Industrial Tracker Reference Guide

abeeway

Smart geolocation technology

Industrial Tracker

Firmware V1.7

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1 Introduction

1.1 General Description

Designed to withstand harsh environment, the Industrial Tracker combines high performance GPS receiver, a WIFI receiver and a Semtech Lora™ transceiver making it ideal for low-power industrial indoor and outdoor tracking applications.
An accelerometer detector associated with proprietary low power GPS technology extends significantly its battery life time.

1.2 Applications

- Asset and vehicle tracking at fixed frequency updates or on demand
- Anti-theft systems
- Activity monitoring
- Geofencing applications

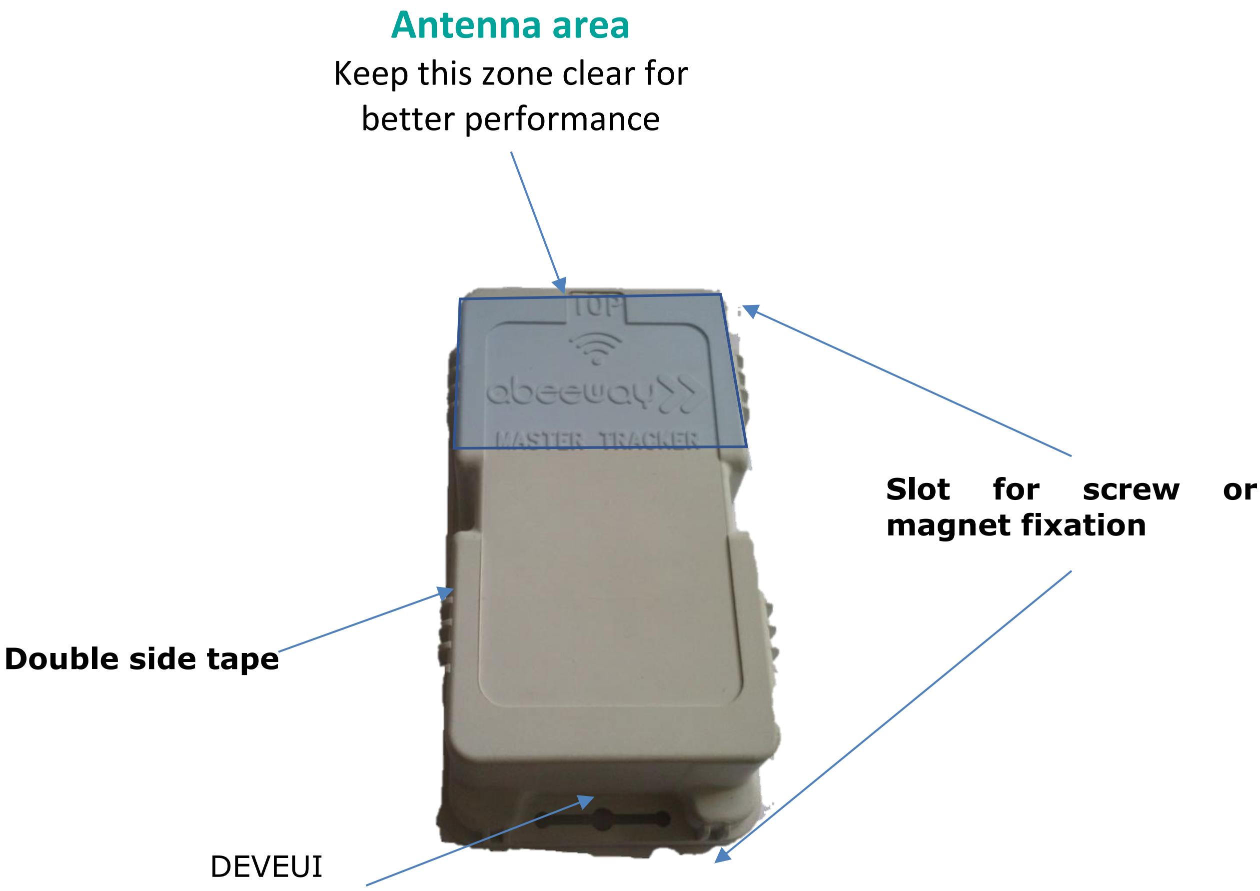
2 Features

- **Multiple operating modes**
  - ✓ **Motion tracking:** Get the tracker position at a given cycle when motion is detected.
  - ✓ **Permanent tracking:** Get permanently a position of the tracker.
  - ✓ **Start/End motion tracking:** Get position messages during motion start and end events.
  - ✓ **Activity tracking:** Monitor activity rate with embedded sensors.
- **Position on demand:** Receive the tracker position only when requested (very low power operating mode).
- **Used geolocation technologies**
  - ✓ **GPS**: Precise outdoor position.
  - ✓ **Low power GPS:** Get quick position outdoors and daylight indoor conditions.
  - ✓ **WIFI:** Position indoors and urban area.
- **LED**
- **Temperature monitoring**
- **Embedded antennas**
- **LoRa™ Class A radio**
- **Dust-proof and powerful water jets - (IP66)**

Note:

1- Low power GPS is referred as LPGPS or LP-GPS in the rest of the document.

3 Installation



3.1 Getting started

- The tracker is provided with battery connected
- Your network can use two activation modes:
  - ✓ OTAA (Over The Air Activation) that requires the following keys to join the network: DEVEUI, APPEUI and APPKEY for each device. (the most used)
  - ✓ ABP (Activation by personalization) that requires the following keys to connect to the network: DEVEUI, DEVADDR and NWKSKEY for each device
- Depending on your operator, some actions need to be done to activate the transfer of the data through Abeeway servers. Please refer to your vendor for more information.

3.2 Fixation

For optimum radio performance the tracker has to be positioned vertically (as shown on the picture).
It can be fixed with a magnet, screws or a double-sided tape.

Note:

1- the environment and orientation of the tracker can influence the radio performance. For optimum results keep the zone around the antenna area clear from any conducting material or magnetic fields.

4 Functioning

4.1 Main operating modes

This section describes the different operational modes supported by the trackers.

