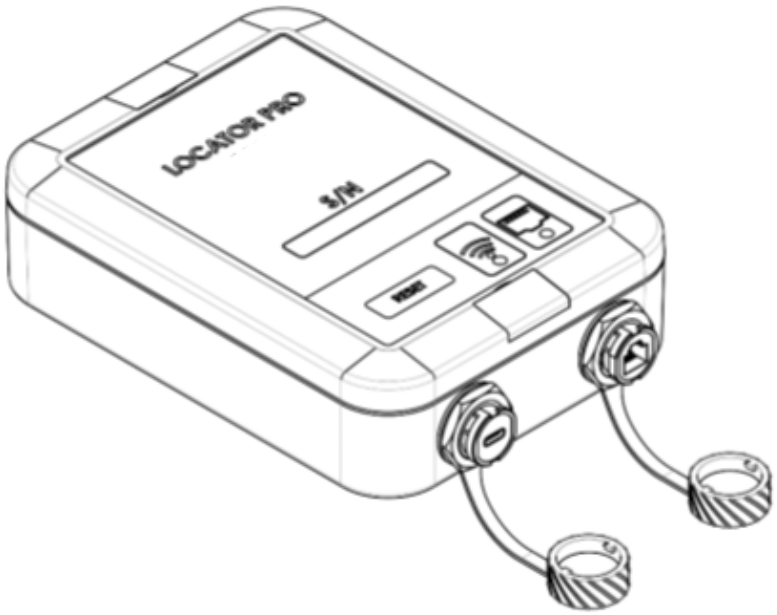
2.2. Enclosure Details

With Front Panel	Without Front Panel
	

Button and LED Indicators

2.5. Enclosure Dimensions





3. Configuration Parameters

3.1. Brief Overview

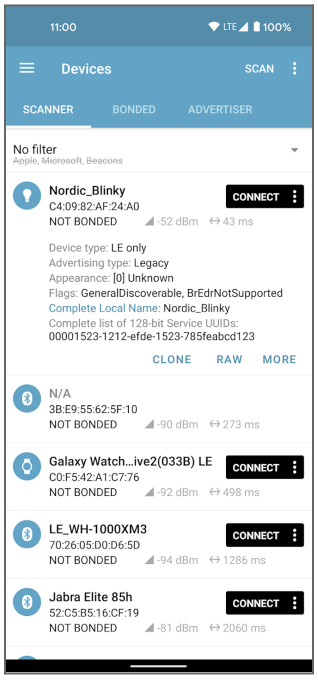
Locator PRO devices support configurations via the following two interfaces:

1. **BLE GATT parameters** - using Leantegra Config App or 3rd-party applications, such as Nordic nRF Connect.
2. **MQTT messages** - from Leantegra PowerGate Server or 3rd-party applications for MQTT publish-subscribe operations, such as MQTT Explorer.

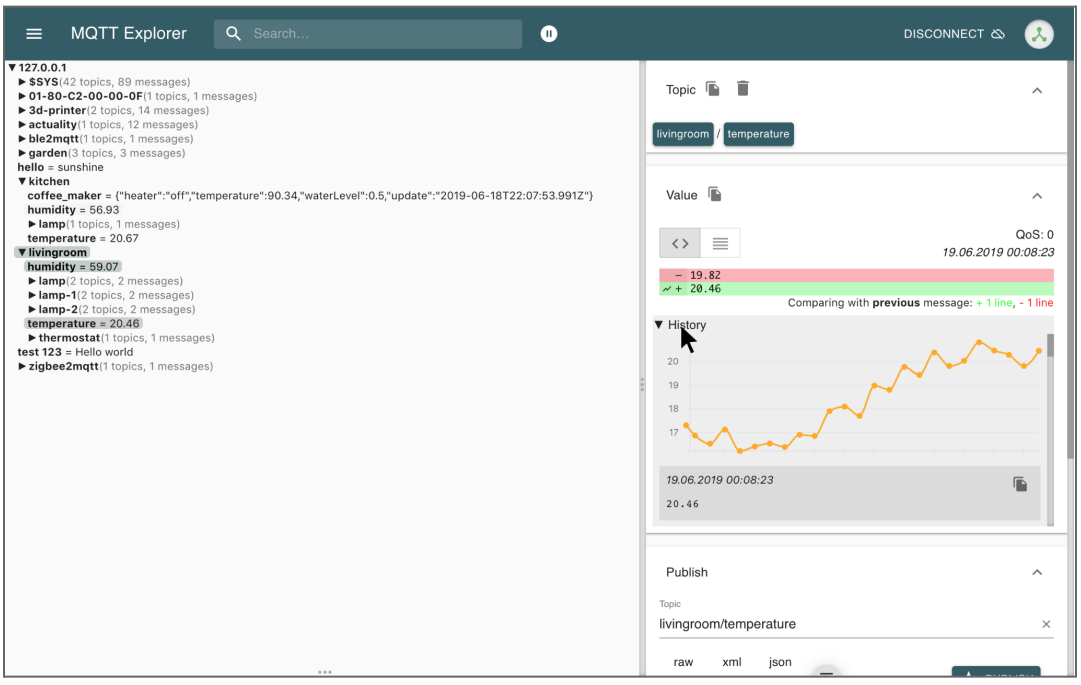
Important:

- If you're using nRF Connect App for changing any BLE GATT parameters, then please **disconnect** after such changes. The new values won't be applied until disconnecting via BLE.
- "Reset" button on the front panel of Locator Pro can be used for factory default parameters:
  - Long press for "Reset" button: 3 seconds - restarting the device.
  - Long press for "Reset" button: 20+ seconds - factory default parameters.

nRF Connect App



MQTT Explorer



3.2. Parameters Table

Name	Read, Write	UUID for BLE GATT	MQTT Field (JSON)	Format	Comments
Serial Number	RW	0x5201	“Serial”	16 bytes, string	Should be changed only once
BLE MAC Address	R	0x5202	“BLE_MAC”	6 bytes, byte array	Standard MAC address
Firmware Version	R	0x5203	“FW_Version”	10 bytes, string	Might includes letters and numbers
Device Name	RW	0x5204	“Device_Name”	20 bytes, string	User-friendly name of this device
UWB RTLS Mode: TWR or TDoA	RW	0x5205	“UWB_Mode”	1 byte, uint8	1: TWR; 2: TDoA
RTLS Anchor Role: Master or Slave	RW	0x5206	“Anchor_Role”	1 byte, uint8	1: Slave; 2: Master
UWB Channel: 1-7	RW	0x5207	“UWB_Channel”	1 byte, uint8	1: Channel #1; 2: Channel #2 etc. Default = Channel #7
UWB Data Rate	RW	0x5208	“UWB_Rate”	1 byte, uint8	1: 6.8 MBit/sec; 2: 850 KBit/sec; 3: 110 KBit/sec Default = 110 KBit/sec
UWB Preamble Size	RW	0x5209	“UWB_Preamble”	1 byte, uint8	1: 64; 2: 128; 3: 256; 4: 512; 5: 1024; 6: 1536; 7: 2048; 8: 4096 Default = 2048
UWB PRF	RW	0x520a	“UWB_PRF”	1 byte, uint8	1: 16 MHz; 2: 64 MHz Default = 16 MHz
UWB PAN ID	RW	0x520b	“UWB_PAN_ID”	2 bytes, uint16	Network ID for UWB RTLS
Wi-Fi SSID	RW	0x520c	“WiFi_SSID”	20 bytes, string	SSID name for WLAN connection
Wi-Fi Password	RW	0x520d	“WiFi_Password”	20 bytes, string	By default, not encrypted

RTLS Server Address	RW	0x520e	“Server_Address”	20 bytes, string	IP address or DNS name
RTLS Server Port	RW	0x520f	“Server_Port”	2 bytes, uint16	Default = 1883 TCP port
Configuration Version	R	0x5210	“Config_Version”	4 bytes, uint32	Increments upon each change to any parameter
Master Anchor MAC Address	RW	0x5211	“Master_MAC”	6 bytes, byte array	Relevant for the Slave anchors only
UWB “Smart Power” Mode	RW	0x5212	“Smart_Power”	1 byte, uint8	0: The longest range; 1: The lowest power consumption
Network Connectivity Mode	RW	0x5213	“Connectivity”	1 byte, uint8	0: Ethernet LAN; 1: WLAN; 2: Wi-Fi Mesh
Use DHCP (Dynamic IP)	RW	0x5214	“Use_DHCP”	1 byte, uint8	0: false; 1: true
Static IP Address	RW	0x5215	“Static_IP”	20 bytes, string	Own static IP address
IP Gateway Address	RW	0x5216	“Gateway_IP”	20 bytes, string	IP address of the network gateway
NTP Server Address	RW	0x5217	“NTP”	20 bytes, string	IP address of the NTP server
Mesh Role	RW	0x5218	N/A	1 byte, uint8	For Wi-Fi Mesh only: 0: Client; 1: Relay; 2: Gateway;
Mesh Relay Neighbors	RW	0x5219	N/A	List of MAC addresses	Please see the details of Wi-Fi Mesh architecture
Mesh Client Neighbors	RW	0x521a	N/A	List of MAC addresses	Please see the details of Wi-Fi Mesh architecture
BLE Zoning Enabled	RW	0x521b	“BLE_Zoning”	1 byte, uint8	Turn on/off the feature about BLE zone tracking
BLE Zoning Calibrated RSSI	RW	0x521c	“BLE_CAL_RSSI”	1 byte, uint8	The calibrated BLE RSSI value on 1 meter