Standby mode: The tracker is sending periodically short LoRa messages, called heartbeat at the chosen period (*lora_period*). Device positions can be obtained in this mode by using the side operations features (see side operations section).

Motion tracking mode: The tracker provides positions when the device is moving. The reporting is done at the chosen period (*ul_period*). The positions are acquired based on the *geoloc_sensor* geolocation technology. If the device is not moving, heartbeat messages are sent regularly at the *lora_period* frequency. End of motion is validated when the device hasn't moved for 2 minutes.
When the device is static, only heartbeat messages are sent at the chosen period (*lora_period*). (like in standby mode)

Note:

1- **Whatever the chosen geolocation policy, the first position is always a WIFI one, sent immediately after the beginning of the motion.**

Permanent tracking mode: The device reports its positions at *ul_period* frequency regardless the motion. It uses the *geoloc_sensor* geolocation technology. Heartbeat messages are sent if there are no uplink message during *lora_period* seconds.

Note:

1- Having regular position can also be obtained using standby mode + side operation periodic position

See section Example to have an example of configuration

Motion Start/End tracking mode: In this mode, position messages are sent (*motion_nb_pos* +1)
times at the start and the end of a motion (one WIFI plus *motion_nb_pos* times using the *geoloc_sensor* geolocation technology). The end of the motion is detected when there is no movement during 120 seconds. Heartbeat messages are sent if there are no uplink message during *lora_period* seconds.

Activity mode: This mode sends activity reports instead of positions. The tracker focuses on detecting movements. Each shake detection increases a counter (after applying an integration period). The value of the counter is reported via the LoRa link at the *ul_period* frequency. Heartbeat messages are sent if there are no uplink message during *lora_period* seconds.

Notes:

1- **The accuracy of the different frequencies is not guaranteed as extra delays may be introduced by the LoRa network duty cycle.**
2- **In all these modes, side operation can be used to obtain additional positions**

4.2 Side operations

Whatever the operating mode, optional messages can be sent according to the configuration. The side operations are:

- Periodic position message
- Position on Demand
- SOS mode

For Periodic position message, Position on Demand and Alert mode, sending of the position is driven by the chosen transmit strategy:

- *Transmit_strat* equal to 2 or 3: Position message is sent twice if static, 4 times if moving
- *Transmit_strat* equal to 0, 1 or4: Position message is sent 3 times

4.2.1 Periodic position message:

The device sends periodically its position at the *periodic_pos_period* frequency. Usually, this reporting frequency is very long. If the *periodic_pos_period* is set to 0, this message is not sent.
This periodic position uses the *geoloc_method* geolocation strategy.
It can be accrued to all operational modes

4.2.2 Position on Demand:

Position requests are done via LORA downlink message. The device answers with its current position.
The geolocation strategy chosen for *geoloc_method* is used to have this position.

4.2.3 SOS mode:

Activation/deactivation:

- using LoRa downlink (See section SOS mode configuration for more details)

When activated:

- Send continuously positions at a fixed period of 120 s.
- Geolocation strategy: WGPS (WIFI then GPS if WIFI fails).
- GPS timeout set to 120 seconds (fixed).
- LoRa messages tagged with an alert flag. (see uplink description for more detail)

Note:

1- The side operations can be accrued.

4.3 Geolocation strategies

4.3.1 Main operating modes

The following geolocation policies (*geoloc_sensor* parameter) are used by the operating modes: motion-tracking, permanent-tracking and start/end tracking. Note that in standby mode, only side operations can report positions.

- **WIFI only** → Only WIFI scans are used for position determination.
- **GPS only** →Only the GPS is used for position determination.
- **LP-GPS only**→ GPS and low power-GPS are used for position determination.
- **Multimode (WIFI + AGPS + GPS**) → Alternate WIFI, LP-GPS and GPS technologies on failure, with timeout.
- **WIFI-GPS only** → WIFI then GPS if WIFI fails in one geolocation cycle.

- **WIFI-LPGPS only** → WIFI then Low power-GPS if WIFI fails in one geolocation cycle.
- **WIFI-LPGPS/ WIFI-GPS** → WIFI-low power GPS first, then WIFI-GPS if WIFI-low power GPS fails until timeout, then back to WIFI-low power GPS.

Note:

1- The first position is always a WIFI one whatever the chosen geolocation strategy.

4.3.2 Side operations

The following geolocation policies (*geoloc_method* parameter) are used for periodic-reporting or on-demand actions.

- **WIFI only** → Only WIFI scans are used for position determination
- **GPS only** →Only the GPS is used for position determination
- **LP-GPS only**→ GPS and LP-GPS are used for position determination
- **WIFI-GPS only** → WIFI then GPS if WIFI fails in one geolocation cycle
- **WIFI-LPGPS only** → WIFI then low power-GPS if WIFI fails in one geolocation cycle

4.3.3 Geolocation technology description

4.3.3.1 GPS

When doing a cold start, the tracker uses systematically a timeout of 5 minutes instead of the configured one.
To complete a position, the GPS module expects one of the two following conditions to be achieved.

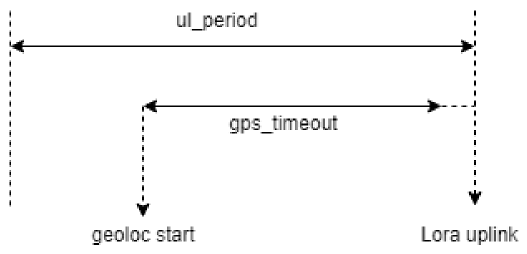
- The *GPS_convergence* timeout (time let to the GPS module to have a more precise position)
- The *gps_ehpe* value is below the configured value. EHPE (Estimated Horizontal Position Error) is provided by the GPS module and is expressed in meter.