BLE GATT Password	RW	`0x521d`	N/A	20 bytes, string	If not empty, then all GATT parameters are password-protected
Restart-Shutdown	W	`0xffff`	N/A	1 byte, uint8	Write-only parameter: 1: Restart; 2: Shutdown; 99: Factory reset;

4. Data Interfaces

4.1. JSON over MQTT

JSON over MQTT is the default protocol for data communications from/to Locator PRO devices. Such data communications can happen between Locator PRO and Leantegra RTLS Server, but there is no limitation here - any MQTT brokers, compatible with MQTT 3.1.1 specification, can be used for direct data exchanges with Locator PRO devices. Some examples of MQTT brokers:

- VerneMQ - used by Leantegra RTLS server
- HiveMQ
- Mosquitto

Please note that some projects might require QoS2 support for MQTT, so we recommend using VerneMQ by default, because it supports all MQTT QoS policies.

MQTT is used by Locator PRO for the following purposes:

- Sending RTLS data - UWB TWR, TDoA and all other types of RTLS use MQTT for data payloads.
- Configuration parameters - MQTT is used for “mirroring” BLE GATT parameters (see Chapter 3.2). It means that each configuration parameter can be changed using BLE GATT or MQTT.
- OTA firmware upgrade - triggering the firmware upgrade via publishing to the specific MQTT topic.

Sample MQTT messages:

UWB TDoA Message	UWB TWR Message
{ "MessageID": 8011593, "MessageType": 0, "LocatorID": "UWBANCH0001", "TagID": "f2:e8:b8:50:63:a1", "DeviceType": "uwb2", "Timestamp_ref_1": 1071423525934, "TimestampTDoA": 1072283984540, "Timestamp_ref_2": 1081407487022, "Counter": 0, "Sensor_Own_Pressure": 101325, "Sensor_Own_Temperature": 19.7, "Sensor_Tag_Pressure": 101321, "Sensor_Tag_Temperature": 19.5 "Sensor_Tag_AccX": 2205, "Sensor_Tag_AccY": 1510, "Sensor_Tag_AccZ": 14914, "Sensor_Tag_GyrX": 392, "Sensor_Tag_GyrY": -910, "Sensor_Tag_GyrZ": -237, "Timestamp": 1107511, }	{ "MessageID": 542201,, "MessageType": 0, "LocatorID": "UWBANCH0001", "TagID": "f2:e8:b8:50:63:a1", "DeviceType": "uwb", “Distance”: 2438, "Sensor_Own_Pressure": 101322, "Sensor_Own_Temperature": 19.2, "Sensor_Tag_Pressure": 101321, "Sensor_Tag_Temperature": 19.5 "Sensor_Tag_AccX": 2205, "Sensor_Tag_AccY": 1510, "Sensor_Tag_AccZ": 14914, "Sensor_Tag_GyrX": 392, "Sensor_Tag_GyrY": -910, "Sensor_Tag_GyrZ": -237, "Timestamp": 982511, }

4.2. BLE GATT

BLE GATT interface is used by Locator PRO for two purposes:

1. Configuration parameters (see Chapter 3.2)
2. Data exchange with mobile applications - for example: Android HMI application for Collision Avoidance.

When mobile applications need to communicate with Locator PRO in the offline mode, independently from any LAN or WAN connections, then BLE GATT interface is the most optimal choice. It can stream the RTLS data with acceptable latency and throughput, which are needed for Collision Avoidance Systems and similar applications.

Sample BLE GATT characteristic, which is used by Android HMI for Collision Avoidance System (CAS):

SERVICE_UUID for CAS: 00005100-1210-ef1e-1423-7851af03d463
CHARACTERISTIC_UUID for CAS: 00005111-1210-ef1e-1423-7851af03d463

GATT characteristic value - 4 bytes:

- Nearest distance in meters: (value & 0xFFFF) / 100
- Number of vehicles: (value & 0xFF0000) >> 16
- Number of people: (value & 0xFF000000) >> 24

5. UWB Details

5.1. Typical Configurations

When selecting the most optimal UWB parameters, such as UWB preamble and data rate, the following basic recommendations should be considered:

- Smaller UWB frame durations are enabled by configuring shorter UWB preambles and higher data rates.
- Smaller UWB frame durations consume less power and prolong battery life.
- Smaller UWB frame durations enable higher RTLS tag densities, but limit the maximum range of UWB signals and obstacle penetration possibilities.
- When you need the best possible range for UWB signals, then configure longer UWB preambles and lower data rates.

Typical configurations:

Better Tag Density	Better Range
Preamble: 256 Data rate: 6.8 Mbit/sec	Preamble: 2048 Data rate: 110 Kbit/sec

By default, Locator PRO and Leantegra RTLS tags are configured with 2048 preamble and 110 Kbit/sec data rate.

5.2. Adaptive Transmission Feature

Leantegra RTLS tags, such as Tag PRO/LITE, support power saving by using the adaptive transmission feature for UWB - using different blink rates in active and inactive modes, which are triggered by the accelerometer values:

- Active mode - any motion for the last 10 seconds
- Inactive mode - no motion for the last 10 seconds

Specific thresholds for the accelerometer values are calibrated inside the firmware code and can’t be changed at runtime.

Blink rates for active and inactive modes are configured via BLE GATT parameters (see the datasheets of Leantegra RTLS tags) - for example:

- Active blink rate - 500 msec
- Inactive blink rate - 10 seconds

By using the adaptive transmission feature it is possible to achieve 3-4 times smaller power consumption numbers for UWB TWR or TDoA. Still, some other UWB parameters might be considered when planning the battery life for Tag PRO devices (see Chapter 5.1).

6. Connectivity Options

6.1. Internal Cabling

The enclosure of Locator PRO contains the protected connectors for Ethernet and USB, which are routed inside the enclosure and connected to the on-board Ethernet and USB ports via internal cables. There is a plenty of space inside the enclosure to place a USB powerbank or to connect extra modules (e.g. Cellular modem).

Default Configuration with Ethernet and USB	USB Powerbank
	

6.2. Ethernet LAN with PoE

When to use: when IT policies and common IT procedures require Ethernet and PoE for connecting the network devices. For example: large warehouses or factories with the existing Ethernet LAN infrastructure.

How it works:

- Connect the device via a single Ethernet cable for power supply and data transfers over Ethernet LAN.

- Locator Pro supports the main PoE standards: 802.3af and 802.3at. Additional tests and customizations were conducted for staying compliant with the Cisco PoE equipment, such as Cisco Catalyst 2960 switches
- The device has a dedicated LED on its panel for indicating the Ethernet LAN connectivity status.

6.3. WLAN with USB Power Supply (External Cable)

When to use: when Ethernet connectivity is an overhead or not possible at all.

How it works:

- Connect the device to a Wi-Fi network for data transfers and USB Type-C for power supply.
- This connectivity option assumes an external USB cable with the standard 5V-1/2A power supply.
- The device has a dedicated LED on its panel for indicating the WLAN connectivity status.

6.4. “Sealed Mode” - WLAN with the Internal USB Powerbank

When to use: construction sites, open pit mines or other places, where only temporary RTLS installations are possible. When cabling is not allowed or might become very expensive.

Another possible use case - temporary RTLS installations at football stadiums for recording RTLS data.

How it works:

- Connect the device to a Wi-Fi network for data transfers and the internal USB powerbank for power supply.
- This option is called the **“Sealed Mode”**, because the enclosure doesn’t have any external cables connected. The external connectors for Ethernet and USB are closed.
- The powerbank is attached internally to the enclosure and connected via a short cable to the internal USB connector.

Forecasted lifetimes on a single charge with UWB, BLE and Wi-Fi actively transmitting:

- 5000 mAh powerbank - at least 6 hours
- 10000 mAh powerbank - at least 12 hours
- 20000 mAh powerbank - at least 24 hours

6.5. Wi-Fi Mesh for Network Extensions

When to use: when it’s impossible to use Ethernet LAN or WLAN for connectivity - for example: no Wi-Fi coverage and it’s physically impossible to use Ethernet cabling. It allows extending your LAN with RTLS devices to extra segments (network legs) in challenging areas for installations.

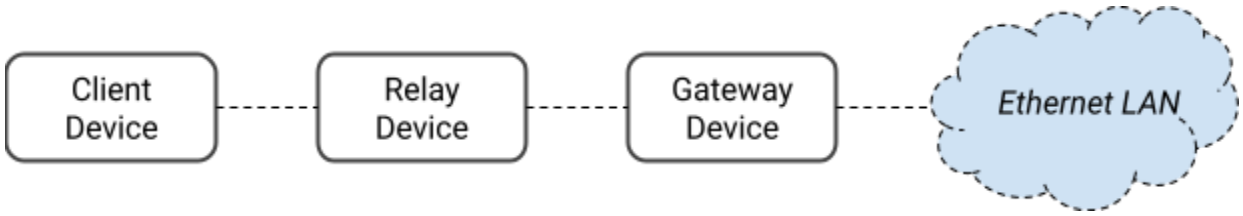
Important:

- This is not a standard 802.11s Wi-Fi Mesh, but a custom implementation to exchange RTLS messages among Locator Pro devices.
- Remote firmware upgrade is currently not possible via the Wi-Fi Mesh network. Regular Ethernet LAN or WLAN connection must be used for this purpose.
- It is recommended to use the regular Ethernet LAN or WLAN, where it's possible instead of the Wi-Fi Mesh network, because the Wi-Fi Mesh network doesn't support the standard tools and protocols for network administration (e.g. PING, SNMP, DHCP).