Once completed the position is reported via LoRa and the GPS module switches to standby state.
Then, it waits *gps_standby_timeout* delay before going to the off state (losing all data and ephemeris)

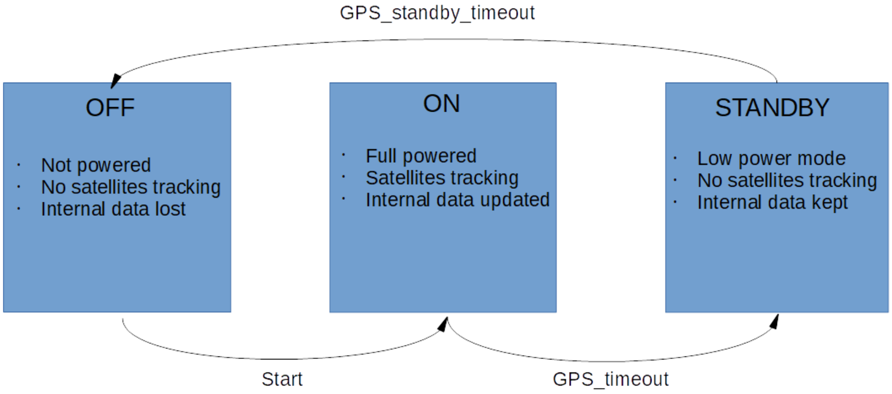
In the case where the GPS module didn't succeed, a GPS timeout message is sent instead of a GPS position message.

Note:

1- If a period smaller than *gps_timeout* is set for *ul_period* the GPS timeout used will be *ul_period* instead of *gps_timeout*



GPS state diagram

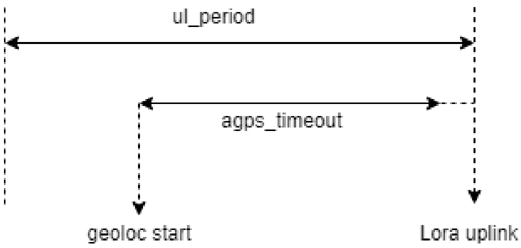


4.3.3.2 *Low power GPS*

In this mode, the device sends the data given by the GPS module before the *agps_timeout* delay expiry and the position calculation is done in our server.
If the GPS module didn't succeed in having enough data to provide to the server, a LP-GPS timeout message is sent instead of a LP-GPS data message.

Note:

1- If a period smaller than a*gps_timeout* is set for *ul_period* the LP-GPS timeout used will be *ul_period* instead of a*gps_timeout*



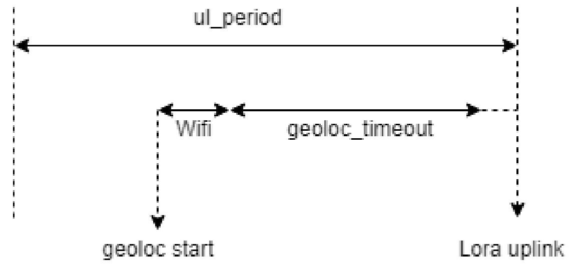
4.3.3.3 *WIFI*

Since a WIFI scan is always done within five seconds, there is no timeout parameter.
Once the scan is done, BSSID are sent via loRa with the related RSSI and the position calculation is done in our server.
In a multi technology geolocation strategy, a WIFI scan with less than 3 BSSID triggers a technology switch.
Regardless the number of BSSID (including 0) a LoRa WIFI position is sent.
In the case where the communication fails with the WIFI module, the device sends either a WIFI failure message or a WIFI timeout message.

4.3.3.4 *WIFI/LPGPS or WIFI/GPS*

Using these strategies, the tracker can use two location technologies in the same cycle if needed

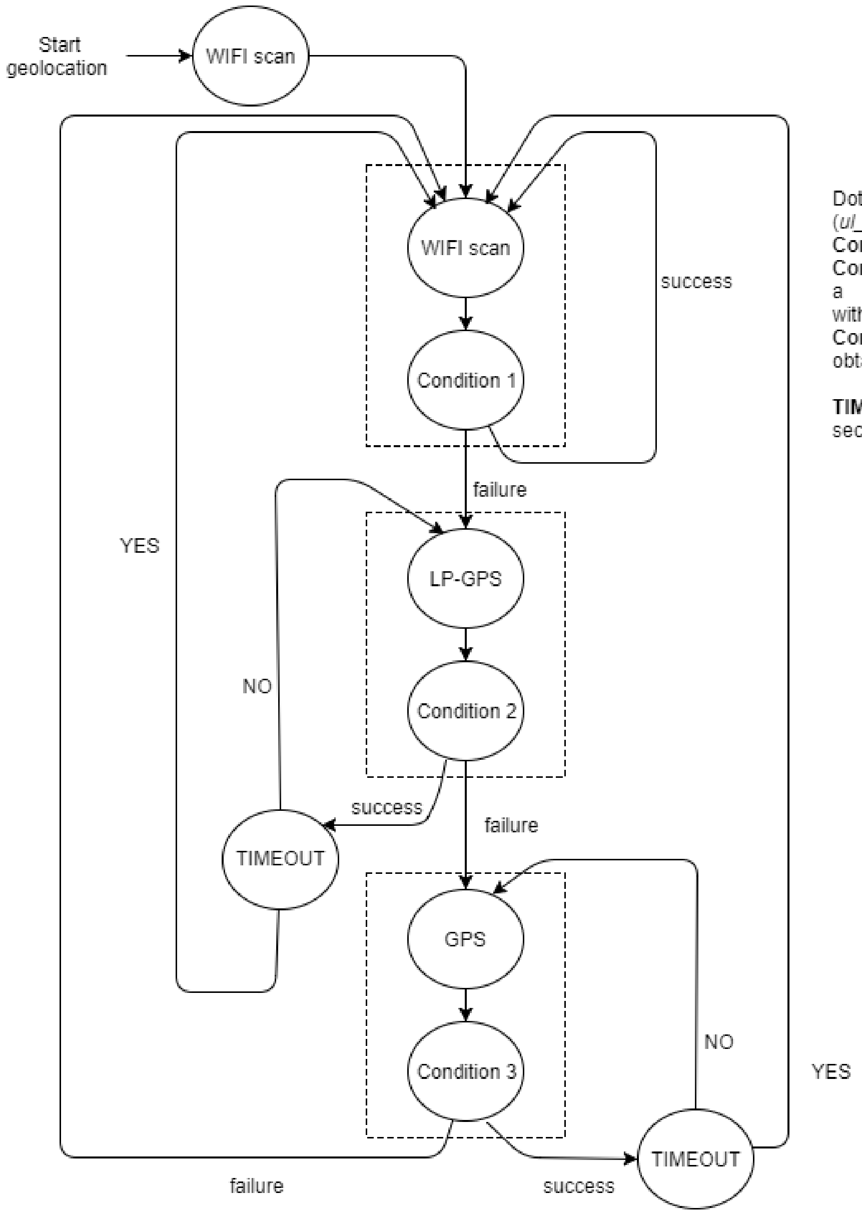
A WIFI scan result considered as successful (at least three BSSID) triggers a WIFI position message. Otherwise, the tracker tries immediately the next geolocation technology (GPS or LP- GPS), in the same geolocation cycle. That way, two geolocation technologies are used (if needed) before sending a given position uplink.