How it works:

- There are three possible roles in the Wi-Fi Mesh network for Locator Pro devices:
    - **Relay** - the device handles both RTLS data generation and forwarding in the Wi-Fi Mesh network. Such devices are typically positioned somewhere in the middle between the Client and the Gateway devices.
    - **Gateway** - the device handles both RTLS data generation and proxying between Wi-Fi Mesh and Ethernet LAN. The Gateway device must be physically connected to your Ethernet LAN.
    - **Client** - the device handles RTLS data generation only. No forwarding in the Wi-Fi Mesh network and no LAN connectivity.

- Configure each Locator Pro device via BLE GATT parameters - its role and neighbors in the Wi-Fi Mesh network (see Chapter 5).
- The recommended depth of the Wi-Fi Mesh network is 4 devices - it means not more than 4 sequentially connected devices in the Wi-Fi Mesh network.



6.6. Cellular WAN Module via UART (Custom Version)

When to use: when 3G-4G connectivity is the only possible option for Locator Pro devices and it's not possible to install a separate WLAN-to-Cellular router device.

How it works: Locator Pro devices have dedicated pins and software support for the external UART modems. Adding such UART modems is possible as a custom option for your hardware order.

7. RTLS Features

7.1. Brief Overview

Locator PRO device and Leantegra RTLS software enable highly customizable and configurable RTLS features with several algorithms based on UWB and BLE. Please see Chapter 3.2 for the relevant configuration parameters - for example: changing between UWB TWR and TDoA, selecting UWB channels, enabling BLE RSSI tracking etc.

The below table provides a brief summary for each RTLS technology or algorithm:

Feature Name	Technologies	Average Accuracy	Average Range	Key Advantages
UWB TWR	1D, 2D, 3D RTLS	5-20 cm	70-80 meters	The best location accuracy.
UWB TDoA	2D RTLS	30-60 cm	70-80 meters	Highly scalable, low power consumption.
Tunnel UWB RTLS	1D UWB TWR	30-60 cm	50-60 meters	Works with 2 RTLS anchors, good balance of accuracy and cost for underground mines.
Reverse BLE RTLS (Tunnel BLE)	1D BLE RTLS, Matchpoints	10-20 meters	60-80 meters	No cables are needed for tunnels, low cost RTLS for underground mines.
BLE Zoning	BLE RSSI Tracking	2-3 meters	15-20 meters	Simple option for room-level tracking.
Collision Avoidance and PDS	UWB TWR, BLE RSSI Tracking, BLE GATT	10-50 cm	100+ meters	Integrated system with Android HMI for vehicles.
Height Tracking	Barometer or 3D RTLS	30-50 cm (relative). Using Bosch BMP390 by default.	70-80 meters	Only one RTLS anchor is needed for height tracking.
Orientation-Motion	Gyroscope,	Depends on the	70-80 meters	Only one RTLS anchor is

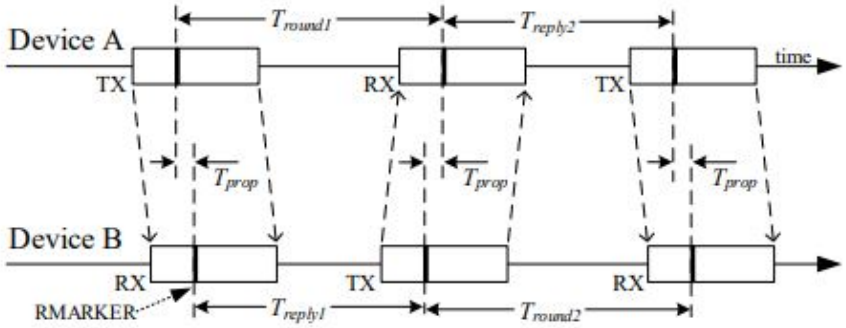
Tracking	Accelerometer	UWB tag. Using Bosch BMI270 by default.		needed for tracking orientation and motion.

7.2. UWB TWR

The firmware of Locator PRO implements a custom DS-TWR algorithm: double-sided **two-way ranging**.

This algorithm requires three UWB frames to be exchanged between an RTLS anchor and each RTLS tag for calculating distances. The original implementation of DS-TWR from Qorvo / Decawave was customized to achieve a better ranging accuracy.

We observed 4-5 times improvement for the ranging accuracy with our customized DS-TWR algorithm compared to the default implementation, which is bundled with Qorvo / Decawave DW1000 libraries.



Both range and tag density for UWB TWR can be adjusted according to the project requirements by changing the corresponding parameters using BLE GATT or MQTT (see Chapter 3.2). The most important parameters for range and tag density are “UWB Data Rate”, “Preamble Size” and “UWB Ranging Rate” (on the tag side).

The basic approach is that the longer preamble with the lower data rates increases the resulting UWB range, but decreases the resulting UWB tag density.

Main characteristics:

- Accuracy:
  - 5-10 cm for static objects.
  - 10-30 cm for moving objects.
- Range:
  - Settings for longer range: best case LOS - 80 meters, worst case LOS - 60 meters.
  - Settings for higher density: best case LOS - 50 meters, worst case LOS - 30 meters.

- Tag density:
    - Settings for longer range : 1 Hz rate - up to 120 tags, 5 Hz rate - up to 25 tags.
    - Settings for higher density: 1 Hz rate - up to 800 tags, 5 Hz rate - up to 160 tags.

When to use:

- When the location accuracy is very important and you need sub-30 cm accuracy.
- When you need UWB ranging only (distance) between two objects, instead of the location coordinates.
- 1D UWB RTLS scenarios for tunnels or rails - can't be implemented using TDoA.
- 3D UWB RTLS scenarios have a better Z-axis accuracy with less RTLS anchors.

When not to use:

- When your RTLS installation must be powered by batteries or accumulators, which can't be frequently recharged. Power consumption for UWB TWR is 50-80 times higher than for the case of TDoA!
- When the tag density is really high - for example: tracking 1000+ objects inside the same area.

7.3. UWB TDoA

Fully wireless and asynchronous TDoA (Time Difference of Arrival) algorithm, which doesn't require clock synchronizations among RTLS anchors. Our patent-pending UWB TDoA implementation is included into the firmware of Locator PRO and other Leantegra UWB devices.

Battery life is the main concern for UWB TWR systems, because the task of recharging or replacing batteries might become a major issue from both operational and financial perspectives.

At the same time, reducing UWB transmissions and data rates for battery saving purposes might not be accepted as an optimal solution. For example: Leantegra UWB devices have the so-called "adaptive blink rates" based on accelerometers and motion recognition. Still, some projects require 24x7 location monitoring for continuously moving assets, so the adaptive blink rates will not help to resolve the power consumption issue.

TDoA requires only one broadcast TX message from each UWB tag for positioning. Comparison: TWR requires three messages between each UWB tag and each UWB anchor – 9 messages in total for 3 anchors.

Main characteristics:

- Accuracy:
    - 30-50 cm for static objects.
    - 50-60 cm for moving objects.
- Range:
    - Settings for longer range: best case LOS - 80 meters, worst case LOS - 60 meters.
    - Settings for higher density: best case LOS - 50 meters, worst case LOS - 30 meters.
- Tag density:
    - Settings for longer range : 1 Hz rate - up to 360 tags, 5 Hz rate - up to 75 tags.

    - Settings for higher density: 1 Hz rate - up to 2400 tags, 5 Hz rate - up to 480 tags.

When to use:

- When your project requirements define 50-100 cm location accuracy for 2D RTLS scenarios.
- Long-term RTLS installations with “install-and-forget” approach - when onsite maintenance is expensive and must be rare. For example: changing batteries for UWB tags every 12+ months.
- When the tag density is really high - for example: tracking 1000+ objects inside the same area.
- When you need the lowest possible power consumption for the whole UWB RTLS system - anchors and tags.

When not to use:

- When you need sub-30 cm location accuracy from UWB RTLS.
- 1D UWB RTLS for tunnels or rails - can’t be implemented using TDoA.
- 3D UWB RTLS installations - still possible with TDoA, but good accuracy for Z-axis needs more RTLS anchors to be installed.