Geoloc_timeout =*gps_timeout* or *agps_timeout* depending on the used technology
If geoloc_timeout + wifi_time (8 seconds) is higher than *ul_period*, geoloc_timeout is adjusted and reduced to fit the *ul_period*.

4.3.3.5 Multi technology switching state diagrams

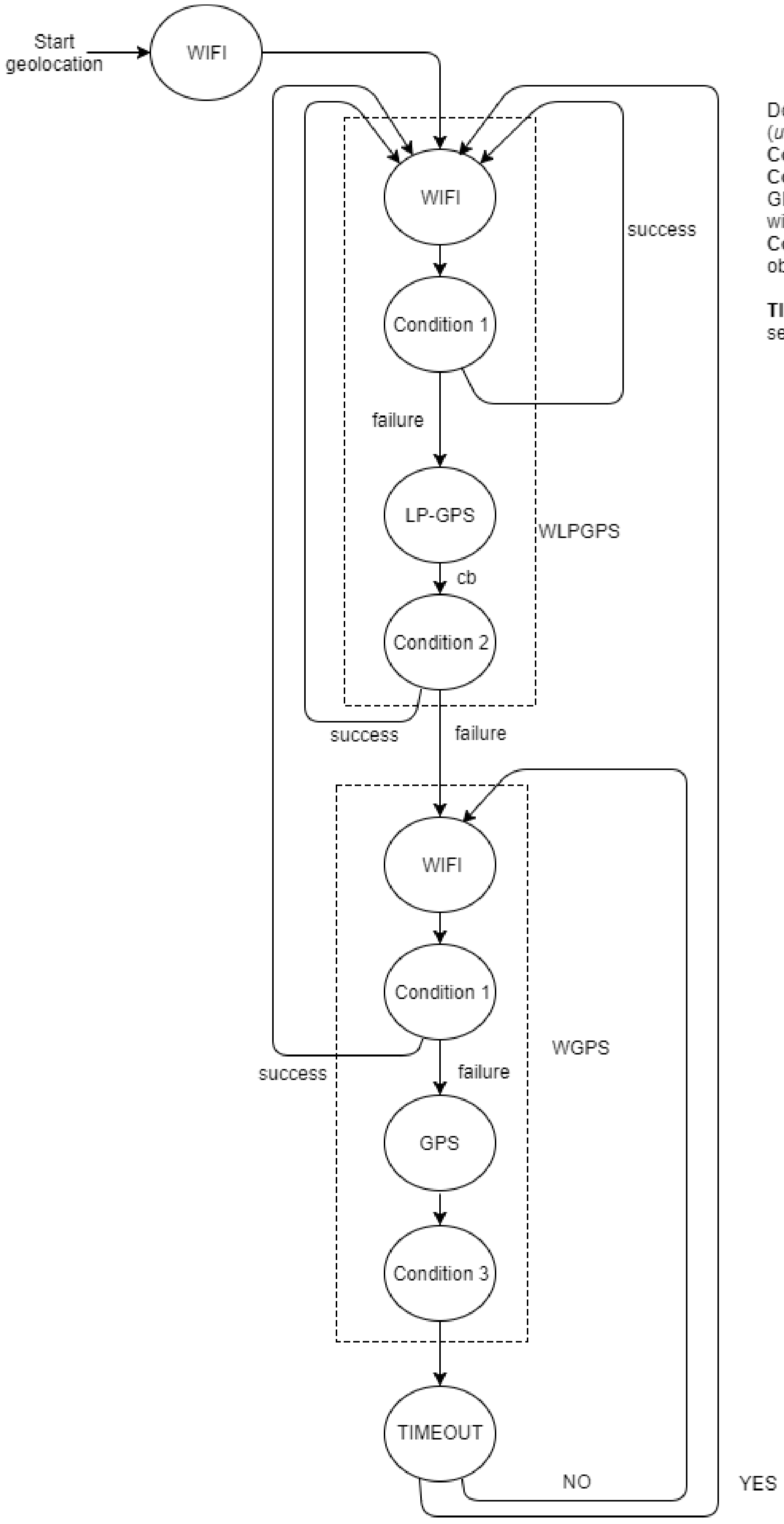
- Multimode (WIFI + low power-GPS + GPS) (with reset to WIFI on timeout) strategy: (*geoloc_strategy*=5)



Dotted rectangles represent 1 cycle of geolocation (*ul_period* time)
Condition 1: success if at least 3 WIFI BSSIDs are seen
Condition 2: success if at least 5 satellites with C/N>= 15 a GPS position are found by the GPS module within *agps_timeout* period
Condition 3: success ifa GPS position is obtained within *agps_timeout* period

TIMEOUT= Maximum(10 minutes; (3 **ul_period*+ 10 seconds))

➢ In multimode WIFI/LPGPS WIFI/GPS (*geoloc_strategy*=9):



Dotted rectangles represent 1 cycle of geolocation (*ul_period* time)
Condition 1: success if at least 3 WIFI BSSIDs are seen
Condition 2: success if at least 5 satellites with C/N>= 15 a GPS position are found by the GPS module within *agps_timeout* period
Condition 3: success if a GPS position is obtained within *agps_timeout* period

TIMEOUT= Maximum(10 minutes; (3 ****ul_period*+** 10 seconds))

5 Uplink messages

This section describes the payload messages supported by the tracker.
Unless otherwise specified, all values are transmitted in network byte order (MSB first).
Each message is composed by:

- A common header
- A specific data part

The tracker supports different types of uplink messages, that are described in following sections:

Message type		Content
Frame pending	**0x00**	This uplink message is sent to trigger the sending. (and speed up the configuration of the tracker) if downlink messages are available on gateway and no other uplink message is on the queue
Position message	**0x03**	GPS, low power GPS or WIFI position data
Energy status message	**0x04**	Used by the server to estimate the battery level. Contain information related to the power consumption
Heartbeat message	**0x05**	Notify the server the tracker is operational and under LoRa coverage
Activity Status message (1)	**0x07**	Reports the activity counter. Used only by the activity tracking operating mode
Configuration message (1)	**0x07**	Reports the partial or whole configuration of the trackers,
Debug message	**0xFF**	Internal use only

Note:

(1) Activity status message and configuration message share the same identifier. They are differentiated by another field.