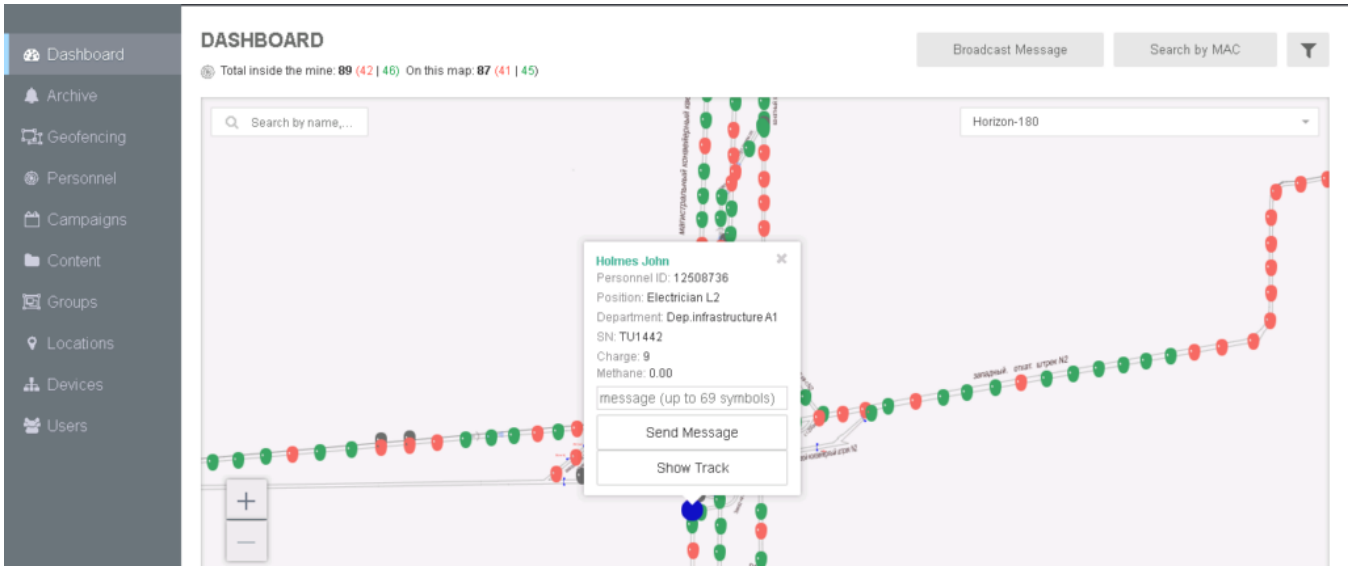
7.4. Tunnel UWB RTLS

The tunnel RTLS has been developed specifically for underground mines, but can be used anywhere where long corridors or rails are present. Both tunnel UWB and tunnel BLE RTLS enable location tracking with 2 anchors only, while the classic RTLS setup requires at least 3 anchors to be present.

To enable the tunnel UWB RTLS two Locator PRO devices must be installed at the ceiling within 40-60 meters from each other. The actual distance between two Locator PRO devices depends upon LOS-NLOS characteristics:

- For the case of good line-of-sight (LOS) conditions it is safe to install Locator PRO devices at 60 meters from each other.
- Good LOS conditions mean that UWB signals between each Locator PRO and UWB tag will not face any obstacles, such as human bodies.
- When UWB tags might be behind human bodies, then Locator PRO devices must be installed 40 meters from each other.

Leantegra CVO Portal - Map Dashboard



When to use:

- When you have areas in underground mines or long corridors, which require sub-50 cm location accuracy.
- When you physically can't install the needed RTLS anchors for 2D or 3D RTLS, because of the environmental specifics.

When not to use:

- When you need 2D or 3D RTLS.
- When you don't need high accuracy for 1D RTLS, then you can use the tunnel BLE RTLS instead of UWB.
- When you can't provide the needed power supply for each UWB anchor and must use batteries. Then using the tunnel BLE RTLS is a better option, because it is based on BLE beacons, which can operate for 2+ years on the same battery charge.

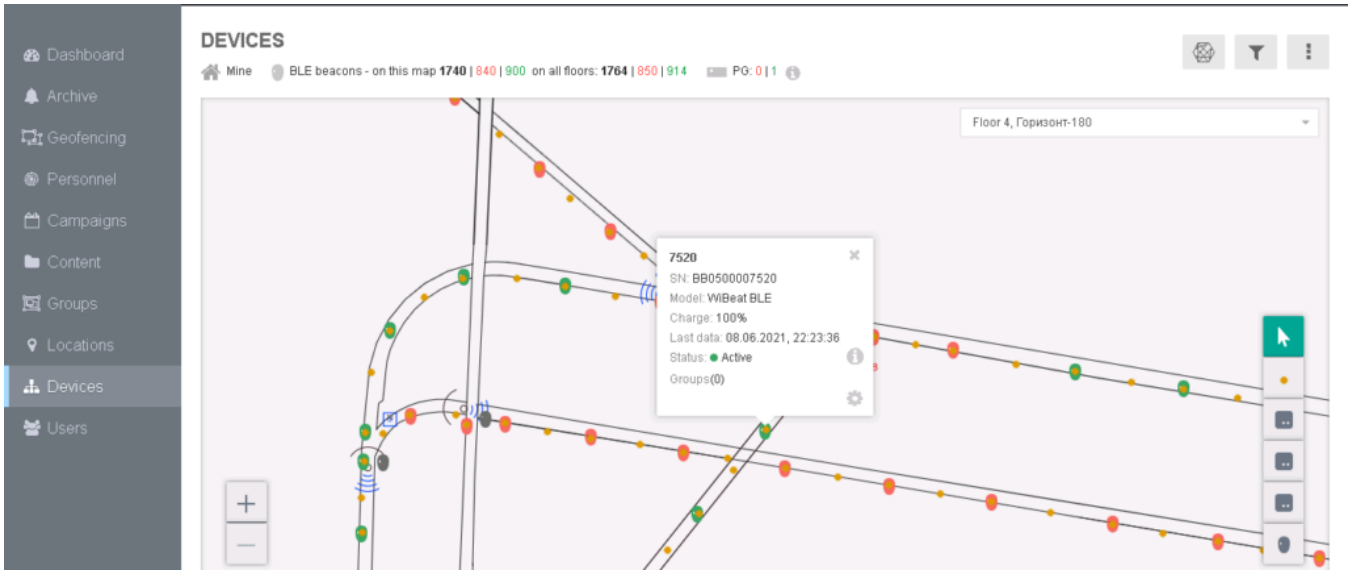
7.5. Reverse BLE RTLS (Tunnel BLE)

The reverse BLE RTLS feature was originally developed for coal mines to track miners using BLE beacons and mining cap lamps. It is based on the reverse RTLS architecture, where BLE beacons are installed along tunnels and RTLS anchors are carried by personnel inside their cap lamps.