5.1 LoRa uplink transmission

5.1.1 Strategy used

The tracker follows the LORA requirements regarding the transmission (like duty cycle).
Each transmission is managed according to the *transmit_strat* parameter:

<table>
<tr><th>Strategy</th><th>ID</th><th>Static device</th><th>motion device</th></tr>
<tr><td>Single fixed</td><td>0x00</td><td rowspan="4">Single transmission using network ADR(2).</td><td>Single transmission using a fixed data rate: SF10 (1).</td></tr>
<tr><td>Single random</td><td>0x01</td><td>Single transmission using a random data rate within [SF7-SF12].</td></tr>
<tr><td>Dual random</td><td>0x02</td><td>Double transmissions:
• First transmission using a random data rate within [SF7-SF8].
• Second transmission using a random data rate within [SF9-SF12].</td></tr>
<tr><td>Network ADR</td><td>0x04</td><td>Single transmission using network ADR(2).</td></tr>
<tr><td>Dual fixed</td><td>0x03</td><td>Double transmission using network ADR(2).</td><td>Double transmissions:
• First transmission using a random data rate within [SF7-SF8].
• Second transmission using a fixed data rate: SF10 (1) .</td></tr>
</table>

Notes:

(1) Value provisioned in the device in the factory
(2) Number of retransmission and rate managed by the network (with the same sequence number)

Refer the section LoRa parameters for more details.

5.1.2 Confirmed uplink

The device can be configured to request LoRa confirmation for a collection of uplink message types. The parameter *confirmed_ul_bitmap* is used to select the message types that requires a confirmation. Only message types in the range 0x00 to 0x0F can be selected.
Example:

Confirmed uplink of message types 0x0 and 0x3:
bitmap = $2^0 + 2^3 = 1 + 8 = 9$.

The parameter *confirmed_ul_retry* gives the number of retransmissions that the tracker should do in the case where the LoRa confirmation is not received.
A value 0 means that the uplink will request the LoRa confirmation but will not retry in a case of a failure.

5.2 Encoded form

Some parameters are encoded with the following algorithms:

static float _step_size (float **lo**, float **hi**, unsigned **nbits**, unsigned **nresv**)
{ return 1.0/((((1 << **nbits**) -1) -**nresv**)/(**hi** -**lo**)); }

float mt_value_decode(uint32_t **value**, float **lo**, float **hi**, unsigned **nbits**, unsigned **nresv**)
{ return ((value -**nresv** /2) * _step_size(**lo**, **hi**, **nbits** , **nresv**) + **lo**);}

Where:
- ✓ **nbits:** number of bits used to encode.:
- ✓ **lo:** min value that can be encoded
- ✓ **hi:** max value that can be encoded
- ✓ **nresv**: number of reserved values, not used for the encoding.

5.3 Common message header

Common header					Data
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Variable
Type	Status	Battery	Temperature	Ack/opt	Information

Type: refer to Message types

Status:

Bit7-5	Operating mode: ➢ 0- Standby ➢ 1- Motion tracking ➢ 2- Permanent tracking ➢ 3- Motion start/end tracking ➢ 4- Activity tracking
Bit 4	Set if the user alert/SOS has been entered
Bit 3	Set if the tracker is in tracking state, else idle state.
Bit 2	Set if the tracker is moving
Bit 1	Set for a periodic position message
Bit 0	Set for a position on demand message

Battery: Battery voltage expressed in volt. Encoded form using **lo**= 2.8, **hi**= 4.2, **nbits**= 8, **nresv**= 2. It is given with a step of 5,5mV

Temperature: Temperature measured in the device, expressed in degree Celsius. Encoded form using lo= -44, hi= 85, nbits= 8, nresv= 0. It is given with a step of 0.5°C

Ack/opt:

Bit 7-4	Acknowledge token. Refer the section Acknowledge token for more details
Bit 3-0	Optional data (depending on message type)

Information: Variable part depending on the message type.

Decoding of the encoded form is detailed in the Encoded form section

5.4 Heartbeat messages

Byte 0-4	Byte 5	Byte 6-8 (optional)
Header	Cause	FW version

Cause: Last reset cause

FW version: Firmware version on the device, it is sent only twice a day

5.5 Position messages

Common header		**Data**
Byte 0-3	Byte 4	(1)
Header	Ack/opt	Position Information

Note:

1- The size of data part depends on the type of position message

Ack/opt:

Bit 7-4	Acknowledge token
Bit 3-0	Optional data: position type (see the values below)

Position Information: type of position message

- 0 – GPS fix:
- 1 – GPS timeout
- 2 – No more used.
- 3 – WIFI timeout
- 4 – WIFI failure
- 5, 6 – LP-GPS data (encrypted, not described in this document)
- 7 – BLE beacon scan (not available in industrial trackers)
- 8 – BLE beacon failure (not available in industrial trackers)
- 9 – WIFI BSSIDs

5.5.1 GPS fix payload

Common header	Data				
Byte 0-4	Byte 5	Byte 6-8	Byte 9-11	Byte 12	Byte 13-15
Header	Age	Latitude	Longitude	EHPE	Encrypted

Age: Age of the fix. Encoded form using **lo**= 0, **hi**= 2040, **nbits**= 8, **nresv**= 0. Expressed in seconds. The step is 8 seconds.

Latitude: Latitude of the position (expressed in degree) calculated as follow:
Latitude = Latitude << 8
If Latitude > 0x7FFFFFFF then Latitude = Latitude – 0x10000000
Latitude = Latitude / 10^7

Longitude: Longitude of the position (expressed in degree) calculated as follow:
Longitude = Longitude << 8
If Longitude > 0x7FFFFFFF then Longitude = Longitude – 0x10000000
Longitude = Longitude / 10^7

EHPE: Estimated Horizontal Position Error, expressed in meters. Encoded form using **lo**= 0, **hi**= 1000, **nbits**= 8, **nresv**= 0. The step is 5.9 meters.

Encoded form is detailed in the Encoded form section.

5.5.2 GPS timeout payload

Common header	Data				
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Header	Cause	C/N 0	C/N 1	C/N 2	C/N 3

Cause: Timeout cause
- 0 - User timeout cause

C/N 0: Carrier over noise (dBm) for the first satellite seen.
C/N 1: Carrier over noise (dBm) for the second satellite seen.
C/N 2: Carrier over noise (dBm) for the third satellite seen.
C/N 3: Carrier over noise (dBm) for the fourth satellite seen.

Notes:
1- **C/N** encoding uses: **lo**= 0, **hi**=2040, **nbits**=8, **nresv**= 0. It is expressed in dBm with a step of 0,2dBm
2- Encoded form is detailed in the Encoded form section.

5.5.3 WIFI timeout payload

Common header	Data					
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10
Header	v_bat1	v_bat2	v_bat3	v_bat4	v_bat5	v_bat6

v_bat1: encoded voltage at the start time (T0) of the WIFI scan.
v_bat2: encoded voltage at T0 + 0.5 second.
v_bat3: encoded voltage at T0 + 1 second.
v_bat4: encoded voltage at T0 + 1.5 second.

v_bat5: encoded voltage at T0 + 2 seconds.
v_bat6: encoded voltage at T0 + 2.5 seconds.

Notes:

1- Most of time a WIFI timeout occurs due to low battery.
2- **v_bat** encoding uses **lo**=2.8, **hi**=4.2, **nbits**=8, **nresv**=2. It is expressed in volt with a step of 5.5mV
3- Encoded form is detailed in the Encoded form section

5.5.4 WIFI failure payload

Common header	Data						
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11
Header	v_bat1	v_bat2	v_bat3	v_bat4	v_bat5	v_bat6	Error

v_bat1: encoded voltage at the start time (T0) of the WIFI scan.
v_bat2: encoded voltage at T0 + 0.5 second.
v_bat3: encoded voltage at T0 + 1 second.
v_bat4: encoded voltage at T0 + 1.5 second.
v_bat5: encoded voltage at T0 + 2 seconds.
v_bat6: encoded voltage at T0 + 2.5 seconds.

Error:

- 0– WIFI connection failure
- 1 – Scan failure
- 2 – Antenna unavailable
- 3 – WIFI not supported on this device

Notes:

1- Most of time a WIFI timeout occurs due to a low battery condition.
2- **v_bat** encoding uses **lo**=2.8, **hi**=4.2, **nbits**=8, **nresv**=2. It is expressed in volt with a step of 5.5mV
3- Encoded form is detailed in the Encoded form section

5.5.5 WIFI BSSID payload

Common header	Data								
Byte 0-4	Byte5	Byte 0-4	Byte5	Byte 0-4	Byte5	Byte 0-4	Byte5	Byte 0-4	Byte5
Header	Age	Header	Age	Header	Age	Header	Age	Header	Age

Age: encoded form of scan age with **lo**=0, **hi**=2040, **nbits**=8, **nres**=0. Expressed in seconds.

BSSID x: BSSID of the WIFI station x.

RSSI x: Receive Signal Strength Indication of the WIFI station x. Non encoded form (signed 8 bits). It is expressed in dBm.

Notes

1- The payload contains the listened WIFI stations (up to 4).
2- If less than 4 stations are listened, the payload will be reduced.
3- BSSID address is provided in big endian format. So, the byte 6 of the payload contains the MSB of the BSSID0, while the byte 11 contains its LSB.
4- Encoded form is detailed in the Encoded form section.

5.6 Energy Status messages

Common header	Data		
Byte 0-4	Byte 5-8	Byte 9-12	Byte 13-16
Header	GPS ON	GPS Standby	WIFI scan

This message should be used for the primary battery life estimation.

GPS ON: Number of seconds the GPS module is ON.

GPS Standby: Number of seconds the GPS module is in standby mode.

WIFI-SCAN: Number of times a WIFI scan has been done.

Consumptions:

- GPS ON: 40 mA
- GPS standby: 100 uA
- WIFI scan: 100 mA during 3 seconds.
- LoRa: 40mA (EU). 90 mA (other regions).

5.7 Activity status messages

Common header	Data	
Byte 0-4	Byte 5	Byte 6-9
Header	Tag=1	Activity

Activity: Activity counter. Unsigned 32 bits value in big endian format (MSB first).

5.8 Configuration messages

Common header	Data					
Byte 0-4	Byte 5	Byte 6-10	Byte 11-15	Byte 16-20	Byte 21-25	Byte 26-30
Header	Tag=2	Parameter 0	Parameter 2	Parameter 2	Parameter 3	Parameter 4

Parameter x: Configuration parameter x, coded on 5 bytes as follow:

- First byte: Parameter identifier. Refer to the parameter identifier in the section Parameters configuration
- Next 4 bytes: Parameter value. Unsigned 32 bits value in big endian format (MSB first).

5.9 Frame pending messages

Byte 0	Byte 1
Type=0	Acknowledge token

When additional messages are available on a gateway, this uplink message is sent to trigger the gateway sending (if no other messages are pending).

Note:

1- To shorter the payload, this message is only 2 Bytes long (no common header).

6 Downlink messages

These messages are sent from the server to the tracker through the LoRa network. They are used to either configure or manage the tracker. Each message contains a header including:

- A message type
- An acknowledgement token

The remaining of the message depends on the message type described in the following table.