This architecture enables low cost RTLS installations in underground mines by removing the need for cabling and power supply per each RTLS anchor. This is especially relevant for ATEX environments, such as coal mines, where costs of electrical equipment are really high.

Important - Locator PRO can be used for the reverse BLE RTLS installations without ATEX requirements. Please use other Leantegra RTLS devices with ATEX certifications, which you can find on our website.

Leantegra CVO Portal - Map Dashboard



When to use:

- When power supply and cabling for each RTLS anchor is expensive - for example: ATEX certified power supply units.
- When you have a large total length for underground tunnels (e.g. 50+ km) and you need to find a balance between cost and accuracy.
- When you need good scalability to track thousands of people or assets in underground mines.
- When 10-20 meters for location accuracy is enough.

When not to use:

- When you need a better location accuracy than 10 meters.
- When you need 2D or 3D RTLS.

7.6. BLE Zoning

RSSI-based tracking over BLE is available in the firmware of Locator PRO and can be configured via BLE GATT parameters (see Chapter 3.2):

- Enabling and disabling BLE zoning
- Changing the calibrated RSSI value for 1 meter - used to convert the collected RSSI values to meters

BLE zoning is a good choice for room-level or zone-level tracking with an average accuracy of 2-3 meters. Still, it is not recommended as a basis for any 1D, 2D or 3D RTLS scenarios.

Important - despite the available algorithms (e.g. Kalman filtering) in the firmware of Locator PRO and Leantegra RTLS Server there is no guarantee that RSSI-based tracking and BLE zoning will provide the needed accuracy.

Various obstacles and multipath environments might impact the resulting accuracy in a major way. Please use this feature with caution and select UWB instead of BLE for all scenarios, where predictable accuracy is needed.

7.7. Collision Avoidance and Proximity Detection Subsystem

Locator PRO firmware supports the features of Collision Avoidance and Proximity Detection Subsystem, which is a part of Leantegra CVO Platform R2023:

- Data communications with the Android HMI application over BLE GATT.
- Ranging vehicles and people over UWB TWR and custom payloads.
- Triggering the control signals over UART interfaces as a feedback to the ranging events.

Android HMI Application

For on-vehicle installations please consider using Locator LITE or Tag PRO devices instead of Locator PRO. Unless your installation requires PoE connectivity or other features, which are available in Locator PRO only.

7.8. Sensor Data Transmission

The firmware of Locator PRO supports the custom UWB payloads from Leantegra devices, such as Wristband PRO or Tag PRO, for carrying extra data from sensors.

The default version supports accelerometer, gyroscope, barometer and temperature data over UWB from Leantegra devices. Such sensor data is forwarded in the raw form via MQTT without any averaging or any other pre-processing. Please see Chapter 6.1 for the format descriptions of MQTT messages.

Locator PRO has its own barometer and temperature sensors on-board, which are also monitored by the firmware and transmitted over MQTT.

All technical characteristics for accuracies, latencies and sampling rates can be found in the corresponding datasheets of Leantegra UWB devices, such as Wristband PRO and Tag PRO. Both device models use the same IMU and barometer modules, so extra information can be obtained from the sensor datasheets:

- Accelerometer and gyroscope: Bosch BMI270
- Barometer: Bosch BPM390

8. OTA Firmware Upgrade

In addition to configurations over MQTT and BLE GATT there is a support for the remote firmware upgrades over MQTT. The logic for upgrade is implemented in two parts:

1. Firmware of Locator PRO device
2. Python script on the host side for controlling the upgrade process: “update_fw_uwb_anch.py”

The Python script can work with any MQTT broker, which supports MQTT 3.1.1 specification. There are no dependencies on Leantegra RTLS Server, so any available MQTT broker can be used - please see Chapter 4.1 for some examples.

The script sends commands to the specific MQTT topics for triggering the upgrade process, which includes sending the firmware file in chunks over MQTT. The whole upgrade process normally takes 1-2 minutes to complete.

Parameters for the Python script:

-a MQTT broker address
-sn Serial number for Locator PRO device, the script builds the needed MQTT topic from this serial number
-fw Firmware file to be used for the upgrade process

Sample command for launching the Python script:

```
python update_fw_uwb_anch.py -a 10.5.24.105 -sn UWBANCH0001 -fw UWB_anch_fw_v0.1.5.bin
```