Message type	ID	Description
POD	0x01	Position on demand
Set Mode	0x02	Change the tracker mode
Request configuration	0x03	Request actual config
Start SOS mode	0x04	Turn on SOS mode
Stop SOS mode	0x05	Turn off SOS mode
Set Param	0x0B	Modify parameter(s)
Debug command	0xFF	Reset the tracker

Notes

1- Any unexpected message (unknown message type, bad length, ...) is discarded. However, the ack token is updated even if the message is discarded (if the payload is at least 2 bytes long).

2- The **LoRa port** to be used for downlink is **2**.

6.1 Acknowledge token

It provides a way to indicate to the application that a given message has been received by the tracker.
The acknowledge token is transmitted in every uplink message, and it is updated when the tracker receives a LoRa message. This way, each time the server receives a LoRa uplink, it knows whether the previous message has been received.
The acknowledge token is four bits size. Its value ranges from 0 to 15 (0x0F).

Notes

1- The ack token value must be changed for each downlink.

2- It's up to the application to process or not the ack tokens.

3- It's up to the application to manage the confirmations. It can either wait for the matching ack token in the uplink message before sending another downlink or send multiple downlink and later waits for the acks.

6.2 Operational mode configuration

The operating mode can be remotely configured with a downlink LoRa message built as follow:

Byte 0	Byte 1	Byte 2
0x02	ACK	Mode

ACK: Acknowledge token. Refer to the section Acknowledge token.

Mode: operating modes. Acceptable values are:
- 0- Standby
- 1- Motion tracking
- 2- Permanent tracking
- 3- Motion start/end tracking
- 4- Activity tracking

Example:
Changing the operating mode to "motion track" (01) with an ack token of 3: **0x020301**.

6.3 Position on demand

Whatever the state, a position can be requested from the tracker using the message:

Byte 0	Byte 1
0x01	ACK

Example:
Position on demand message with ack token of 2: **0x0102**.
The tracker will answer with a position message.

6.4 Request device configuration

Byte 0	Byte 1	Byte 2-21
0x03	ACK	Parameter ID list (optional)

Parameter ID list: List of requested parameters identifiers.
- Each single byte contains a single identifier.
- The list can have up to 20 parameters.
- Parameter IDs are the one used to configure the device (see section Parameters configuration).
- Special parameters can be requested.
- The list can be empty. In this case, all parameters are requested.

Special parameter Id:
- 0xFE: get the firmware version.

Notes
1- The tracker answers this request with a Configuration uplink message (section Configuration messages).
2- The uplink contains a maximum of 5 parameters.
3- If the number of parameters is greater than 5, the tracker will send the needed number of uplinks to fulfill the request.

6.5 SOS mode configuration

Turn on SOS mode of the tracker:

Byte 0	Byte 1
0x04	ACK

Turn off SOS mode of the tracker:

Byte 0	Byte 1
0x05	ACK

See section Side operations to have more information about the SOS mode behavior.

6.6 Parameters configuration

Any parameter can be remotely modified with a downlink LoRa message.
Such messages are built according to the following format:

Byte 0	Byte 1	Byte 2	Byte 3-6
0x0B	ACK	Parameter ID	New value [31-00]

It is possible to modify up to 5 parameters in the same message by using the following format:

		Parameter 1		Parameter 2	
Byte 0	Byte 1	Byte 2	Byte 3-6	Byte 2	Byte 3-6
0x0B	ACK	ID	New value1 [31-00]	ID	New value2 [31-00]

The parameters identifier and the values are given in the following tables

6.6.1 Parameters for operational modes

Parameter	ID	Unit	Range	Description
ul_period	0x00	second	60 - 86400 (min 30 for US)	Period of position or activity messages in motion, start/end, activity or permanent operating mode
lora_period	0x01	second	300 - 86400	Period of LoRa heartbeat messages
geoloc_sensor	0x05	none	0 - 9	Geolocation sensor profile used in motion, start/end or permanent tracking operating mode 0- WIFI only 1- GPS only 2- LP-GPS (AGPS/GPS) 3- Reserved (do not use) 4- Reserved (do not use) 5- Multimode (WIFI + low power-GPS + GPS) (with reset to WIFI on timeout). **Superseded by mode 9**. 6-WIFI-GPS only (WIFI then GPS if WIFI fails in one geolocation cycle) 7- WIFI-LPGPS only (WIFI then low power GPS if WIFI fails in one geolocation cycle) 8- Reserved (do not use) 9- WIFI-LPGPS first, the WIFI-GPS until timeout, then back to WIFI-LPGPS
motion_nb_pos	0x08	none	1-60	Number of positions to report during motion events (motion start/end mode only).

6.6.2 Parameters for side operation modes

Parameter	ID	Unit	Range	Description
periodic_pos_period	0x03	second	0, 900 - 604800	Period of the periodic position report. A null value (0) disables this reporting.
geoloc_method	0x06	none	0-4	Oneshot geolocation policy used for periodic or on demand positions: 0- WIFI 1- GPS 2- LP-GPS (AGPS/GPS) 3- WIFI-GPS only (WIFI then GPS if WIFI fails in one geolocation cycle) 4- WIFI-LPGPS only (WIFI then low power GPS if WIFI fails in one geolocation cycle)

6.6.3 Parameters for GPS and low power GPS geolocation modes

Parameter	ID	Unit	Range	Description
GPS				
gps_timeout	0x09	second	30-300	Timeout for GPS scans before sending a GPS timeout message.
gps_ehpe	0x0B	meter	0-100	Acceptable GPS horizontal error for GPS geolocation
gps_convergence	0x0C	second	0-300	Time let to the GPS module to refine the calculated position
gps_standby_timeout	0x11	second	10-7200	Duration of the GPS standby mode before going OFF.
Low power GPS				
agps_timeout	0x0A	second	30-250	Timeout for low power GPS scans before sending the timeout message.

6.6.4 LoRa parameters

Parameter	ID	Unit	Range	Description
Transmit_strat(1)	0x0E	none	0-4	Transmit strategy in motion: 0 - Single fixed. Single TX. Use provisioned data rate. 1 - Single random: Single TX. Rate in [SF7..SF12]. 2 - Dual random: First TX with rate in [SF7..SF8], next TX with rate in [SF9..SF12]. 3 - Dual fixed: First TX in [SF7..SF8]. Next Use provisioned data rate. (not recommended) 4 – Network ADR. The LoRa network controls the number of transmissions.
confirmed_ul_bitmap(2)	0x12	none	0x0 – 0xFFFF	Bitmap enabling the LoRa confirmation of specific type of uplink message

Parameter	ID	Unit	Range	Description
confirmed_ul_retry(2)	0x13	none	0-8	The number of retries for each confirmed uplink when the confirmation is not received

Note:

(1) Refer to the section Strategy used for more details
(2) Refer to the section Confirmed uplink for more details

6.6.5 Miscellaneous parameters

Parameter	ID	Unit	Range	Description
pw_stat_period	0x02	second	0, 300 - 604800	Period of the Energy status report. When 0, no energy status report is transmitted.
config_flags	0x0D	none		Configuration flags: bit 0: Frame pending mechanism bit 1: Not used bit 2: Not used bit 3: Send a configuration uplink message in response to a configuration modification downlink. Used to confirm the action. bit 4: WIFI payload with Cypher(0) or No Cypher(1) bit 5: Not used

Example:
To modify the heartbeat period to 1 hour, the command **0x0B020100000E10** should be sent.
Description:

- (0x0B): set the parameter
- (0x02): with an ack token of 2
- (0x01): heartbeat message period
- (0x 00 00 0E 10): to a value of 3600s = 1 hour

6.7 Debug command

Debug downlink commands allow to trigger specific behavior.

Byte 0	Byte 1	Byte 2
0xFF	ACK	Debug CMD ID

Debug CMD ID:

- 0x01 reset the device

7 Examples of configuration

7.1 Accurate position using GPS mode only

Case description:

Accurate Motion tracking of an asset. Configuration:

- ✓ Environment: outdoor only (GPS mode only).
- ✓ Reporting position period: 5 minutes.
- ✓ LoRa TX strategy: Dual transmit with random SF when moving.
- ✓ No power consumption restriction

To improve the GPS accuracy, you can either decrease *gps_ehpe* parameter or increase the *gps_convergence* time.

The GPS timeout can be also modified to let more time to have or refine a position.

Proposed configuration

- ✓ *Operational mode*: motion tracking
- ✓ *ul_period*: 300 (5 minutes)
- ✓ *geoloc_sensor*: 1 (GPS only)
- ✓ *gps_timeout*: 290s.
- ✓ gps_ehpe: 3m
- ✓ *gps_convergence*: 120s
- ✓ *gps_standby_timeout*: 3600s (1 hour)
- ✓ *Transmit_strat=2*

Results:

Accurate GPS positions are obtained each five minutes under good condition (weather, …).

7.2 Low power configuration,

Case description:

Long battery life time, with position only when desired.

- ✓ Single position on request.
- ✓ High position cadency on request
- ✓ Environment: indoor/ outdoor

Proposed configuration

- ✓ *Operational mode*: Standby
- ✓ *geoloc_method*: 4 (WIFI/ A-GPS)
- ✓ *Transmit_strat=2*
- ✓ Downlinks:
    - o Receive position of the device (position on demand
    - o Activate the **SOS mode** to accurately track the device.

Results:

- ✓ Single position: When requested, the position is sent twice (it is doubled if the device is moving).
- ✓ Continuous positions (each 120s using WIFI/GPS) until the **SOS mode** is stopped.

7.3 Tracking in low power mode (beginning and end of motions only)

Case description:
Long-battery life time. Tracking an asset to get its final location in an indoor/outdoor environment.

Proposed configuration

- ✓ *Operational mode*: Start/End tracking.
- ✓ *geoloc_sensor*: 9 (WIFI/ A-GPS - WIFI/GPS)
- ✓ *ul_period*: 120 (2 minutes)
- ✓ *motion_nb_pos: 2*
- ✓ *Transmit_strat: 1*

Results
At the beginning or at the end of a motion, the device sends its position twice with a period of 2 minutes

7.4 Indoor only position

Case description:
Fast tracking of an asset inside buildings or in dense urban area.

Proposal configuration

- ✓ *Operational mode*: Motion tracking
- ✓ *ul_period*: 120 (2 minutes)
- ✓ *geoloc_sensor*: 0 (WIFI only)
- ✓ *geoloc_method*: 0 (WIFI only)
- ✓ *Transmit_strat=4*

Results
The device sends its position once, every 2 minutes when moving, using WIFI mode only.
Medium power consumption (due to the fast tracking).

7.5 Fixed frequency positioning

Case description:
Asset to be geolocated at regular interval (no matter if moving or not) in an indoor/outdoor environment.

Proposed configurations

Position every 6 hours

- ✓ *Operational mode*: Standby
- ✓ *geoloc_method*: 4 (WIFI/ A-GPS)
- ✓ *periodic_pos_period: 21600 (6 heures)*
- ✓ *Transmit_strat=2*

Position every 30 minutes

- ✓ *Operational mode*: Permanent
- ✓ *ul_period*: 1600(30 minutes)
- ✓ *geoloc_sensor*: 9 (WIFI/ A-GPS - WIFI/GPS)
- ✓ *Transmit_strat=2*

Results

Position every 6 hours

Every 6 hours the device sends its position **twice** using WIFI/AGPS method. The number of uplinks is doubled if the device is moving.

Position every 30 minutes

Every 30 minutes the device sends its position **once** using Multimode strategy. The number of uplinks is doubled if the device is moving.

7.6 Activity tracking

Case description:

No geolocation needed. The focus is the activity measure of an asset.

Proposed configuration

- ✓ *Operational mode*: Activity tracking
- ✓ *ul_period*: 1600(30 minutes)
- ✓ *Transmit_strat=2*

Results

When moving the device sends an activity message every 30 minutes, containing a counter which is incremented on each motion detection.

Note:

1- To locate the tracker, the **position on demand** downlink can be used. In this case, the configuration should be enhanced with the *geoloc_method* set to the appropriate value.

Another way to locate the tracker is the use of the **periodic position report** side operation. In this case the configuration should contain: the *geoloc_method* and the *periodic_pos_period.*

8 Hardware Specifications

Refer to the related datasheet